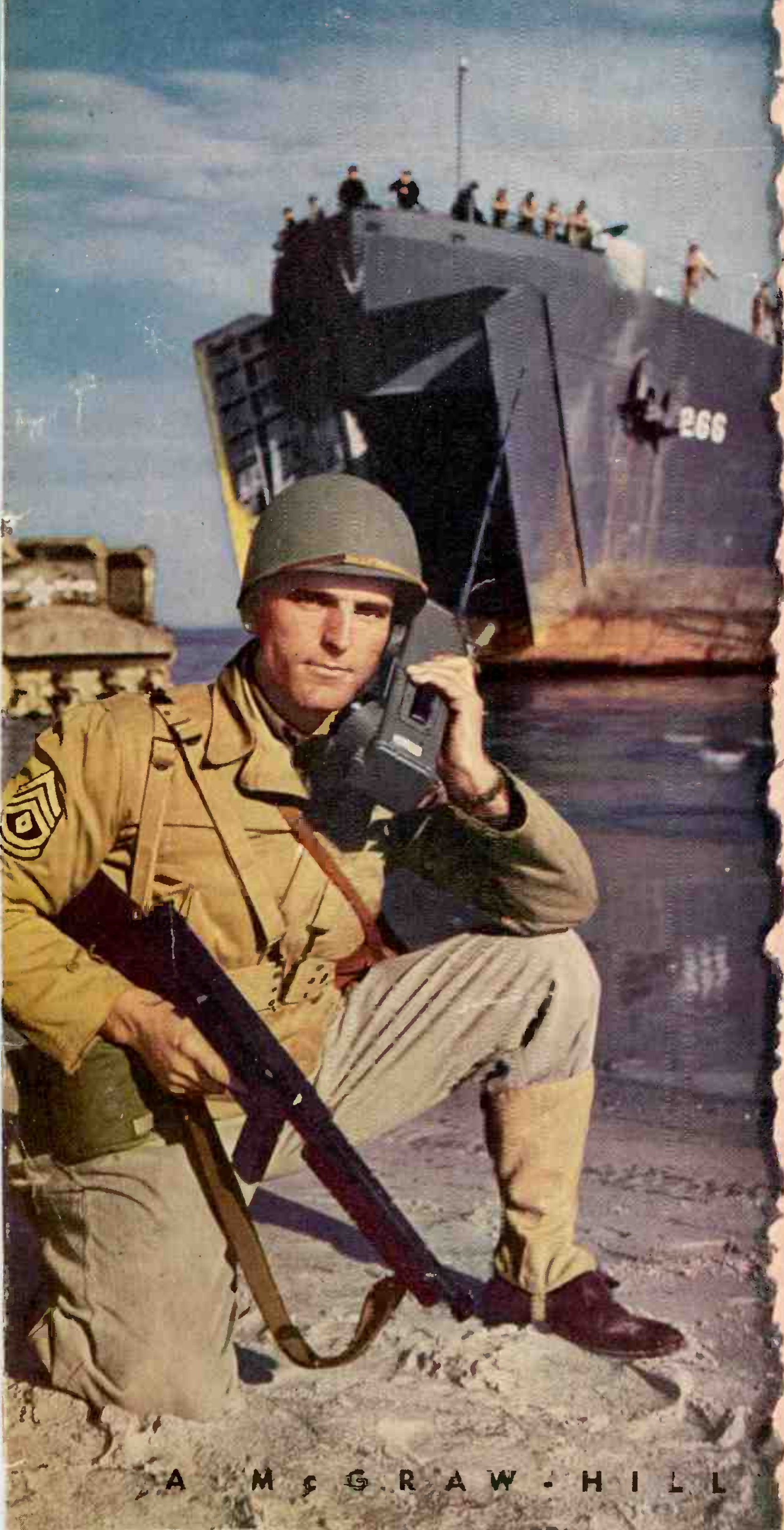
JULY • 1945

electronics



TO THE AMERICAN PEOPLE:

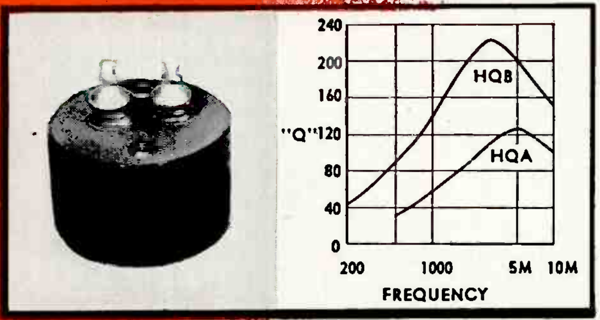
Your sons, husbands and brothers who are standing today upon the battlefronts are fighting for more than victory in war. They are fighting for a new world of freedom and peace.

We, upon whom has been placed the responsibility of leading the American forces, appeal to you with all possible earnestness to invest in War Bonds to the fullest extent of your capacity.

Give us not only the needed implements of war, but the assurance and backing of a united people so necessary to hasten the victory and speed the return of your fighting men.

A McGRAW-HILL PUBLICATION

FOR INDUCTORS



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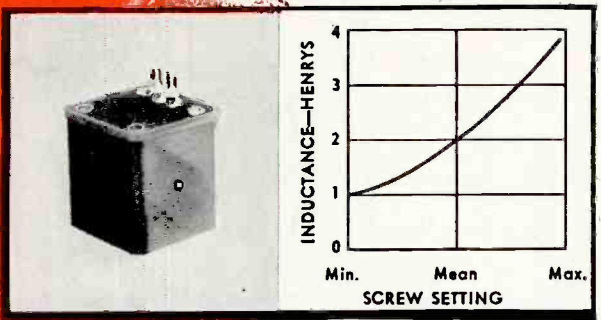
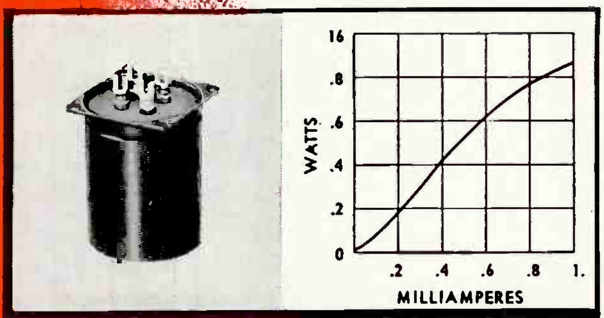
This series of toroid wound high stability inductors are available from 5 Mhy. to 2 Hys. Voltage stability is excellent, hum pickup is very low. Temperature effects are negligible. HQA units 1-13/16" in diameter by 1-3/16" high.



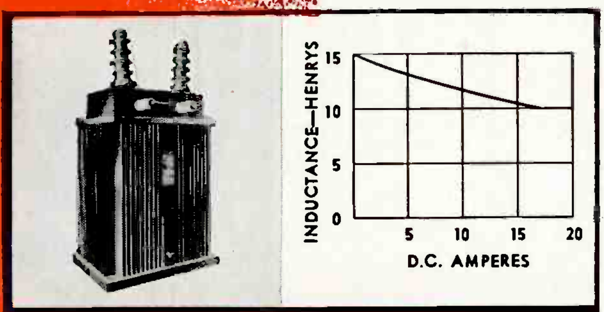
TYPE VI-C VARIABLE INDUCTORS

These inductors are available in optimum values from 10 Mhy. to 10 Hys. They are tunable over a wide range by inserting an Allen Head wrench in the adjusting screw. Units measure 1¼" x 1-7/16" x 1-7/16".



SENSITIVE SATURABLE INDUCTORS

UTC Saturable Inductors cover a wide range of application for magnetic amplification and control. These units are supplied to specific requirements. The curve shown illustrates a high sensitive type, showing DC saturation vs. AC watts into load.



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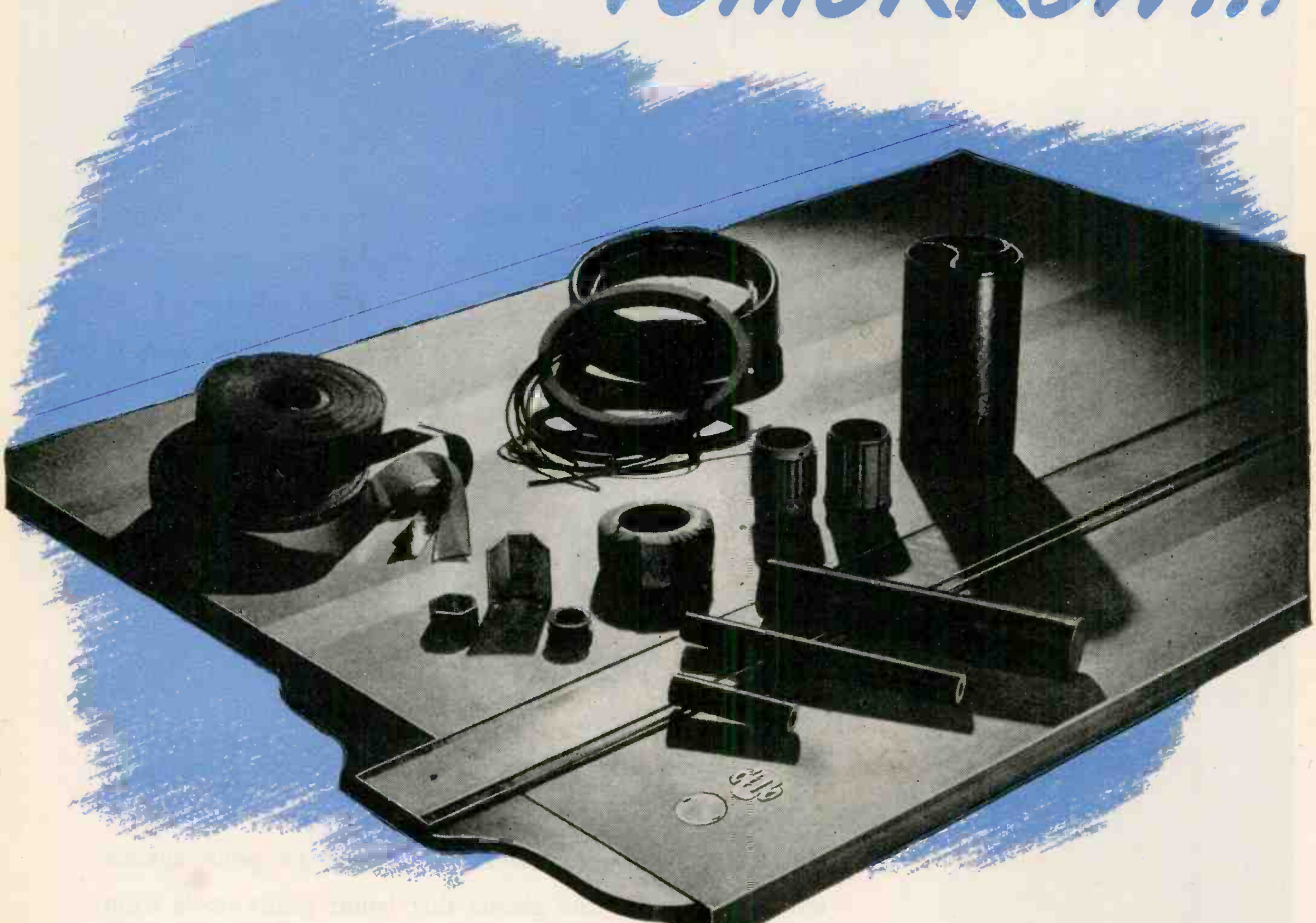

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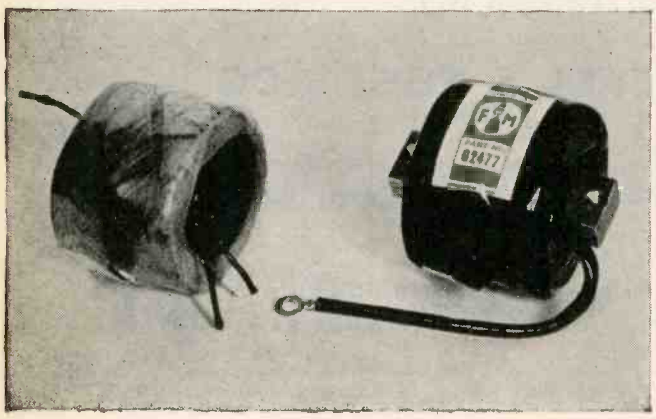

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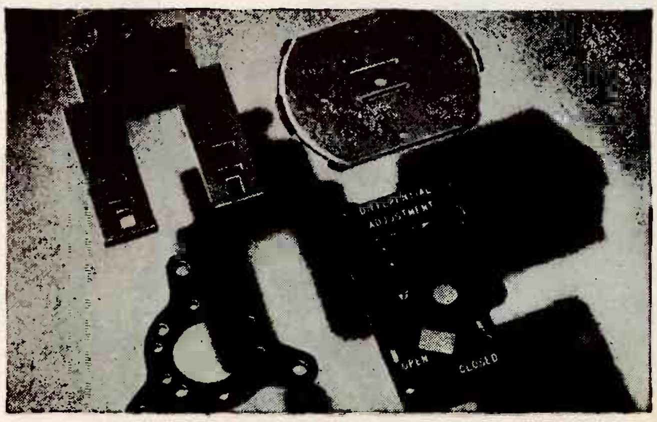

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Product engineers can build future performance into all of their products by anticipating and eliminating every possible cause of insulation failure. That is why many manufacturers engaged in designing new and improved electrical and electronic products are consulting Mica Insulator Company. Insulation standards may be revised to incorporate wartime insulation developments, techniques and improved materials.

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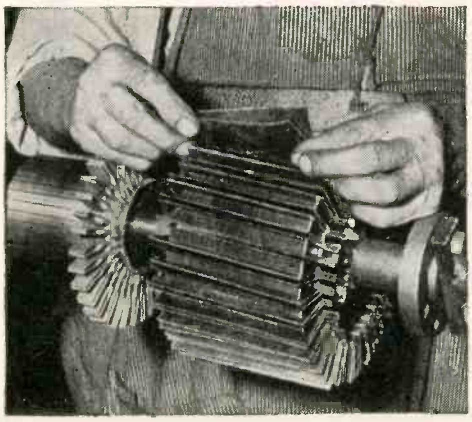

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"CQ..." we'll hear it again-SOON

THE HAM IS COMING BACK... STRONGER THAN EVER

Who Said The "Ham" Is Finished?

THERE have been rumors to the effect that the radio Amateurs were going to be denied their old frequency bands, and given new bands of such high frequency as to be useless for medium and long distance communication.

Some rumors say "Remember the last War? We are going to get the same treatment this time!"

Now, we don't believe the "Hams" should be denied their rightful place on the air in bands suitable for communication beyond the horizon—and further, we do not believe that our Government would want to see those privileges denied.

Are not the "Hams" fighting on many battlefronts, working in war factories and laboratories for a New World wherein the individual will be able to live and enjoy his hobbies, his church and other personal freedoms which go to make up a healthy, happy world?

It is well-known among Government officials whose task it was to build our great war-time communications system that from the rank and file of amateurs came executives, instructors and thousands of engineers and operators. Without this nucleus of experienced men, it would no doubt have taken a much longer time to reach the present high degree of perfection in the communications branch of our fighting forces.

In every emergency Amateurs have proved their ability and willingness to come to the aid of their Country—who would be so unjust as to want to deny them their small place in the radio spectrum? We do not believe these rumors that the "Ham" will be denied his privileges, we believe rather that those who speak so much of justice coming out of this war will see to it that the Amateur receives his just reward.

The entire radio industry knows well, and appreciates the many contributions "Hams" have made for the advancement of high frequency radio communications, and surely they too can be counted on to assist the "Ham" in regaining his privileges *when the right time comes.*

HAMMARLUND MANUFACTURING CO., Inc.
460 West 34th Street, New York 1, N. Y.

THIS AD APPEARED IN MARCH, 1944

WE never lost faith in the friends of amateur radio. We believe progress up to this very moment indicates that Hams have many friends in high places. Of course, there is a lot of romance to Ham radio, but the place won by the Ham in the hearts and minds of important people is the result of a very practical demonstration of real worth—real American ability.

We wish to openly express our sincere appreciation for the wisdom of those whose job it was to guide amateur radio through these troubled times. And those who have given Hams a just portion of the spectrum are to be commended for their farsightedness.

American amateurs can be thankful they live in a country where ability receives its just reward.

LLOYD A. HAMMARLUND, President

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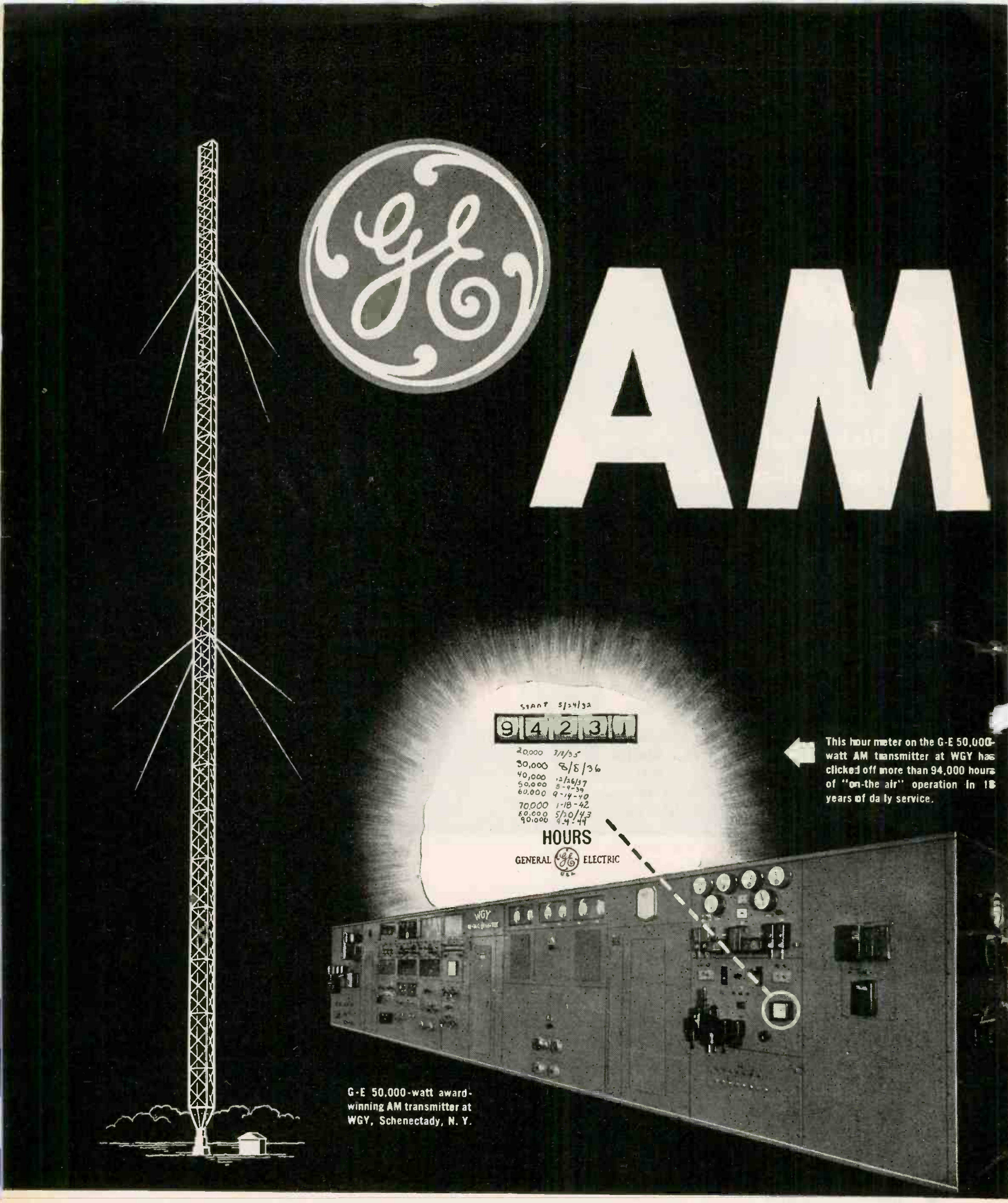

This hour meter on the G-E 50,000-watt AM transmitter at WGY has clicked off more than 94,000 hours of "on-the air" operation in 18 years of daily service.

G-E 50,000-watt award-winning AM transmitter at WGY, Schenectady, N. Y.

● *Award presented to NBC's affiliated AM station WGY for having the most nearly perfect operation record in 1944. WGY holds a similar award for 1936.*

wins top honors

Again, a G-E AM transmitter wins the NBC network award for the most perfect operating record.

OFF the air but 52 seconds in 6947 hours of program time during 1944, General Electric's 50,000-watt AM transmitter wins for WGY in Schenectady the NBC network award for greatest broadcast service in terms of solid hours of program delivery—the second time since 1936!

With a record of more than 94,000 hours of operation to its credit during thirteen years of daily service, this transmitter is typical of all G-E AM broadcast transmitters—transmitters that are famous for lower equipment cost per hour of broadcast service. This is the kind of performance that has built advertiser confidence. And this is the kind of reliability you can count on getting in your new G-E broadcast equipment—whether it is AM, Television, or FM. General Electric AM transmitters are built on a rich background of research and development, both in radio and in every line of electrical equipment. For more than thirty years, G. E. has been designing and making the most advanced and reliable broadcast apparatus in the world. During this time, General Electric manufactured many of the first high-power AM transmitters and all of America's 100-kw international transmitters. Today, G.E. operates its own AM broadcast proving-ground in Schenectady where seven big AM, FM, television, and international stations are on the air.

Whether your AM requirements are for standard band or international service, General Electric will supply everything for your needs—AM transmitters ranging in power from 250 watts to 1,000 kilowatts, complete studio equipment, auxiliary electrical components, entire antenna systems. G-E equipment will include all the refinements of modern AM transmitter design—with new basic improvements in modulation quality, frequency response, and low noise level. G-E AM equipment will be simplified, easy to control and to maintain, economical to operate. For further information on General Electric's AM broadcast equipment, see your G-E sales representative, or write: Electronics Department, General Electric, Schenectady 5, N. Y.

Establish a priority on delivery of your AM equipment. Write for your copy of the "G-E Equipment Reservation Plan" which explains General Electric's plan to help you obtain early delivery of AM transmitters and associated equipment.

Use G-E Electronic Tubes in your station for maximum dependability and finer performance.

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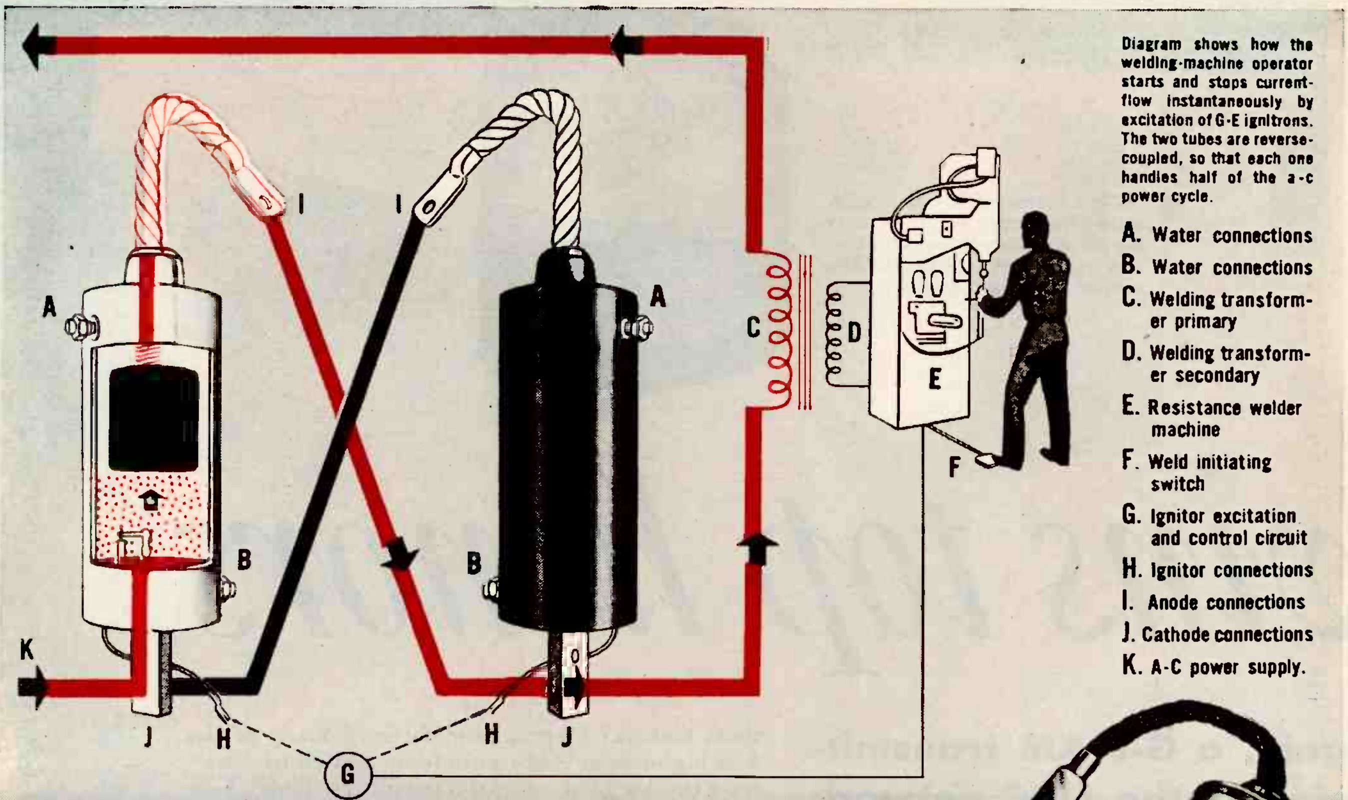

IGNITRONS "trigger" the heavy currents for resistance welding

AN important use of G-E ignitron tubes is shown above—controlling the primary current of resistance welders. The same benefits of split-second, positive "valve" action, with no mechanical linkage and no arcing between movable contacts, are provided by G-E ignitrons for other control circuits—furnace, motor, etc.—involving heavy electrical currents.

- Current control is but one of this tube's functions in industry. Another is current conversion—a-c to d-c. Here ignitrons offer the advantages of silent operation, no rotating parts, no need for lubrication, no mechanical upkeep.

- Steel-jacket construction and mercury-pool type cathode, among other features, make the G-E ignitron sturdy, dependable, and long-lived. Learn more about this versatile electronic tube from G.E.'s new Booklet ETI-21, "Ignitron Tubes and How They Are Used." Its 24 profusely illustrated pages, complete with selected circuits, tell the full story of ignitrons and how they serve industrially. Your free copy is waiting. Telephone TODAY your nearest G-E office or distributor, or write to *Electronics Department, General Electric, Schenectady 5, N. Y.*

Hear the G-E radio programs: "The World Today" news, Monday through Friday, 6:45 p. m., EWT, CBS. "The G-E All-Girl Orchestra," Sunday 10 p. m., EWT, NBC. "The G-E House Party," Monday through Friday, 4 p. m., EWT, CBS.

IGNITRON FG-235-A . . . $75.

This tube is one of the most widely used G-E ignitrons. It is a steel-jacketed, water-cooled, gas-filled triode with mercury-pool cathode, used for welder and other heavy current controls, and as a low-power current converter. For welder-control service, ratings are: max kva demand 1,200, with corresponding avg anode current 75.6 amp—max avg anode current 140 amp, with corresponding kva demand 400. (These ratings are for voltages of 600 v rms and below.) Ignitor requirements are 200 v and 30 amp. . . . Ratings for current conversion will be supplied on request, in which case please include a brief description of the application or circuit.

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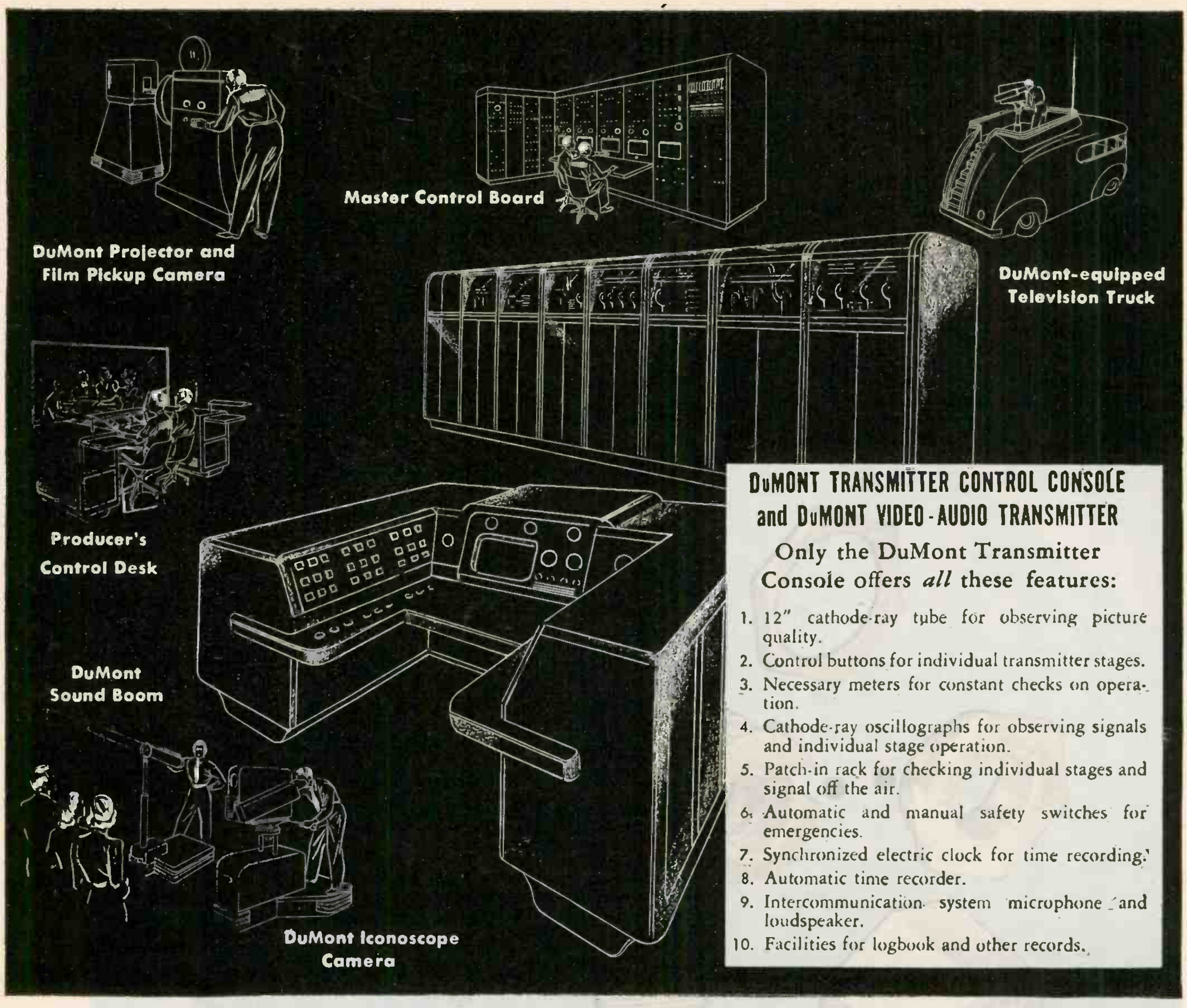


DUMONT TRANSMITTER CONTROL CONSOLE and DUMONT VIDEO-AUDIO TRANSMITTER

Only the DuMont Transmitter Console offers *all* these features:

1. 12" cathode-ray tube for observing picture quality.
2. Control buttons for individual transmitter stages.
3. Necessary meters for constant checks on operation.
4. Cathode-ray oscillographs for observing signals and individual stage operation.
5. Patch-in rack for checking individual stages and signal off the air.
6. Automatic and manual safety switches for emergencies.
7. Synchronized electric clock for time recording.
8. Automatic time recorder.
9. Intercommunication system microphone and loudspeaker.
10. Facilities for logbook and other records.

DUMONT—FOR THE TOOLS OF TELEVISION

Simplified precision control is the design keynote of all DuMont Television Broadcasting Equipment. Typical of this bull's-eye concentration on basic essentials is the DuMont Transmitter Control Console. All meters and controls of the Video-Audio Transmitter are combined with the station monitor (formerly a separate unit) to achieve a new standard in safety, easy visibility and centralized operation. Operators can be quickly trained to attend it.

DuMont has equipped *more* television stations than any other company. Week-in, week-out, these stations are demonstrating the high pickup and transmitting quality and efficiency, the extreme flexibility, rugged dependability and low operating cost of DuMont-engineered equipment.

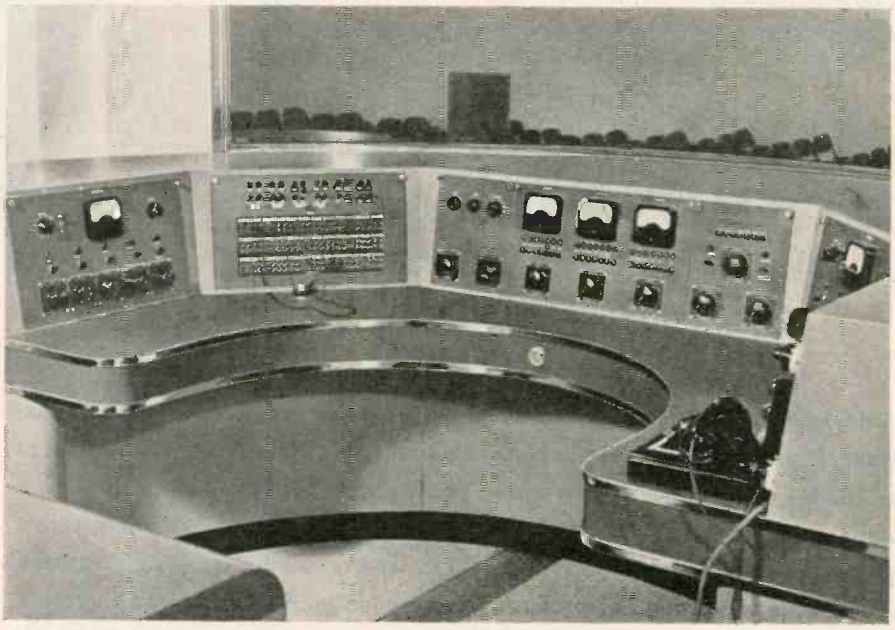
DuMont has pioneered the profit pattern for peacetime commercial television... is setting the pace in television broadcasting equipment design. Climb aboard the television bandwagon today by using the DuMont Equipment Reservation Plan to insure early delivery of equipment and training of personnel. *Ride with the leader!*

DUMONT *Precision Electronics and Television*

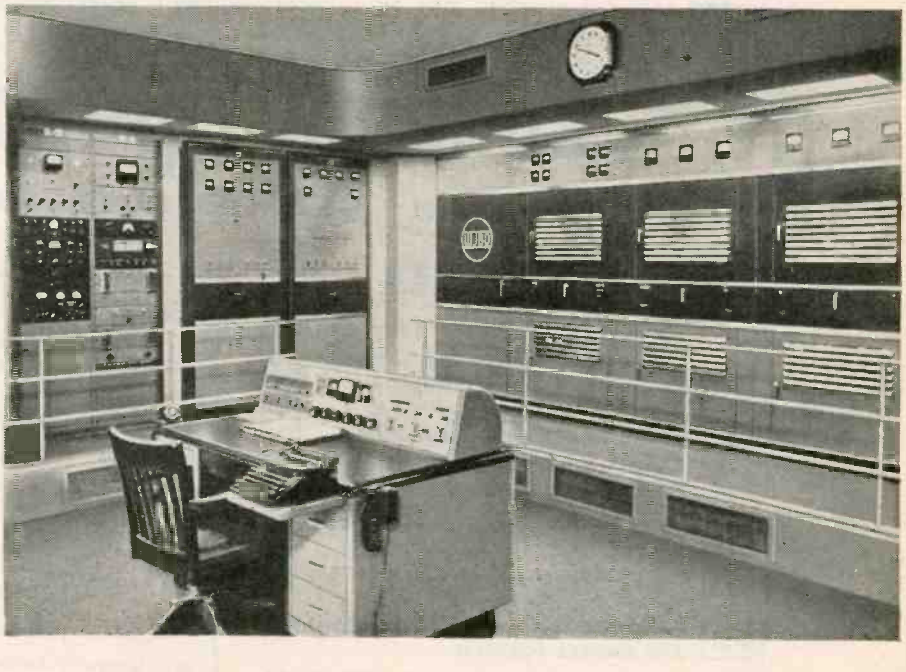
ALLEN B. DUMONT LABORATORIES, INC., GENERAL OFFICES AND PLANT, 2 MAIN AVENUE, PASSAIC, N. J.
TELEVISION STUDIOS AND STATION WABD, 515 MADISON AVENUE, NEW YORK 22, NEW YORK

FM Equipment

One of the studios used interchangeably by FM station WBRL and AM station WJBO. RCA-Type 44-BX Microphones are used in this studio, in the smaller announce-type studio, and in the large, auditorium-type studio.



The specially built RCA control console in the master control room shared by WBRL and WJBO. Individual panels control the output from three studios. Network lines and remotes are controlled from a fourth panel. The push-button selector system in the center panel allows any program to be fed to each of the three output lines (one AM, one FM, one spare or network).



The transmitter room shared by WBRL and WJBO. The 1 KW FM Transmitter is the unit just left of center in this picture. At the far left are racks containing the FM audio input and monitoring units. At the right is the 5 KW AM transmitter. Not shown in this picture are the AM audio and monitoring racks and AM phasing units. All of the equipment in this picture is of RCA manufacture.


For once, we were
More than 1000 tubes like the one above, duplicates of an unknown German tube, were produced by Bell Labs and Western Electric in 17 days. They helped put an important enemy communications system back to work for our Army.

copy-cats!

. . . by special request

Somewhere on the Western front, the retreating Germans left behind their strategic telephone communications system—all intact—*except that every vacuum tube had been removed from the repeaters.*

The Signal Corps went to work speedily to restore this valuable system for our own use. An engineer who had worked under the Germans supplied some general notes on the system and its operation. One tube believed to be of the missing type was found. Notes and tube were rushed to the U. S. by air.

At Bell Labs, tests and X-rays revealed the tube's inner construction and electrical characteristics and proved that no similar tube was available in this country. The German tube differed also in dimensions of the bulb and base and in the arrangement of the pins. Hurried consultations and calculations indicated that a suitable tube could be built from existing parts of American tubes—except for a grid and the base.

At Western Electric, the tube shop went to work—modified machines to wind the grid, and in three days produced eight tubes with hand-made bases, which were flown to Europe for trial in the system. Meanwhile, production went ahead at top speed and just 17 days after the lone German tube was received at Bell Labs, 1,015 duplicates of it had been completed. Result: the Signal Corps soon had the German telephone system in operation again.

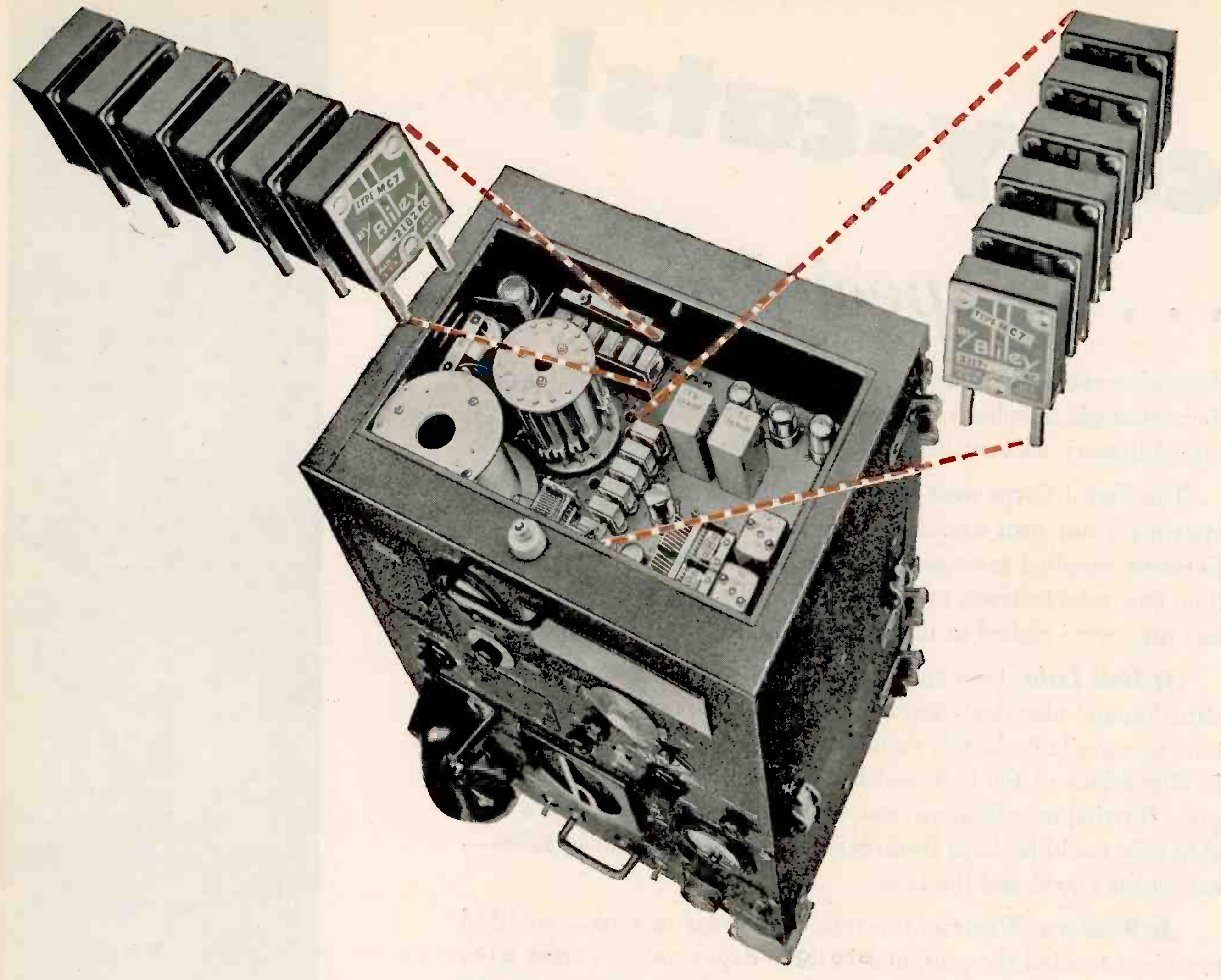
Bell Labs and Western ordinarily wouldn't be happy about copying *anybody's* products. We developed the first repeater tubes —which later led to trans-Atlantic telephony and radio broadcasting. It has long been our tradition to create our own superior designs. Working together, Bell Labs and Western have solved many of the war's toughest electronic problems. After the war, count on this team for continued leadership in communications equipment.

BELL TELEPHONE LABORATORIES

Exploring and inventing, devising and perfecting for our Armed Forces at war, and for continued improvements and economies in communications.

Western Electric

Manufacturing team-mate of Bell Labs, and the country's largest producer of communications and electronic equipment for war.



"HYTRON Tubes Are Good—SO WHAT!"

Sure, Hytron tubes are good — so what! All tubes made for Uncle Sam are good. They have to be, or he wouldn't accept them.

But Hytron goes further. Not satisfied just to meet Uncle Sam's JAN-1A specifications, it always sets factory testing specifications to tighter tolerances than the Services require. In this way, Hytron assures top quality despite slight meter inaccuracies and the human element. When more uniform adherence to specifications can be attained, tests simulating actual equipment performance are added.

This same insistence on the best will continue after the war. Then, too, we shall say, "Hytron tubes are good — so what! They have to be good to be good enough for you."

OLDEST EXCLUSIVE MANUFACTURER OF RADIO RECEIVING TUBES

HYTRON

RADIO AND ELECTRONICS CORP.

MAIN OFFICE: SALEM, MASSACHUSETTS
PLANTS: SALEM, NEWBURYPORT, BEVERLY & LAWRENCE

BUY ANOTHER WAR BOND

A MILLION MILES

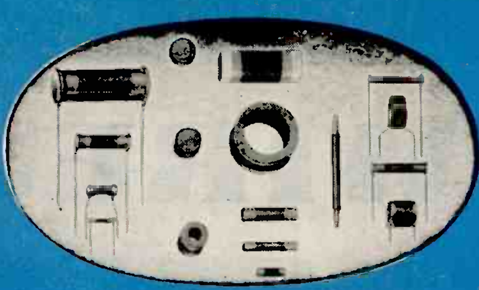
GENERAL CABLE CORPORATION'S ST. LOUIS PLANT CELEBRATES RECORD WIRE PRODUCTION ACHIEVEMENT

More than twenty months of inspired war effort on the part of the Men and Women Employees of the St. Louis Plant of General Cable Corporation were crowned today with gratifying success when the millionth mile of critical field communication wire, single conductor, rolled off the production line ready for shipment to our armed forces overseas.

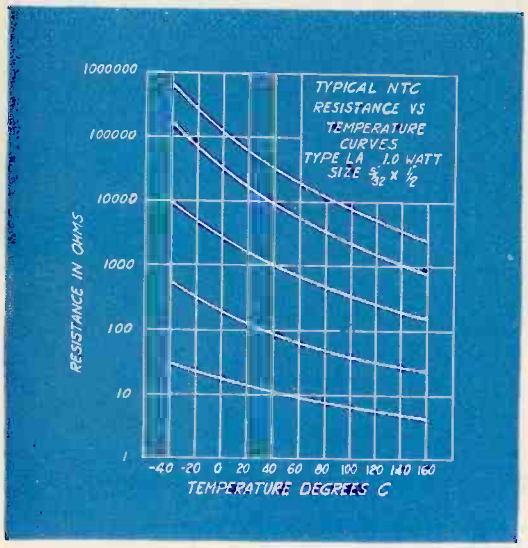
This notable General Cable achievement, one of the most significant accomplishments in the production of a vital war material to be achieved in the St. Louis area and unequalled in performance in any communication wire plant in the world, marks an epochal milepost in the production of field wire which began in the local plant in October, 1943.

More than four thousand employees working on an average of fifty-two hours per week in three shifts, seven days, are engaged in meeting the urgent requirements for field wire of the United States and its allies. Current production is running in excess of four thousand miles per day or, putting it another way, approximately five times around the globe once a month.

In commenting on the production feat of the local organization, Mr. Dwight R. G. Palmer, President of General Cable Corporation stated, 'Though the performance of our St. Louis Plant was accomplished in the ordinary line of duty, Management nevertheless is particularly gratified that its personnel, comprising all races, creeds and colors, harmoniously evidenced their patriotic sincerity by establishing this outstanding record. We salute the Men and Women of our St. Louis Plant for this production achievement'.

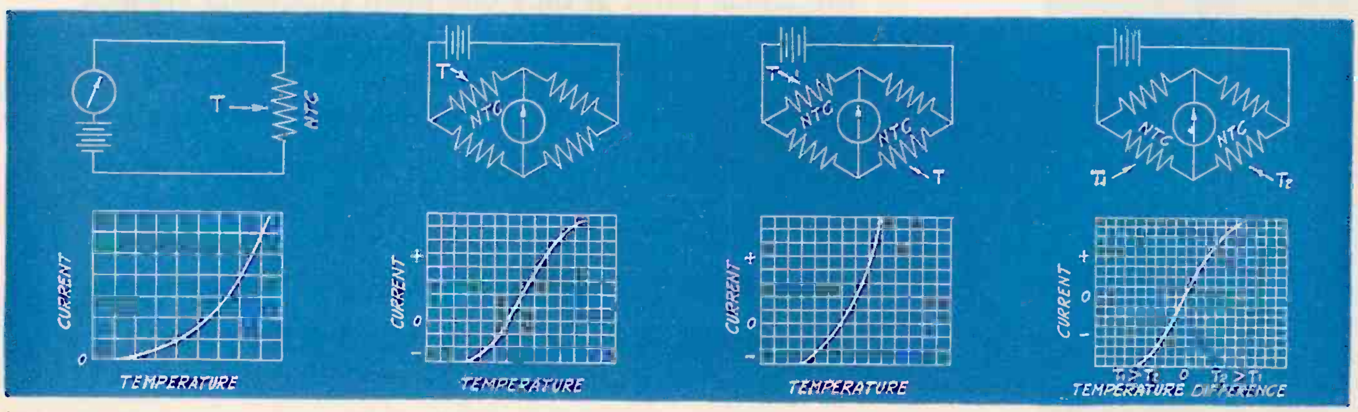


Do you have a TEMPERATURE MEASUREMENT OR CONTROL PROBLEM?



CHECK THESE ADVANTAGES OF KEYSTONE NTC UNITS FOR YOUR APPLICATION

Keystone NTC units are electrical resistors especially developed to have an unusually high negative temperature coefficient of resistivity. The slopes are much greater than those observed with pure metals or their alloys. The result is an element with very high thermal sensitivity, useful on AC or DC, inherently suitable for remote indication, which has gained wide acceptance for temperature measurement and control purposes. NTC units are made in wide range of shapes, resistance values, temperature coefficients and wattage ratings, of which the characteristics at the left are typical. The circuits below suggest basic means for translating resistance changes into current or voltage variations. Modifications and extensions of these principles are many, especially in conjunction with electronic apparatus.



This simple series circuit of voltage source, instrument and NTC unit has been utilized to indicate engine coolant temperature, etc. It provides sufficient accuracy for many applications despite scale crowding at the bottom.

Basic bridge circuit straightens and steepens the characteristic. Zero-center meter may be used or balance point may be placed near the lowest temperature. Electronic balance indication provides enhanced sensitivity.

Adding a second NTC unit, and exposing both to the temperature to be indicated, gives a double unbalancing effect and increases sensitivity under certain conditions over part of the temperature range.

Two NTC units in adjacent arms is a method of indicating equality of two temperatures, or temperature difference or rise. Temperature of either source can be obtained by substitution of standard resistance for other NTC unit.

Keystone NTC resistors are also valuable for neutralizing the change in resistance with temperature of electrical indicating instruments and control devices, for introducing time delays and many other applications. Write and tell us about your problem—we'll be glad to analyze it for the applicability of NTC units.

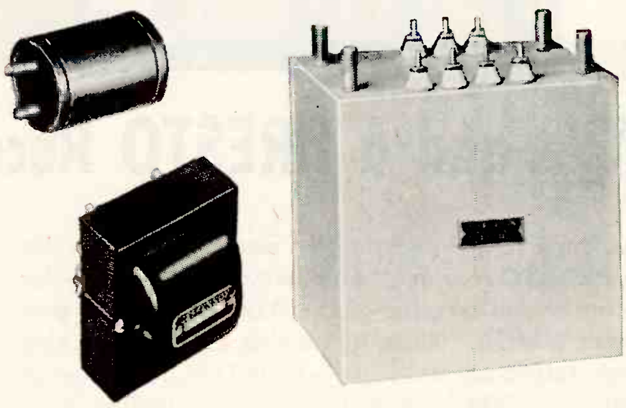
KEYSTONE CARBON COMPANY, INC.
SAINT MARYS . . . . PENNA.

A NEW DEVELOPMENT — NTC — DECREASE IN RESISTANCE WITH INCREASE IN TEMPERATURE

AIDING THE WAR TODAY . . . .

. . . . SERVING THE PEACE TOMORROW

Tomorrow, when the tools of strife are turned to the ways of peace, Jefferson Transformers will serve with the same fidelity. Improved manufacturing techniques established under the stress of war will be turned to producing still better transformers for your post war needs. Let Jefferson engineers examine your particular requirements now and make suggestions that will save you time later . . . JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Illinois. *In Canada:* Canadian Jefferson Electric Co. Ltd., 384 Pape Avenue, Toronto, Ont.

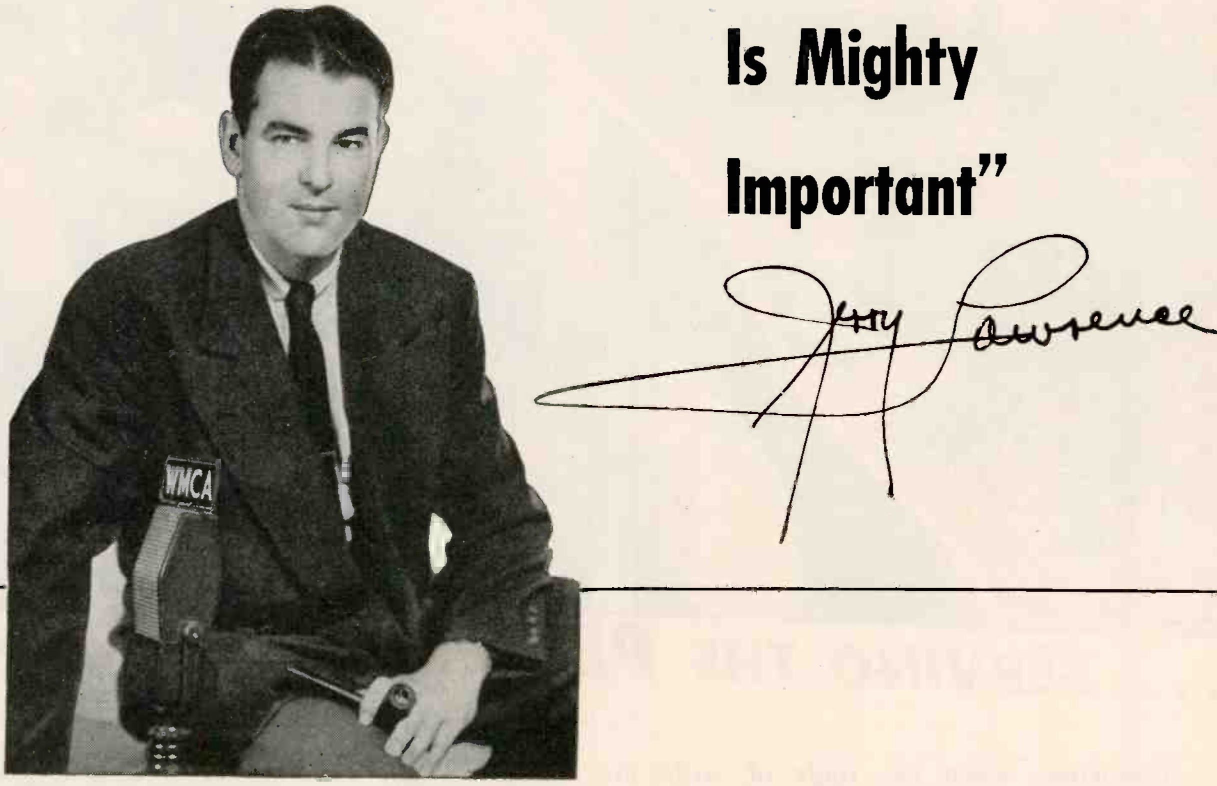


In all theatres of war, on the invasion beaches, wherever allied forces march against aggression, Jefferson Electric Transformers establish records of dependable performance. Today—on radio, radar, "walkie-talkies," television communications systems, electronic and control applications,—Jefferson Transformers aid our war effort with a long-life reliability based on engineering skill and Jefferson's basic principle of "quality—with quantity" production.

JEFFERSON ELECTRIC

TRANSFORMERS

"Hearing Myself As Others Hear Me Is Mighty Important"



"...and a PRESTO Recorder Helps Me Do It!"

"Yes, Sir, I frequently run off a recording of my voice on a PRESTO recorder," says Jerry Lawrence, popular announcer and director of the AIR THEATRE program at WMCA. "Then, by playing it back, I am able to keep tab on my technique—to find out if any change in delivery might improve it. Accurate reproduction is of course essential, and that's why I prefer a PRESTO recorder . . . it always produces cuts of good fidelity and clarity."

Many of America's major broadcasting companies rely on PRESTO sound recording and transcription equipment to keep their stations operating at peak efficiency. In schools and colleges, and in the training of sales, industrial and military personnel, you'll find PRESTO equipment widely used to give dramatic significance to sound, and increase the effectiveness of the spoken word. PRESTO equipment is rugged, dependable and easily operated, because every unit is made in strict accordance with PRESTO'S high standards. Write for complete information.

WORLD'S LARGEST MANUFACTURER OF INSTANTANEOUS SOUND RECORDING EQUIPMENT AND DISCS

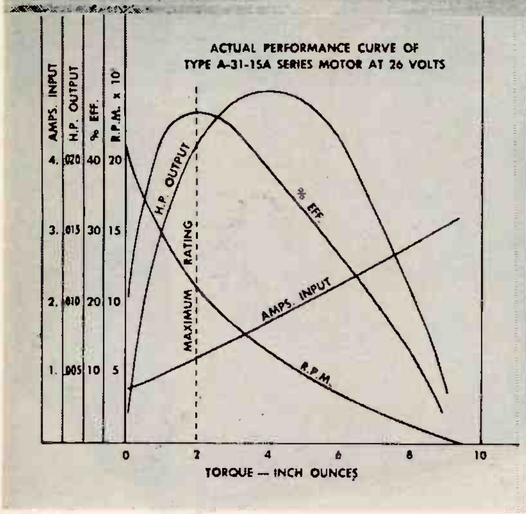
PRESTO

RECORDING CORPORATION

242 West 55th Street, New York 19, N. Y.

Walter P. Downs Ltd., in Canada

This Type A-31-1SA Oster Motor operates dependably in many aircraft applications.



Now available . . . an Oster Motor thermostatically protected *

REG. U. S. PAT. OFF.

to prevent motor burnouts, and adjusted to open motor circuit in approximately one minute under locked rotor conditions at rated voltage . . .

Here is another Oster motor with features that make it ideal for many applications in aircraft. The thermostatic control prolongs the life of the motor by preventing burnouts. Its weight (11 ounces) and body size (1½ x 3″) are reduced to a minimum without impairing efficiency. The performance record is backed by 16 years of engineering experience in the fractional-horsepower field.

You can depend on it to deliver creditable results that add to your own reputation for selecting sources wisely. Let us help you fit this or other Oster motors to your requirements. Write for further details.

IN 1955 — YOU'LL WISH YOU HAD PURCHASED "EXTRA" BONDS IN 1945 — BUY YOURS TODAY!

M-23

Rating of type A-31-1SA Motor

Horsepower — 1/50 intermittent.
Speed — 10,000 rpm.
Voltage — 26 D.C.
Winding — series.
Rotation — clockwise viewing rabbet end.
Duty Cycle — 15 min. on — 30 min. off.

Features of type A-31-1SA Motor

Housing — die cast aluminum, totally enclosed.
Finish — black anodized.
Weight — 11 ounces.
Bearings — High quality single shielded ball bearings, lubricated with grease suited for any specific application. Bearing housings fitted with steel inserts.
Brushes — High grade metal graphite of ample size to assure unusually long brush life.
Thermostatic Protector — Prevents motor burnouts, adjusted to open motor circuit in approximately one minute under locked rotor conditions at rated voltage.
Temperature Rise — 55° C. maximum frame temperature rise at rated load.
Mounting—Standard ¾″ dia. Air Corps rabbet.
Modifications—Special shaft extensions, mounting arrangements, leads, etc. Information regarding motors for specific applications furnished upon request.

Suitable for various aircraft applications.

All ratings and data are approximate.

John Oster Manufacturing Co.

DEPARTMENT E-23 • RACINE, WISCONSIN

Callite Tungsten Heaters in these Tung-Sol Miniatures will weather whip and any vibration . . . .

The tiny Tung-Sol Tube type 6AK5, not much bigger than an acorn, has an enviable record in military equipment for its ability to stand abuse and remain efficient under adverse conditions.

Features, that contribute to the remarkable ruggedness of this miniature tube, are its unique plate construction, the method of anchoring the mount, and its Callite tungsten heater. These heaters are processed by Callite for Tung-Sol with the right proportions of tungsten to give the required life and stability, plus the strength to withstand vibration and shock.

Through years of research in tungsten, molybdenum and special alloys, Callite has developed metallurgical components with the special qualities that facilitate tube-making and result in fine products. It will pay you to investigate our complete range of metallurgical specialities. Call on us for cooperation on designs and applications. Callite Tungsten Corporation, 544 Thirty-ninth Street, Union City, New Jersey. Branch Offices: Chicago, Cleveland.

Callite

tube components

CALLITE TUNGSTEN CORPORATION CT

HARD GLASS LEADS, WELDS, TUNGSTEN AND MOLYBDENUM WIRE, ROD AND SHEET, FORMED PARTS AND OTHER COMPONENTS FOR ELECTRON TUBES AND INCANDESCENT LAMPS.

Here's the RCA Sweep Generator You Need For Video Development Work

RCA 711-A VIDEO SWEEP GENERATOR

THE RCA VIDEO Sweep Generator, Type 711-A. has been specially developed to meet the demand for a convenient, accurate means of testing and adjusting wide-band video amplifiers. When this generator is connected to the input of a video amplifier, and the output of the amplifier connected to a suitable oscilloscope, a trace is produced that accurately depicts the dynamic frequency characteristic of the amplifier.

The output of the 711-A changes smoothly from a low frequency, usually 100 k-c, to a high frequency, which may be easily adjusted to an upper range limit of 2 m-c to 9 m-c. The sweep to high frequency, and return, is completed in one cycle of the power-line frequency.

An absorption type wavemeter coupled to the output circuit serves as marker. The marker frequency is controlled by a range switch and a large vernier dial calibrated in megacycles. A "blanking" circuit provides a base or zero-level line for qualitative checking. A built-in monitor diode, in conjunction with an oscilloscope, permits checking wave shape and linearity of output.

Write for more information about the 711-A Video Sweep Generator, and the RCA 709-B wide-band Sweep Generator, which operates in the 5 to 65 m-c range. Use the coupon below.

BUY WAR BONDS

USE THIS COUPON TO GET SWEEP GENERATOR BULLETINS

TEST AND MEASURING EQUIPMENT SECTION,
Radio Corporation of America, Camden, N. J.

Send me more information about RCA Sweep Generators.

Name...

Street Address...

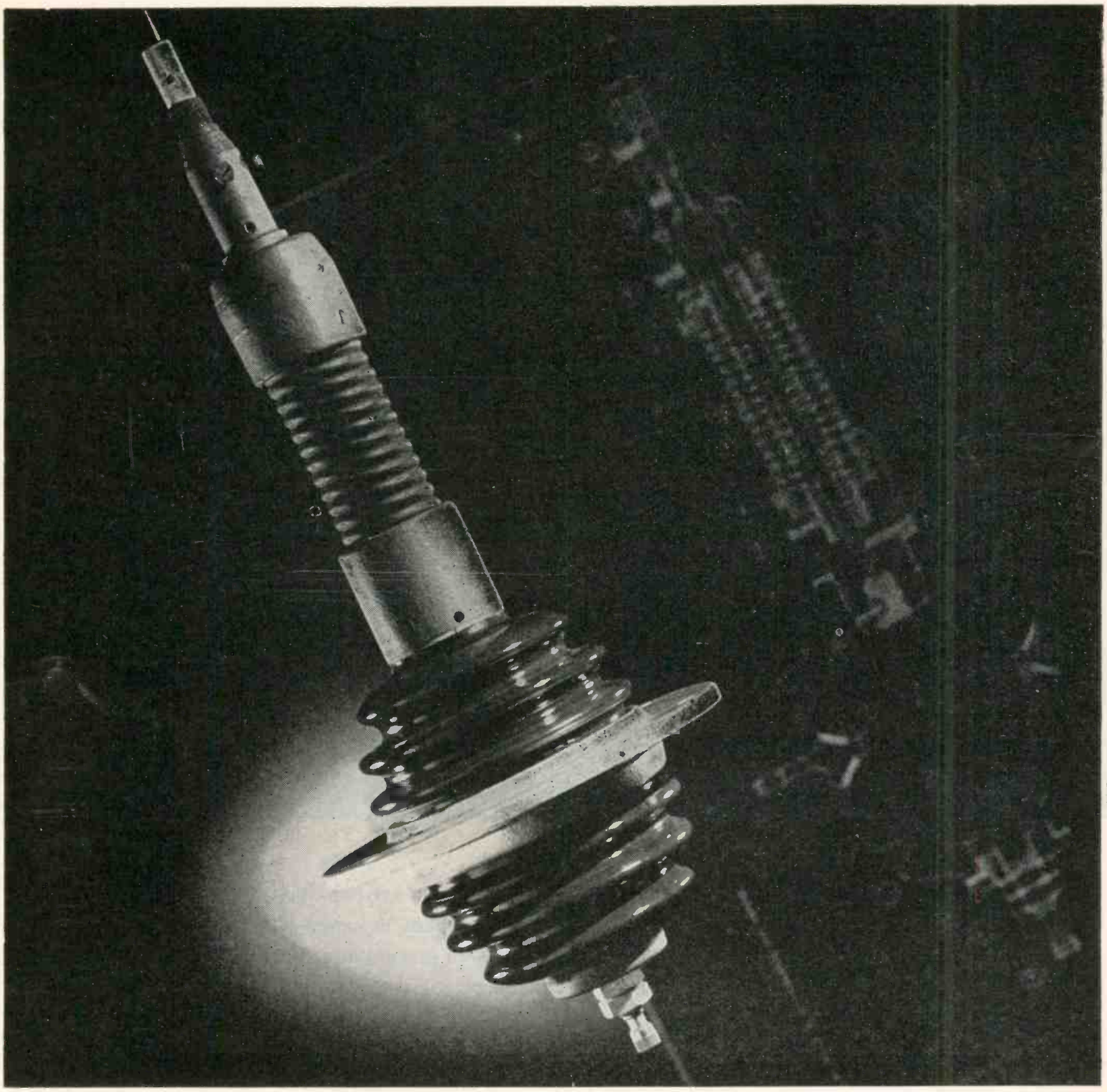
City and State...

138-C

RADIO CORPORATION OF AMERICA

RCA VICTOR DIVISION • CAMDEN, N. J.

In Canada, RCA VICTOR COMPANY LIMITED, Montreal



The demand for Wilco tubing, wire and other products used in various electronic applications for the Army and Navy has caused the H. A. Wilson Company to increase its manufacturing facilities and develop new products and techniques. Both present and future customers will find these new Wilco developments of great advantage.

The H. A. Wilson Company manufactures and is interested in receiving inquiries regarding the following products—

WILCO RADIO TUBING

Silver Tubing (Fine, Coin, Sterling)
Gold Tubing (any karat)
Gold on silver (on one or both sides)
Gold on bronze (on one or both sides)
Silver on copper (on one or both sides)
Tubing made to order from special materials or any combination of materials.

WILCO RADIO WIRE

Silver (Fine, Coin, Sterling)
Silver-jacketed Invar
Silver-jacketed Brass and Bronze
Silver-jacketed Copper
Gold Wire
Gold on silver
Gold-jacketed Bronze and Brass
Any other type of jacketed wire desired

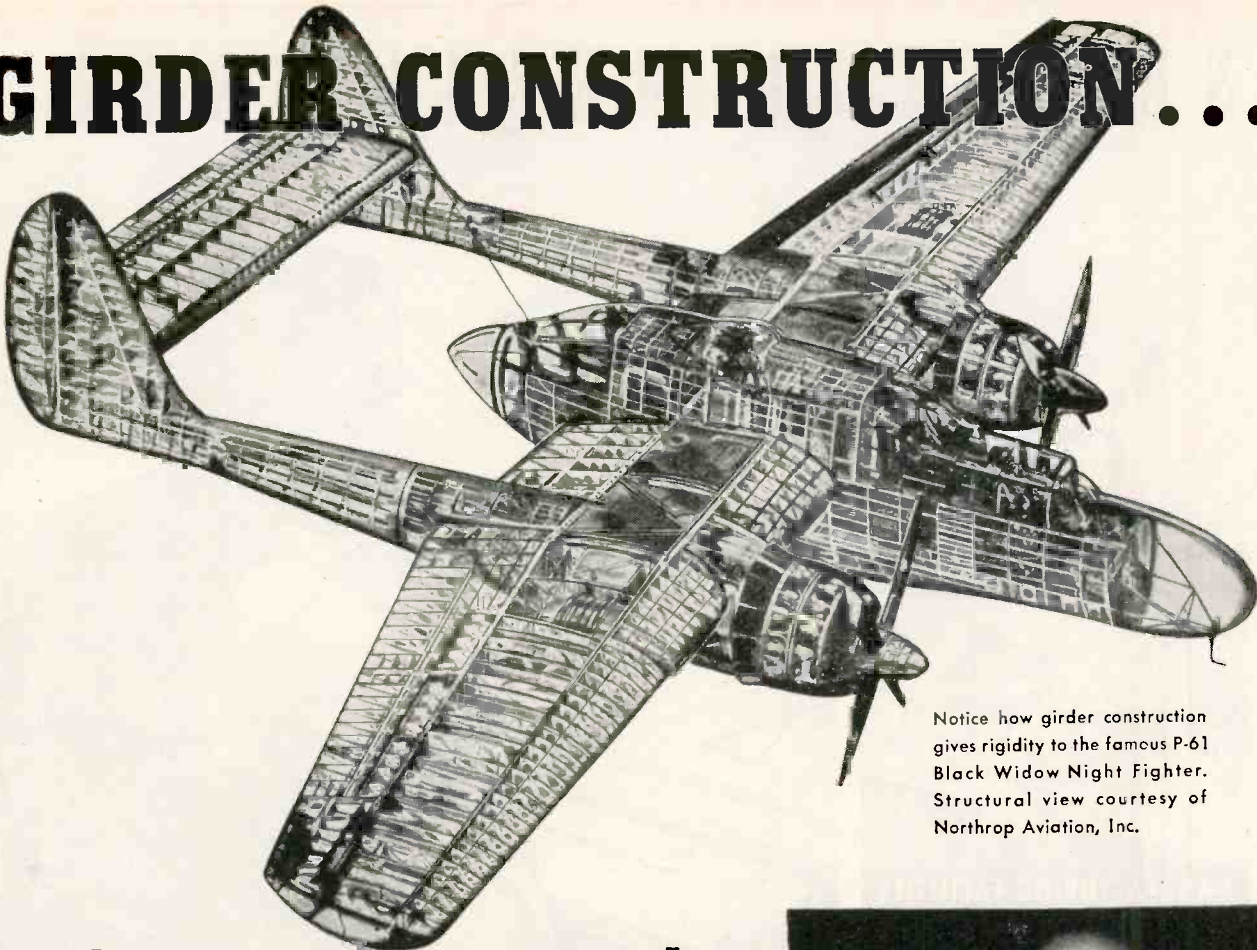
Let us analyze your problems. Write

THE H. A. WILSON COMPANY

105 Chestnut Street, Newark 5, N. J.

Branches: Detroit • Chicago

GIRDER CONSTRUCTION...



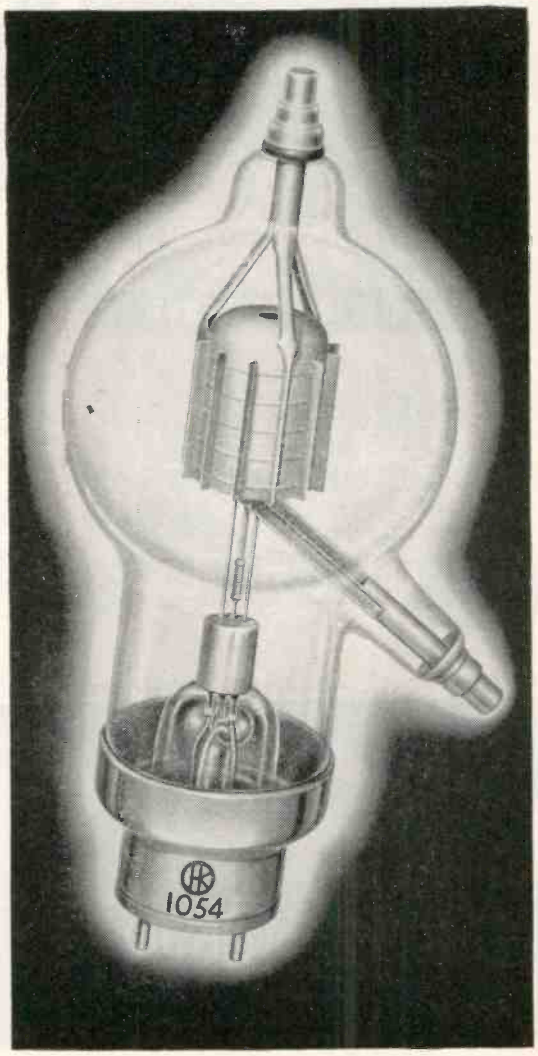
Notice how girder construction gives rigidity to the famous P-61 Black Widow Night Fighter. Structural view courtesy of Northrop Aviation, Inc.

gives greater strength to *Gammatron Tubes*

The same type of construction which gives strength and rigidity to a modern airplane, skyscraper, or bridge has been successfully incorporated into the design of the HK-854 and HK-1054 triodes. Compare the girder construction of the P-61 with the plate and grid supports of the HK-1054—the structural principles are identical! Note particularly how the heavy tripod plate support is welded to large diameter tubing, which in turn is firmly secured to the copper plate cup.

Because of their girder construction, HK-854 and HK-1054 Gammatrons stand up exceptionally well even when subjected to the vibration and stresses which usually accompany their use in such industrial applications as dielectric heating.

This superior internal strength is important since it prevents internal shorts, and variations in the characteristics of the tubes due to movement of the elements.



NEW LOW PRICES NOW IN EFFECT

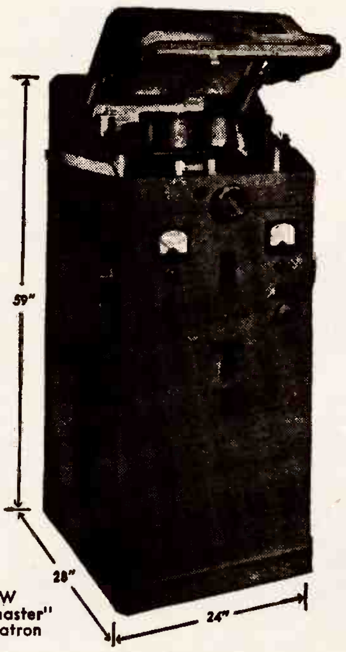
TUBE TYPE	NEW LIST PRICE
HK 854-H (High amplification factor) . .	Now only **$60.00**
HK 854-L (Low amplification factor) . .	Now only **60.00**
HK 1054-L (Low amplification factor) . .	Now only **135.00**

KEEP BUYING WAR BONDS

HEINTZ AND KAUFMAN LTD.
SOUTH SAN FRANCISCO · CALIFORNIA

EXPORT AGENTS: M. SIMONS & SON,
25 WARREN STREET, NEW YORK CITY, U. S. A.

RADIO RECEPTOR'S NEW "MASTER" SERIES THERMATRON ATTRACTING WIDE ATTENTION



5 KW "Heatmaster" Thermatron

The new "Master" Series of THERMATRON electronic dielectric heat generators, headed by the popular 5 Kilowatt output "Heatmaster," is now enlarged by the addition of two new models. They are the "Heatmaster, Jr.", with an output of 2½ Kilowatts, and the "Weldmaster" and "Weldmaster, Jr.", especially designed for sealing and bonding thermoplastic sheets, with outputs of 1 Kilowatt and 500 Watts respectively. According to *Radio Receptor* engineers, each of these machines fills a definite place in the new industry which is growing up around electronic heating.

The "Heatmaster" illustrated gives a new high value per dollar in electronic heating, and has the additional advantage of occupying little floor space. As shown, it incorporates a built-in, highly shielded "oven," or electrode cage, automatically operated, and designed especially for the plastic and rubber industry. It is also supplied without the "oven" so that it may be used with external electrodes in connection with conveyor belts or other applications. Floor space is only 24" x 48".

The "Heatmaster, Jr." embodies the same excellence in design, manufacture and the use of highest class standard components including the new type radial fin tubes as the "Heatmaster," but has an output of 2½ Kilowatts or a BTU output of 8550 per hour as against the 17,000 BTU's of the larger model. The same safety features and simplicity of control as characterize the larger model are found in the "Heatmaster, Jr." Both models are available at 27.4 mc frequency, and at 15 and 5 mc as may be required. Other frequencies can be supplied. The larger model operates on 200 volt 60 cycle three-phase current, while the smaller unit runs on 200 volt 60 cycle single-phase.

A folder describing the complete THERMATRON line will be forwarded on request.

"Desalter" Life Saver Produced on THERMATRON Machines

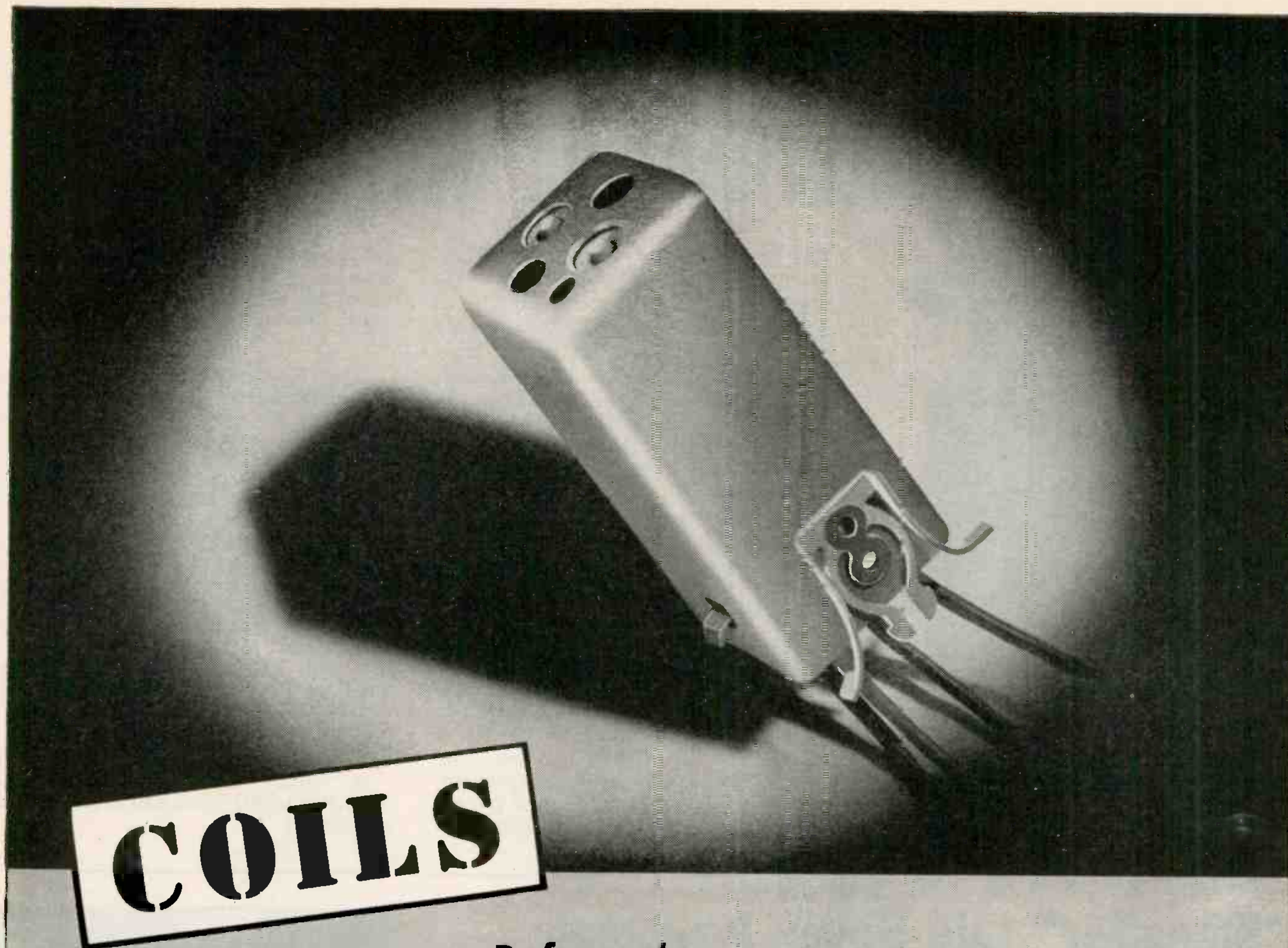
The Permutit Company's "desalter," which makes sea water potable in 20 minutes and which has been supplied by the hundreds of thousands to Army and Navy fliers who may be possibly forced down at sea, is known to many. It is one of the outstanding developments of the war. But what is not generally known is that the Gemloid Corporation of Elmhurst, Long Island, which makes a large proportion of these "desalters," uses THERMATRON in their assembly. THERMATRONS of the "Weldmaster" series are designed especially to weld, seal or bond thermoplastics such as Vinylite, of which these bags are made. Both the "Weldmaster" of 1 KW output and the "Weldmaster, Jr.", which has an output of 500 watts, are designed for welding or bonding thermoplastics. The Permutit "desalter" is a tough, collapsible, non-corrodible plastic bag with a simple strap closure and built-in filter that can be used over and over again. This product is the forerunner of many other plastic products to be manufactured economically on THERMATRON electronic heat welders by Gemloid and other plastics products makers.

Already, manufacturers of such products as raincoats, shower curtains, baby pants, tobacco pouches, cosmetic bags and other articles of widespread use, are displaying great interest in this new production method which offers so many outstanding advantages.

Radio Receptor Company's laboratories offer manufacturers a complete service in the adaptation of electronic dielectric heating equipment in their manufacturing processes. While the plastic industry has been among the first to grasp the possibilities of this new tool, many other industries are searching out its potentialities and are making plans to use THERMATRONS as soon as they become more generally available.

Permutit Desalting Bag

RADIO RECEPTOR COMPANY, Inc.
251 WEST 19th STREET NEW YORK 11, N.Y.
Engineers and Manufacturers of Airway and Airport Radio Equipment
SINCE 1922 IN RADIO AND ELECTRONICS



Before the war
We made millions of coils each year
For many years.

Our organization was mass-production minded.
That organization is intact.
We are still mass-production minded.
Be safe.
Order your mass-production coils and trimmers from people who "know how".

ARMY E NAVY

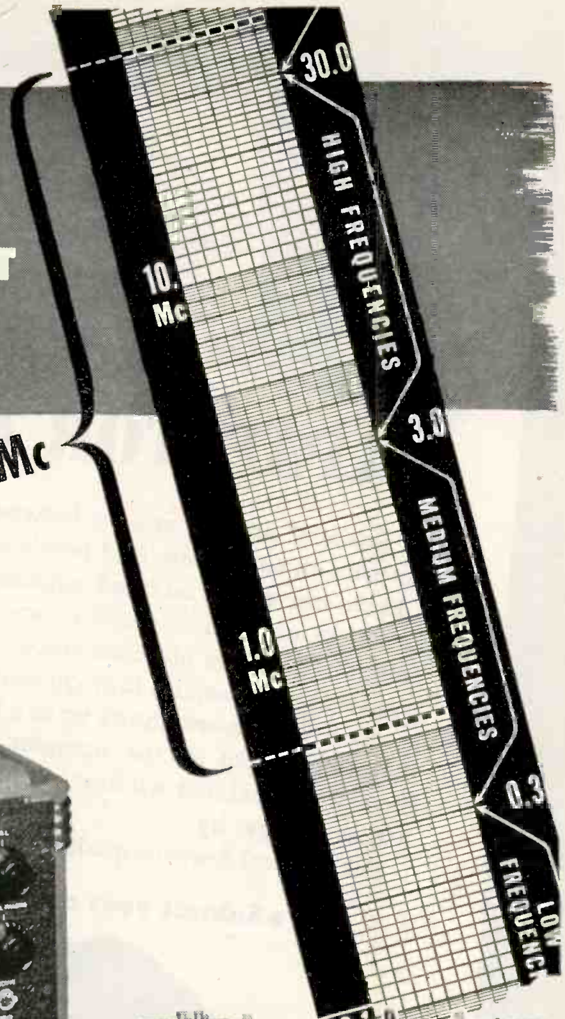
AUTOMATIC MANUFACTURING CORPORATION

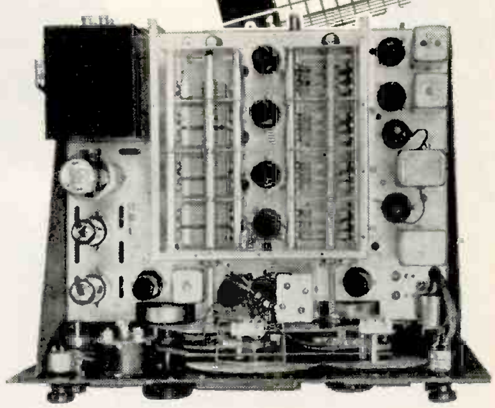
MASS PRODUCTION COILS & MICA TRIMMER CONDENSERS

900 PASSAIC AVE. EAST NEWARK, N. J.

HOW hallicrafters EQUIPMENT COVERS THE SPECTRUM

MODEL SX-28A — from 550 kc to 42 Mc

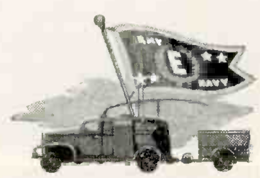




HALLICRAFTERS Super Skyrider, Model SX-28A, covers the busiest part of the radio spectrum – standard broadcast band, international short wave broadcast bands, long distance radio telegraph frequencies, and all the other vital services operating between 550 kilocycles and 42 megacycles. Designed primarily as a top flight communications receiver the SX-28A incorporates every feature which long experience has shown to be desirable in equipment of this type.

The traditional sensitivity and selectivity of the pre-war SX-28, ranking favorite with both amateur and professional operators, have been further improved in this new Super Skyrider by the use of "micro-set" permeability-tuned inductances in the RF section. The inductances, trimmer capacitors and associated components for each RF stage are mounted on small individual sub-chassis, easily removable for servicing.

Full temperature compensation and positive gear drive on both main and band-spread tuning dials make possible the accurate and permanent logging of stations. Circuit features include two RF stages, two IF stages, BFO, three stage Lamb-type noise limiter, etc. Six degrees of selectivity from BROAD IF (approximately 12 KC wide) for maximum fidelity to SHARP CRYSTAL for CW telegraphy are instantly available. Speaker terminals to match 500 or 5000 ohms are provided and the undistorted power output is 8 watts.

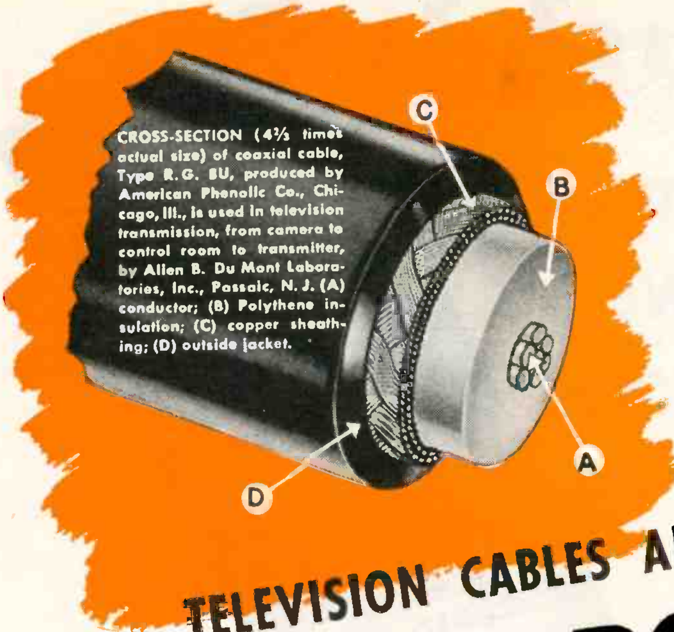


BUY A WAR BOND TODAY

hallicrafters RADIO

THE HALLICRAFTERS CO., CHICAGO 16, U.S.A., WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT

AEROVOX TYPE 616CT .5 MFD. 600 V.D.C.
ULTRA-VIOLET INSPECTED
Just another of the quality controls that put the final OK on AEROVOX
CAPACITOR CRAFTSMANSHIP
● "Leakers" are few and far between in Aerovox oil capacitors. And here's why:
Each and every oil-filled capacitor is examined under ultra-violet or so-called "black" light. The slightest trace of impregnating oil seeping through seams or cracks in containers, shows up as a bright fluorescent spot as the operator peers through the cabinet window. A "leaker" just cannot get by.
Such typical Aerovox quality inspection means much to the oil capacitor user. The life of such capacitors is dependent upon perfect hermetic sealing. This prevents the entry of moisture. Also, even a slight oil leak might damage or interfere with the operation of associated equipment.
Outstanding quality control — from incoming raw materials through each step in production and on to final inspection — is the final endorsement of Aerovox Capacitor Craftsmanship.
● Submit your capacitance problems and requirements.
ARMY E NAVY
AEROVOX
Capacitors
INDIVIDUALLY TESTED
AEROVOX CORPORATION, NEW BEDFORD, MASS., U. S. A. · SALES OFFICES IN ALL PRINCIPAL CITIES
Export: 13 E. 40 ST., NEW YORK 16, N. Y. · Cable: 'ARLAB' · In Canada: AEROVOX CANADA LTD., HAMILTON, ONT.



CROSS-SECTION (4⅔ times actual size) of coaxial cable, Type R.G. 8U, produced by American Phenolic Co., Chicago, Ill., is used in television transmission, from camera to control room to transmitter, by Allen B. Du Mont Laboratories, Inc., Passaic, N. J. (A) conductor; (B) Polythene insulation; (C) copper sheathing; (D) outside jacket.

FOR LOW POWER LOSS AT HIGH FREQUENCIES

TELEVISION CABLES ARE INSULATED WITH

Du Pont POLYTHENE

SOME OF THE CIRCUITS used in television transmission carry electrical current which changes its direction at the rate of 100 million cycles per second. This extremely high frequency is one of the chief reasons why polythene, a versatile Du Pont plastic, is chosen for insulating coaxial cables used in television transmission.

Polythene is non-polar. Unlike most other insulating materials, its molecules are not influenced by the cycles of oscillation of a current—no matter how rapid.

For this application, polythene's non-polarity is perhaps the most striking advantage. It is far from being the only advantage. Consider, for instance, these others:

1. **Polythene's dielectric constant (2.2—2.3) and its power factor (less than 0.0005) *remain almost constant over a wide range of temperatures*, from—50°F to 220°F.**
2. **Polythene's specific gravity is 0.92.**
3. **Polythene has outstanding chemical inertness.**
4. **Its moisture absorption is less than 0.005 per cent.**
5. **Polythene is flexible over a wide range of temperatures.**

This unique combination of properties is responsible for polythene's displacement of other materials in insulating high-frequency wires used by the U.S. Army Signal Corps. This same combination of properties will see polythene advancing into many other fields as soon as it is less urgently needed on the war fronts.

Du Mont Portable Television Equipment in Studio Use.

Du Pont is now producing polythene under WPB allocation. Quantities up to 25 pounds for experimental purposes can be obtained according to WPB Order M-300, Schedule 60. Write for properties chart and other data to E. I. du Pont de Nemours & Co. (Inc.), Plastic Department, Arlington, N. J.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

For Plastics—consult **DU PONT**

ALWAYS A GOOD BUY—WAR BONDS!

Centralab

Medium Duty Power Switches

- 7½ amp. 115 V. 60 cycle A. C.
- Voltage breakdown 2500 V to ground D. C.
- Solid silver contacts
- 25,000 cycles of operation without contact failure
- Fixed stops to limit rotation
- 20° indexing

Centralab medium duty power switches are now available for transmitters (has been used up to 20 megacycles) power supply converters and for certain industrial and electronic uses.

It is indicated in applications where the average Selector Switch is not of sufficient accuracy or power rating. Its accuracy of contact is gained by a square shaft, sleeve fit rotor, and individually aligned and adjusted contacts. It is assembled in multiple gangs with shorting or non-shorting contacts. Torque can be adjusted to suit individual requirements. Furnished in 1 pole . . . 2 to 17 positions (with 18th position continuous rotation with 18th position as "off"); and 2 or 3 pole . . . 2 to 6 position including "off".

Centralab

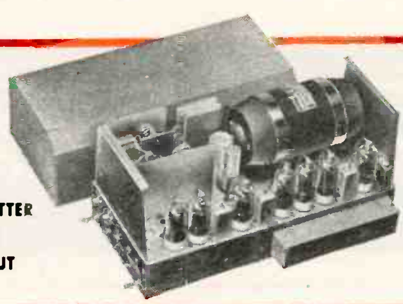
Division of GLOBE-UNION INC., Milwaukee

PRODUCERS OF Variable Resistors • Selector Switches • Ceramic Capacitors • Fixed and Variable • Steatite Insulators and Silver Mica Capacitors

KAAR makes 50 and 100-watt mobile FM practical with instant-heating tubes

Kaar engineers—who pioneered instant-heating AM radiotelephones—have done it again! In presenting the new KAAR FM-50X and FM-100X, they now give you the advantages of FM *plus* instant-heating tubes... greater power and range with lower battery drain! Standby current is zero. Yet the instant you press the button microphone, you are on the air with a full 50 or 100 watts output, improved voice quality, and minimum distortion—sending out a strong, clear message that insures excellent reception.

KAAR FM TRANSMITTER
MODEL FM-50X
50 WATTS OUTPUT



KAAR
ENGINEERING CO.
PALO ALTO • CALIFORNIA
Export Agents: FRAZAR & HANSEN • San Francisco, California

We repeat: 25,000 volts accelerating potential on a cathode-ray tube! That's front-page electronic news. Likewise cathode-ray history in the making.

The DuMont Multi-Band Tube (Type 5RP) permits recording at writing rates in excess of 2500 km/sec (using a 35 mm camera with f:1.9 lens) corresponding to sine wave transients at 10,000 megacycles!

This is a hot-cathode, permanently-sealed, high-vacuum tube. Subdivision of the intensifier element provides a controlled gradient allowing a total accelerating potential of 25,000 volts to be employed, with only slightly reduced deflection sensitivity. Greatly increased brightness with small spot size results in a writing rate far exceeding that heretofore obtainable.

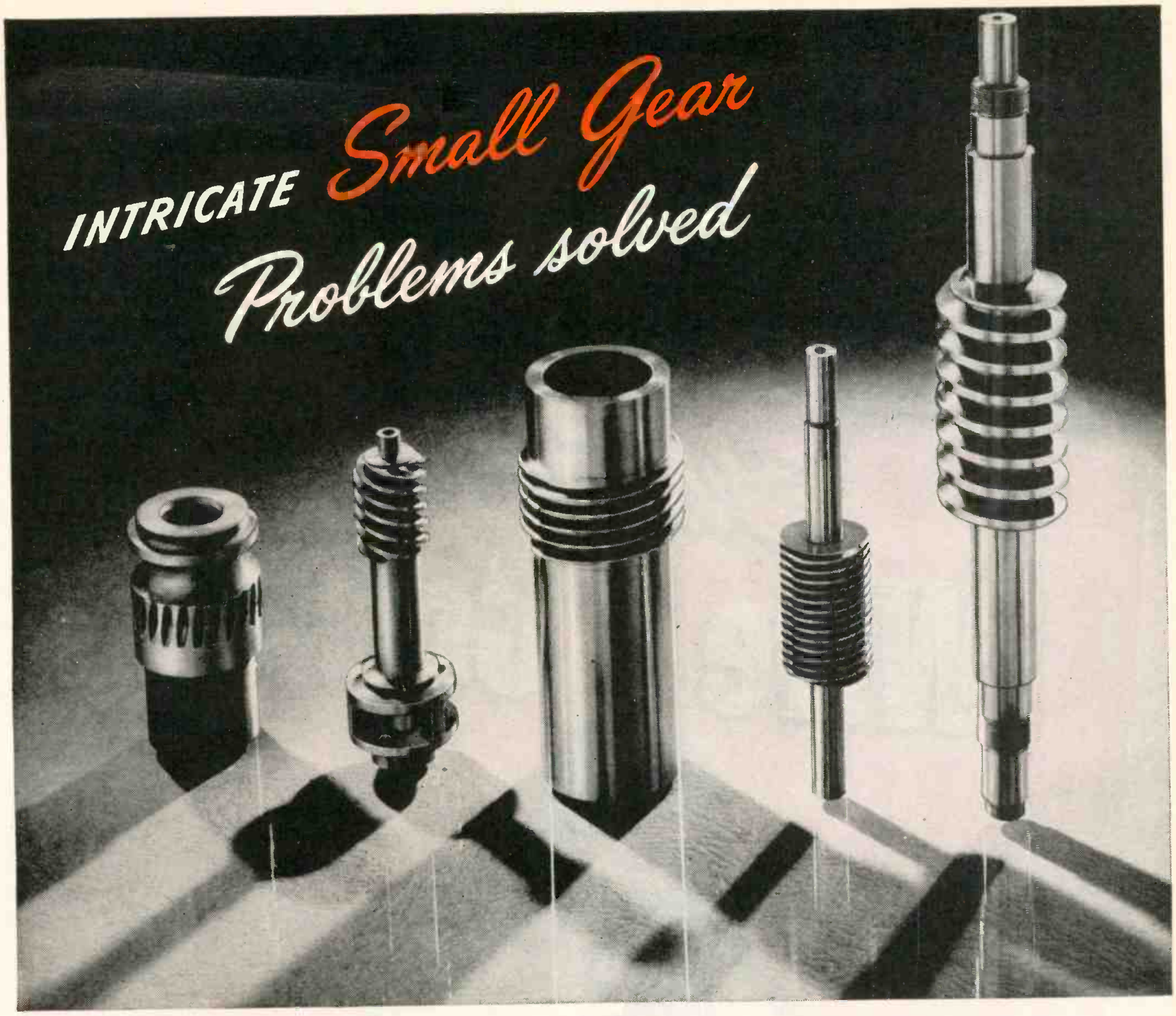
Yes, DuMont pioneering continues.

Literature on request.

Cylindrical flat-face tube. Approximately the size of conventional 5-inch tubes. Deflection-plate leads brought out through neck instead of base. Shunt input capacities and cross-coupling effects reduced to minimum. Second anode and intensifier leads brought out through envelope to facilitate high-voltage operation.

DUMONT *Precision Electronics & Television*

ALLEN B. DUMONT LABORATORIES, INC., PASSAIC, NEW JERSEY



Making fine, Fractional Horsepower Gears *to the most exacting specifications* is a highly developed specialty of ours. So well known is the unusual skill and accuracy of GS craftsmen, in working to extreme tolerances that long since we've become the "world's largest exclusive manufacturers of Fractional Horsepower Gears"! Should your post-war plans include products in which better small gears are involved, by all means submit your problem to our staff of long experienced engineers.

FRACTIONAL HORSEPOWER 12 TO 96 D.P.

GEAR Specialties

Spurs • Spirals • Helicals • Bevels • Internals • Worm Gearing • Racks • Thread Grinding

2635 WEST MEDILL AVENUE • CHICAGO 47, ILLINOIS

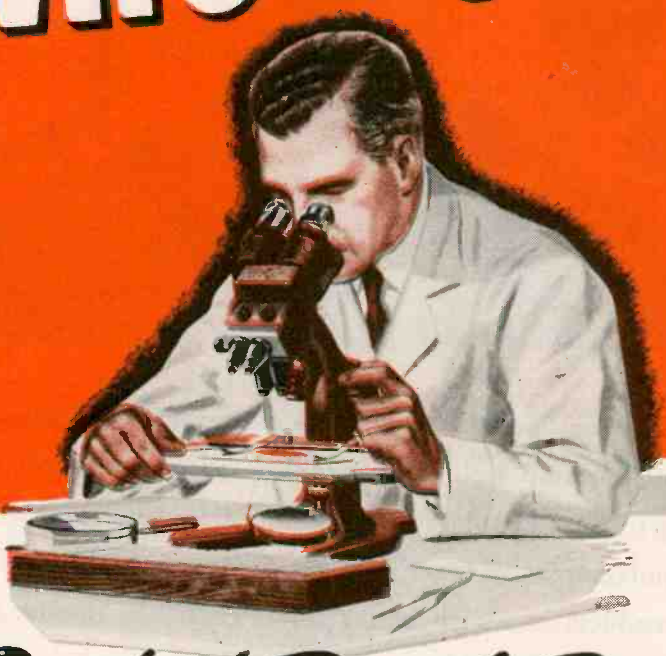
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARS

WAR BONDS

AUTO-LITE

Electrical

Wire AND Cable



The Proof of Sound Engineering

Many years of experience in meeting the need of the users of wire in many industries, laboratory research and a continuing effort to develop the finest manufacturing methods and devices —this has made Auto-Lite the quality line of wire and cable. There is a full range of sizes, shapes and materials for every wiring need.

Should new designs present unusual problems for wire in your product, take advantage of this Auto-Lite engineering experience. Just write to

THE ELECTRIC AUTO-LITE COMPANY

PORT HURON, MICH. — *Wire and Cable Division* — SARNIA, ONT.

TUNE IN "EVERYTHING FOR THE BOYS" STARRING DICK HAYMES—TUESDAY NIGHTS—NBC NETWORK

THORDARSON

celebrates its 50th Anniversary by joining hands with

MAGUIRE INDUSTRIES

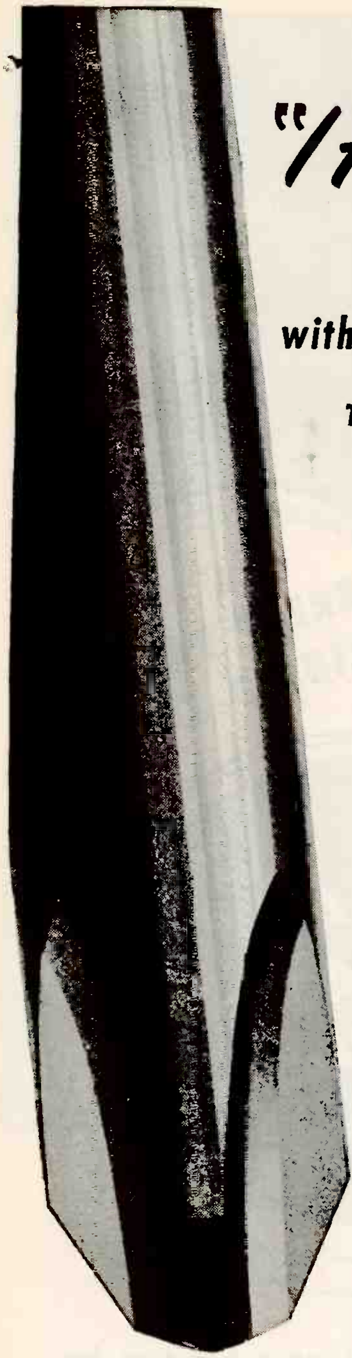
Throughout the past half century, the name "THORDARSON" has been a synonym for highest quality in transformers and other electrical equipment.

Under the banner of Maguire Industries, this tradition of leadership will be maintained in even fuller measure.

Thordarson's new plans include outstanding improvements in present lines . . . new products and services to meet the expanding needs of the radio and electronic industries . . . vigorous and liberal merchandising policies . . . and a generally forward-looking viewpoint with regard to all of the industries we are privileged to serve.

A Subsidiary of Maguire Industries

THORDARSON
ELECTRIC MFG. COMPANY
500 WEST HURON STREET
CHICAGO 10, ILLINOIS



"I Finish More Work by Noon

with AMERICAN PHILLIPS SCREWS

THAN I DID IN A WHOLE DAY WITH SLOTTED SCREWS!"

50% FASTER . . . that's the average speed-increase wherever modern American Phillips Screws replace outdated slotted screws. And that's because American Phillips Screws prevent driver-slippage, which means power drivers can be used on any job. So these straight-driving, fumbleproof screws take the brakes off your workers' hands, and the strain off their nerves and muscles. Self-confidence and pride in work is built up . . . and so is output and product quality, for there's no more scarred work or burred, broken screw heads. Time-savings alone are enough to make American Phillips Screws least costly to use on any assembly job in small shop or big plant. But there's another saving that comes from American's own system of quality control and individual 3-point inspection that give you higher "perfection-percentage" in every order. Try American Phillips Screws yourself . . . and see what happens to what you thought were *fixed costs!*

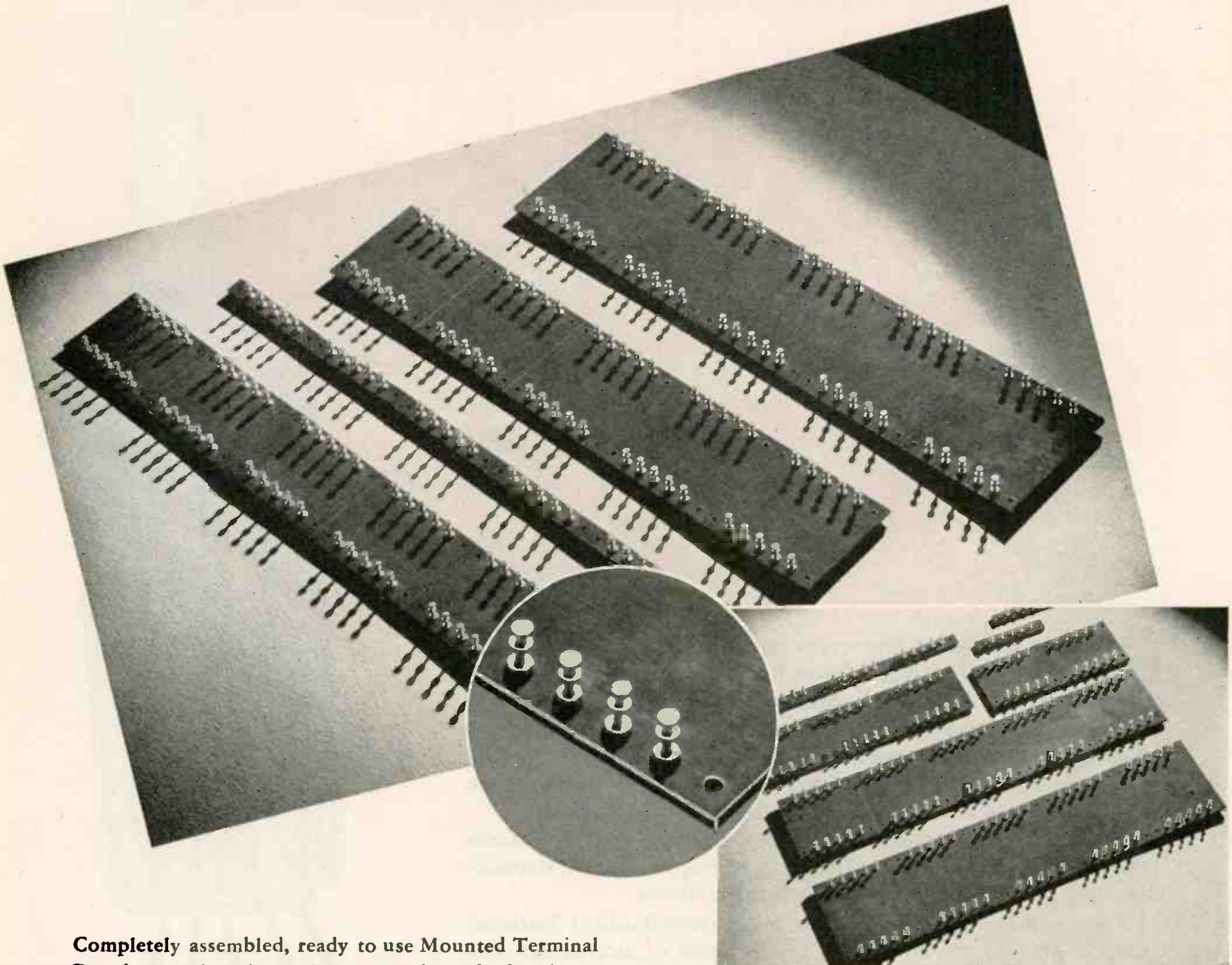
AMERICAN SCREW COMPANY, PROVIDENCE 1, RHODE ISLAND

Chicago 11: 589 E. Illinois Street **Detroit 2: 502 Stephenson Building**

AMERICAN PHILLIPS *Screws*

PUT THE SCREWS ON THE JAPS . . . BUY WAR BONDS

Announcing C.T.C.'s NEW TIME-SAVING *All-Set* TERMINAL BOARDS



Completely assembled, ready to use Mounted Terminal Boards covering the entire range of standard resistors and condensers. Specially designed by C.T.C. for experimental laboratories and manufacturers to speed the development of model equipment and the assembly of established products.

These new C.T.C. Mounted Terminal Boards are made of 3/32″, 1/8″ and 3/16″ linen bakelite only and are available in four widths—3″, 2½″, 2″ and 7/16″.

They are made in five-section boards which can be broken into fifths by inserting in a vise and bending back on a scribed line. Each fifth is drilled for twelve lugs.

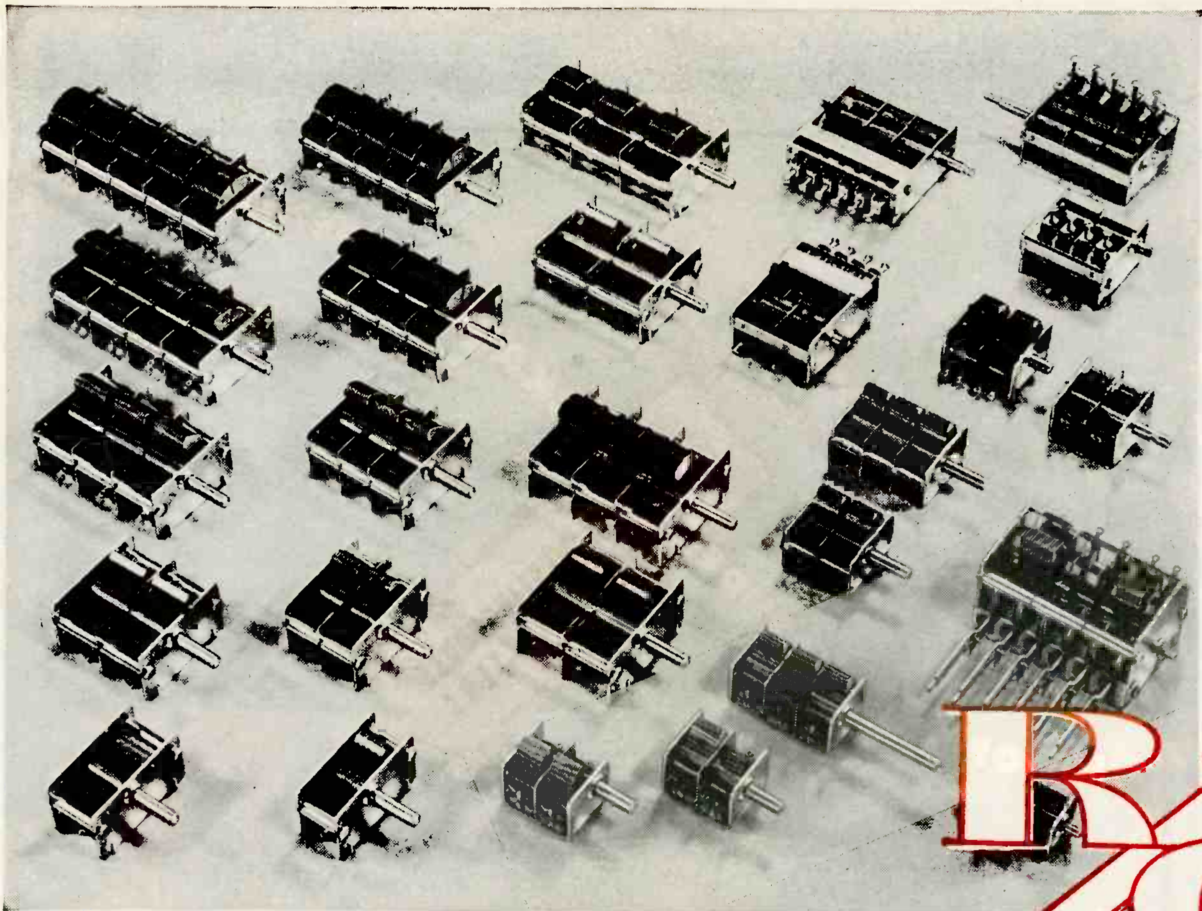
C.T.C. *All-Set* Terminal Boards are available in sets of four widths, or in lots of 6 or multiples of 6 in any single width. Extra lugs and standoffs supplied.

C.T.C.'s new *All-Set* Terminal Boards can be supplied with any size C.T.C. Turret Terminal Lug—as listed in catalog #100, drawing #1724.

CTC

WRITE FOR C.T.C. CATALOG No. 100. *It contains complete information on C.T.C.'s new ALL-SET Terminal Boards, Terminal Lugs and other C.T.C. components. It's yours for the asking.*

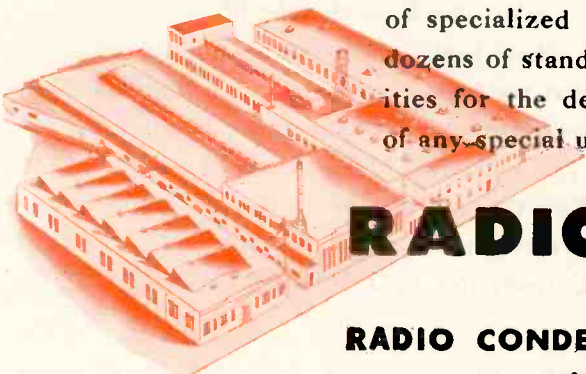
CAMBRIDGE THERMIONIC CORPORATION
439 CONCORD AVENUE, CAMBRIDGE 38, MASS.



WHEN YOU GET TO THE *VARIABLE CAPACITOR*

NO component today is more important than the tuning unit. On it, to a large extent depends your over-all design and, consequently, the essential sales features of your product.

And whether your call is for a variable capacitor or a complex tuning assembly, R/C can offer more and better informed help than you can obtain from any other source. Here you will find an unsurpassed wealth of specialized tuning unit experience at your disposal—dozens of standard types from which to choose—and facilities for the design, engineering and quantity production of any special unit that may be required.

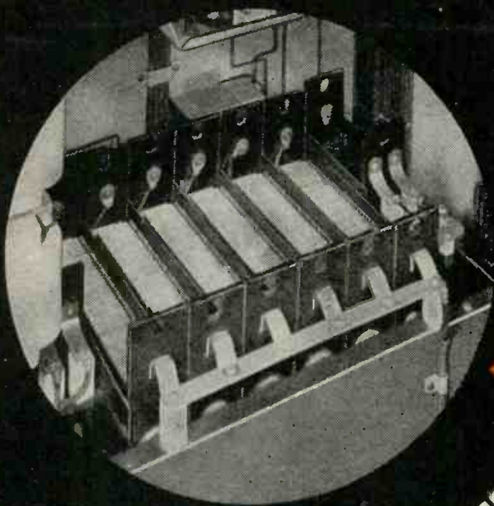


RADIO CONDENSER CO.

CAMDEN, N. J.

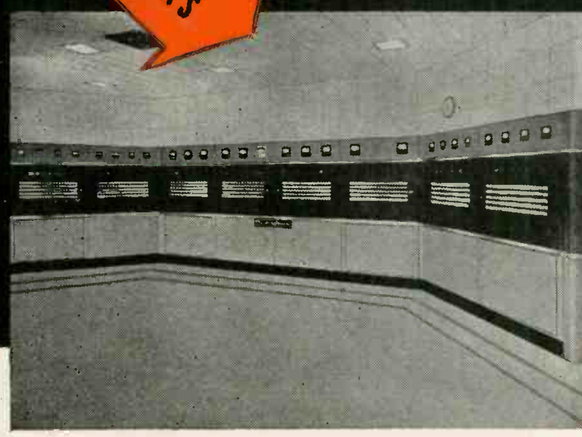
RADIO CONDENSER COMPANY LTD., TORONTO, CANADA

(Suppliers to Set Manufacturers)



HERE'S ONE OF THE FEATURES OF PACKAGED DEPENDABILITY

IN WESTINGHOUSE TRANSMITTERS



The smartly-styled Westinghouse 50-kw transmitters are built with 12 new, important design features. Ask your nearest Westinghouse office for the complete story.

Dependability in transmitter performance is a package of many features . . . and one which contributes heavily to program continuity in Westinghouse 50-kw transmitters is the use of metal-plate rectifiers.

With virtually unlimited life, these surge-proof rectifiers have cut tube replacement to a new low, for only the power amplifier and modulator utilize tube rectifiers. Dependable performance is reinforced by quick tube transfer for emergency tube replacement.

Westinghouse 50,000-watt transmitters offer other advantages for clear channel service:

Example: the equalized audio feedback system strengthens the naturally high fidelity of the audio and modulation circuits. No complicated circuit adjustments are needed.

Example: "De-ion" circuit breakers supply full overload and undervoltage protection, automatically reduce outage time.

Example: a tube life-meter provides a constant check on all tube life.

These basic advantages in faithful reproduction and solid dependability are features of the complete line of Westinghouse transmitters . . . 5, 10 and 50-kw AM, and 1, 3, 10 and 50-kw FM. You can get all the facts from your nearest Westinghouse office. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa.

J-08111

Westinghouse
PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Electronics at Work

XXV RADIO'S 25TH ANNIVERSARY KDKA

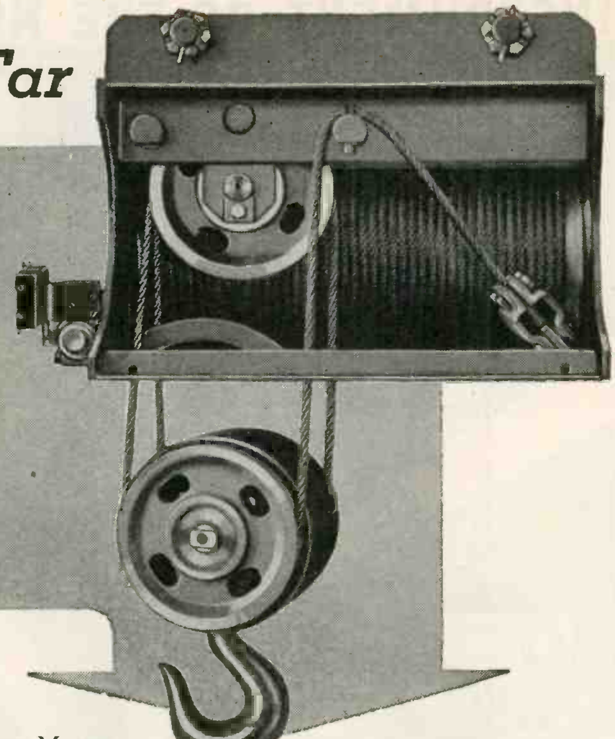
one step
Nearer...
Smashing the Swastika does not mean total Victory. There is still the Rising Sun to be taken care of . . . But the victory in Europe is one step nearer to conversion to peacetime pursuits.
Here at JENSEN total conversion will be merely a matter of continuing to produce outstanding, improved, high quality acoustic equipment. This is a continuing tradition at JENSEN . . . One example of advancement will be JENSEN Loud Speakers with ALNICO 5.
Jensen
SPEAKERS WITH ALNICO 5
Specialists in Design and Manufacture of Acoustic Equipment
JENSEN RADIO MANUFACTURING COMPANY, 6601 SOUTH LARAMIE

This Hoist Can't Go Too Far

MICRO SWITCH

SNAP-ACTION

Takes Care of That



There's a limit to how far a hoisting operation can safely go. These Meteor Electric Hoists protect themselves automatically, should the operator fail to stop the hoist in time.

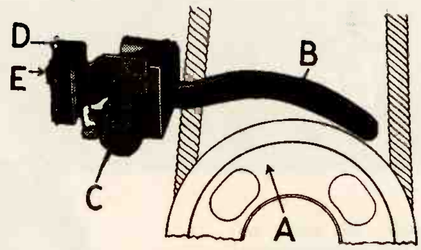
Chisholm-Moore Hoist Corporation of Tonawanda, New York, use two Micro Switch snap-action switches in the safety limit which make it impossible to jam the lower hook block into the drum.

When the hook block reaches its uppermost limit of travel, it raises a limit lever. This is mechanically connected to the two Micro Switch snap-action switches which break the pilot circuit, stop the flow of current to the motor, and apply a quick-acting motor brake.

These streamlined Meteor Electric Hoists, backed by 50 years of hoist-building experience, make use of Micro Switch products in a design which utilizes all space to advantage . . . avoids all cumbersome bulk and excess weight.

This use of these dependable, long-lived, snap-action switches is typical of the increasing use which every branch of industry is finding for Micro Switch products. In some applications their sensitivity, the small operating force and small travel required to operate them are important. In other applications the ability of these tiny switches to handle substantial amounts of power at line voltages without the use of relays is of prime importance. Their millions of accurate repeat operations make these switches valuable components of the highest type of industrial products.

Here is How It Works



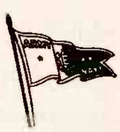
Two roller lever actuated switches are used.

When hook block "A" reaches the uppermost point of travel it strikes lever "B" which is connected by a shaft to cams "C". One cam is set slightly ahead of the other in order that one switch may be operated first.

Operation of switch "D" opens the pilot circuit of the hoisting motor. Should the gear train continue to move in excess of a predetermined amount, the second cam operates switch "E" which closes the lowering pilot circuit, momentarily reversing the motor. This lowering circuit is again opened as soon as the hook is lowered a small amount.

DO YOU NEED A SWITCH TO...

control temperatures, help to package products, bottle fluids, record airplane flights, make change, dispense drinks, heat water, control electronic tubes, or steer ships? Micro Switch snap-action switches successfully control many such operations . . . and thousands more. Micro Switch engineers, experienced in the application of millions of these precise, snap-action switches to products for both war and peace, will be glad to show you how they can add long life and reliability to your product at lower cost. Write for the Micro Switch Handbook-Catalog today.

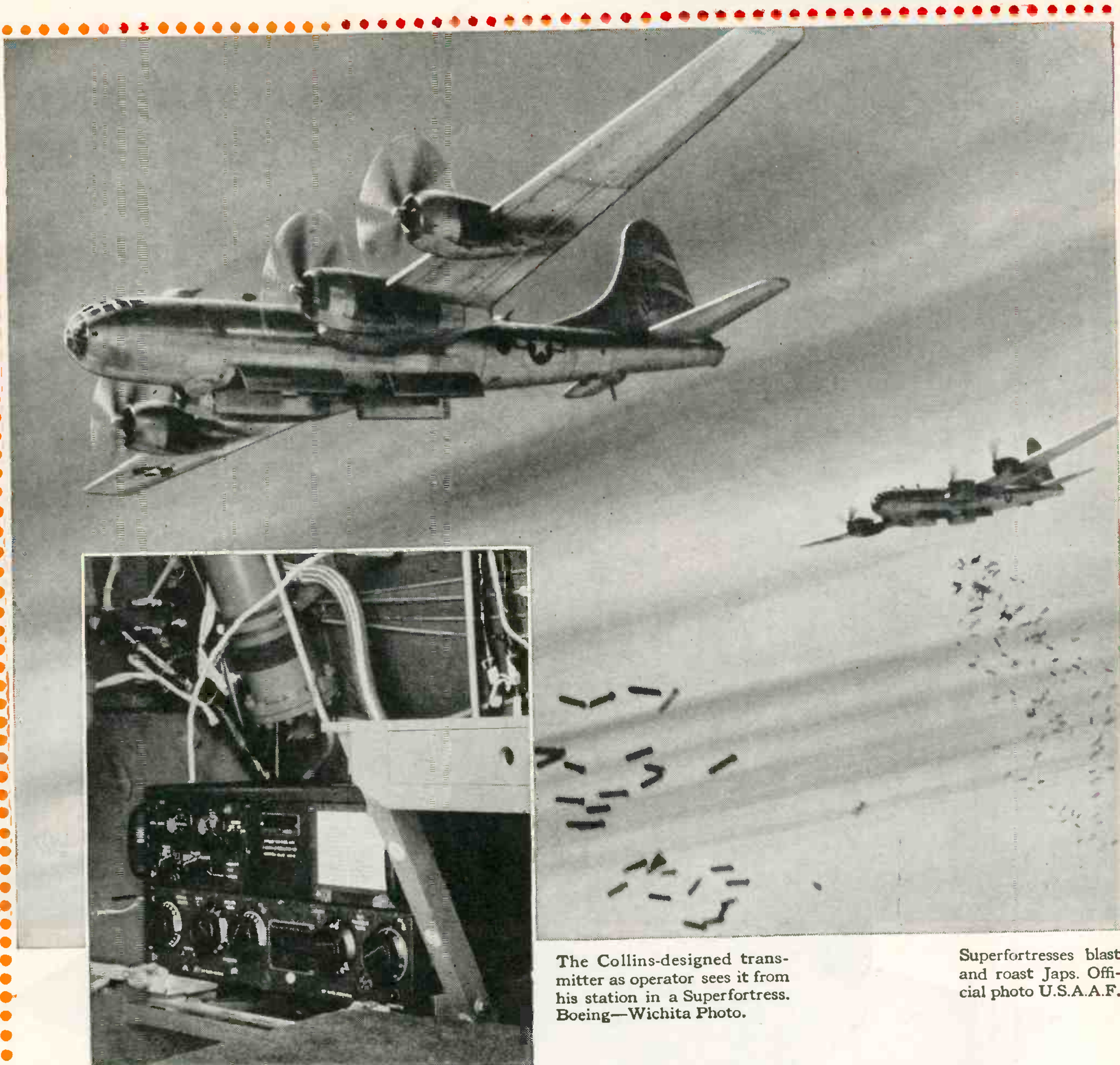
LET'S ALL BACK THE ATTACK  ***BUY EXTRA WAR BONDS***

MICRO (MS) SWITCH TRADE MARK

A DIVISION OF FIRST INDUSTRIAL CORPORATION

Freeport, Illinois, U. S. A., Sales Offices in Principal Cities

The basic switch is a thumb-size, feather-light, plastic enclosed, precision, snap-action switch, underwriters' listed and rated at 1200 V. A., at 125 to 460 volts a.c. Capacity on d.c. depends on load characteristics. Accurate reproducibility of performance is maintained over millions of operations. Basic switches of different characteristics are combined with various actuators and metal housings to meet a wide range of requirements.



The Collins-designed transmitter as operator sees it from his station in a Superfortress. Boeing—Wichita Photo.

Superfortresses blast and roast Japs. Official photo U.S.A.A.F.

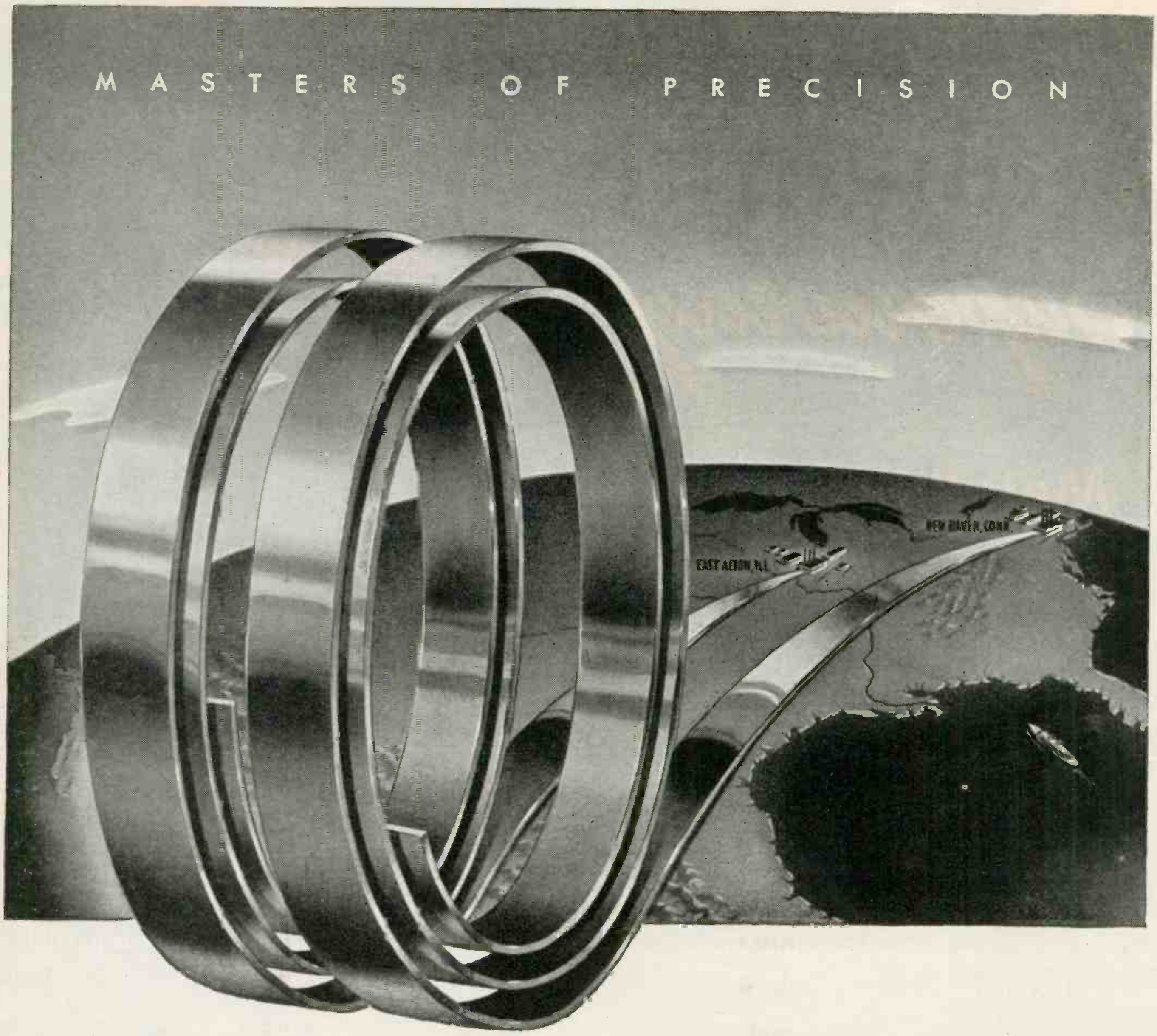
In the Boeing B-29 from the first

THE FIRST MESSAGE from the Army's first Boeing Superfortresses over Japan, on the Yawata mission of June 15, 1944, was transmitted by a Collins radio transmitter of the type shown above. From that time on, this transmitter has been standard equipment for all the Superforts, as it is also for the larger Naval aircraft.

As the Army and Navy demand increased, requirements exceeded the capacity of the extensive Collins facilities, and other manufacturers of radio equipment were drawn into the production program, aided by Collins engineers. Total deliveries have been very large.

Collins engineering and production have gained much valuable experience during the war in providing reliable radio communications under all operating conditions in practically every quarter of the globe. This experience will be available to commercial and personal users as soon as military requirements permit. Collins Radio Company, Cedar Rapids, Iowa; 11 West 42nd Street, New York 18, N. Y.

IN RADIO COMMUNICATIONS, IT'S . . . COLLINS



Two Mills.. Supplying "Tailor-Made" Metals

Western mills at East Alton, Ill., and New Haven, Conn., are strategically situated to supply alloy metals to manufacturers throughout the country.

Both of these mills specialize in supplying metals made to rigid requirements. When close tolerances are a "must" we meet the specifications. If your needs call for exacting tempers or finishes they are furnished as ordered.

We will welcome your inquiry regarding "tailor-made" metals . . . in sheet, strip, long coils or stamped parts.

WESTERN BRASS MILLS

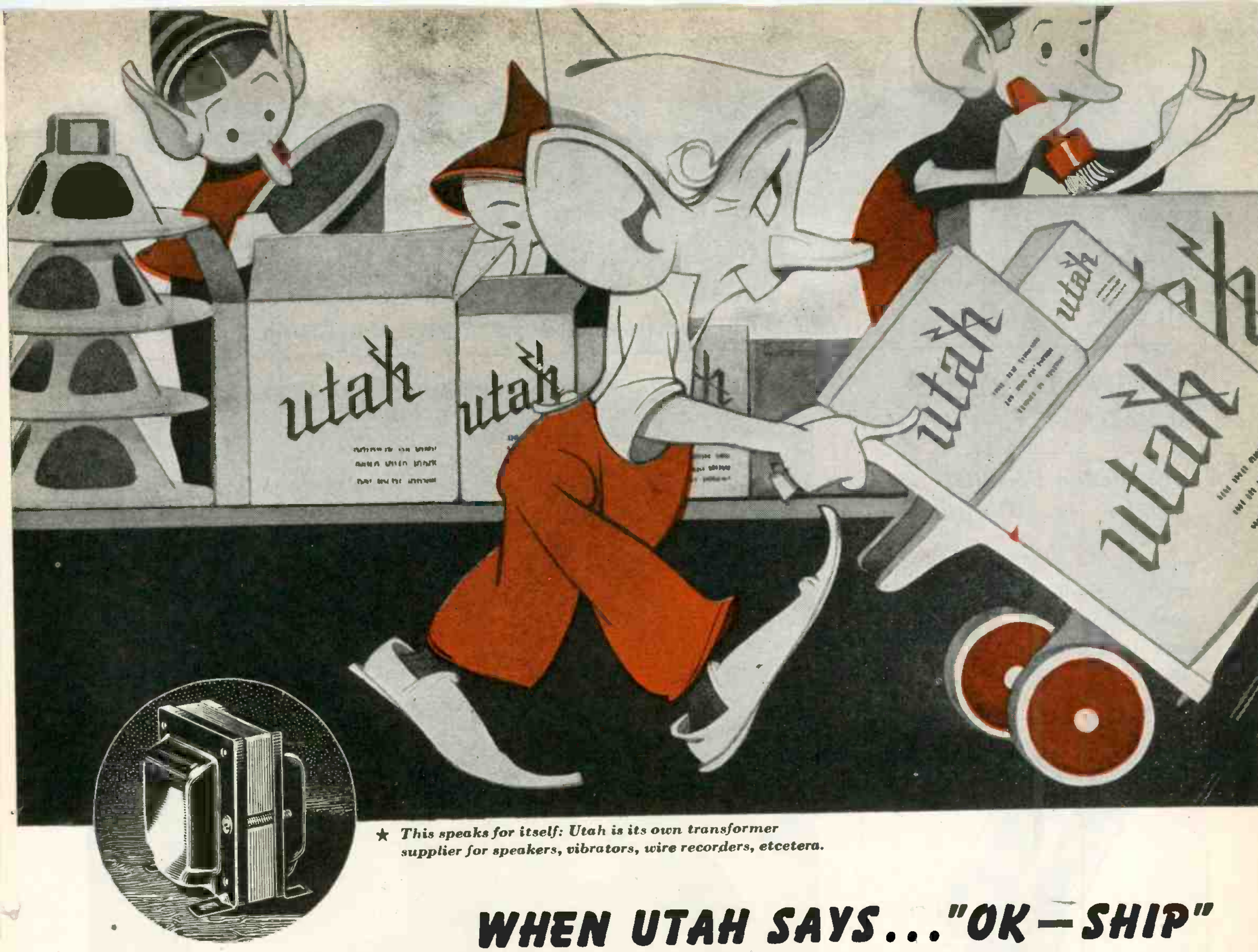
Western BRASS PRODUCTS
WESTERN BRASS MILLS

DIVISION OF OLIN INDUSTRIES, INC.

East Alton, Illinois

DIVISION OF OLIN INDUSTRIES INC.

BRASS • BRONZE • PHOSPHOR BRONZE • NICKEL SILVER • COPPER



★ *This speaks for itself: Utah is its own transformer supplier for speakers, vibrators, wire recorders, etcetera.*

WHEN UTAH SAYS..."OK—SHIP"

It's like putting a big liner into water. Like a launching. Only here at Utah, we don't take time for celebration. Radio makers and electronics dealers appreciate the highly specialized product that has been manufactured . . . the way a skipper appreciates a fine craft. Radio listeners, like ships' passengers, take all this precision for granted.

Here at Utah our workers (assisted by Utalins*) begin with nothing but the raw materials from which they make the tools that turn out Utah radio parts and electronic devices. At each step in manufacture . . . punch press, electroplating, welding, coil winding . . . from the beginning through to the finished product, Utah workers check, recheck, test and prove to Utah standards. When Utah says . . . "OK—SHIP" products of quality that stand up under every condition known to man leave to broadcast Utah performance around the world.

*Utah's Helpers

UTAH RADIO PRODUCTS COMPANY, 820 ORLEANS ST., CHICAGO 10, ILL.

Utah Electronics (Canada) Ltd., 300 Chambly Road, Longueuil, Montreal (23) P.O. • Ucoa Radio, S.A., Misiones 48, Buenos Aires

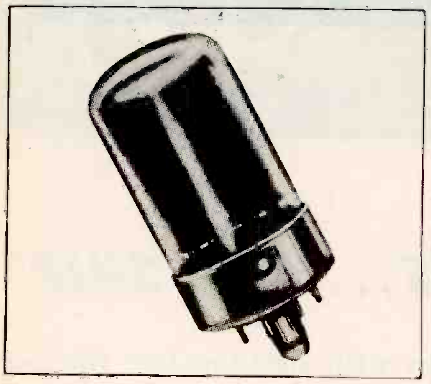
SYLVANIA NEWS
ELECTRONIC EQUIPMENT EDITION

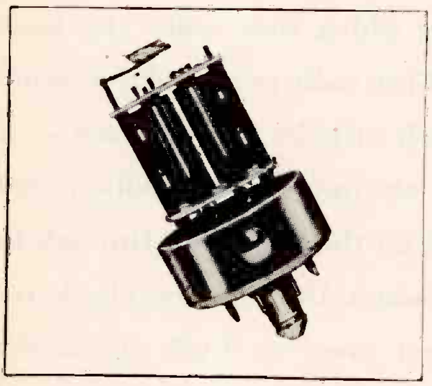
JULY — *Published by* SYLVANIA ELECTRIC PRODUCTS INC., Emporium, Pa. — 1945

NEW TUBE HAS SEPARATE CATHODES

Construction Permits Use As A Discriminator

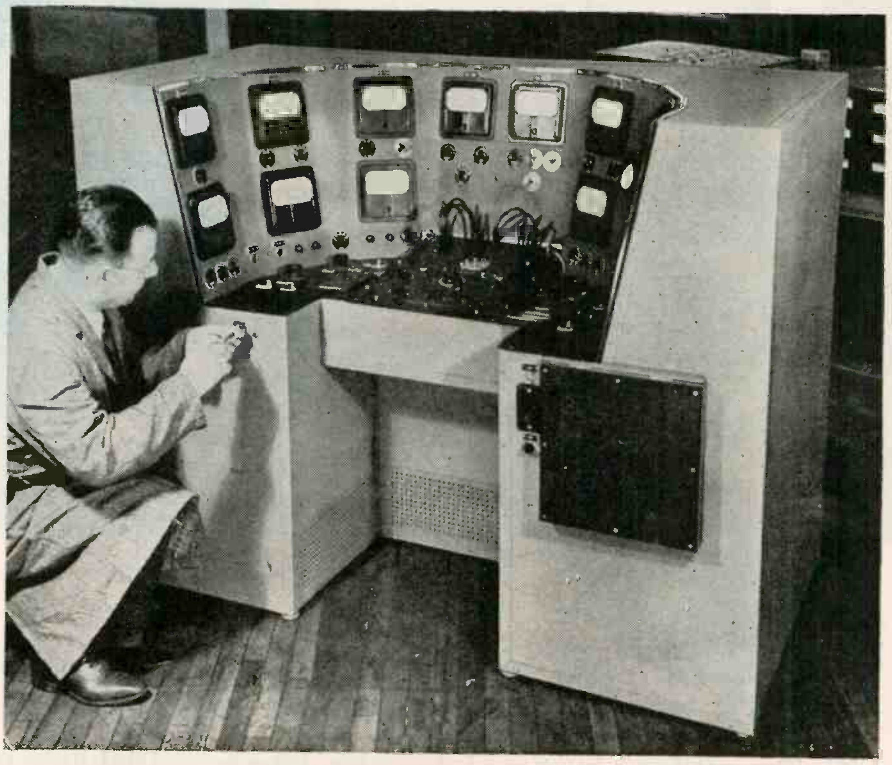
Sylvania Type 7K7 is a duo-diode high-mu triode differing from the usual diode-triode by having two separate cathodes, one for the triode and the other for the diodes.





This difference permits the tube to be used as a discriminator.

The cut-away view shows that although the construction looks like a duo-triode the second plate is really a shield around the two diodes.



SYLVANIA RADIO TUBE BRIDGE SET INSURES PERFECT PERFORMANCE

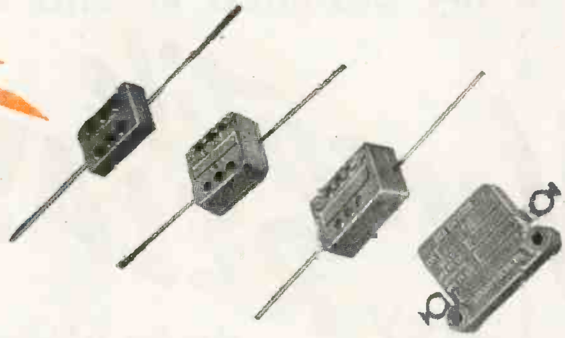
Measures Static And Dynamic Characteristics Of Vacuum Tubes

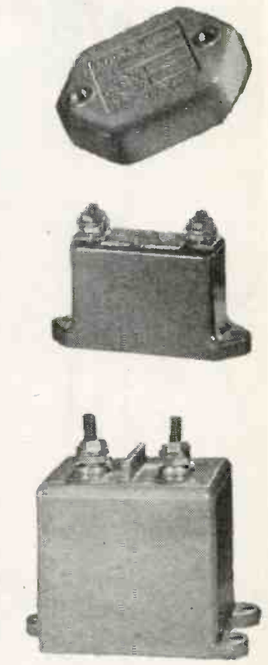
As ultra-high frequencies and a very wide range of intricate electronic applications make strict demands on tube performance and circuit designs, an accurate testing of tube and circuit characteristics becomes of the greatest importance.

One of Sylvania Electric's latest essential radio vacuum tube bridge test sets for precision engineering data is pictured above. Manufactured at Sylvania's plant at Williamsport, Pa., this equipment measures static and dynamic qualities of radio tubes, such as plate current, filament voltage and current, screen current, gas current, plate resistance, power output, mutual conductance, and amplification factor, as well as the characteristics of electronic devices.

The set is compact, fully shielded, with well-filtered, self-contained power supplies, complete with voltage regulators except AC and DC filament voltages.


MARION ELECTRICAL INSTRUMENT COMPANY
D.C. MILLIAMPERES
ANODIZED ALUMINUM FLANGE
CORNING GLASS TO METAL BOND
DRAWN STEEL CUP
KOVAR GLASS BEAD TERMINALS





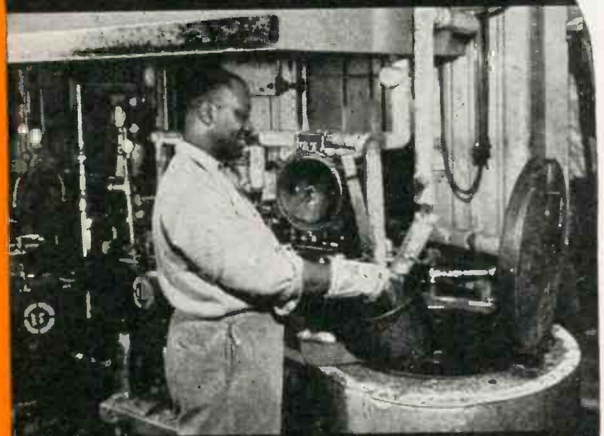
Cartridge IMPREGNATION

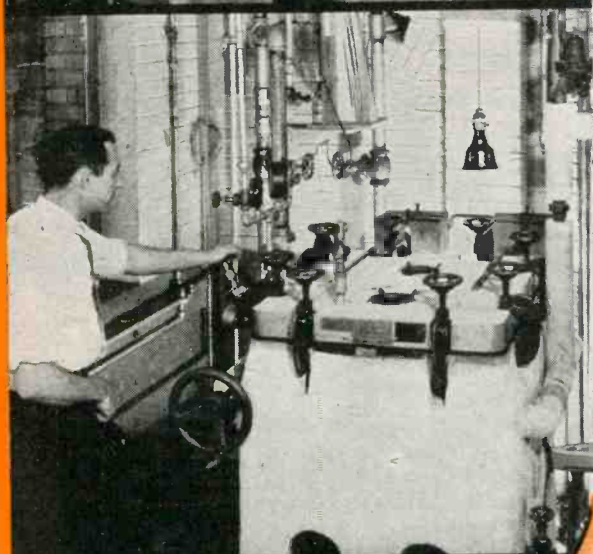
THE processing of the capacitor cartridge before moulding is a very important step in controlling the quality of the finished capacitor. Not only must all traces of air and moisture be removed from the cartridge, but the cartridge must also be treated to insure permanence of the desired characteristics, such as power factor and insulation resistance, when once these have been attained.

These conditions are achieved by subjecting the cartridges to a high degree of vacuum for the removal of moisture and air, and by impregnating them with moisture resistant waxes or varnishes, in special vacuum impregnating tanks. To assure that the prescribed electrical characteristics are obtained, various waxes and varnishes may be used. All excess wax is removed by centrifugal force so that it does not interfere with the proper moulding of the plastic case in the subsequent operation. The plastic case additionally seals the capacitor against atmospheric conditions, thus further contributing to the long, trouble-free life of capacitors in service.

By maintaining constant vigilance in each of the manufacturing processes, the Sangamo standard of excellence is assured for Sangamo Mica Capacitors.

• Impregnating and spinning equipment for vacuum wax impregnating mica capacitor cartridges and spinning off excess wax.





• Impregnating tank for vacuum impregnation of capacitors and capacitor cartridges.

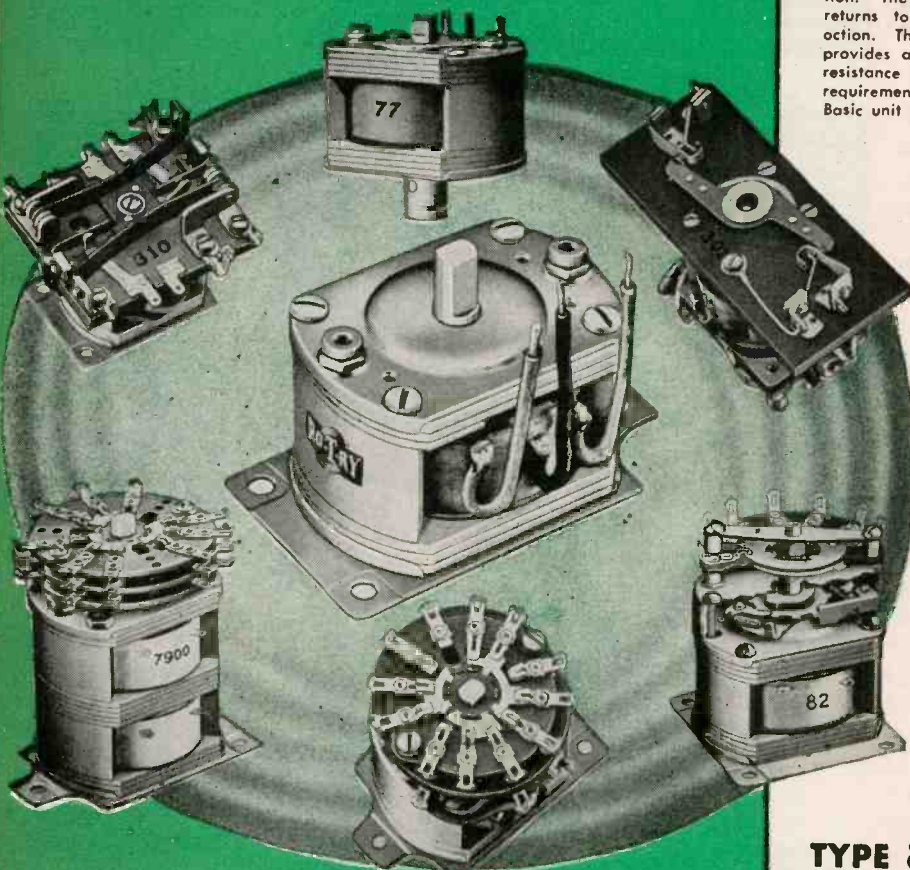
COMPANY SPRINGFIELD ILLINOIS

• • • WATT HOUR METERS • • • TIME SWITCHES • • •

Many Post War Products are being designed around this

Versatile ROTARY RELAY

that has achieved such outstanding performance in war Communications Equipment.



RO-T-RY

A NEW BASIC RELAY UNIT

of Versatile Adaptability

RO-T-RY introduces a new basic principle of Relay operation especially designed to withstand severe vibration, temperature and humidity conditions. When used to operate switch wafers it provides a great variety of contact arrangements, a few of which are here shown.

TYPE 76 This basic "RO-T-RY" (center photo) is a compact, two position driving mechanism providing up to 30 degrees of clock-wise or counter clock-wise rotation as specified from the normal (power-off) position. The shaft is rotated one way under power, and returns to the normal (power-off) position by spring action. This unit incorporates a two winding coil which provides a high initial torque, then switches in a high resistance holding winding which reduces the coil current requirements to a minimum in the energized position. Basic unit measures 2½" x 1½" x 1¾".

TYPE 77 Designed to operate a shaft extension through 30 degrees rotation. In general this provides means of operating wide'y spaced wafer switches, or for operating them in separate compartments. A special coupling provides easy means of connecting to a separate shaft.

TYPE 301 A keying relay providing instantaneous break in operation, in addition to other features. Extended shaft provides positive mechanicol interlock between keyed circuits and switching of antenna from transmitter to receiver.

TYPE 310 A special compact DP-DT and a SP-ST relay designed to meet standard aircraft vibration specifications. The unit is primarily designed as a motor generator control relay, with the DP-DT contacts rated at 40 amps. DC and the SP-ST contacts at 5 amps. DC.

TYPE 7900 A Duplex Driving Mechanism for use where no spring return is needed, or provided. For momentary operation only. Develops 16 oz. in. Torque at minimum operating voltage. Provides positive driving power for multiple switching of "on-off" or "Set" "Reset" operations.

TYPE 82 *Stepping Unit*
A compact 12 position driving mechanism which operates a shaft extension through 360° in 12 progressive steps. When built up as shown, the unit provides a 12 position selector switch which indexes one position for each momentary current impulse. The unit will drive up to three wafer switches or any other load not in excess of 8½ ounce inches torque. 12 or 24 volt DC operation is standard. Other DC voltages available.

Get Catalog E-75

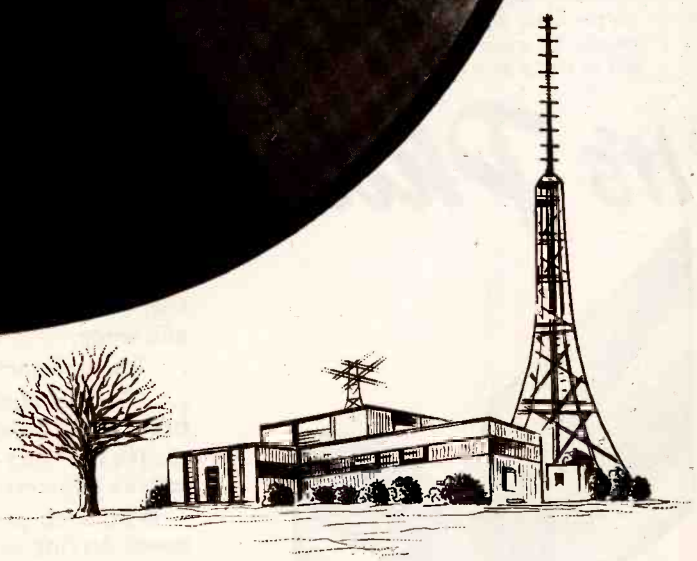
Illustrates "RO-T-RY" adaptability to unusual and varied relay applications. Complete specifications and detail drawings. Also illustrates other Price Bros. Co. Relays for Time Delays, Motor Starting, High Speed Keying, Antenna and Power Contactors. Write today for this Catalog.

PRICE BROTHERS CO.—FREDERICK, MD.
HUSKY RELAYS AND CONTROLS

ARMY E NAVY

PRICE Brothers Co. FREDERICK, MARYLAND

RELAYS, CONTROLS, AND MAGNETIC DEVICES FOR ELECTRONIC & INDUSTRIAL APPLICATION



There are no finer recordings than those transcribed on

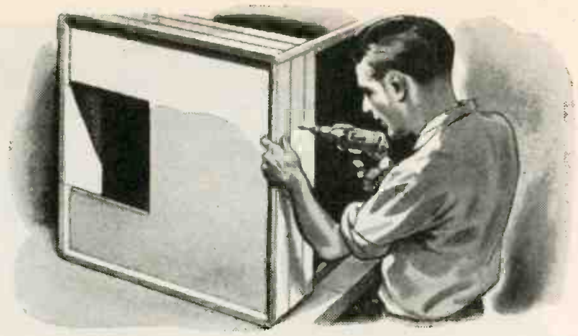
audiodiscs

AUDIO DEVICES INC. • 444 MADISON AVE., N. Y.

they speak for themselves **audiodiscs**

SHUTS OUT SLIP-UPS!

Assembling baby furniture was mighty slow work with slotted screws, one manufacturer found. Too many scratches to refinish – scratches caused by driver skids. So to pick up production he switched to Phillips Screws . . .



FRIENDLY TO PROFITS!

. . . out went burred heads and driver skids and slant driven screws. Out went slow-as-molasses hand driving. In came power driving – and with it, savings in time and materials that sliced a big chunk off assembly costs.

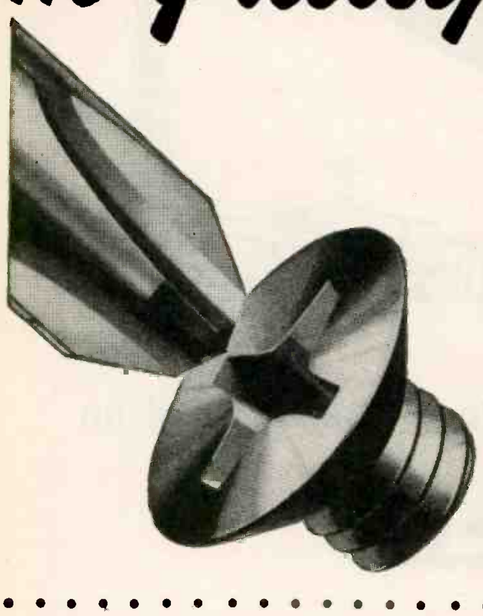
LONG ON SAFETY!

By making it stronger and more rigid, and by banishing dangerous burrs, Phillips Screws made this furniture safer for the kids. And your designers will find they do the same things for your product – whether it's tiny as a hearing aid or hefty as a harvester!

TOUGH ON COMPETITION!

Because of the ornamental design of the recess, Phillips Recessed Head Screws impart a "quality look" to any product. They give you a burr-free, blemish-free job that tells prospects you're on *your* toes – and warns competitors to watch out for *theirs!*

It's Phillips . . . the engineered recess!



In the Phillips Recess, mechanical principles are so correctly applied that every angle, plane, and dimension contributes fully to screw-driving efficiency.

. . . It's the exact pitch of the angles that eliminates driver skids.

. . . It's the engineered design of the 16 planes that makes it easy to apply full turning power – without reaming.

. . . It's the "just-right" depth of recess that enables Phillips Screw Heads to take heaviest driving pressures.

With such precise engineering, is it any wonder that Phillips Screws speed driving as much as 50% – cut costs correspondingly?

To give workers a chance to do their best, give them faster, easier-driving Phillips Recessed Head Screws. Plan Phillips Screws into your product now.

PHILLIPS *Recessed Head* SCREWS

WOOD SCREWS • MACHINE SCREWS • SELF-TAPPING SCREWS • STOVE BOLTS

Made in all sizes, types and head styles

25 SOURCES

American Screw Co., Providence, R. I.
Atlantic Screw Works, Hartford, Conn.
The Bristol Co., Waterbury, Conn.
Central Screw Co., Chicago, Ill.
Chandler Products Corp., Cleveland, Ohio
Continental Screw Co., New Bedford, Mass.
The Corbin Screw Corp., New Britain, Conn.
General Screw Mfg. Co., Chicago, Ill.
The H. M. Harper Co., Chicago, Ill.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
Manufacturers Screw Products, Chicago, Ill.
Milford Rivet and Machine Co., Milford, Conn.
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Reading Screw Co., Norristown, Pa.
Russell Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterville, Conn.
Shakeproof Inc., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
The Steel Company of Canada Ltd., Hamilton, Canada
Wolverine Bolt Co., Detroit, Mich.

WESTINGHOUSE CREATED THE

Ignitron

. . . it revolutionized welding and is now finding new fields of usefulness

The smooth, silent operation of resistance welding equipment is made possible by the ignitron tube—originated by Westinghouse. Ignitron tubes have broadened the field of welding to include projection welding. They have lowered costs, and increased speed and efficiency in all types of resistance welding operations. Westinghouse makes a complete line of ignitrons, the smallest of which is the WL-681/686 shown here.

But welding is only one field where ignitrons can be used. They are useful in timing operations requiring high peak currents for short durations, as X-Ray timers. They are useful in the field of motor speed control to govern the speed of medium horsepower motors. They may also be used in the field of frequency conversion and inversion.

In the WL-681/686, you have a small, light, compact tool of many applications and many adaptations of present applications. Write Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey.

IGNITRON WL-681/686
for welding service

Maximum welder demand	300 kva
Maximum average current per tube	22.4 amp
Maximum RMS supply voltage	600 volts
Length+lead	9.75+7 inches
Diameter	2.13 inches

Westinghouse

PLANTS IN 25 CITIES OFFICES EVERYWHERE

Electronic Tubes at Work

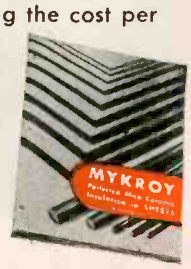
Supplied in thicknesses ranging from ⅛"—1¼"

Now You Can Use MYKROY For:

- Large Terminal Boards
- Switch Board Panels
- Large Inductance Bars and Strain Insulators up to 29 inches long
- Switch Connecting Rods
- Transformer Covers
- Large Meter Panels
- Bases for Radio Frequency and Electrical Equipment assemblies requiring large one-piece sheets

HERETOFORE the largest sheet of glass-bonded mica insulation available measured 14½" x 19¼". By doubling the size, Electronic Mechanics, exclusive manufacturers of Mykroy, now afford Design and Production Engineers many important, new application and fabricating advantages.

Lower Cost per square inch affects savings as high as 33% depending upon work piece size, greatly reducing the cost per fabricated part. *Better Cutting* efficiency lowers cost still further extending the use of Mykroy to a longer list of electronic applications where formerly cost prohibited its use.



Get the full facts about this versatile dielectric now. Ask for a copy of the new MYKROY BULLETIN 102 which describes the new, larger 19¼" x 29¾" sheets.

MADE EXCLUSIVELY BY

ELECTRONIC MECHANICS INC.

70 CLIFTON BLVD., CLIFTON, N. J.

CHICAGO 47; 1917 N. Springfield Ave., Tel. Albany 4310

EXPORT OFFICE: 89 Broad Street, New York 4, New York

MYKROY IS SUPPLIED IN SHEETS AND RODS — MACHINED OR MOLDED TO SPECIFICATIONS

MECHANICAL PROPERTIES*

MODULUS OF RUPTURE 18000-21000psi

HARDNESS

Mohs Scale 3-4 BHN. BHN 500 K9 Load. 63-74

IMPACT STRENGTH .... ASTM Charpy .34-.41 ft. lbs.

COMPRESSION STRENGTH .... 42000 psi

SPECIFIC GRAVITY 2.75-3.8

THERMAL EXPANSION .... 000006 per Degree Fahr.

APPEARANCE .... Brownish Grey to Light Tan

ELECTRICAL PROPERTIES*

DIELECTRIC CONSTANT 6.5-7

DIELECTRIC STRENGTH (⅛") .... 630 Volts per Mil

POWER FACTOR .... 001-.002 (Meets AWS L-4)

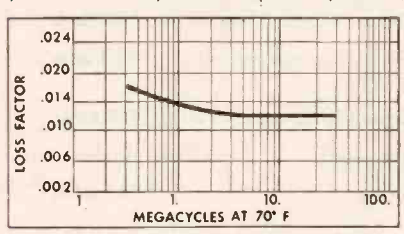
*THESE VALUES COVER THE VARIOUS GRADES OF MYKROY

GRADE 8 Best for low loss requirements.

GRADE 38. Best for low loss combined with high mechanical strength.

GRADE 51 Best for molding applications.

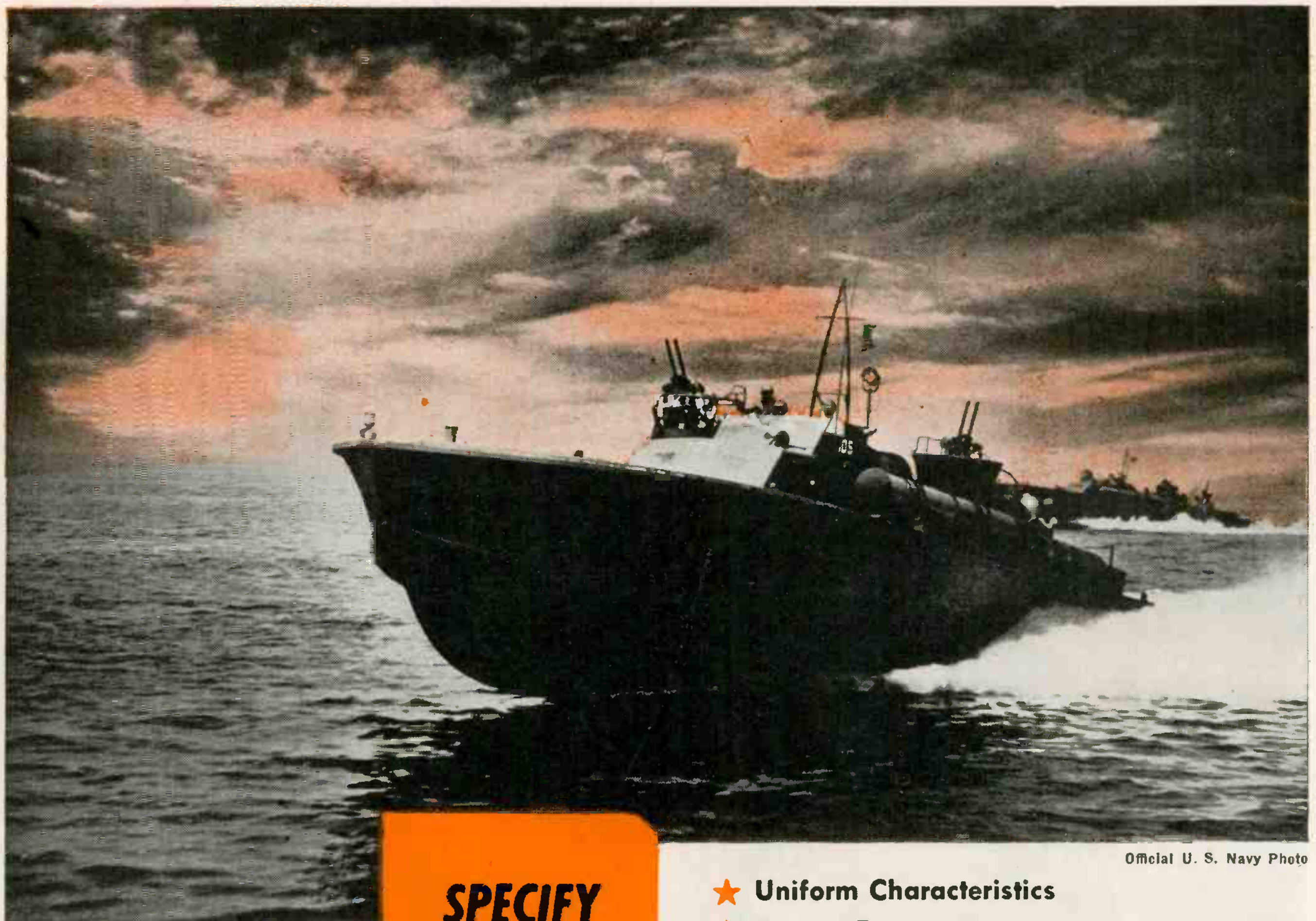
Special formulas compounded for special requirements.



Based on Power Factor Measurements made by Boonton Radio Corp. on standard Mykroy stock.

HERMASEAL

HERMETICALLY SEALED TRANSFORMERS —DEPENDABLE IN SEA WARFARE!



Official U. S. Navy Photo

SPECIFY HERMASEAL AND GET ALL TEN

- ★ Uniform Characteristics
- ★ Correct Terminations
- ★ Vacuum Immersion Test
- ★ Vacuum Impregnation—Varnish or Wax
- ★ Vacuum Filling—Oil or Wax*
- ★ Strong Mechanically
- ★ Soldered by Induction Heating
- ★ Infra-red Pre-heating
- ★ Continuous Inspection
- ★ 42 years Experience

HERMASEAL BY AMERTRAN

THE AMERICAN TRANSFORMER CO., 178 Emmet St., Newark 5, N. J.

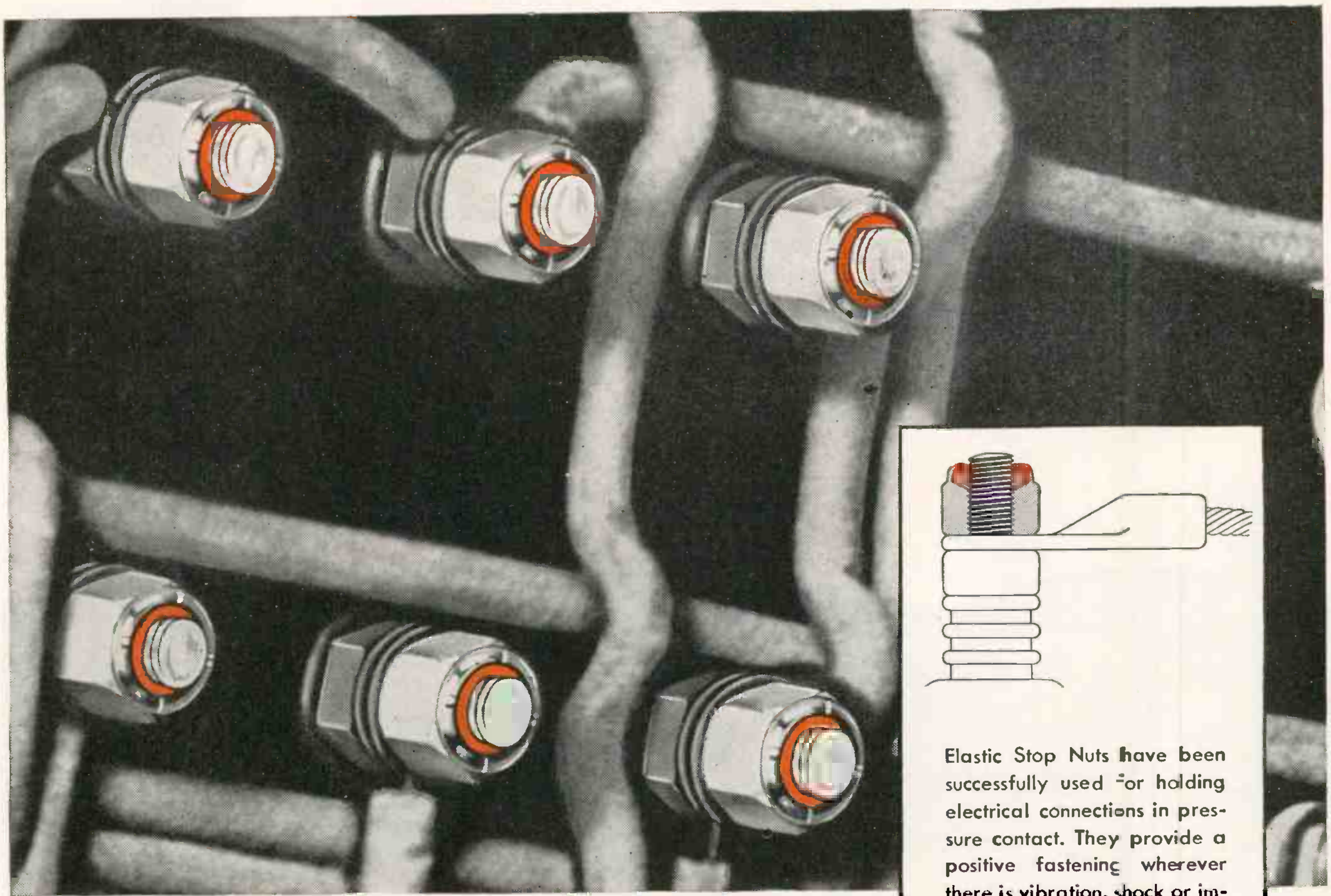
HERMASEAL

*May now be specified instead of compound filling.

Pioneer Manufacturers of Transformers, Reactors and Rectifiers for Electronics and Power Transmission

AMERTRAN

IT'S A NATURAL *to keep connections tight*



Elastic Stop Nuts have been successfully used for holding electrical connections in pressure contact. They provide a positive fastening wherever there is vibration, shock or impact. The Elastic Stop Nut prevents loose connections which arise from nut failures. Let us send an application engineer to discuss this method of reducing service charges on your products.

LOCKS FAST TO MAKE THINGS LAST

LOOSE CONNECTIONS CAN BE ELIMINATED

Loose connections, the bane of radio, appliance and electrical equipment manufacturers and servicemen, can be eliminated.

Vibration, shock, impact and other forces that tend to make a nut "back off" after it is wrenched into place are precisely the forces that the Elastic Stop Nut overcomes. Tens of thousands of them keep connections tight on military aircraft, tanks, trucks and other equipment today — and they will perform their important tasks on peacetime products in the years to come.

The Elastic Stop Nut is a maximum service, minimum servicing device.

The tough, durable elastic collar firmly fixed in each nut forms itself to the bolt threads. A friction bond that really holds is the result. Once on, an Elastic Stop Nut stays on. And it can be used over and over again without losing the grip of its elastic collar.

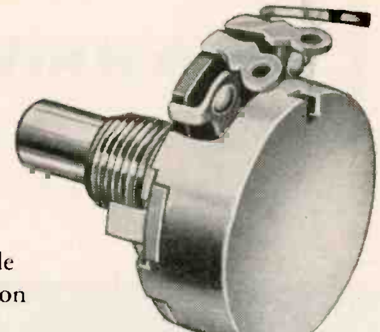
ESNA
TRADE MARK

ELASTIC STOP NUT CORPORATION OF AMERICA

Plants at Union, New Jersey and Lincoln, Nebraska • Sales Office: 1060 Broad Street, Newark 2, New Jersey

YOUR PRODUCTION NEED NEVER BE DELAYED

by faulty variable resistors



1½ times actual size

Chicago Telephone Supply Company has achieved its world-wide leadership in variable resistors because of a well-earned reputation for prompt deliveries and flawless accuracy.

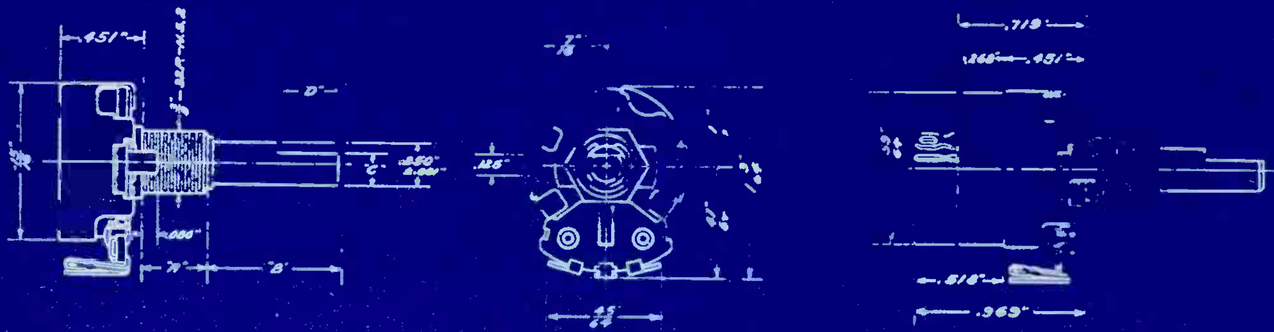
When CTS sets a delivery date it is only after making sure that, barring some major catastrophe, their production departments can keep that schedule.

And when the controls are delivered they always have the right characteristics to do the job, because CTS engineers will not start production on orders for new applications until samples have been delivered, tested and found to be exactly right.

Thus costly delays are avoided. A customer's entire production line will not be held up because the resistors have not arrived as promised, or because the characteristics do not fit the application.

If variable resistors are *your* problem, CTS service can save you considerable time, trouble and expense.

SPACE REQUIREMENTS FOR 45 SERIES AND GC-45 SERIES



REPRESENTATIVES

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406 W. Thirty-fourth Street
Kansas City 2, Missouri
Phone: Logan 7495

Frank A. Emmet Co.
2837 West Pico Boulevard
Los Angeles 6, California
Phone: Rochester 9111

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401 North Broad Street
Philadelphia 8, Pennsylvania
Phone: Walnut 5389

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IN ENGLAND

Chicago Telephone Supply Co.
St. John's Woods
103 Grove End Gardens
London, N. W. 8, England

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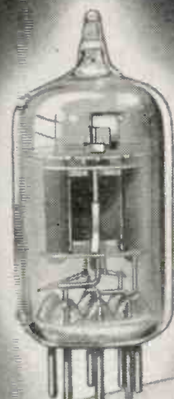
VARIABLE RESISTORS
PLUGS AND JACKS
SWITCHES, RINGERS
TELEPHONE GENERATORS

CTS

CHICAGO TELEPHONE SUPPLY
Company

ELKHART • INDIANA

Manufacturers of Quality Electro-Mechanical Components Since 1896



RAYTHEON
Type 6N4
Miniature U-H-F Triode

SPECIFICATIONS OF 6N4

DIMENSIONS:		
Maximum Overall Length	1¾	inches
Maximum Seated Height	1½	inches
Maximum Diameter	¾	inches
RATINGS:		
Heater Voltage	6.3	volts
Heater Current	0.2	amps.
Maximum Plate Voltage	180	volts
Maximum Plate Dissipation	3	watts
DIRECT INTERELECTRODE CAPACITANCES:*		
Grid to Plate	1.1	μμf
Input	3.0	μμf
Output	1.6	μμf
TYPICAL CLASS A CHARACTERISTICS:		
Plate Voltage	180	volts
Grid Voltage	– 3.5	volts
Plate Current	12	ma
Amplification Factor	32	
Transconductance	6000	umhos

** Approximate — with close fitting shield connected to cathode.*

● An important contribution by Raytheon tube-design engineers to the efficient generation of ultra high frequency power is a miniature triode designated as type 6N4.

This cathode type tube combines the desirable features of reduced interelectrode capacitances and lead inductances with high transconductance. Thus the inevitable internal losses are minimized, making the 6N4 particularly adaptable as an amplifier, doubler, or oscillator at frequencies up to approximately 500 megacycles.

The foregoing characteristics can be used to advantage in many types of equipment which may not be publicized. However, such important functions as those performed by the local oscillator in a u-h-f television or FM receiver are readily visualized possibilities.

In addition, Raytheon type 6N4 will be an ideal tube for civilian "walkie-talkies" and other portable radio equipment of the future. It has moderate heater power requirements and performs efficiently in the 460-470 megacycles region of the spectrum which is expected to be approved, by the Federal Communications Commission, for civilian use.

Whether or not Raytheon type 6N4 fits your particular plans, be sure to consider Raytheon High-Fidelity Tubes for your postwar products. There's a Raytheon tube that will fill your need efficiently and dependably.

All Four Divisions Have Been Awarded Army-Navy "E" with Stars

RAYTHEON
MANUFACTURING COMPANY
Radio Receiving Tube Division
NEWTON, MASSACHUSETTS · LOS ANGELES
NEW YORK · CHICAGO · ATLANTA

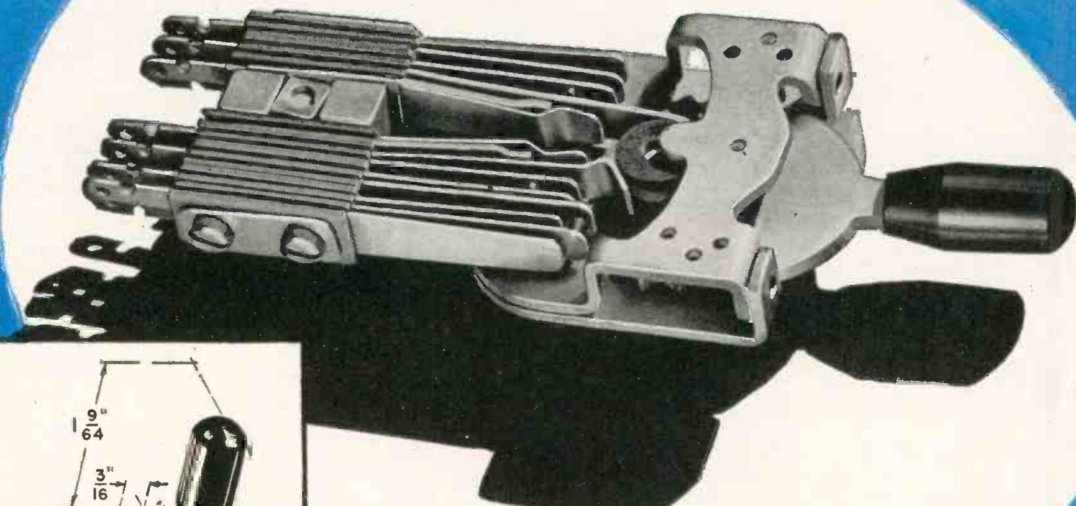
Listen to
"MEET YOUR NAVY"
Every Saturday Night
AMERICAN BROADCASTING CO.
Coast to Coast
181 Stations

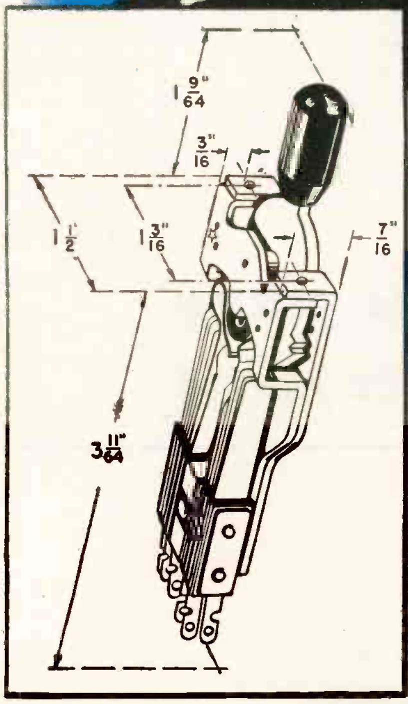
DEVOTED TO RESEARCH AND THE MANUFACTURE OF TUBES AND EQUIPMENT FOR THE NEW ERA OF ELECTRONICS

Superior
CATHODES
SEAMLESS
and
LOCKSEAM
(PATENTED)
SUPERIOR TUBE CO.
NORRISTOWN, PENNSYLVANIA
ARMY
NAVY
"THE BIG NAME
IN SMALL*
TUBING"
*Maximum OD ⅝"

The Little GIANT

FEDERAL'S *New* LEVER KEY





- Small Size—5/8" horizontal mounting centers.
- Large Spring Capacity — 18 springs; over 500 possible combinations.
- Palladium Contacts . . . Nickel Silver Springs.
- High-Quality Phenolfibre Insulation.
- Universal Cam — 1 or 2 way — locking or non-locking.
- Free-Moving Roller . . . Positive Snappy Action.

Designed for finger-tip control of electronic and communications equipment where size is important, the FTR-810 Series Lever Key occupies less than half the horizontal mounting space required for older types.

And at the same time, its eighteen nickel-silver springs and low-resistance palladium cross-bar contacts permit more than five hundred possible switching combinations.

High-quality phenolfibre insulated throughout, the overall simplification in design has resulted in a more rugged, dependable lever key with a positive, snappy action that once set — stays set.

The universal cam has an unusually long bearing surface for smooth action and long life . . . for either locking or non-locking operation . . . one or two-way, simply by a change in position of the stop pins.

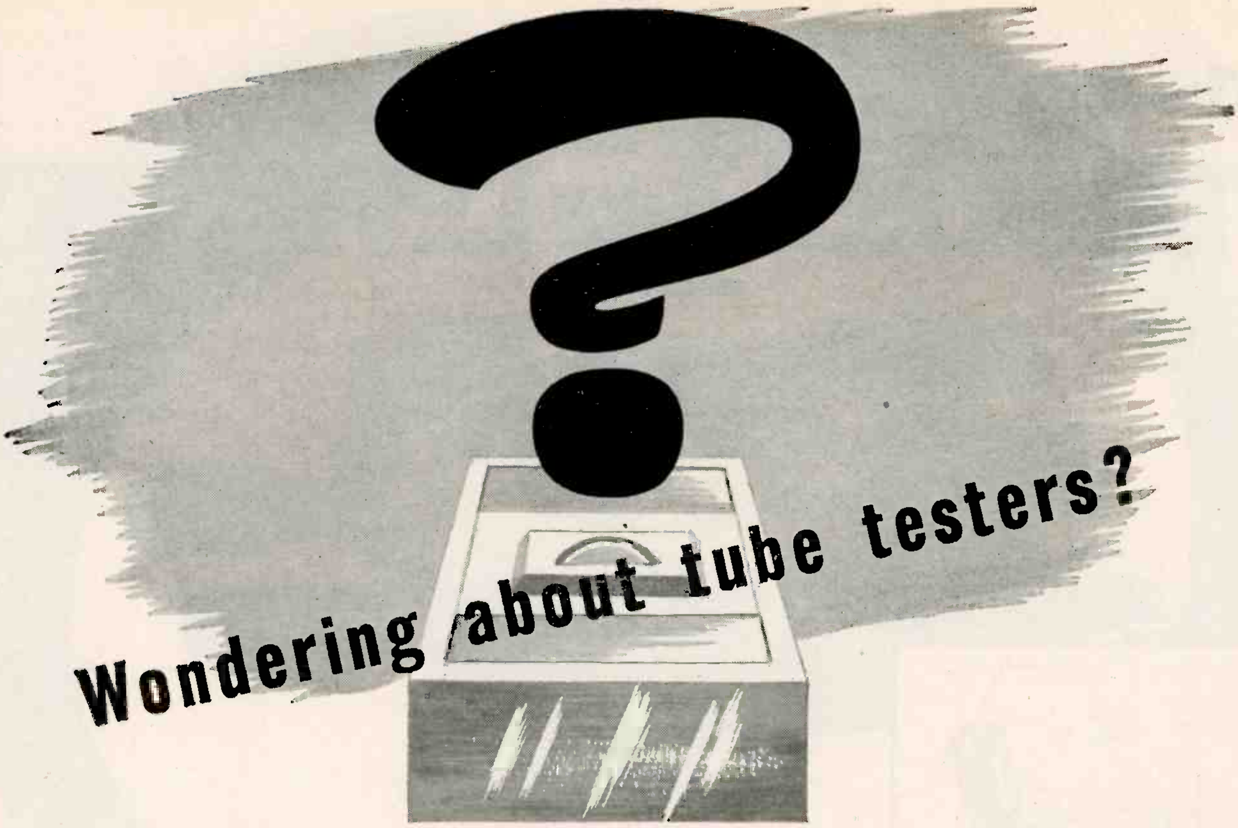
Here is another compact component by Federal with a wide variety of applications in control circuits, and another reason to see Federal first for electronic and communications equipment.

FEDERAL FTR TELEPHONE & RADIO

Federal Telephone and Radio Corporation

AN IT&T ASSOCIATE

Newark 1,
New Jersey



Wondering about tube testers?

...Here's what Simpson has ready and waiting for your postwar needs

---

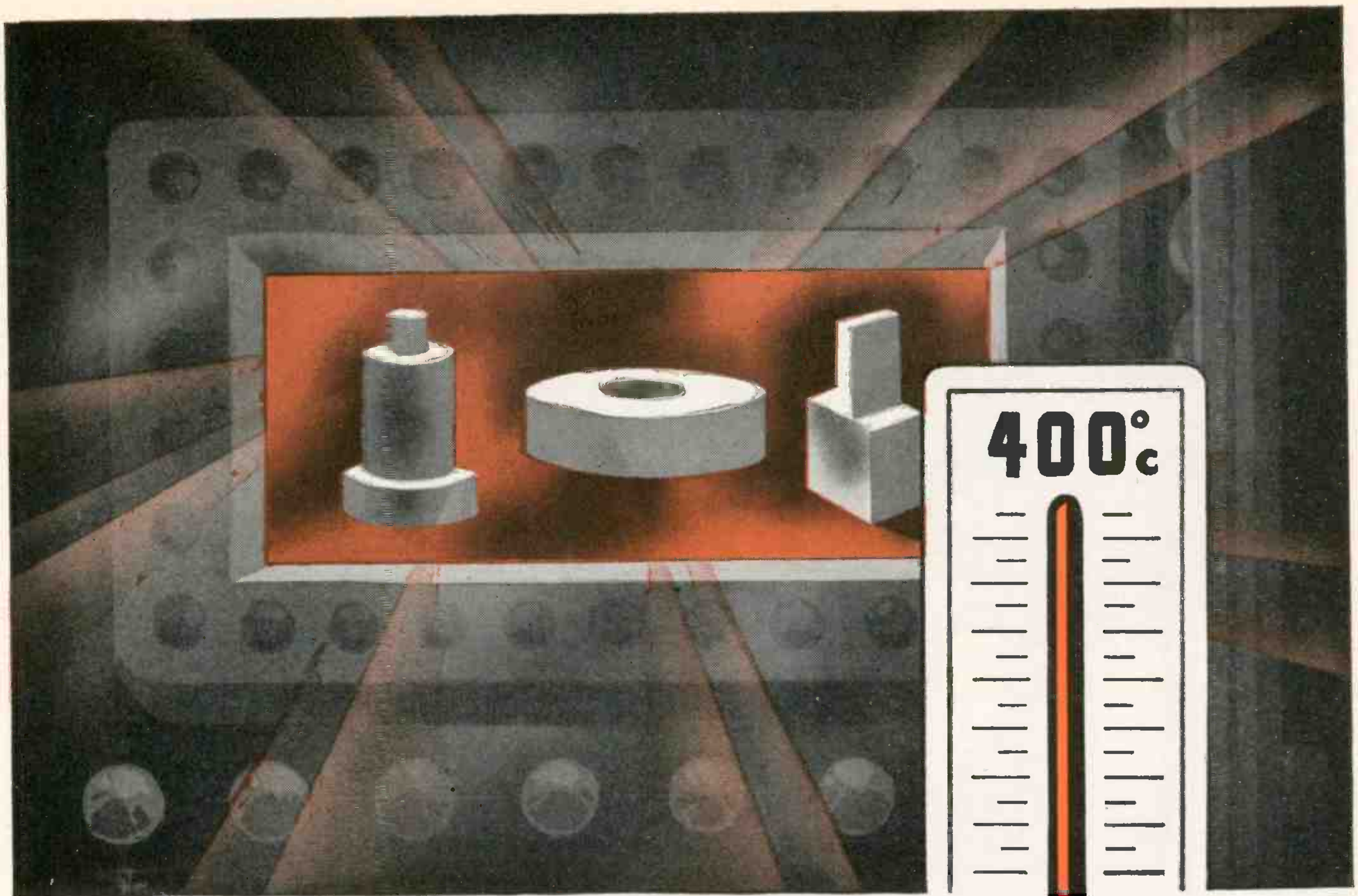
Sensational? Yes . . .

1. This new Simpson Mutual Conductance Tube Tester tests tubes with greater accuracy than any commercial tube tester ever designed.
2. Provides greater flexibility for future tubes than any other tester.
3. Tests tubes with voltage applied automatically over the entire operating range.
4. Simplifies as never before the interpretation of tube condition from mutual conductance readings.

SIMPSON ELECTRIC COMPANY
5200-18 Kinzie Street, Chicago 44, Ill.

Simpson

INSTRUMENTS THAT STAY ACCURATE



MYCALEX 400

WITHSTANDS HIGH TEMPERATURES

An outstanding characteristic of MYCALEX 400 is that it can withstand temperatures above 400° C. without softening or any permanent change in dimensions or properties.

Thus MYCALEX 400 has proved of great value as a low loss insulator in communications and other high frequency apparatus intended for use at elevated operating temperatures.

MYCALEX 400 is inorganic, free of carbonization . . . impervious to oil and water . . . not subject to cold flow. It meets all Army and Navy specifications as Grade L-4 material (JAN-I-10). It combines low loss factor with machinability to close tolerances. In sheets and rods. Fabricated to specifications.

SINCE 1919
MYCALEX
THE INSULATOR
TRADE MARK REG. U. S. PAT. OFF.

OTHER MYCALEX CORPORATION PRODUCTS

●

MYCALEX K

A series of ceramic capacitor dielectrics, with dielectric constant selectable from 8 to 19. Low power factor, high dielectric strength. Meets Army and Navy requirements as Class H material (JAN-I-12). To specifications.

MOLDED MYCALEX

Low loss, high temperature injection molded insulation. Molded in union with metals in irregular shapes. High production rates result in economical prices.

MYCALEX K and MOLDED MYCALEX will also withstand 400° C.

MYCALEX CORPORATION OF AMERICA

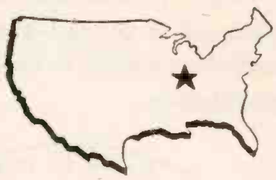
"Owners of 'MYCALEX' Patents"

Plant and General Offices, CLIFTON, N. J. *Executive Offices,* 30 ROCKEFELLER PLAZA, NEW YORK 20, N. Y.

Yes, Here's Why Bridgeport's the Answer to Postwar Coil Supply Problems

Bridgeport has the personnel and facilities. Right now, they're turning out highly important search coils and variometers for the armed forces. After their war job is done, the same skilled technicians will be able to give you the benefits of this experience in high production of quality radionic equipment.

And look at Bridgeport's central location! Because it is located near the population center of America, Bridgeport can give you fast, trunk line service to any part of the country. Place your order with Bridgeport NOW to insure early postwar delivery.

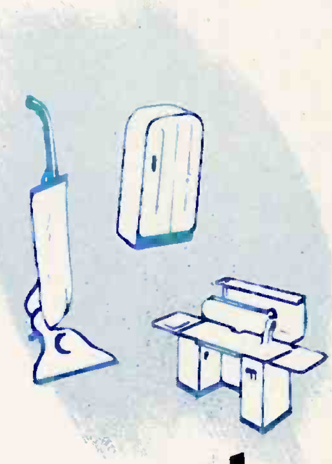


BRIDGEPORT

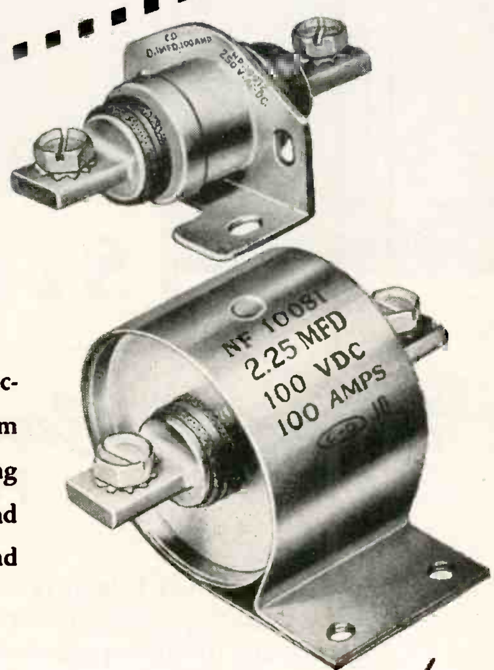
MANUFACTURING COMPANY
Bridgeport, Illinois

R. F. Coils • R. F. Chokes • I. F. Transformers
Transmitting Coils • Transmitting Chokes

stop that noise!



Capacitor Engineering That Licked Radio Noise . . .

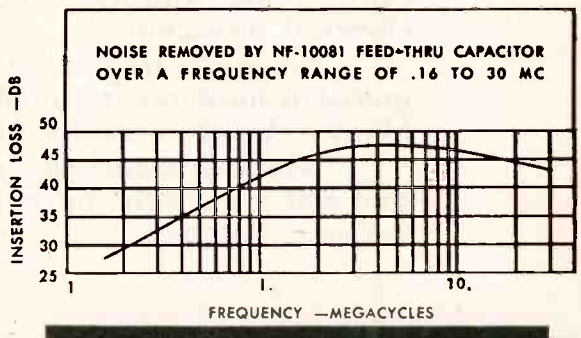


Vehicular radio equipment being manufactured now for military use is free from radio noise . . . thanks to the engineering that produced small compact capacitors and filters for generators, inverters, motors and other equipment.

The NF series of C-D feed-thru capacitors is specially designed and built for this service . . . to reduce radio noise.

Small and compact, they can be mounted in any position and will operate over a temperature range of plus 85° to minus 55° C. One power line can be fed through the unit, reducing internal inductance and resistance and increasing filtering efficiency. Rated up to 250 V. AC-DC, 100 amps., in sturdy, round metal containers.

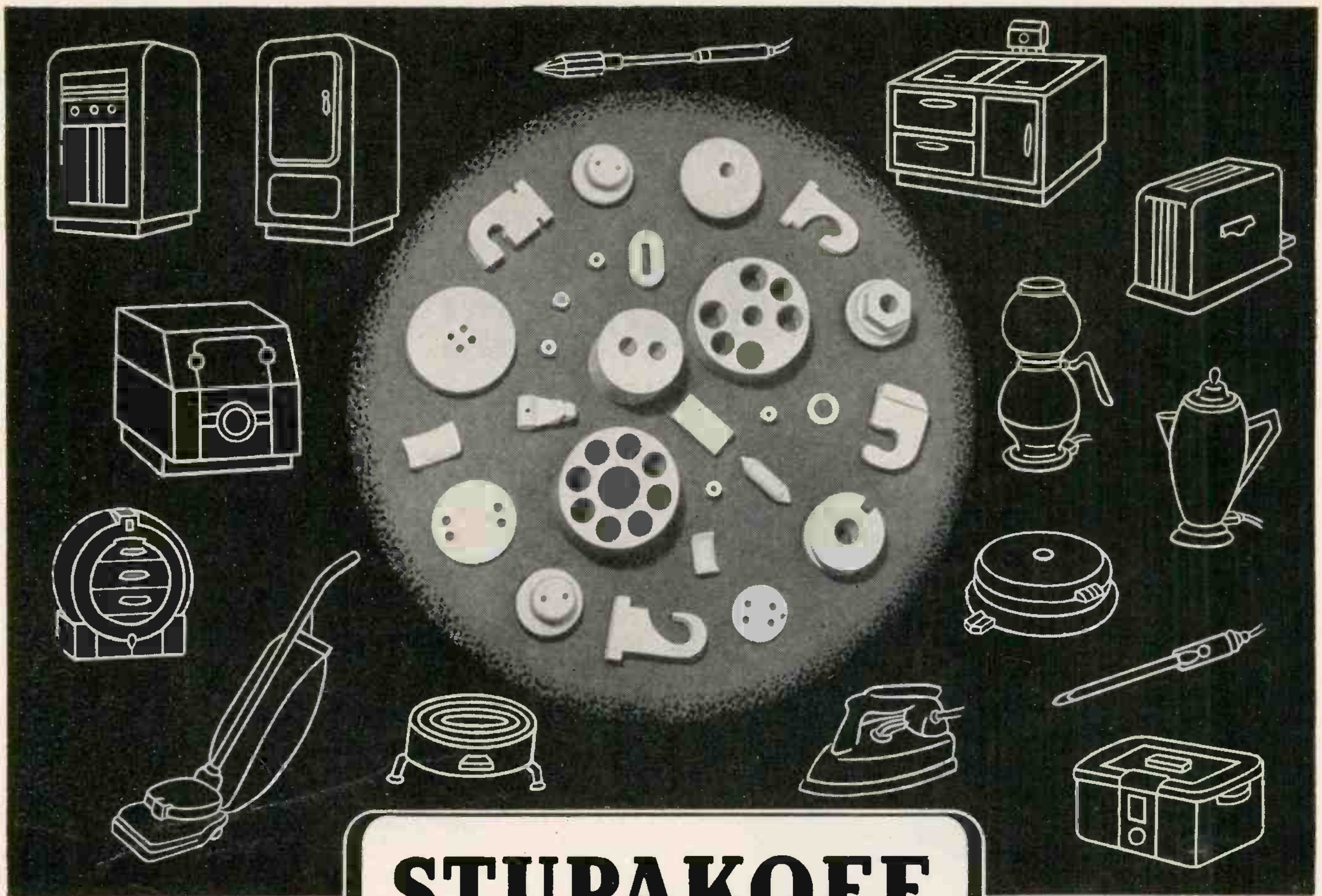
Other types of filters and feed thru capacitors are available in a range of sizes and ratings. Write for information. Cornell-Dubilier Electric Corporation, South Plainfield, N. J. Other plants at New Bedford, Brookline, Worcester, Mass., and Providence, R. I.



1910 1945

CORNELL-DUBILIER CAPACITORS

MICA ★ DYKANOL ★ PAPER ★ ELECTROLYTICS



STUPAKOFF

Engineered Ceramic Insulators

FOR ELECTRICAL APPLIANCES

STUPAKOFF Insulators—engineered to meet the rigid requirements of mass production methods—offer profitable advantages to manufacturers in the appliance industry.

They are mechanically strong to withstand manufacturing operations—dimensionally accurate for quick assembly—always uniform, keeping production lines flowing smoothly. Made of ceramic—inorganic, dense, non-hygroscopic materials—they provide maximum electrical protection.

Stupakoff facilities are geared to provide an unending flow of precision insulators to builders of electrical and electronic products. Many styles of insulators are stocked for immediate shipment.

Write us about your requirements. A competent and experienced staff will work with you in the development of engineered ceramics for your products.

BUY MORE WAR BONDS

ARMY E NAVY "FOR GREAT ACHIEVEMENT"

STUPAKOFF CERAMIC AND MANUFACTURING CO., LATROBE, PA.

Ceramics for the World of Electronics

RADIO MANUFACTURERS ASSOCIATION RMA MEMBER

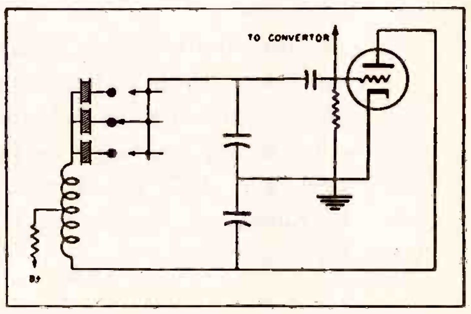
Deriving the most from frequency control and selection circuits employing quartz crystals calls for a recognition of the fact that a crystal is also a circuit element and, as such, is influenced by and in turn influences other circuit characteristics. It is a case of fitting the key to the lock.

The interdependence of crystal and tube in any circuit application poses design problems that are common to the crystal engineer, the tube engineer and the circuit engineer. Solutions are more readily arrived at by a pooling of specialized knowledge.

As manufacturers of crystals *and* tubes, the North American Philips Company has an intimate knowledge of both. Our engineers are therefore particularly well equipped to coöperate with circuit design engineers in any application problems involving the use of crystals. As an example, the circuit shown at right was suggested by our crystal applications laboratory as one means of employing crystal control in a push-button tuned receiver.

Although the armed forces have first call on our crystal production facilities, we invite inquiries from manufacturers interested in the utilization of low-cost precision quartz crystals for industrial and commercial applications. A booklet "How Quartz Crystals are Manufactured" is available on request.

Crystal-controlled oscillator circuit for push-button tuned receivers, using the series resonance of the crystal as the control factor. No adjustment is required over a frequency range as great as 2 to 1.

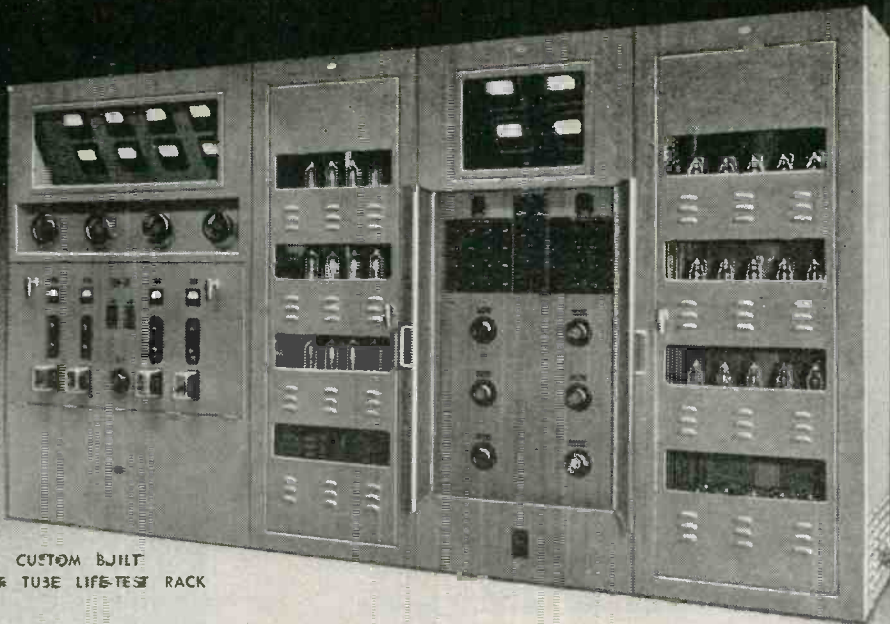


OTHER PRODUCTS: Amplifier, Transmitting, Rectifier and Cathode Ray Tubes; Searchray (Industrial X-ray) Apparatus; X-ray Diffraction Apparatus; Medical X-ray Equipment, Tubes and Accessories; Tungsten and Molybdenum products; Fine Wire; Diamond Dies. ●We invite you to visit our office and showroom when in New York City.

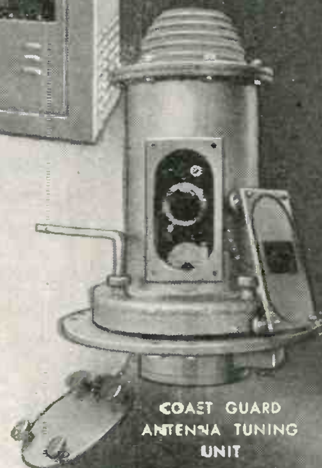
Norelco Reg. U. S. Pat. Off. *Electronic Products by* **NORTH AMERICAN PHILIPS COMPANY, INC.**

Dept. B-7, 100 East 42nd Street, New York 17, N. Y.
Factories in Dobbs Ferry, N. Y.; Mount Vernon, N. Y. (Metalix Div.); Lewiston, Maine (Elmet Div.)

350 WATT
POLICE HEADQUARTERS
TRANSMITTER



CUSTOM BUILT
POWER TUBE LIFE-TEST RACK



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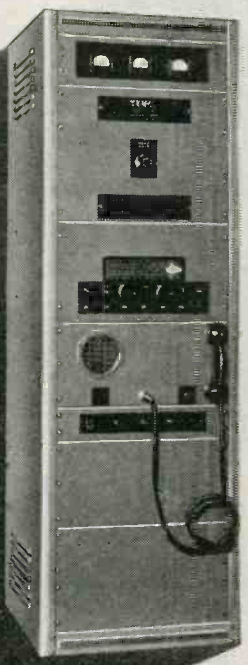

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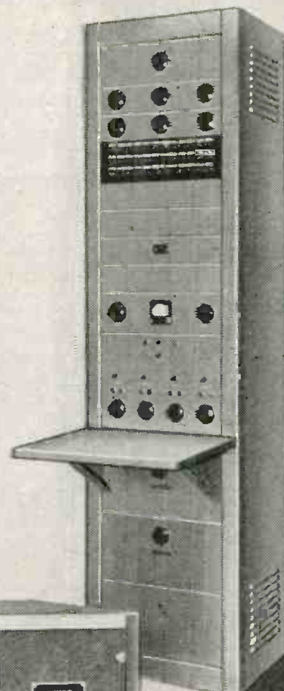

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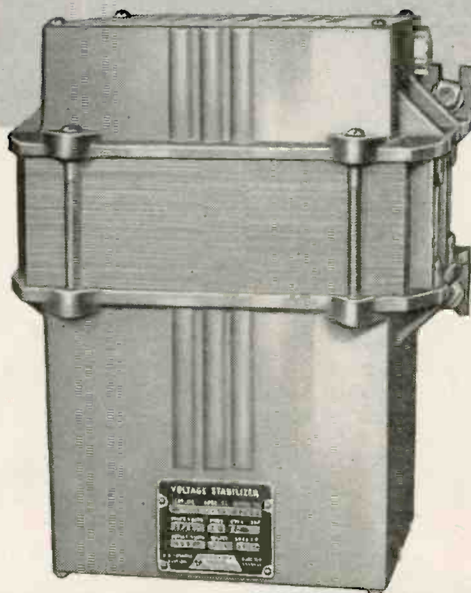

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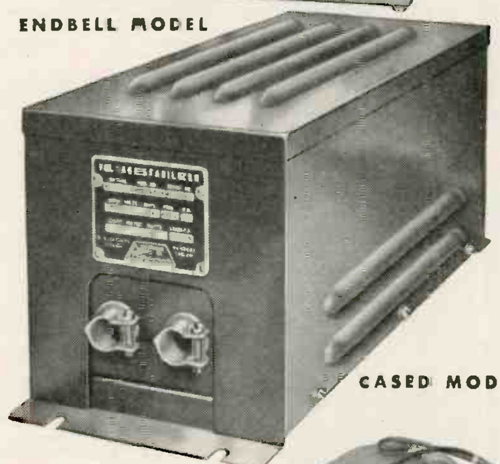
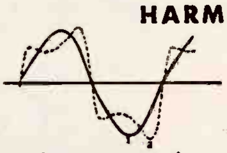


CASED MODEL

HARMONIC CONTENT



The high magnetic density in one of the transformers introduces harmonics in the output voltage wave. The actual harmonic content is usually unimportant except when instruments are being calibrated.

The output wave form is illustrated in the accompanying figure and table.

ANALYSIS OF OUTPUT VOLTAGE

Curve No.	Input Volts	Percentage Harmonic 1st	3rd	5th	7th
I	95	99.4	7.1	2.2	Trace
II	131	96.8	24.0	7.0	3.6

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STEADY JOBS *and* EQUIPMENT BUYING

SUSTAINED employment is not an attainable goal unless we can moderate the erratic fluctuations which have characterized the markets for producers' equipment in past periods.

In the 35th editorial of this series, "Sustained Construction Activity", it was pointed out that there is no specific that can cure our economy of its "boom-or-bust" proclivities. Rejecting the notion that the construction industry could be so managed as to stabilize business as a whole, that editorial stressed the important contribution it could make to that end, and suggested several practical expedients through which construction activity might be regularized.

Producers' equipment represents an area of production quite as broad and diverse as construction, though smaller in aggregate value. The classification embraces all types of durable equipment bought and used for profit—locomotives, motor trucks, electric generators, conveyors, machine tools, farm implements, and so on down to surgical instruments and dentists' drills.

Although the output of such equipment averages over a long period only 5 or 6 per cent of the nation's total output, it resembles construction in its extraordinary ups and downs. While its component items differ widely in the amplitude and violence of their fluctuations, the class as a whole is one of the most unstable sectors of the economy, making therefore a quite disproportionate contribution to the cyclical swings of total production and employment. From 1929 to 1932, for example, the decline in the output of producers' equipment (at constant prices) was 65-70 per cent, in contrast to a decline of 25-30 per cent in the national output exclusive of such equipment and construction.

A more recent example of the volatility of demand in this field may be found in the movement of a monthly index of orders for industrial equipment, which rose from 92 in the spring of 1936 to 160 in the spring of 1937, falling thence to 65 in the summer of 1938 and rising again to 142 in the fall of 1939. Such fantastic oscillations present an obvious and inescapable challenge to all concerned with economic stabilization.

Not only are these fluctuations bad for the economy; they represent demonstrably bad buying policy on the part of the purchasers of equipment. Peaks in demand come characteristically just before a business depression (1919, 1929, and 1937, for example) when machinery costs the most to buy and install and when it has the lowest expectancy of continuous use. At exactly the wrong moment everyone wants to buy. In the depression itself, on the other hand, with costs down, and with nowhere for the economy to go but up, equipment is a drug on the market. No one wants it when it is cheap and has the greatest prospect for steady employment. Here is a behavior pattern so profoundly irrational there must be hope for its correction.

There is an inveterate tendency for business management to forecast the future simply by projecting the trends of immediate past. Although it is axiomatic that the chance for an extended period of further prosperity is inversely related to the duration of the prosperity already experienced, this truism is generally ignored. The longer the boom has run, the more certain is business management that it will continue indefinitely. Convinced at last by "actual experience" that prosperity is here to stay, executives give the green light to commitments for expansion and modernization previously deferred in a skeptical attitude of "wait and see". The result, so often repeated in our economic history, is an explosive burst of demand for equipment coincident with, and contributing to, the final spasm of a boom. Witness the phenomenal rise in industrial equipment orders during 1928 and the spring of 1929.

The same prophetic illusion works in reverse during a depression. Recent experience is projected into the future. Although the mathematical probability of an imminent and prolonged period of prosperity increases directly with the duration of a depression, it finds little reflection in business decisions. Timidity and caution are the order of the day.

Compounding the errors caused by faulty perspective, are a number of influences which make it extremely difficult for individual enterprises to follow a policy geared to sensible long-term considerations. In a boom, particularly in its climactic phase, most producers find their order books crowded beyond the potential of their current capacities and are faced with the alternatives of expanding or losing trade to competitors. In depression the situation is reversed, and producers with unused facilities find it difficult to justify increases in their capital charges.

An even more controlling factor in many cases is the availability of funds. This is especially important for small concerns. Typically such firms enjoy but limited credit, and with no ready access to the securities markets, their capital expenditures depend primarily on earnings. When they are making money, they can afford to buy equipment; when they are losing, they largely disappear from the equipment market. Even great enterprises, though less dependent on earnings as a source of capital financing, are profoundly influenced by the volume of internal funds available for the purpose, a volume as a rule far greater in prosperity than in depression. Moreover, it is usually easier in good times to obtain outside funds through the sale of stock or by borrowing, since in bad times bankers, underwriters, and investors are susceptible to the same timidity and caution that afflict business management generally.

We are dealing here with a combination of psychological, physical, and financial forces which conspire to aggravate the instability of demand for capital equipment. What can be done to reduce this instability and thus to bring equipment purchasing into a more sensible and constructive pattern?

There is no panacea, no royal road to the solution. The problem has been with us since the beginning of the industrial economy. It is complex and difficult. It is not, however, wholly intractable. We may reasonably hope that industry will, through intelligent effort, make substantial progress toward a satisfactory solution. The industrial equipment field is one in which government, except for war periods, has exerted little direct control. The best insurance against the institution of government measures is to so conduct activities in the equipment field that no justification for government interposition can be made.

☆ ☆ ☆

1. The first and most important step is for industry itself to reconsider its heretofore haphazard and opportunistic policy in the purchase of equipment, substituting so far as possible a regularized, long-range programming of expenditure that will resist both the excited long-buying of booms and the equally disturbing underbuying of depressions. Such long-range programming is particularly appropriate and advantageous for large enterprises in established industries such as railroads, electric power, steel, automobiles, and the like, but it makes sense much more generally.

Once executives come to realize that a reasonably stable equipment program contributes not only to the welfare of the economy but also to the lowering of their long-run equipment costs, the opportunity to combine a public service with private advantage should induce them to recast their policies accordingly.

There is an even more compelling reason for purchasers of industrial equipment to do everything possible to regularize their demands. Some concerns unquestionably will find themselves in a postwar position where speedy delivery of needed equipment, even though it involves the payment of premium prices, will seem to be justified. But there is no system of accounting that can show it to be a profitable transaction to promote an equipment industry boom that runs a brief course only to collapse when the backlog of deferred maintenance and development has been satisfied. That, historically, has been the trigger which trips the door to the depression phase of the business cycle. No immediate advantage can compensate for the contagious paralysis that infects all business enterprise when major layoffs occur in any major segment. No precautionary measures, self-imposed by business, can be regarded as unduly severe if they can prevent this devastating blight.

2. Financial agencies can and should play a responsible role in regularizing equipment demand. Funds for the purchase of producers' equipment should be offered boldly and at low interest during depression periods, and should progressively tighten as a boom market bids up the price of purchase and installation. Banks and financial houses have excellent facilities for gathering and interpreting market and general economic information. It is good business for them, and for the national economy, to exercise their accepted discretions in a manner that will help to promote economic stability.

3. There now is almost universal recognition of the need for a thorough-going revision of our corporate tax structure to the end that effective incentives may be offered for private capital investment. The possibility of including provisions which would offer special tax concessions to equipment investments made in depression periods is worthy of intensive exploration.

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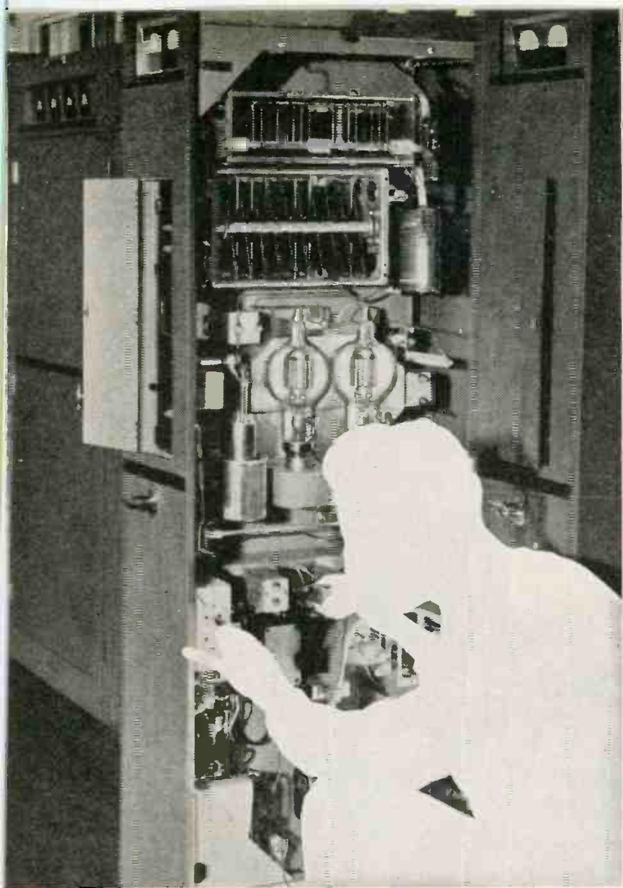
The fundamental problem here is educational. If all business enterprises in a position to do so were to regularize their equipment expenditures, it would have a tremendously beneficial effect. True, it would accomplish no miracles. For many concerns it is not feasible to schedule equipment buying over a long period. Even those who do schedule it are likely in practice to attain only a relative stability. It must be acknowledged, moreover, that few programs could withstand indefinitely a very deep and prolonged depression such as we had in the thirties. Nevertheless the adoption of stabilization policies where feasible would make a signal contribution both to the restraint of booms and to the mitigation of depressions. Here is something industry can do for itself.

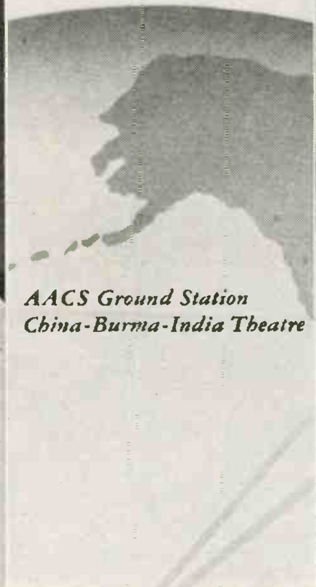
It is easy to disparage such remedies for economic instability as are here proposed on the ground that they are partial only. However, joined with others also partial, they can achieve in combination a solid progress toward the goal of sustained high level employment—progress that is unattainable through economic cure-alls. The road suggested is a slow road, and difficult, but it leads upward.

James H. McGraw, Jr.

President, McGraw-Hill Publishing Co., Inc.

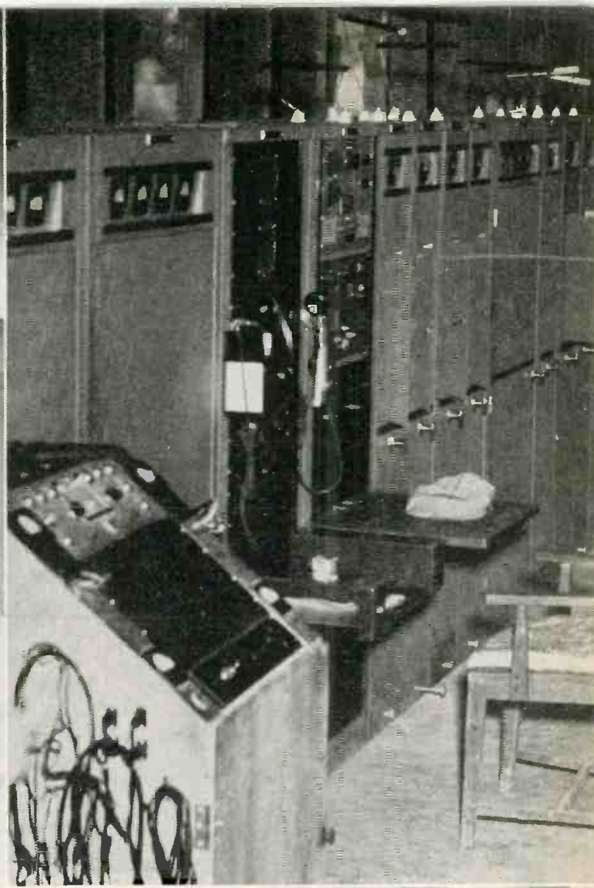
THIS IS THE 37TH OF A SERIES





AACS Domestic Station showing a pair of Eimac 450-T tubes

AACS Ground Station China-Burma-India Theatre

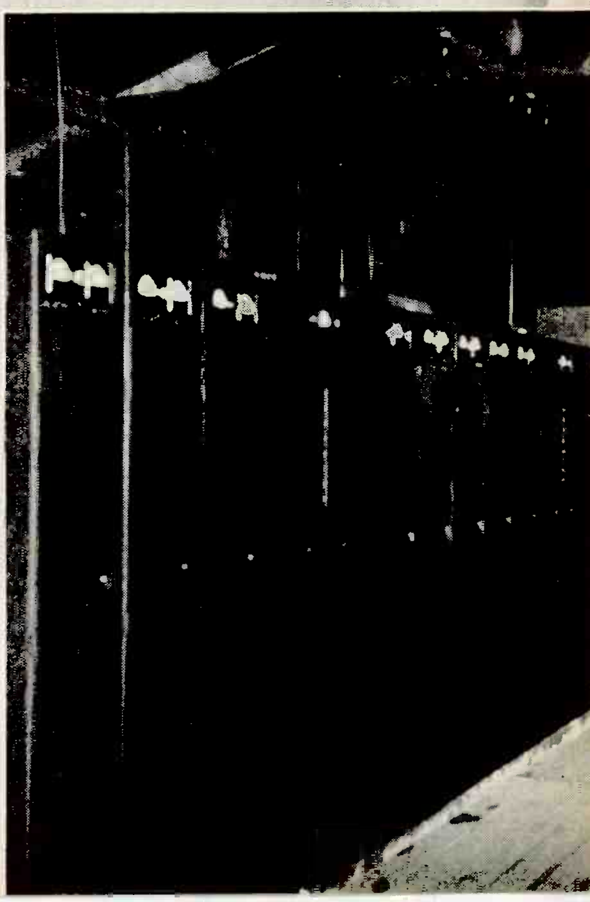


AACS* BLAZES THE TRAIL FOR SAFE FUTURE WORLD AIR TRANSPORTATION

World-wide aviation communications are an established fact today. Almost overnight a great radio network has been created. The actual physical difficulties involved were great enough, to say nothing of the variety of extreme operating conditions encountered and overcome. Needless to say, the equipment employed must be dependable, both from a standpoint of construction and performance capability.

The establishment of radio ground stations on every continent and in fifty-two different countries...overcoming the widest extremes in operating and climatic conditions (from 40 degrees below zero to 140 degrees above)...stations in jungles ...in deserts...in mountains and towns...and to have these stations constantly operating at near peak levels is a tribute to the equipment employed. On this page are shown three AACS Stations located at widely separated spots on the globe.

AACS Station on an island in South Pacific



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CROSS TALK

▶ **FM's FUTURE . . .** FCC's decision to postpone final allocation of f-m channels until fall, as reported elsewhere in this issue, has a background of controversy which deserves most careful analysis. The debate started, last year, as a technical argument concerning v-h-f propagation, a field where differences of opinion are the rule—not the exception. Since the economic aspects of fm were involved, the argument quickly broadened to include questions of public and private investment. The economic arguments were two: (1) any change in the f-m band would make obsolete equipment in public hands and (2) any change would depreciate, if not wholly wipe out, the broadcasters' investment in existing f-m stations.

First, the public investment: if a set owner wishes to retain his pre-war f-m set to receive fm on any new band, he has to install a simple converter. Moreover, such a converter is required, *in any event,* to cover extension of the existing f-m band to provide more channels for a nationwide, competitive system. The necessity for such extension has never been in question at any stage of the discussion.

Second, the broadcasters' investment; at the beginning of the controversy, the broadcaster may well have believed that by insisting on retention of the present band he could preserve his investment intact. But here, again, technical judgment has indicated otherwise. It is now agreed, by all parties to the argument, that high-power f-m broadcasting stations should move above 50 Mc to avoid F_2-layer interference. Since all present allocations are below 50 Mc, this means that all high-power statoins (50-kw and 10-kw power) must move in any event. These stations represent a very large part of the broadcasters' present investment.

In short, as far as investment is concerned, public or private, additional costs must be borne to allow fm to expand.

The remaining items of controversy are technical: what is the effect of frequency, over the range from 44 to 108 Mc, on (1) the extent of the several forms of interference and (2) the coverage afforded? Here, also, there is much more general agreement than appeared earlier in the year. As noted, there is agreement that F_2 reflections may give trouble, during the sunspot maximum, at the lower frequencies, between high power stations. The argument turns on a matter of degree: where in the region between 44 and 108 Mc will the interference cease to be troublesome? Major Armstrong believes that the trouble will be negligible above 60 Mc. He favors the lowest of the three FCC alternative bands, 50-68 Mc, with the high power stations in the upper 10 Mc of that range. E-layer reflections are now discounted as being of negligible importance compared to the F_2 reflections and those from the troposphere. As for tropospheric effects, experience has indicated that they become more serious as the frequency increases. Further study this summer will establish the facts.

The matter of coverage seems to favor the lower frequencies, but not unalterably so. High transmitting power is harder to get at 108 Mc than at 44, but our guess is that, with tubes shortly to become available, 50 kw can be obtained anywhere in this band. The question of field strength washes out. The volts-per-meter are higher as the frequency goes up but the length of the antenna decreases in proportion, so the developed voltage at the receiver terminals remains fixed for a given transmitter power, so long as free-space propagation is considered.

The effect of the earth's surface on propagation is, of course, pronounced. Further measurements are needed to establish the extent of absorption effects, but the diffraction effects are fairly evident. Shadows are sharper, and the diminution of signal strength beyond the horizon more rapid, as the frequency is increased. These matters can be proved in the coming months.

On the F_2-layer question, unfortunately, no proof can be forthcoming until the next sunspot maximum. In the meantime we must guess, by extrapolation from previous experience, what the effects will be. Of course the extrapolation procedure must be scrutinized with the greatest care, without professional bias or personal rancor, if we are to make a sound estimate.

Broadcast Band

Use of boosters to fill in dead spots or extend coverage when a directional antenna system is not feasible. The unattended booster transmitter may be fed by r-f line as with WWDC or by space radiation as with WINX, using standard telephone lines for remote control

By
ROSS H. BEVILLE
Chief Engineer
Station WWDC, Washington, D. C.

Much interest has been exhibited recently by broadcast engineers in a system of r-f signal reinforcement usually known as an r-f booster or a synchronous amplifier. Since late 1940 when the system was first used in connection with a standard broadcast station, it has proved both practical and of considerable benefit in the improvement of coverage in dead-spot areas and in aiding to override interference from other stations operating on the same or adjacent frequencies.

Uses for Boosters

The use of a booster system is desirable for local-channel stations that are limited by FCC regulations to 250 watts or less and are not allowed to use a directional antenna system, and for other stations even with directional antennas, to cover adequately an urban area having high noise level or absorption; WSAI is an example. A low-power station with several stragegically located boosters can provide coverage comparable to that of a much higher-power station; such a system was planned for Worcester, Mass. but was shelved due to wartime restrictions.

Three booster systems are now in operation, two being in Washington, D. C. (WWDC and WINX) and one in Cincinnati (WSAI). A construction permit has been authorized for a fourth system, now under construction at Ft. Benning, Ga., that will be operated as a satellite of WRBL in Columbus.

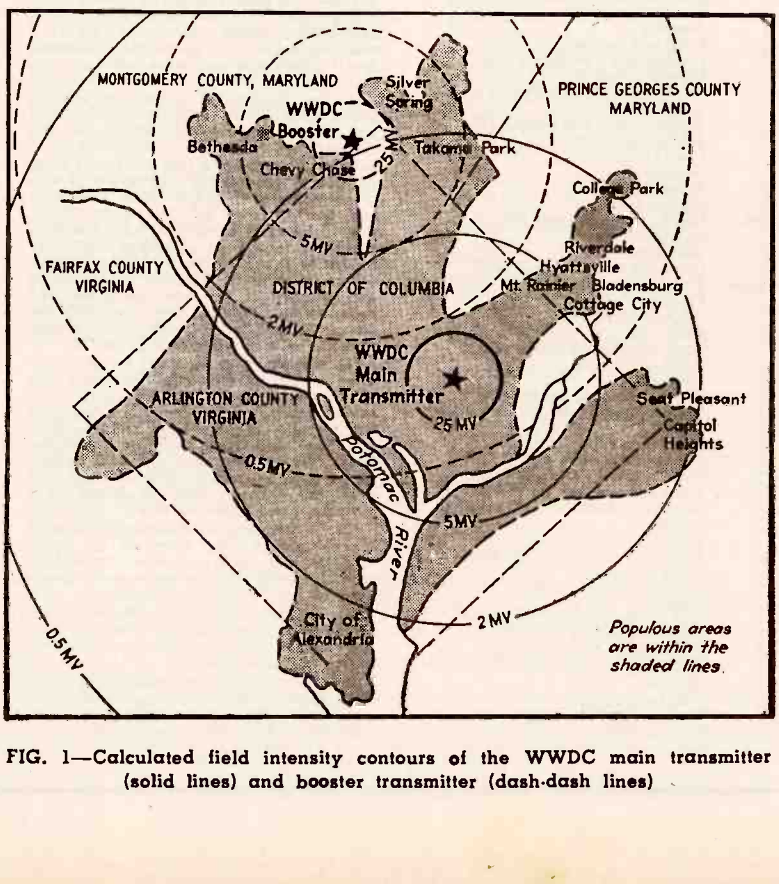


FIG. 1—Calculated field intensity contours of the WWDC main transmitter (solid lines) and booster transmitter (dash-dash lines)

How Boosters Function

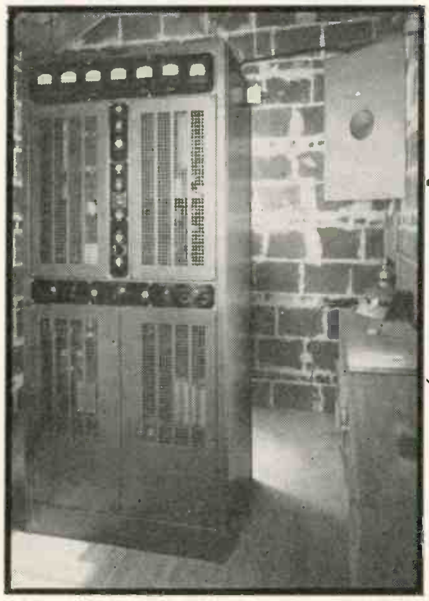
Basically, an r-f booster as referred to here is nothing more than a linear amplifier receiving excitation in the form of modulated r-f power from the main transmitter and reradiating this signal by means of a suitable antenna system in an area in which the main transmitter field requires reinforcement. The difference between this and earlier work done in the synchronization of broadcast transmitters (WBZ and WBZA) is that an r-f booster has no oscillator or other frequency-generating apparatus and no modulators. It is automatically synchronous due to the fact that it receives excitation voltage from the output of the main transmitter and does not require modulation since this signal is already modulated.

From a practical standpoint the booster amplifier, antenna coupling unit and radiating antenna can be conventional in every respect, the only special consideration being that the booster amplifier be linear and very low in noise and distortion percentage. To accomplish this, all stages should be operated as closely to class A as is practical considering the power output requirements.

Methods of Feeding Boosters

Since the booster transmitter must be a linear amplifier and has no frequency-generating apparatus, some means must be provided to deliver a sample of the modulated r-f output voltage from the main transmitter to be used as excitation voltage at the input of the booster amplifier. This can be done by land

Satellite Transmitters



Left — WWDC main transmitter, with booster control panel mounted on the right side of the cabinet

Right—WWDC booster transmitter, unattended and operated by remote control from the main station

lines extending from the main transmitter to the booster or by space transmission whereby the signal from the main transmitter is received at the booster with a directional receiving antenna. A third method that has been suggested is modulation of a high-frequency relay transmitter with amplitude-modulated r-f voltage at the main transmitter, with subsequent demodulation by a receiver at the booster end. With suitable amplification this signal could then be reradiated to supply reinforcement to the main transmitter field. There is some question as to the practicability of this method due to the wide channel required for the relay transmitter.

Proposed UHF Links

Many standard broadcast stations now operating, except those on clear channels, have areas where the signal-to-noise ratio could be improved or interference conditions alleviated, through the use of unattended satellite transmitters, according to Howard S. Frazier in testimony given recently before the Federal Communications Commission and abstracted here:

"Prior to the development of ultrahigh-frequency techniques, the use of satellite transmitters has not been general due to the complexities of the equipment usually employed for the interconnecting control circuit and the economic factors involved. However, it is now believed practical to provide the connecting circuit between the controlling standard transmitter and the unattended satellite by the use of ultrahigh-frequency radio channels.

"It is proposed to use a very small portion of the antenna carrier current from the controlling transmitters for the double-sideband amplitude modulation of the high-frequency transmitter. The audio program would be present as secondary modulation. At the unattended satellite a high-frequency receiver would eliminate the high-frequency component and the resultant broadcast-frequency carrier would be amplified in order to drive the antenna of the satellite. It is proposed to use highly directive antennas with both the transmitter and the receiver.

"Equipment for this service should be inexpensive and not complicated from a technical standpoint. Some manufacturers have already had experience with equipment of this type in connection with other services. It is recognized that the location of satellite transmitters should be based on sound engineering practice and that the location of the satellite and the amount of power radiated should be such that mush areas would be reduced to a minimum and would occur in areas where few listeners are located."

WWDC Booster Uses Land-Line Feed

In the case of WWDC, land-line feed is used exclusively. Original calculations showed that if the main 250-watt transmitter were located in the business area of downtown Washington, the field strength in Northwest Washington, Chevy Chase, Maryland and Silver Spring, Maryland would be inadequate for proper coverage. It was obvious that the booster should be located near this area and a site was selected common to these points, approximately half-way between Silver Spring and Chevy Chase and just off the East-West Highway.

Then came one of the problems of this installation, routing of the r-f feed line from the main transmitter to this point. It was simplified to some extent by the availability of Western Union telegraph pole facilities along the B & O railroad right-of-way from the Washington Terminal to Silver Spring, a run of slightly more than six miles.

From Silver Spring over to the booster site was around 2.5 miles and from the Washington terminus of the Western Union facilities to the site selected for the main transmitter was a little over one mile. The problem of covering this latter span was a little more complex since no overhead facilities were available from the main transmitter to the Washington railroad yards.

It was planned to construct a

special open-wire transmission line on Western Union poles from the Washington railroad yards to the booster, following the B & O railroad to Silver Spring and then from there along East-West Highway on telephone line poles. This was arranged, but for the span from the main transmitter to the Washington railroad yards there was very little choice other than to use the underground cable facilities of Western Union. This was a standard No. 19 gage 26-pair lead cable of which the majority of the pairs were already in use by Western Union.

No special treatment was given the cable other than to select the best available pair after noise and leakage tests were made on the pairs open for use. The length of this cable is 7,762 feet and, surprisingly, the loss along this portion of the line is less than would normally be expected at this frequency (1450 kc). To date no difficulty has developed due to induction or cross-modulation effects.

The open-wire portion of the line consists of 8¾ miles of No. 9 copper wire spaced 10.25 inches apart, presenting an approximate impedance of 700 ohms. The twisted pair in the lead cable measures 170 ohms at this frequency.

The loss in the entire line, which is over 10 miles long, is around 97 db. Approximately 29 watts is fed into the line from the final stage of the main transmitter, with approximately 2 millivolts being received at the booster end.

Coupling of the line to the main transmitter is accomplished by means of a variable capacitance which also provides a means for varying the amount of power fed into the line. A suitable matching transformer is used to couple the 170-ohm cable pair into the 700-ohm open wire transmission line. At the booster end, the line is terminated into a 700-ohm network, the output of which is link-coupled to the first stage of the transmitter.

Booster Amplifier Design

A modified Western Electric model 310B transmitter serves as the booster amplifier. The oscillator stage was removed and the coupling, the loading and the bias voltage of each succeeding stage was adjusted. Each stage was operated as closely to class A as possible while still obtaining the required 100 watts power output from the final with the excitation voltage available from the line. All stages are essentially class A with the exception of the final, which is class AB. In addition, a tuned circuit was substituted for the grid resistor in the first r-f stage to give better coupling into the phasing network, and avc was added to the first stage to compensate for minor variations in excitation voltage.

For an audio monitor, the modulation amplifier was utilized and now supplies power not only to the monitor speaker but also to a line extending to the main transmitter for monitor purposes. The final stage is coupled in a conventional manner to a 150-foot Lehigh tower.

Figure 1 shows the calculated contours of both the main and booster transmitters. Measurements have shown, however, that the radiation efficiency of the booster antenna is not quite as great as calculated due to a limited ground system.

Remote Control Equipment

The entire WWDC booster plant is operated by remote control, as shown in Fig. 2. This is accomplished by means of three telephone circuits and a small r-f amplifier which is bridged across the main r-f transmission line and operates time-delay relays for the filament and plate switches. One pair of lines is used alone for the audio monitor circuit and the other two pairs are used in duplex with samples of plate current, plate voltage and antenna current appearing on duplicate meters at the main transmitter. The excitation voltage to the booster is controlled by variation of the input to the transmission line at the main transmitter.

The r-f amplifier circuit that controls the filament and plate switches is shown in Fig. 3, and is designed to actuate the filament switch relay immediately upon arrival of an r-f signal from the main transmitter over the transmission line. The plate switch relay operates approximately one minute later. These relays drop out when excitation voltage is removed from the line, thereby removing the possibility of the booster transmitter remaining on in case of line failure.

The r-f carrier signal arriving over the transmission line is amplified by VT_1. Tube VT_2 is biased to cutoff, hence its plate circuit relay is inoperative with no carrier.

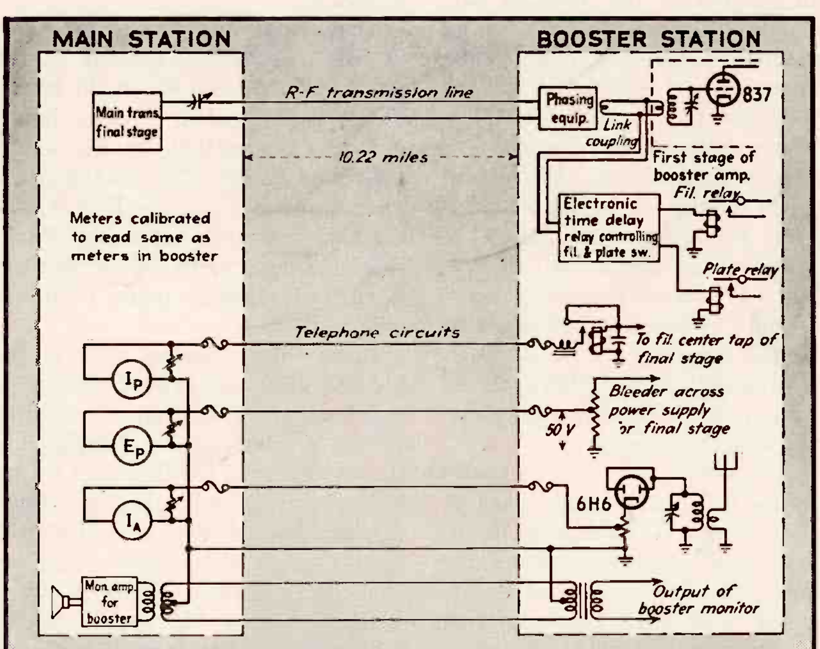


FIG. 2—Remote control system for WWDC booster transmitter

Arrival of the carrier overcomes this bias, making relay *1* operate and close the filament supply relay of the booster transmitter. Tube VT_3 has a high negative bias when relay *1* is open (no carrier), amounting to half the plate supply voltage or 125 volts. Closing of relay *1* (on arrival of a carrier) shorts the resistor providing this negative bias, allowing the charge on the grid capacitor to leak off through the grid resistor to the point where VT_3 draws enough plate current to operate relay *2* and apply plate power to the booster transmitter. The time delay of the grid circuit is made sufficiently long to permit heating of tube filaments.

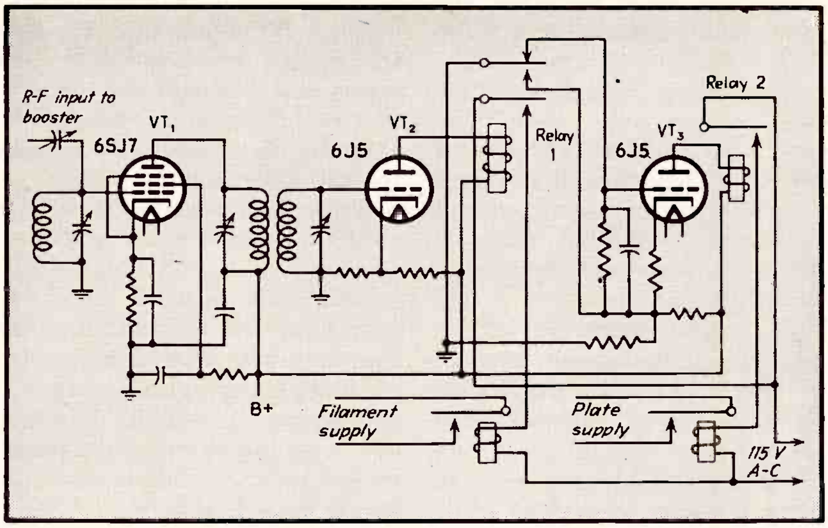


FIG. 3—Circuit of amplifier developed by C. R. Shaffer, Technical Supervisor of WWDC, to apply power automatically to the booster transmitter when a program signal arrives over the r-f transmission line from the main station

Space Transmission Method

The booster system originally installed at WINX, Washington, D. C., is an example of the method wherein the booster receives its signal through space rather than over wires. As with WWDC, original calculations showed that signal reinforcement would be required in Northwest Washington if the transmitter were to be located in the downtown area. A site for the booster transmitter was selected in an area approximately four and one half miles from the main transmitter, where the field from the main transmitter was calculated to be 2.5 millivolts. Later measurements proved this to be correct.

At the booster site, two receiving loops are oriented and phased to give a unidirectional pattern. The output of the loops is fed through a phasing network to a preamplifier consisting of two voltage stages and one 802 power stage. The output of this amplifier is then fed into a quarter-inch concentric line extending to the booster amplifier approximately 800 feet away, as shown in Fig. 4. At this point the line is terminated in another phasing network, the purpose of which is to synchronize the booster output with the main transmitter signal.

The WINX booster amplifier is of composite construction and has two stages—an 828, class A, driving two 203A tubes operating as class B, designed for 50 watts output. This is coupled to the antenna in a conventional manner. The antenna itself is novel, consisting of a 125-foot brick smoke stack encased with four copper leads suspended from the top and bonded together top and bottom.

The booster amplifier is operated by remote control from the main station, as shown in Fig. 5. Four pairs of standard telephone wires are used in this control circuit. One pair provides a monitor circuit. Another pair actuates a reversible stepper relay to control the r-f input to the transmitter and with the third and fourth pairs also serves to read samples of plate current, antenna current and plate voltage and to operate the main power switch to the transmitter. This latter circuit is so arranged that the transmitter automatically shuts down in case of failure of the control circuit.

Closing the toggle switch at the main station actuates relay *1* at the booster station through telephone line *1*, applying power to the booster transmitter and associated equipment. Lines *2* and *3* serve as return circuits for the remote plate current and antenna current meters when not in use as relay control circuits. Operating pushbutton *1* closes relay *2*, making the stepper relay rotate one step in one direction and moving the arm of a potentiometer that controls the r-f output from the loops. Releasing and again depressing this pushbutton repeats the action. Pressing pushbutton 2 closes relay 3 and causes the potentiometer to move in the opposite direction. The excitation voltage fed to the booster transmitter by its pickup loops can thus be controlled remotely by operation of pushbuttons 2 and 3 at the main station.

Lines 4, 5 and 6 carry samples of plate current, antenna current and plate voltage to the remote meters located at the main station. The booster monitor loop is excited by a portion of the booster monitor output and is terminated into the monitor system at the main station.

Design of Pickup Loops

The most interesting portion of the WINX booster system is its method of feed by means of a directional receiving array. This is accomplished by taking advantage of the natural bidirectional characteristics of the loops and also by introducing sufficient electrical phase difference in addition to the physical spacing so as to discriminate against signals arriving from the rear of the array.

The loops are spaced approximately 35 feet apart or roughly 15 degrees at this frequency, and are mounted about 30 feet above ground. The physical arrangement is such that the two loops are lined up in the direction of the main transmitter but are at right angles to the booster antenna. With this arrangement the natural null of the loops is presented to the booster antenna while the lobe of maximum pickup is in a plane with the main transmitter. Careful orientation gives rejection ratios between the main and booster transmitter signals of 10,000 to 1 or better. A rejection ratio of this order is critical and difficult to maintain, however, which is one of the principal objections to this system.

The physical dimensions of the loops are approximately two by four feet. They are constructed of two-conductor copper-shielded cable, with the two inner conductors cut and reconnected so as to form a two-turn loop. The outer shield is cut at the top and acts as an electrostatic shield. In the case of WINX the two loops were connected in series and then connected through the above-mentioned phasing network to the preamplifier.

Comparison of Line and Loop Methods

In evaluating the advantages and disadvantages of the two methods of excitation for the booster transmitter it appears that neither of the above systems offers the ideal solution. In the case of the WWDC land line feed, where open-wire transmission line is used, weather conditions cause variable line losses which are sometimes difficult to compensate for. Also, the cost of such a line is usually greater than that of receiving equipment. A concentric line between the two transmitters would minimize weather effects and provide an ideal system in other respects, but the cost would generally be prohibitively high. The transmission line method does offer greater stability than the loop method, however, and also provides a simpler means of control over the input where remote-control operation is utilized.

When the loop system is located close to the booster radiating antenna, as in the WINX system, adjustments become critical. As an example, suppose the loop system is located within the 200-millivolt area of the booster transmitter, where the field from the main transmitter is 2 millivolts. The signal ratio is 100 to 1 in favor of the booster. In order to provide a signal ratio of 100 to 1 in favor of the weak signal from the main transmitter, which is the approximate ratio required for satisfactory performance, a rejection ratio of 10,000 to 1 would be required for the loop system.

While such a rejection ratio is entirely possible with careful adjustment of a well-designed loop system, many variable factors appear which make it difficult to keep such a system in adjustment. One of the greatest disadvantages of this system, however, is the pickup and reradiation of interference caused by other stations operating on the same frequency.

If the loop system is located in an area where the signal strength from the main station is below that required to override all interference, then reradiation of interference becomes serious. In a two-loop array with outputs phased so as to approximate a unidirectional receiving pattern, interference is eliminated to some extent but signals arriving at a high angle cause a great deal of trouble. Also, signals appearing at approximately 45 and 135 degrees on each side of the main axis can and do cause difficulty. The advantages of the loop system lie in economy of installation and elimination of long-line maintenance.

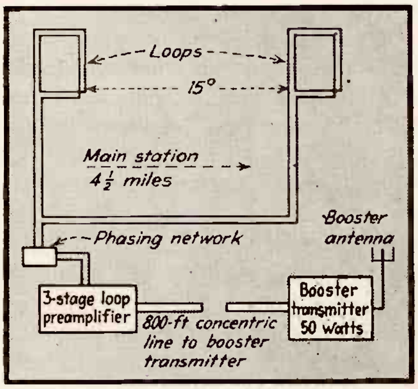


FIG. 4—Block diagram of WINX booster system, which obtains its r-f signal through space with a pair of loops beamed at the main transmitter

Possibly the best practical method of feed would be a combination of the two systems whereby a single loop is located in a heavy field from the main transmitter, at some distance from the booster transmitter, and connected with the booster transmitter by means of telephone cable or, if possible, concentric line. This should greatly reduce the interference problem, reduce the cost of line installation and also materially increase the stability of the loop system due to the increased distance between it and the booster transmitter.

Control of Mush Areas

The principal disadvantage with any booster station is the resulting mush areas. They are not limited to areas between the two transmitters, and are dependent to a great extent upon the ratio of the power output of the booster transmitter to the power output of the main transmitter. In some cases, where the power ratio is considerably in favor of the main transmitter and where no phasing network is utilized to put the two signals in step at points beyond the booster transmitter, the mush areas may completely surround the booster and will appear at any point where the two signals are of equal intensity and displaced as to phase.

It is not essential that the main and booster transmitters be operated in phase, but in most cases better results can be obtained when they are. Inphase operation is used at WWDC and WINX, eliminating mush areas beyond the booster. Generally speaking, when the booster output is low in comparison to that of the main transmitter and the booster is located in an area subject to high absorption (as with WSAI), mush areas will completely surround the booster if phasing is not used.

Selection of the power ratio is important in that it provides a means by which the mush areas can be controlled to some extent. If care is exercised in the selection of this ratio, the mush areas can be made to fall, for the greater part, in predetermined areas which in some cases may be thinly populated or in some way not so desirable from a coverage standpoint as others. There are other factors involved in making this determination, such as variable soil conductivity between the two transmitters and the efficiency of the two antennas, but with normal antenna efficiency in each case, the actual output of the two transmitters will be the dominant factor.

Causes of Distortion

Mush areas are roughly a half wavelength wide and are found at points at which the main and booster transmitter signals are of equal or nearly equal intensity and are opposite in phase. In these areas, cancellation or partial cancellation of the two signals occurs and the resultant appears as a considerably weakened signal accompanied by distortion of the audio component. The amount of distortion is dependent principally upon (1) distortion introduced by the booster amplifier, and (2) distortion occurring as a result of phase differences between the two r-f signals.

Distortion occurring as a result of the first case can be partially controlled by careful design and adjustment of the booster amplifier, and will considerably reduce the mush area. For example, assume a theoretical amplifier completely free of distortion. With such an amplifier the modulated r-f excitation voltage would be reradiated from the booster antenna with no change in the wave form other than an increase in amplitude. With an exact 180-degree phase displacement at a point of equal field intensity from the main and booster transmitters, complete cancellation of the two signals would occur. Still assuming 180-degree phase displacement, at any point other than one in which the two signals are exactly equal there would be a weakened signal but no distortion of the audio component.

Now consider the practical case where some distortion is introduced by the booster. In this case the two r-f envelopes are not the same and only that portion of the booster signal which originated with the main transmitter will be cancelled, leaving the distortion to appear as a small but greatly overmodulated r-f signal. The amount of this distortion will to a great extent control the width of the over-all mush area since for every half-wavelength, where the two signals are approximately equal, there will be cancellation to the extent that they approach each other in amplitude.

If the distortion present is small in comparison to the resultant signal, then the mush areas will be small and sharply defined. Under normal circumstances mush areas tend to disappear when the ratio between the two signals is of the order of 2 to 1 or more. If the distortion percentage is large, however, the area over which this condition will be noticeable will be increased proportionately. This is important, since by maintaining the booster transmitter with as low a percentage of distortion as is practicable, the area over which this condition is prevalent can be reduced to a minimum.

Phase Considerations

In the above, only the half cycle which was exactly out of phase with the main transmitter signal has been considered. The following half cycle, due to the two signals traveling in opposite directions, will be in phase and the two voltages will add, causing no particular difficulty.

The above analysis also assumes an exact 180-degree phase displacement. This would occur normally only on a straight line between the two transmitters (or on this same line extended beyond either transmitter if phasing equipment is not used) and not necessarily at a point of equal signal intensity.

It is not likely that any point could be found at which complete cancellation of the two signals occurs, because when they are equal in amplitude they are generally not exactly 180 degrees out of phase. At any point off this theoretical line, the phase angle between the two signals becomes less than 180 degrees. At such points and along the line of approximately equal signal intensities, phase distortion of the modulated r-f envelope is most apparent and results in a distorted audio component. This is by far the most serious of the causes for mush areas since no method of control has yet been devised. No amount of phasing equipment will put the two signals in phase at all points between the two transmitters.

Conclusion

In summation, it may appear that a negative viewpoint has been adopted as to the use of boosters due to the mush areas involved. On the contrary, it is felt that amplifiers of this type may in many cases be the solution to the dead spot and interference problems of many broadcast stations. Actually, mush areas cover only a very small percentage of the service area of a station and in many cases these can be made to fall in areas not considered of great importance from a coverage standpoint. The additional service rendered by such an installation greatly offsets any disadvantage occasioned by its use.

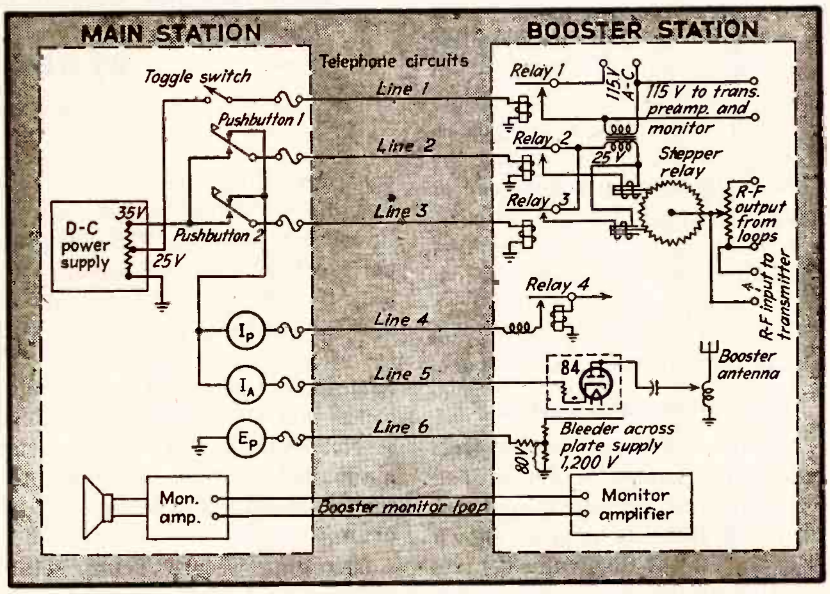
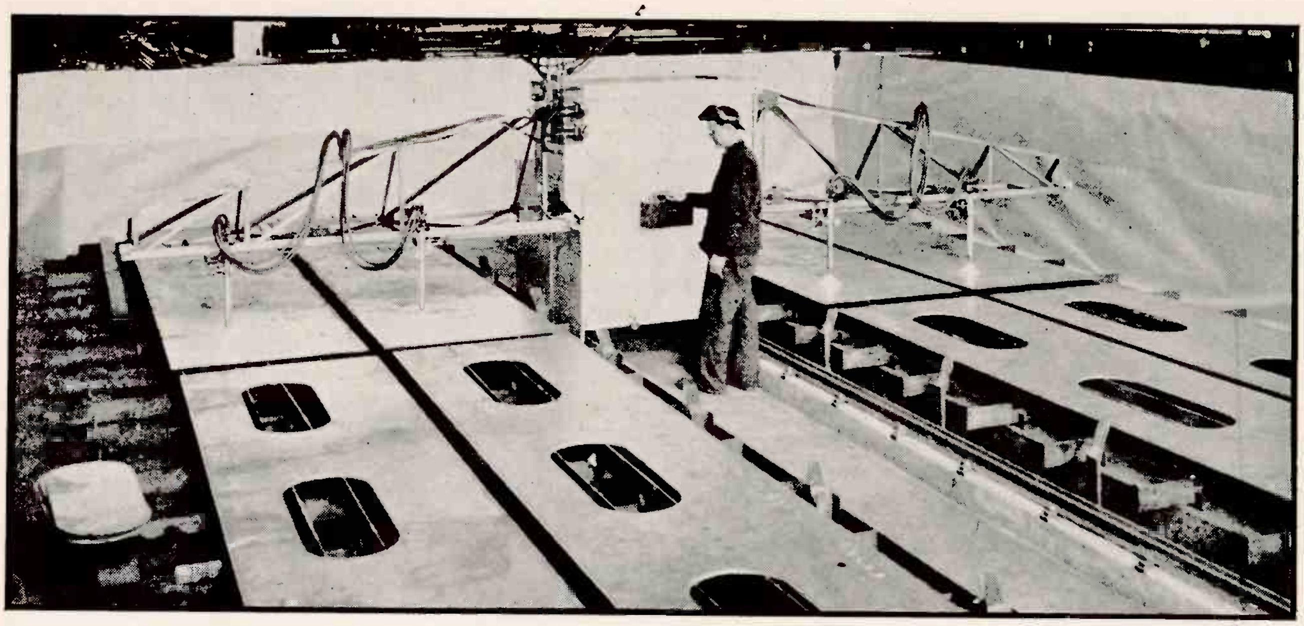


FIG. 5—Remote control system for WINX booster transmitter, using four pairs of standard telephone lines. Relay 4 connects line 4 to the high side of the overload relay in the filament center-tap of the final stage



Four-torch electronically positioned flame cutter being used to cut weight-reducing holes in girder frame members for a rayon spinning machine. The torches have already completed cutting of the four pieces in the foreground, and have accurately trimmed all four edges of the pieces about to be perforated

Phototube-Controlled

Electronic control makes possible accurate oxyacetylene cutting of large steel sheets on a mass-production basis, using photoelectric scanning of small master drums in place of conventional contour tracing of costly full-size master patterns

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AUTOMATIC control in oxyacetylene flame cutting of steel shapes on a mass-production basis is achieved with the ISC flame cutter by using electronic control. The flame cutter has been in continued use in shipyards and machine fabrication plants for over three years. The system utilizes photoelectric control in a unique manner that eliminates the follower or outline-tracer requiring full-size templates.

Templates for flame cutting by commercially developed follower or manual tracer systems are full size, some being more than seven feet wide and thirty feet long. Fabricating, repairing and storing such templates is quite expensive and requires a great deal of floor space.

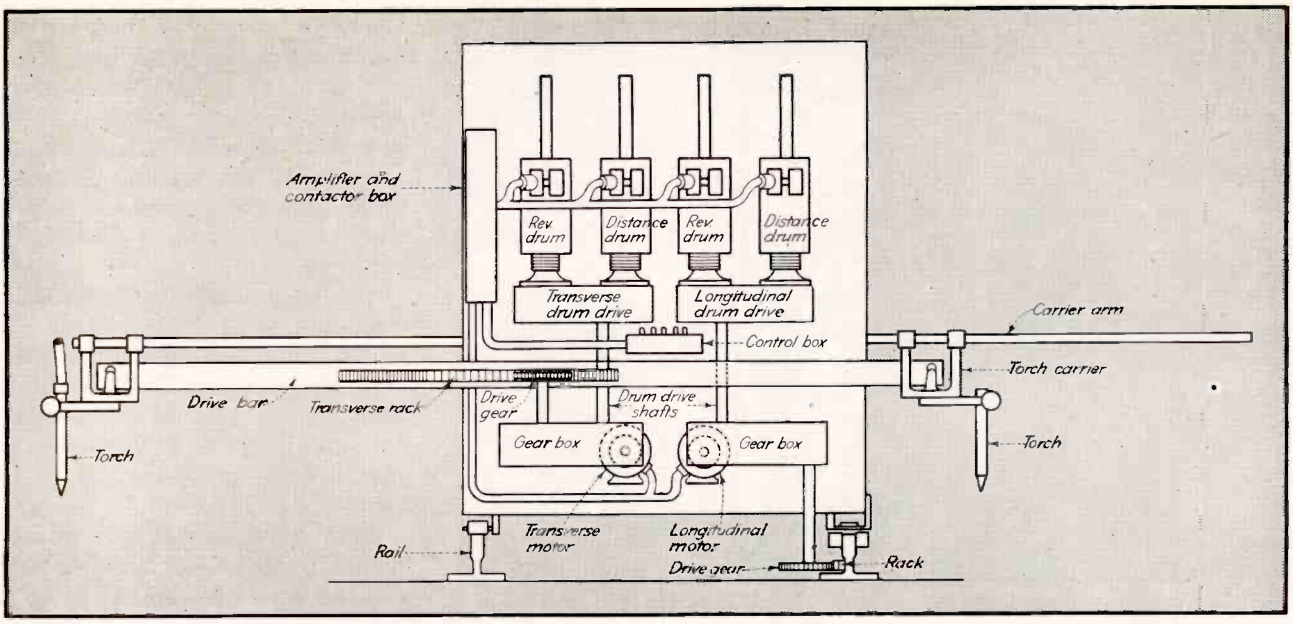
Four Drums Guide Cutters

The outline to be cut by the electronic flame cutter is determined by markings or reflecting spots on four black Bakelite drums, shown in Fig. 1. Two of the drums control the action of the longitudinal drive motor, and the other two control the transverse drive motor. One set of four drums has sufficient space for controlling the actions of the machine to between 100 and 200 lineal feet of cut. The available cutting length on one set of drums may be used to make up the control for one large piece to be cut, or for several smaller shapes. The changeover from cutting one shape to another on the same drum is accomplished by setting the drums manually so that the phototube scans the proper section of the drum.

Changing record drum sets is simple. Each drum is set-screwed to its holder. Unloosening the set screws allows the drums to be removed and the new set to be placed on the holders. Drums do not wear out, as scanning with a light beam eliminates any surface wear on the records. The drums are lightweight paper-base phenolic cylinders with a dull black surface.

Operating Principle

The method of operation is based on the resolution of any shape into its Cartesian coordinates. Considering longitudinal cuts as being along the Y axis and transverse cuts as being along the X axis, any cut along a diagonal is determined by its projection on both the X and Y axes. Longitudinal movements are controlled by one distance drum



Sketch showing relationship of major elements of the flame cutter. Additional torches may be added, for simultaneous cutting of four or more pieces. On large, intricate shapes requiring high accuracy, it has been found economical to prepare master drums for production runs as small as 12 pieces

Flame Cutter

and one reversal drum, and transverse movements are controlled by the other two drums. As an illustration of how the drums control the movement of the cutting torches, when the two longitudinal drums are black the torches may be moving longitudinally in one direction and cutting a straight line. Arrival of the scanner at a white dot on the longitudinal distance drum stops the longitudinal drive motor and starts the transverse drive motor. Now if the scanner on the transverse distance drum reaches a white dot soon, the transverse motor stops and the longitudinal motor starts again in the same direction as before. Repetition of this process at equal very short intervals gives a zig-zag torch motion corresponding to a cut on a straight line at 45 degrees, while unequal and varying intervals produce torch motion along curves. Arrival of either of the reversal scanners at a white area causes the corresponding motor to travel in the reverse direction thereafter.

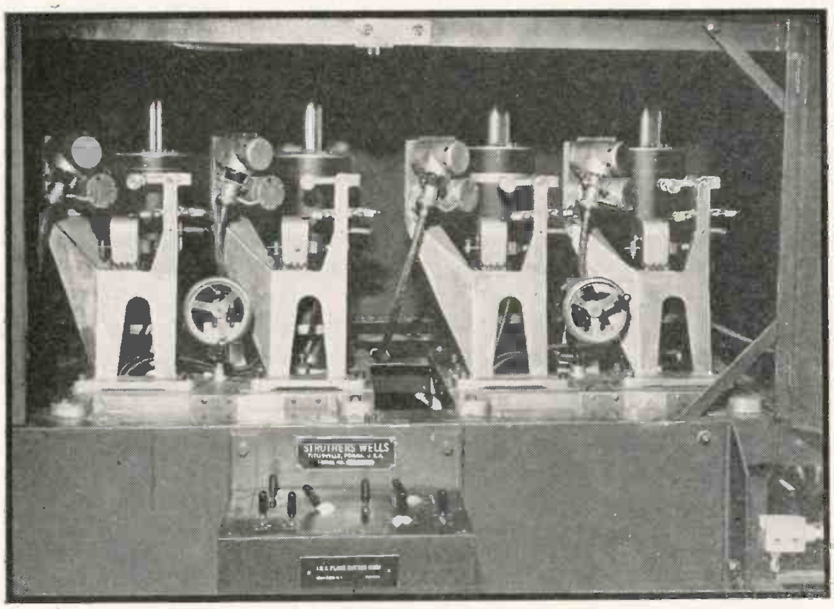
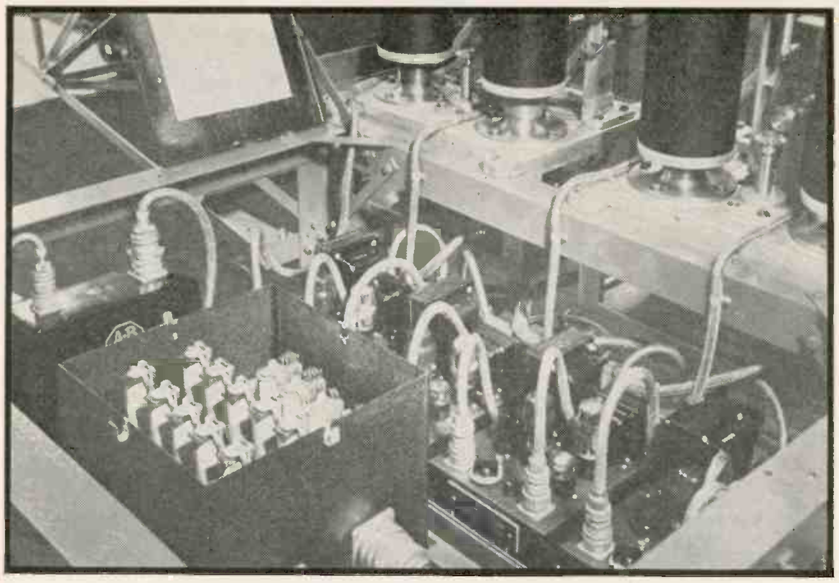


FIG. 1—Control drums and scanning heads of the flame cutter. Longitudinal and transverse travel drums have many white reflecting dots in this setup, for cutting curved objects. The drive motors may start and stop as often as 100 times per minute. The two reversing drums have relatively large alternate areas of black and white

All four drums are inscribed simultaneously with jeweled styli by a step-by-step process while the scribing machine is tracing a sample of the finished product, and the controlling markings are later filled in with white ink to make them light-reflecting. In describing a curve or diagonal cut, intervals are taken to most nearly approximate the instantaneous slope. In tracing curves, the intervals may be



View of the four amplifiers and the relay box, with master drums in background

very small in order to follow faithfully the instantaneous slope, while in straight-line cuts the interval may be of any desired length.

Scanning Apparatus

The photoelectric pickup units are in cast aluminum housings. Each exciter lamp and its associated optical system projects a small spot of light on its drum. The reflecting surface allows a large part of the incident light to be reflected onto the cathode of the phototube. The system employs accurately ground lenses in both projector and pickup units so that there is in practice no interference from stray light.

Control impulses from the four scanners go through low-capacitance cables to four amplifiers which are of the direct-coupled type, as the machine must operate equally well at very low speeds and at speeds in excess of 24 inches per minute. Control frequencies range from zero to 100 square-wave cycles per second.

Amplifier Circuit

Each amplifier circuit utilizes a 921 phototube feeding into a 6SJ7 amplifier which in turn is directly coupled to a 6V6 output tube driving a telephone-type d-c plug-in relay, as shown in Fig. 2. One type 80 and one type 6H6 form the power supply. Line voltage regulation is provided to minimize variations in supply voltage. The 921 phototube has its cathode grounded, necessitating an additional voltage supply. The few extra components needed for the additional supply are more than justified by the higher frequency response due to comparatively low anode-ground capacitance. Polarizing voltage on the phototube and plate voltage of the 6SJ7 are both 80 volts. This value is well under the ionization potential of the gaseous type cell, insuring fairly constant response with the wide variations in cell temperature. The low plate voltage also achieves good voltage sensitivity on the 6SJ7; a very small negative grid voltage will completely cut off the tube.

The 6SJ7 actually operates very near to zero bias with no light on the phototube, with potentiometer R_4 taking care of variations in dark current when replacing the phototube. Thus, when no light falls on the phototube there is minimum bias on the 6SJ7 and maximum current flows in the first amplifier plate circuit. Light falling on the phototube anode decreases its internal resistance, allowing more current to flow, and produces a voltage drop in resistor R_1 which is both phototube load resistor and amplifier grid resistor. The resultant negative bias cuts off the 6SJ7.

The sharp cutoff characteristic of the 6SJ7 and the low plate operating voltage together allow considerable latitude in bias for cutoff. Since the amplifier serves as a sensitive switch with no linear response necessary between output and input, wide variations are permissible in bias setting, phototube sensitivity, line voltage and exciter-lamp output without influencing performance.

The plate current of the 6SJ7 is thus seen to be always either zero or the value corresponding to zero bias for load resistor R_2, which is also the grid resistor for the 6V6. In controlling the 6V6, overswinging the grid insures stable operation.

If the phototube is dark, current flows in the 6SJ7 plate circuit, causing a voltage drop in R_2 which in turn cuts off the 6V6. Conversely, when light is incident on the phototube, the 6SJ7 is cut off and the plate current of the 6V6 is determined by the plate voltage and the resistance of the relay coil. A 10,000-ohm resistance value for R_3 limits voltage surges when the magnetic field of the relay collapses.

Power Supplies

The direct-coupled amplifier as described above has very good square-wave response, with the upper frequency limit determined principally by the inductance of the relay used in the output circuit. Well-filtered power supplies are necessary to achieve both the fast action required of the relay and the high sensitivity of the pickup.

The power supply for the output tube is a conventional full-wave rectifier feeding into an L-type filter. The other two power supplies in each amplifier are designed to take advantage of the low power drain required. A 6H6 is used in conjunction with a center-tapped winding on the power transformer to provide two independent, equal half-wave rectified voltages in series. Each voltage source has a filter comprising a 10,000-ohm resistor and two 8-μf capacitors. Total bleeder current, including capacitor leakage, is over 3 ma, while the 921 phototube requires only a few microamperes and the 6SJ7 a little over 1 ma. Resistor-capacitor filtering provides cheap, compact and dependable filtering in these ranges.

All amplifiers are interchangeable so that one spare amplifier is all that is needed to assure continued operation should any one of the four amplifiers in the machine become inoperative. Unplugging the two AN connectors of an amplifier allows it to be removed for inspection and the spare amplifier assures that there is no holdup in production. The power supply for all four amplifiers is so inter-connected that none will operate unless all four are plugged in.

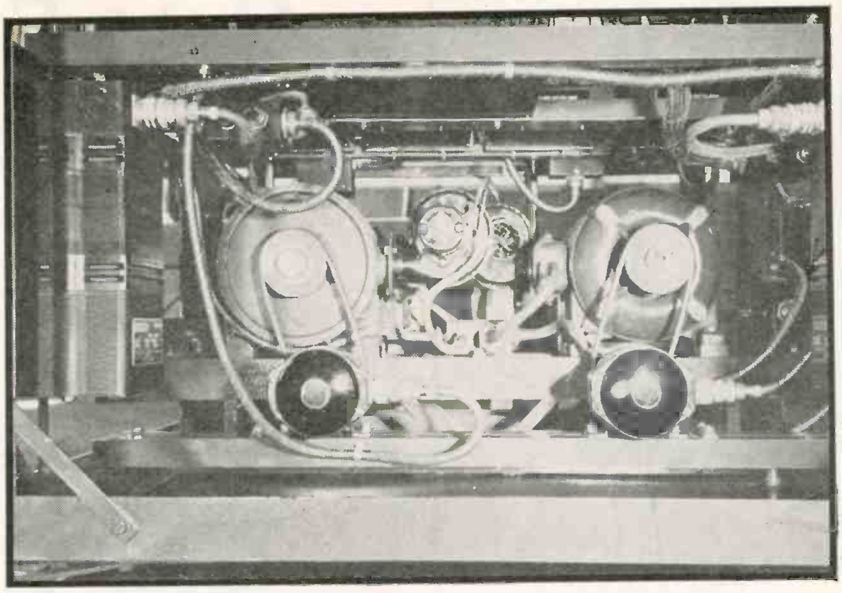
The control impulses of the four d-c relays actuate the a-c telephone-type relays and their associated contactors in such a way that the required sequence of operations of the motors is achieved.

The final drive is through two specially designed three-quarter horsepower three-phase induction motors capable of making more than a hundred stops and starts a minute. Positive stopping without overtravel is assured by the use of plugging switches. The drive motors are coupled directly to the record drums and to the longitudinal and transverse racks so that the record drums always rotate in synchronism with the movements of the torches.

The torches travel in a transverse direction along arms projecting from the machine. Longitudinal travel of the torches is achieved by moving the entire machine on its rails.

The operator can position the torches electrically through lever switches provided. There is an interlock which cuts out all automatic functions while positioning.

When the torches are all lined up and the work preheated, the operator flips the lever to automatic operation. He need not touch the control box again until the entire piece has been cut, at which time he presses the stop lever. During all the intervening time he may give his full attention to the torches, regulating them so that the best cut is achieved. Up to sixteen torches may be used. Stoppages from torches blowing out are reduced not only because the operator can give them his full attention but also because of the uniform speed of cut.



Transverse and longitudinal driving motors. The voltage-regulating transformer at the left serves the a-c contactors and the amplifiers

Maintenance is Simplified

Operation under mill conditions has proved the advantages of plug-in components, not only in reducing outage time but in the ability of plant men, unskilled in electronics or electrical controls, to make replacements themselves. It is no more difficult for them to replace a defective amplifier or relay than to change tubes in a radio.

The flame cutter has proven itself in operation to have many advantages over machines doing comparable work. It produces at least four times as much in cutting any given shape in comparison with other machines. Accuracy of cut is unequaled by any other method, as every movement, even to the smallest increment, is positively controlled. Operator fatigue is reduced to a minimum. Finally, electronic control gives a wear-free, unchanging record.

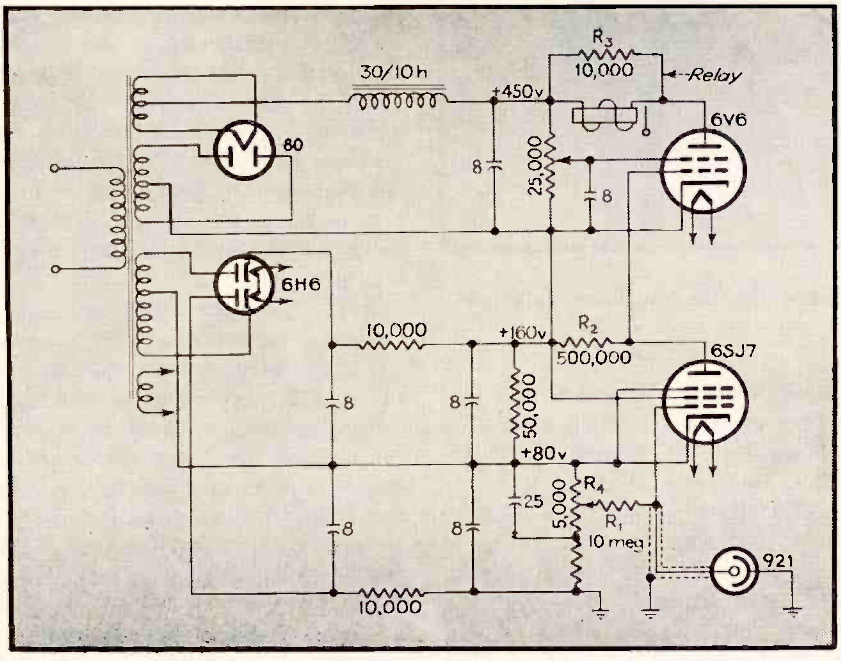
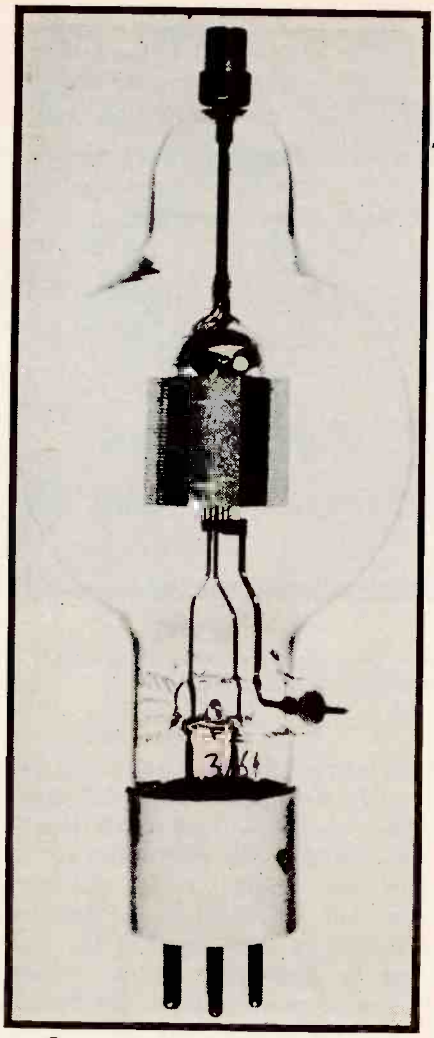
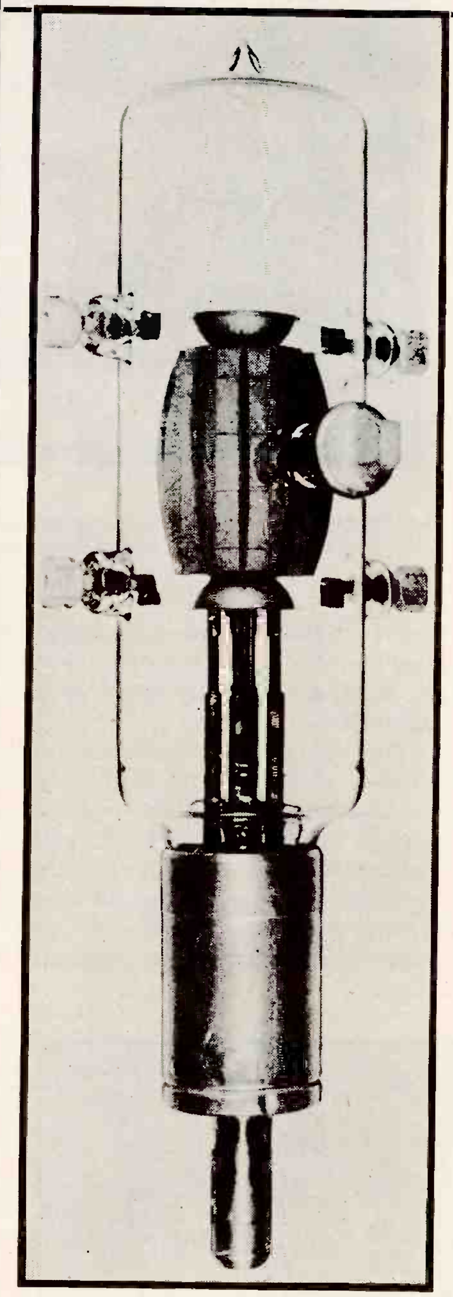


FIG. 2—Schematic circuit diagram of amplifier serving the phototube of one of the drums. All four amplifiers are identical. The output relay controls other contactors in the driving motor circuits

Grid Emission in



Eimac type 100T tube used as a guinea pig in many of the tests discussed here



Type 527 tube, employing an X-grid

THIS ARTICLE deals with the problem of electron emission from the control grid in a high-vacuum triode having a thoriated-tungsten filament. The specific type of cathode employed is early mentioned, because emission from the grid is directly tied up with the nature of the active material on the cathode. The remedy for grid emission in a tube having a thoriated filament, for example, is not necessarily the answer to grid emission troubles in a tube containing an oxide-coated cathode.

In its broader aspects the question involves the suppression of emission from an electrode whose normal function is best performed by selective emission, or no emission at all. The term selective emission is advisedly used because there can be two distinct kinds of emission from a grid: primary emission and secondary emission. Much confusion has resulted by failure to distinguish between these, and to identify their causes and effects. Since electrons leave the grid by both primary and secondary mechanisms, like effects under certain conditions would naturally be expected. That the effects are not always the same has led to one cause being mistaken for the other in a great many cases.

The primary electrons about which we are concerned are those emitted by reason of the fact that the grid runs at an elevated temperature; in other words, thermionic emission from grid. Grid heating in a power triode is caused by electron bombardment of the grid during its positive excursions, and also by thermal radiation from the filament and plate. Since primary emission from the grid is a function of grid temperature, such primary electrons as are emitted leave the grid continuously during operation of the tube. As with other continuous processes based on temperature, the effects are cumulative. This matter of continuity of emission is worth keeping in mind while distinguishing between primary and secondary emission from a grid. Mouromtseff and Kozanowski[1] describe a simple circuit for measuring primary emission.

Primary and Secondary Emission Effects

By definition, secondary electrons are those released from the grid under the impact of electrons originating from another source, such as the filament. Since the grid is bombarded when positive with respect to the filament, secondary emission occurs only during the positive half-cycle of the grid driving-voltage. Being a discontinuous process, the direct effects of secondary emission are not cumulative.

Both primary and secondary emission reduce the grid current when power tubes are operated in the positive-grid region, and may cause the grid current to reverse its normal direction of flow. In grid-leak bias circuits this results in a loss of bias, accompanied by increased plate current. The primary component of grid emission is the bad actor in this case, because a vicious circle is started. The increased plate current causes increased plate temperature, which in turn raises the grid temperature,

Vacuum Tubes

Causes and effects of primary and secondary emission are discussed. Emission photographs of various materials, taken with an electron microscope, are presented. Tests which resulted in the development of a special grid are described

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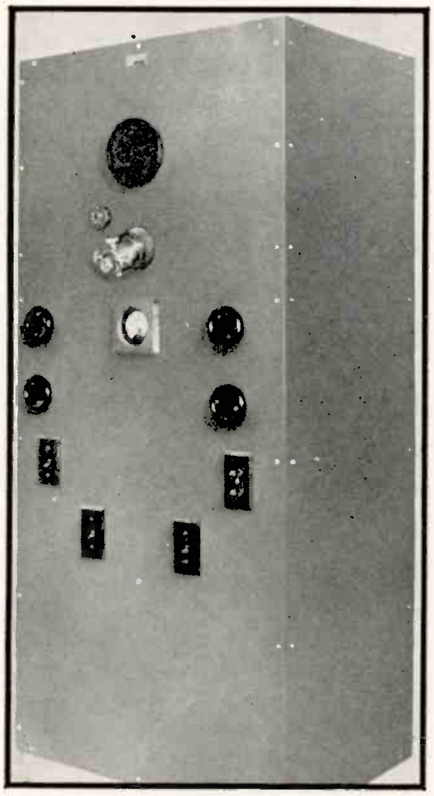

FIG. 1—Special electron-microscope developed to take emission photographs. The instrument is shown schematically in Fig. 2

causing further increase in primary emission from the grid. The effect is cumulative, and once the grid current starts to drop the grid may lose control, allowing the tube to run away.

The effects of secondary grid-emission are less obvious. Secondary electrons are emitted by reason of electron bombardment from the filament, which occurs only during the positive half-cycle of the grid driving-voltage. The effects are not cumulative and, if primary emission is under control, can be beneficial because the grid current is reduced and hence the grid driving-power lowered. This apparent something-for-nothing is frequently accompanied by instability of operation, however, the tendency toward dynatron-type parasitic oscillation being enhanced. The effects of secondary emission from a control grid may be summed up by saying that secondary electrons are beneficial if moderate, but can lead to instability if excessive. For practical purposes the ideal control-grid is one which exhibits no primary emission and negligible secondary emission.

Metallurgy Provides the Key

Several years ago it was recognized that unless a solution could be found for the grid-emission problem, a serious barrier stood in the path of power-tube development, where grid temperature is an important factor. While experimenting with high-vacuum tubes having thoriated-tungsten filaments and grids of refractory metals, such as tantalum and molybdenum, it was observed that primary grid-emission was materially increased by activation of the grid with thorium sputtered or otherwise deposited from the filament. After a period of operation these tubes were found to contain not only a thoriated filament but also a thoriumized grid. So activated, the grid developed primary emission.

A reverse phenomenon was also occasionally observed in the case of the filament. Some sort of contamination was reaching the filament, killing its emission. This was interesting. If something would poison the emission of a thoriated filament, why would't the same thing be good for the unhappily thoriumized-grid? With this key the search went on, resulting in the perfection of what is now known as the X-grid. Initial development work was done by Wil-

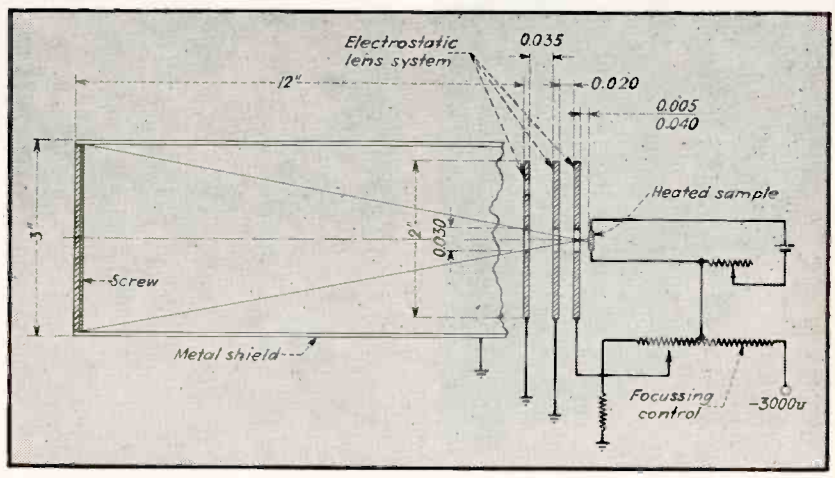

FIG. 2—Schematic of the special electron microscope pictured in Fig. 1

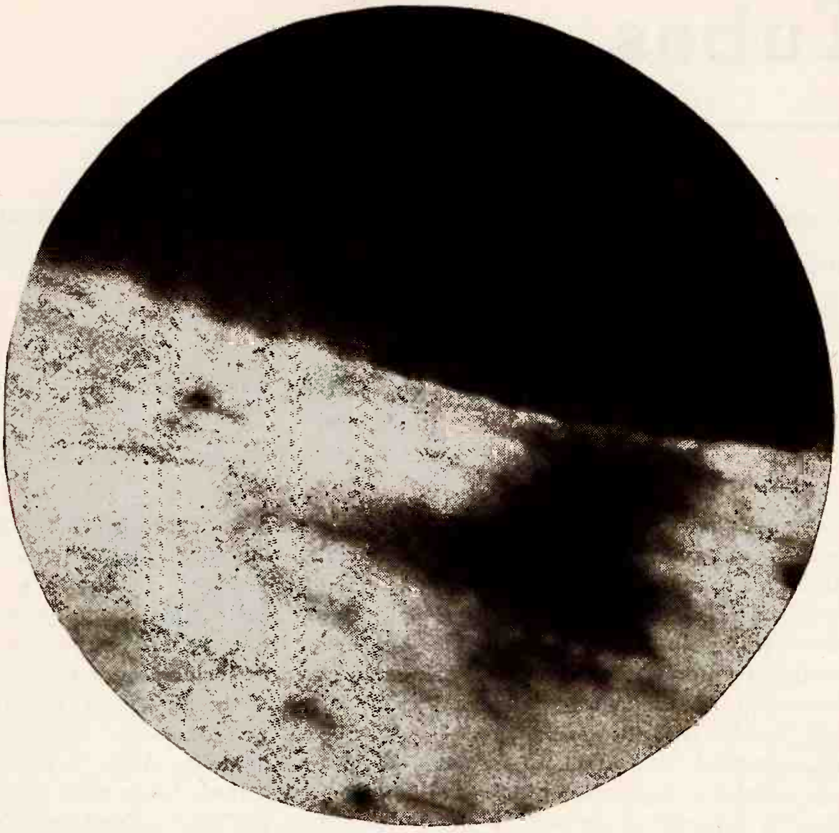

FIG. 3—Emission photograph of thoriated tungsten, taken at 1300 deg C. In this instance an edge of the sample was photographed, so that emission streamers are visible

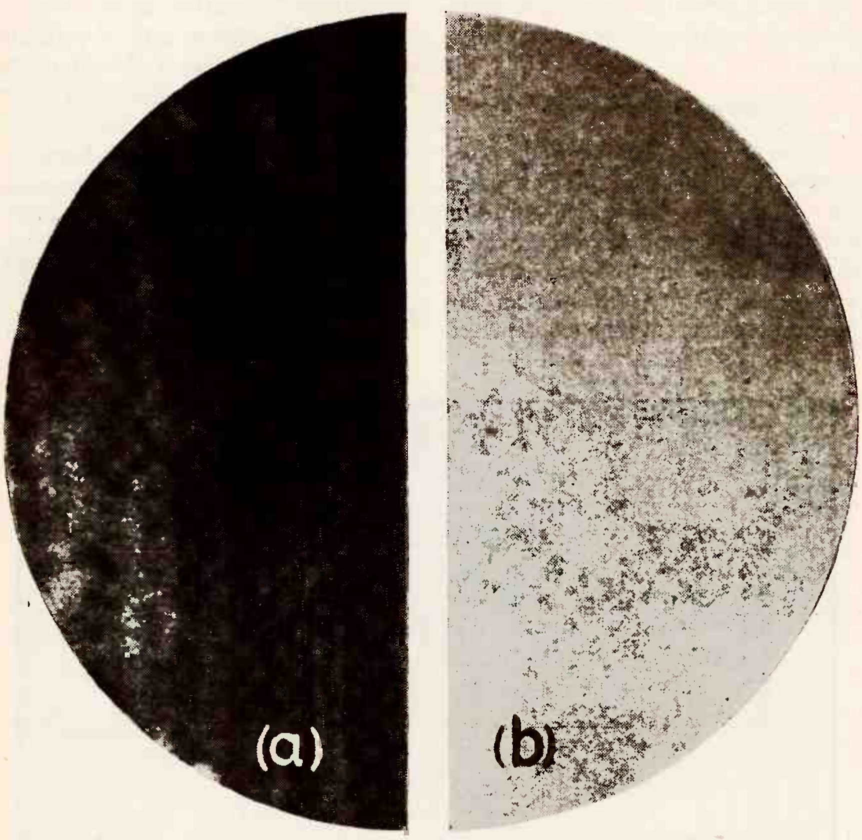

FIG. 4—(a) Emission photograph of pure tantalum, taken at 1500 deg C, and (b) at 1700 deg C. Half-photographs are shown adjacent to each other to conserve space and facilitate comparison

liam W. Eitel and Jack A. McCullough. While the X-grid was developed principally to overcome primary emission, it fortunately also exhibits a low order of secondary emission.

During the course of the investigation the emission properties of numerous metals other than tantalum and molybdenum were studied. Platinum has unique properties and deserves special mention. If properly handled in tube manufacture a platinum grid will exhibit little or no primary emission during subsequent life of the tube. Resistance of platinum to activation by thorium is apparently due to an absorption phenomenon. The principal disadvantages of platinum, aside from the element of cost, are its relatively low melting-point, its poor mechanical strength compared to the more refractory metals, and its relatively high secondary-emission properties.

Special Electron Microscope Used

Much of the subject work on grid emission was done with the aid of a special electron-microscope. Figure 1 shows a photograph of the complete unit and Fig. 2 is a diagrammatic view of the essential parts. This unit provides means for visual examination of electron emission from any desired metal, and the effects of contaminants thereon, at any desired temperature. For example, a specimen containing thorium can be mounted adjacent to a specimen of grid material, and the latter contaminated with thorium vaporized from the former. The emission properties of the contaminated grid material may then be studied. Emission patterns are directly observed on the screen. For later study and record purposes, photographs and even moving pictures can be taken of the specimens.

A series of emission photographs taken with the electron microscope are illustrated. (*Ed. Note:* All emission photographs reproduced here were originally taken at a magnification of 125. As reproduced, however, they represent a magnification of about 100.)

Figure 3 shows the emission pattern of ordinary thoriated tungsten. This photograph is included here merely because thoriated tungsten is a familiar type of emitter material and serves as a reference for comparison purposes. The photograph was taken with the specimen at 1300 deg C; all temperatures herein being brightness temperatures as indicated by an optical pyrometer. The light areas in the photograph are the actual traces produced on the screen by primary-electrons emitted from the sample, the darker areas indicating a lack of emission. This particular photograph happens to show an edge of the specimen, and the streamers present constitute electron emission from the edge.

Figures 4 (a) and 4 (b) show emission patterns of the surface of pure tantalum at 1500 deg C and 1700 deg C, respectively. Figures 5 (a) and 5 (b) show similar patterns of pure molybdenum at like temperatures. It is evident that tantalum exhibits somewhat higher primary emission than does molybdenum at a corresponding temperature. The pronounced increase in emission from both metals, for an increase of 200 deg C in the temperature region indicated, is worth noting.

Figure 6 shows the emission pattern of a sample of tantalum contaminated with thorium at 1400 deg C, the streamers visible being from an edge of the sample. The tremendous increase in primary emission seen in comparison with Fig. 4 (a) explains why a tantalum grid used with a thoriated filament often causes a tube to run away during operation. Molybdenum exhibits a similar increase in primary emission upon contamination with thorium. Curves in Fig. 7 illustrate the effects of this contamination in a tube.

Figure 8 shows the emission pattern at 1700 deg C of the surface of a sample of tantalum partially treated by the X-process. The lighter area at the left in the photograph constitutes the emission from the pure tantalum, and the darker area at the right indicates the absence of emission from the treated portion of the sample. Since the X-processed material is seen to have a lower order of primary or thermionic emission than either tantalum or molybdenum, one would expect it to have

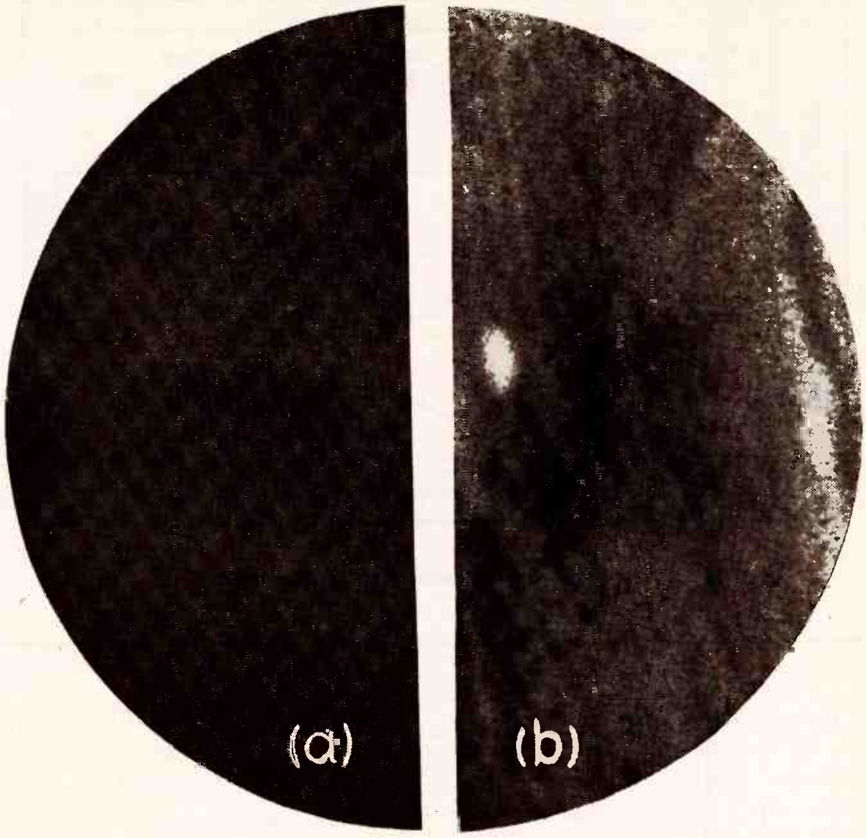

FIG. 5—(a) Emission photograph of pure molybdenum, taken at 1500 deg C, and (b) at 1700 deg C

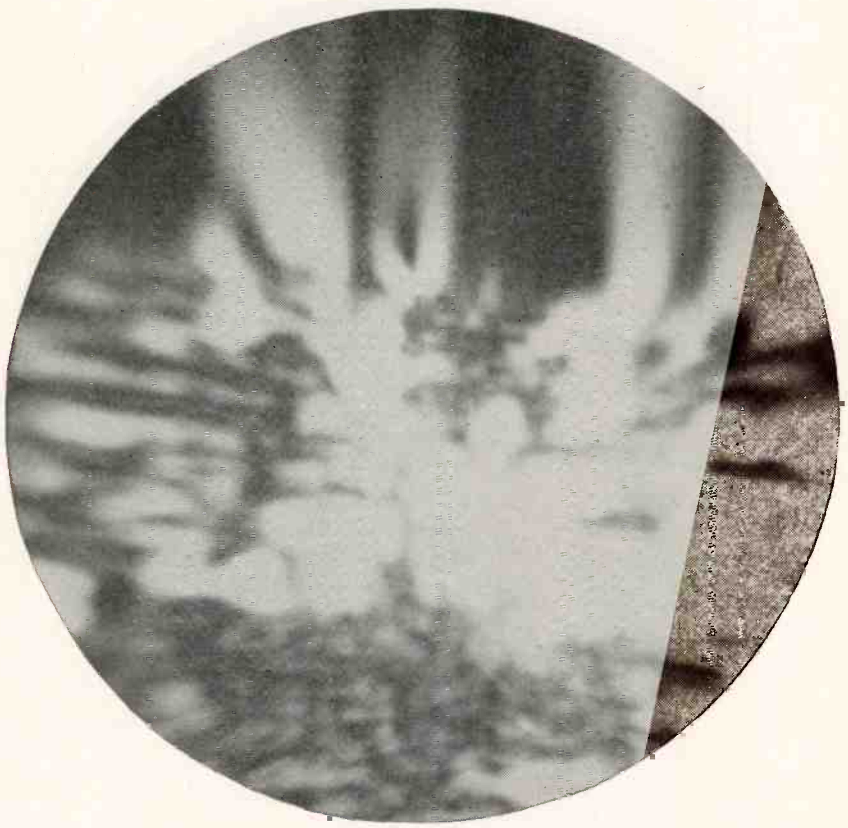

FIG. 6—Emission photograph of tantalum contaminated by thorium, taken at 1400 deg C. The edge of the sample was photographed so emission streamers may be seen

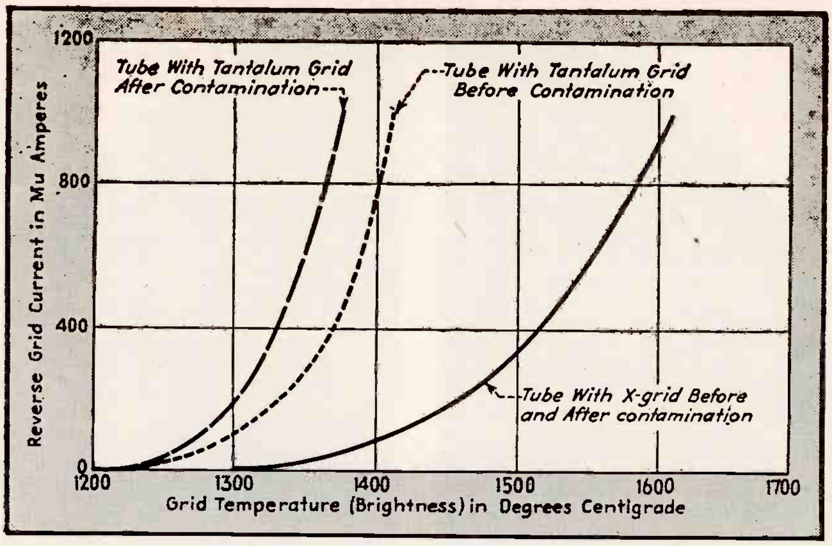

FIG. 7—Primary emission grid characteristics

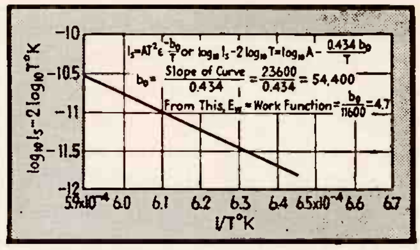

FIG. 9—Emission from a tantalum grid

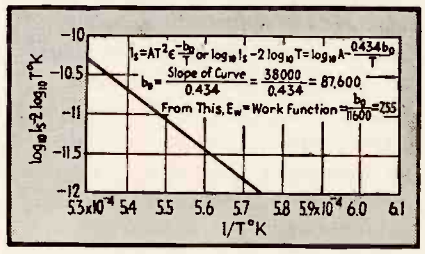

FIG. 10—Primary emission from an X grid

a higher work-function. Such is the case. Figure 9 is a plot of primary emission from tantalum, from which a work function of 4.7 is derived. This value compares favorably with that previously determined by others. A similar plot is illustrated in Fig. 10 for the X-grid material, from which a work function of 7.55 is derived.

Test Results

It is now interesting to observe what happens when the X-grid is contaminated with thorium. Figures 11 (a) and 11 (b) show emission patterns of the surface of X-grid material so contaminated, taken at 1700 deg C and 1900 deg C, respectively. These evidence a negligible increase in primary emission as compared with the pronounced increase exhibited in the case of contaminated tantalum. The ability of the X-grid to render thorium inactive is responsible for this improvement.

The solid-line curve in Fig. 7 shows that contamination of an X-grid in a tube does not increase its primary emission properties. By comparison with the dashed-line curve it will be observed that if 500 μa is taken as a safe value of primary emission, a tantalum grid must be operated at a grid temperature under 1350 deg C whereas an X-grid may be operated in excess of 1500 deg C. A more striking difference will be noted at a grid temperature of 1350 deg C, where the tube with the X-grid has a reverse grid current of nearly zero, while that with a contaminated tantalum grid exhibits a reverse grid-current of about 600 μa at the same temperature.

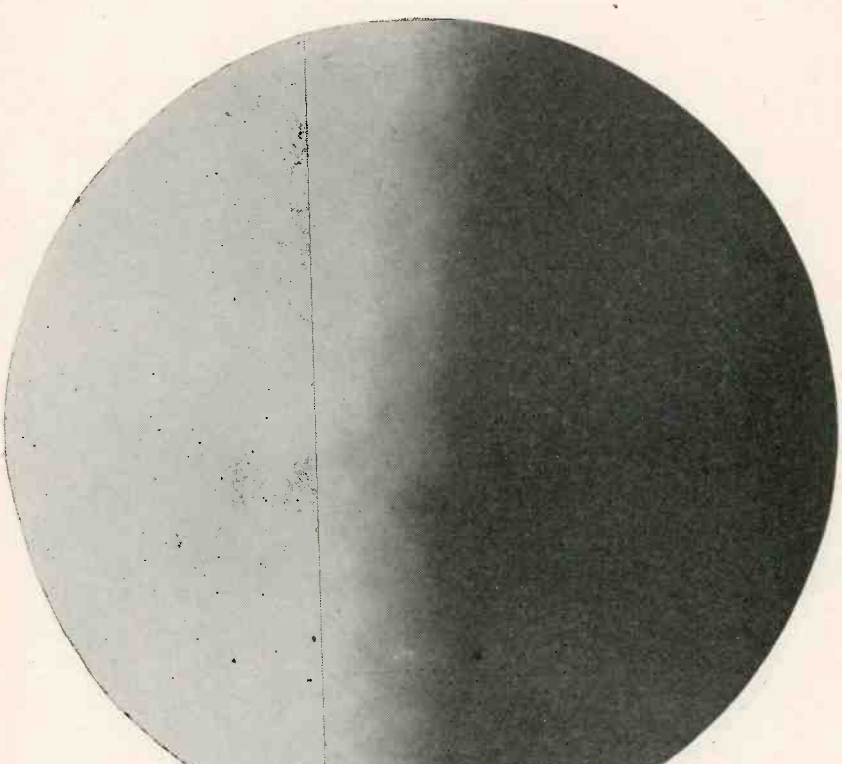

FIG. 8—Emission photograph of tantalum partially treated by X-process, taken at 1700 deg C. The left side shows the greater emission from the untreated portion, while the right side shows the reduced emission from the treated portion

The secondary emission properties of the X-grid, compared to platinum for example, are illustrated by curves in Fig. 12, these curves being taken on two tubes having identical geometry. The

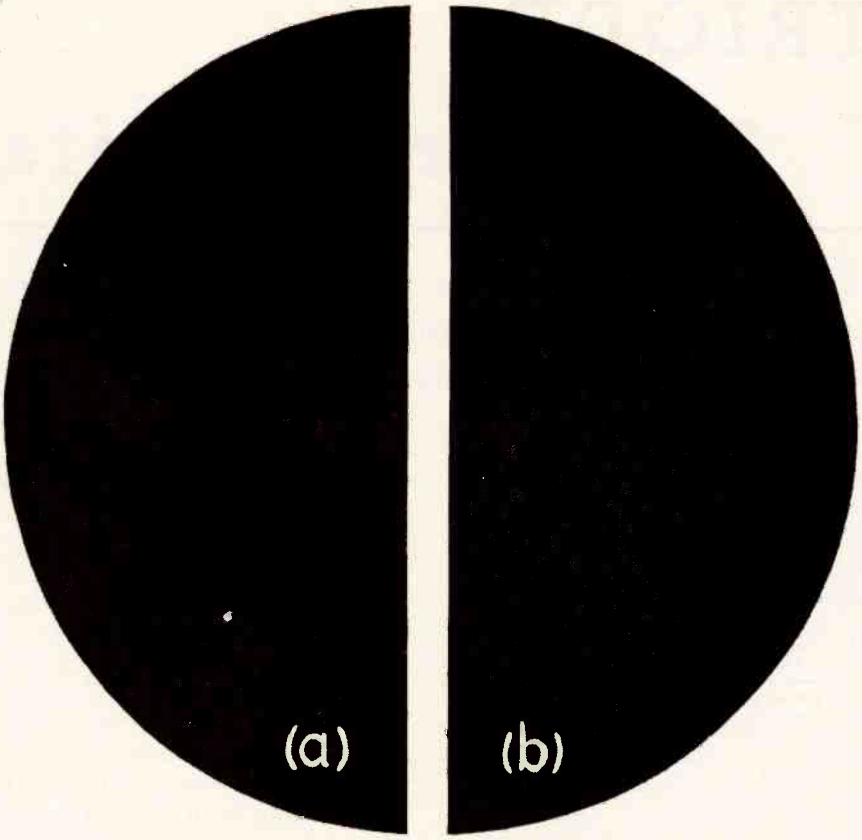

FIG. 11—(a) Emission photograph of X-processed material contaminated with thorium, taken at 1700 deg C, and (b) at 1900 deg C

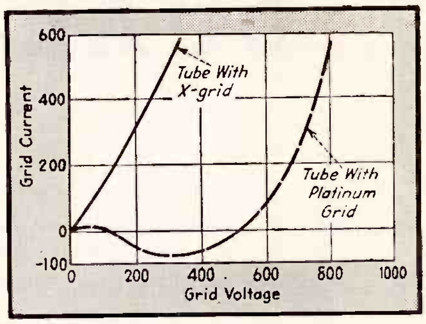

FIG. 12—Secondary emission characteristics, both tubes under test having identical geometry and operating with 2500 volts on their plates

higher order of secondary emission for platinum is indicated by lower values of grid current, which, for certain values of grid voltage in the tube used, actually become negative. Secondary emission shows up in constant-current charts as loops in the grid current lines. Figure 13 is a chart of a tube having a platinum grid. This can be compared with the chart in Fig. 14 on a tube of identical geometry, but having an X-grid, showing the absence of such loops in the grid-current lines.

It is apparent that operation along a load line passing through the region of negative values of grid current would give a distorted wave of grid current, sufficient to cause instability and parasitic oscillations.

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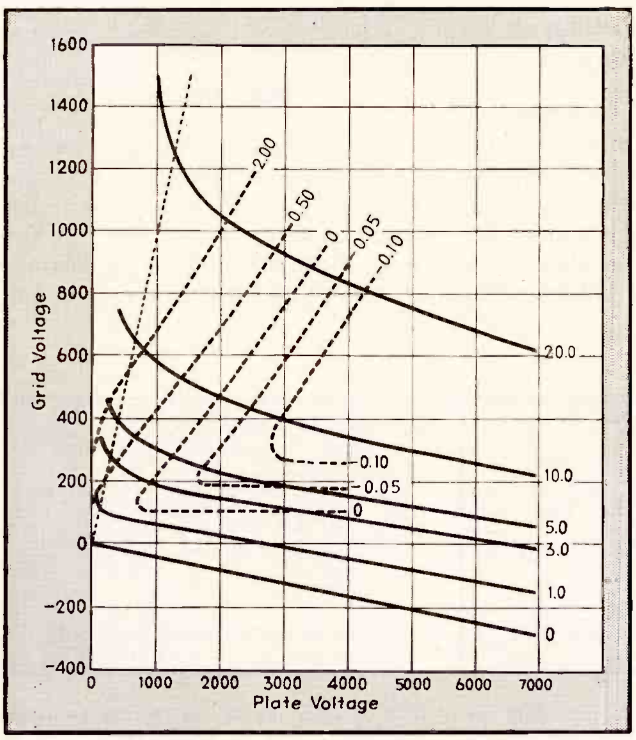

FIG. 13—Constant-current characteristics of a tube with a platinum grid. Solid-line curves represent plate current in amp; dashed-line curves represent grid current in amp

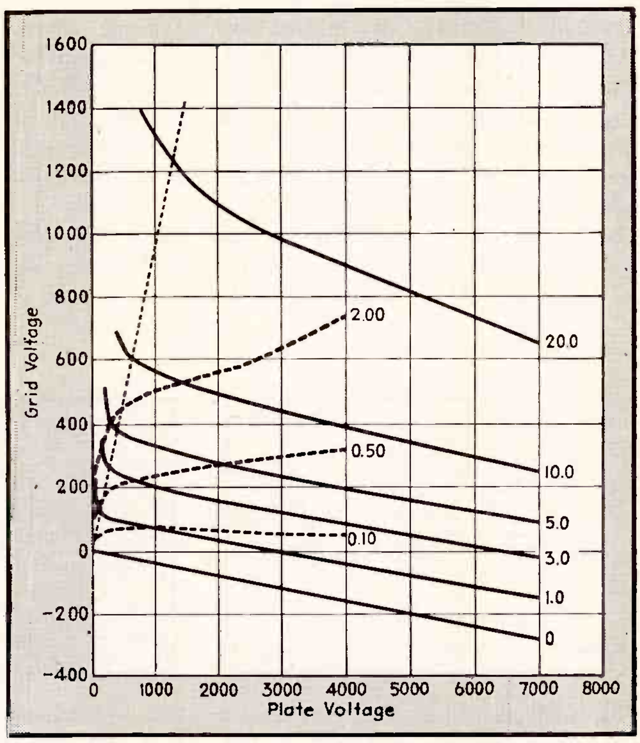

FIG. 14—Constant current characteristics of a tube with an X-grid. Solid-line curves represent plate current in amperes, while dashed-line curves represent grid current in amperes

DUAL-TRIODE Trigger Circuits

Non-mathematical step-by-step description of the operation of the Eccles-Jordan trigger circuit, with practical suggestions for making the circuit distinguish between positive and negative pulses, and other helpful design data

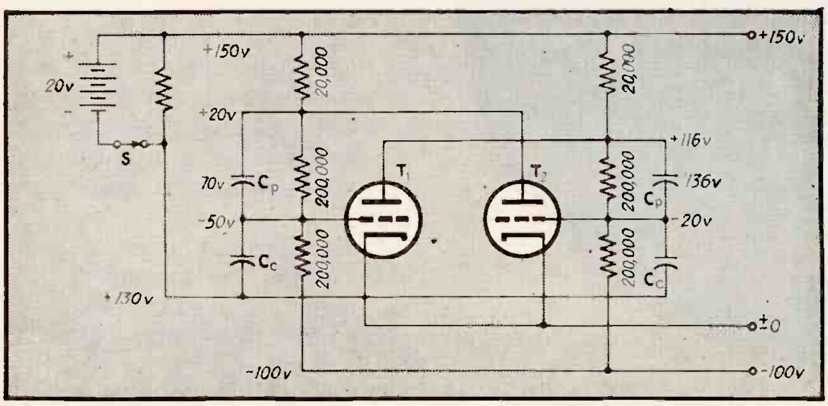

FIG. 1—The basic Eccles-Jordan trigger circuit

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THIS PAPER is an attempt to give a graphical analysis of dual-triode trigger operation. It is hoped that it will clear up several points that apparently have not been too well understood, in particular the very vital function of the grid-to-plate capacitor (C_p in attached sketches) and the ability of the Eccles-Jordan type of triode trigger circuit to distinguish between positive and negative pulses if properly designed.

The dual-triode trigger described here is a device using two triode tubes so interconnected that one tube is normally conducting while the other is non-conducting. A suitable impulse applied at the proper points causes the first tube to become non-conducting and the other to conduct. A second impulse restores the original condition. This cycle may be repeated at will at any speed from zero up to speeds in the low radio-frequency range or even higher, depending on the circuit constants used.

The trigger may be used as a locking circuit, somewhat as a gaseous tube is used. Where it is so used, the circuit may be turned off as fast as it can be turned on, and very little energy is required to make it perform either function. Since two impulses are required to provide a complete trigger cycle, ie., to turn any one tube on and then off, the trigger can also be arranged to give one output impulse for every two input impulses and thus act as a frequency divider.

Basic Principle

Figure 1 shows the basic Eccles-Jordan trigger circuit. The two triodes T_1 and T_2 are so connected that the plate of each controls the grid of the other in such a manner that only one tube can conduct (on)

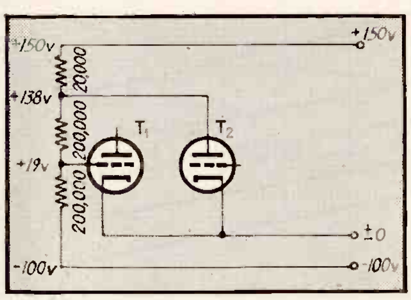

FIG. 2—Assuming that both tubes are initially non-conducting, application of voltage to the resistor network makes the grid of T_1 positive with respect to its cathode and this tube conducts

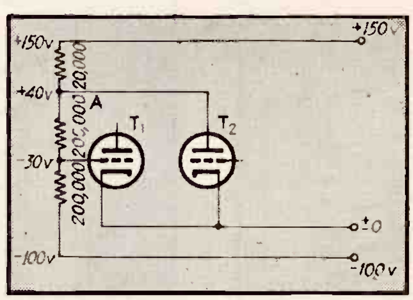

FIG. 3—When tube T_2 is conducting, tube T_1 is negatively biased and does not conduct. The plate of tube T_2 drops to $+40$ volts and point A is held at that potential during this part of the operating cycle

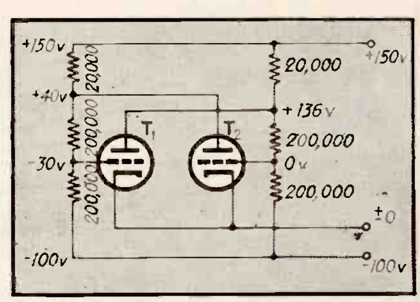

FIG. 4—The use of two resistor networks enables tube T_1 to control tube T_2 in a manner similar the way in which T_2 controls T_1 in Fig. 3. Voltages shown here are those applying when T_2 is conducting

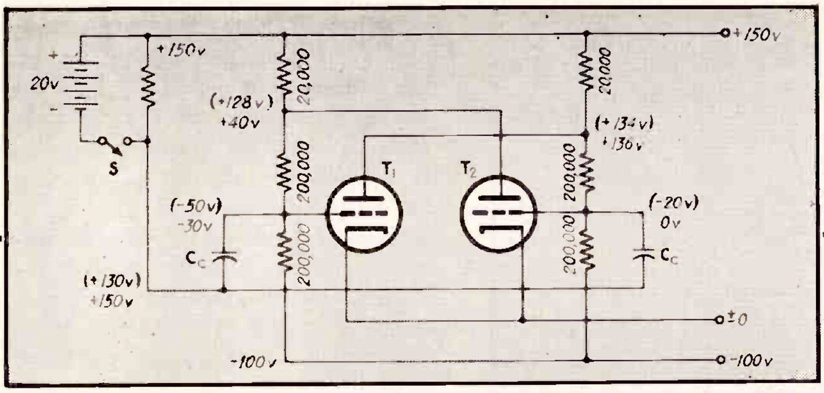

FIG. 5—Coupling capacitors C_c provide a means of temporarily biasing both grids together. This circuit is, however, incapable of reversing on the application of an impulse to both grids. Voltages indicated without parentheses are those applying with T_2 conducting but with switch S open. Voltages in parentheses are those applying at the instant switch S is closed

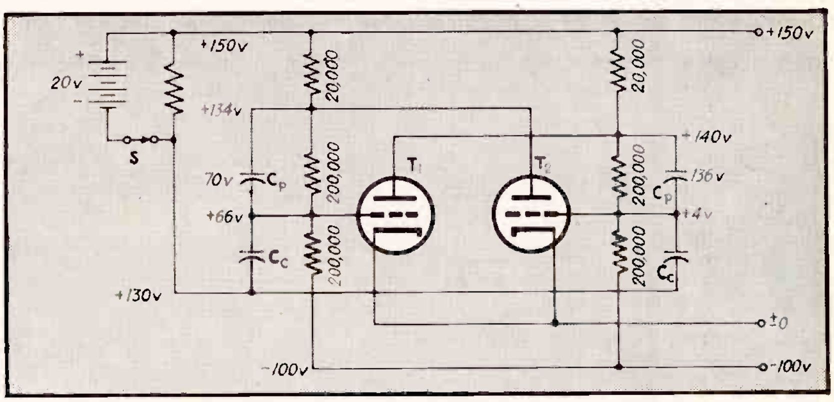

FIG. 7—Addition of capacitors C_p as shown here to the circuit of Fig. 5 makes possible the desired reversing trigger action. Voltages are those applying with T_2 conducting

at a time. The component values shown are merely illustrative and are used to simplify the analysis. However, these values will make a satisfactory trigger for relatively slow-speed operation.

The tubes used are 6J5's or equivalent and may be considered essentially as switches. When the grid of a 6J5 is at the same potential as its cathode the tube is conducting, just like a closed switch except that there is in the circuit illustrated a 40-volt drop between plate and cathode. When the grid is made negative with respect to its cathode by 8 volts or more, the tube is non-conducting and resembles an open switch in that no current can flow between plate and cathode.

Figure 2 shows more clearly how tube T_1 can control tube T_2. With both tubes arbitrarily rendered non-conducting, the voltage at the grid of T_1 is determined by the resistor network shown between the +150-volt line and the −100-volt line. By Kirchhoff's law, the grid of T_1 may be calculated to be 19-volts positive with respect to its cathode, thus turning T_1 on. (Actually, sufficient grid current will normally flow in T_1 to hold its grid down to approximately cathode potential).

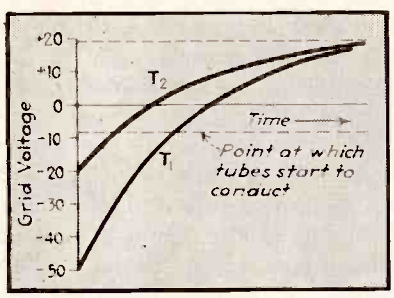

FIG. 6—Calculated grid-voltage rise after switch S of Fig. 5 is closed. Obviously, the grid of tube T_2 will be the first to reach the − 8-volt line, so that T_2 turns on first when an initiating pulse arrives

When tube T_1 is made conducting as shown in Fig. 3, its plate will drop to +40 volts and point A will be held at that potential. Again applying Kirchhoff's law, we find that the grid of T_2 is now 30-volts negative with respect to its cathode and that T_2 is thus held non-conducting by T_1. Connecting the grid of T_1 to the plate of T_2 with a similar network as shown in Fig. 4, will enable T_2 to control T_1 in the same manner, and we have the desired condition in which only one tube can be on at a time.

Circuit Details

Figure 5 shows a means of temporarily biasing-off both grids together through coupling capacitors C_c. Although this circuit has sometimes been shown as the basic Eccles-Jordan trigger circuit, it is fundamentally incapable of reversing on application of an impulse to both grids. The voltage values shown without parentheses are those existing with T_2 conducting and switch S open. Those in parentheses are the instantaneous values obtained when switch S is closed, delivering a 20-volt negative impulse to the grids through capacitors C_c. This 20-volt negative impulse will render both tubes non-conducting. Both grids will immediately start to rise to the resistance-network-limited value of +19 volts, the rate of rise being determined by the time constant of the resistor network and the C_c combination. Since these are the same for each tube, the time constant will be the same for both grids.

The rise of voltage on both grids will be as shown in Fig. 6. Obviously the grid of T_2 will be the first to reach the −8-volt line, which means that T_2 will be turned on first and will hold T_1 off as before. In other words, the trigger has not been reversed. Likewise, a positive pulse will not reverse the trigger since any effect it might have on the non-conducting tube will be

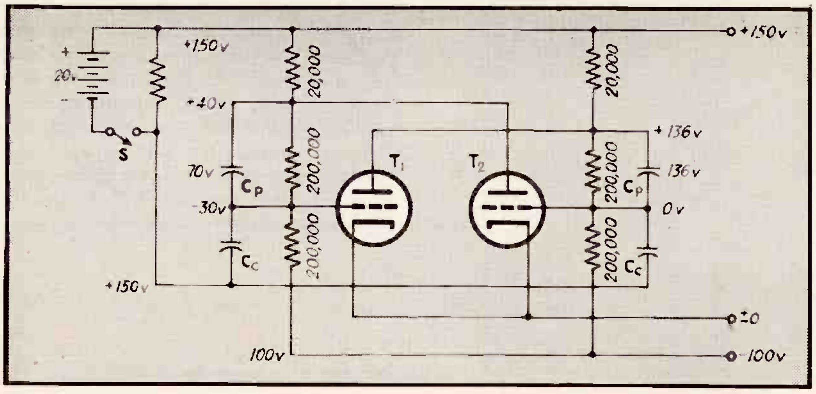

FIG. 8—A 20-volt negative impulse applied to the circuit of Fig. 7 by closing switch S, as shown here, drops instantaneous resistor-network potentials 20 volts

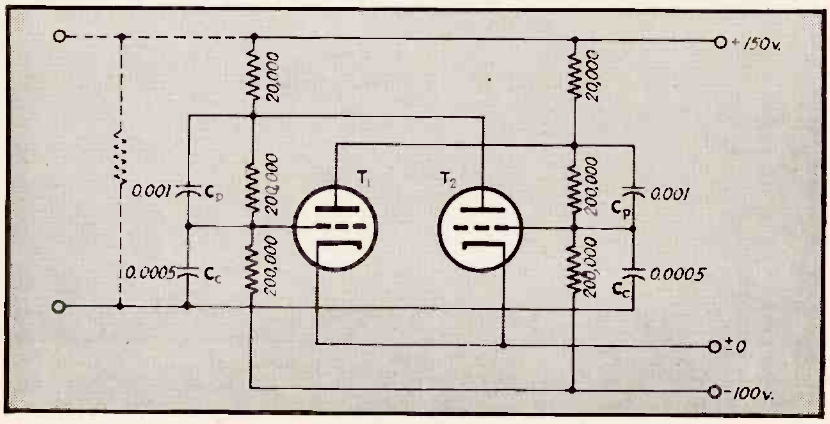

FIG. 9—If both tubes are held non-conducting by some external means, voltages shown in Fig. 8 will rise to these values soon after switch S is closed

offset by a stronger effect on the conducting tube.

It is the addition of the plate-to-grid capacitors C_p that makes possible the desired reversing trigger action. Figure 7 shows the addition of such capacitors to Fig. 5 and the steady-state voltages that exist with T_2 conducting. A 20-volt negative impulse provided by closing switch S will instantly drop all network voltages by 20 volts, as shown in Fig. 8. For simplification, assume that plate-to-grid capacitors C_p are so large in comparison to coupling capacitors C_c that there will be no change of voltage across them in the time required for the smaller coupling-capacitors to reach a steady-state condition. Assuming that the tubes are held non-conducting by some external means, the voltages in Fig. 8 will soon change to those in Fig. 9, with the coupling capacitors C_c in equilibrium. The rise of voltage of the grids will be as shown in Fig. 10.

While these curves might be accurately calculated, they were actually obtained by plotting an ε^{-x} curve between the known limits of grid voltage. Because of the much greater voltage-swing on T_1, caused by the relatively low voltage existing on the grid-to-plate coupling capacitor C_p between it and the plate of T_2, we see that the grid of T_1 (which has been non-conducting) is the first to reach the conducting point of -8 volts. Thus T_1 becomes conducting and blocks off T_2 and the trigger is reversed. The addition of the plate-to-grid capacitors C_p has produced the desired trigger action and the trigger will now reverse itself every time the grids are given a negative impulse.

In drawing Fig. 10, it was assumed that the grid-to-plate capacitors C_p were much larger than the grid capacitors C_c. That this assumption does not alter the general shape of the curves of grid voltage rise is best shown in Fig. 11, which is a sketch of the grid-voltage rise in an actual trigger circuit (as shown in Fig. 1 with $C_p = 2\ C_c$) as viewed on a large cathode-ray oscilloscope.

Originally tube T_2 is conducting and T_1 is held non-conducting by the -30-volt potential on its grid (voltage as shown in Fig. 7). At time T_0 a 20-volt negative impulse is applied to both grids through the coupling capacitors C_c. Due to internal impedance of the square-wave generator used in this instance, the negative impulse as it appears at the grids is not quite square and at the grids the peak negative dip is -15 volts. As soon as the maximum negative potential is reached, both grids start to rise in potential. As in Fig. 10, the grid of T_1 rises much faster than the grid of T_2 and reaches the conducting point first. When T_1 starts to conduct, its plate goes down, forcing the grid of T_2 way down and holding T_2 non-conducting. After an interval of less than 0.0001 sec., the charges on all capacitors have been equalized and the circuit is as before, except that T_1 is now conducting instead of T_2. The dotted lines indicate what the rise of the grid voltages might look like if the tubes could be held non-conducting by some external means.

Figure 12 shows both grid and plate-voltage changes for tube T_1 when the trigger (circuit as in Fig. 1) is triggered or reversed continually by a 3000-cycle square-wave input. (The grid-voltage curve is the same as those in Fig. 11.)

Positive and Negative Impulses

So far nothing has been said about the ability of this trigger circuit to distinguish between positive and negative impulses.

If a square-wave input is of a low enough frequency, the positive rise of the square wave will appear to the trigger grids as a positive impulse of a magnitude equal to the negative impulse produced by the negative shift of the square-wave signal. To act as a frequency divider, the trigger must respond only to the negative shift. This it will do if the impulse is kept within reasonable limits. For example, a 20-volt negative impulse will cut off the conducting tube, enabling the trigger to transfer; a 20-volt positive impulse will not bring the grid of the non-conducting tube up to the conducting point and thus cannot make the tube start to conduct. Its only action on the conducting tube is to drive the grid slightly positive. Therefore, the trigger will transfer only on a negative impulse or voltage shift and the trigger will act as a frequency divider on a 20-volt square-wave input.

The trigger circuit as shown will respond to negative pulses only, as long as they remain between the limits of 10 to 40 volts. Figure 12 shows why the trigger is not reversed on a positive pulse which is theoretically large enough to bring the grid of the non-conducting tube up to the conducting point. Notice that a point *B* the grid of the non-conducting tube actually appears to go negative although the square-wave input is shifting positively. This is because the positive impulse acting on the grid of the conducting tube drives its plate down almost 20 volts (point *C*). Through the plate-to-grid capacitor *C*, this dip of the plate of the conducting tube over-rides the positive impulse on the grid of the non-conducting tube, producing a negative dip as shown at *B*. (Although point *C*, as shown for tube T_1 is 180 deg. out of phase with point *B*, the corresponding point on the plate of T_2, if it were shown on Fig. 12, would be in phase with point *B*.

For a positive impulse to turn on the non-conducting tube, it must be large enough to overcome the initial bias plus the negative swing produced at the non-conducting tube's grid by the voltage dip of the conducting tube's plate. The dip in the conducting tube's plate voltage is in this case caused by the same positive impulse acting on its own grid. The input limits depend on the impedance of the input circuit. The figures of 10-40 volts were obtained with a battery serving as a very low impedance source. With a 20,000-ohm output impedance of the square-wave generator, the input may be varied from 10 to over 70 volts at 3000 cycles.

Coupling Several Triggers

All that is required to use a trigger circuit of the type described as a frequency divider is to hold the input signal to reasonable limits (25 volts ±15 volts for a low-impedance source). No extra tubes or pulse selectors are required.

To couple two triggers together, it is only necessary to tap one plate resistor of the first trigger at one-quarter to one-half its value, coupling to the input capacitors of the second trigger as shown in Fig. 13. Tapping the plate-load resistor at one-quarter to one-half its value serves to furnish a portion of the output of the first trigger within the required limits for operation of the second trigger. Thus we have a simple straightforward trigger circuit which is capable of distinguishing between positive and negative pulses without additional tubes. Such triggers when properly designed are stable, dependable, and independent of any reasonable voltage-supply variation (±20 percent variation in either bias or plate supply, more if both vary together).

As many triggers as desired may be coupled together by the methods outlined above to obtain any desired frequency reduction, the frequency being reduced by a factor of two for each trigger used. Such a frequency divider may be used in many ways, in combination with a mechanical counter for counting high-speed pulses far above the speed of the mechanical counter alone, in high-speed calculating, etc. A combination of a trigger and a power tube, where the trigger controls the power tube, may be used in place of a thyratron with the advantage that it may be turned off as easily as it is turned on. The triggers alone or in combination may also be used as electronic storage devices, since they are perfectly stable in either position.

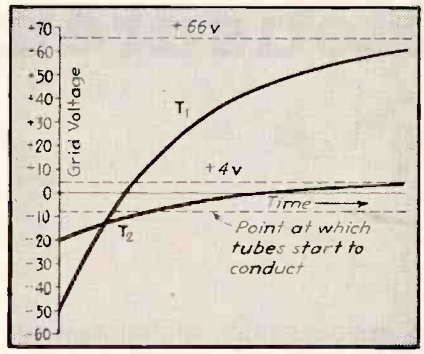

FIG. 10—Calculated grid-voltage rise as circuit voltages change from those shown in Fig. 8 to those shown in Fig. 9

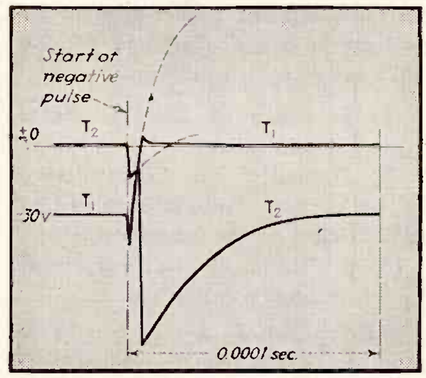

FIG. 11—Actual grid-voltage rise in the circuit of Fig. 1. as viewed on a cathode-ray oscilloscope

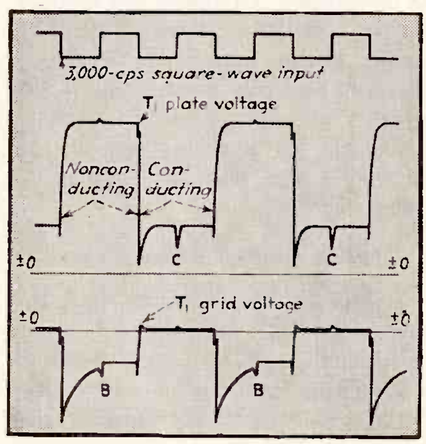

FIG. 12—Overall trigger circuit operation, as sketched from a cathode-ray oscilloscope

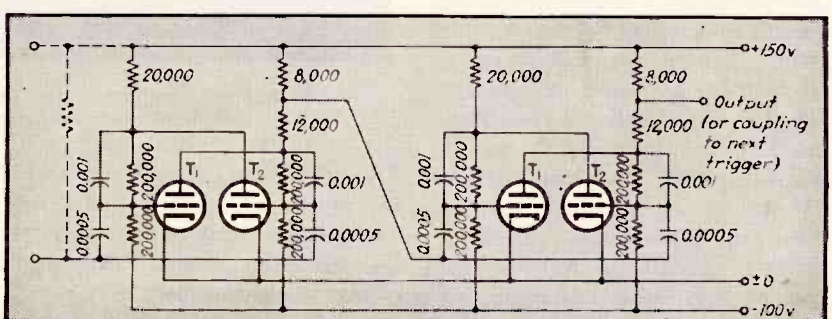

FIG. 13—Method of coupling two or more dual-triode trigger circuits

Measurement of STRESSES in

Resistance-wire strain gages mounted on the shaft facilitate vibration analysis and fatigue-strength calculations. Methods of measuring both steady and alternating stresses caused by thrust, bending and torque are discussed. Tests on the propeller shafts of naval vessels are used as examples

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MEASUREMENT of alternating stresses in rapidly moving mechanical parts has long been desirable for vibration analysis and fatigue-strength calculations. This has been difficult to accomplish by mechanical means because of the following major problems:

(1) Presence of inertia effects in mechanical linkages.

(2) Difficulty of transmitting the indications from a rotating or moving part to the observer.

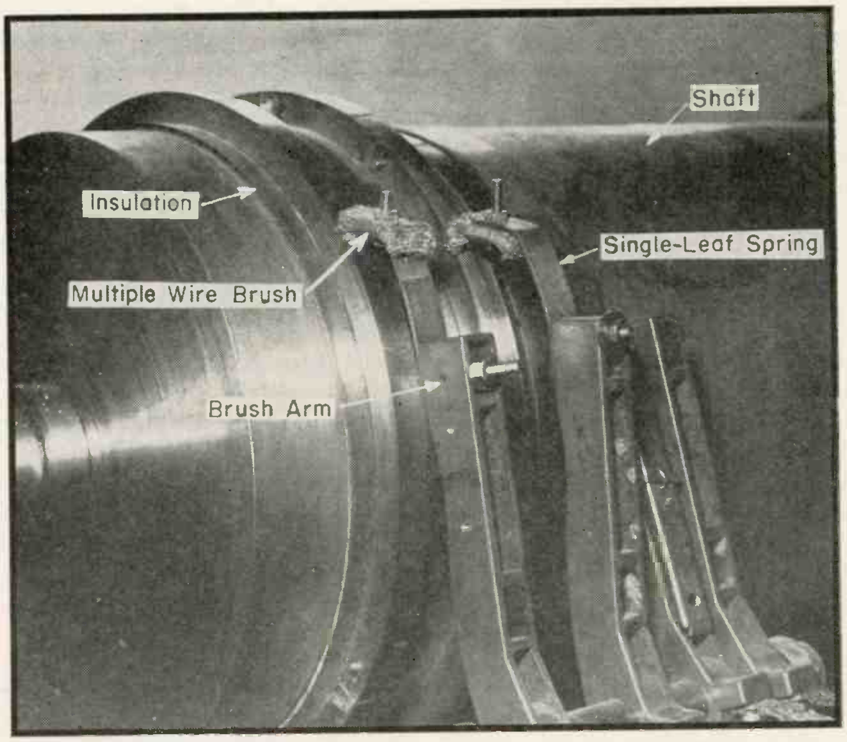
(3) Difficulty in calibration of the indicating mechanism.

These problems are all easier to solve when electrical or electronic methods of measurement are employed. There are a number of such methods by which stress can be measured. Of these, the method which utilizes resistance-wire strain gages has been developed farthest and has been used in the widest variety of rotating-shaft applications. For this reason, the present paper will be confined to this method.

Resistance-Wire Strain Gages

It has long been known that the resistance of granulated carbon can be changed by pressure. Following this lead, carbon strips have been used as strain gages, but while the resistance of such strips changes markedly with stress, the behavior of carbon-strip gages is quite erratic.

The same effect exists in metals, although to a lesser degree than in carbon. When a metal wire is stretched, it becomes longer and thinner and its electrical resistance increases; the increase in resistance is usually somewhat larger than can be accounted for by the change in dimensions. Development of practical methods for utilizing this effect to measure stress and strain started about 1938, E. C. Simmons[1] and associates at California Institute of Technology and Ruge[2] and DeForest at Massachusetts Institute of Technology carrying out the work independently and apparently almost simultaneously.

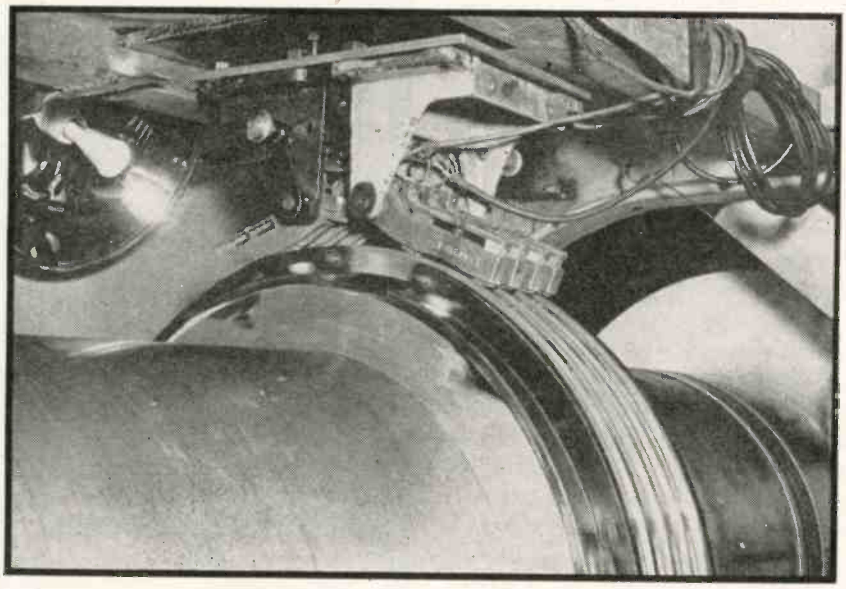


Slip-ring test stand, showing ring and brush construction recently adopted for measurement of stresses where the end of the shaft is not accessible

Strain gages employing this principle were soon made commercially available by the Baldwin-Southwark division of the Baldwin Locomotive Works. These gages have been used extensively for vibration measurements and strength testing. Dohrenwend's paper[3] is typical of much of such work.

The active element in these

ROTATING SHAFTS



Early slip-ring installation on the propeller shaft of a naval vessel. Four carbon brushes were used on each ring

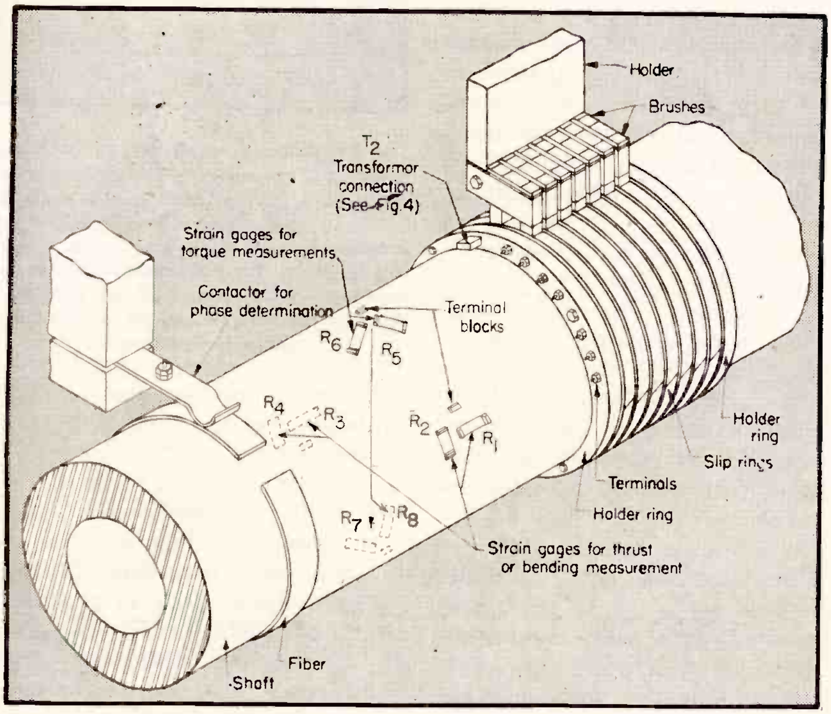


FIG. 1—Schematic of measuring apparatus mounted on a shaft

gages is a metal wire about 0.001 inch in diameter, laid in multiple-W form and conveniently mounted on paper for cementing to the part under test. The diameter of the wire must be of this order of magnitude to assure adequate bonding to the test piece. An essential property of the gage is that it undergoes a change in resistance proportional to the strain in the wire and hence to the strain in the member under test, or

$$\Delta R/R = k\Delta l/l$$

This equation is valid for both tension and compression if the wire is adequately bonded to the test piece so as to prevent buckling. Exact values of k are supplied by the manufacturer for each lot of gages; $k \simeq 2$ for gages of Advance wire having a low temperature coefficient and generally used for measurement of steady strains. For gages of isoelastic wire, $k \simeq 3.5$; these gages have a higher temperature coefficient than the Advance wire gages but are very satisfactory for measuring alternating strains.

Locating Gages on Shaft

Figure 1 shows the location of gages on a shaft for measuring the three principal stresses: thrust, bending, and torque. It will be noted that from two to four gages are used in each circuit. The chief purpose of this multiplicity of gages is to discriminate among the different types of stress, but the arrangement also results in a reduction in temperature errors, a reduction in the electrical disturbances caused by the sliding brushes, and an increase in sensitivity.

Gages R_1 and R_3 are mounted with their strain-sensitive axes parallel to the axis of the shaft; the axes of gages R_2 and R_4 are perpendicular to the shaft axis. If the shaft is subjected to an axial compression, such as the propeller thrust produces in the propeller shaft of a ship steaming ahead, gage R_1 is subjected to a compressive strain and gage R_3 is subjected to a compressive strain of equal magnitude. Because of the Poisson effect, gages R_2 and R_4 experience a tensile strain a third to a fourth as great as the compressive strain in gages R_1 and R_3.

Any rotating shaft will be subjected to an alternating bending stress, due to its own weight, and to other bending stresses due to any misalignment and unbalance which may exist. These forces are usually small in themselves, but their effect on the shaft may be magnified by resonance effects to a degree which endangers the shaft or its bearings. If at any instant gage R_1 is subjected to a compressive stress due to bending, gage R_4 is also subjected to a compression and gages R_2 and R_3 are subjected to a tension. Furthermore, the magnitude of the compressive stress in R_1 is equal to the magnitude of the tensile stress in R_3, and R_2 and R_4 are similarly affected.

If a shaft is subjected to torsion, the principal strains in the surface are directed at an angle of 45 degrees to the shaft axis, the strains being compressive for one set of 45-degree lines and tensile for the set which is at right angles to the direction of the compressive stress. Thrust and bending forces produce no strains along these 45-degree lines. Gages can be readily located along these lines by using a paper template wrapped around the shaft.

These facts can be used to devise circuits in which resistance changes due to the desired type of stress have an additive effect on the output and changes due to the undesired type balance out. Cancellation of the undesired effect is complete if the orientation of the gages is exact and if $R_1 = R_3$ and $R_2 = R_4$. The circuits of Fig. 2 and 3 are arranged to accomplish this cancellation.

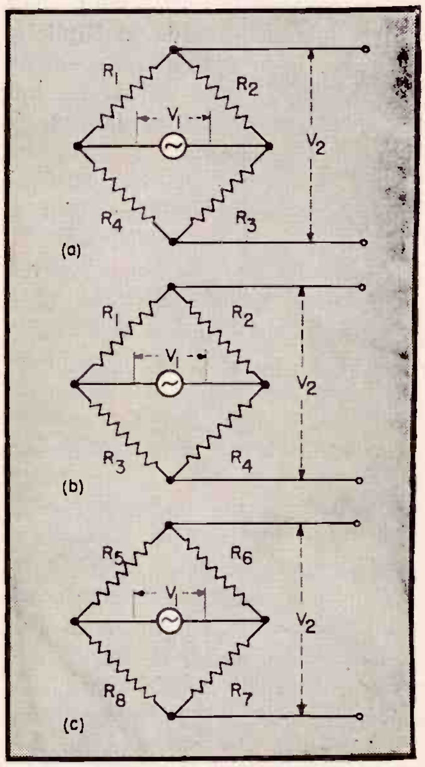


FIG. 2—Basic bridge circuits for measuring steady and alternating stresses. Resistors are the strain gages shown in Fig. 1. The arrangement at (a) is used for thrust measurements, that shown at (b) is employed for bending measurements, and (c) is for torque measurements

Choice of Circuit

Several types of measuring circuits are available. The choice of circuit depends, first of all, on the frequency characteristics of the stresses being investigated. Wherever steady stresses are to be measured, a bridge type of circuit is indicated. For measuring steady stresses only, on land installations, a d-c bridge supply is used and a sensitive galvanometer is employed as an indicator. Such galvanometers are useless on shipboard, so that some other method must be used if shipboard experiments or the measurement of vibratory quantities is contemplated.

A d-c bridge-supply could conceivably be used with d-c amplification, but the use of a-c bridge-supply and carrier-current methods is much to be preferred. Some additional complications are introduced by the use of carrier, notably those due to the necessity of maintaining the bridge in reactive as well as resistive balance, but these complications are outweighed by the fact that the carrier-current amplifier is superior to the d-c amplifier in reliability, freedom from hum, gain, stability and simplicity. Carrier-current methods are well adapted to simultaneous measurement of both steady and alternating stresses.

If alternating stresses only are to be measured, the circuits of Fig. 3 are indicated. This makes it possible to dispense with the carrier-current source (usually a 5-watt electronic oscillator) and the bridge control equipment. In addition, the inconvenience of maintaining the balance of a bridge is avoided, and the potentiometer supply-battery can often be mounted on the shaft, thus minimizing much of the difficulties experienced with brush contacts.

Obtaining stress records by photographing the screens of

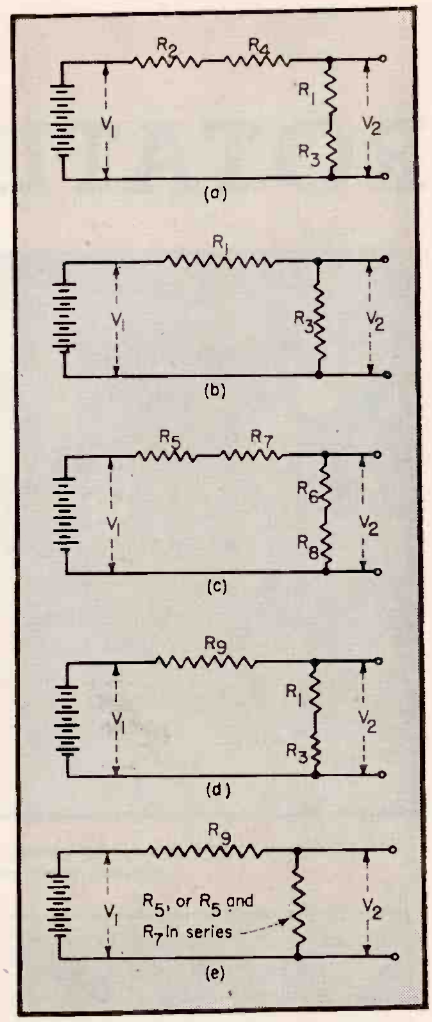


FIG. 3—Basic potentiometer circuits for measuring alternating stresses only. Resistors R_1 to R_8 are strain gages, while R_9 is a fixed resistor generally mounted on the rotating shaft but not shown in Fig. 1. Circuit (a) is for thrust measurements, (b) for bending, (c) for torque, (d) for simplified thrust measurements, and (e) for simplified torque measurements

cathode-ray oscilloscopes in the ordinary way is possible but not very satisfactory. The stresses are subject to random variations in time which confuse a record taken with repeating sweep and are apt to cause misconceptions if single sweep is used. Due to the short length of record, harmonic content is difficult to determine from cathode-ray pictures; furthermore many vibration investigations require taking four to 12 simultaneous records. This can be done conveniently with a magnetic oscillograph but not so conveniently with cathode-ray oscilloscopes.

Choice of Recording Instrument

Several commercially available oscillographs are supplied with galvanometers that have an undamped natural frequency of about 2000 cps and will therefore reliably record frequencies up to 600 or 700 cps, which is ample for unrectified carrier recording and more than ample for rectified carrier or direct recording of vibration stresses in machine parts. These galvanometers require about 5 ma per inch deflection and hence can be driven direct-coupled from low-power receiving tubes such as the 6J5. A further increase in sensitivity would offer little advantage and would involve a galvanometer sensitive to mechanical shock and inferior in frequency range.

Unrectified Carrier Method

The unrectified carrier method of measurement is the simplest method by which both steady and alternating stresses can be measured. Gages are mounted in accordance with Fig. 1 and connected in accordance with Fig. 2. The choice of carrier frequency is dictated by a typical engineering compromise. A high carrier frequency permits the measurement of higher-frequency stress oscillations but requires a somewhat more critical reactance balance. Carrier frequencies in the neighborhood of 400 cps have been found satisfactory for most shipboard applications, although frequencies as high as 1500 cps have been used.

The principal circuit arrangements are shown in Fig. 4. All long connections are made with shielded microphone cable; by following this practice it has been found possible to locate the measuring instruments as much as 200 feet from the shaft without deleterious effects. This fact is often useful on shipboard, where instrument locations near the propelling machinery are often undesirable for one reason or another. Transformer T_2, shown as located on the shaft, can be located at the amplifier input without great loss in signal-to-noise ratio. Capacitors C_1 and C_2 are used for balancing out stray capacitances.

In practice, switches S_1 and S_2 and resistor R_0 are adjusted so that a value of decade shunt resistor S between 20,000 and 50,000 ohms will balance the bridge when the shaft is idle. Adjustment of the bridge to balance when the shaft is idle—that is, stressed as little as possible—is known as the zero balance adjustment.

Suppose the bridge is adjusted to zero balance and the shaft then subjected to its normal load. If, as is normally the case, the stress being measured has a steady component and an alternating component whose peak value is less than the steady component, the bridge output will be a modulated sine wave whose percentage modulation is less than 100. The distance between the upper and lower envelopes at any point of an oscillogram of this modulated wave is proportional to the instantaneous stress in the shaft.

Figure 5 is a sample oscillogram taken by the unrectified carrier method. Changing the setting of shunt S (Fig. 4) will change the amplitude of the unmodulated portion of the bridge output by a constant amount. So far as the bridge output is concerned, this is equivalent to adding or subtracting a constant stress, the magnitude of the addition being calculable by formulas presented later in this paper. If the alternating component of stress is a small fraction of the steady component, this feature can be used to increase the portion of the record taken up by the alternations. If the alternating component of the stress is greater than the steady component, this feature can be used to prevent overmodulation. The bridge must always be adjusted so that the bridge output never falls to zero, otherwise the interpretation of the oscillogram is uncertain.

Figure 6 shows the circuit of an amplifier suitable for both the unrectified and rectified-carrier methods of measurement.

Rectified Carrier Method

Two advantages result from rectifying the bridge output before applying it to the oscillograph; the oscillograph is not required to record such high frequencies, and the resulting oscillogram is easier to read.

Simple diode rectification of the output is easily accomplished but is not too satisfactory. The bridge must in any case be adjusted so that its output is not overmodulated and yet the steady component of carrier frequency must not be large enough to saturate the amplifier. The presence of an unsuitable amount of carrier is not very obvious on the oscillograph when the carrier is simply rectified.

It is much better to use a bridge-detector circuit which registers the direction as well as the amplitude of the bridge unbalance. Many balanced detectors are phase-sensitive. A particularly simple and successful circuit is the one given in Fig. 7, which is similar in some respects to the circuit of the cosine galvanometer manufactured by the Hickock Instrument Company.

In practice, R_1 is adjusted so that the output milliammeter reads zero

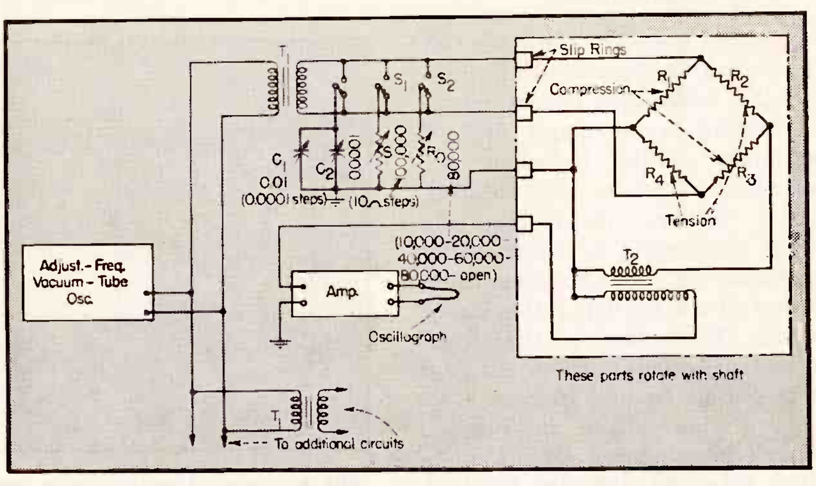


FIG. 4—Circuit used for unrectified carrier method of measurement. T_1 is an isolating transformer which also matches bridge input impedance to oscillator output impedance. T_2 is a step-up transformer bridge output to single grid, chosen for low 60-cycle hum pickup

when the input terminals of the carrier-current amplifier are shorted. Then, if the bridge is unbalanced in a direction such that the grids of VT_1 and VT_2 are positive when the plate of VT_1 is positive, the plate current of VT_1 is increased. This requires that the grids be negative when the plate of VT_2 is positive, so that the plate current of VT_2 is decreased. As the current through the galvanometer

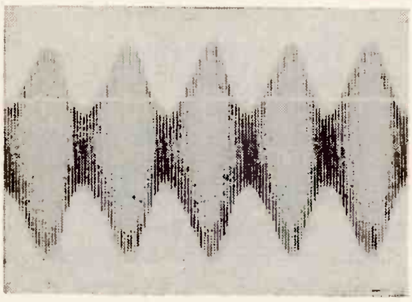


FIG. 5—Sample oscillogram obtained by the unrectified-carrier method

and output meter is the difference of these two currents, the net result is an average rectified current in the direction given by the arrow. An unbalance in the opposite direction results in output current in the opposite direction. The bridge can therefore be kept balanced for the average existing stress at all times, the oscillograph recording the instantaneous departures from average and the milliammeter serving as a null indicator for the steady component.

A sample oscillogram taken by the rectified carrier method is given in Fig. 8.

Direct Method

In many cases, a knowledge of the alternating component of stress is all that is desired; in fact, vibration testing is the major field of usefulness of the technique for measuring stresses in rotating shafts. Where measuring the steady component is unnecessary or impractical, labor and apparatus are conserved by using the direct method. The output of the strain gages (connected as shown in Fig. 3) is fed to an amplifier such as the one diagrammed in Fig. 9, through blocking capacitor C_1.

The principal difficulty involved is that the extremely low frequencies encountered complicate the amplifier design. Alternating stresses whose frequencies are as low as 2 cps are often encountered; frequencies above 30 cps are rare. For these low frequencies, transformer coupling is out of the question. The oscillograph galvanometer, which has an impedance of 12 ohms or less, must be direct - coupled to the output stage. The other stages are resistance-capacitance coupled and their design presents no particular difficulties except drift. That is, the output voltage of a very low-frequency amplifier is likely to vary spontaneously over a considerable range, the period of the variations being rather indeterminate but of the order of several seconds.

Mr. George Cook of the David Taylor Model Basin staff points out that drift is largely due to small variations in the amplifier supply voltages and particularly to the difficulty in maintaining the potentials of the screen grids of the early stages rigidly constant over so long a period. For this reason, the plate supply is derived from a carefully designed electronic regulator. Type 12SJ7 amplifier tubes are used, and their heaters (in series) are supplied with direct current from the regulator. As screen bypass capacitors adequate down to a fraction of a cycle are impractical, screen potentials are supplied from a dry battery. Although the current required is only 0.1 ma per tube, the smaller-size B batteries were found unsatisfactory due to high internal resistance, so that medium-size B batteries had to be used.

When this development was started, it was anticipated that the connections to and from the gages mounted on the rotating shaft would represent the most difficult of the problems to be solved. While this expectation proved to be correct, it has been found possible to make slip rings and brushes which are quite satisfactory.

Slip-Rings and Brushes

A ray of hope was offered at the outset by A. C. Ruge, who pointed out that if a complete bridge is mounted on the shaft and the brush connections inserted in the input and output leads of the bridge, variations in brush resistance produce only second-order effects on the output. Nevertheless, the second-order effects are sufficiently troublesome so that good brush contacts are required in any case.

Analysis of the circuits involved shows that the total variation in the contact resistance of the brushes carrying the input current is the principal disturbing factor. The necessity for using the adjustable shunt resistor off the shaft (S in Fig. 4) makes the problem much worse than it otherwise would be. Brush contacts also generate small random voltages or brush hash when the rings are rotating. The voltages thus arising from the sliding contacts in the bridge or potentiometer output circuit are objectionable if present, but in general cause less trouble than varying resistance in the input contacts.

The requirements for brushes for this purpose are, then, great

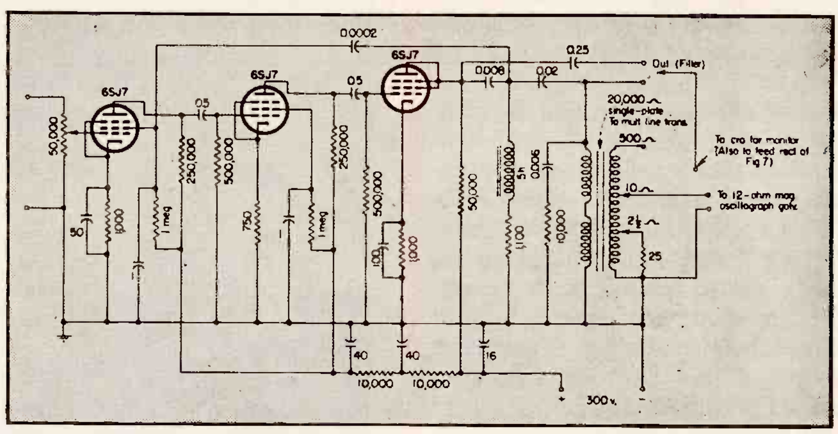


FIG. 6—Circuit of amplifier used with both unrectified carrier-current method and rectified carrier-current method. The filter is adjusted to give maximum flatness between 800 and 1,200 cps and maximum attenuation below 180 cps for minimizing hum. When using the amplifier in conjunction with the rectifier of Fig. 7 the filter is omitted to avoid possible phase shift

constancy of contact resistance and low-amplitude brush hash. At the low current levels used, the contact does not show the nearly constant drop-of-potential characteristic of motor and generator brushes. The brush has a fairly definite average contact resistance. As the disturbing factor is the total resistance change rather than the percentage change in contact resistance, low average contact resistance is a desirable feature. In general, brush hash is likely to be tolerable if the materials of brush and ring are not too dissimilar. It will be seen that the requirements for a good brush for this application are quite different from the requirements for a motor or generator brush in conventional applications.

It is obvious that any tendency for the brush to leave the ring even momentarily produces intolerable interference; nevertheless the paramount importance of proper alignment of the rings was not appreciated for some time. In many cases, as for example when measuring stresses in the propeller shafts of ships, the ends of the shaft are not accessible so that it is necessary to make the rings in halves and clamp them around the shaft. It has been found that filling the crack between the ring halves with solder and dressing down with a file reduces brush interference by a large factor. Polishing the rings with a commutator-dressing stone while they are rotating has also proved helpful.

A number of different combinations of ring and brush material have been tried. Present practice is as follows: A standard connector unit comprising 12 silver rings with silver-graphite brushes has been constructed. The construction of this unit is shown in Fig. 10 and 11. This provides enough contacts for almost any test and is used whenever the end of the shaft being tested is accessible. For installation where the end of the shaft is not accessible, half-rings are formed from square brass stock and clamped around the shaft, as shown in a photograph appearing on the first page of this paper. A multiple-wire brush is now always used. The optimum brush-pressure is the least pressure which will hold the brush on the ring.

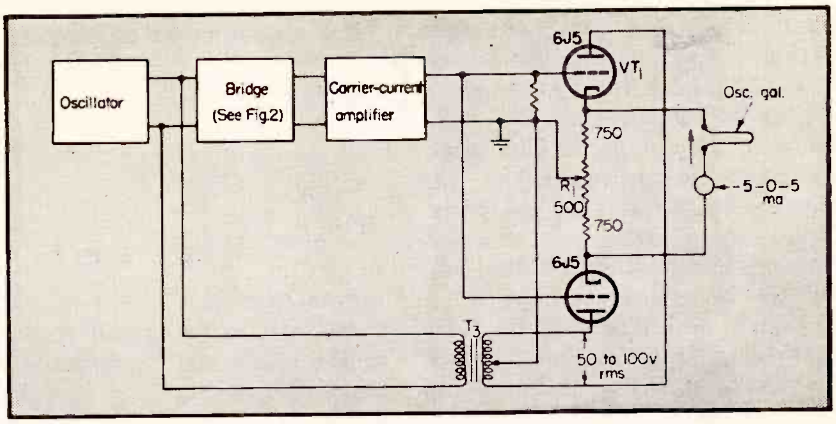


FIG. 7—Circuit used for the rectified-carrier method of measurement

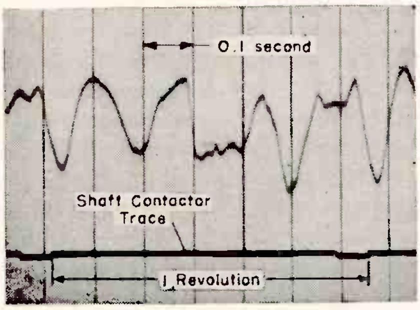


FIG. 8—Sample oscillogram obtained by the rectified-carrier method

Computation of Results

Let

A = cross-sectional area of shaft, sq. in.,
D = outside diameter of shaft, in.
d = inside diameter of shaft, in.
E = Young's modulus of shaft, lb. per sq. in.;
G = shear modulus of shaft, lb. per sq. in.;
N = Poisson's ratio of shaft
Q = torque applied to shaft, lb.-in.
T = axial thrust applied to shaft, lb.
M = bending moment at gage location, lb.-in.
S_V = shearing stress in shaft due to torque, lb. per sq. in.
S_T = axial stress in shaft due to thrust, lb. per sq. in.
S_B = fibre stress at gage location due to bending, lb. per sq. in.
R_1 to R_8 = unstressed resistances of gages of Fig. 1, ohms
R_9 = resistance of ballast resistor, Fig. 4.
δ = specific resistance variation of gage
v_1 = instantaneous value of input to strain-gage bridge or potentiometer, volts (v_1 is constant for potentiometer)
V_1 = input to strain-gage bridge, rms volts
v_2 = instantaneous value of output from bridge or potentiometer, volts
V_2 = output from bridge or potentiometer, rms volts

When the shaft is subjected to an axial compression (thrust) T, gages R_1 and R_3 (Fig. 1) are subjected to a strain along their strain-sensitive axes of magnitude T/AE. As a compressive strain produces a decrease in resistance, the resulting specific change in resistance is

$$\delta_T = -kT/AE$$

Due to the Poisson's effect, gages R_2 and R_4 are subjected to a strain of magnitude NT/AE in tension. This produces an increase in specific resistance

$$\delta_T' = NkT/AE = N\delta_T$$

Similarly, a bending moment M, if applied to the shaft in the proper orientation, produces a specific resistance change

$$\delta_B = \frac{k\,S_B}{E} = \frac{32\,k\,M\,D}{\pi E\,(D^4 - d^4)}$$

in gage R_1, a specific resistance change of $-N\delta_B$ in gage R_2, etc.

Torsion in the shaft subjects R_1 to R_4 to a shear strain only, and hence does not affect their resistances. Similarly, thrust and bending do not affect the resistances of gages R_5 to R_8. Torsion produces a strain

$$\frac{\Delta l'}{l'} = \frac{S_V}{E}\,(1 + N)$$

in gages R_5 and R_7 and a strain

$$\frac{\Delta l''}{l''} = \frac{-\,S_V}{E}\,(1 + N)$$

in gages R_6 and R_8. As $E = 2G\,(1 + N)$ and $Q = (\pi/16)\,[(D^4 - d^4)/D]S_V$, the corresponding specific resistance change is

$$\frac{\Delta l''}{l''} = -\,S_V\,(1 + N)$$

$$\delta_Q = \frac{k\,\Delta l'}{l'} = \frac{8\,k\,Q\,G\,D}{\pi\,(D^4 - d^4)}$$

The resistances of the gages under stress are then respectively

$$\begin{aligned}
&R_1\,(1 + \delta_T - \delta_B)\\
&R_2\,(1 - N\delta_T - N\delta_B)\\
&R_3\,(1 + \delta_T + \delta_B)\\
&R_4\,(1 - N\delta_T + N\delta_B)\\
&R_5\,(1 + \delta_Q)\\
&R_6\,(1 - \delta_Q)\\
&R_7\,(1 + \delta_Q)\\
&R_8\,(1 - \delta_Q)
\end{aligned}$$

where the δ's have all been defined in terms of the unknown forces or moments and shaft geometry.

It is now only necessary to determine the δ's in terms of the resistor values used and the output voltages found during the experiments. This can readily be done by setting up the Kirchhoff law equations for the circuits of Fig. 2 and 3, using the resistances of the gages under stresses as just given. These computations are straightforward but rather lengthy and will not be reproduced here.

Taking advantage of the facts that (a) all the δ's are very much less than unity (of the order of 0.001 or less); (b) the shunt resistor S can be kept very much larger than any of the gage resistances; and that (c) the value of the auxiliary shunt resistor does not affect the result if it is kept constant during the tests, the results can be expressed by the following simple formulas:

If any one of the bridges shown in Fig. 2 is balanced when the shaft is substantially unstressed, and if when the shaft is subjected to a load the bridge output is V_2, then

For measurement of thrust

$$\delta_T = \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

$$S_T = \frac{2E}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

$$T = \frac{2AE}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

For measurement of bending

$$\delta_B = \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

$$S_B = \frac{2E}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

$$M = \frac{\pi E\,(D^4 - d^4)}{16\,(1+N)\,kD}\left(\frac{V_2}{V_1}\right)$$

For measurement of torque

$$\delta_Q = \frac{V_2}{V_1}$$

$$S_V = \frac{2G}{k}\left(\frac{V_2}{V_1}\right)$$

$$Q = \frac{\pi G\,(D^4 - d^4)}{8\,k\,D}\left(\frac{V_2}{V_1}\right)$$

Note that $V_1/V_2 = v_1/v_2$. The phase-shift in the carrier produced by the bridge and amplifier reactances results only in a time delay which is constant for all frequencies of stress variation if the phase-distortion in the amplifier has been kept low, and is of negligibly small magnitude if the carrier frequency is larger than the frequencies of stress variation by a sufficiently large factor. For this reason, either instantaneous or rms voltage values can be used in the preceding set of equations, and also in the two sets of equations immediately following. These equations can be readily extended to cover cases where the bridge is not maintained at zero balance. If S_o is the value of the shunt resistor S which results in zero output when the shaft is not stressed, then the values of the typical specific resistance, stress, and force or moment of force which will result in zero output with some other value of shunt resistance S' are given. For measurement of thrust, the specific resistance change for obtaining balance with shunt S'

$$\bar{\delta}_T = \frac{R_4\,(S_o - S')}{2\,(1+N)\,S_o\,\delta'}$$

The stress for balance with shunt S'

$$\bar{S}_T = \frac{E}{k}\,\bar{\delta}_T'$$

The thrust for balance with shunt S'

$$\bar{T} = \frac{AE}{k}\,\bar{\delta}_T$$

For measurement of bending

$$\bar{\delta}_B = \frac{R_4\,(S_o - S')}{2\,(1+N)\,S_o\,S'}$$

$$\bar{S}_B = \frac{E}{k}\,\bar{\delta}_B$$

$$\bar{M} = \frac{\pi E\,(D^4 - d^4)}{32\,k\,D}\,\bar{\delta}_B$$

For measurement of torque

$$\bar{\delta}_Q = \frac{R_4\,(S_o - S')}{4\,S_o\,S'}$$

$$\bar{S}_V = \frac{2G}{k}\,\bar{\delta}_Q$$

$$\bar{Q} = \frac{\pi G\,(D^4 - d^4)}{8\,k\,D}\,\bar{\delta}_Q$$

The resistance of the auxiliary shunt R_o does not matter as long as it is the same for all values of S. Furthermore, if the bridge output is V_2 when the shunt resistance is S', then the total specific resistance changes δ_T, δ_B and δ_Q, the total changes in stress S_T, S_B and S_V and the total changes in force or moment T, M and Q are given by thrust

$$\delta_T = \bar{\delta}_T + \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

$$S_T = \bar{S}_T + \frac{2E}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

$$T = \bar{T} + \frac{2AE}{(1+N)k}\left(\frac{V_2}{V_1}\right)$$

bending

$$\delta_B = \bar{\delta}_B + \frac{2}{1+N}\left(\frac{V_2}{V_1}\right)$$

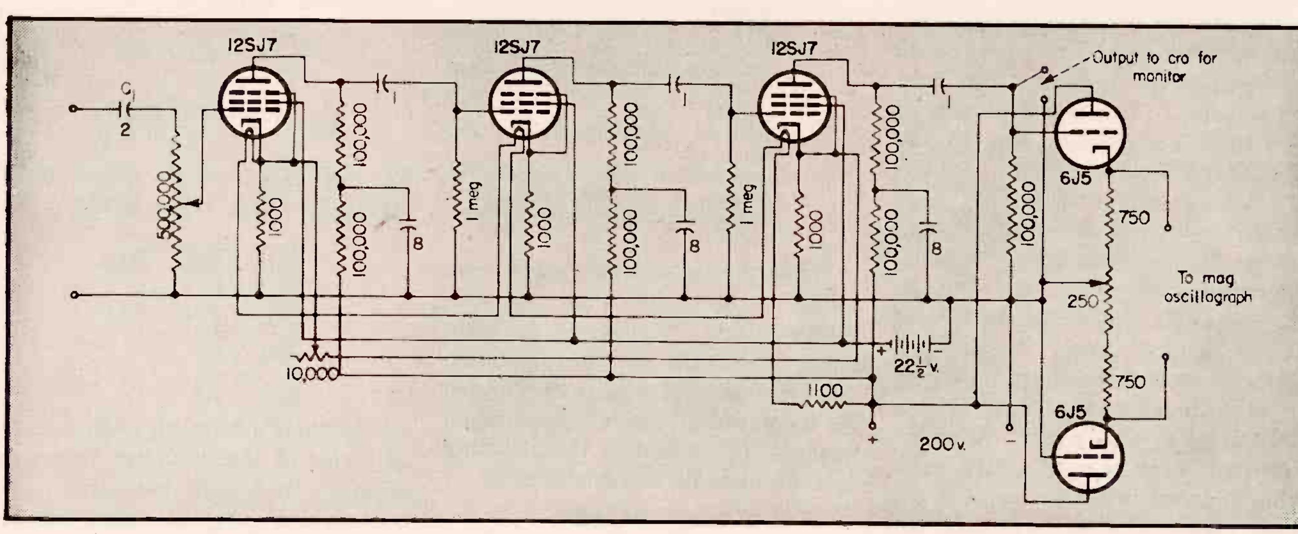


FIG. 9—Circuit of amplifier used for the direct method of measurement

$$S_B = \overline{S}_B + \frac{2E}{(1+N)\,k}\left(\frac{V_2}{V_1}\right)$$

$$M = \overline{M} + \frac{\pi\, E\,(D^4 - d^4)}{16\,(1+N)\,k\,D}\left(\frac{V_2}{V_1}\right)$$

torque

$$\delta_Q = \overline{\delta}_Q + \frac{V_2}{V_1}$$

$$S_T = \overline{S}_T + \frac{2\,G}{k}\left(\frac{V_2}{V_1}\right)$$

$$Q = \overline{Q} + \frac{\pi\, G\,(D^4 - d^4)}{8\,k\,D}\left(\frac{V_2}{V_1}\right)$$

The circuits given in Fig. 3 are always used with capacitance coupled amplifiers, so that the oscillograph indicates only the alternating component of output voltage. For this reason, it is best to express the results thus obtained in terms of departures from average values of resistance, stress, and force, rather than in terms of departure from the condition of no external load as was done for the bridge circuits. With this understanding, the formulas for interpreting the results of measurements by the direct method are as follows:

for circuit of Fig. 3(a)

$$\delta_T = \frac{4}{1+N}\left(\frac{V_2}{V_1}\right)$$

for circuit of Fig. 3(d)

$$\delta_T = \frac{(R_1 + R_3 + R_9)^2}{(R_1 + R_3)\,R_9}\left(\frac{V_2}{V_1}\right)$$

for circuit of Fig. 3(b)

$$\delta_B = 2\,\frac{V_2}{V_1}$$

for circuit of Fig. 3(c)

$$\delta_Q = 2\,\frac{V_2}{V_1}$$

for circuit of Fig. 3(e)

$$\delta_Q = \frac{(R_5 + R_7 + R_9)^2}{(R_5 + R_7)\,R_9}\left(\frac{V_2}{V_1}\right) \text{ or } \frac{(R_5 + R_9)^2}{R_5\,R_9}\left(\frac{V_2}{V_1}\right)$$

Calibration of Equipment

In cases where the shaft studied may be stopped at will, the two carrier-current methods lend themselves to very simple and accurate calibration in terms of the shunt resistor S, which should be a precision decade resistance box.

Let y be the peak-to-peak carrier amplitude as measured on the oscillogram in an unrectified carrier system, or the deflection of the trace in an oscillogram taken by the rectified carrier system. If then y_1 is the observed amplitude or deflection taken when the shunt resistance is $S_1 < S_o$ and y_2 is the observed amplitude or deflection taken when the shunt resistance is $S_2 > S_o$ (where S_o is the shunt resistance for zero balance), then it can be shown from formulas already presented that

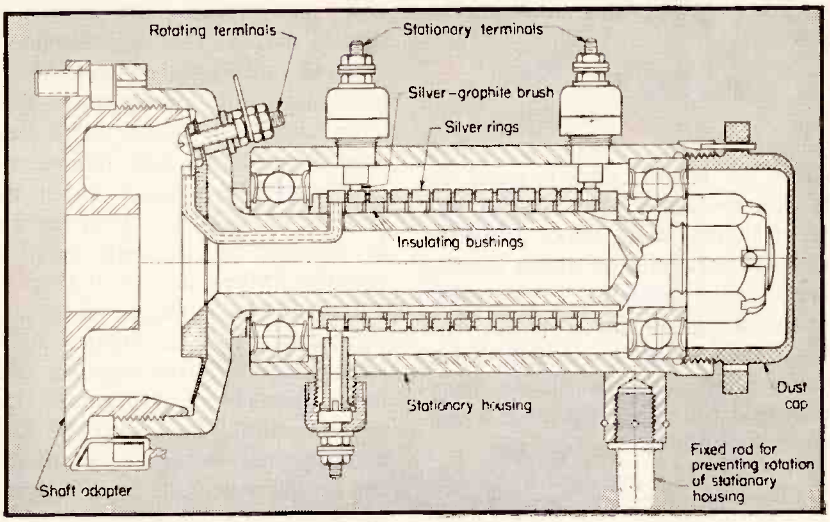


FIG. 10—Drawing of connector unit employed whenever the end of the shaft under test is accessible, an adaptation of a design furnished by the Hamilton-Standard Propeller Company. The unit is pictured in Fig. 11

for circuit of Fig. 2(a)

$$T = \frac{A\,E}{2\,k\,(1+N)}\;\frac{R_1\,(S_2 - S_1)}{S_1\,S_2}\;\frac{y}{(y_1 + y_2)}$$

for circuit of Fig. 2(b)

$$M = \frac{\pi\,E\,(D^4 - d^4)}{64\,k\,(1+N)\,D}\;\frac{R_1\,(S_2 - S_1)}{S_1\,S_2}\;\frac{y}{(y_1 + y_2)}$$

for circuit of Fig. 2(c)

$$Q = \frac{\pi\,G\,(D^4 - d^4)}{32\,k\,(D)}\;\frac{R_5\,(S_2 - S_1)}{S_1\,S_2}\;\frac{y}{(y_1 + y_2)}$$

where y is the instantaneous deflection or amplitude on an oscillogram taken with any desired load on the shaft, and T, M, Q are corresponding instantaneous values of thrust, bending moment, and torque respectively.

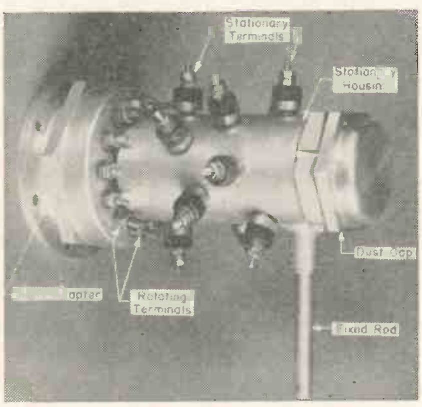


FIG. 11—The connector unit shown schematically in Fig. 10

Unfortunately some shafts, as for example the propeller shafts of ships, cannot be stopped at will. Calibrations of this type can be made with the shaft under load by using averages values of y_1 and y_2, but if the average stress varies in the interval between the recording of the first and second oscillograms, errors will be introduced.

Potentiometer-type strain-gage circuits can be calibrated by momentarily shunting the gages in one arm of the potentiometer with a known high resistance. As the associated recording equipment is not capable of registering d-c potentials, this results in a transient excursion of the oscillograph beam; the deflection corresponding to the resistance change can be estimated but is subject to some uncertainty. The experience of the author with this method of calibrating potentiometer-type gage circuits indicates that the accuracy is rather low. Change of shunt resistance, however, is the most accurate method of calibrating strain-gage bridges if the stresses in the shaft can be maintained constant during the calibration.

Alternatively, calibration can be accomplished by measuring the voltage sensitivity of the amplifier-oscillograph combination and the voltage supplied to the gage circuit. It must be remembered, however, that while the deflection of the oscillograph beam is proportional to instantaneous voltage, most a-c voltmeters and standard signal-generators are calibrated in rms volts.

The voltage sensitivity of the

amplifier-oscillograph combination is

$$K_o = \frac{2.828\ V_e}{y_o}$$

(instantaneous) volts per inch where y_o is the peak-to-peak deflection produced by an input signal of V_e rms volts, when using the unrectified carrier or direct method and y_o is the deflection (from zero) produced by an input of V_e rms volts when using the rectified carrier method. Then for thrust measurements by either of the carrier-current methods

$$T = \overline{T} + \frac{2\,AE}{(1+N)\,k}\ \frac{K_o\,y}{(2.828\ V_1)}$$
$$= \overline{T} + \frac{2\,AE}{(1+N)\,k}\ \frac{V_e}{V_1}\ \frac{y}{y_o}$$

where T is total instantaneous thrust, $\overline{T}$ is the steady thrust for which the bridge is balanced, y is the distance between the upper and lower envelopes at any point of the oscillogram if unrectified carrier is used, and y is the distance from the zero line to the trace if rectified carrier is used.

For thrust measurements by the direct method, instantaneous values of the alternating component of thrust are given

for the circuit of Fig. 3(b)

$$T = \frac{4\,AE}{(1+N)\,k}\ \frac{K_o\,y}{v_1} = \frac{11.31\ AEV_e}{(1+N)\ kv_1}\ \frac{y}{y_o}$$

for the circuit of Fig. 3(c)

$$T = \frac{AE}{k}\ \frac{(R_1 + R_3 + R_9)^2\ K_o\,y}{(R_1 + R_3)\ R_9\,v_1}$$

Similar formulas for bending and torque measurements can be written readily enough.

Accuracy and Sensitivity

The accuracy of measurements made with resistance-wire strain-gages is affected by many factors in a complex way. No completely definitive analysis of the errors involved has yet been made so far as the author is aware. Nevertheless, the upper limit of the probable over-all error is quite definitely known and it can be confidently stated that the accuracy and sensitivity are sufficient for most engineering tests.

If four strain-gages are cemented to a nonrotating part and connected into a bridge-type network, it will be found that the zero balance of the bridge drifts rather erratically as time goes on, even under laboratory conditions. The reason for this is not entirely understood. In general, temperature effects are the principal source of errors in measuring steady stresses. The gage-wire itself has a low temperature coefficient of resistance, but in general the material to which the gage is cemented has a coefficient of expansion different from that of the wire, and the resulting differential expansion produces strains in the wire which in turn produce resistance changes. Furthermore, it is possible that there may be small changes in the gage constant k as the temperature changes. However, in laboratory experiments of the type just described, observed temperature changes did not correlate very well with the drift in zero balance.

Another source of difficulty is the leakage resistances associated with the bridge. This effect is especially severe when measurements must be made in a damp location such as the shaft alley of a ship. Radiant heaters have occasionally been installed in the hope of preventing condensation of moisture on the slip-ring insulators by raising the temperature slightly. The effect of leakage resistance increases with the square of the gage resistance; however, reducing the effective gage resistance by using two or three gages in parallel in each arm of the bridge did not appreciably improve the over-all accuracy.

Still another probable source of error is plastic flow in the cement used to secure the gages to the parts under test. The accuracy which has been obtained in tests, where it was possible to check the results of the gage measurements, indicate that the gage wire must follow the strains in the surface to which it is attached quite closely. However, the precise magnitude of effects of flexibility in the cement is still somewhat in doubt.

In some cases, it has been possible to check the values of the steady component of stress in shafts by means of independent measurements. In these cases, the stress values obtained from the strain-gage measurements were rarely in error by more than 100 pounds per square inch; this result agrees with early estimates published by the Baldwin-Southwark Company. This error is quite tolerable if the stress being measured is at all high. In cases where temperature changes do not occur rapidly and zero balance can be checked frequently, it should be possible to improve this figure considerably.

It has not been possible to obtain such definite checks on the alternating components of stress in shafts. It is estimated that the accuracy of measurement is about 10 per cent in cases where severe temperature changes are involved, and three to five per cent under more favorable circumstances.

The sensitivity to stress changes depends on whether or not the change occurs rapidly enough to be distinguishable from the drift in zero balance. When the stress change occurs at a frequency of 2 cps or more, the sensitivity depends only upon the ability to distinguish stress changes from interfering stray potentials arising from the amplifier and particularly from the brush contacts. Such differentiation can often be made on the basis of wave-form or frequency.

Under good conditions, alternating stresses as low as 10 pounds per square inch have been detected. It will thus be seen that the sensitivity of the method is ample for engineering tests.

Acknowledgments

The author desires to express his indebtedness to the following members and former members of the David Taylor Model Basin staff:

Capt. A. G. Mumma, U.S.N., whose interest, cooperation and advice were invaluable in the early stages of the development; W. J. Sette, who shared responsibility for the development throughout the early stages; F. B. Bryant and V. E. Benjamin, who performed much of the experimental work; and L. E. Wedding, who also performed experimental work and was largely responsible for the slip-ring and brush design.

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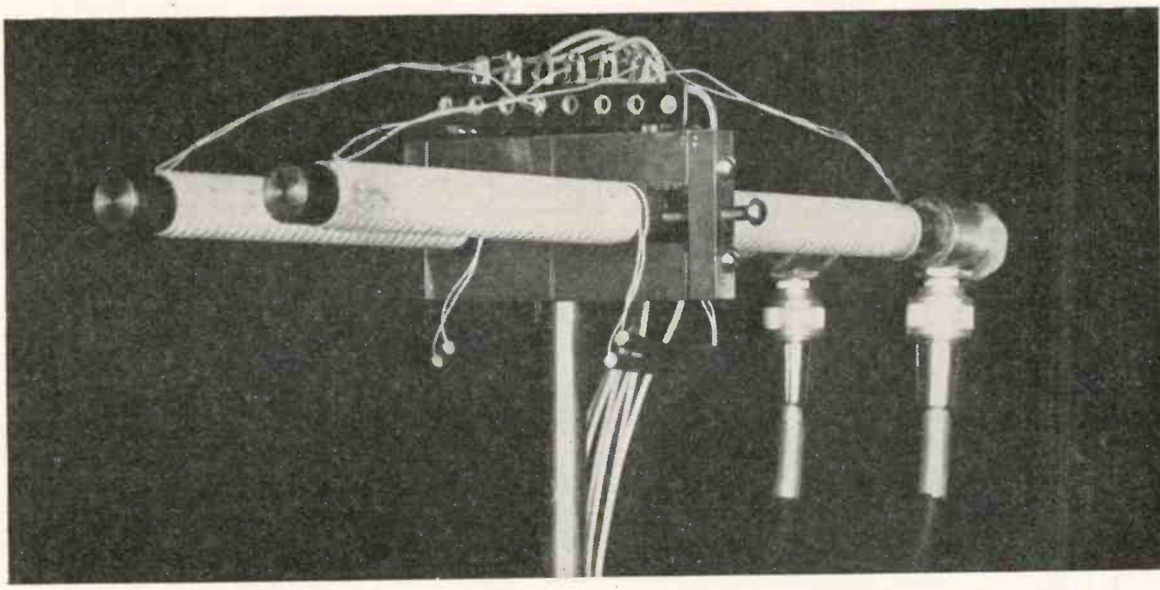

Experimental model of magnetostriction compass, employing a balanced two-rod arrangement. Systems employing a single rod are equally feasible

MAGNETOSTRICTION COMPASS

Rods of magnetostrictive material are subjected to an a-c magnetic field, and rotation in the earth's field changes the amplitude of vibration sufficiently to actuate a crystal pickup feeding an electronic amplifier and zero-center direction-indicating meter

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WHILE THE GYRO COMPASS and radio range systems have aided immeasurably in the art of avigation, the magnetic compass still persists as a tremendously useful and important device. All magnetic compasses, however, suffer several definite impediments to accurate operation, one of which is known as the acceleration error. For example, with a magnetic compass mounted in aircraft, for a right turn from a north course the compass will indicate that the pilot is turning left, due to the fact that during the banked turn the plane of the pendulously mounted compass card tilts from horizontal and rotates erroneously owing to the now-present vertical component of the earth's field. On a left turn the reverse action will take place, rendering this type of compass inaccurate as a turn indicator.

A further compass error is often introduced through the unfavorable magnetic location of the compass on the instrument panel of the aircraft, because of the proximity of the motor and the disturbing fields of wires carrying current to other instruments and controls.

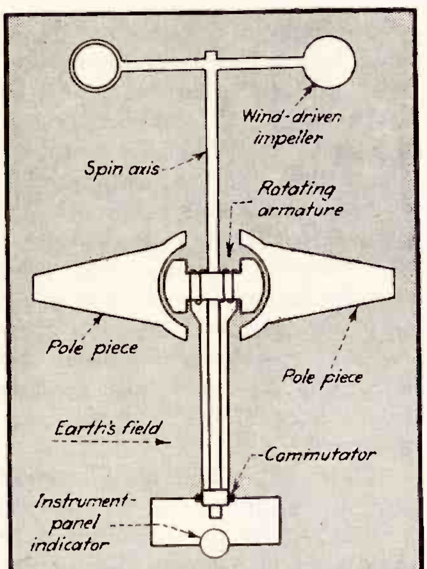


FIG. 1—Elementary magneto compass, in which the field for the rotating armature is provided by the magnetic field of the earth passing through the highly permeable pole pieces

Magneto Compass

The magneto compass provided one of the first means for eliminating errors due to unfavorable magnetic location of the field-responsive device as well as substantially reducing errors due to acceleration. In Fig. 1 is an elementary sketch of the magneto compass, which consists of a coil rotating between the specially shaped pole pieces consisting of two highly permeable rods. When the rod axes lie in an east-west direction no poles are induced and no voltage is generated by coil rotation. When the rod axes are in a north-south direction poles are induced and a voltage is generated. By pendulous or gyro stabilization of the rods, acceleration error may be reduced. The rod axes may tilt over a restricted range with respect to the armature spin axes without affecting compass operation. This field-responsive device may be installed in a variety of favorable magnetic locations, with appropriate leads to the indicating meter on the instrument panel.

In the magneto type of compass there are limits to the reduction of the acceleration error, partially due to the mechanical limits of the tilt between the rod axis and the armature spin axis. Further, this compass requires some sort of motor drive for the armature as well as commutation to rectify the developed voltage. It would be an advantage to eliminate the rotating armature and provide some other means for indicating flux density in the permeable rod. In recent years this has been accomplished effectively by using rods or thin sheets of a material which is partially or fully saturated by the earth's magnetic field. Electrical means are provided for indicating the state of saturation of the material according to its position in the earth's field, generally employing various modifications of a transformer with the easily saturable material as the core.

Magnetostriction Phenomenon

The experimental magnetic field-responsive device or compass described here, which may be called a magnetostriction compass, does not depend on core saturation for its operation. Instead, this compass employs the effect of weak fields, such as the earth's field, on the magnetostrictive action of various materials exposed to the observed field.

In general, magnetostriction refers to that set of phenomena in which certain materials exhibit a change in dimension upon magnetization. Figure 2 graphically illustrates the way in which various

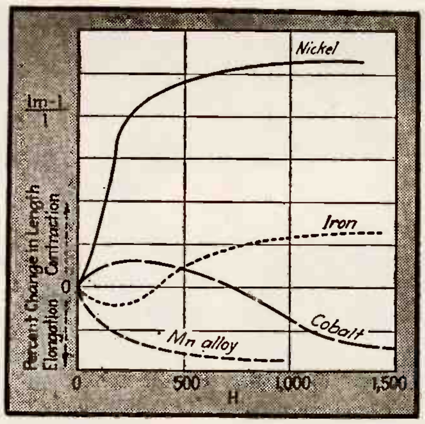


FIG. 2—Examples of magnetostriction curves for various materials, showing the percent change in length with intensity of a magnetic field H

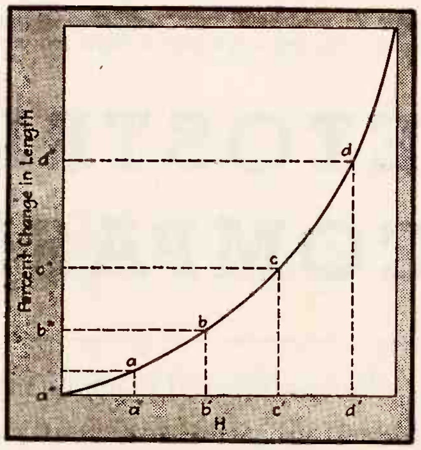


FIG. 3—Expanded magnetostriction curve, illustrating how shifting of the operating point causes changes in amplitude of vibrations produced by a superimposed a-c field

ferromagnetic substances change their length in a magnetic field.

If a rod of ferromagnetic or magnetostrictive material is suspended in the field of the earth, the length of the rod changes in accordance with its position in the field. The change in length attending magnetization by weak fields such as that of the earth is so exceedingly minute, however, that rugged mechanical means for indicating the dimensional changes would be difficult to design and construct.

When an alternating current field is impressed on a partially premagnetized rod in addition to the steady field under observation, however, variations in the intensity of the observed field will cause a remarkable change in the resonant amplitude of vibration of the rod. This action can be readily explained with reference to the expanded magnetostriction curve in Fig. 3.

When the rod is so positioned that the earth's magnetic field places the operating point at b on the curve, an a-c field that swings H from a' to c' about operating point b will make the change in rod length vary between a'' and c''. If the rod is then moved more nearly parallel to the earth's magnetic field so as to shift the operating point to c on the curve, the same a-c field will now cause a much greater change in rod length, from b'' to d''.

When the frequency of the applied alternating magnetic field is closely matched to that of a natural elastic longitudinal period of the rod, resonance occurs between the electrical and mechanical systems and the amplitude of rod displacement becomes large enough to be detected electrically by conventional vibration pickups. Steady magnetic fields of low intensity, such as the earth's field of 0.15 to 0.30 gauss, are of sufficient magnitude to shift the operating point on the curve and produce variations in the amplitude of vibration of the rod.

Magnetostriction Compass

An experimental version of the magnetostriction compass is shown schematically in Fig. 4. Magnetostriction rods A and B are made of annealed steel and cut to identical dimensions so both will resonate at the same frequency. A close approximation of the fundamental longitudinal period of the rods may be determined by

$$f = \frac{1}{2l}\sqrt{\frac{E}{d}}$$

where f is frequency in cps, l is rod length in cm, E is the elastic modulus of the rod material in dynes per sq cm, and d is the density of the rod material in grams per cu cm. For a rod of annealed steel 25.4 cm long for which d is 7.8 and E is 22 x 10^{11}, the resonant frequency is approximately 10,000 cps.

Both of the rods in Fig. 4 are firmly clamped at their midpoints (nodes), permitting the assembly to be rotated in the horizontal component of the earth's field while the rods are retained parallel and in the same plane. To facilitate mounting, the coils on each rod are split into two sections. The alternating-current winding is close-wound directly on each rod, with the premagnetizing winding space-wound directly over it. The a-c windings are excited from a convenient source of alternating current such as an audio signal generator. The battery, potentiometers, and premagnetizing windings cooperate to magnetize each rod oppositely and independently.

To detect the longitudinal rod vibration, a shielded piezoelectric rochelle salt crystal is affixed at the end of each rod. The remainder of the circuit is quite conventional, with two audio amplifiers to amplify the rod output signals, two tuned filter circuits to pass only the rod frequency, and a balanced metering circuit to indicate changes in amplifier output which are caused by changes in rod output.

Operation of Compass

Initially, rods *A* and *B* are positioned in an east-west direction and slightly but oppositely magnetized by the battery, potentiometers and premagnetizing windings. An alternating excitation voltage is then applied to the other windings by a variable-frequency generator, the frequency of which is tuned to the mechanically resonant fundamental longitudinal period of the rods. Rod resonance is easily observed by noting amplifier output. When the approximate fundamental period is first determined by calculation, slight frequency adjustment over the neighboring range will assure resonance between the electrical and mechanical systems. The gain of the amplifiers and the setting of the potentiometer in the metering circuit are now adjusted so that the center-zero meter shows no deflection.

Now when the rods are rotated, magnetic flux lines appear along the longitudinal axes of the rods due to the earth's magnetic field. If the polarity of this new field adds to the premagnetized condition of rod *A*, it will simultaneously buck the premagnetized condition of rod *B*, because the two rods are oppositely premagnetized. The vibrational amplitude of rod *A* will increase and that of rod *B* will decrease, unbalancing the balanced metering circuit and causing the meter to deflect to the right, for example. For opposite polarity of this new field, the meter will deflect in the opposite direction. When the longitudinal axes of rods *A* and *B* are parallel to the horizontal component of the earth's field, the zero-center meter will give a maximum deflection either to right or left, according to the field polarity.

Other Applications

Another promising circuit utilizes one premagnetized magnetostriction rod as a magneto-mechanical feedback link in a regenerative system equipped with volume compression, where the plate current of the compressor tube indicates the direction or magnitude of the observed field. Other circuits measure the phase angle between the exciting and output voltages of the rod as modified by the external field.

An unmagnetized nickel rod becomes shorter when introduced into a magnetic field, the change in length depending on field intensity but not field polarity. In an alternating field the rod will be shortened twice for each complete cycle of the exciting voltage. A steady field may shift the operating point, varying the percentage of second harmonic component in the fundamental vibration, and this waveform distortion is easily detectable.

The discovery that magnetic fields of low intensity exert an electronically measurable influence upon mechanically resonant magnetostrictive systems, as well as the initial development of suitable electronic measuring means, points out the way for further development in the field of magnetics. To the physicist it provides an approach to plotting magnetostrictive curves at low field intensities. To the metallurgist it offers the possibility of developing magnetostrictive materials with particularly suitable and novel magnetic properties. To the electronic engineer it affords the basis for new concepts and improvements in instrumentation.

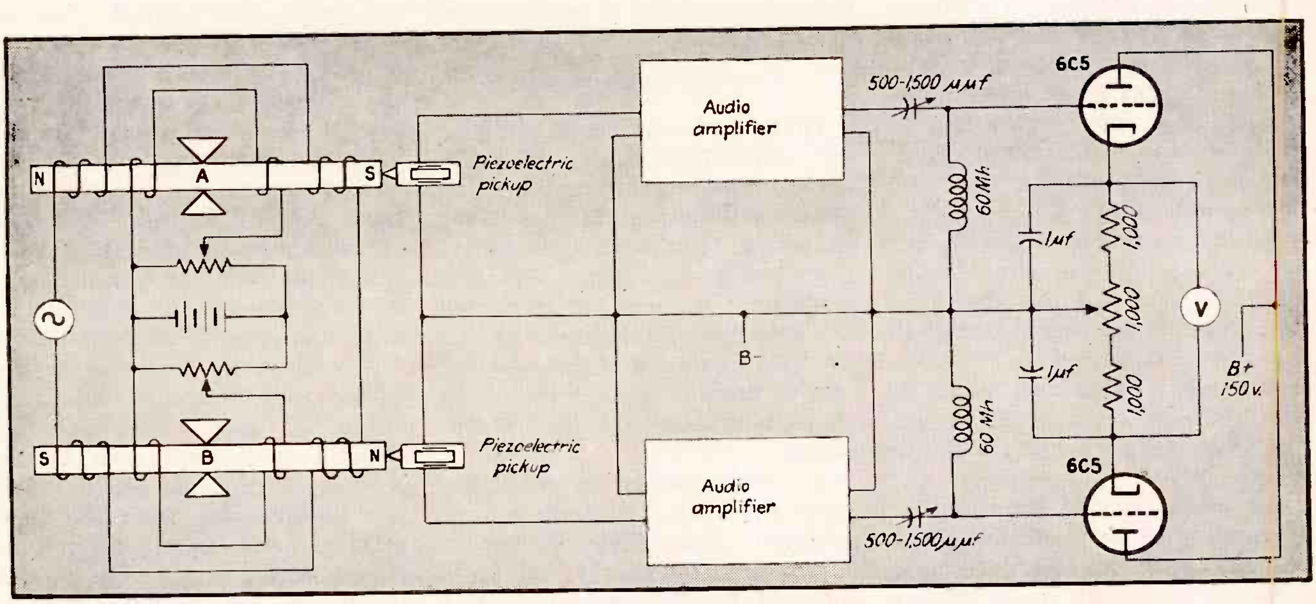
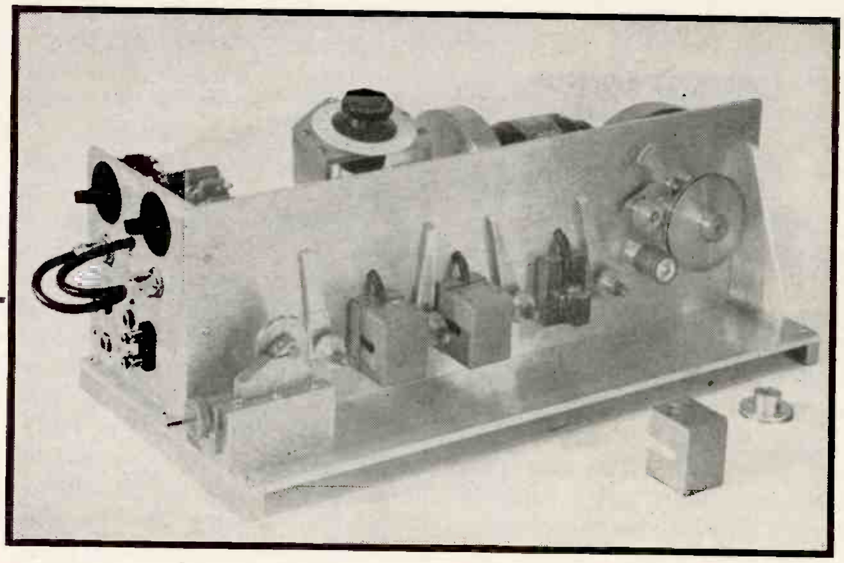


FIG. 4—One form of magnetostriction compass circuit, employing two vibrating rods in a balanced arrangement, with zero-center voltmeter *V* calibrated to indicate direction

Supersonic Bias for



Front view of loop tester, showing the shielded recording, erasing, and reproducing heads. To the extreme right is the driving capstan. The calibrated dial for speed control is above and to the back; this dial reads wire speed in fps

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Research indicates the optimum value of a supersonic bias field for improving linearity of magnetic transfer characteristics and reducing magnetic noise level. Measurements indicate the effects of recording-reproducing head design and wire speed on frequency response

RECENT DEVELOPMENTS in magnetic recording have created a new and widespread interest in this recording method. Using magnetic recording it is easily possible to produce records of any desired length. It is possible to record a complete symphony or, in the case of speech recordings, an entire book on a single length of wire without any splice. Another great advantage in the use of magnetic recording, as compared with recording on discs, is that the record material shows no appreciable wear.

When a record has served its usefulness, the wire recording can be erased by exposure to a supersonic field and the recording medium will then be in condition to receive a new record. This also makes it possible to correct errors in recording without destroying the entire record.

As the novelty of recording on magnetic wire wears off, those who are interested in recorded music from the viewpoint of the fidelity of the recording rather than the novelty of the method are going to compare this newer method critically with some of the older methods. If magnetic recording is not equal to, or better than the older methods which are now used for the recording of music, it will soon lose favor with these critical listeners except for novel entertainment.

Recording Characteristics

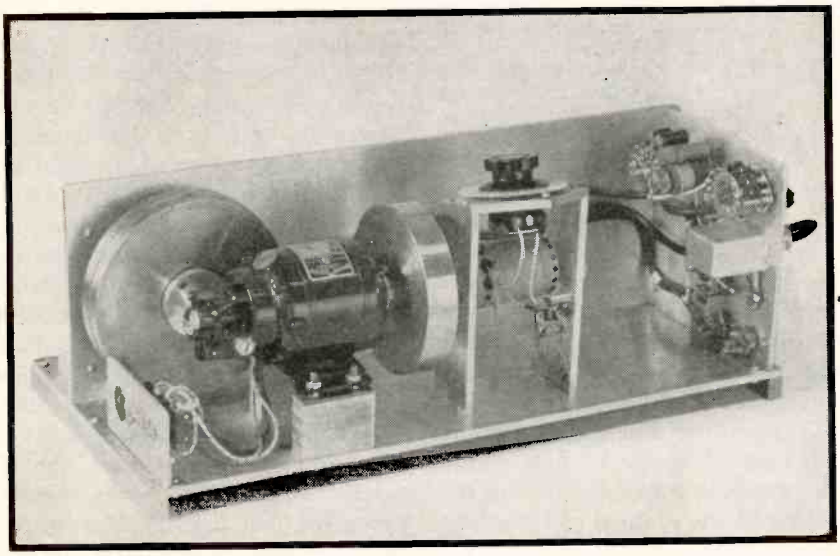
There are four major performance characteristics to be considered in the study of any recording system. These are: (a) non-linear distortion; (b) frequency response; (c) signal-to-noise ratio; (d) wow or flutter. We have not attempted to name these in the order of importance. Any one of these factors may be the limiting one insofar as the enjoyment of the listener is concerned.

We shall consider magnetic recording in relation to the first three in detail. The effects of wow or flutter are well-known and it is sufficient for the purpose of this paper to point out that wows which are not even noticeable with speech may be intolerable with music. In general, it is also true that all the requirements for good reproduction of music are much more severe than those for the intelligible reproduction of speech.

In any practical magnetic recording system, some method of biasing is necessary in order to place the operating range on a linear portion of the transfer characteristic. The most obvious method and the one used in early systems employed direct current in the recording head. Investigation of the effects of superimposed alternating fields and direct fields on ferromagnetic materials showed the possibility of using a supersonic field for bias.

Any magnetic recording system using direct-current bias will ordinarily leave the recording medium magnetized even in the absence of an audio signal. This is a disadvantage from the viewpoint of noise, as will become apparent later. On the other hand, the system using a supersonic bias leaves the recording medium practically demagnetized except when an

Magnetic Recording



Back view of loop tester. Flywheels for reducing speed fluctuations are attached to the high and low-speed shafts of the driving motor. An alternator connected to the high-speed shaft actuates the electronic speed control

audio signal is being recorded. This is an inherent advantage and should result in a higher signal-to-noise ratio than is obtainable with earlier systems.

Laboratory Apparatus

A block diagram of a complete magnetic recording system employing a supersonic bias field is shown in Fig. 1. The recording medium used for the work described in this paper was in the form of round wire; longitudinal magnetization was employed. For laboratory work the system was made as flexible as possible. Two well-shielded, recording-reproducing heads and an erasing head are used, making it possible to record and then play back a fraction of a second later. The auxiliary equipment includes amplifiers with flexible equalizers for recording and reproducing, oscillators with adjustable output and frequency for biasing and erasing, and an electronic speed control for the reversible-drive motor. Frequency-response measurements are made with an automatic frequency-response recorder.

Photographs of a loop tester for making tests with a short, endless loop of wire are shown. With this apparatus it is possible to test experimental recording, reproducing, and erasing heads, as well as samples of recording wire. Frequency response measurements, signal-to-noise ratio measurements and even listening tests can be made, as well as various other tests.

Magnetic recording is possible because certain ferromagnetic materials retain some magnetic induction after removal of an applied magnetic field. The portion which is retained is called remanence. For the benefit of those readers who may not be familiar with the distinction between remanence and residual induction in magnetic terminology the following definitions are given. *Remanence* is the magnetic induction which remains in a magnetic circuit after the removal of an applied magnetomotive force. *Residual induction* in a magnetic material is the magnetic induction at which the magnetizing force is zero when the material is in a symmetrically cyclicly magnetized condition. Remanence is usually less than residual induction because of the self-demagnetizing field.

Magnetic Materials

The relation betwen the residual induction and the field intensity by which it is produced is not linear. A graph showing the normal magnetization curve and the residual induction curve for a sample of carbon-steel wire is shown in Fig. 2. Starting with a completely demagnetized recording medium, it can be seen that severe distortion will occur unless some means of biasing is used. A field alternating at a supersonic frequency can be used to provide this bias.

We shall now analyze the com-

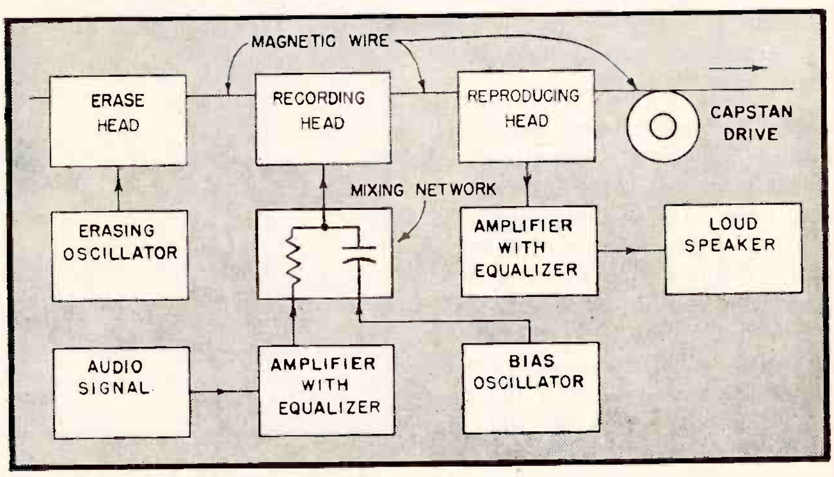


FIG. 1—Block diagram of an experimental magnetic recording system employing a supersonic bias field

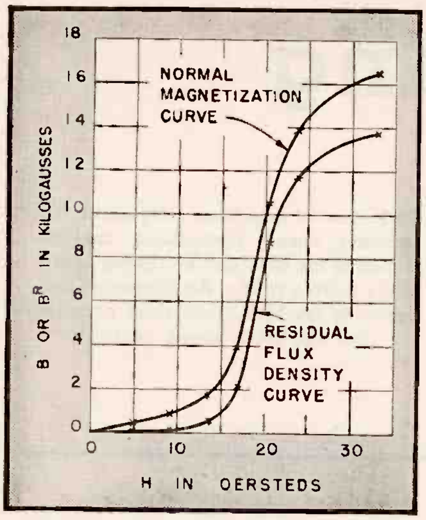


FIG. 2—Normal magnetization curve and residual induction curve for carbon-steel wire

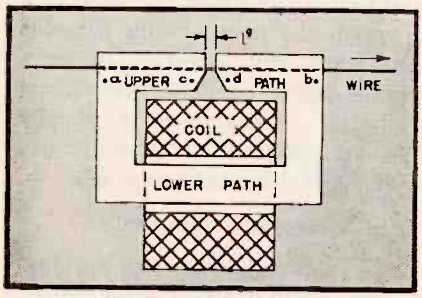


FIG. 3—Schematic diagram of a typical recording-reproducing head

bined action of the audio field and supersonic bias field from three points of view. In the first place, we shall examine the step-by-step relations as successive elements of the recording medium enter the recording gap. Next, we shall extend the analysis to show the averaging effect from point to point for a complete audio cycle. Finally, we shall show the analogy between these explanations and the commonly accepted graphical analysis for a pair of triodes in push-pull.

Magnetic Action of Supersonic Field

Figure 3 shows a schematic diagram of a typical recording-reproducing head. Let us now consider, step by step, the sequence of events taking place as a demagnetized element of the recording medium enters the recording gap from the seclusion of one of the poles, travels through the resultant field in the gap, and finally enters the slot in the second pole piece, where it is again shielded from the influence of the recording field.

The instantaneous value of field intensity in the gap, H_g can be expressed as follows

$$H_g = H_A \sin(\omega_1 t + \theta_1) + H_B \sin(\omega_2 t + \theta_2) \quad (1)$$

in which H_A is the maximum instantaneous value of the field due to the audio signal

H_B is the maximum instantaneous value of the field due to the bias signal

ω_1 and ω_2 are the angular velocities corresponding to the frequencies of these signals

θ_1 and θ_2 are the relative phase positions of their respective signals

The graph of Fig. 4(a) shows curves of instantaneous values of field intensity in the gap, together with the audio component for a typical case.

Assume that the gap length is such that 1.5 cycles of bias signal will have been completed during the passage of the element of recording medium through the gap. This means that as each element passes through the gap, it will be subjected at least once to a field corresponding to the instantaneous audio signal plus the peak value of bias field in the same direction. The resultant maximum instantaneous field is the one which in large measure determines the value of the remanent flux density.

The graphs in Figure 4(b) illustrate three possible cases for successive elements entering the recording gap during a positive half-cycle of audio signal. Let us refer to the first of these graphs and consider in detail the phases through which an element of recording medium passes as it is subjected to the varying resultant field in the gap. Assume that the element enters the gap in a demagnetized state at time t_1, at which time the resultant field is zero. As the field rises to its first positive maximum value P, the flux density in the element follows the initial magnetization curve to point P'. Succeeding variations $PQRS$ in the resultant field cause the flux density to follow the path $P'Q'R'$ to S'. At this instant the element is assumed to start to enter the second pole piece, the resultant field acting on the element remanent flux density corresponds to the signal recorded on the element. The other two graphs represent the changes in flux density for elements entering the gap at t_2 and t_3. A linear system exists only if the values of remanent flux density are in direct proportion to the corresponding instantaneous values of audio signal.

It should be noted that this analysis differs considerably from a recently published explanation of the function of the supersonic bias

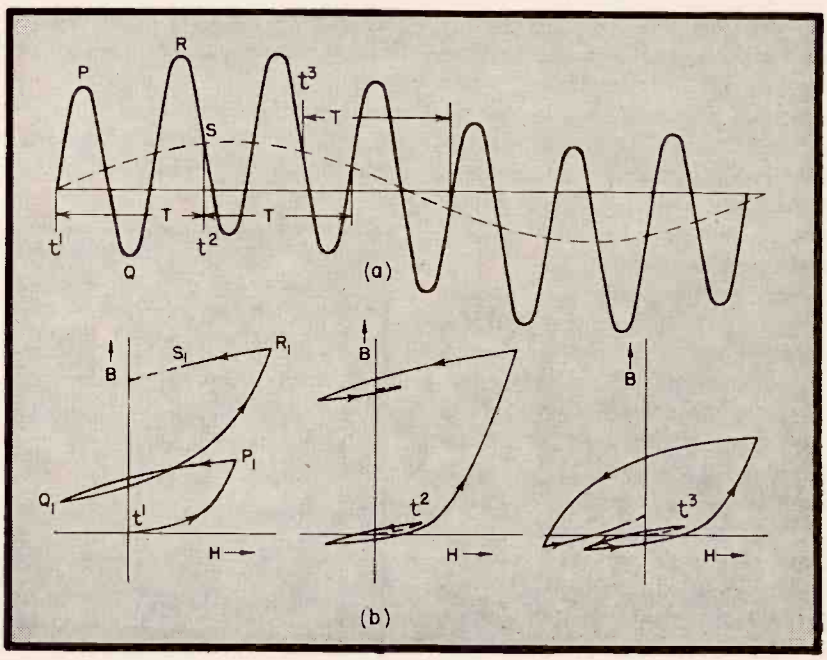


FIG. 4—(a) Curves of audio field and resultant supersonic field in the recording gap. (b) Curves showing assumed changes in gap field intensity acting on elements of recording medium

field in that each of the curves in Fig. 4(b) starts from the origin and cannot be assumed to be a part of or attached to any hysteresis loop.[1] It is well-known that several cycles with constant maximum values of field intensity must be completed before the induction in a given magnetic material can be assumed to follow the same path around either a major or a minor hysteresis loop. In a practical case there is not enough time to produce a stabilized major loop because there is considerably less than one-half cycle of audio signal during the passage of an element through the gap. Neither can stabilized minor loops, due to the bias field, be assumed because for even a relatively high value of bias frequency only three or four cycles will be completed during the transit time of an element across the gap. Furthermore, the audio signal is never quite constant, even for this short time interval.

Analysis of Magnetic Transfer Characteristics

An extension of this step-by-step analysis to explain the averaging effect for a complete audio cycle is shown in Fig. 5. As shown in the block diagram of Fig. 1, the supersonic bias signal is mixed with the audio signal in a mixing network. The resulting current in the recording coil and field strength in the gap should be a simple mixed signal without modulation.

When no audio signal is present, the record on the wire will consist of a signal of supersonic frequency and of low amplitude. The amplitude will be low for two reasons. In the first place, the magnitude of the bias field is adjusted to a value which will just bring the operating point for zero audio signal up to the lower knee on the residual magnetization curve. The corresponding value of residual flux density for most ferromagnetic materials is low. In the second place, self-demagnetization is very pronounced at the supersonic frequency which is used for the bias field because this frequency corresponds to short magnet lengths on the recording medium. Thus the effective remanence is still lower than indicated by the curve under the condition of zero audio signal.

Now assume a sinusoidal audio signal to be superimposed on the supersonic bias field. Although in this case the combined signal recorded on the wire will have small variations corresponding to the bias frequency, it will have short time average values which are nearly proportional to the instantaneous magnitudes of the audio signal. The small variations are eliminated because any practical reproducer will not respond to the bias frequency.

This being the case, we can analyze the performance of the system during recording as follows. Referring again to Fig. 5, the positive peak values of resultant field are projected up to the residual-flux-density curve. The corresponding residual-flux-density values are plotted on the time axis at the right as curve *A*. The construction for the second positive peak is shown. The negative values are found in a similar manner and are plotted as curve *B*. The sum of curves *A* and *B* represents the residual flux density. If self-demagnetization can be neglected, this represents the flux signal recorded on the wire.

It can be seen that some distortion is still present, although the distortion has been reduced greatly from what it would have been without the bias field. Some further reduction could probably be obtained by a more judicious choice of bias and audio signals.

The distortion with high-level audio signals cannot be reduced by adjustment of the bias because this distortion is due to the upper bend of the residual-flux-density curve. An increase in the bias field beyond that giving minimum distortion with low-level audio signals only re-

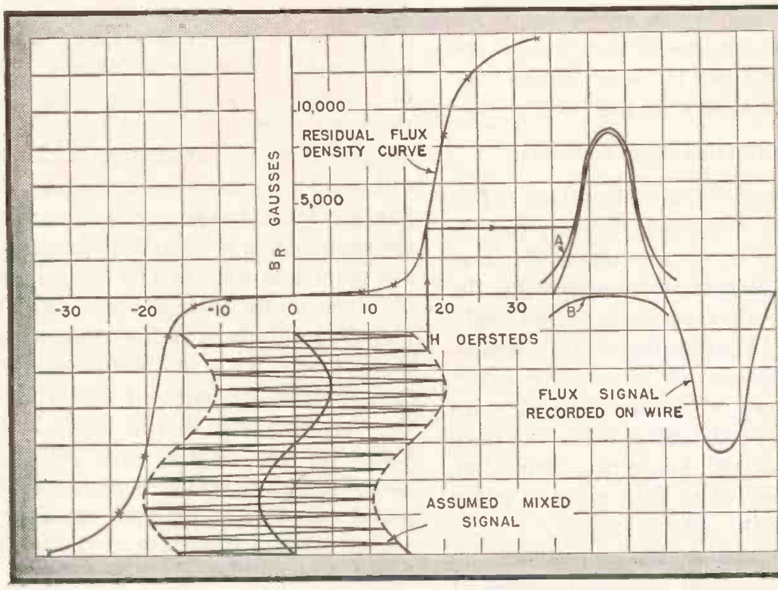


FIG. 5—Graphical analysis shows the combined actions of the audio and supersonic fields in the recording gap. Construction shows how recorded flux is obtained from combined magnetizing fields and magnetization curve

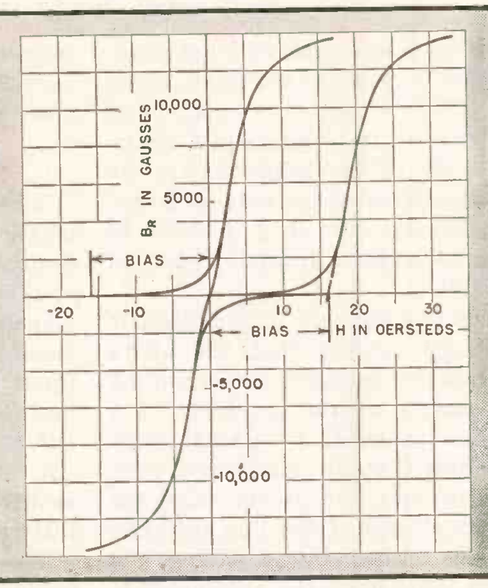


FIG. 6—Determination of correct bias field and construction of overall magnetic transfer characteristic

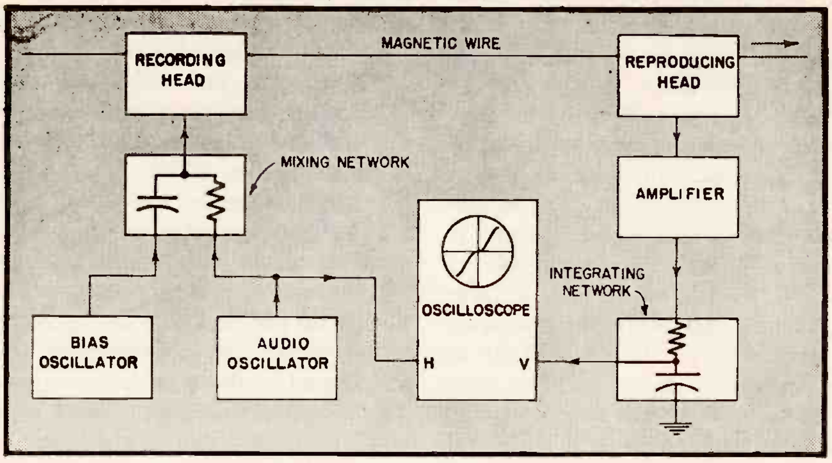


FIG. 7—Block diagram of the equipment for experimental observation of the overall magnetic transfer characteristic

sults in deterioration of the high-frequency response and reduction in the length of the linear portion of the over-all transfer characteristic. It is obviously desirable to have the linear portion of the over-all transfer characteristic long in order to have as large a dynamic range as possible.

The thought will probably occur to many readers that the above analysis is somewhat similar to the explanation of the operation of a pair of triodes as a class-AB push-pull amplifier. In accordance with this analogy, the proper value for the amplitude of the bias field can be determined by extending the steep portion of the residual-flux-density curve downward until it intersects the zero axis and reading the corresponding value of field intensity. The positive and negative portions of the curve can be shifted to the left and right respectively by the amplitude of the bias field, and the overall transfer characteristic can be considered to be the sum of the two portions. These relations are shown in Fig. 6.

Distortion Measurements

The non-linear distortion of a magnetic recording system can be evaluated in several ways. We have studied distortion by observing the transfer characteristic on an oscilloscope, by obtaining output-versus-input curves, by measuring intermodulation with two-frequency input, and by listening tests. We have not measured harmonic distortion, as we feel that this method gives little useful information.

The transfer characteristic can be observed on an oscilloscope if variations in the wire speed are very small. A signal from an audio oscillator is recorded on the wire in the usual manner and is also applied to the horizontal plates of the oscilloscope. The recorded signal is reproduced an instant later in a reproducing head located near the recording head, but well shielded from its stray-field influence. This signal is amplified and passed through an integrating network to the vertical plates of the oscilloscope. A block diagram for this setup is shown in Fig. 7. It is necessary to adjust the frequency of the audio oscillator so that the delay introduced while the wire travels from the recording head to the reproducing head is an integral number of half cycles. The integrating network is necessary because the output from the reproducing head depends upon the rate of change of flux through its magnetic circuit.

By use of this rather simple setup, the transfer characteristic can be observed while the amplitude of the bias or audio signal is varied, or the transfer characteristics of different wire samples can be compared. Photographs of transfer characteristics obtained in this way are shown in Fig. 8. The amplitude of the audio signal was great enough to produce overloading with correct bias, as is evident from the curvature at the ends of the transfer characteristic in Fig. 8(c). The loops in the oscillograms of the transfer characteristics are due to phase distortion in the amplifier and to slight instability of the wire speed and oscillator frequency.

Curvature of Transfer Characteristics

Output-versus-input curves are useful in finding out quickly the limit of input signal level, the corresponding magnitude of the output signal from the reproducing head, and the noise level. If these curves

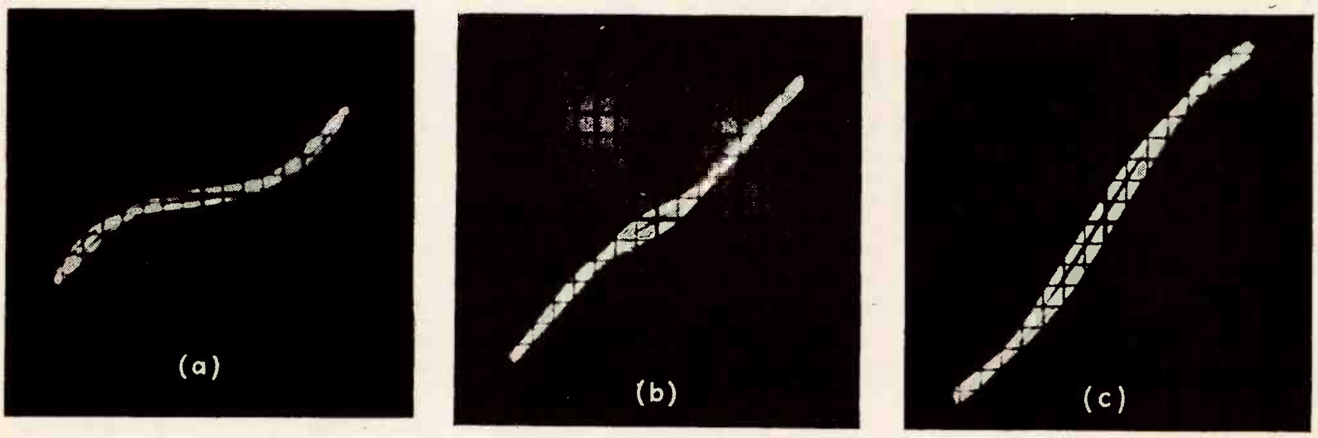


FIG. 8—Photographs of transfer characteristics as reproduced on an oscilloscope show the effect of supersonic bias: (a) no bias; (b) insufficient bias; (c) correct bias

are plotted in decibels, they should be straight lines rising at a 45 degree angle over the range of input which gives linear operation. The point at which the curvature becomes appreciable is a fair indication of the maximum input signal that can be used and the maximum output signal available. Typical curves taken at several frequencies are shown in Fig. 9. It is apparent from these curves that the input current at which overloading starts is about the same at widely different frequencies. In some cases, however, overloading occurs with lower input levels at the higher frequencies. The use of these curves in determining signal-to-noise ratio will be discussed later.

Intermodulation measurements afford a more accurate method of determining distortion than either of the two discussed. This method consists of simultaneously recording two sine waves, one of low frequency and large amplitude and the other of high frequency and small amplitude, and of measuring in the output of the reproducing head any resulting modulation of the higher-frequency component by the lower.[2]

Figure 10 shows typical modulation envelopes of the high-frequency component for conditions of no bias, insufficient bias, and correct bias. The corresponding percentages of modulation are: 65 percent, 25 percent, and 32 percent, respectively. The oscillograms of the modulation envelopes were taken with the same peak audio signal and the same values of bias as the correspondingly lettered transfer characteristics in Fig. 8.

As mentioned before, overloading and consequent modulation occurred with correct bias because of the large amplitude of the audio signal. If the amplitude of the audio signal is reduced somewhat and the bias is left at the correct value, the transfer characteristic becomes nearly straight, the modulation envelope nearly uniform in width, and the percentage of modulation correspondingly low.

Procedure for Listening Tests

The listening test is the final criterion in judging a recording system. It has been found convenient to make listening tests by re-recording from high-quality vertically-cut Vinylite transcriptions. The pickup used is a Western Electric 9-A. The recording and playback amplifiers contribute a total of not more than about 4 percent intermodulation, and 1 percent harmonic distortion. The recording amplifier includes a flexible equalizer for both low and high frequencies. The playback amplifier includes a flexible low-frequency equalizer. A dual-coaxial speaker having substantially uniform response from 80 to 10,000 cps. is used. An additional high-quality amplifier fed from the same 9-A pickup is used for playing the transcriptions directly. Arrangements can be made for comparing the two systems on the same loudspeaker by quick switching. When using the magnetic wire loop tester there is sufficient delay between recording and reproducing so that the same phrase can be heard first from the transcription and then from the magnetic recording. This test gives much better comparisons than listening to an entire selection, first from a transcription and then from a magnetic recording. When the level of the two systems is the same, quick switching is the best method we know of for showing significant differences introduced by the magnetic recording system.

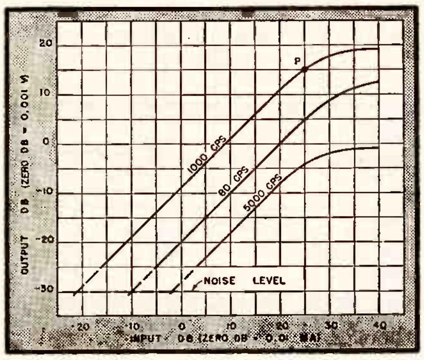


FIG. 9—Typical input-output curves for constant frequency show the range of linear response of the magnetic wire at various frequencies

Frequency Response

Magnetic recording is a phenomenon depending on current. The field intensity in the recording gap is nearly directly proportional to the mmf of the coil and this mmf is directly proportional to the current in the coil. The current in the coil can be made practically independent of the frequency of the input signal voltage by using a series resistance which is large compared with the reactance of the coil. With constant input voltage this should result in nearly the same value of field intensity in the gap for all fre-

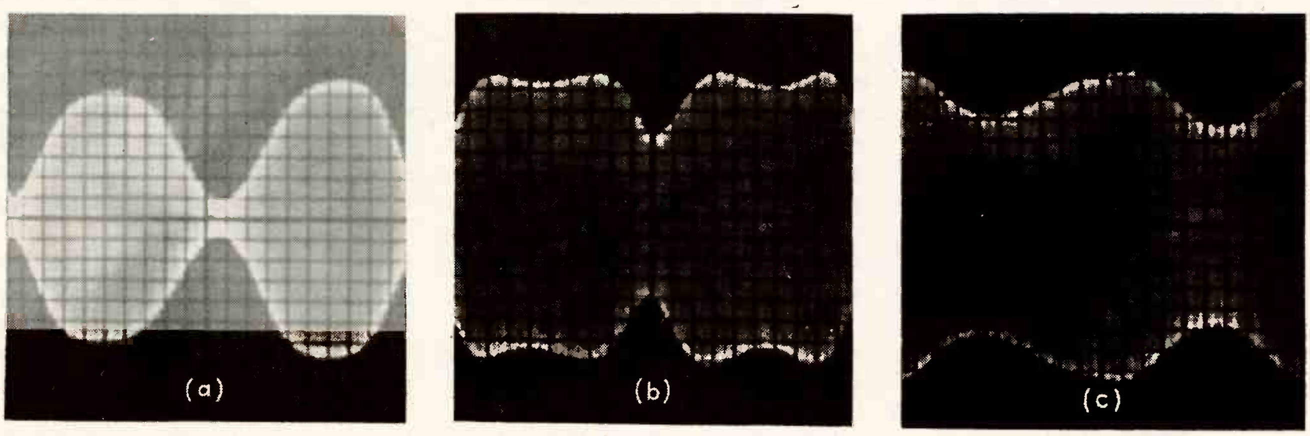


FIG. 10—The modulation produced by one audio frequency on another indicates curvilinear transfer characteristics. The greatest cross modulation occurs with no bias (a). As the bias is increased (b) the modulation decreases. Although the percent modulation shown at (c) is greater than at (b), fewer sidebands are produced, thus this condition represents the optimum supersonic bias

quencies within the desired range. Unless otherwise specified, all of the frequency response characteristics to be discussed or shown represent the open-circuit voltage at the terminals of the reproducing head and are recorded with constant-current.

Under these conditions, if we disregard for a moment the serious demagnetization effect which takes place with short magnets, the magnitude of the residual flux density should be independent of the frequency. The length of the individual magnets is inversely proportional to frequency. Hence, as the frequency increases, the magnets become shorter. Because the flux lines must pass through the surface of the wire and through the air or other medium to a pole of opposite polarity, the surface density of the lines increases in direct proportion to the frequency, even though the maximum internal density across the sectional area of the wire may remain constant.

Effect of Air-Gap Length

The time rate of change of the lines leaving the surface of the wire at a north pole and returning through the magnetic circuit of the reproducing head to a nearby south pole determines the value of emf induced in the reproducing head. The maximum rate of change for a constant total number of lines is thus directly proportional to the frequency. This should produce a constant rise in output with frequency at the rate of 6 db per octave. Actually, this is found by measurement to be nearly true only at the lower frequencies. As the frequency is increased, the air-gap length in the reproducing head influences the frequency response according to the following equation:

$$E = KB_m S_w \sin\left(\frac{\pi l_g}{\lambda}\right) \qquad (2)$$

n which E is the rms voltage at the terminals of the coil
B_m is the maximum value of the remanence corresponding to the maximum instantaneous audio signal
S_w is the wire speed
λ is the wavelength corresponding to the audio signal recorded on the medium
l_g is the air gap length in the reproducing head
K is a constant depending on the units, and also upon the coupling between the wire and the magnetic circuit, as well as the size and configuration of the magnetic circuit, and on the properties of the reproducing coil itself

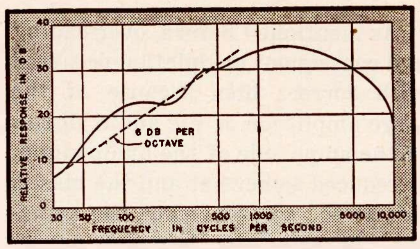


FIG. 11—Experimental frequency-response curve for constant-current magnetic recording

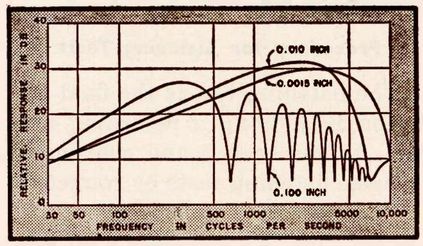


FIG. 12—Effect of gap length on frequency response

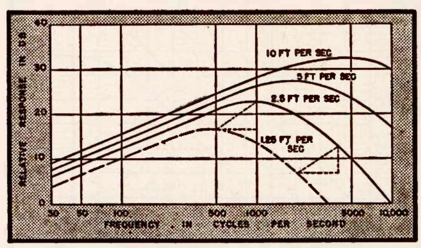


FIG. 13—Effect of wire speed on frequency response; solid curves were obtained experimentally, dashed curve was obtained graphically

At low frequencies $\sin \pi l_g/\lambda$ is approximately proportional to the frequency and the output voltage should rise at the rate of nearly 6 db per octave. At higher frequencies $\sin \pi l_g/\lambda$ is not proportional to the frequency and at a frequency such that $l_g = \lambda/2$, the output voltage reaches a maximum, then falls to zero when $l_g = \lambda$. The voltage again increases to a maximum at a frequency such that $l_g = 3/2\,\lambda$, falls to zero at $l_g = 2\,\lambda$, etc. A typical frequency response curve for constant-current recording is shown in Fig. 11.

The effect of using gaps of different lengths for the reproducing head is shown in Fig. 12. For the long gap there is much better correlation between the calculated and observed values of frequency at which maximum response occurs than with the short gaps. This is true for two reasons. In the first place, fringing effect causes a smaller percentage increase in the effective length of a long gap than of a short gap. Secondly, with a long gap, the demagnetizing effect is negligible at the frequency of the first maximum, whereas with a short gap, the demagnetizing effect tends to reduce the output voltage at the higher frequencies, resulting in a reduction in the frequency at which the first maximum response occurs.

Effect of Speed on Frequency Response

The speed at which the recording medium is driven has a pronounced effect on the high-frequency response of a magnetic recording system. On the other hand, the speed has only a slight effect at low frequencies. This is shown by the experimental curves of Fig. 13, which were all taken with the same input level. For simplicity the peaks and dips in the low-frequency region were averaged out when the curves were redrawn.

The more pronounced effect of speed on the high-frequency response is caused by self-demagnetization and by the relation between wavelength and gap-length. At low frequencies self-demagnetization is negligible, so that the remanent flux density is independent of wavelength and hence of the speed which, at any given frequency, determines the wavelength.

At the higher audio frequencies self-demagnetization is pronounced and, at a fixed frequency, increases rapidly as the speed is reduced. This results in a reduction in the high-frequency response. The high-frequency response also deteriorates when $\pi l_g/\lambda$ lies between $\pi/2$ and π. In a practical system, the wire speed is made such that this occurs near the upper end of the working frequency range.

Both of these effects are important, but the experimental determination of the relative reduction in response caused by either is difficult.

Assuming a given fixed wavelength recorded on the wire, the demagnetizing effect and the effect of the gap-length will be constant and independent of the speed at which the wire is driven. Both the output voltage and its frequency will then be directly proportional to speed. Knowing this, it is easy to find the constant-current frequency response at any wire speed from the response curve at a known speed by a simple graphical construction. A right triangle is drawn with its hypotenuse rising 6 db per octave. The length of the base is taken as the distance on the logarthmic frequency scale between two frequencies having the same ratio as that of the known speed to the speed at which the frequency response is desired. An example of this construction is shown in Fig. 13 where the dashed curve represents the frequency response at 1.25 feet per second as obtained from the response at 2.5 feet per second. The dashed curve is traced by the lower left hand corner of the triangle as the apex is moved along the response curve for 2.5 feet per second while the base is kept parallel to the zero axis.

Recording-Reproducing Heads

In spite of the fact that the frequency response for a given medium can be modified somewhat, especially at the higher frequencies, by changes in the design of the recording head, we find that these modifications are small as compared with those which occur with minor changes in the reproducing head. For practical reasons, it is desirable to use the same head for both recording and reproducing. Therefore the limitations imposed by the playback conditions are the ones which ordinarily control the design. The power required for recording is in the order of a few milliwatts, so that this does not impose any severe limitation on the amplifier design, even if a recording head with low recording efficiency is used.

For playback, the design of the reproducing head is very critical. The gap must be short in order to obtain good response at the higher audio frequencies. The material should have as high a permeability as possible at low flux densities. The eddy-current losses should be low in order that the high-frequency response will not be impaired. The magnetic coupling between the recording medium and the head should be good, especially in the immediate vicinity of the gap. On the other hand, the magnetic coupling between the recording medium and the head at the points of entry and exit should be kept as low as possible in order to reduce the magnitude of the secondary or stray flux which may produce certain undesirable variations in the frequency-response curve.

Effect of Coil Location

Let us consider the manner in which these undesirable variations are produced. If we refer again to Fig. 3, it can be seen that the passage of the wire through the slot in the reproducing head sets up an alternating magnetic potential between points a and b, and at the same time another alternating magnetic potential is set up between c and d. The magnetic potential between a and b reaches a maximum effective value at a relatively low audio frequency in a playback head of practical size. Alternate dips and peaks occur in the effective values of this magnetic potential at regularly spaced frequency intervals, depending upon the wavelength recorded on the wire relative to the effective width of the reproducing head. We shall call the flux due to this magnetic potential the secondary or stray flux.

There are two paths for this stray flux. One is directly across the top of the head and through the gap. The other is from a down through one of the vertical legs, across the lower leg and up the other vertical leg to point b in Fig. 3.

The alternating magnetic potential existing between c and d is the one which gives the useful response. There are also two paths for the flux produced by this alternating magnetic potential. One of these is directly across the gap. The other is around the complete magnetic circuit in a counter-clockwise direction for the positive values of magnetic potential.

Now consider the coil to be mounted as shown in Fig. 3. The resultant alternating flux and emf produced are the result of two alternating magnetic potentials. The useful component increases with frequency, according to the equation previously given. As mentioned above, the other component passes through several positive and negative peaks as the frequency changes over the audio spectrum. The total response will now show peaks and dips which become less pronounced as the frequency is increased.

If the coil is moved to a position where it surrounds the upper leg of the circuit, a similar response curve will result, except that the phase of the emf due to the stray flux is reversed, causing the positions of the peaks and dips to be interchanged. Experimental curves showing these effects are given in Fig. 14.

Correlation Between Magnetic Characteristics and Frequency Response

In the design of permanent magnets, great stress is attached to the proper shape and size of the magnetic circuit so that the permanent-magnet material may be used at or near the point of maximum energy. This makes the most efficient use of the costly alloys which are used for permanent magnets. Such a design is not possible for the case of a medium used for magnetic recording because the ratio of length to diameter for the individual magnets which make up the record varies from a value which is large at low frequencies to one which is less than unity at the higher frequencies.

The retentivity of the magnetic recording medium for a given wire speed determines the maximum value of the output voltage at the lower audio frequencies. At these frequencies the wavelength is relatively long and self-demagnetization is not serious. For this reason, one would expect to have good bass response for materials with high retentivity. A large number of our experimental frequency-response curves have shown this to be true.

The second magnetic characteristic which affects the frequency response to a very great degree is the coercive force of the material. The demagnetizing field intensity can be considered to be equal to the product of the demagnetization factor and the remanent flux density. The demagnetization factor increases in magnitude as the ratio of the length of a permanent magnet to its diameter decreases. Whether or not the flux density is greatly reduced because of the demagnetization factor depends on the shape of the demagnetization curve, and especially upon the value of the coercive force.

The effect of demagnetization is less with materials having high coercive force. It is generally considered to be true that a magnetic material which has high coercive force will also have low retentivity. This is especially true of many of the materials which are being considered for use in magnetic recording. This means that we may have to sacrifice some output voltage at the lower audio frequencies in order to extend the upper frequency range by use of a material which has high coercive force but low retentivity.

Mechanical Sources of Noise

At the present time we cannot say that magnetic recording gives a system with negligible noise. We can say, however, that for a given reproduced-frequency bandwidth and for carefully controlled laboratory recording and reproducing conditions, the background noise is considerably less than that for the corresponding-frequency bandwidth on shellac records, but that it is not as low as the background noise on vertically-cut Vinylite transcriptions.

Mechanical imperfections in the wire which result in changes in sectional area along the wire may be responsible for the generation of noise voltages in the coil of the playback head. For a wire diameter of 0.004 inch, a variation in diameter of 0.0001 inch corresponds to an area change of about 5 percent. Corresponding changes in the recorded flux signal appear as noise when reproduced. If the variation in diameter is random, random noise will result. However, if the imperfections occur at regularly spaced intervals along the wire, a distinct tone will appear.

Either transverse or longitudinal vibrations of the medium as it is drawn through the reproducing head may also be the cause of undesirable background noise. These vibrations may be produced either by the irregular surface of the wire or by nonuniform torque anywhere in the driving system. These vibrations of the medium result in corresponding pulsations of flux linkages through the coil and a noise voltage in addition to the signal voltage appears at the terminals of the playback head.

Magnetic Noise Sources

We have found that although different wires may seem to be perfectly uniform in external appearance, they may vary considerably in noisiness. Some samples show an absolute noise level which is 20 db greater than that of some other samples. Although we have not yet been able to correlate the noise level with the composition, heat treatment, and degree of cold work used in preparing the samples, we think that it depends on the final magnetic structure which in turn is determined by these factors.

The magnetic noise increases in the presence of a recorded signal. This can be demonstrated by recording a sine-wave signal on the medium and filtering out the signal and its harmonics in the reproducing system. The reproduced noise will have frequency components distributed throughout the band passed by the filter. This noise increases as the amplitude of the recorded signal is increased and is reduced to a low value after the medium has been subjected to the erasing field. It seems probable that this noise is caused by the finite size of the elementary magnetic particles of the medium. A certain amount of such noise is not noticeable, as it is ordinarily masked by the signal. However, an excessive amount imparts a disagreeable fuzzy quality to the reproduction. It was pointed out earlier that any magnetic recording system using direct-current bias ordinarily leaves the recording medium magnetized even in the absence of an audio signal. In this case, the noise is particularly bad because there is no signal to mask it.

Equation (2) indicates that the noise voltage should increase with wire speed. This is confirmed by our measurements which show that the noise level rises at least 6 db each time the speed is doubled.

Another effect which may contribute to the noise is socalled crosstalk. This is the effect of adjacent turns or layers of the recording medium on each other when wound on a spool for storage. It is possible for one turn of strongly magnetized recording medium to magnetize an adjacent turn. This re-recorded signal may show up as objectionable noise, particularly during quiet passages of a selection where it would not be masked by the desired signal. Crosstalk can be reduced to a negligible amount by choosing a recording medium having low retentivity and high coercive force.

In considering noise, that originating in the reproducing system should also be mentioned. The signal output from a high impedance reproducing head is of the order of only a few millivolts, which makes it necessary to use a large amount of amplification. The amplifier must be carefully designed to minimize thermal noise and to be free from hum. In addition, the effects of stray electrostatic and electromagnetic fields on the reproducing head must be minimized by shielding or other means. The problem of eliminating hum is aggravated when post-equalization of the low frequencies is used. This is apparent from the fact that 15 or 20 db of equalization at 60 cycles is necessary in some cases for flat response.

Loss of Output Signal With Repeated Playings

There have been many general statements concerning the permanency of the records on magnetic wire. Much more information than we have at present is needed before we can make well-founded statements concerning the ability of the wire to retain a record indefinitely without loss. Experiments show that there is a loss of from 3 to 25 db in output from a given record during the first few playings. After this initial aging process there seems to be little further loss for a reasonable time and a reasonable number of playings. In general, materials which have properties desirable from other view-points tend to show small loss with repeated playings. As far as we know, no great difficulty has been experienced on account of this effect.

Equalization and Signal-to-Noise Ratio

Once the factors affecting the maximum signal and those affecting the noise have been determined, the problem of determining the effective signal-to-noise ratio remains. The effective signal-to-noise ratio depends not only upon the factors already discussed but also upon the frequency distribution of the noise, the frequency distribution of the speech or music to be recorded, and upon the amount of pre-equalization and post-equalization.

It has been accepted practice in some other fields to record with a characteristic rising toward the high frequencies and equalize in the reproducing circuits to give an overall flat response. It has been found that some increase in the signal-to-noise ratio can be accomplished by this practice. In the case of magnetic recording, however, it is not feasible to use a comparable amount of such pre-emphasis and post-equalization because at the speeds which are desirable for recording, the frequency response at the higher audio frequencies falls off very rapidly. However, even in this case, enough pre-equalization can be used to make the overall response flat within a specified frequency range. Post-equalization for increasing the high-frequency response is not desirable, because the objectionable noise has been found by rough measurements and by listening to occur largely at medium and high frequencies. Post-equalization would amplify the noise as well as the signal.

Due to the fact that, in reproduction, the low-frequency response of the system is inherently lower than the response in the middle-frequency range, some form of bass equalization must be used. It is not feasible to use sufficient pre-equalization to obtain even flat overall response because the wire will not accept the resulting large recording signals without overloading. A sufficient reduction of the recording level to permit the use of pre-equalization would result in a less favorable signal-to-noise ratio. On the other hand, post-equalization is feasible because the amount of noise in the low-frequency region is small.

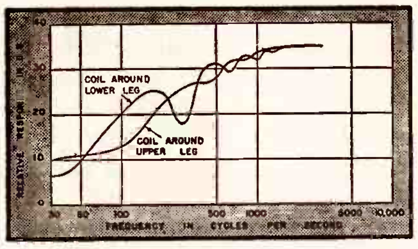


FIG. 14—Experimental curves showing that peaks and dips in the frequency response are dependent upon coil placement

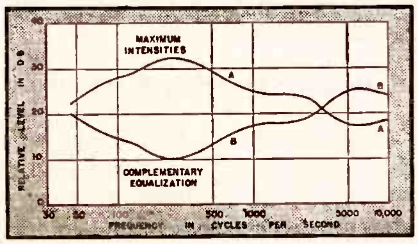


FIG. 15—Curve *A* shows frequency distribution of maximum sound intensities for a symphony orchestra. Curve *B* shows the desired complementary pre-equalization.

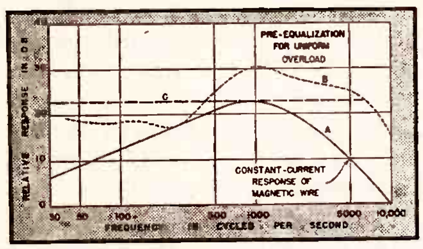


FIG. 16—By using a pre-equalization network having the characteristics of curve *B*, which is the sum of curve *A* in this figure and curve *B* in Fig. 15, overloading of the magnetic tape is equally likely to occur at all frequencies

Equalization Against Overload

The following example serves to illustrate the application of these principles to a practical magnetic recording system. Curve *A* of Fig. 15 represents the frequency distribution of the maximum intensities occurring in symphony orchestra music.[3] This curve is drawn at a level which is exceeded by 5 percent of the peaks and can be used as an indication of the relative levels which must be accommodated by the system at various frequencies. Having this information, it is possible to decide upon the amount and type of equalization which will result in the highest signal-to-noise ratio, and to arrive at the approximate value of the signal-to-noise ratio.

From curve *A* of Fig. 15 it is apparent that with constant current recording the system will overload most often at about 250 cps. In order to make the most effective use of the system it would be desirable to have overloading occur equally often at all frequencies. This can be done by using pre-equalization which is complementary to curve *A* of Fig. 15, as shown by curve *B* of the same figure.

Passing on to Fig. 16, there is shown (curve *A*) a typical, smoothed constant-current response curve. This is the curve at 2.5 feet per second replotted from Fig. 13. If we now take the complementary equalization curve *B* of Fig. 15 and add it to this constant-current response curve we obtain curve *B* of Fig. 16 representing the over-all frequency-response of a system which has equal probability of overloading at all frequencies under the conditions assumed. This curve is obviously unsatisfactory from the standpoint of frequency-response, but is useful as a guide in determining the maximum amount of pre-equalization that may safely be used. For example, a useful amount of pre-equalization may be employed below about 250 cps and the remaining equalization found necessary to secure flat over-all response may be applied to the reproducing circuits. We have found that such low-frequency post-equalization does not appear to raise appreciably the random-noise level.

Upper Frequency Limit

Turning now to the upper portion of the frequency range we find that, without loss in signal-to-noise ratio, the high-frequency response can be made flat out to the frequency at which the uniform overload curve intersects a flat response line *C* drawn through the highest level of the constant-current response curve. The signal-to-noise ratio can then be taken as the difference between the level of the maximum undistorted output signal at the frequency of maximum response and the noise level. If it is desired to extend the frequency range, this can only be done with a sacrifice in signal-to-noise ratio.

For example, with the system for which curves are shown, when the high-frequency response is made flat up to 6500 cps, the maximum inherent capacity of the system can be utilized. If the flat response is extended to 9000 cps a loss of 5 db in signal-to-noise ratio will result. This loss is the difference between the level of the flat-response line drawn through the maximum level of the constant current curve and the ordinate of the uniform-overload curve at 9000 cps.

The maximum undistorted signal can be defined for the present purpose as that at which the output-versus-input curve for the frequency of maximum response departs 1 db from linearity. This is represented as point *P* on the 1000-cycle curve of Fig. 9. For the curves shown, the signal-to-noise ratio according to our definition would be 45 db for flat response to 6500 cps, and 40 db for flat response to 9000 cps.

The foregoing example tends to give an optimistic picture of the performance under the assumed operating conditions first, because it has been assumed that overloading occurs at equal input level regardless of frequency, and second, because it does not take account of magnetic noise. We have observed that overloading in some cases begins to occur with lower input current at the higher frequencies. The difference between the input level for maximum undistorted output signal at the frequency of maximum response and the corresponding value at the highest frequency in the assumed band must be subtracted from the signal-to-noise ratios obtained by the above method. For the example shown, however, this subtractive term amounted to less than one db at 5000 cps, which is negligible. Other measurements have shown that some materials show up to 15 db increase in their magnetic noise level with increase in recording signal. The sample for which the curves are shown was rejected on this account when a listening test was made.

The importance of judging a magnetic recording system by means of a critical listening test cannot be over-emphasized. Objective measurements such as frequency response, distortion, and noise measurements are invaluable in making a preliminary estimate of the quality of any component of a recording system and in pointing the way to improvements. However, the correlation between objective measurements and subjective effects is complex and not completely understood. Therefore, the listening test must always be used as the final criterion.

Magnetic Recording Possibilities

Our studies in connection with magnetic recording systems lead us to make the following general statements concerning the performance of present experimental systems and possible future improvements in magnetic recording systems.

Reasonable fidelity is possible at the present time. In order to get a system with low distortion, careful control of the bias field is necessary. The correct value of the bias field varies within wide limits for different recording media.

The signal-to-noise ratio which can be attained at present is superior to that which is obtained from the ordinary shellac disc recordings. It is not as good as can be obtained from the newest vertically-cut Vinylite transcriptions. We expect that improvement in the signal-to-noise ratio will result from further studies in connection with noise and that this will lead to improved recording media and improved design of the recording and reproducing heads.

It seems feasible at the present time to produce recordings at 2.5 feet per second on 0.004 inch diameter wire which are reasonably flat from 70 to 6500 cps. While the upper limit of frequency response may be raised by increasing the wire speed, it would appear more desirable to attempt to get better high-frequency response by improving certain magnetic properties of the recording medium. Actually it would be far more satisfactory from the viewpoint of cost to the consumer if the wire speed could be reduced to a still lower value, say 2 feet per second, or even 1.5 feet per second. These lower speeds seem to be quite satisfactory for the reproduction of speech. There are indications that improved design of the recording and reproducing heads will be necessary in order to utilize fully the newer materials which are being investigated for possible use as magnetic recording media.

In conclusion it should be pointed out that we are not attempting to specify any definite standards for magnetic recording at this time. The examples which have been presented are given simply for the purpose of illustration and do not necessarily represent our ideas as to the most desirable frequency limits, limits of distortion, or wire dimensions, and speeds. The experimental frequency - response curves which have been given represent average, rather than superior, samples and they were made without using special recording and reproducing heads.

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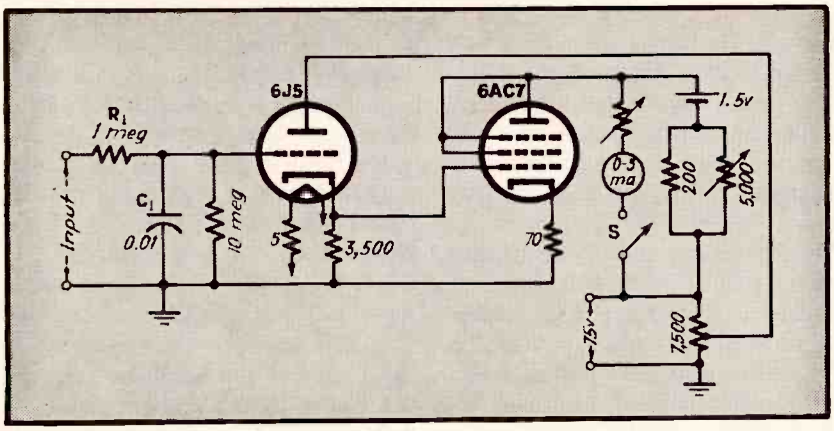

FIG. 1—Direct-current vacuum-tube voltmeter using a high-transconductance pentode isolated from the high-impedance input circuit by a triode connected as a cathode follower

Improved VACUUM-TUBE VOLTMETERS

Full advantage can be taken of the high transconductance and linear transfer characteristics of pentodes by using a cathode-coupled triode in the vacuum-tube voltmeter input. Such a combination provides an instrument having both high input impedance over a wide frequency range and high sensitivity

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Many vacuum-tube voltmeters employ a d-c microammeter as an indicator, with 1.5-volts input giving a deflection of 100-200 microamperes. The sensitive indicating instrument is needed because, (for reasons of stability, linearity, and low grid-current) the amplifier tube is operated in a region of low transconductance, with large degenerative feedback. When the feedback is great enough, calibration can be made nearly independent of tube characteristics and changes.

Microammeters have been improved in recent years so that they are no longer regarded as expensive and fragile instruments. Many voltmeters employing them seem quite satisfactory. However, it appears that a milliammeter would still have advantages when expense, durability, and availability are important. Furthermore, a stable voltmeter built to operate with a milliammeter at 1.5 volts input could have its range extended downward by the use of a more sensitive indicator.

Need for Greater Amplification

In order to use a less sensitive indicating instrument the vacuum tube must be operated in a region where its transconductance is high. Less degenerative feedback may be used but less is needed (for linearity at least) because the characteristic curve is more linear in this region. Although the use of television-type pentodes for voltmeters has occurred to several workers in the field, a tube of this type biased at a suitable operating point suffers from a rather large flow of grid current. This causes the input impedance to be low and produces an error in reading, the degree of error depending upon the impedance of the source.

Turner[1] has not only pointed out in detail the types of tubes with high transconductance that might be used for voltmeters but has also suggested that high effective-transconductance could be obtained by operating two or more tubes in parallel. However, parallel operation of tubes suffers from two disadvantages: first, the input capacitance and conductance are multiplied; and second, the total plate current increases greatly, so that more is demanded of the power supply.

Yard[2] has used a high-transconductance tube in a conventional circuit and obtained a deflection of

5 ma for 1.5 volts input. The deflection can be doubled by using a separate battery or cell to balance out the initial plate current. This circuit suffers from a lack of linear response, a shift of the zero-setting with line-voltage fluctuations, and a low input impedance of about 1.5 megohms. The grid resistor cannot successfully be increased very much because of the flow of grid current. These difficulties are probably inherent in any voltmeter employing a single tube of high transconductance or two or more tubes in parallel.

Cathode Coupling

It will be shown below that high-transconductance tubes can be used successfully in simple and inexpensive voltmeter circuits when some kind of input stage is used to provide high input resistance. High sensitivity and large output current result. The disadvantages accompanying small degenerative feedback are minimized by using balanced circuits and some means for quick calibration.

The circuit in Fig. 1 was designed to overcome, by sacrificing some simplicity, the short-comings of the single-tube voltmeter. This d-c voltmeter is essentially a two-stage amplifier with the first stage serving only to couple the source to the second tube. The first stage is a cathode-follower arrangement and is highly stable because of the large degeneration. The 6J5 is operated with low voltages on the heater and plate in order to reduce the grid current in both tubes. The high side of the input is connected through a shielded lead with a 1-megohm isolating resistor, thus providing an input resistance of 11 megohms. This resistance could be made larger.

Meter Characteristics

The bias for the 6AC7 is the algebraic sum of the voltage drops across the two cathode resistors. The initial plate current is balanced out by a No. 6 dry cell. Instead of this cell, a suitable voltage may be tapped from the bleeder resistance but this reduces somewhat the sensitivity. In order to protect the indicating instrument against excessive deflection, switch *S* is left open until the heater of the 6AC7 has warmed up. The sensitivity can be controlled by the rheostat in series with the milliammeter. The supply voltage is regulated by using a OA3/VR75 tube.

This voltmeter is strictly linear; the zero point is very stable and no appreciable grid current is observable in the 6J5. An input of 1.5 volts gives a full-scale deflection on a 5 ma instrument of 1 percent accuracy. The circuit is sufficiently stable so that, by means of a more sensitive indicator, the range of the voltmeter may be extended downward by a factor of two or three at least, depending upon the voltage fluctuations in the power line. The range may be extended upward by a conventional voltage-divider across the input. Because of the filtering action of the input circuit, d-c voltages can be measured correctly even in the presence of superimposed a-c voltages.

Balanced Circuit

This type of coupling can also be applied to a balanced circuit to avoid employing a dry cell and to stabilize more easily against line-voltage fluctuations. A stabilized power supply is usually not necessary and some simplification results. This is illustrated by the circuit in Fig. 2, a stable circuit with linear response. The two 6AG7 tubes and the two sides of the 6SN7-GT should be approximately matched for optimum stability. The milliammeter is connected to the plates of the amplifier tubes in the conventional bridge circuit. A deflection of 10 ma can be obtained for an input of 2 volts but the circuit is usually operated conservatively with the constants shown so that 1.5 volts produces a reading of 5 ma. When a 1-ma meter is used, satisfactory performance is obtained with a full-scale deflection corresponding to 0.3 volt. Slight effects of line-voltage fluctuations are observable at this sensitivity.

Although other types of tubes were tried in this circuit, the 6AG7 gave maximum sensitivity. The response with 6AC7's is only slightly lower however, and these tubes have the advantage of lower plate current (20 ma for two 6AC7's instead of 35 ma for two

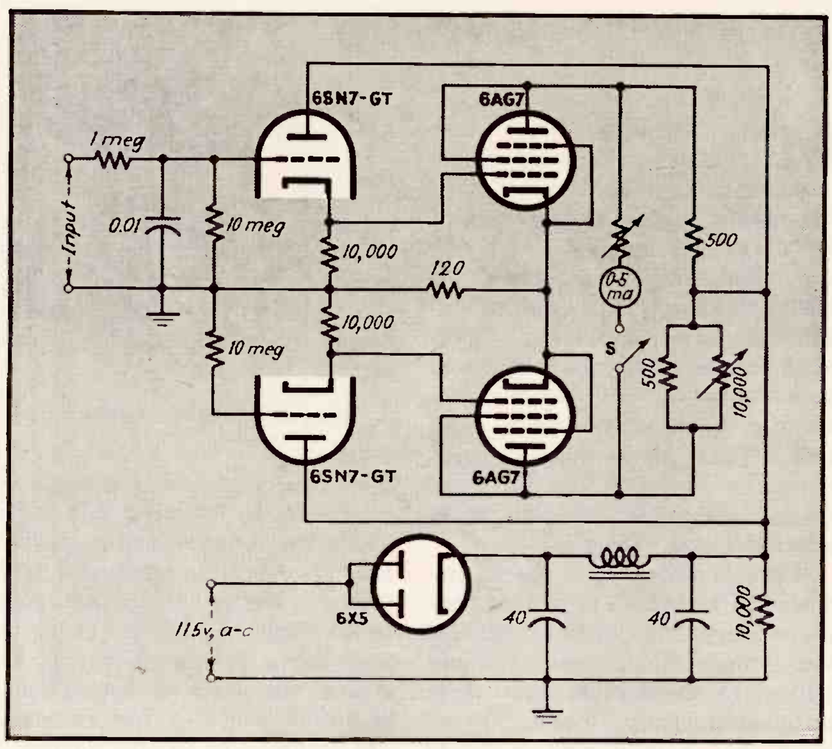

FIG. 2—Balanced voltmeter circuit uses cathode coupling and high-transconductance pentodes

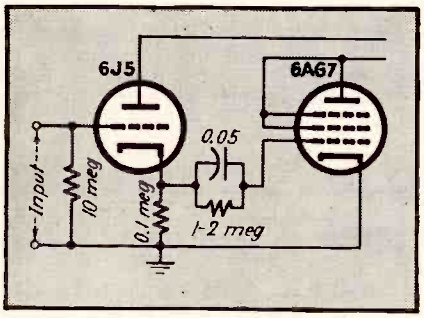

FIG. 3—Alternating-current vacuum-tube voltmeter with a cathode-coupled stage preceding the high-transconductance pentode grid-detector stage

6AG7's). At high plate current 50L6-GT tubes worked fairly well. A 6F8-G, with similar characteristics, might be preferable to the 6SN7-GT because higher input resistance could be obtained to the grid coming out of the top of the tube. It is possible that a selection of tubes with suitable heater ratings could be made in order to dispose of the filament transformer, to use cheaper tubes and to allow complete operation on a-c or d-c lines.

A-C Measurement

This type of circuit can easily be adapted to the measurement of a-c voltages. If R_1 and C_1 of Fig. 1 were removed, the insertion of a diode rectifier either before or after the first stage should work well and provide a linear scale. If placed after the first stage, the high input impedance of the circuit would be retained. An even simpler arrangement would be to allow rectification to take place in the first stage. This tube would then become what Rider[3] calls a reflex rectifier, or what radio publications often call an infinite-impedance detector.

In one adaptation to a-c that was tried, the grid circuit of the second stage was used as a rectifier, as illustrated in Fig. 3. With a 6AC7 tube, a deflection of 5 ma for 1-volt rms input is obtainable. The response is linear except over the very lowest part of the scale. Although this circuit was used only at audio frequencies, it has recently been shown by Daniels[4] that the cathode-follower circuit can be used up to several hundred kilocycles in voltmeter circuits without using an external probe.

By using ordinary triodes in all four arms of a Wheatstone-bridge circuit, Glenn[5] has constructed a voltmeter which can operate a 1-ma instrument on less than 0.5 volt input. Stability and high input resistance are claimed along with this high sensitivity. Instruments of higher range are not suitable for this circuit because all tubes must be operated at very low plate currents in order to avoid a large grid current in the input tube.

Wheatstone Bridge

The circuit shown in Fig. 4 is similar to that of Glenn, but contains the added resistors R_1 and R_2. The latter increase the power output greatly, especially when power tubes are used in the second stage. When tubes like 6V6-GT, 6L6 and 6AG7 are used at very conservative plate currents, a maximum deflection of 15 to 25 ma for 1.5 volts input is easy to obtain. Preliminary experiments have shown that the output can be made linear over the first 5 or 10 ma and that practical stability is possible. The use of separate resistors in the cathode circuits of the first stage is desirable.

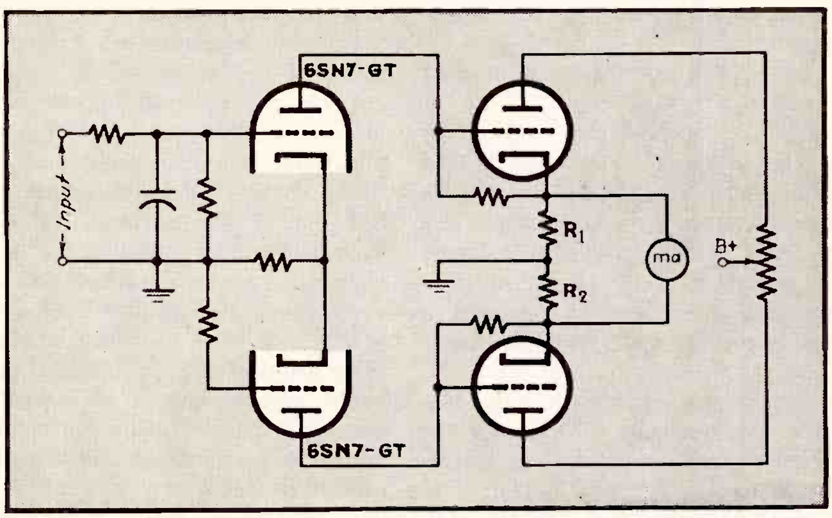

FIG. 4—Wheatstone-bridge balanced vacuum-tube voltmeter circuit combines high sensitivity and stability

Line-Voltage Compensation

Although balanced circuits like those of Fig. 2 and Fig. 4 are advantageous, complete compensation for line-voltage fluctuations is not attained in them. The difficulty arises from slight differences in dynamic characteristics and in heater characteristics of similar tubes and should be more prominent in circuits like those shown above, especially when little or no degenerative feedback is used. However, it was found that power-line fluctuations in our laboratory caused a negligible error in reading when balanced circuits were used. For cases where these fluctuations are larger or where a more sensitive indicating instrument is to be used, greater stability could be obtained by using a stabilized power supply or a constant-voltage transformer.

It can be expected in the above circuits that the calibration, depending more than usual upon tube characteristics, will change slightly as the tubes age. The inclusion of a Mallory bias cell in a voltmeter allows a frequent and rapid check upon this calibration.

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Stabilized NEGATIVE

Negative impedance is produced from a positive impedance of the desired type by positive feedback through an amplifier stabilized with negative feedback. Basic circuits and fundamental equations indicate the regions and limits of stability for ideal conditions

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INVERSE FEEDBACK is one of the most important developments in communication-network technique since the invention of the vacuum tube. Evolution of this principle can be traced along several independent courses two of which form the basis for this three-part article.

One of these courses culminated in Black's[1] disclosure in 1934 of negative feedback by means of which amplifiers can be stabilized and improved in many ways. A somewhat earlier contribution was made by Aiken[2], and Crisson[3] who discovered that by an appropriate application of positive feedback a two-terminal negative impedance could be obtained.

By combining the stabilizing feature described by Black and the negative-impedance concept introduced by Crisson and Aiken, it is possible to obtain a negative impedance that can be used as a stable circuit element. Thus by adding negative resistance, negative capacitance, and negative inductance to the list of positive impedances, the engineer now has at his disposal six elements for design instead of the usual three, making possible not only an improvement in some of the present circuit applications, but also opening an entirely unknown field of design.

The first two parts of this article show how stabilized circuit elements can be obtained and investigate their stability and reliability. A few practical applications are described in the final part —not to give an air of completeness, but merely to illustrate some of the ways in which the negative circuit elements can be used.

A positive resistance R is defined by Ohm's law as the constant of proportionality between the voltage across and the current flowing through that resistance. That is, $R = E/I$ where E and I are voltage and current, respectively. According to Joule's law, power will be dissipated in resistance R at rate P where $P = I^2R$.

Nature of Negative Resistance

From these two laws a definition of negative resistance may be formed. If R is replaced by $-R_n$, it will be seen that Ohm's law will still hold, for voltage and current will still be proportional to each other. Joule's law will state, however, that instead of dissipating power, the negative resistance will generate power, introducing it into the circuit at the rate I^2R_n.

Obviously, if any device is to show a negative-resistance characteristic, it must contain a source of power, such as a battery, and a means of controlling that power source so that Ohm's law will be followed. Since, in any practical case a source of power is limited, the negative-resistance characteristic will be shown by the device only over a limited range of voltage or current.

Negative Reactances

The definition of negative inductance and negative capacitance may be formed analogously. The reactance of inductance X_L is defined by an extension of Ohm's law to alternating currents. Thus $X_L = E_L/I = j\omega L$ where E_L is the voltage across the inductance, I is the current through the inductance, and L is the inductance in henrys. As is shown by this relation, a positive inductance is one whose re-

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PART I

Basic ideal circuit and fundamental equations for producing the negative of a positive impedance.
Eq. (1)-(29), Fig. 1-9, Ref. 1-10

PART II

Effect on negative impedance of variations with frequency of amplifier parameters.
Eq. (30)-(56), Fig. 10-20, Ref. 11-13

PART III

Illustrative applications of negative impedances show how improved circuits can be obtained.
Eq. (57)-(67), Fig. 21-27, Ref. 14-16

IMPEDANCES . . . Part I

actance increases with frequency.

If L is replaced by $-L_n$, the impedance is $\omega L_n/j$. This equation may be used as a definition of a negative inductance. Thus, it is seen that a negative inductance is equivalent to a capacitive reactance whose magnitude increases with frequency.

A negative capacitance may be defined in the same way. It will be found that a negative capacitance is equivalent to an inductance whose reactance decreases with frequency.

In passing, it should be noted that positive and negative inductances and positive and negative capacitances can store energy equally well. But in the case of the negative impedances, the amount of energy that can be stored is limited by the amount of voltage or current that the negative-impedance-producing element can supply.

Because amplifiers will be used to produce the negative impedances it will be necessary to consider their limits of linearity and power handling capacity. This consideration will be taken up in Part II; for the present we will assume that an amplifier which is linear within the range of operation required for the production of the required negative impedances can be built.

Negative Resistance Sources

There are many sources of negative resistances known at present. Some of them occur in natural phenomena such as in gaseous discharges, others are produced by artificial means such as a source of energy and a control device arranged to maintain current and voltage in their required ratio.

An example of the latter is a direct-current series generator which shows a negative-resistance characteristic because current flowing through the generator excites its field and the generator produces a voltage which tends to increase the current.

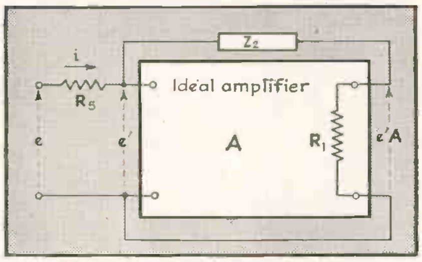

FIG. 1—Circuit for producing shunt negative impedance across its input terminals

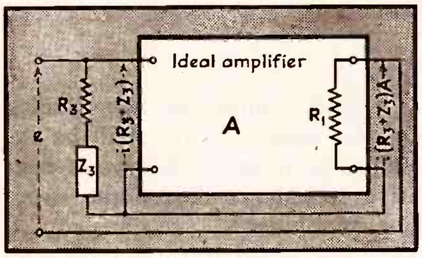

FIG. 2—Circuit for producing series negative impedance across its input terminals

Sources of negative resistance which are useful in communication circuits were described by Herold[4] and others. Some of these are: Arc discharge, the dynatron, retarding-field type of negative resistance[6], a space-charge grid tube which operates with a temperature-limited cathode, the split anode magnetron, and a low gas-pressure triode.

None of these methods of obtaining negative resistances are capable of producing pure negative reactances. Moreover, examination of the various methods reveals that in most cases the resistance is not linear, but depends greatly upon the magnitude of the applied voltage or current.

A different method of obtaining negative circuit elements has been suggested by Crisson, Dudley, and Mathes by means of which it is possible to obtain linear negative resistances of any value whatever and also pure negative reactances. The following section will discuss the methods suggested by Crisson.[3]

There are two ways in which it is possible to obtain negative impedance provided a positive of this impedance can be constructed in the form of a two-terminal network. The two methods can be used to produce the same impedance, but it will be found that only one of them can be used in any particular application. This consideration will be discussed in greater detail later.

First, equations will be determined for the input impedances of the two circuits which have been found to give negative impedances. This analysis will indicate the range and limiting factors of the negative impedances so produced.

Shunt Negative Impedance

Consider the amplifier shown in Fig. 1. The square labelled A represents an ideal amplifier with a voltage amplification A and an output resistance R_1. (Output impedance R_1 in this paper will mean the impedance looking into the output terminals of the amplifier. It is not necessarily equal to the physical output impedance of the amplifier because it may be affected by the presence of negative feedback in the amplifier.)

By an ideal amplifier is meant an amplifier which has a uniform frequency response from zero to infinity cycles per second, infinite power handling ability, zero phase shift for all frequencies, and an output resistance R_1 which is independent of frequency.

Let

e = voltage applied to the amplifier
e' = voltage at the input terminals of the amplifier (see Fig. 1)
Z_2 = any positive impedance, the negative of which it is desired to obtain
R_5 = a resistance placed as shown in Fig. 1
i = current taken from the source of voltage e

The circuit shown in Fig. 1 may be rearranged by means of Thévenin's theorem. If this is done, the output of the amplifier as shown in Fig. 1 may be replaced by the equivalent voltage $e'A$ in series with the output resistance R_1. With

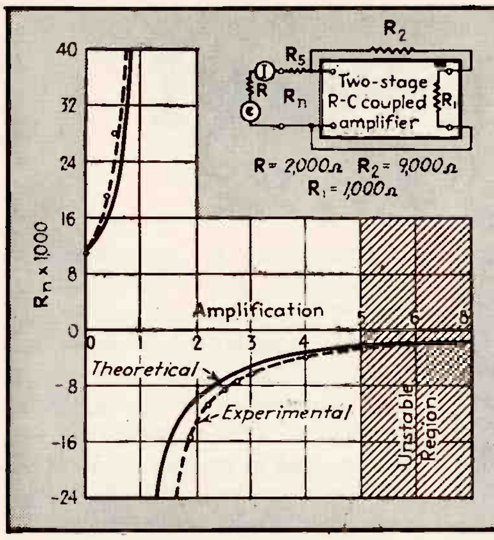

FIG. 3—Gain of amplifier determines magnitude and sign of negative resistance produced across its input although a single positive resistance is used

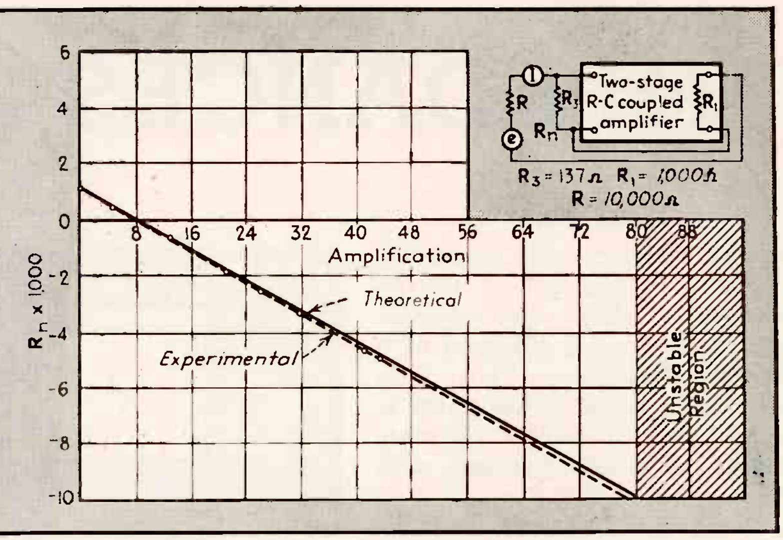

FIG. 4—A wide range of negative resistances can be produced by choice of amplification and of either shunt or series circuits

this transposition in mind, the following relations can be written. The net voltage acting across the output impedance R_1 and impedance Z_2 is $(e' - e'A)$, according to the convention of polarities of voltages indicated in Fig. 1 by means of arrows. Hence, the current that flows through R_1 and Z_2 in series is

$$i = \frac{e' - e'A}{Z_2 + R_1} = \frac{e'(1 - A)}{Z_2 + R_1} \quad (1)$$

Solving for e'/i

$$\frac{e'}{i} = \frac{Z_2}{1 - A} + \frac{R_1}{1 - A} \quad (2)$$

This ratio represents an impedance at the amplifier terminals where e' is measured. The impedance offered to the source of voltage e must be the sum of R_5 and this apparent amplifier input impedance. Defining the impedance offered to the source e by the entire circuit as Z_n

$$Z_n = e/i = R_5 + e'/i$$

$$Z_n = R_5 + \frac{Z_2}{1 - A} + \frac{R_1}{1 - A} \quad (3)$$

If R_5 is adjusted so that $R_5 = R_1/(A - 1)$, then $R_5 + R_1/(1 - A) = 0$, and therefore Eq. (3) becomes

$$Z_n = Z_2/(1 - A) \quad (4)$$

If the amplification A is positive and greater than unity, then the input impedance of the circuit of Fig. 1 is negative and determined in character only by the nature of Z_2. Crisson attributes this type of a negative impedance to Dudley and for reasons which will be explained later calls this type of negative impedance the *shunt negative impedance.*

Series Negative Impedance

The second method of obtaining negative impedance is illustrated in Fig. 2. In this case Z_3 is the positive impedance the negative of which is the desired result. R_3 is a resistance whose function is similar to that of R_5 in the previous case.

If e is the voltage applied at the terminals of the circuit as is shown in Fig. 2, then a current i will flow through the circuit. The following equation can be written.

$$e = i(R_3 + Z_3 + R_1) - i(R_3 + Z_3)A \quad (5)$$

From which

$$Z_n = (e/i) = Z_3(1 - A) + R_3(1 - A) + R_1 \quad (6)$$

If R_3 is adjusted so that $R_1 = R_3 (A - 1)$, then $R_1 + R_3(1 - A) = 0$, and therefore

$$Z_n = Z_3(1 - A) \quad (7)$$

If A is positive and greater than unity, the input impedance of the circuit is negative and determined in character only by the nature of Z_3. This type of a negative impedance is called a *series negative impedance.* Crisson attributes its discovery to Mathes.

From the preceding discussion it is evident that by means of application of positive feedback in an ideal amplifier it is possible to obtain negative impedances without depending upon natural phenomenon such as gas discharge or secondary emission, or upon a device which may be inherently nonlinear.

Reliability

The elementary picture given above is not sufficient for a practical application of negative impedances. One can readily observe that both of these circuits are essentially members of the same family and involve positive feedback, and one would be rightly justified in raising the question of stability and how the deviations from the assumed ideal amplifier will affect its performance. These questions will be discussed later where it will be shown that negative circuit elements can be made to possess extraordinary stability, and that the deviations of an actual ampilfier from the ideal modify the results only in special regions.

In addition to the positive feedback that is obviously necessary to obtain the negative impedances, the amplifiers themselves can be stabilized with negative feedback. It will be shown that simultaneous application of positive and negative feedback in an amplifier may be made use of to produce negative impedances which are just as stable and reliable as ordinary commercially available circuit elements. Nor in this simultaneous application of positive and negative feedback does the effect of one cancel the effect of the other. Amplifier gain does, however, play a major part in determining the magnitude and stability of negative impedance. The effect is different for negative impedances produced by the two methods, as the following considerations will show.

Amplifier Gain in Shunt Circuits

If the amplification in Fig. 1 is zero, the input impedance offered to the source of a voltage e is the sum $(R_5 + Z_2 + R_1)$, and the current flows from the source of voltage, being entirely determined by this sum. If A is increased positively from zero towards infinity, the current will decrease and when A is of such a magnitude that the output voltage of the amplifier just equals e, the current must be zero and therefore the input impedance Z_n must be infinite. This is also observed from Eq. (3) and (4), because when $A = 1$, Z_n becomes infinite.

If A becomes greater than unity, the current reverses and flows into the source of voltage e and the circuit exhibits negative impedance characteristics. When A reaches a value so that the resultant current flowing into the voltage source e supplies all the losses in its path, oscillations will result.

An example of this kind of a negative impedance is illustrated in Fig. 3, where Z_2 was chosen to be a pure resistance so that the input impedance of the amplifier is a pure negative resistance. The shaded region indicates the values of A for which the amplifier is unstable and in which case current is limited only by the power handling ability of the amplifier. It is seen from Fig. 3 that the negative resistance supplied by the amplifier in the stable region is greater in magnitude than the resistance R in parallel with which it is connected, and approaches an open circuit.

It should be observed at this point that a combination of a positive resistance in parallel with a larger negative resistance results in a positive resistance, although the series combination of the same two resistances will result in a negative resistance.

From interpretation of the performance of the circuit it was found that the arrangement of Fig. 3 is stable as long as the negative resistance supplied by the amplifier is greater than the positive resistance across which it is connected, i.e., in the region where the parallel combination of the two is positive. Because of this phenomenon, the type of the negative impedance supplied by the arrangements shown in Figs. 1 and 3 is called a shunt negative impedance.

Amplifier Gain in Series Circuits

The situation in the case of Fig. 2 will be found to be different. If the amplification is zero, then the input impedance of the amplifier consists of the sum $(R_3 + Z_3 + R_1)$. As A is increased from zero to unity, the voltage developed across the output terminals of the amplifier will be of such a direction that it will aid the applied voltage and the current will increase. When $A = 1$, the input voltage just equals the output voltage, and the voltage drop across the entire arrangement will be zero, which corresponds to zero input impedance. The current at this point will be limited entirely by the internal impedance of the source of voltage e.

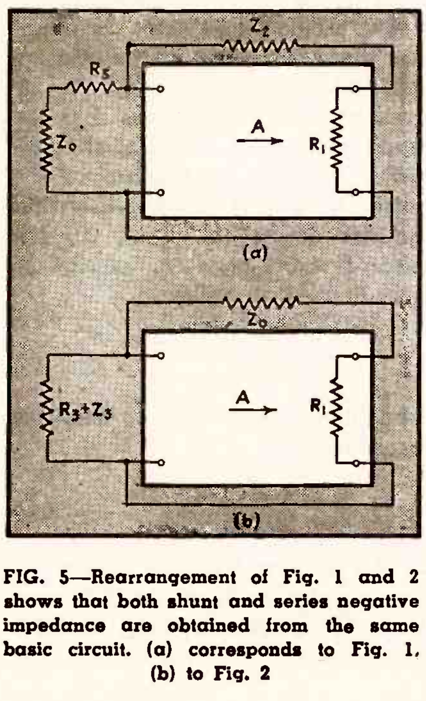

FIG. 5—Rearrangement of Fig. 1 and 2 shows that both shunt and series negative impedance are obtained from the same basic circuit. (a) corresponds to Fig. 1, (b) to Fig. 2

If A is larger than 1, there will be a negative drop across the amplifier and its input impedance will be negative as defined by Eq. (6) and (7). If A is increased to the point where the current is so large that it supplies all the losses in its path, instability will be reached. As is shown in the special case illustrated in Fig. 4, the current for a constant voltage will continuously increase, from a value determined by $(R_3 + R_1 + Z_3)$ when $A = 0$ to infinity when all the losses are supplied by the amplifier.

As is clearly evident from these considerations and Fig. 4, the negative impedance will be stable and finite as long as its value is smaller in magnitude than the impedance in series with which it is connected. Thus, in the stable region of operation, the series combination of positive and negative impedance is positive, and for this reason, this type of a negative impedance is called a series negative impedance.

Negative-Impedance Limits

From this discussion it is evident that across a given positive resistance any value of negative resistance may be placed, from zero to infinity, and providing the negative resistance is of the right kind (shunt or series), a stable result will be obtained. It is plain that the ordinary concept of resistance is incomplete; a prediction regarding the behavior of the combination of positive and negative impedances cannot be made without complete information regarding the method used to supply the negative element. A more complete, but not any more rigorous, discussion will be found in the literature.[3, 4, 6]

In Fig. 1 and 2 resistances R_5 and R_3 are not essential parts of the negative impedances and Eq. (3) and (6) show that negative impedances will result whether these two resistances are present or not. However, due to the finite magnitude of the output impedance of the amplifier the negative impedance obtained by means of the amplifier alone will contain a term which is due to the output impedance of the amplifier. By placing proper positive resistances in series with the negative impedance the resistive component of this term will be cancelled and a pure negative impedance can be obtained. In the case of an ideal amplifier this cancellation can always be done; in the discussion which follows, it will be invariably assumed to have been done. Errors due to this assumption in the case of an actual amplifier will be discussed and analysed in Part II.

Stability

Before launching into the discussion itself, the particular sense in which the terms are used will be defined.

Conventional technical terminology is often confusing, the word stability having more than one meaning. In this paper there are discussed two kinds of stability and, although somewhat related, their meanings are different.

Operation of an amplifier is generally termed stable if introduction of an infinitesimal voltage anywhere in the amplifier will result in a transient which will decrease with time. If, on the other hand, the introduction of such voltage will produce currents which will increase indefinitely with time (or until limited by saturation of some element), operation of the amplifier is said to be unstable but in this paper such a result will be termed oscillation.

The second type of stability will be defined by the word stability itself, and will refer to the amount that the negative impedance can change due to a small variation in amplification of the amplifier, as for example by power supply voltage variation.

Conditions for Oscillation

Because positive feedback around an amplifier is used to produce negative impedance, it is to be expected that oscillation will occur for some conditions; in fact the previous qualitative examination of the effect of amplifier gain indicated, that for large amplification, oscillation does take place; therefore a more rigorous analysis of the conditions for oscillation will be made.

Figures 5(a) and 5(b) are rearranged forms of schematic circuits shown in Fig. 1 and 2 in which Z_0 is the internal impedance of the source e. From these it is seen that the actual circuits which develop negative impedances are identical in character, the difference being merely in the two points across which the desired negative impedance is developed.

On the basis of the criterion given by Nyquist[7] the possibility of oscillation may be determined by considering the circuits as positive-feedback circuits in which the impedance Z_0 is the impedance which is actually used across the terminals of the negative impedance. In general, it is impossible to predict whether oscillation will or will not occur except by applying Nyquist's criterion. In simple cases, however, it is possible to examine the circuits in the following manner.

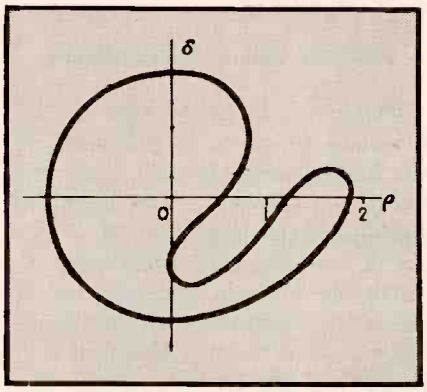

FIG. 6—Oscillations can not occur unless point (1, 0) of the Nyquist diagram is enclosed by the feedback-factor curve

The oscillations cannot occur unless there is a value of the positive feedback factor αA equal to or greater than unity, where A is the amplification parameter of the amplifier and α is the fraction of the output voltage of the amplifier that appears across its input. In the case of shunt negative impedance, α is defined as follows

$$\alpha = \frac{R_5 + Z_0}{Z_0 + R_5 + Z_2} \qquad (8)$$

And in the case of series negative impedance

$$\alpha = \frac{R_3 + Z_3}{Z_0 + R_3 + Z_3} \qquad (9)$$

The positive-feedback factor αA is a complex number and is a function of frequency in a way which is determined by the type of amplifier used and the character of the feedback network. It can be divided into a real and an imaginary part $\alpha A = \rho + j\delta$.

A not sufficient but a necessary condition for oscillation is that $\delta = 0$. There may be several frequencies at which this condition is satisfied, say, at $f_1, f_2, f_3, \ldots f_n$. If the real part of αA at any one of these frequencies exceeds unity, then oscillations will exist. Hence, the condition for oscillation may be stated as

$$\rho\,(f_1, f_2, f_3 \ldots f_n) \geqq 1$$
$$\delta = 0$$

The one possible but unusual and seldom met exception to this rule may occur as is shown in Fig. 6 where, according to Nyquist's criterion, oscillations cannot occur. On the other hand, if the smallest value of $\rho(f_1, f_2, f_3 \ldots f_n)$ is greater than unity, then re-entrant curves around the point ($\rho = 1, \delta = 0$) are impossible and oscillations will necessarily exist. This is by far the most usual case.

If, for instance, the source impedance Z_0 is zero in the case of the series negative impedance, then according to Eq (9) $\alpha = 1$ and $\alpha A = 1$. In the ideal amplifier (or in a practical one at the point where the phase shift is zero) A is a real constant so that $\delta = 0$. If A is greater than unity, then oscillations must occur. In the case of a shunt negative impedance, if the source impedance Z_0 is made infinite, then $\alpha A = 1$ and oscillations must occur. This is seen to be in agreement with the physical interpretation of the negative impedance previously described.

Stabilization of Negative Impedances

Behavior of the negative impedance obtained in the manner illustrated in Fig. 1 and 2 depends only upon two factors, namely, the amplifier and the positive impedance. The positive impedances Z_2 and Z_3 are ordinary impedances constructed from resistors, inductors, and capacitors. The resultant negative impedance will obviously possess all the characteristics of these elements such as impedance change with temperature or with the amount of current or voltage applied to them. But in addition to these, the negative impedance is

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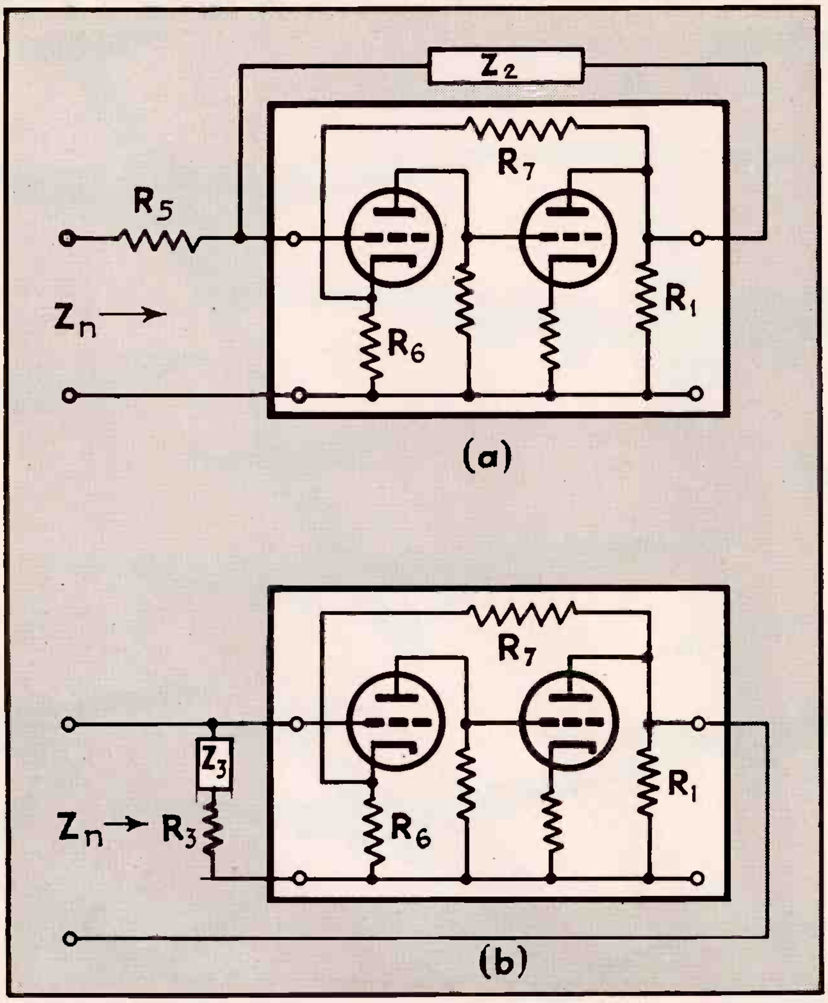

FIG. 7—Feedback to stabilize amplifiers used to produce negative impedance is produced by R_6 and R_7 at (a) for shunt and at (b) for series negative impedance

also dependent upon the gain of the amplifier used to supply that negative impedance.

In ordinary amplifiers the amplification often changes because of voltage fluctuations of the power supplies. Slow changes in tube characteristics and aging of the components of the amplifier also produce slow variations in the gain of the amplifier, and these, of course, will change the magnitude of the negative impedances. However, all of these factors may be greatly reduced by sufficient negative feedback within the amplifier itself. As will be shown later, the characteristics of the negative impedance can be easily made dependent, not upon the properties of the amplifier that supplies it, but upon the variations of the positive impedances Z_2 and Z_3 in the way mentioned previously.

The stabilization of the amplifier that supplies the negative impedances is well known and does not need to be fully described here.[1, 8, 9, 10] Important properties of stabilized amplifiers of particular interest in connection with the negative impedances will be taken up in Part II. Simplified diagrams of possible ways in which feedback can be applied to amplifiers supplying negative impedances are shown in Fig. 7(a) and 7(b).

Effect of Negative Feedback

The amplifier shown in both cases is a two-stage amplifier with all sources of power and filter network omitted for the sake of simplicity. A two-stage amplifier is necessary because the output and the input must be of the same relative polarity. A fraction β where $\beta = R_6/(R_6 + R_7)$ of the output voltage of the amplifier is returned to its input in such a manner that negative feedback is developed in the amplifier and its gain is stabilized by the factor $A\beta$, where A is the amplification of the amplifier with all feedback networks omitted. Except for the introduction of negative feedback, these circuits will be found to be the same as the schematic representations shown in Fig. 1 and 2.

The negative impedance developed by the amplifiers shown in Fig. 7 may be found in the same manner as in Eq. (4) and (7) if

A = amplification of the amplifier without negative feedback
β = fraction of the output voltage returned to the input of the amplifier as negative feedback
G = gain with negative feedback

$$G = A/(1 - A\beta) \tag{10}$$

and R_3 and R_5 so adjusted that

$$R_5 = R_1/(G - 1) \tag{11}$$

$$R_3 = R_1/(G - 1) \tag{12}$$

then, the shunt negative impedance will be given by

$$Z_n = Z_2/(1 - G) \tag{13}$$

and the series negative impedance by

$$Z_n = Z_3(1 - G) \tag{14}$$

In the material that is to follow, it will be assumed that R_3 and R_5 are so adjusted that Eq. (11) and (12) hold and Eq. (13) and (14) will be used with this implication in mind. For the sake of simplicity, all diagrams shown from this point on will not show resistances R_3 and R_5, although their presence is implied in all cases where a pure negative impedance is desired.

Stability of Negative Impedances

At first sight it may be thought that simultaneous application of positive and negative feedback in the same amplifier will simply produce cancellation, and if equal feedback factors are used the result would be the same as if no feedback were used at all. However, this is not so, as will become apparent as the discussion progresses.

As was seen in the above derivations and discussions, circuits shown in Fig. 1 and 2 produce negative impedances. By application of negative feedback internally to the amplifier its gain may be stabilized in the conventional manner. The extent to which the negative feedback stabilizes the negative imped-

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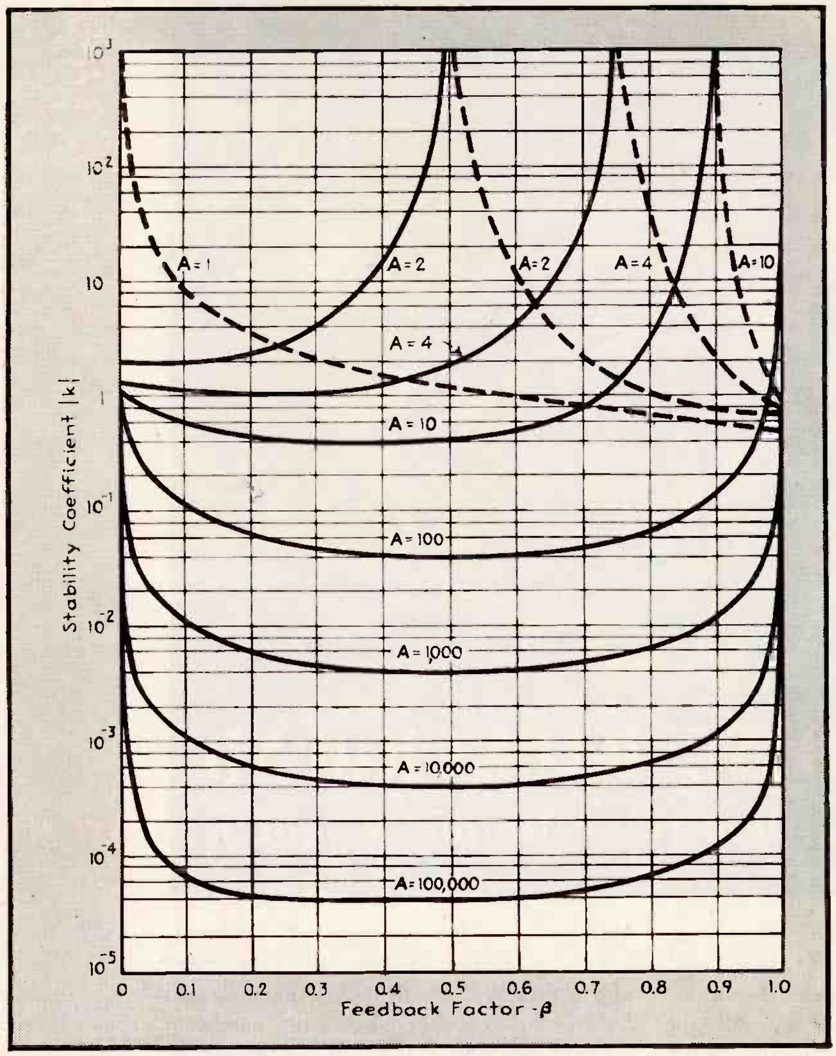

FIG. 8—Stability coefficient as a function of amplification and negative feedback shows regions in which best stability of negative impedance can be obtained

ances will now be determined quantitatively.

Stability of a negative impedance may be defined as the fractional change in negative impedance produced by a small change in gain of the amplifier which supplies that negative impedance. Stated algebraically $\partial Z_n/Z_n = k\partial A/A$ where A is the gain of the amplifier, ∂A is a small change in the gain, ∂Z_n is the change in the negative impedance, and k is a coefficient of stability, obviously dependent upon the amount of negative feedback utilized in the amplifier.

The coefficient of stability k describes to what extent negative impedance is affected by small changes in the propagation parameter of the amplifier. The ideal case would be obtained if k were zero, i.e., when a small change in the propagation parameter of the amplifier would produce no change in negative impedance.

As will be seen presently, stability of the shunt and series negative impendance is different, and the analyses will be divided into separate parts.

Stability of Shunt Negative Impedance

The shunt negative impedance is dependent upon the gain of the amplifier in the way expressed by Eq. (13). Substituting the value of G given by Eq. (10) in Eq. (13) one obtains for negative impedance the expression

$$Z_n = Z_2 \frac{1 - A\beta}{1 - A\beta - A} \qquad (15)$$

The stability coefficient may be obtained from this expression by differentiating with respect to A giving change in Z_n to change in A

$$\frac{\partial Z_n}{\partial A} = Z_2 \frac{\beta(A\beta + A - 1) + (1 - A\beta)(\beta + 1)}{(1 - A\beta - A)^2} = Z_2 \frac{1}{(1 - A\beta - A)^2} \qquad (16)$$

and therefore

$$\frac{\partial Z_n}{Z_n} = \frac{\partial A}{(1 - A\beta - A)(1 - A\beta)} \qquad (17)$$

From which, the stability coefficient may be recognized as

$$k = \frac{A}{(1 - A\beta - A)(1 - A\beta)} \qquad (18)$$

This important relation states that shunt negative impedance is stabilized by a factor which does not contain Z_t and hence, the stability of shunt negative impedance is independent of its magnitude.

Investigation of the properties of the stability coefficient shows that there is an optimum value of β for any given value of A. The best value of β may be obtained by maximizing Eq. (18) with respect to β, as follows

$$\frac{\partial k}{\partial \beta} = \frac{A[(1 - A\beta - A)A + (1 - A\beta)A]}{(1 - A\beta - A)^2(1 - A\beta)^2} = 0 \qquad (19)$$

Solving this for β

$$\beta_{opt} = \tfrac{1}{2}\left(\frac{2}{A} - 1\right) \qquad (20)$$

from which the optimum value of β for any given value of A may be obtained. The stability coefficient at β_{opt} is

$$k_{opt} = -4/A \qquad (21)$$

Another critical point occurs when the denominator of Eq. (18) becomes zero, i.e., when $(1 - A\beta - A) = 0$. This is the case when

$$\beta = (1 - A)/A \qquad (22)$$

At this value of β the stability coefficient is infinite and a small change in gain would produce an infinite change in the negative impedance. However, at this value of β the gain of the amplifier is unity

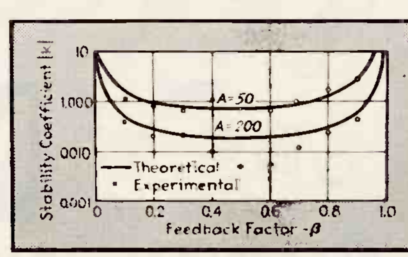

FIG. 9—Experimental determination of stability verifies the theoretical predictions

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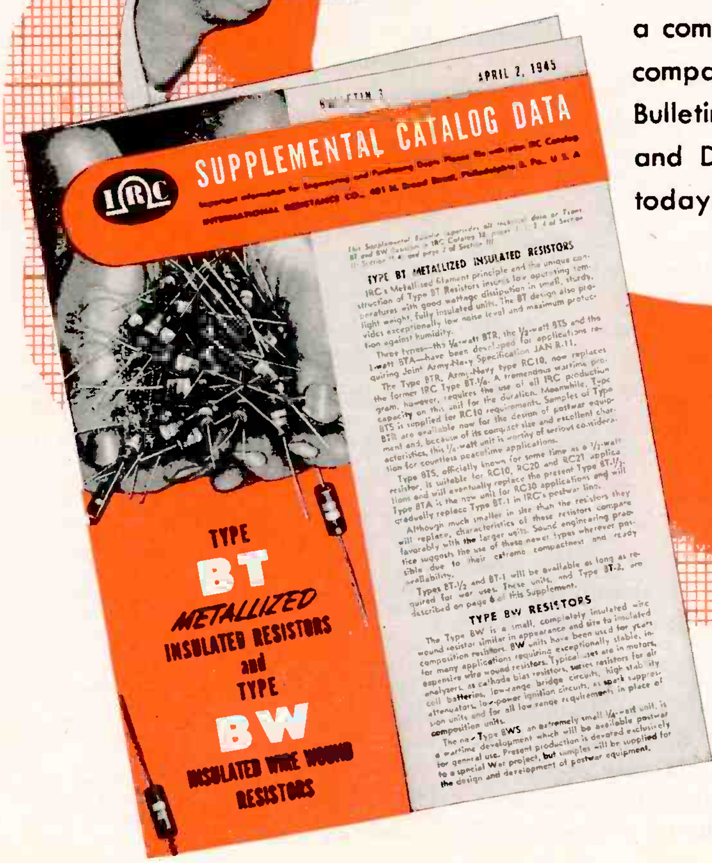

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and the negative impedance is infinite and obviously this critical point is of no importance.

Stability Calculations

Figures 8 and 9 show Eq. (18) in graphical form as a function of A and β. From Fig. 8 it is seen that the larger the propagation constant of the amplifier, the better the stability of the shunt negative impedance. If A is very large, then $\beta = -0.5$ gives the best k, but there is little improvement beyond $\beta > 0.1$ and in all practical cases this is the most satisfactory value due to the difficulty of obtaining a high value of A and a higher value of β than 0.1 due to the shunting effects of the β network.

With present day tubes it is easy to obtain an amplification of 10,000. If enough negative feedback in the amplifier is used to make $\beta = -0.1$, then, according to Eq. (18) or Fig. 8, the stability coefficient is nearly 10^{-3}.

A test of a simple amplifier has shown that a 20 percent change in the supply voltage of a typical amplifier produced an 8 percent change in amplification. Hence, the change in the negative impedance supplied by this amplifier would be in the neighborhood of eight parts in 100,000. This stability is better than that encountered with ordinary circuit elements in cases where no temperature compensation is provided.

Stability of Series Negative Impedance

Effects of small changes in amplification of the amplifier which supplies the series negative impedance may be obtained in a similar manner. Series negative impedance is dependent upon the gain of the amplifier as given by Eq. (12) and (14). Combining this with the Eq. (10) which takes into account the negative feedback in the amplifier

$$Z_n = Z_3' \left(\frac{1 - A\beta - A}{1 - A\beta}\right) + R_1 \qquad (23)$$

where $Z_3' = Z_3 + R_3$

From this, the stability coefficient may be obtained by differentiation

$$\frac{\partial Z_n}{Z_n} = \frac{-\partial A}{(1 - A\beta)\{(1 - A\beta)[(R_1/Z_3') + 1] - A\}} \qquad (24)$$

The stability coefficient is

$$k = \frac{-A}{(1 - A\beta)\{(1 - A\beta)[(R_1/Z_3') + 1] - A\}} \qquad (25)$$

This relation is different from the corresponding one for the shunt negative impedance because it involves the terms Z_3', which means that the stability of a series negative impedance depends upon the magnitude of the negative impedance developed by the amplifier. A physical interpretation of this dependence may be seen by examining two boundary cases.

If the output impedance of the amplifier $R_1 << Z_3'$, then the stability coefficient becomes very much the same as the one in the shunt negative impedance. If $Z_3' = R_3 = R_1/(G\text{-}1)$, the second bracket in the denominator of Eq. (25) reduces to zero. In this case, the stability coefficient becomes infinite. This latter case is of not much practical importance, for it corresponds to zero series negative impedance offered by the amplifier. In a practical amplifier, the output impedance of the amplifier can be made small, and for any given value of the negative impedance, the stability coefficient may be made as small as is desired by increasing A sufficiently. Rewriting Eq. (25) shows this more clearly

$$k = \frac{-1}{(1 - A\beta)[1 - (1 - A\beta)/A][(R_3/Z_3') - 1]} \qquad (26)$$

If A is made very large, then

$$k \approx \frac{1}{A\beta[1 + \beta][(R_3/Z_3') - 1]} \qquad (27)$$

and the stability can be made as good as desired by making A large enough.

For any given value of R_1/R_3' and A there is a best value of β. This critical value may be obtained by maximizing k as given by Eq. (25) with respect to β. This leads to the result.

$$\beta_{opt} = -\tfrac{1}{2}(1 - 4R_3/AZ_3') \qquad (28)$$

This again differs from the best value of β in the shunt negative impedance as given by Eq. (22) because Eq. (28) involves the factor R_3/Z_3', i.e., it depends upon the value of the negative impedance developed by the amplifier. The stability coefficient for the series negative impedance at the best value of β is obtained by combining Eq. (28) with Eq. (25) or (26). This gives

$$k_{opt} = -\frac{4}{A}\,\frac{1}{[(2R_3/Z_3')^2 - 1][(R_3/Z_3') - 1]} \qquad (29)$$

which differs from the optimum value of the stability coefficient in the case of shunt negative impedance in the same general manner discussed above in connection with Eqs. (25) to (28).

Most Stable Condition

It is interesting to notice that if $R_3/Z_3' << 1$ then the optimum value of β in the case of the series negative impendance is $-\frac{1}{2}$. This is also true (exactly so, however) in the case of the shunt negative impendance. Remembering the fact that the gain of the negative-feedback amplifier approximates $-1/\beta$ it is seen that if the optimum value of feedback is used for best stability, the gain of the amplifier supplying negative impedance is just equal to 2. Hence, from Eq. (13) and (14) it is seen that the negative impedances developed by the amplifier in the two possible manners are

shunt type $Z_n = -Z_2$
series type $Z_n = -Z_3$

In other words, if the most stable operation of the negative impedance is desired, the value of the negative impedances obtained are merely the negative values of the positive impedances Z_2 and Z_3.

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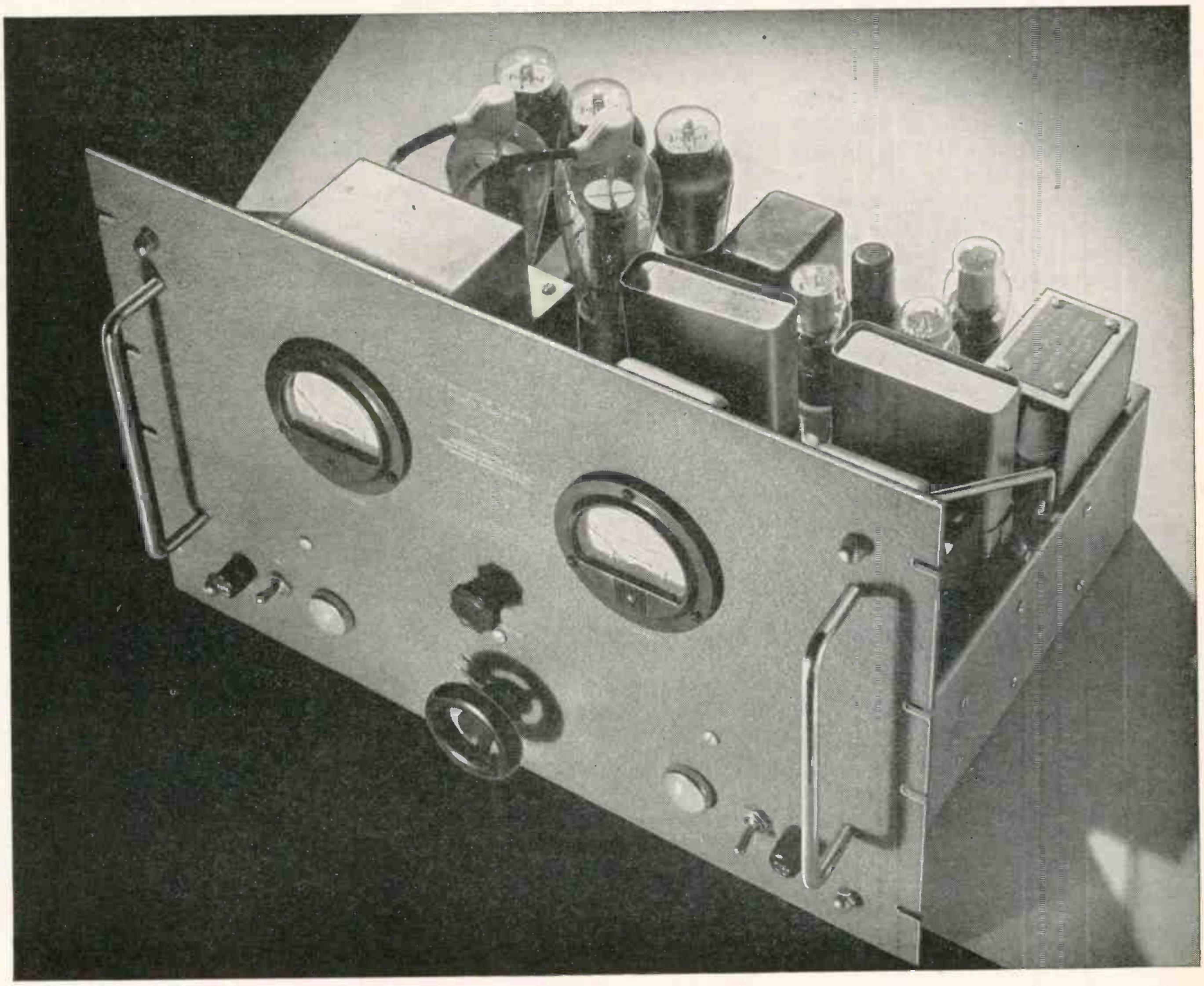

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Phototubes for Railroad Operations

AT THE NEW DIESEL locomotive maintenance shop of the Erie Railroad, phototubes are used for two purposes—to open electrically operated overhead doors and for drying and elevating sand into overhead storage tanks.

The door control is actuated by the beam from the headlight of the approaching locomotive while it is still some distance away. This allows plenty of time for the ponderous doors to open and permit the locomotive to enter the shop without a preliminary stop.

A sun visor is provided over each phototube to prevent the sun from activating it. Pushbuttons inside the building operate the door-closing mechanism after the locomotive has entered.

The sand for the sand boxes of the 5400-hp four-unit diesel freight locomotives is dried by steam coils over a drum, into which the sand flows by gravity as it dries. Into the side of this drum is welded a pipe, so shaped that it permits sand to spill over when the drum becomes full. About half-way down the interior of this pipe is welded a box containing a glass window on each side. Through these windows a beam of light is passed to a phototube.

When the drum becomes full of sand, the surplus flows over into the pipe and interrupts the beam of light. Compressed air is immediately turned on, closing the inlet to the drum and applying pressure to the top of the sand. The sand is blown into elevated bins, where it is ready for use in servicing the locomotives.

When the drum has been emptied, the windows of the box inside the pipe are again cleared and the lightbeam pases through them to reach the phototube. This turns off the compressed air, re-opens the inlet to the drum, and allows it to fill again—ready for the next operation. This mechanism has proven much more dependable than any previous combination of springs, switches, or other mechanical action.

When diesel locomotives approach this Erie maintenance shop, the headlamp shines into a phototube which actuates a door opener and eliminates a preliminary stop while trainmen open the door

More Accurate Liquid Level Indicator for Aircraft Industry

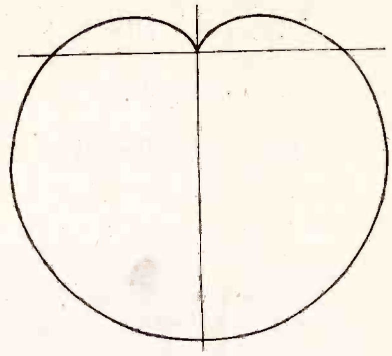
THE PRINCIPLE of operation of an electronic gas gage for bombing planes, recently announced by Minneapolis-Honeywell, can well be applied to a large number of manufacturing operations, in refineries, large storage vats, and even as a means of measuring the moisture content of wheat and other materials.

The illustration shows the installation of the gas gage units in a typical four-engined airplane. In the gas tanks are mounted capacitance units which connect to an electronic amplifier and meter mounted in the fuselage. Each capacitance unit consists of a piece of tubing which contains two smaller pipes inside to form the elements of an electrical capacitor. Gasoline can flow inside the tubing and between the two inside pipes. The minute current flow from one pipe through the gasoline to the other pipe shows the electrical capacitance of the gasoline. This changes with the height of the liquid within the tank unit and is measured electronically by the amplifier. Actuated by the amplifier, an indicating dial on the plane's instrument panel shows the contents of the tank in gallons.

Unusual Conditions

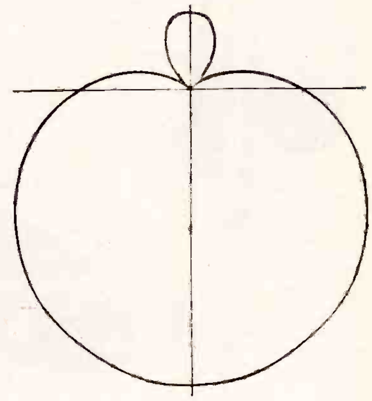
The problem of determining fuel supplies is not an easy one for plane crews. Gasoline actually shrinks in volume with a drop in temperature and, from ground level to 25,000 feet, this shrinkage frequently reaches 10 percent. In addition, the level of gasoline constantly changes with the roll (or tipping) axis of the plane, giving false readings on conventional gages of as much as 20 percent error. This degree of error, when coupled with shrinkage and other

. . This is Cardioid



"Cardioid" means heart-shaped. It describes the pickup pattern of a microphone as illustrated in this diagram. Unwanted sounds approaching from the rear are cancelled out and the pickup of random noise energy is reduced by 66%. The actual front to back ratio of reproduction of random sound energy is 7 to 1.

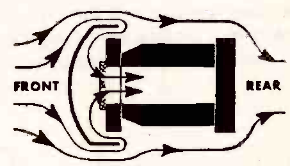
. . This is Super-Cardioid



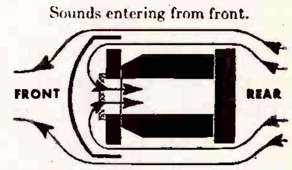
"Super-Cardioid" also describes a pickup pattern and is a further improvement in directional microphones. The Super-Cardioid has a wide front-side pickup angle with greater exclusion of sounds arriving from the sides and the rear. The front to back random sound ratio is 14 to 1 which makes it twice as unidirectional as the "Cardioid." A 73% decrease in the pickup of random noise energy is accomplished.

. . This is Uniphase

"Uniphase" describes the principle by which directional pickup is accomplished in a single Microphone unit. This is a patented Shure development and makes possible a single unit "Super-Cardioid" Directional Microphone eliminating the necessity of employing two microphone units in one case—it gives greater uniformity in production, greater ruggedness, lower cost for comparable quality and more uniform vertical pickup pattern.



Sounds entering from front.



Sounds entering from rear.

. . This is the result

The SHURE Super-Cardioid

A decrease in the pickup of random sound energy by 73%—reduction of feedback and background noise—simplification of sound pickup are among the many advantages offered by the Shure "Super-Cardioid" Dynamic. These, plus faithful reproduction, are the reasons why Shure "Super-Cardioid" Microphones are used by more than 750 Broadcast Stations in the United States alone, by our Armed Forces throughout the world, and on thousands of Public Address Systems everywhere.

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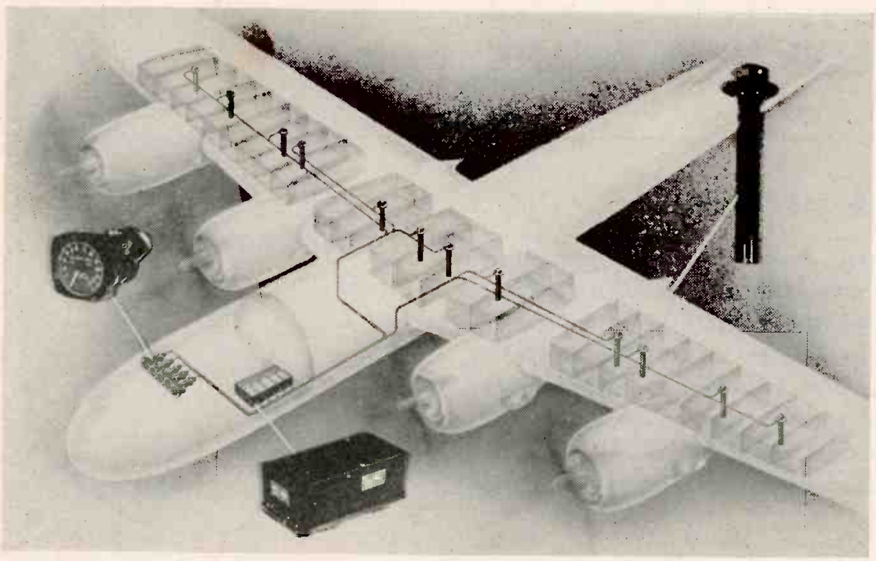
factors, can lead a pilot to believe that he has hundreds of gallons more (or less) available than are actually in the tank.

The needles of float-type fuel gages fluctuate constantly. This is sometimes further amplified because at the low pressures encountered at high altitudes, the fuel boils, causing a foam to form—similar to a bubble bath—on the surface of the gasoline and the float rides on top of the bubbles, thus indicating a still greater supply.

Developed at the request of the Air Technical Service Command, Wright Field, Dayton, Ohio, the new device is accurate within five percent under extreme conditions of temperature, altitude and plane attitude. This compares with at least a 15 percent error in the best of all existing means of aircraft fuel measurement. With no moving parts, bellows, gears, cams or levers to get out of calibration, the liquid level indicator weighs about 16 pounds, slightly more than present fuel measuring systems.

The unit now being manufactured is actually the second of two designs developed by Minneapolis-Honeywell. Both of these developed from a basic electronic circuit used by the company in an ice indicator which measures ice forming on wing and plane surfaces and turns on the deicer pumps before weight and bulk of the ice become dangerous.



Gas-gage installations in a typical four-engined plane. The liquid level unit, shown at upper right, makes use of electrical capacitance and may find extensive use in industrial applications. Accuracy is within five percent as against fifteen percent for other devices used in fuel measurement

Elongation Recorder for Materials Testing

By Jens Sivertsen
Electrical Engineer
Tinius Olsen Testing Machine Co.
Philadelphia, Pa.

Military Needs—in aviation, ordnance, marine equipment, and industrial mechanisms—have forced greater tensile strengths, higher working limits and lower safety factors for many classes of materials.

In testing most materials, the stress-strain diagram is recognized as the fundamental characteristic and helps to find modulus of elasticity, hysteresis, elastic deformation, proportional limit, yield strength, and proof stress. Essentially the Olsen high magnification recording unit is a specially designed extensometer which transmits the characteristics of the material under test by electronic means to a letter-size chart applied to the recorder drum.

Degree of Strain

The strain of most rigid materials in the elastic straight-line region is very little. In a piece of plain carbon, cold C. R. steel it may be 0.001-0.002 in./per inch length of material, corresponding to a load at 30,000-60,000 lb/per square inch; for cast iron it may be as little as 0.00025-0.0005 in., and for high grade heat-treated

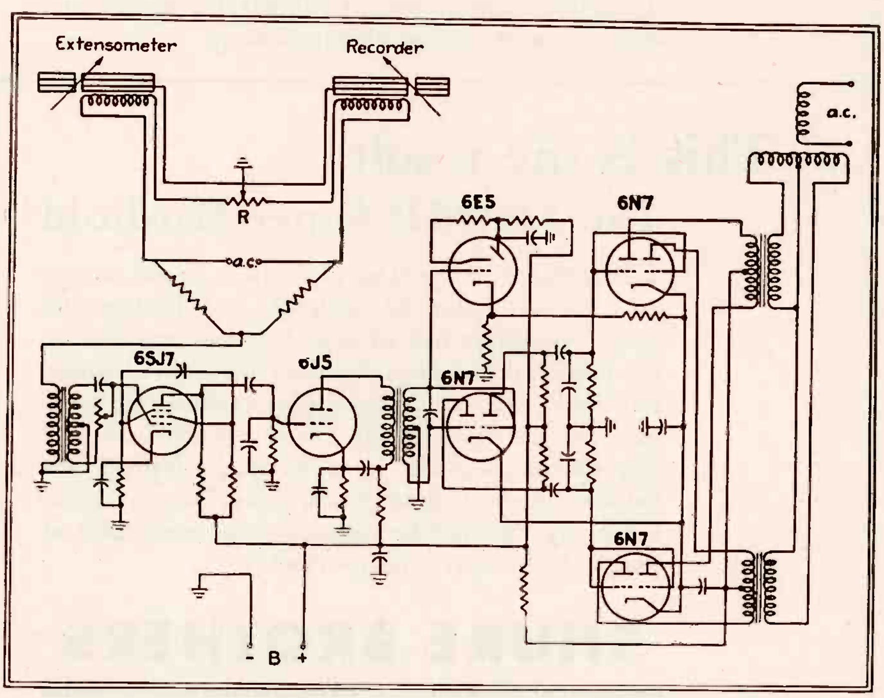
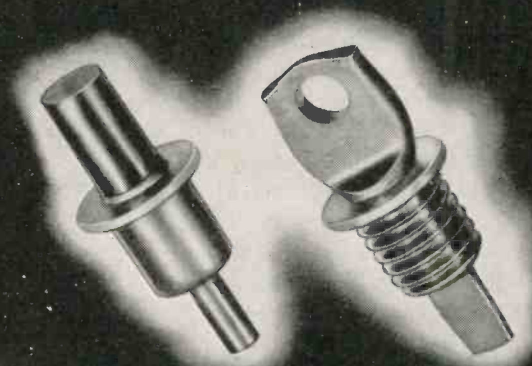


Fig. 1—Electronic amplifier and Wheatstone bridge arrangement used in the materials tester. The motor speed is variable and reversible depending on the signal from the bridge circuit

Choose the Right Fastenings—
PLAN THEM EARLY
In the Product Design Stage



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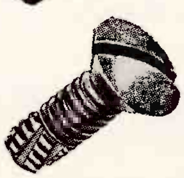

2 Self-Tapping Machine Screws—Eliminate separate tapping operations for fastenings to castings, heavy gauge sheet metal, and plastics. Also available with Phillips Recessed Head.

3 Washer-Screw Assemblies—When use of lock washers is indicated, the time-saving of pre-assemblies is obvious. Also available in standard slotted head styles.

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The degree of perfection you will obtain on that vital fast assembly job may very well depend on the fastenings chosen for your product. That's why it is important to play safe by making your precise choice early in the design stage. Remember—no assembled product can be better than its fastenings.

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tool steel, it may be as much as .005 in.

Instruments to measure and record these small dimensional changes were made 50 years ago. They used long specimens which were cumbersome to use and the operator had to be an expert. However, it is remarkable how good the results were with such equipment.

The recorder was ready and a few were in use before the war, by people who were not afraid of the radio tube in industry. Some organizations like Chrysler, Ford and the U.S.S.R. had quite a few of them. When the war came, the requirement for accuracy and volume of testing increased rapidly, and the work had to be done by operators with no previous training in this field. Since the recorder was simple to operate, anybody with normal intelligence could learn its use in a few hours.

Modern Design

The complete instrument comprises three units: the extensometer which is attached to the specimen, the electronic amplifier, and the recorder unit. In the extensometer is a magnet coil with an air gap between two iron cores. In the recorder unit is a similar coil and air gap. These two coils and their air gaps form an automatically balanced electrical circuit. The air gap in the extensometer is actuated by the elongation of the specimen. The air gap in the recording instrument is actuated by a micrometer screw which is rotated by the same motor which drives the recorder drum.

The electronic circuit is shown in Fig. 1. It consists of an a-c Wheatstone bridge, having a permanent base of two closely matched resistors. The other arms consist of one induction coil with a magnetic core and an air gap actuated by the strain in the test piece, and one identical inductor arranged in the recorder box actuated by a micrometer screw. The screw is synchronized by gears with the recording drum. The reversible motor drives the arrangement as a self-balancing assembly.

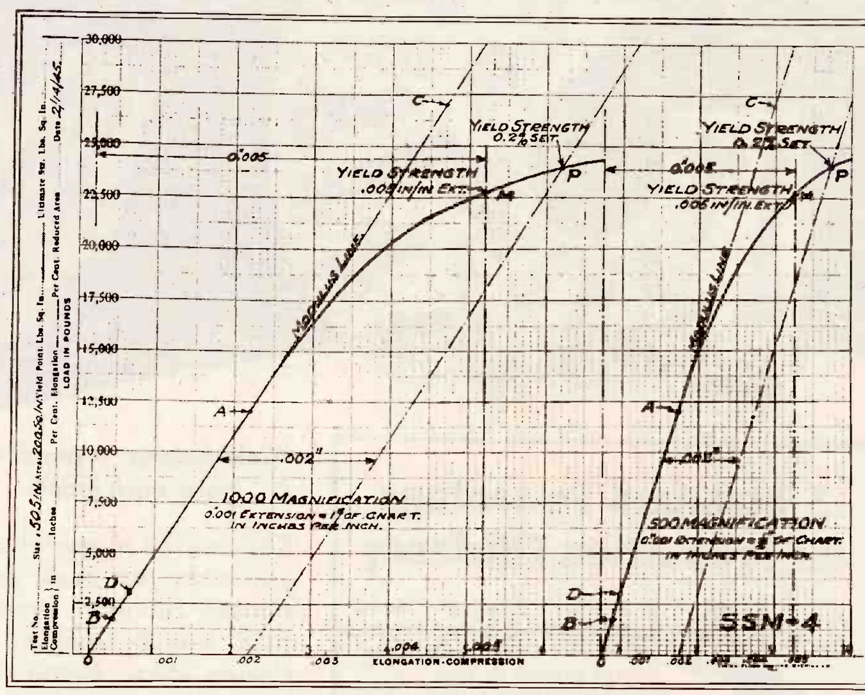
The output from the bridge energizes the primary of an input transformer. The secondary feeds the grid of a 6SJ7 pentode and the rest is a straightforward amplifier up to the two 6N7 output tubes. The plates of these tubes act in respect to the shading coils of the motors as variable impedances which for large signals may become negative. In this way, the motor becomes automatically reversible with change in phase of the incoming signal. The motor speed becomes variable over a large range and causes the recording drum to follow smoothly any strain of the specimen.

In spite of the very high sensitivity obtained, 0.000001 to 0.000005 in. elongation of the specimen, the amount of hunting is negligible. Some of the models are supplied with dynamic brake (aluminum disk in a magnetic field) while many are without this brake.

Balance

In view of the high sensitivity and the low signal, a 6E5 tube is used for balance adjustment. The arrangement is such that only inductance unbalance can affect the motor, as voltage caused by resistance unbalance is 90 deg. out of phase. A large resistance unbalance will, however, impair the sensitivity of the recorder. For this reason, the resistance balance can be adjusted by the small potentiometer R, shown on top in the bridge circuit, while observing the 6E5 balance indicator.

The 6E5 tube will also indicate whether the motor keeps the bridge circuit balanced at all times, which means that the recorder follows the elongation of the specimen minutely. Some small change in resistance may take place during



Typical stress-strain diagram (not retouched) made with a 30.000-lb. Olsen testing machine. Such recordings can be used to follow a material during cold working, heat treatment, and other operations, to provide a product with greater uniformity in shape, size and dimensions in service

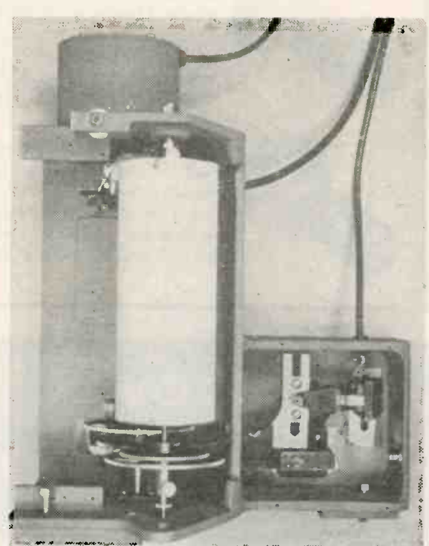


Fig. 2—Mechanical features of the recording unit

the first hour of a day's work, as the coils do not heat completely uniformly.

Figure 2 shows the mechanical parts of the recorder. The rack carrying the pen parallel to the axis of the recording drum has been removed. This pen provides the load ordinate for the chart and many types of testing machines give this automatically as an integral part of the weighing system of the machine.

A typical recording made with a 30,000-lb testing machine is shown. The specimen is a round steel bar 0.505 in. in diameter, which has a cross-section of 1/5 square inch. The testing machine gives load values in pounds; material constants are generally given in pounds per square inch. To get

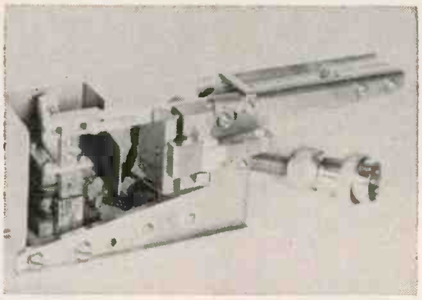


Fig. 3—One type of extensometer for the elongation tester

these, we divide by 1/5 or multiply by 5. For example, the proportional limit is at point A on the curve. The corresponding load reading from the chart is 12,000 lb. The proportional limit is, therefore, $12{,}000 \times 5 = 60{,}000$ lb per square inch.

If we measure along the elongation axis on the original graph, we find the extension between origin and A equal to 2 in. Since the magnification is 1000 this represents 0.002 in. strain.

The modulus of elasticity is therefore:

$$E = \frac{60{,}000 \text{ lb per sq. in.}}{0.002 \text{ in. per inch}} = 30 \times 10^6 \text{ lb per sq. in.}$$

The right side of the chart shows the same curve with magnification of 500, which is used extensively in routine production testing, allowing a number of curves on the same chart. In view of the ease whereby the curve is obtained, the time may not be far off that all quality materials will be bought on the basis of a curve. Thus, a structural designer may now be able to use a safety factor of 10, 20, or 30 percent instead of 500 percent.

Pipe Gaskets Tested for Pressure

ELECTRONICS has come to the aid of engineers coping with one of the problems of pipeline equipment design—the uneven distribution of gasket pressure. Such a condition often leads to costly leaks. A new tester utilizes an audio howl as an aid to measuring pressures exerted by rubber gaskets in pipe couplings, clamps and repair sleeves. Called a Sealometer, it was developed by engineers of the Dresser Manufacturing Division of Dresser Industries, Inc.

In many types of pipe, a thick rubber gasket, compressed by bolting down iron clamps, is used to make a seal around the pipe. The unit pressure of this rubber gasket must exceed the pressure of the gas or liquid inside the line in order to prevent leakage. If there is any variation of the gasket pressure, the minimum pressure is the one which determines the safeness of the joint. It is very important to determine accurately the distribu-

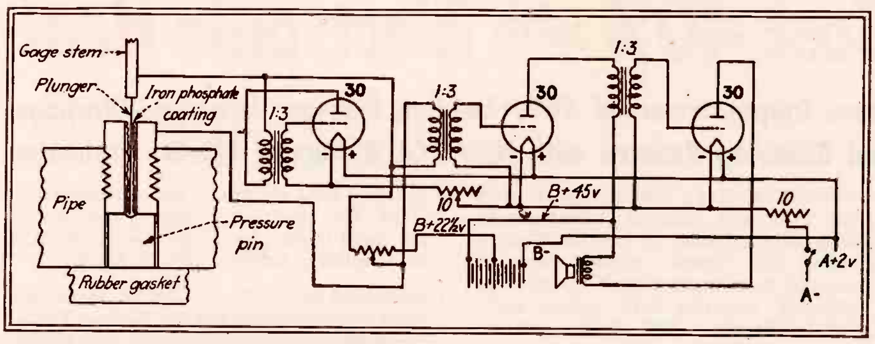
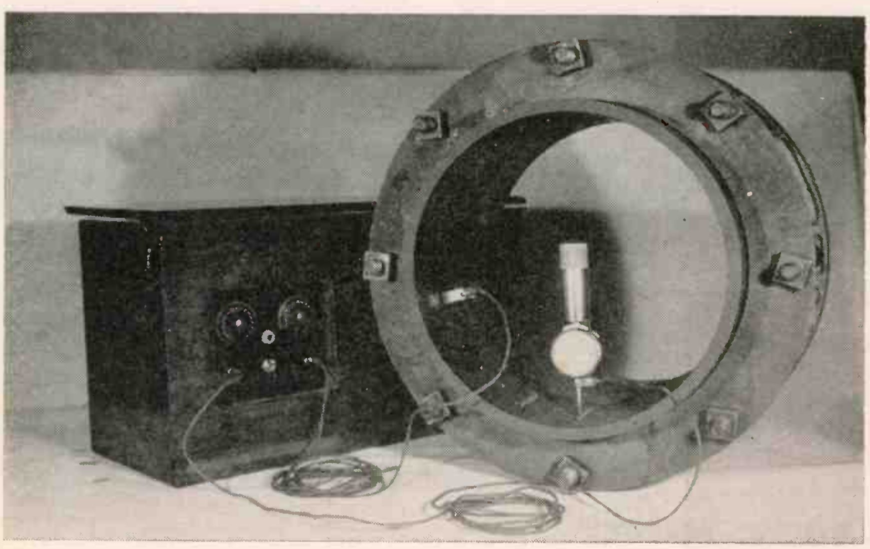


Fig. 1—Assembly details of the gage applied to a pipe gasket and the electronic circuit of the instrument for measuring gasket pressure in pipelines. When pressure is applied manually to the gage head, the plunger moves the pin away from contact with the shoulder of the threaded bushing



Complete setup of gage and audio oscillator-amplifier arranged to determine the variation of gasket pressure that occurs at different points of a pipeline joint

tion of the pressure which the gaskets exert in order to properly design a successful joint.

Most gasket tests have been based on the assumption that the pressure was uniformly distributed and that the unit pressure was equal to the total load divided by the area of the gasket. The problem of measuring the pressure which is exerted by an elastic solid such as rubber is much more com-

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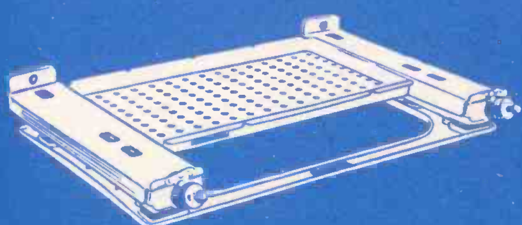

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plex than the measurement of fluid pressure. In the latter, the displacement of fluid necessary to actuate a gage does not usually affect the applied pressure. In measuring rubber pressure, any appreciable displacement of the rubber will cause a considerable change in the pressure being measured. This introduces an error of unknown proportions.

Two methods existed for determining force or pressure with very minute displacement. One used a quartz crystal and the other used a sensitive carbon pile. Both employ large instruments and readings could not be taken close enough together to plot satisfactory pressure distribution curves for the gasket. Also, frequent calibration is necessary.

The principle of operation of the Sealometer involves measuring the force exerted by the gasket upon the end of a "pressure pin" having an area of exactly 1/100 of an inch. Movement of the pin is limited to a few millionths of an inch—thus reducing the displacement error to a negligible value.

Test Procedure

For testing, each pressure pin is accurately fitted in carefully reamed holes at desired points in the test specimen and adjusted by means of a special screw so that one end is flush with the surface contacting the gasket. A specimen thus prepared has packing surfaces substantially the same as those in a joint in actual use, and the behavior of the gasket is not altered in any way. After the rubber ring in the test specimen is compressed, the pressure acting upon each pin is measured by applying an opposing force until a balance is obtained and the few millionths of an inch displacement of the pin occurs. This breaks the electronic circuit, setting up an audio howl. Figure 1 shows the wiring circuit.

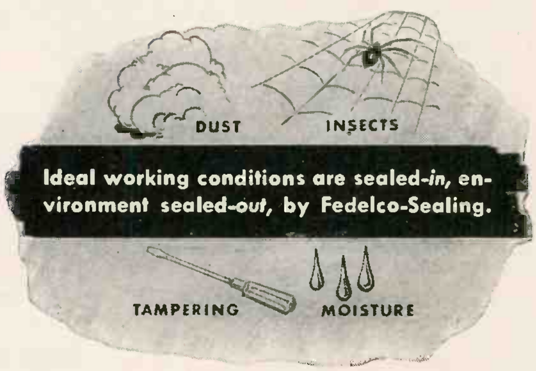
Three important factors influenced the design of the wiring circuit for the Sealometer. Frequent opening and closing of the circuit in measuring the pressures would foul the contacts unless a very small current were used. Also, the limitation of movement on the pressure

How Fedelco-Sealing Protects

this Automatic Electric Co. Relay

Against Environment

Actual Size of relay and housing. Wires will be soldered to spring terminals; metal cover is then Fedelco-Sealed to base. When container has been nitrogen-filled, glass tube (right) is sealed off at base. Octal plug is wired and locked into base.



To prevent tampering with electrical and mechanical devices, and to keep out bugs, dust and moisture, the Fedelco-Sealing process encloses these devices in a hermetically sealed metal housing, which can be exhausted and filled with dry air, or other gas, at atmospheric pressure. The enclosure is designed to withstand vibration and shock of any kind specified. The Fedelco-Sealing process assures the long life and unfailing performance built into your product, by eliminating the effects of environment.

Ship your product to us, and we will Fedelco-Seal it for you; or, when you require quantities large enough to do your own Fedelco-Sealing, we will design for you complete methods and equipment as used in the Federal Electric Plant. Get the details of this new protection now—from any of the offices listed below.

How Fedelco-Sealing protects this Aviation Type S Automatic Electric Relay

An 8-point multiple header is sealed into the round metal base. The relay is fastened to the U-shaped bracket. Wires are soldered to spring terminals and carefully cleaned to eliminate all traces of flux or other foreign matter. The relay is carefully checked for all operating characteristics. The metal cover is then Fedelco-Sealed onto the base.

Air is exhausted, and the container flushed with nitrogen for complete removal of oxygen. Finally, the case is filled with dry nitrogen and the tube sealed off, close to the base. Terminals are then wired to the octal plug, which is locked into position, completing the assembly. Thus protected from dust, moisture, and fungus, the relay provides longer life, and decreased maintenance.

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pin in order to avoid errors from distortion of the rubber gasket made it necessary to have a current that could not jump a gap of a few millionths of an inch. The problem of insulating the pressure pin so the current would flow properly also was involved.

One test lead of the unit connects to the stem of the indicator gage. The other test lead is attached to the specimen being tested. Thus the current travels through the shoulder of the adjusting screw by way of the pressure pin to the plunger of the gage stem.

Special Insulation

The circuit is broken when pressure on the plunger moves the pin away from contact with the shoulder of the adjusting screw. Difficulty was had with insulation of the pin on all surfaces where it comes in contact with the reamed hole. A coating of iron phosphate finally was selected to be the insulating layer. While not a superior insulation, it is sufficient to interrupt the slight current of the circuit. This material overcame the tendency to cause the pin to stick that other types of insulation exhibited.

The opposing force applied on the pressure pins is exerted manually. The stem of a dial indicator gage is fitted with a special needle-like plunger which can be inserted through the hollow adjusting screw to engage the pin. Mounted over the stem is a handle housing an accurately calibrated engine indicator spring that requires one pound of pressure for each 0.01-inch deflection. Pressure on the handle is transmitted to the pin through the plunger, the pressure being measured by the spring and recorded on the dial indicator. The area of the pin is 0.01 inch and each pound of pressure applied manually represents 100 psi.

Advantages

Since the audio signal sounds when the balanced pressure condition is reached, the operator can take readings without lifting his eyes from the gage. This makes possible the reading and recording of pressures at the rate of about 150 per hour. Accuracy has been

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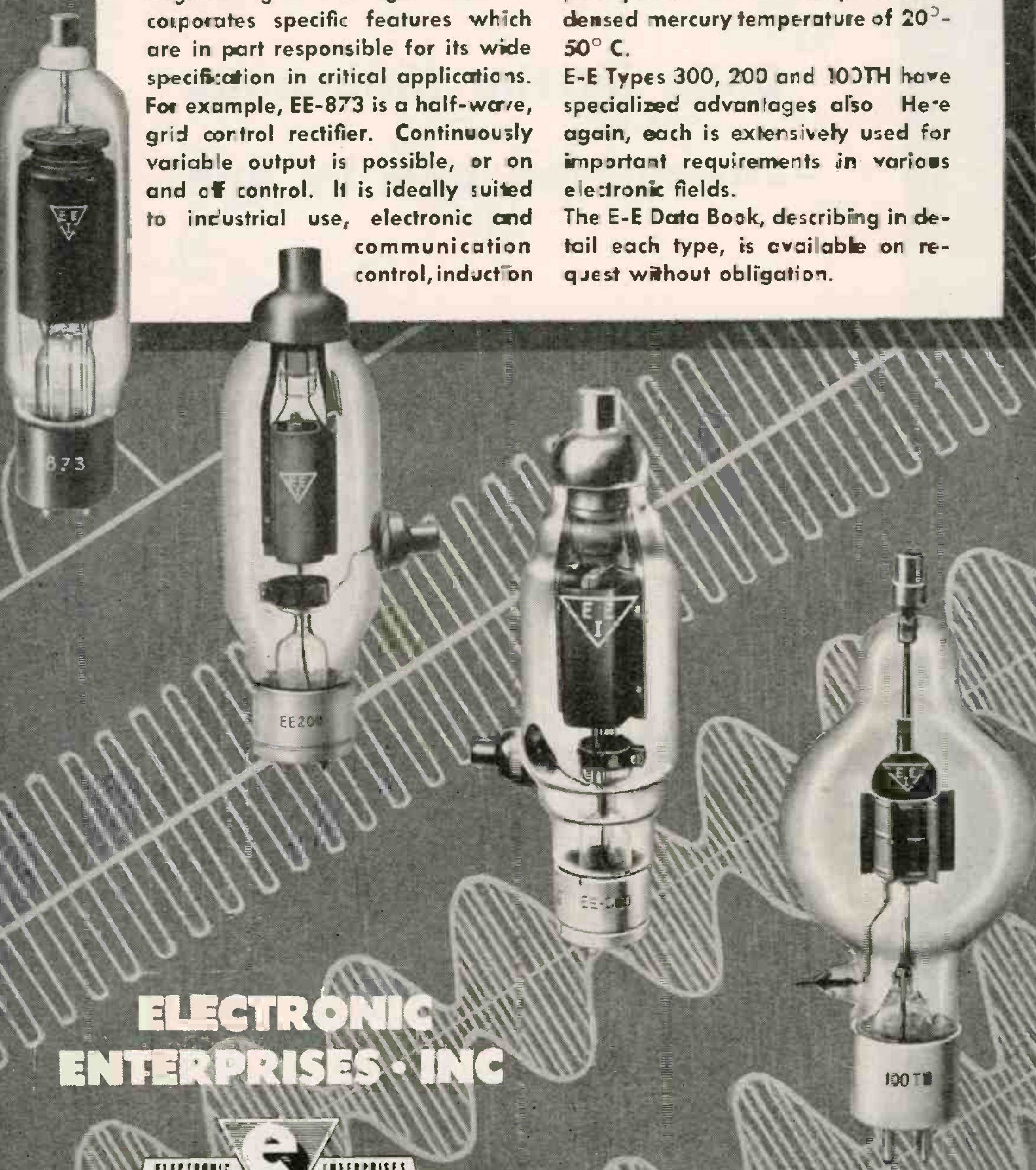

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. . . ATLAS *a load off your shoulders . . onto ours* checked at better than 98 percent correct by independent methods. Since the actual diameter of the pins is only 0.1128 inches, they can be spaced as closely as $\frac{1}{8}$-inch apart on the test specimen. Another advantage of the gage is that it permits pressure readings to be taken during assembly of a pipe joint as well as at any time thereafter. It is also possible to take readings while the joint is under line pressure. The gage is not affected by such factors as condition of the pipe or bloom on the gaskets, which seriously distort the results obtained by internal pressure tests.

In tests on one type of pipe joint, in spite of the fact that all bolts were tightened to exactly the same tension with a torque wrench, pressures ranging from 200 to 1000 pounds were recorded at various points around the gasket. On another, clamp pressures were found just above zero and dangerously close to the point at which leaks would occur. By using data compiled with the instrument, the pipe couplings were redesigned to equalize pressure throughout the gasket at a level well above minimum safety requirements.

• • •

Simplified Training for Assembly-Line Workers

By S. FREDERICK AUERBACH

Engineer, Emerson Radio Television Corp.

ISOMETRICS is the pictorial delineation of mechanical parts. More recently isometrics has been accepted and extensively used in the radio and aircraft industries for its clarity when used to show assembly of parts in exploded views.

During the war, many plants found that the personnel available for the assembly line was difficult and unsuited to train in blueprint reading. This condition necessitated an increased staff of key men and women to interpret and supervise the work. This type of assembly-line tutoring required many hours of training for supervisors and then, in turn, especially for workers who had to master the simple operations and commit them to memory. This was true even though the assemblies were broken down

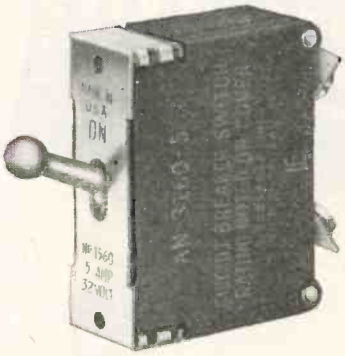
LF

First in Circuit Protection

LITTELFUSE

Snap! make...Snap! break

CIRCUIT BREAKER SWITCHES



A product with a military reputation, pioneered and developed by Littelfuse. High lag, quick reset feature adapts it to many commercial uses. Its "finger trigger" principle, with high spring compression, gives it instantaneous action and maximum contact. Its magnetic blowout minimizes the arc—which reduces pitting in the switching action, assuring longer breaker life.

These non-trip free, circuit breaker switches come in either a push-pull button (series 802000) or toggle control (series 801000—illustrated)—in 5 to 50 amp ratings at 32 volts or less DC or AC. Conform to specification AN-C-77a. Bi-metal design, assures little variation in use at temperatures as low as 60° below F. and (5 amp. breaker—without electrical load) takes 350° F. without opening.

Send for descriptive literature to Littelfuse Incorporated, 4757 N. Ravenswood, Chicago 40, Ill.

Plants in Chicago and
El Monte, California

QUALITY IS BASIC

Today, our business continues to expand as satisfied customers voluntarily recommend our fuses to the manufacturers of airplanes, automobiles, radios and electronics equipment . . . and to the utilities and building industries, as well. The reputation which we won prior to the war, gave us the opportunity to design circuit protection devices for the Army, Navy and Air Forces. Early in the war, we were awarded the Army and Navy "E".

Throughout the years of progress, never have we lost sight of the basic fundamental on which our business was founded, namely: a quality of workmanship and materials which makes for precision in circuit protection and safety.

President

LITTELFUSE LF *Incorporated*

New ELCO A1-F RESISTOR 38,500 OHMS

its FUNGUSIZED!

Temperature coefficient is such that a minus 50° centigrade change in temperature from plus 22° centigrade will produce no greater than plus .0.1% change in resistance.

A1-F—15/32 long x 1/2" diameter. Mountable with 6-32 flat or filester screw No. 21 Tinned Copper wire leads. 1% standard accuracy. Non-inductive pie wound—1/2 watt, 200 D.C. maximum operating voltage. Fungusized varnish finish.

CAN ALSO BE MADE IN OTHER SIZES ACCORDING TO YOUR SPECIFICATIONS

ALL ELCO RESISTORS ARE PRECISION WIRE-WOUND

SPECIFICATIONS:

"A-1"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 300,000 ohm value—1/2% standard accuracy—non inductive pie wound—1/2 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—200 D. C. maximum operating voltage. Baked varnish finish.

"A-R"—Same as A-1, with leads reversed.

"B-1"—15/16 long x 1/2" dia.—Mountable with 6-32 flat or filester screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value—1/2% standard accuracy—non inductive pie wound—1 watt, 30° C. temperature rise in free air—100° C. maximum operating temperature—300 D. C. maximum operating voltage. Baked varnish finish.

"M"—1-13/32 long x 3/4" dia.—Mountable with 6-32 screw—1/8 x .015 thick strap terminals—non inductive wound—1 meg ohm maximum resistance—600 volts maximum operating voltage—100° C. maximum operating temperature—1.5 watts—1% normal accuracy. Baked varnish finish.

"G"—15/32 long x 1/2" dia.—Mountable with 6-32 flat or filester head screw. No. 21 tinned copper wire leads. 1 to 500,000 ohm value. 1/2% standard accuracy—non inductive pie wound .8 watts, 30° temperature rise in free air. 100° C. maximum operating temperature. 200 D. C. maximum operating voltage. Baked varnish finish.

"B-R"—Same as B-1, with leads reversed.

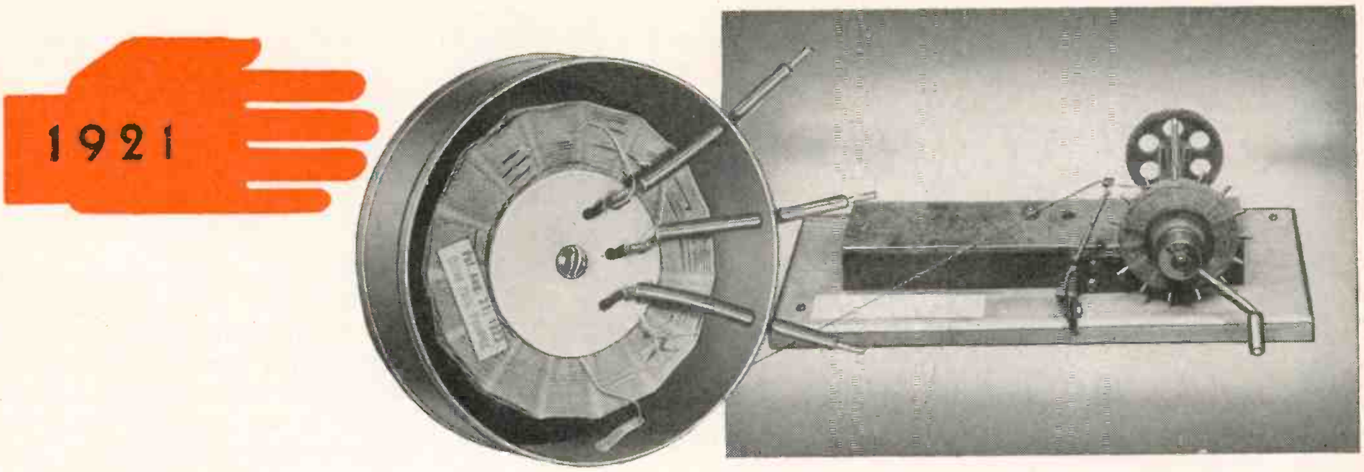
PROMPT DELIVERIES on the New A1-F and others described and illustrated

Get to know ELCO

RESISTORS COMPANY

114 West 18th Street, New York, N. Y.

Telephone · Watkins 9-4774-5



The Leader is Still the Leader

The first radio coils were wound by hand . . . a laborious, time-consuming process. Then, in 1921, Sickles developed a manually cranked machine that did a much faster, *much better* winding job . . . slashing production time and costs and turning out the most efficient coil of its day.

Today, the Sickles R. F. Coil reflects twenty-four years of steady progress in electronics design and manufacture. Wound on a complex machine, the 1945 model is hermetically sealed against water, corrosive chemicals and gases — *permanently*. The deep-drawn zinc housing has wide-soldered joints and fused metal-to-glass bushings; all adjustments are enclosed and sealed with neoprene gaskets.

An enormous improvement over its ancestor of the early 20's, but still upholding the family tradition. . . . *Still the Leader!*

To Sickles' peacetime pioneering in the electronics field has been added a wealth of war-inspired advancement — new techniques that can benefit *your* production. May we tell you how? . . . Send us your requirements for prompt, helpful discussion.

THE F. W. SICKLES COMPANY — CHICOPEE, MASS.

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1775 Broadway, New York 19, N. Y.
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into many smaller components and cycles than the job ordinarily warranted. It also required many more checkers and inspectors.

Advantages

It was soon discovered that isometrics could play an important part toward solving this problem. With such a drawing, all workers could easily recognize the parts required in the assembly when the subassemblies were properly prepared and broken down into cycles of fair size. It was simple to read with no explanation required or training necessary for the worker. And, more important than that, assembly was mastered more quickly by the individual worker so that a minimum amount of time was required for the breaking-in period. This has resulted in maximum production per worker. It has also eliminated a number of supervisors and, in the event a supervisor was

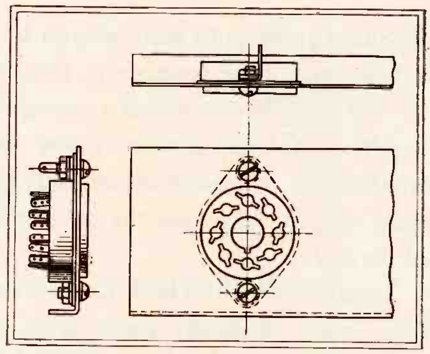

FIG. 1—An orthographic view of a socket and mounting requires three drawings to show the correct order of assembly

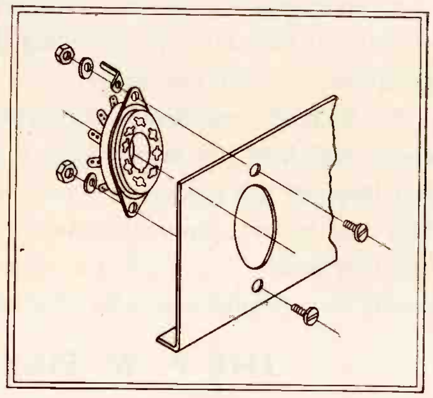

FIG. 2—Isometric view of the socket assembly shown in Fig. 1. Visualization of the order of operations is simplified for the assembly-line worker

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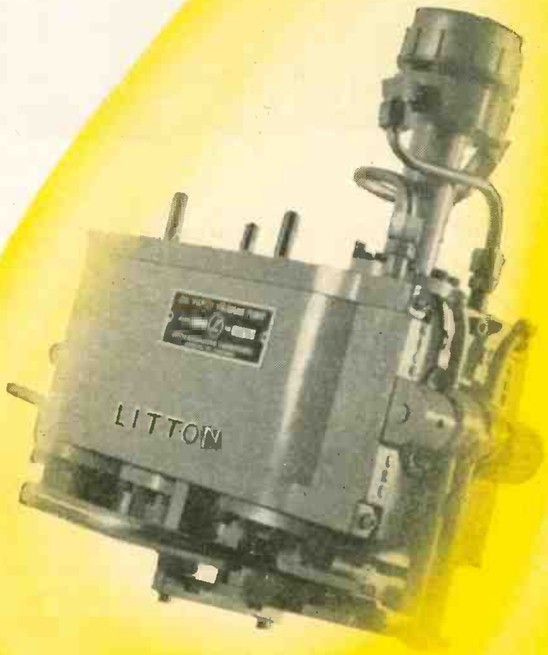
the best in High Vacuum



Litton Molube (Molecular Lubricant), a highly refined vapor pump medium, from carefully selected petroleum base, with high stability and extremely low vapor pressure, is now available in unlimited quantities for immediate delivery at prices that revise former operational economy.

Molube will operate advantageously in practically all equipment designed for organic media. Its complete sorption by activated charcoal makes it ideal for the attainment of ultimate vacuum, but it is equally adapted to ultra speed dynamic systems.

Literature on Litton Molube, High Vacuum Pumps and auxiliaries—glass working fires and machines, and accessories—metal glass seals and special products available on request.

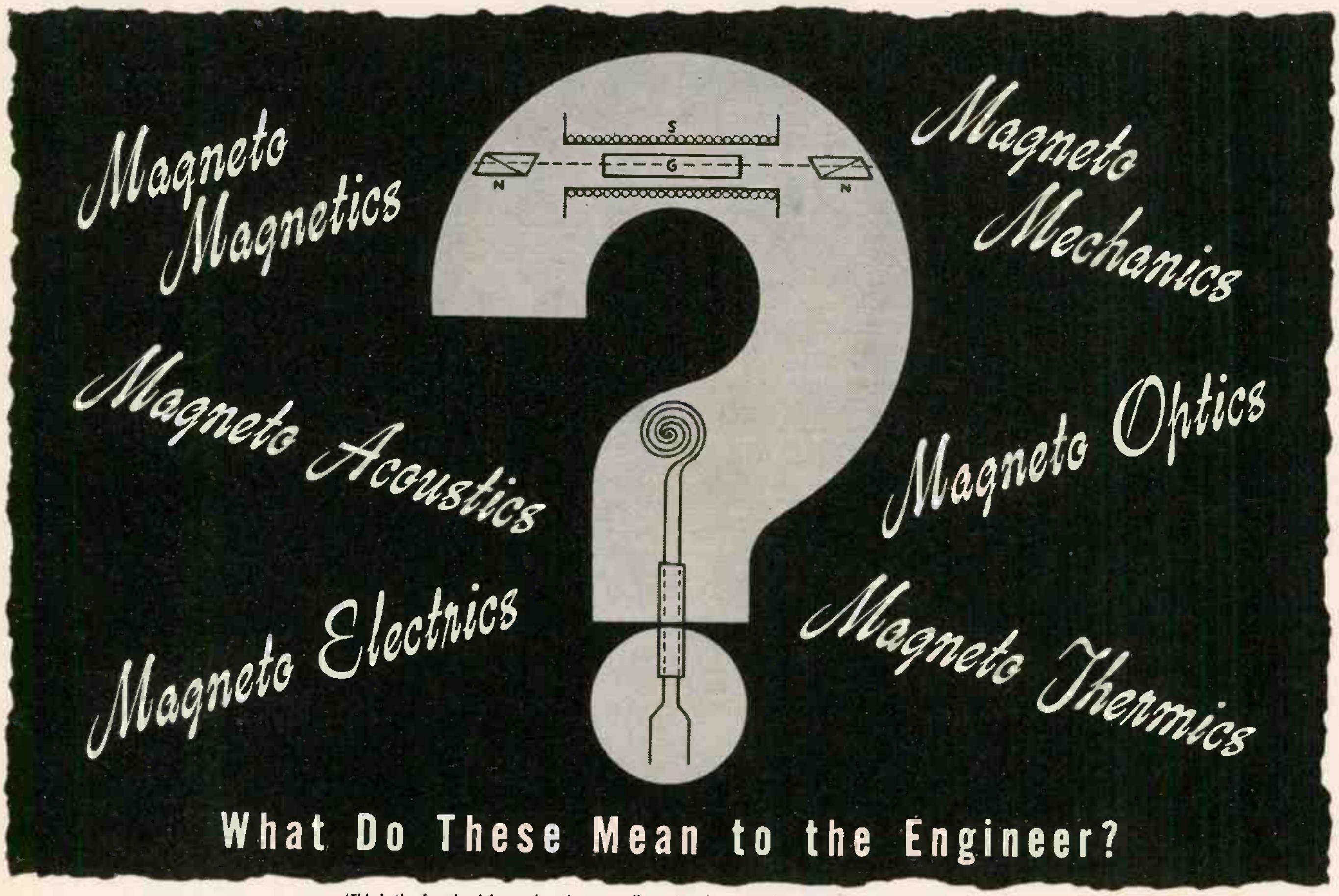
"For Twelve Years the Standard of the Industry"

Litton

ENGINEERING LABORATORIES

REDWOOD CITY, CALIFORNIA, U. S. A.

PERMANENT MAGNETS MAY DO IT BETTER



(This is the fourth of four advertisements discussing the major functions of permanent magnets.)

THE LEAST KNOWN FUNCTION OF PERMANENT MAGNETS

To Change Apparent Characteristics of Materials

What are the commercial and scientific possibilities in the application of magnetism which changes the characteristics of certain materials whether gas, liquid or solid?

We know, for example, that the application of a magnetic field will cause the following changes:

IT WILL CHANGE

- *the apparent a.c. permeability of soft magnetic substances*
- *the normal hysteresis curve of magnetic materials*
- *the dimensions of nickel and some other metals*
- *the frequency of a tuning-fork*
- *the electrical resistance of bismuth*
- *the boiling point of some materials*
- *the rotation of polarized light through many materials*

These and kindred effects, which are known and are being investigated by physicists, may well lead to new fields for the application of permanent magnets. The potential uses of this little known property of magnetism have been scarcely touched industrially, although it has been employed in magneto stricture oscillators, in remote control indicators and, by the use of bismuth to determine field densities.

Our own research, based upon 35 years of specialization in the manufacture of permanent magnets, may help you to find some new means of achieving desired results. Write for consultation. Without obligation, send for copy of technical handbook: "Permanent Magnets Have Four Major Jobs."

★ THE INDIANA STEEL PRODUCTS COMPANY ★

6 NORTH MICHIGAN AVENUE, CHICAGO 2, ILLINOIS

SPECIALISTS IN PERMANENT MAGNETS SINCE 1910

Now—General Electronics is proud to announce nation-wide sales representation on its complete line of electron power tubes—nine of which are illustrated above. These representatives have been appointed because of wide acquaintance in territory, knowledge of products, customers' requirements and ability to render excellent service.

In all phases of electronics—induction heating, broadcasting or medical—General Electronics tubes have earned a reputation for extra-long life—the result of advanced design technique and completely modern production facilities and methods.

Wherever you are—whatever your tube requirements—consult the new General Electronics Catalog . . . then communicate with your nearest representative if you need immediate help.

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NICKERSON & RUDAT
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WGFMK SOUTHERN CALIFORNIA

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G. G. WILLISON
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TEXAS, OKLAHOMA, SHREVEPORT, LA.

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FRANK C. FASSETT
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Tampa, Florida
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CAROLINA RADIO EQUIPMENT
105 East Martin St.,—Ph. Raleigh 4842
Raleigh, N. C.
WRAL NORTH CAROLINA

GENERAL ELECTRONICS INC.

SALES: 1819 BROADWAY, NEW YORK 23, N. Y.

absent, the assembly line was not affected.

Illustrated in Fig. 1 and 2 is a simple assembly in orthographic and in isometric exploded view. In the orthographic view at least two or three views are commonly required to identify the correct order of assembly, whereas in the isometric one drawing is required. Also it has been found that there is more assurance of the parts being correctly assembled by the neophyte worker during the first few hours of breaking-in time.

Isometrics is especially useful in showing wiring of radio parts in the chassis assembly. Figure 3 shows this wiring and when finally

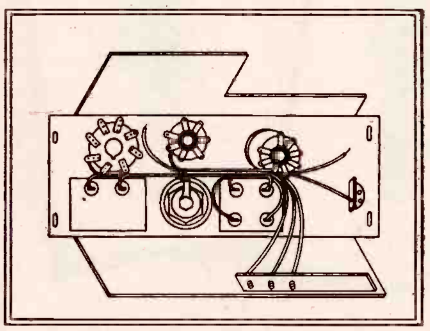


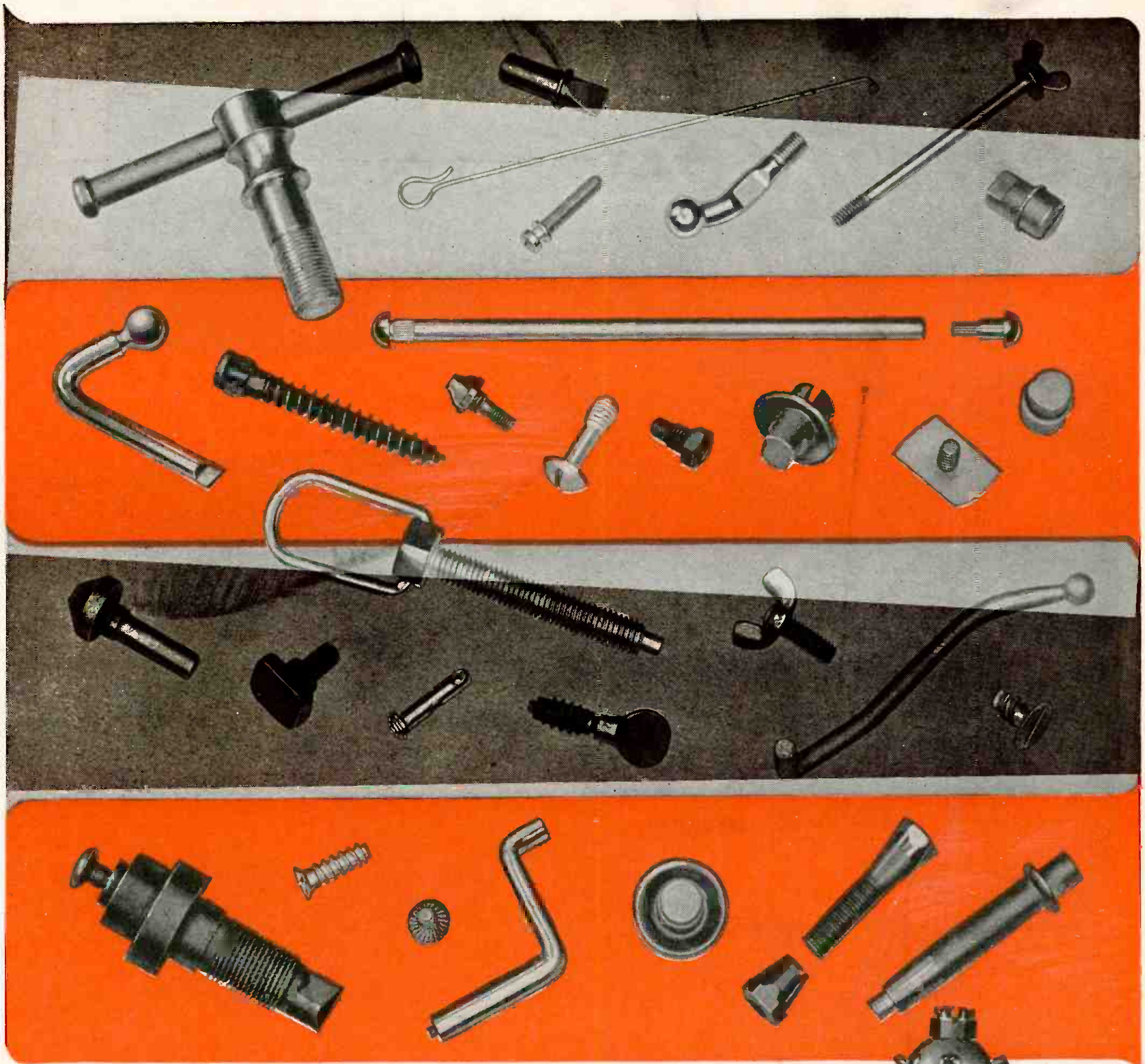
FIG. 3—Chassis wiring in isometric view. Color can be used to show coded wires

printed the wiring is shown in the wiring color markings. Another consideration is the time required for the preparation of the isometric drawing, since a trained draftsman can easily halve the time required to make an orthographic projection drawing.

Procedure

A method much in use is for a hubsman or layout man to make a complete layout in isometric of a certain section of the equipment, as in Fig. 4. Then the isometrician's assistants or draftsmen draw the subassemblies from this master drawing. See Fig. 4(a) showing a section of (b). This method of producing drawings has saved considerable time for the drafting departments. Sometimes the subassemblies are reduced in size to accommodate small chart folders, which are placed in front of each assembler with a print of the required assembly to be made.

Three more considerations are



Yes· we make "SPECIALS"!

Just take a good look at the picture above—a sample assortment of nonstandard products which we have made by the upset method. Most of these could not have been produced, in the time and quantity required, in any other way.

The upset or cold forging method also saves materials and lowers costs. And in many cases it makes a stronger, better product than that produced by other methods.

Maybe we can show YOU some important SAVINGS. Tough "specials" are right down our alley. Write us.

National HEADED AND THREADED PRODUCTS

THE NATIONAL SCREW & MFG. CO., CLEVELAND 4, O.

Two reasons why Essex *EXTRA-TEST* MAGNET WIRE is ideal for Coil Winding

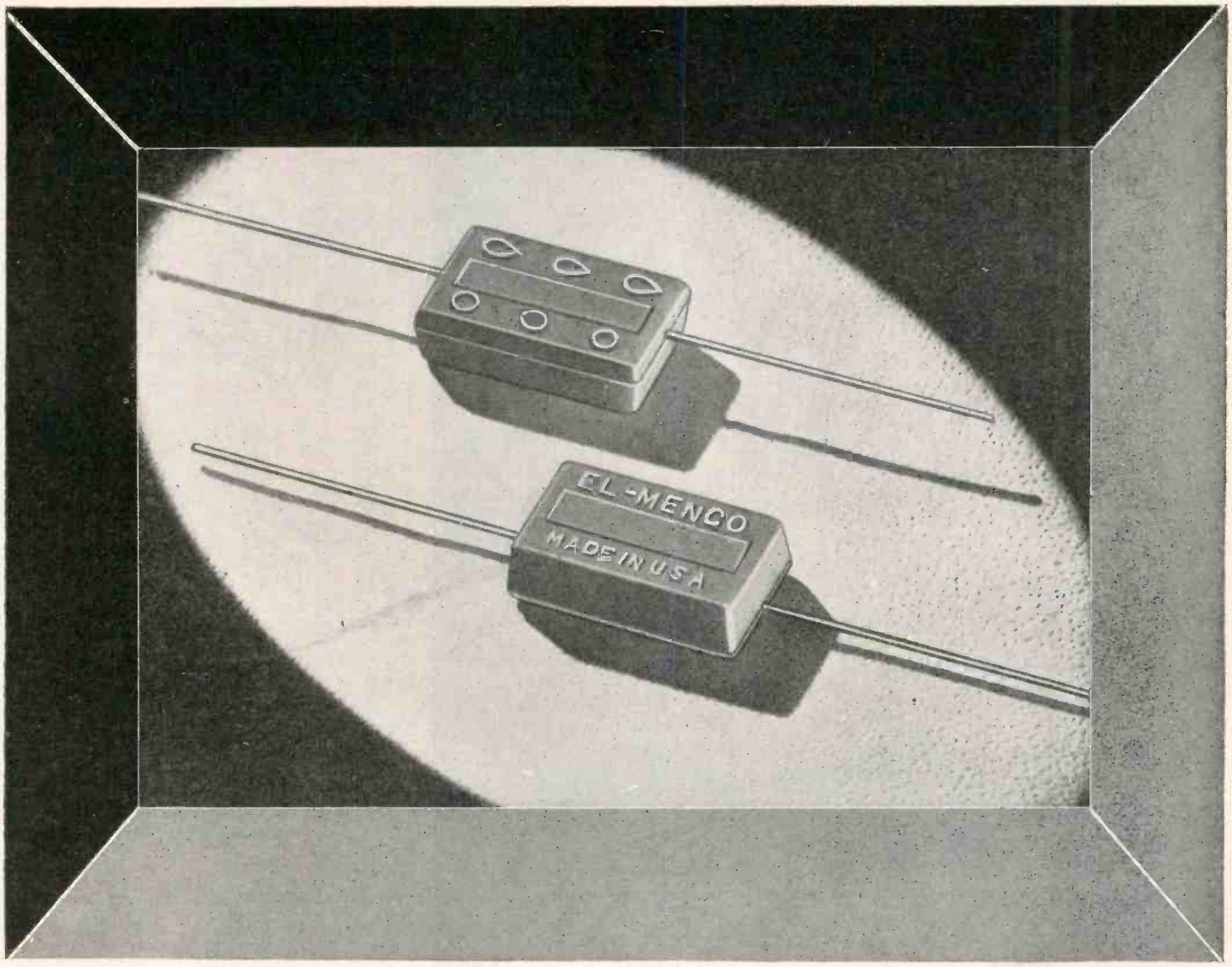
Essex *Extra-Test* Magnet Wire is carefully and thoroughly tested for softness and "stretch" before shipment from the factory.

All flat, square, and heavy round wire is given the Rockwell Test. Round wire in intermediate and smaller sizes is subjected to Elongation Tests. In every case, Essex demands results better than ordinary specifications require.

These constant, severe Essex *Extra-Tests* give definite assurance that every spool of this fine magnet wire will be soft enough—sufficiently annealed for ideal "wind-ability" in coils. No more hard, springy wire to cause trouble and slow up production. No more annoying complaints and adjustments.

Essex also uses the most modern methods of spooling wire—and all essential data (size, weight, insulation) is plainly indicated on the label of every spool. This prevents costly errors in your warehouse and winding room.

ESSEX WIRE CORPORATION
FORT WAYNE 6, INDIANA



PORTRAIT OF *Precision*

Precision marks every step in the manufacture of El-Menco Capacitors, for well we know the vital role our products must play, and how much depends upon their unfailing performance. That this precision is appreciated is best evidenced by the Army-Navy award we so proudly display.

Postwar products in which El-Menco Capacitors will be used will undoubtedly be *fine* products — products of quality in *every* detail.

Manufacturers of
Electronic Equipment:

Send, on firm letterhead
for new Capacitor Catalog.

THE ELECTRO
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MOLDED MICA-
MICA TRIMMER
Capacitors

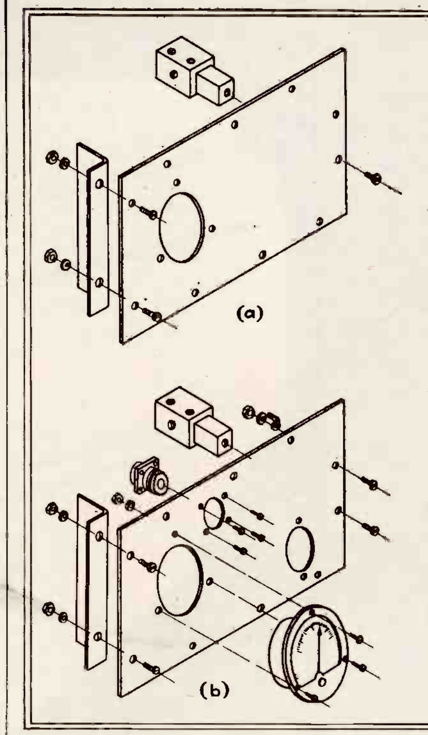


FIG. 4—An isometric layout of a complete panel is shown at (b). From this master, the view at (a) of the subassembly is drawn

important. One is that this type of assembly guidance does not tie up many small units used as models in the plant. A second is that, in the event of a change in the part, the isometric drawing revision is much simpler and less costly to make than the model used in the plant. The third is that inspection depart-

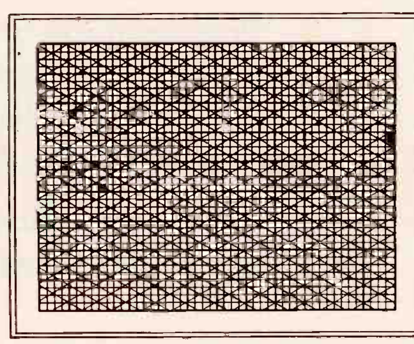
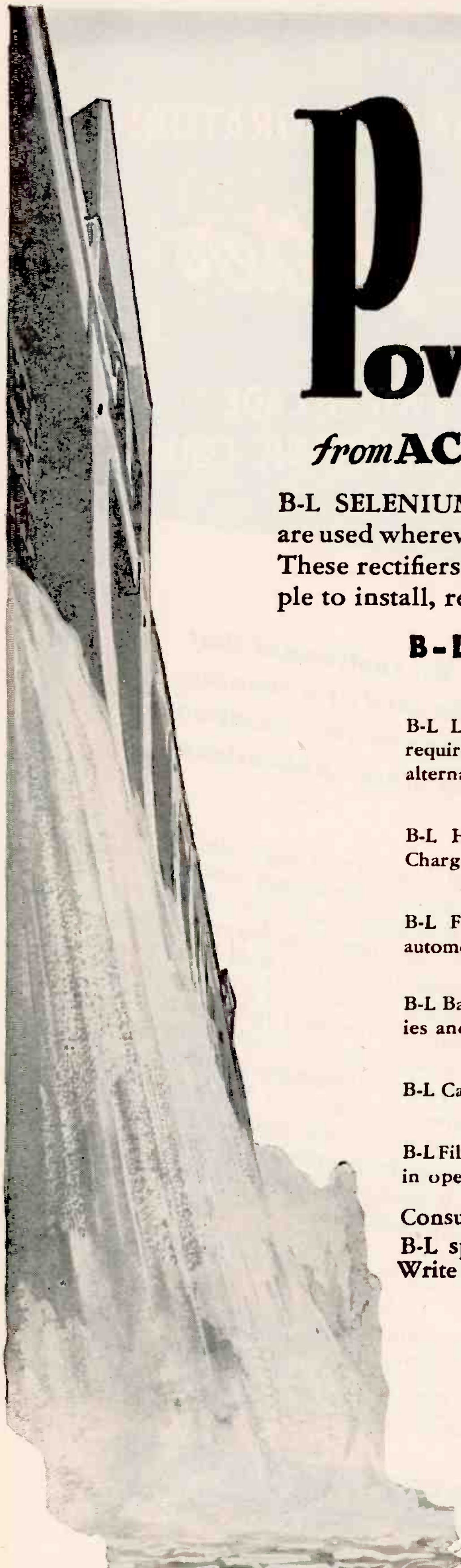
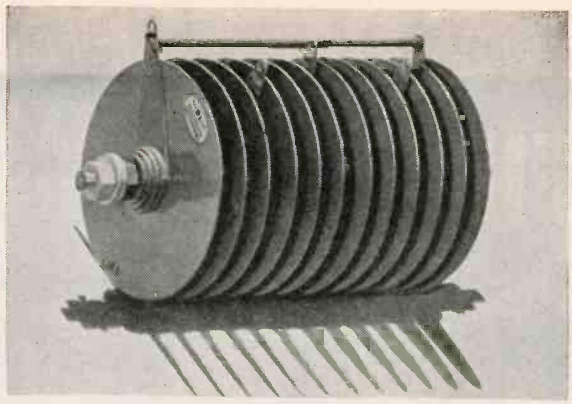


FIG. 5—Cross-ruled sheets can be used as guides if diagonal lines are added for making isometric drawings

ments find it a great deal easier to use than the conventional orthographic assembly blueprints.

The training time for most draftsmen in this type of work is anywhere from about three days to two weeks. The work can generally

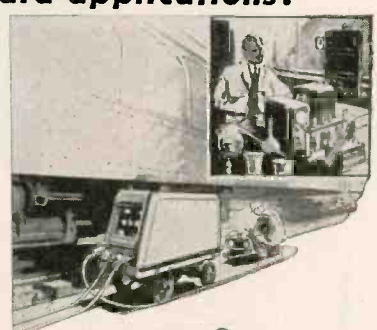




POWER CONVERSION
from AC to DC with B·L RECTIFIERS

B-L SELENIUM AND COPPER SULPHIDE ELECTRICAL RECTIFIERS are used wherever direct current is required from an alternating current source. These rectifiers are compact—durable—silent; have no moving parts; are simple to install, require no maintenance. Ratings from milliwatts to kilowatts.

B-L RECTIFIER TRANSFORMER ASSEMBLIES
are built for many standard applications:



B-L Laboratory Rectopacs for supplying the required voltage of direct current from the alternating current source.

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B-L Heavy Duty Portable Railroad Battery Charger, for use in terminals.

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B-L Fast Battery Charger for "no removal" automotive battery service.

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B-L Battery Booster for use in charging batteries and keeping them charged.

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B-L Cathodic Protection for pipe lines.

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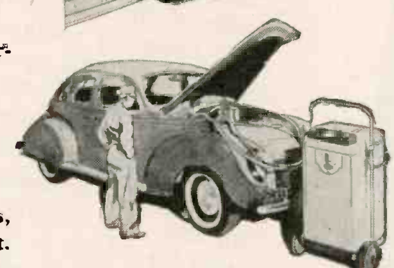
B-L Filterpacs, eliminating the need of batteries, in operating 6-volt DC electrical equipment.



Consult us if you have a Power Conversion Problem. Twenty-five years of B-L specialized skill in AC-DC conversion problems is available to you. Write for Bulletin R38-A.

SELENIUM — BL METALLIC RECTIFIERS SINCE 1923 — COPPER SULPHIDE

THE BENWOOD LINZE COMPANY
1815 Locust Street • • • St. Louis 3, Mo.
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Designers and Manufacturers of Selenium and Copper Sulphide Rectifiers, Battery Chargers, and DC Power Supplies for practically every requirement.

RIGHT from the START!

You'll find WHITAKER is a dependable source —if your production needs include CABLE ASSEMBLIES

Let specialists who are experts produce the cable assemblies, wiring harnesses or bonding jumpers required in units you manufacture. Turn the job over to Whitaker —and it will be *right from the start*.

Throughout every stage of our production we make exacting inspections, tests and checks. (Illustration above shows positive continuity check of assemblies being made for an electronic manufacturer).

In addition to an engineered wiring service, Whitaker also offers a quality line of standard cable requirements . . . Write us for complete information.

Whitaker Can Wire It

WHITAKER CABLE CORPORATION

General Offices: 1307 Burlington Avenue, Kansas City 16, Missouri
Factories: Kansas City, Mo. • St. Joseph, Mo. • Philadelphia • Oakland

1920--Silver Anniversary--1945

be done from blue prints of assemblies or actual assembled parts.

Since isometric drawings are usually shown at 30-deg angles, a simple chart as shown in Fig. 6 can be prepared to use under the drawing sheet. It is prepared by drawing 64 squares to the square inch (such ruled sheets can be purchased), then diagonal lines are drawn in both directions at 30-deg angles at ½-in. intervals. However, there is available on the market a small size (8½ x 11) prepared isometric chart.

• • •

Electronic Equipment for Commercial Aircraft

By DAVID WILLIAM MOORE, JR.
Fairchild Camera and Instrument Corp. New York City

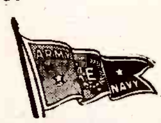
TO BE A PRACTICAL commercial conveyance, or a very useful private one, an aircraft must be capable of sustained operation through areas of limited visibility. This limitation of visibility, to be overcome, presents problems which are not encountered in any other type of vehicle. It was for many years an impossible problem to even determine the actual height above the ground. It still is a nice problem, but one which has been solved at least for large commercial craft by the application of electronics.

When the weather is such that visibility is limited to a very few feet, and no accurate altitude indication is available, no true ground speed and obviously no indication of the plane's exact location, flying can be far from enjoyable. This is just the predicament that flyers found themselves in not many years ago, before the days of radio ranges, automatic radio compasses, absolute altimeters, etc. It is, unfortunately, the state of the private flier even today due to the prohibitive cost of the available electronic aids, and of even the standard mechanical blind flying equipment. As private flying becomes more popular, accurate radio direction finders will undoubtedly approach a cost not much higher than good automobile radios. The radio range is available to anyone with a radio receiver, but radio altitude equipment will not be common on private

transformers
FOR RADIO-RADAR-ELECTRONIC CONTROLS

Call on Kyle Engineers . . . Trained experts are ready at all times to assist in the design of new transformers to meet your specifications. Write Kyle today.

Kyle Transformers are the product of one of the leading manufacturers of electric power distribution equipment. ¶ Kyle's unusual facilities for the design and manufacture of precisely built, dependable small transformers have been thoroughly proven in the service of wartime radio communications, radar detection and electronic controls. ¶ Specializing in hermetically sealed equipment of highest quality, Kyle transformers function perfectly under the most extreme conditions of climate and altitude. ¶ Experienced Kyle engineers are anxious to work with you in the design of specific transformers to meet your postwar requirements.



KYLE CORPORATION

SOUTH MILWAUKEE, WISCONSIN

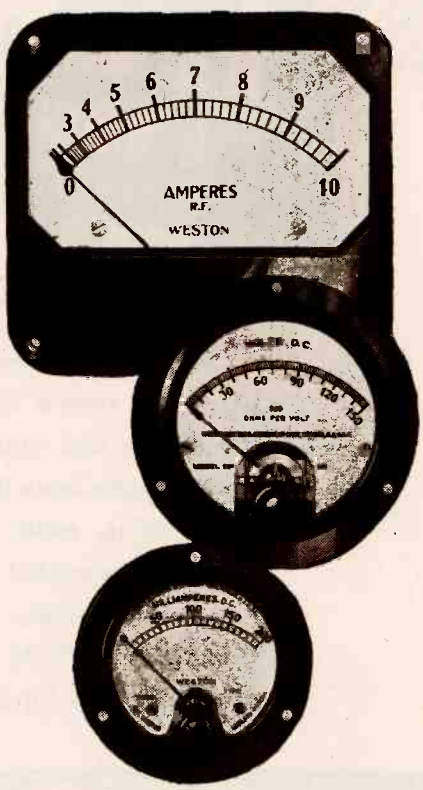
Pointing the way to BUYER ACCEPTANCE *for tomorrow*

Many a brain-child of far-sighted companies now on the drawing-board, is destined for early birth. *Tomorrow, these products will be seeking market acceptance not only at home, but in all corners of the earth.*

With postwar markets highly competitive, manufacturers will strive to put into the product the best in materials components, and engineering skill. And if an indicating instrument is essential, it must be one not only of *proved* dependability, but one which has world-wide preference as well.

Logically, the instrument choice will be WESTON. For a WESTON on the panel gains instant recognition from equipment buyers throughout the world. To them, it is outward evidence of engineering soundness all throughout the device or machine. And to the manufacturer it brings an added sense of security . . . knowing that wherever they are used, his machines have a dependable and trouble free WESTON at the controls.

Before your equipment gets into the manufacturing stage, why not check your instrument needs with WESTON. Complete engineering service is freely offered. Weston Electrical Instrument Corporation, 578 Frelinghuysen Avenue, Newark 5, New Jersey.



Weston

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The high quality of RADIART VIBRATORS is well known. That high quality has characterized all Radiart Products that have been and are being used by the Armed Forces on all fronts. As production for civilian users expands it will continue to increase the demand for RADIART VIBRATORS.

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While production for civilian users may increase gradually, by far the greater part of our production will continue to be required for the U. S. Armed Forces. We must and will meet all of their schedules on time.

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By eliminating many little used types of vibrators Radiart has been able to increase production of all popular types. *NOW the dozen or so types of RADIART VIBRATORS necessary for over $\frac{7}{8}$ths of all needs are more readily obtainable.*

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planes for quite a while, due to its weight and cost.

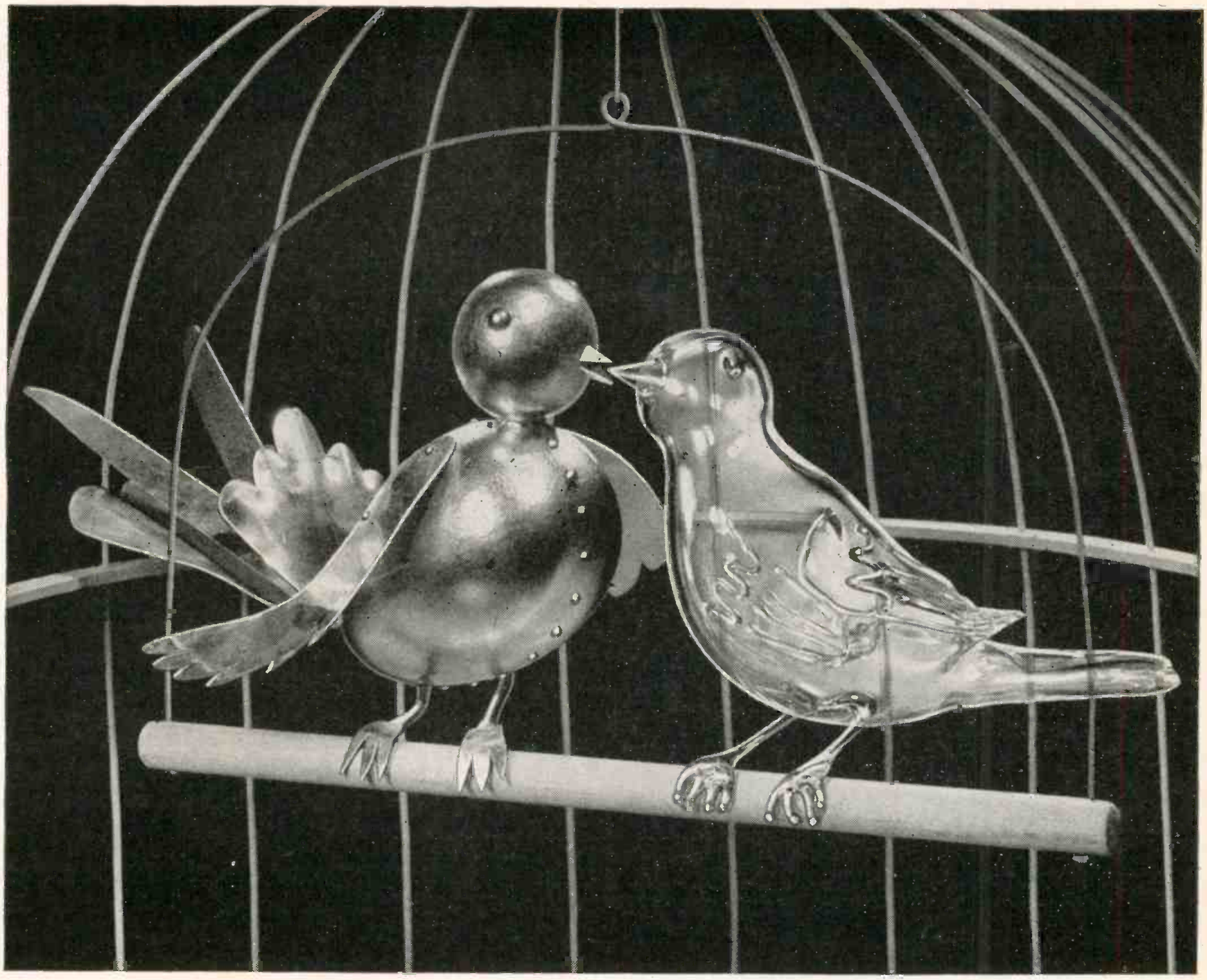
Use for Radar

Radar is furnishing the pilot with the first tangible link with the ground since the conception of mechanical flying. It enables the pilot to definitely contact the ground and to actually "feel" it through his electronic circuits to determine its characteristics, or those of any other object which may be within range of his beam of concentrated radio energy. This is probably the greatest single step forward in aircraft navigation under limited visibility yet to be made. It is at present out of the price range of the private flyer, and probably of most of the commercial airlines, but it has furnished answers to many seemingly unsolvable problems presented to our army in connection with establishing reliable flight routes independent of weather conditions. This type of navigation has been a dream since shortly after the last war, but has become a reality through greatly increased knowledge of microwave technique and of electronic circuit characteristics.

Ice Indicator

An electronic instrument has been developed to warn the pilot of the formation of ice on his wing surfaces, a very serious problem in cold weather flying. There are so many different forms of ice, and such widely varying rates of ice-creation that satisfactory detection has been and is still difficult. Electrical instruments are being developed in competition with the electronic type. The main problem is to determine the rate of ice formation so that a pilot can, upon changing his course, decide whether conditions have been improved or not.

The formation of wing and tail surface ice has been practically solved on large aircraft, experimentally at least, by the use of heated wings which preclude the possibility of any formation of ice. The propeller and the carburetor are not protected by wing heating and still offer possibilities for electronic detection. But the heated wing will probably never be practical for smaller aircraft where the



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Corning's metallizing process, combined with the excellent mechanical and dielectric properties of Corning's glasses, produces hermetic seals between glass components and metal by ordinary soldering methods or furnishes accurate and constant capacitances and inductances or electrostatic shielding.

Metallized glass as developed by Corning offers a wide variety of new applications in the field of electronics. Perhaps you have a problem where the union of glass and metal can help. Why not write us about it? Address Electronic Sales Department, E-7, Bulb and Tubing Division, Corning Glass Works, Corning, New York.

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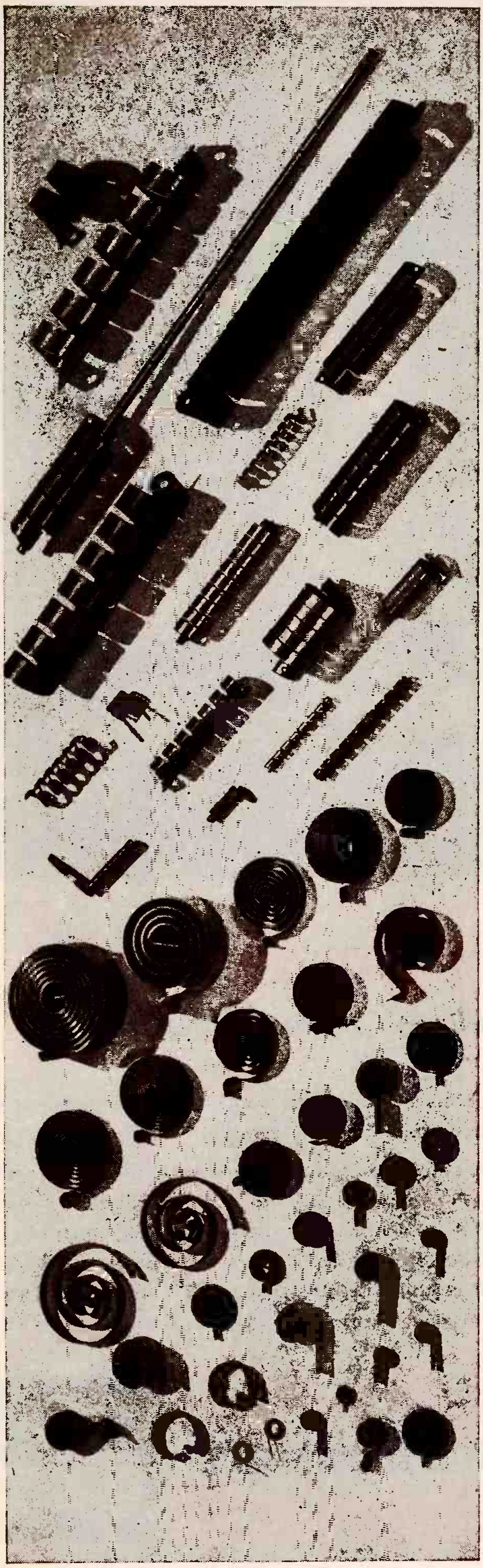

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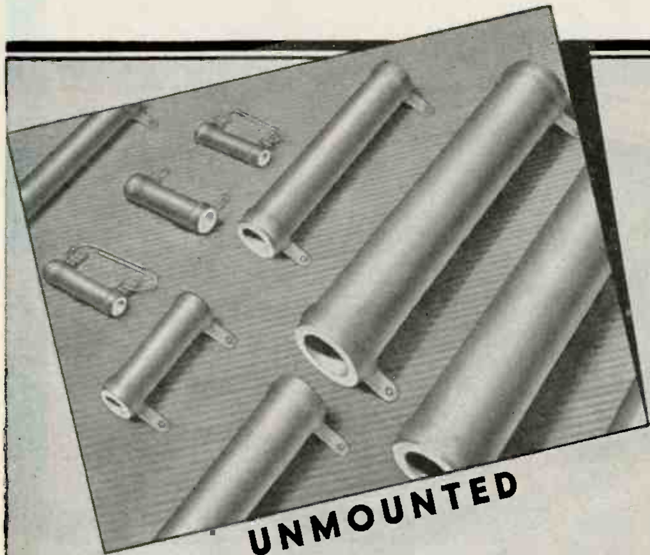
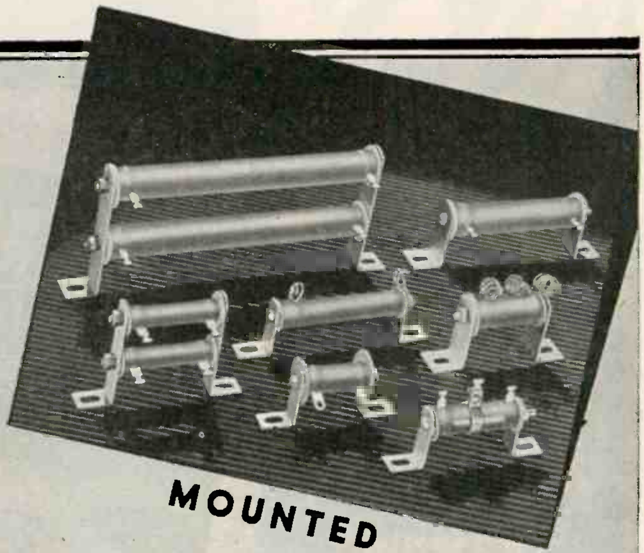
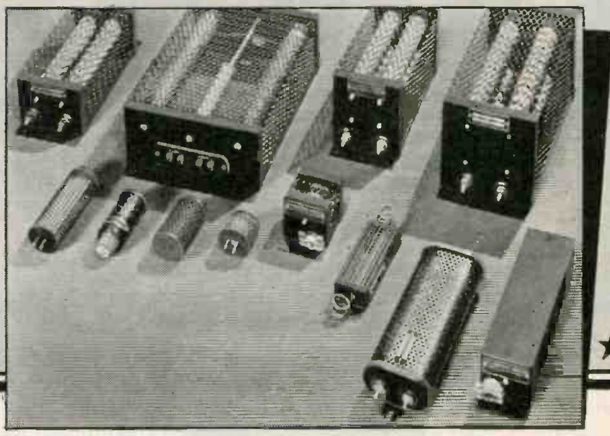


UNMOUNTED



MOUNTED



ENCLOSED

THE LINE of Ward Leonard Wire Wound Resistors has been developed through over half a century of meeting the requirements of the electric and electronic industries. The line, therefore, is complete. Ward Leonard not only offers wire wound resistors of every type, size and watt rating, but also resistor asssemblies for usual and unusual purposes. You can find exactly the resistors you are looking for at Ward Leonard.

Send for the New Resistor Handbook. It describes the entire line giving full data on enclosures, mountings, terminals and resistance values.

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doubtedly be modified to take all engine adjustments away from the pilot, giving him a selection of engine horsepower only. The control will then make all of the necessary engine adjustments selecting the optimum operating conditions for the engine horsepower desired.

Carburetor Control

A device of this type coupled with the electronic engine-detonation detector which has recently been perfected would enable a control which would automatically lean an engine to the maximum economy consistent with safe engine operating characteristics. In other words, for a given desired horsepower, the control would automatically lean the engine until one or more of the cylinders were detonating and then enrich the mixture slightly until the detonation ceases. Thus, it may be possible to save as much as ten percent of the fuel consumption of an engine operated in the conventional manner.

It is pure conjecture to say whether or not automatic engine controls will be used in the near future on private aircraft. But it is certainly safe to definitely state that if a suitable control at a moderate price were available, it would be used on all planes if for no other reason than for freeing the pilot of any concern over the operation of his engines. In large planes, the saving in fuel alone would pay for the cost of the instrument, and the ease of engine adjustment might free the operators from the necessity of carrying a flight engineer. A very substantial amount of work is now being done on this problem, both along the mechanical and electronic approach.

Automatic Compass

Completely automatic radio compasses in which the loop constantly and automatically indicates the direction of the desired radio transmitting station are being manufactured in quantity by several concerns. These units will stand up indefinitely under any conditions of operation yet found by our armed forces.

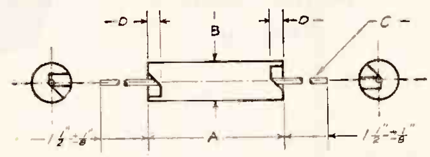
Transmitters and receivers for reliable plane-to-plane and plane-to-ground communication are continu-

...assure GREATER PRODUCTION, LESS SPOILAGE—IMPROVED QUALITY!

For manufacturers of coils, R. F. Choke coils and wire-wound resistors, the small, inexpensive SPEER *Lock Notch* Coil Winding Forms provide a solution to several production and quality problems. The patented SPEER *Lock Notch* molded into each end of the coil winding form holds the coil end firmly in place before, during and after soldering. No accidental unwinding—no lost production time—no spoilage—no changes in impedance. After winding, any finish can be applied or the unit covered with molding compound in standard injection molds. It pays to investigate. Perhaps there's a saving!

SEND FOR a sample card displaying standard units. Please use company letterhead and indicate your title.

WINDING FORM SPECIFICATIONS



Part No.	A	B	C	D
CF-107	3/8 ± 1/32	.107 ± .005	.025	.040
CF-1/8	1/2 ± 1/32	.125 ± .005	.025	.040
CF-5/32	1/2 ± 1/32	.156 ± .005	.028	.040
CF-170	3/4 ± 1/32	.170 ± .005	.028	.030
CF-178	3/4 ± 1/32	.178 ± .005	.028	.062
CF-3/16	3/4 ± 1/32	.187 ± .005	.028	.062
CF-7/32	1 ± 1/32	.218 ± .005	.035	.070
CF-1/4	1 ± 1/32	.250 ± .005	.035	.070
CF-3/8	1 1/2 ± 1/32	.375 ± .005	.040	.070

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Now I. C. E. makes it possible for you to order vacuum capacitors with the correct capacitance value to meet requirements of your equipment. I. C. E. Vacuum Capacitors are now available in any value range from 6 to 110 mmfd. in steps of 1 mmfd.

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Value Range	*Accurate to*
6 mmfd. to 25 mmfd.	$\pm$0.5 mmfd.
26 mmfd. to 60 mmfd.	$\pm$1.0 mmfd.
61 mmfd. to 110 mmfd.	$\pm$1.5 mmfd.

I. C. E. XX GRADE VACUUM CAPACITORS

Value Range	*Accurate to*
6 mmfd. to 25 mmfd.	$\pm$0.2 mmfd.
26 mmfd. to 60 mmfd.	$\pm$0.3 mmfd.
61 mmfd. to 110 mmfd.	$\pm$0.5 mmfd.

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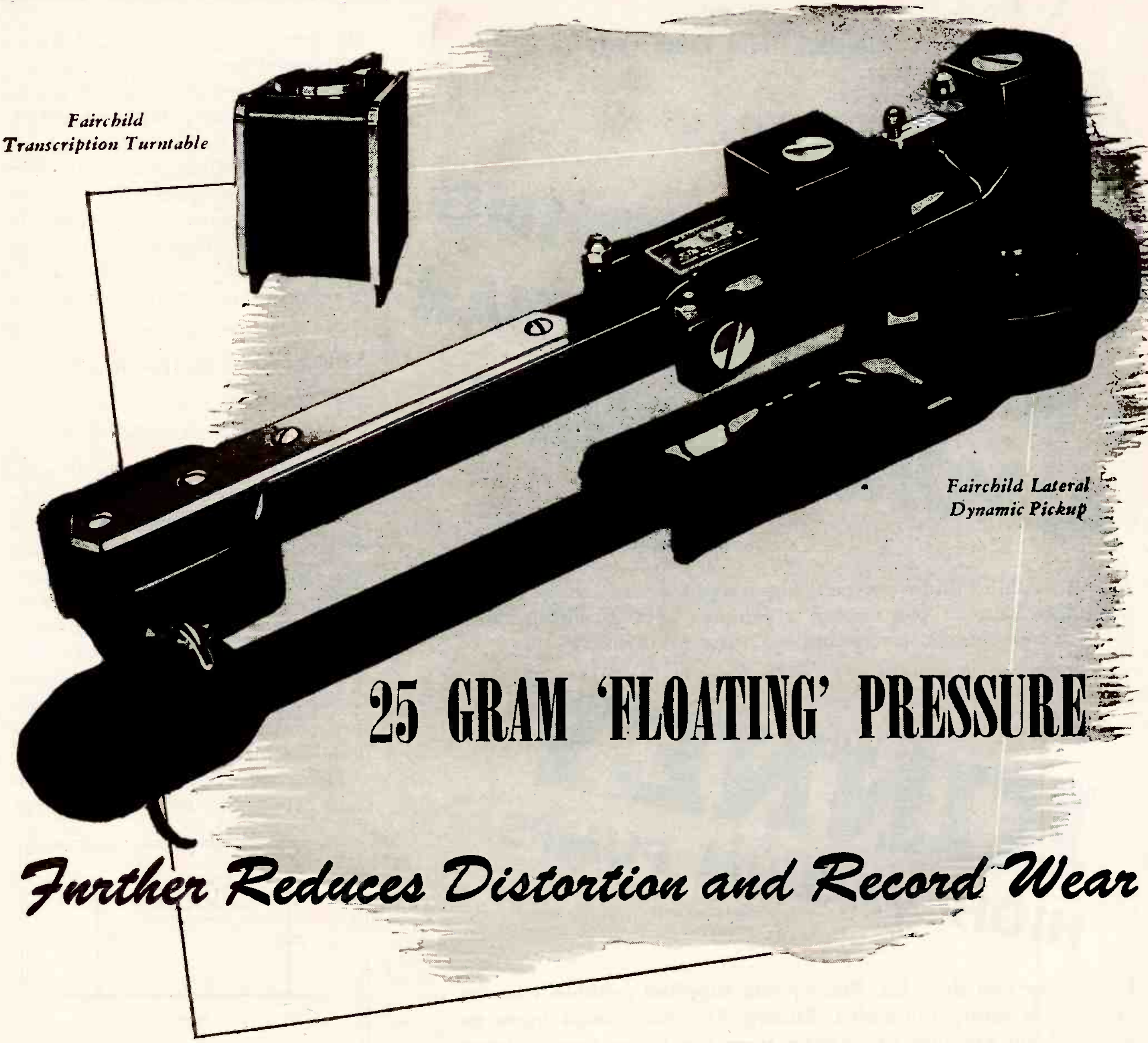

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Further Reduces Distortion and Record Wear

FAIRCHILD offers an unusually mounted 'floating' design for low-pressure, dynamic pickup. Designed for radio broadcast and other exacting transcription requirements, it reproduces all of the quality and natural beauty of recorded music or speech *with full naturalness.*

All microscopic undulations — that determine the quality of the transcription— are picked up without distortion *even from heavily modulated grooves.*

How? By means of several Fairchild patented design features: Let's start with the 3 ounce cartridge mounted on a two-point suspension in the pickup head casting. It's the only vertical moving mass in the Fairchild assembly. High and low spots in the record disc need only displace its 3 ounce weight instead of the total weight of the entire mounting arm. This unusual mounting method affords a near-uniform stylus pressure of 25 grams— even under unfavorable playing conditions.

Next, the pickup head is mounted in the famous Fairchild tone arm with cone ball bearings. Lateral drag is reduced. And still another important source of distortion and record wear is eliminated.

Finally, there is no *overhang* of the tone arm with consequent inertia — another cause of difficulty when playing warped records or on uneven turntables. The tone arm *floats* at any required adjustable height above the disc.

Descriptive and priority data on the newly perfected Fairchild Lateral Dynamic Pickup and Transcription Turntable are now available. Address *New York Office:* 475 - 10th Avenue, New York 18; *Plant:* 88-06 Van Wyck Blvd., Jamaica 1, N. Y.

Fairchild CAMERA AND INSTRUMENT CORPORATION

SOUND EQUIPMENT

ally being improved. A good transmitter and receiver will be almost a must in post-war private flying if any cross-country flight is anticipated. Both transmitters and receivers as well as radio direction finders in more simple form will be available to private flyers and will probably be similar in construction to high-grade automobile radio equipment, and similarly priced.

• • •

Filters for Electronic Equipment

By Gershon J. Wheeler

Many modern industrial electronic devices and auxiliary units are sources of r-f noise covering a wide range of frequencies. As such they interfere with radio communications in all bands. This interference is picked up by the antenna of the receiver or is fed back into the power lines. If the noise generator is in a well-shielded box, then power-line filters should eliminate the interference.

There are a few practical precautions which are not mentioned in the textbooks. Most filters for this application are broadband pi-type configurations consisting of two capacitors and a choke (Fig. 1). Although the larger the choke, the higher will be the attenuation, care must be taken not to make this too large. If the reactance of the choke at the line frequency is too high, the resultant voltage drop would prevent the equipment from operating properly. For example, a 250-microhenry choke in a 110-volt, 800-cycle line (this is not an uncommon line frequency today) would have a reactance of 1¼ ohms. If the equipment draws 20 amperes, the drop across the choke would be 25 volts.

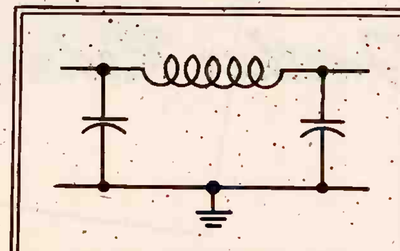
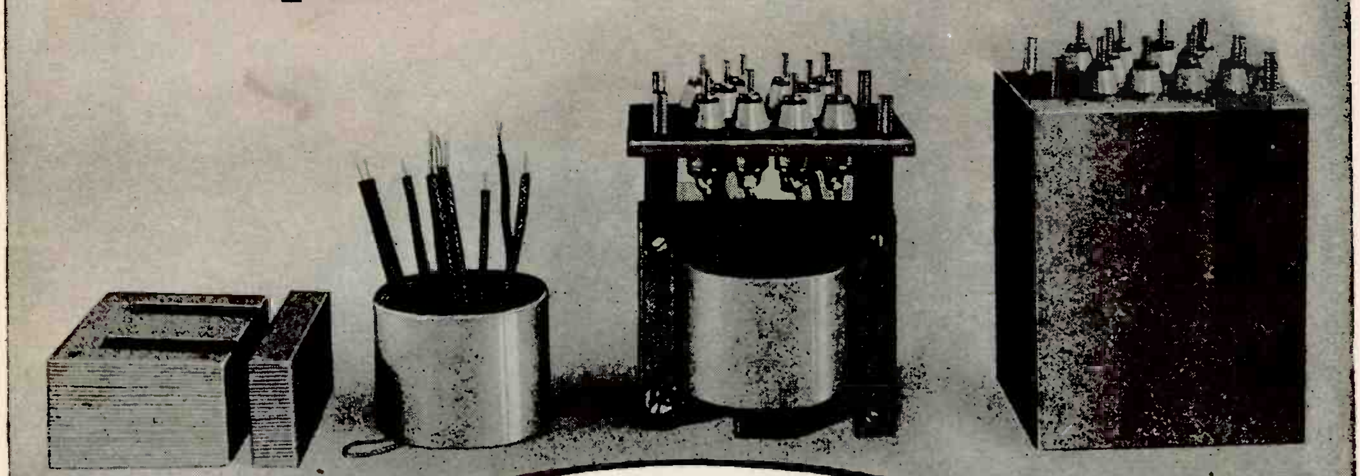


Fig. 1—Popular pi-type of filter under discussion

In a-c circuits, and especially at

Hermetic Sealing Demands Top-Quality Components



Hermetically sealed transformer manufactured by Acme Electric & Mfg. Co. of Cuba, N. Y. . . . Part-by-part assembly view shows E-lamination and I-lamination stacks; assembled coil, insulated with Natvar VC, and with Natvar sleeving on all leads; complete chassis; and completed transformer in hermetically sealed case.

Acme builds transformers to pass the rigid Navy 5 cycle immersion test for hermetically sealed units. Because they are used on important equipment for the Armed Forces, it is essential that quality material be used throughout. *These transformers dare not fail!*

And so every precaution is taken to see that the internal components are far above the standards acceptable for ordinary service. Natvar VC and Natvar sleeving are used because they consistently meet the requirements.

What about *your* requirements? Write, wire or phone us for deliveries, either from nearby wholesaler's stock, or from our own.

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- Varnished cambric — straight cut and bias
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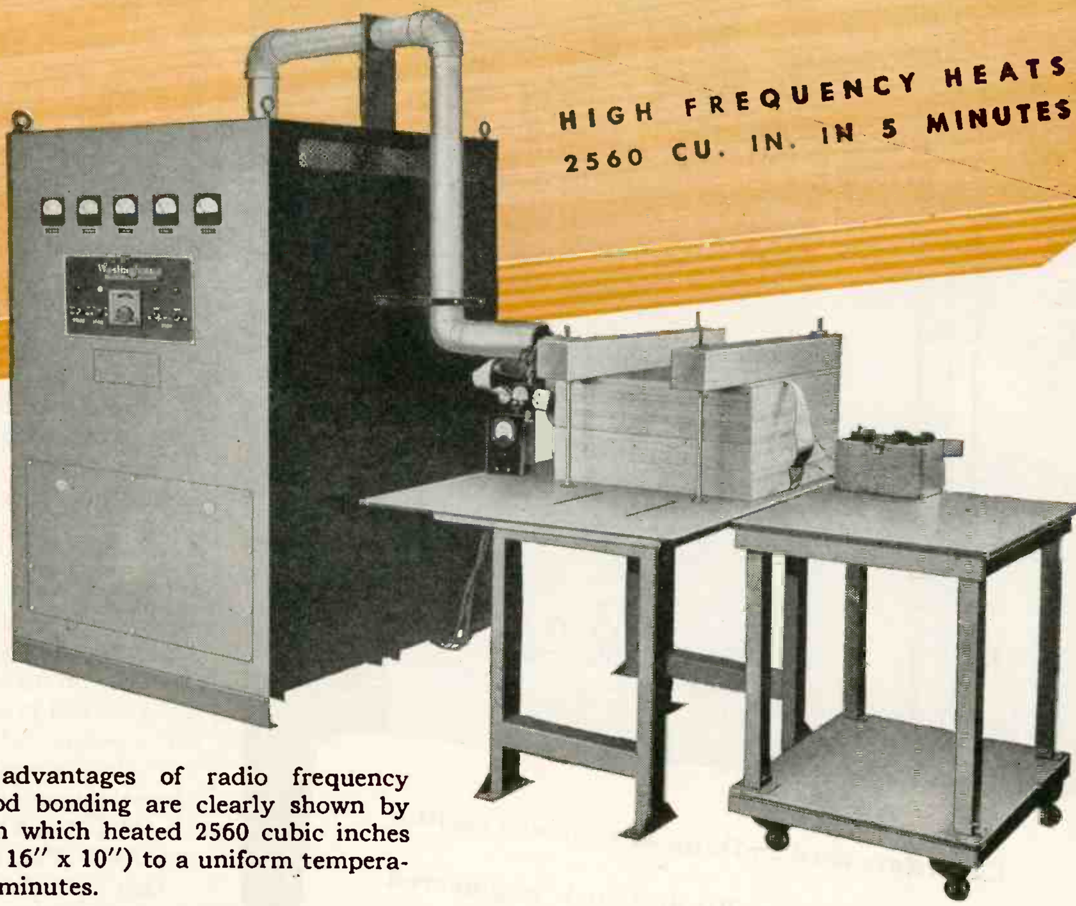

Illustration shows laboratory set-up.

The amazing advantages of radio frequency heating in plywood bonding are clearly shown by this demonstration which heated 2560 cubic inches of plywood (16" x 16" x 10") to a uniform temperature of 270° in 5 minutes.

This is typical of the fast, accurate performance of radio frequency heating. And these compact, easily-installed Westinghouse RF Generators offer many advantages in all types of plywood bonding.

Timing is automatic, for example, and heat after heat can be repeated automatically without interruption, or duplicated in any future job with perfect accuracy. Pushbutton operation is quick and easy and once the Westinghouse heating unit is adjusted to a process, operation merely requires pushing a button and setting dials to calibration data.

RF heating cuts processing costs, too, for power consumption is limited to the amount needed for the operation. The line of Radio Frequency Generators similar to that shown here has wide flexibility in plywood bonding. Operators are protected by dead-front construction.

Your nearest Westinghouse office can give you complete details on the use of radio frequency heating in bonding plywoods. Or write Westinghouse Electric Corporation, P.O. Box 868, Pittsburgh 30, Pa.

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Electronics at Work

line frequencies greater than 60 cycles, care must be taken not to use large capacitors. If the capacitive reactance of the capacitor is too small, the power source may be called upon to deliver more current than it is capable of handling.

Care must also be taken to prevent resonance at a frequency within the rejection band of the filter. The coil and second capacitor form a series-resonant circuit (Fig. 2) and, at the resonant frequency, a high r-f voltage may be developed across the capacitor.

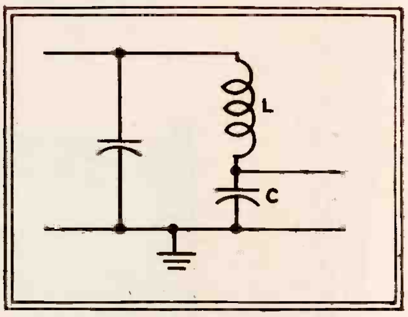

Fig. 2—Redrawing a pi-network shows the resonant circuit formed by *L* and C

Effect of Poor Ground

These problems in design vanish if readily available commercial filters are used, but there still arise problems in installation. The filter must be well grounded. If there is an impedance of any type between the filter ground connection and the actual ground, r-f energy will be fed through the filter back into the line. (Fig. 3).

Lastly, it is important to shield the input of the filter from the output. If this is not done, the unfiltered portion of the line will radiate and this radiation will be coupled into the filtered side.

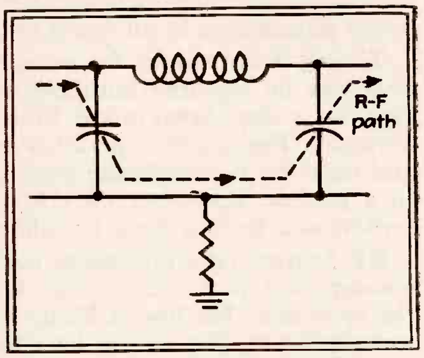

Fig. 3—Passage of r-f current through a filter when the unit is connected to a poor ground

* Ceramicon is the registered trade name of silvered ceramic condensers made by Erie Resistor Corporation.

CHARACTERISTICS			
CAPACITY RANGE IN MMF	JAN-C-20 STYLE	ERIE STYLE	MAXIMUM OVERALL DIMENSIONS
1 to 51	CC20 CC21	A K	.200 x .400 .250 x .562
52 to 110	CC25 CC26	B L	.200 x .656 .250 x .812
111 to 360	CC35 CC36	C M	.265 x 1.125 .340 x 1.328
361 to 510	CC40	D	.375 x 1.110
511 to 820	CC45	E	.375 x 1.560
821 to 1100	CC45	F	.375 x 2.00

ALMOST a decade has passed since the need for extremely stable capacitors with dependable operating characteristics led Erie Resistor to develop and introduce Ceramicons*. These silvered ceramic condensers immediately found wide acceptance throughout the entire communications field.

Augmented by the tremendous requirements of war, millions of Ceramicons, subjected to the severest service tests, have proved unexcelled in dependable performance, particularly as general purpose condensers, where a moderate degree of capacity change with temperature is permissible.

As general purpose condensers Erie Ceramicons have proved superior to other types of condensers in a great many applications. For example, Ceramicons are ideal as coupling condensers, particularly plate to grid, where high insulation resistance is of paramount importance.

Ceramicons may be selected from any one of 10 standard temperature coefficients, ranging from P120 to N750.

The capacity range for equivalent physical size is given in table above. We will gladly send you samples of Erie Ceramicons for your general purpose applications.

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Electronics Division

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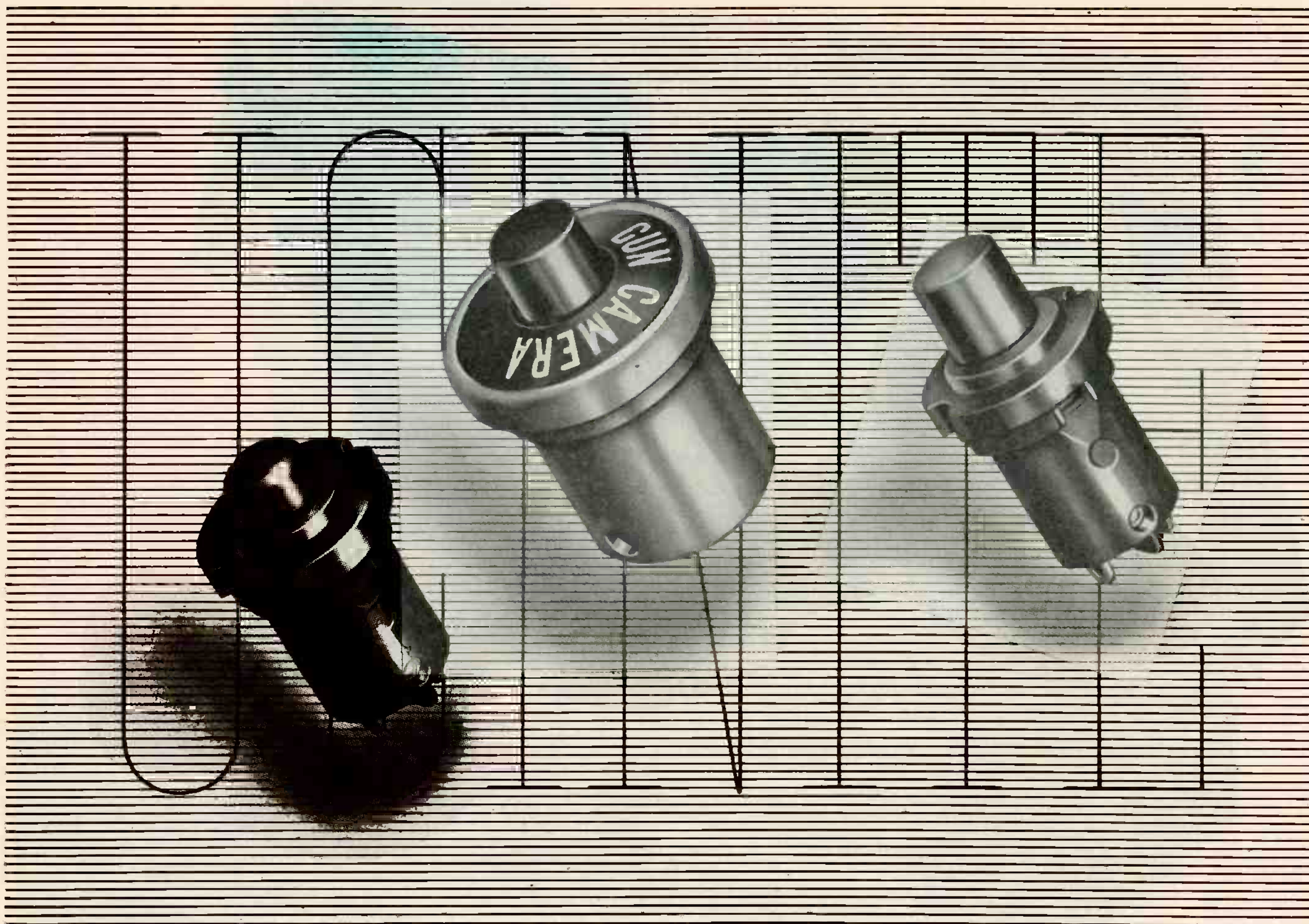

These little switches have big jobs

The Ucinite push-button switch has had a lot of important jobs to do. All of them, so far, have been war jobs, of course . . . like firing machine guns and operating gun cameras and intercom microphones.

We are sure that this unique little gadget has a great postwar future. It is different from any other electric switch in design, especially useful in close quarters and will work anywhere in extreme variations of temperature and pressure.

Here is a war-developed Ucinite specialty that is worth watching from now on.

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LAMINATED BAKELITE ASSEMBLIES
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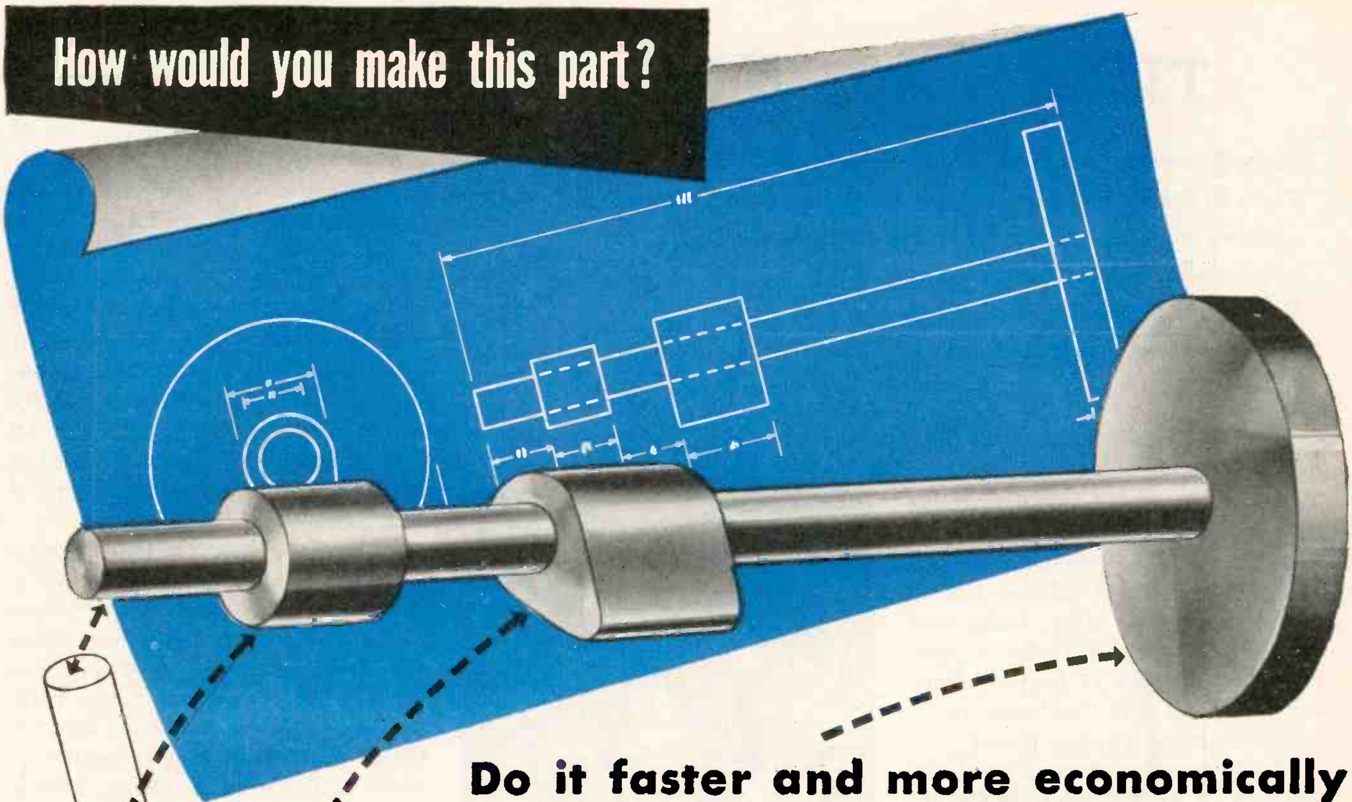

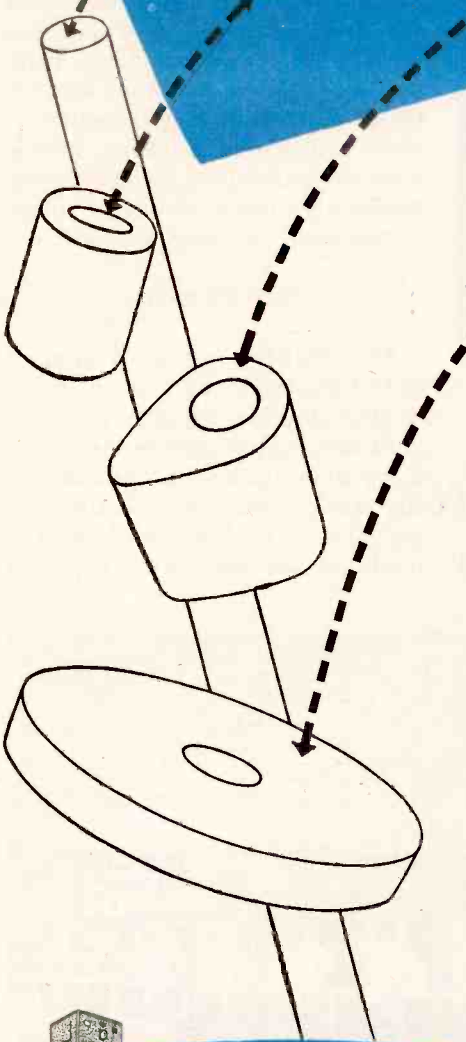

Do it faster and more economically with Lepel Induction Heating

This part could be machined from a solid bar — a costly and wasteful machining job.

— It could be made from a forging or casting, — necessitating expensive dies or patterns and entailing difficult and expensive machining.

— Or it can be made by silver soldering or brazing standard or easily-produced shapes with Lepel Induction Heating — in a fraction of the time, at a fraction of the cost.

A section of seamless tubing forms the collar. The cam is cut from a cold drawn section (or a bar machined to the desired contour) and drilled. The large diameter section is machined from steel plate.

Surfaces to be joined are prefluxed and components assembled with the brazing alloy (preplaced in the form of rings) on the ground shaft. The assembly is positioned in a jig, heat is applied at sections to be brazed by means of properly-designed load coils and the brazing operation is completed in a few seconds.

As the heat is generated within the metal itself, the brazing alloy penetrates throughout the joint, producing maximum strength and soundness.

Accurate automatic control of time and temperature cycles prevents excessive heating, minimizing discoloration and practically eliminating surface scale. Little, if any, finishing is required. There is no waste of brazing alloy.

Lepel Induction Heating can be used to join metals of any analysis — ferrous or non-ferrous — in any form, using brazing alloys of any melting point. It simplifies manufacturing procedure, cuts costs and shatters production bottlenecks.

The same compact, relatively-inexpensive unit can also be used without alteration for speedy localized hardening, normalizing annealing and melting.

A Lepel field engineer will gladly check your parts to determine possibilities for more efficient and economical production by brazing with Lepel Induction Heating. Just write

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TUBES AT WORK

Sixty Kilowatts On Wheels Serves Signal Corps 208
Time Division Multiplex, Eight Channels—One Transmitter 212
Compressed Recordings for Carrier Pigeons 220
Improved Bass for Small Radios 224
Tubes Calibrate Heavy Artillery 240
Postwar Prospects for Modulated Pulse Transmission 244

Sixty Kilowatts On Wheels Serves Signal Corps

A SIXTY-KILOWATT mobile radio station, the largest ever constructed, is now operating in Europe for the U. S. Signal Corps. Called SigCircus and designated officially as mobile radio station P-563, it occupies 17 large trailers and contains the facilities of a fixed station of similar power.

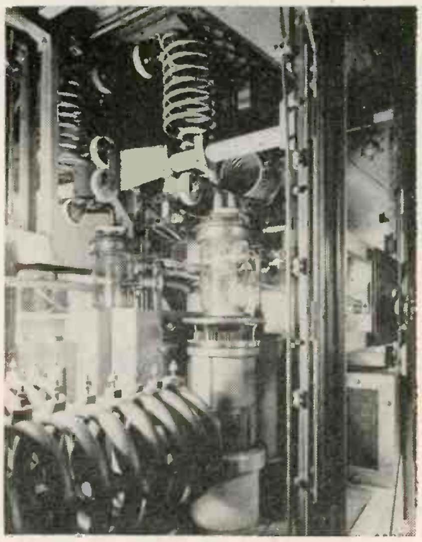
SigCircus can transmit and receive a total of 200,000 words daily. Besides the normal radio-teletype channels, for simultaneous transmission and reception between Europe and the United States, the station has complete broadcast facilities. These include a modern broadcast studio and control booth, a portable American Forces Network studio, complete equipment for two-way facsimile operation, and wire, film and disc recording.

The station was ordered by Brigadier General Carroll C. Bickelhaupt, Director of Communication Division of the U. S. Army, on October 26, 1944 from Le Materiel Telephonique, French associate of International Telephone and Telegraph Corp., and was delivered on schedule within three months after the original contract date.

It was designed for broadcast service to the United States, and is also capable of providing local programs for the entertainment of Allied troops within a radius of 25 to 30 miles. All the services can be carried on simultaneously without interference.

Equipment

A special v-h-f inter-unit communications system is used between the radio transmitting and receiving groups, which are placed some distance apart to prevent mutual interference. This system includes voice-frequency carrier equipment to provide the required number of keying controls and channels.



Air-cooled tubes of the intermediate power amplier of SigCircus

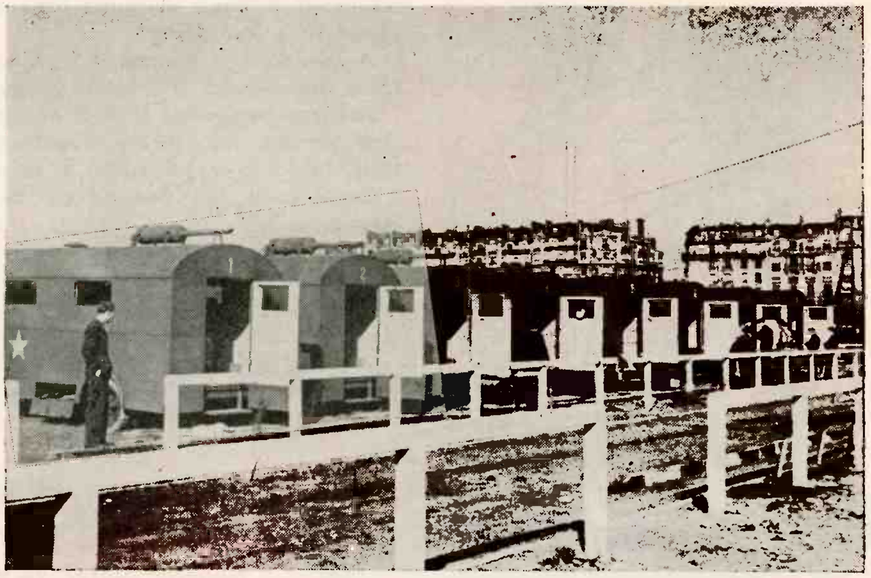
The equipment is distributed among the 17 trailers which are nominally divided into three general groups: transmitter, signal center, and power and pictorial.

In the first, or transmitter group, three trailers each contain a 50-kw Diesel power generator and a 275-gallon fuel tank. Switching from Diesel power to commercial power may be made when the latter is available. The fourth trailer contains a low-tension power supply and voltage regulator, with a 12-kv filter capacitor. Trailer 5 holds a high-voltage direct-current rectifier (12 kilovolts).

A Western Electric two-kilowatt driver unit is contained in another trailer together with v-h-f transmitters, receivers and associated carrier equipment. This trailer also contains the transmitter operating position. The driver stage feeds a 60-kw power amplifier in trailer 7, while trailer 8 has an Army Forces network transmitter, an air blower for its high power air-cooled tubes, a workshop and storage space.

Other Facilities

Five trailers numbered from 9 to 13 form the Signal Center group. Trailer 9 holds supplies and two v-h-f transmitter and receiver systems, while trailer 10 contains special carrier equipment. Trailers 11 and 12 have six high-speed teletype machines and associated facilities



Eight of the seventeen trailers that house SigCircus, the 60-kw mobile station of the U. S. Signal Corps now operating in France. Operated by Army personnel, it was designed and built by Le Materiel Telephonique, French associate of International Tel. and Tel. Corp.

An Original GUARDIAN *Development*

designed for and in conjunction with the Collins Radio Company

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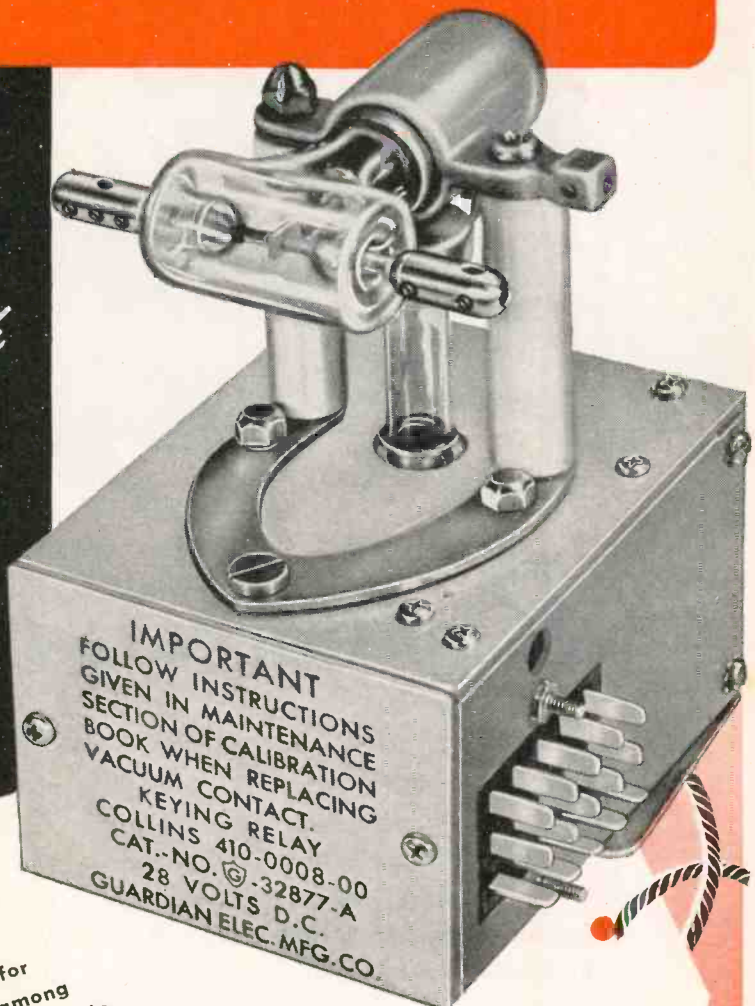
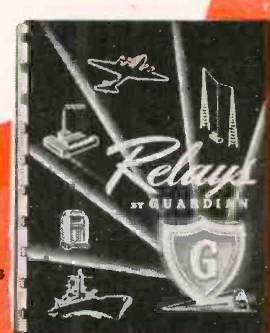
KEYING RELAY

for High Frequency—High Voltage—High Altitude Applications



The confidential development of this vacuum switch keying relay involved design ingenuity and ability to produce immediate results. It called for cooperation and a meeting of minds among Guardian engineers and those of Collins Radio Co., the U. S. Navy, Sperti, and General Electric. Then quantity production and the responsibility of being the sole source of supply for many months followed successful development of the relay. The same confidential treatment, the same engineering ability on electrical control, the same production capacity is yours for the asking. Write.

GUARDIAN G ELECTRIC
1625-H W. WALNUT STREET CHICAGO 12, ILLINOIS
A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY



A request on your business letterhead will bring you Guardian's new catalog.

Right across the "Board"

We've been "burning the midnight oil" . . . not only to deliver to Uncle Sam all the Eastern amplification equipment needed for Army Air Forces bombers and U. S. Navy planes and PT boats, but also to translate our extensive wartime experience into sound amplification equipment for peacetime use.

Our post-war production is *right* on the drawing board! We are ready to manufacture just as soon as Uncle Sam gives the "go-ahead."

To aid the war effort against Japan, our engineers are standing by to consult on any problem of sound amplification. Until the day of final Victory, our resources will be devoted to the design and production of vital war equipment.

Let us send you a series of useful articles prepared by our engineering staff on the newest developments in amplification related to sound systems. Ask for Series 7-F.

Buy War Bonds

EASTERN AMPLIFIER CORPORATION

U. S. Reg'n. Applied For

794 EAST 140th STREET • NEW YORK 54, N. Y.

WHEN YOU REQUIRE OR SPECIFY *Insulating Varnishes* think of the CASHEW NUT...

. . . for from the shell of this delicious nut, Irvington produces HARVEL INSULATING VARNISHES that are tough as the combined strength of Elephant Hide and Walrus Back.

Once applied, by baking or air-drying, HARVEL sticks . . . it cures by polymerization to a solid, monolithic, fused state; protecting electrical equipment against acids, dilute alkalies, moisture, lubricating and transformer oils, high temperatures, etc.

HARVEL'S RESISTANCE TO HIGH TEMPERATURE IS OUTSTANDING . . . it retains its insulation resistance at temperatures up to 300° F.

HARVEL will not soften or "throw-out" at high peripheral speeds, has excellent dip-tank stability, exceptional penetrating power, the highest safety factor under excessive heat, heavy overloads and in atmospheres where acids, alkalies and abrasive materials are present.

HARVEL WILL NOT SUPPORT FUNGUS GROWTH.

Write for your copy of the "HARVEL INSULATION DATA BOOK" and the MITCHELL-RAND "GUIDE BOOK" OF ELECTRICAL INSULATIONS.

HARVEL

- cures to a non-thermoplastic, infusible state
- will not soften or "throw-out"
- has excellent dip-tank stability
- insures constancy of electric properties
- has no objectional solvents that attack enameled wire
- bonds conductors into a compact unit-acting mass
- has exceptional penetrating power
- has excellent insulation value at high temperatures
- produces firm, tough mechanically strong coatings
- does not give off corrosive fumes
- resists acids, alkalies and moisture
- imparts high thermal conductivity to finished coils
- is recommended for Fiberglas and Asbestos windings

and WILL NOT SUPPORT FUNGUS GROWTH

MITCHELL-RAND *for 56 YEARS* THE ELECTRICAL INSULATION HEADQUARTERS

EST. 1889

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A PARTIAL LIST OF M-R PRODUCTS

Transformer Compounds
Friction Tape and Splice
Cable Filling and Pothead Compounds
Fiberglas Varnished Tape and Cloth
Insulating Papers and Twines

Fiberglas Saturated Sleeving and Varnished Tubing
Asbestos Sleeving and Tape
Varnished Cambric Cloth and Tape
Mica Plate, Tape, Paper, Cloth and Tubing

Fiberglas Braided Sleeving
Cotton Tapes, Webbings and Sleevings
Impregnated Varnish Tubing
Insulating Varnishes of all types
Extruded Plastic Tubing

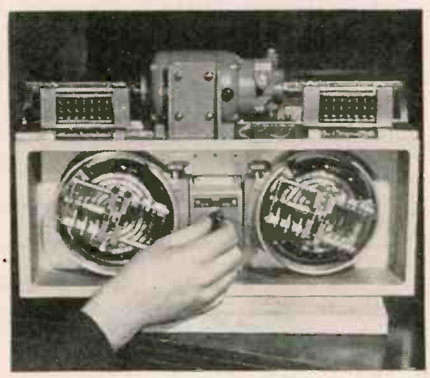
for handling traffic. Trailer 13 contains the facsimile transceiver units, the broadcast studio, and a control booth in which space has been set aside for the wire, disc and film recorders. This trailer is also the home of the portable American Forces network studio.

The receiving station, consisting of one W. E. receiver, v-h-f transmitters and associated carrier equipment, is fitted into trailer 14. In the power and pictorial group, two trailers each contain a 25-kw gasoline powered unit and another trailer carries the army pictorial division hut.

• • •

Time Division Multiplex System Uses Eight Channels With One Transmitter

A COMMUNICATIONS SYSTEM, by which eight channels are transmitted simultaneously by a single radiotelegraph transmitter, is operating between New York and London to increase communication capacity between the United States and Great Britain, and, with extension of channels to San Francisco, to expedite the flow of traffic to and from the United Nations Conference. The equipment can handle 488 words per minute inward and outward



This switch is being set for eight-channel service and also permits selection of two or four channels. At each side of the switch is a face-plate mechanism that feeds to or from the seven-unit printing equipment

simultaneously. This corresponds to eight channels each way with an individual channel speed of 61 words per minute. Operation may be made on four or two channels instead of eight channels, when desired.

The eight channels may be util-

New... High melting point synthetic wax

ACRAWAX C

(Melting point . . . 280° F.)

10 Important Uses For ACRAWAX C

- Insulating Compounds
- Impregnants
- Cable Saturants
- Lacquers
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- Sealants
- Potting Compounds
- Asphaltic Compounds
- Varnishes
- Synthetic Resins

PARTIAL LIST OF PROPERTIES OF ACRAWAX C

1. ACRAWAX C has an extremely high melting point (280°F.), and is also used to raise the melting point of other materials. It has a tendency to produce amorphous characteristics in its blends. Added resistance to cold flow is also imparted.

2. ACRAWAX C has excellent dielectric properties, and good power factor.

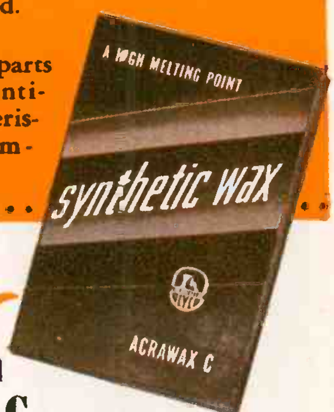
3. ACRAWAX C is insoluble in water, imparts marked water resistance and salt spray resistance to its blends. It is insoluble in practically all solvents in the cold.

4. ACRAWAX C melts to a liquid of low viscosity, thus facilitating penetration and impregnation.

5. ACRAWAX C contains no chlorine.

6. ACRAWAX C is compatible through hot melt procedure with a wide range of materials, many of which serve to modify it to give additional valuable characteristics such as greater adhesion, more flexible film, etc., as desired.

7. ACRAWAX C imparts anti-tack and anti-blocking characteristics to its compounds.



Request Free Bulletin on ACRAWAX C

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GLYCO PRODUCTS CO., INC.

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KEN-RAD
Little Giant MINIATURE TUBES
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KEN-RAD
Better than ever
Wherever compact power is essential, Ken-Rad Miniature Tubes are serving staunchly . . . Now this famous make of tubes, improved still further by important new research and manufacturing facilities, will meet better than ever the exacting specifications being laid down by designers, builders, and users of electronic equipment.
Write for your copy of "Essential Characteristics" the most complete digest of tube information available.
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maybe the mailman can solve YOUR plastics problem

That gap between the ideas created by plastics advertising and all the specific facts a designer, molder, or fabricator may need about a plastic can often be *bridged quickly by mail.*

For this purpose, Monsanto has set up a fast moving Bulletin Information Service for today's fast moving plastics world . . . fact-packed "communiques" issued as soon as new developments are authenticated in both laboratory and field without waiting for fancy printing or arbitrary publication dates.

To "subscribe" to this free service you merely send us your name on the coupon below, indicating how you ordinarily use plastics. Meanwhile if you can use any of the current Monsanto bulletins or catalogs from the list at the right, check these at the same time. MONSANTO CHEMICAL COMPANY, Plastics Division, Springfield 2, Massachusetts.

A	The Family of Monsanto Plastics — A guide for product designers	X500-4	Thalid for impression molding. Application information
B	Resinox — A Monsanto plastic	X500-5	Thalid — Glass cloth laminates. Physical properties
C	Lustron — A Monsanto plastic	X500-6	Thalid for impression molding. Data sheet
D	Monsanto Plastics — A data book for molders and fabricators	X800-1	Resimene 803-A. Melamine molding material
E	How Vuepak Helped 20 Manufacturers to Package for Greater Sales	X800-2	Resimene 801-K — Specifications. Molding laminating resin
F	Monsanto Plastics in Packaging	X800-5	Resimene 803-A — General
G	Monsanto Plastics in Toys	X800-6	Resimene molding compounds and resins
X100-2	Monsanto casting sealant	1000-1	Monsanto vinyl butyral
X200-1	Molding of Cerex	1000-3	Application of vinyl butyral
X200-2	Cerex data sheet	1000-4	Polyvinyl butyral dispersion
X200-3	Cerex—Applications	1100-1	Handling of Fibestos sheet
X300-1	Styramic HT (polydichlorostyrene)	1200-1	Lustron 2020 Improved Polystyrene
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X500-1	Thalid resins for impression molding. Fabrication information		

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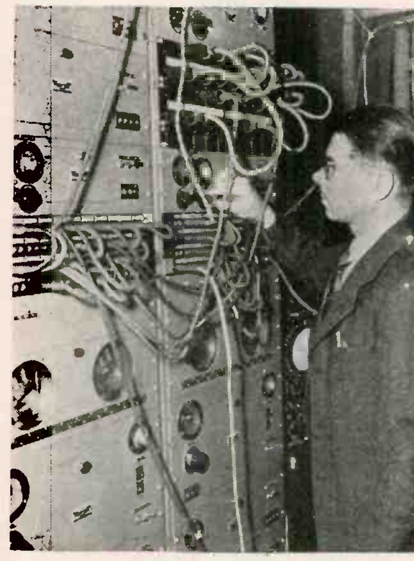
☐ B	☐ G	☐ X300-1	☐ X500-6	☐ X800-6	☐ 1100-1
☐ C	☐ X100-2	☐ X400-1	☐ X800-1	☐ 1000-1	☐ 1200-1
☐ D	☐ X200-1	☐ X500-1	☐ X800-2	☐ 1000-3	☐ 1300-1
☐ E	☐ X200-2	☐ X500-4			

Name ____________________

Company ____________________ *Address* ____________________

City ____________________ *State* ____________________ ized for two-way communication with one distant station or four channels, with a total capacity of 244 words per minute, can be operated in both directions simultaneously between two different stations. Automatic retransmission of one or more of the channels to a third station, may be made.

Developed by RCA, the multiplex system uses a printing mechanism that makes the circuit practically error-proof, despite its high speed. If a letter be mutilated or garbled in transmission, a warning bell rings at the receiving printer. Instead of the mutilated character, a Maltese cross appears to mark the exact spot of the error and facilitate correction.



Receiving and transmission panels used in the multiplex system developed by RCA. On each can be seen the front face-plate assemblies of the multiplex distributors that pass incoming or outgoing signal elements from and to the seven-unit printing equipment in the proper sequence and at the proper time intervals

Seven-unit Printer

Development of the new multiplex equipment began less than two years ago, but for some time before that date RCAC research engineers succeeded in the use of a seven-unit printer which is employed in the new system. Such a printer has been employed continuously since 1939 for handling commercial traffic over the New York-San Francisco radio circuit.

The printer is completely auto-

Presenting

THE BENDIX TG-15 500 WATT TRANSMITTER

for operation

on

L.F. LOW FREQUENCY
200-540 Kilocycles

H.F. HIGH FREQUENCY
2-13 Megacycles

and

V.H.F. VERY HIGH FREQUENCY
108-132 Megacycles

A four-channel transmitter, capable of simultaneous operation on any two channels, the Bendix TG-15 transmitter is rated at a full 500 watts for continuous Commercial Service at any frequency in the L.F. and H.F. ranges and 300 watts C.C.S. in the V.H.F. range.

Ease of maintenance, flexibility and traditional Bendix reliability make this transmitter particularly suited for aeronautical services in this country and in foreign operations.

A bulletin describing the TG-15 transmitter is available. Write for your copy.

Bendix Radio DIVISION

BALTIMORE 4 BENDIX RADIO REG. U.S. PAT. OFF. MARYLAND

PRODUCT OF BENDIX AVIATION CORPORATION

STANDARD FOR THE AVIATION INDUSTRY

VARNISHED FIBERGLAS-AND-FIBER

DUPLEXED VARNISHED FIBERGLAS

SPECIAL THIN SLOT INSULATIONS

3 IMPROVED SLOT INSULATIONS

BY IRVINGTON

Irvington again sets the pace with three improved insulations:

Varnished Fiberglas-and-Fiber, that combines the heat and moisture resistance and high mechanical strength of flexible Fiberglas with the high insulating qualities of Irvington formulated varnish.

Duplexed Varnished Fiberglas, that furnishes added protection against high temperatures and dampness with two layers of varnished Fiberglas that are flexibly bonded together, providing increased dielectric and mechanical strength and improved cushioning effect.

Special Thin Slot Insulations, consisting of varnished Fiberglas, rayon, nylon or cambric, duplexed to rag paper, in extremely thin combinations which provide high dielectric insulations for narrow and shallow slots wherever space is limited.

With these three additions to its broad line, Irvington further increases its leadership in the production of slot insulations to meet all operating conditions and requirements. Complete co-operation in fulfilling your needs is freely offered. Write Department 106.

Other Irvington products include . . . insulating varnish, plastic tubing and tape, varnished tubing, varnished fabrics, varnished Fiberglas, wire markers, Cardolite Compounds.

STANDARD OF THE WORLD IRVINGTON INSULATION TRADE MARK REG. U. S. PAT. OFF.

IRVINGTON

VARNISH & INSULATOR CO.
Irvington 11, New Jersey, U. S. A.

LOOK TO IRVINGTON FOR CONTINUED LEADERSHIP IN INSULATION

matic and, in conjunction with the multiplex mechanism, the system functions with a minimum loss of circuit time. In the seven-unit system, each incoming letter is formed of three marking (signal) impulses, plus four spacing (no signal) impulses. Automatic counting is done in the receiving printer to check the arriving impulses, and if the marking impulses vary from three, the warning bell sounds and the Maltese cross appears to report an error.

The multiplex equipment is also able to handle other telegraphic codes. A different code can be used on each of the four pairs of channels if desired.

Routing Speed

Traffic from San Francisco to London passes through the synchronized equipment in the New York office of RCAC, at 66 Broad Street, where the channels are separated automatically. From there they go to the transmitting station at New Brunswick, then across the Atlantic. Routing from the British capital also includes passage through New York. A mechanical delay of only one-sixth of a second occurs in the transmission in either direction.

The system makes possible simultaneous transmission over four channels each way between San Francisco and London through New York, but the routing can be shifted, for instance, to send messages from either city to the Argentine over the three-channel New York-Buenos Aires circuit.

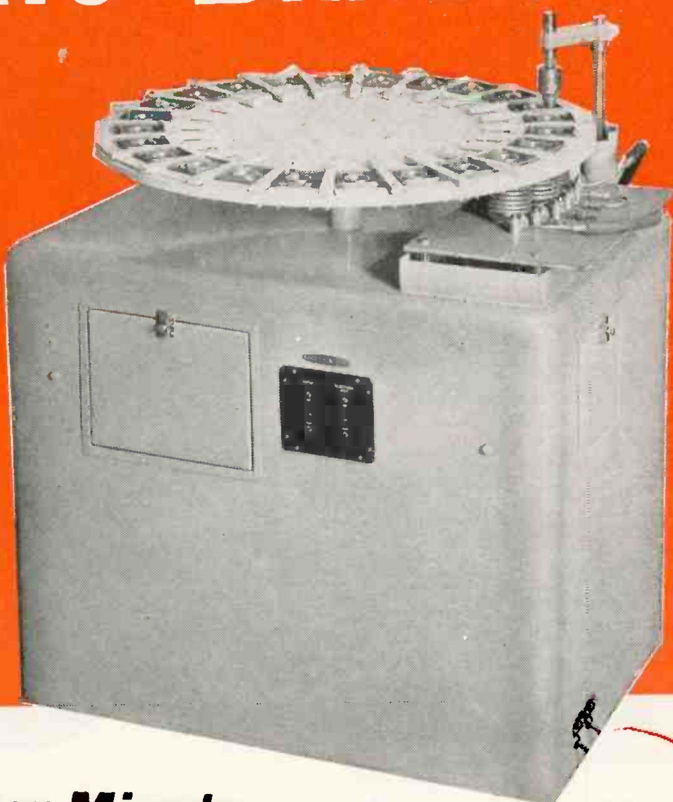
Each channel utilizes two bells for signalling. One rings when an incorrect group of signal elements reaches the receiving printer, and the other, of different pitch, is operated by means of a switch similar to a telephone dial. With it, the receiving operator can pass a number of stock phrases for service instruction to the other end of the circuit, thereby saving channel operating time.

• • •

Compressed Recordings for Carrier Pigeons

ONE HOUR OF SPEECH, reproduced on a light thin film that can be carried in a capsule strapped to the

ELECTRONIC BRAZING UNIT with 24 Station INDEXING Work Carrier



Delivers 5 Complete Assemblies Per Minute

HERE'S a striking example of how Scientific Electric Engineers increased brazing production output by designing a special automatic machine to operate in conjunction with Electronic heating.

A manufacturer of weather-proof control box covers was already using electronic heat to speed up production in the brazing operation involved. But greater production was urgently needed. Each assembly was being inserted and removed from a single heater coil . . . one at a time.

To increase output Scientific Electric engineers designed this compact circular, 24 station indexing work carrier which operates from the 18 KW electronic generator at the left.

The operator merely loads the stations as they come around empty. Heat is applied by three water-cooled induction coils under three of the work positions. The coils are followed by the vertically operating ejecting mechanism and a complete assembly is ejected from the carrier each 12 seconds.

The carrier, which is operated by a small motor can be applied to any of our electronic generators depending upon the heat input requirements of the work to be handled. Normal output of the unit illustrated is at 200 to 600 kc.

Workpiece output up to 20 per minute can be obtained and carriers, custom tailored to your requirements, can be delivered within 30 days. Send us your requirements today.

Scientific Electric Electronic Heaters are made in these power sizes... and a range of frequencies up to 300 Megacycles depending upon power requirements.

3 KW	18 KW
5 KW	25 KW
7½ KW	40 KW
8 KW	60 KW
10 KW	80 KW
12½ KW	100 KW
15 KW	250 KW

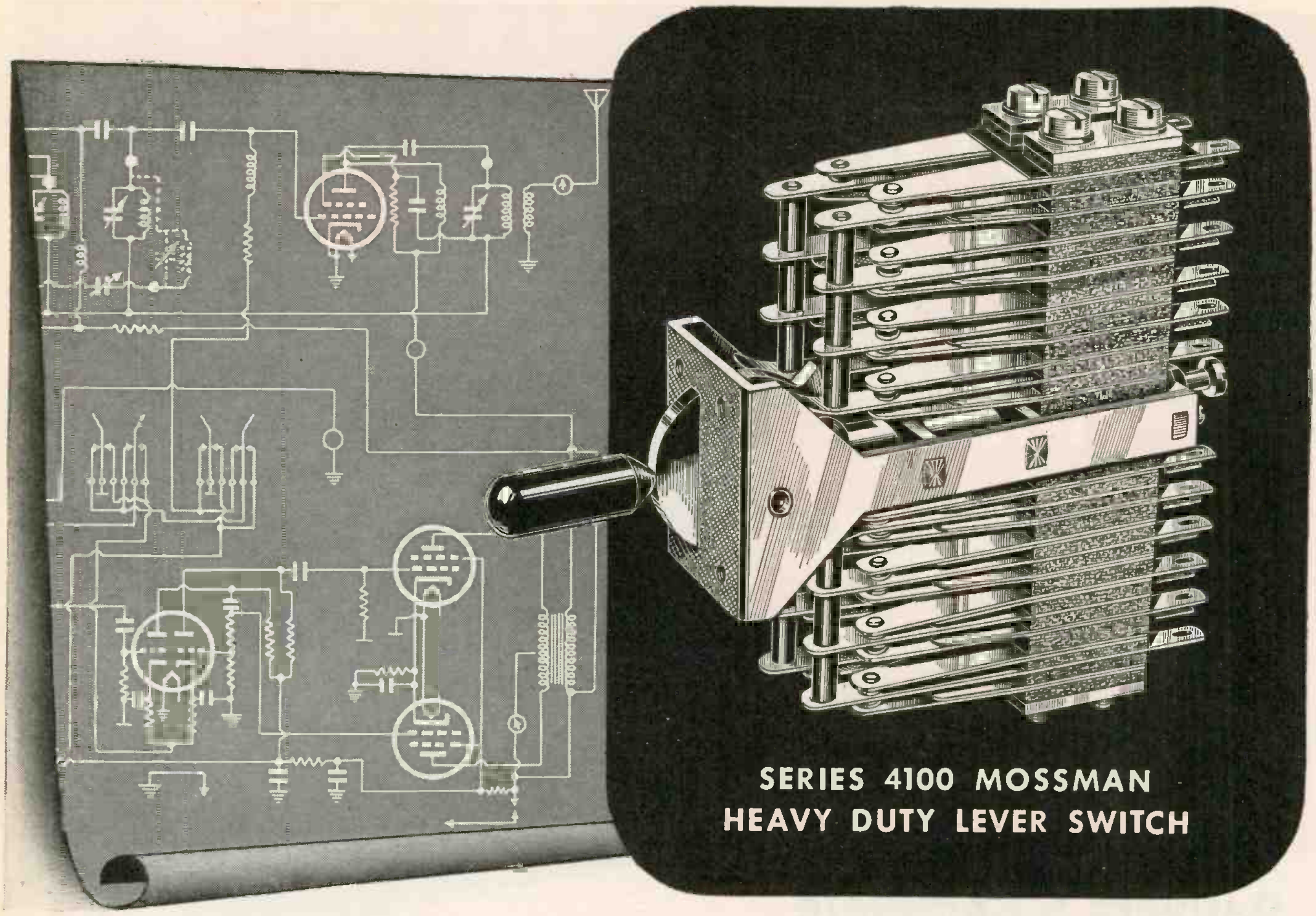
Scientific Electric

Division of

"S" CORRUGATED QUENCHED GAP COMPANY

119 MONROE ST. GARFIELD, N. J.

Manufacturers of Vacuum Tube and Spark Gap Converters Since 1921



This Mossman Lever Switch *Provides Interlocking Contact Arrangements Impractical with Any Other Type of Switch*

The Mossman Series 4100 Switch is especially adapted to radio or electronic control circuits where it is necessary to switch a control or monitoring position to a master control or amplifier station.

The number and type of interlocking circuits possible with this switch are entirely at the discretion of the designer of electrical or radio control circuits.

Interlocking contact arrangements which may be added or provided by the use of this versatile switch would be impractical with any other type of switch or plug-in system.

SEND FOR THE MOSSMAN CATALOG

In it you will find complete details of the Mossman Series 4100 Switches and the many other precision electrical components which make up the Mossman line. These include many types of Mossman heavy duty, multiple circuit lever switches, turn switches, push switches, plug jacks and other special switching components.

Important advantages of this switch for radio and electronic circuits include:

- **Protection of amplifier or transmitter tubes by keeping grid or similar circuits closed until switching is accomplished.**
- Preference automatically given to one station over others when such a station desires to contact the master station.
- Ability to keep certain circuits open until another is closed, or closed until another circuit is opened.
- Elimination of the possibility of cutting in more than one remote station or control. This is often desirable when several remote stations feed to a central unit.

Check these Features

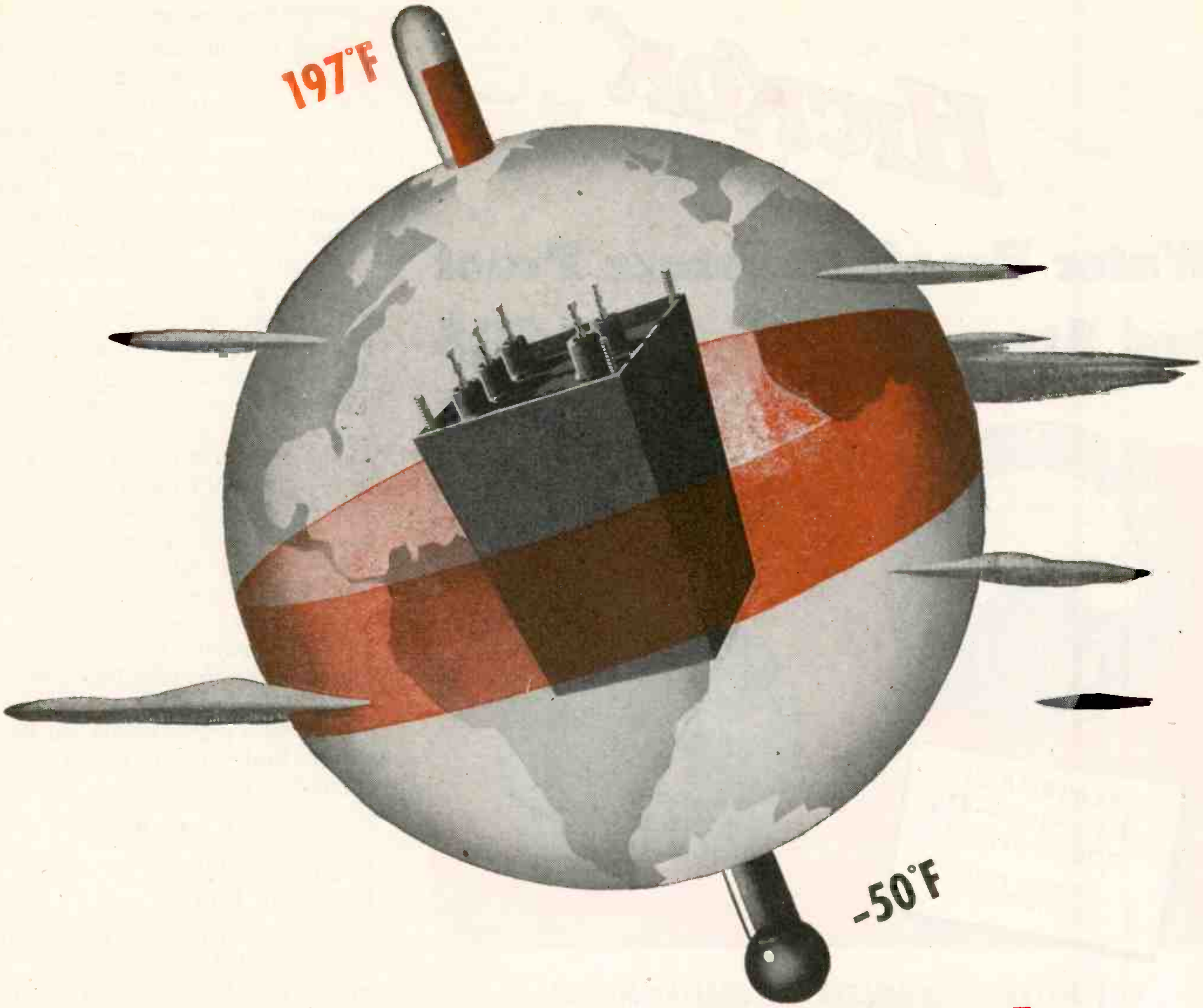
★ A three-position switch (Series 4101) with locking action in center or neutral position, locking or non-locking in other two positions.

★ A two-position switch (Series 4102) by use of a special latch plate which eliminates the neutral position.

★ Contact Ratings: Standard heavy duty—$\frac{3}{16}$" diameter, fine silver, 10 amperes, 110 volts A.C. (non-inductive); Extra heavy duty—$\frac{5}{16}$" diameter, silver alloy, 20 amperes, 110 volts A.C. (non-inductive).

DONALD P. MOSSMAN, Inc., 612 North Michigan Avenue, Chicago 11, Illinois

MOSSMAN
"Electrical" Components



Torture Test—DOUBLED!

The story of a transformer yanked back and forth from Pole to Equator

Men of the U. S. Army Signal Corps say that no matter where they run their lines, "It's either too hot or too cold." To make sure equipment can take it, the Corps runs the five-cycle humidity test.

They were giving this test to a Thermador transformer. They put it into a chamber, pressed a button to get the bleak 50° below. They pressed another button, the thermometer shot to the 197° of a blazing equatorial noon. Five times they raised and lowered the temperature. They watched, through the glass doors, water dripping onto the transformers—condensation.

After forty-eight hours they took an ice pick to get at the terminals.

They wiped them dry, connected the current, threw on the switch. If, after this torture, the transformer could take 2,000 volts it would pass the test. They gave it not 2,000 but 4,000 volts, doubling the test—and, of course, it took it!

BUY MORE WAR BONDS!

THERMADOR ELECTRICAL MANUFACTURING CO.

5119 South Riverside Drive • Los Angeles

THERMADOR TRANSFORMERS

DEFEAT HEAT COLD HUMIDITY

back of homing pigeons, has been made possible by a recent improvement in sound recording sponsored by the Signal Corps. About twenty times as much wordage can be recorded on the film as can be typed on paper of similar surface area.

The film is made of ethyl cellulose, similar to ordinary cellophane. The belt is one foot long and 3½ inches wide, of which three full inches can be used for voice reproduction. The film belt takes thirty minutes to run its full course and can be turned inside out to take a similar recording on the other side so that one full hour of speech fills a single thin belt. Average talking has been found to run about 150 words to the minute, but some rapid talkers are able to enunciate 300 words per minute.

Approximately 18,000 words can be put on one film belt. Two belts fit into a four-inch capsule for harnessing to a pigeon's back, so that a single bird can carry 36,000 words of spoken message.

• • •

Improved Bass for Small Radios

SMALL LOUDSPEAKERS do not radiate efficiently at low frequencies. If one attempts to compensate for this deficiency by feeding greater low-frequency power to the speaker, the speaker will be driven to such an extent that it will introduce non-harmonic distortion.

The shock to the cone on reaching its limit of travel due to large signals will be translated into vibrations at speaker resonnance. Because the cone will break into multiple modes of vibration, the radiation efficiency will be further lowered. The effect is that the speaker booms, not that there is greater low-frequency radiation.

Synthetic Bass Principle

It is not economically feasible in small receivers to use speakers that have flat response to low frequencies. The sizes of speaker and baffle are limited by the receiver dimensions, therefore poor low-frequency radiation is an inherent characteristic of small receivers and phonographs. Synthesized base provides a solution.

What makes such a system pos-

YOU'LL HAVE TO WATCH YOUR PENNIES...

IN THE PEACETIME COMPETITION

With the coming of peace and a return to the American way of producing goods at a profit in highly competitive consumer markets you'll *have* to be certain that every step from initial blueprint and tool design, through the machining, stamping and assembly line, up to packaging and delivery is planned and executed with utmost efficiency and with the minimum of cost.

In the production of war munitions Oiljak has maintained an enviable record of production of intricate parts and on time deliveries, in accordance with strict Government inspection—and has actually reduced the estimated and approved cost, thus saving the Government considerable sums, by skillful planning and supervision of the work. These same skills in metal manufacturing, improving designs and reducing costs are available to manufacturers as they convert to peacetime merchandise. It may transmit your penny savings into dollar profits to confer with us on any metal manufacturing problem.

MACHINING · STAMPING · WELDING · PLATING · FINISHING · ASSEMBLING

METAL MANUFACTURERS

THE OILJAK MANUFACTURING Co., INC.

MONTCLAIR, NEW JERSEY

THE JOB COMPLETE FROM BLUEPRINT TO FINISHED PRODUCT

sible is that the ear itself is a non-linear device introducing harmonics into the sound that it receives. Because of this characteristic of the ear, the aural effect of a low note can be produced by introducing into the ear the harmonics that the ear would generate itself if it were really receiving that low note. Physiologists have long known that a combination of odd harmonics of a low frequency give the impression to the hearing organs of the presence of that frequency even though the fundamental is itself absent. This characteristic of the ear is used by organists to play, in effect, notes that are lower than the ear can actually hear.

Applied to small radio receivers and phonograph amplifiers, the technique consists of introducing non-linearity into the output stage but only at low frequencies. This non-linearity introduces odd harmonics, chiefly third, in place of the low-frequency note. The odd harmonics are efficiently radiated by the speaker and heard and interpreted by the ear as if they were the low note from which the harmonic series was originally derived.

In taking advantage of the ear's characteristic to produce the appearance of low-frequency reproduction through the loudspeaker,

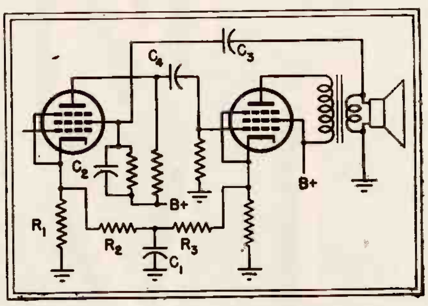
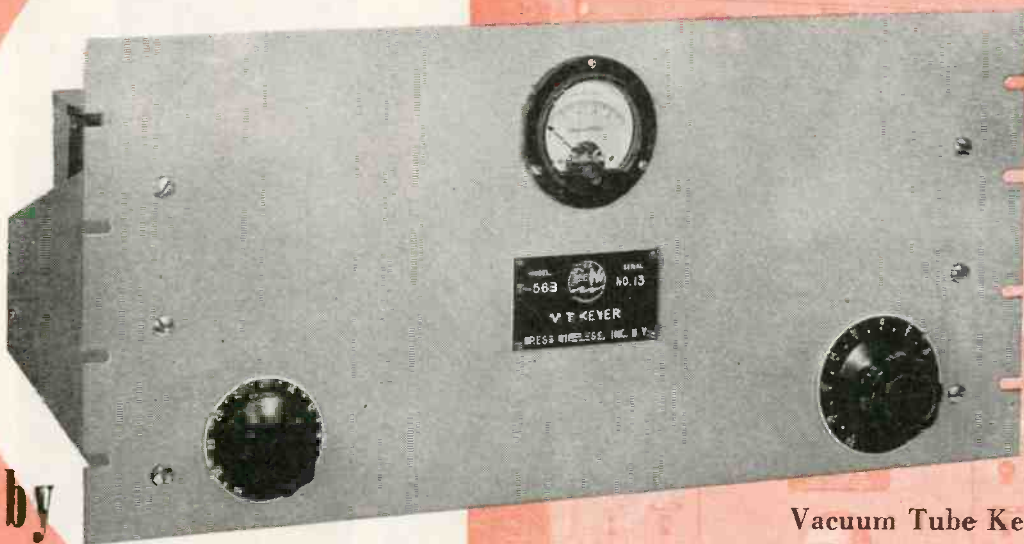


FIG. 1—Application of Synthetic Bass to the output of a typical table-model radio-phonograph, showing essential additions to the circuit

the system also augments the receiver's output characteristic to compensate for the changes in frequency response of the ear with volume level.

The ear's sensitivity for low tones at low volume is relatively less than its sensitivity for low tones at high volume. Thus in listening to low-level reproduction, to the ear the set appears to have less bass output

V T KEYERS



Vacuum Tube Keyer T-156B

by Press Wireless

V T Keyer T-156B was developed in Press Wireless laboratories to provide several specific facilities for handling large volumes of urgent outbound traffic over our international radio press circuits. The job such a unit must perform in this 24-hour-a-day, high speed, mechanized service compelled us to engineer rugged and exacting design into this keyer.

This keyer receives tone signals from a remote control point and delivers d-c pulses for keying a CW transmitter.

The non-critical input level control accommodates signals from +20 vu down to —20 vu.

Unstable transmission losses between the remote control point and transmitter may be disregarded since an automatic level regulatory circuit permits input signal level fluctuations as great as ±6 decibels without appreciably affecting the keyer output, a feature of paramount importance to all mechanized radio circuits.

Undesirable noises and cross-talk will be eliminated when signal is only 6 db above background interference.

The d-c keying output of the T-156B Keyer provides a "space" signal approximately —35 volts and a "mark" signal of zero volts. Simple adjustments — high speed keying capabilities—low maintenance factor — automatic level regulation —self contained power supply—are among the features that give the T-156B Keyer its high efficiency and dependability.

Operates from 110/115 volts, 50/60 cycles AC.

Available in strict priority sequence. Send for free data sheet.

PRESS WIRELESS, INC.

Executive and Sales Office **1475 BROADWAY, NEW YORK 18**

ARMY (E) NAVY

Awarded to our Hicksville, L. I. plant for outstanding achievement in war production.

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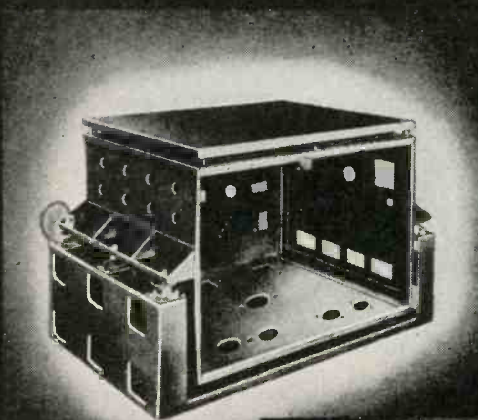
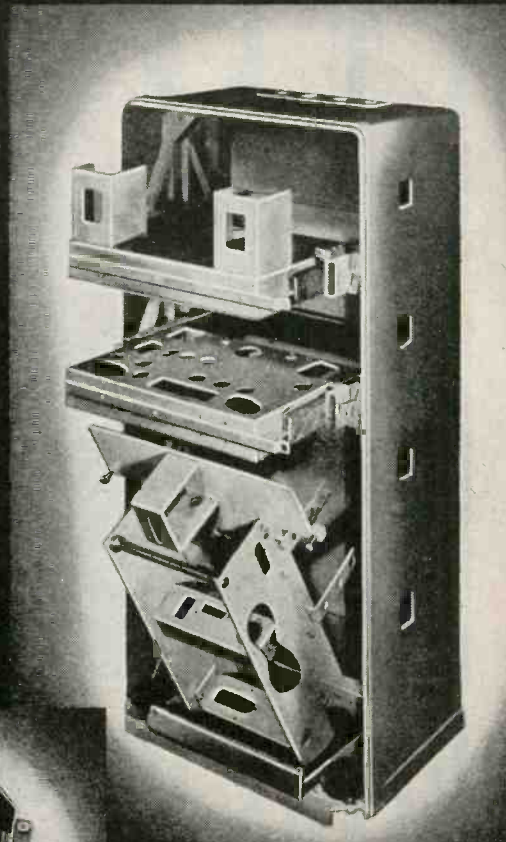
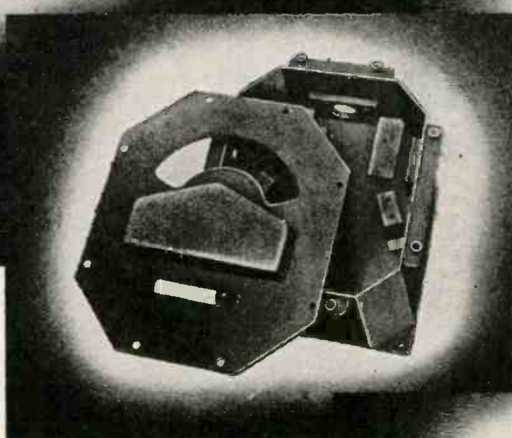
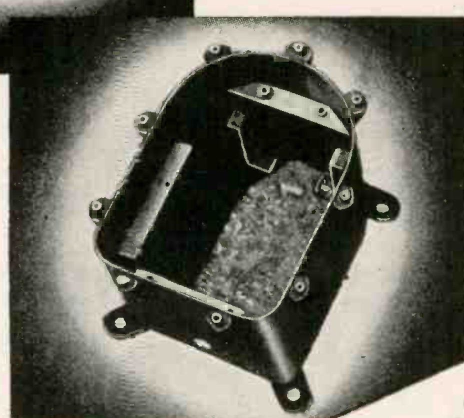
Sheet Metal Fabrication









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than at higher levels. Or putting it another way, changing the volume —although it actually does not change the frequency response of the receiver—nevertheless gives the ear the impression that the frequency response has been changed. Nor is this effect limited to actual changes in receiver volume setting; quiet passages of music will be reproduced with apparently less bass than loud passages.

Circuit

The circuit incorporates automatic increase and decrease of the amount of effective bass response for loud and soft passages, introducing relatively greater bass at low volume levels than at high, thereby counteracting the ear's loss in bass sensitivity at low levels.

The circuit is shown in Fig. 1. Negative feedback in the output through C_3, by lowering the dynamic output impedance of the circuit, damps speaker-cabinet resonance which would otherwise become annoying noticeable with the increased bass response of the amplifier-speaker system.

Hum voltage from the positive high-voltage source is introduced onto the screen of the driver tube in such a polarity by the voltage divider C_2-C_3 as to counteract hum voltage on the plate, thereby lowering the hum signal. This hum-bucking circuit is especially necessary in a circuit whose function is to increase the apparent low-frequency response.

Third harmonic of the fundamental—necessary to give the aural effect of the fundamental—is produced by positive feedback through the network $R_1-R_2-R_3-C_1$. The action of the positive feedback can best be described in reference to the dynamic plate characteristic of Fig. 2. The tube is biased at the symmetrical mid-point of its characteristic. Positive feedback from a signal that has been affected by the tube's characteristic serves to emphasize the non-linearity of this characteristic. If however the signal is so small as not to be distorted in passing through the driver, there will be no increase in nonlinearity.

The accentuation of the non-

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linearity of the characteristic is limited to low frequencies by making the positive feedback network a low-pass circuit. The extremely non-linear but still symmetrical

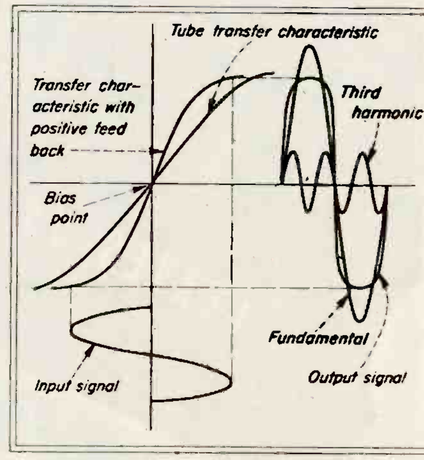

FIG. 2—Positive feedback accentuates non-linearity of the transfer characteristic, increasing generation of third harmonic necessary for aural appearance of bass response of small speakers

characteristic produced at low frequencies introduces strong third harmonics of these low tones.

To attenuate the strong low-frequency fundamental which could overdrive the speaker, the plate-grid coupling capacitor C_4 is made smaller than usual. The ratio of C_1 to C_4 determines the shape of the apparent speaker response, especially the frequency of maximum apparent response.

Acoustic Effect

The effect of the strong third harmonic in place of the fundamental is that, for a speaker which does not radiate low frequencies, acoustic output (taking into consideration all frequencies present in the output) is actually a rising response as frequency is reduced, thereby compensating for aural insensitivity at these low frequencies, instead of a rapidly falling response obtained if the speaker is required to radiate the fundamental. Acoustic output curves illustrating this bass synthesis and the volume-level bass compensation previously described are given in Fig. 3.

For additional information the reader is referred to two reports of the preliminary disclosure of the technique in a review of Shepard's

Pictured equipment of The International Cigar Machinery Company cuts the cigar leaf wrapper. The process involving the hand operation of placing the wrapper leaf on the die on top of the turret shown in the center involves a hazard to the operator against which she is completely protected by the Photo-electric Safety Control.

Its operation (shown diagrammatically) is simple and effective. The area in which hands are in danger is covered by two protective beams of light originating at (A) passing to (B) where it is reflected from an angled mirror to a similar mirror at (C) which in turn reflects it to the photo-electric cell (D). Any interruption of either of these beams automatically stops the machine and protects the hand from the pressure cutter rollers (E) moving across the die and from other moving parts. The interruption of the beam is also indicated by a monitor light at (G). The machine cannot run while the light beams are interrupted and remains at rest even after removal of the obstruction, till the operator presses reset button (F).

In addition to removal of accident hazards and attendant benefits, plants which now use this safety equipment report that the sense of security engendered in the operator has consistently stepped up production.

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SYNTHETIC BASS (continued)

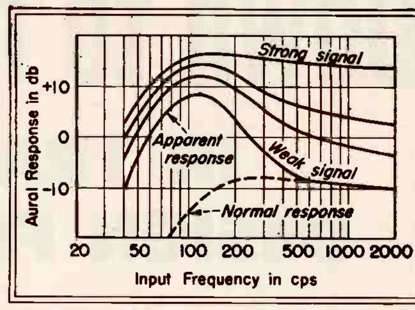

FIG. 3—Relative frequency-response curves indicate compensation for ear's change in sensitivity-frequency characteristic with intensity level and the aural appearance of notes below the radiation register of small speakers. Normal small-speaker response is shown by the dashed line; the solid lines indicate the apparent response using the synthesized bass arrangement

audio system in *Communications*, p 14, Nov 1941; and ELECTRONICS, p 31, Dec 1941 in which an early form of the circuit is given. The anticipated use for home radios and phonographs was reported in *Radio and Television Weekly*, p 6, April 18, 1945. Three patents (2,313,096; 2,313,097; 2,313,098) assigned to Revelation Patents Holding Co., 33 W 60th St., New York City 23, N. Y., describe the several principles of the circuit.

• • •

Tubes Calibrate Heavy Artillery

THE BATTLE USEFULNESS of American heavy artillery was extended by new electronic equipment used by Army Ordnance teams in Italy and Germany. The test units, installed in 2½-ton trucks and transported right up to the battlefront, are capable of measuring the speed of projectiles within 1/100,000 second.

The problem was to determine the velocity or speed of the projectiles of guns and howitzers that had been in service for several weeks or months, as compared with the velocity of new artillery pieces in action for the first time. When guns of different ages are fired together at the same target, allowances have to be made for each used gun. Figures for this purpose were provided by seven ordnance calibration teams that worked on the various battlefronts.

The results so far reported show

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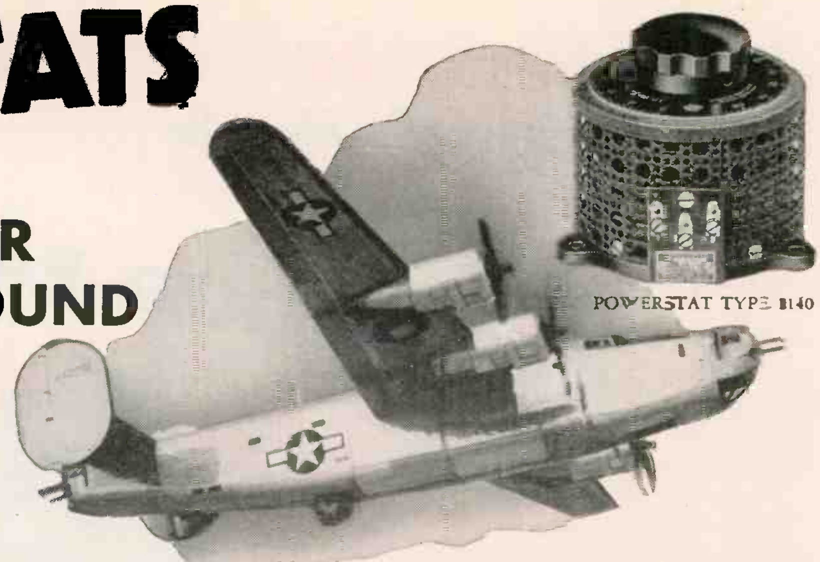

POWERSTAT TYPE 1140

400 cycles

Pictured above is the new 400 cycle POWERSTAT Variable Transformer designed especially for aircraft use. This lightweight, rugged, dependable POWERSTAT type 1140 is an aircraft component where ounces count and failure cannot be tolerated. Having the features of advanced design, carefully selected improved materials and conservative ratings, the POWERSTAT type 1140 is the air-borne variable transformer. The new POWERSTAT type 1140 retains the features of the 60 cycle POWERSTATS — essential components of many types of ground and shipboard war equipment. Type 1140 is readily available for similar use on 400 cycle equipments.

RATINGS OF UNITS ILLUSTRATED

POWERSTAT Variable Transformer Type 1140:
Input: 115 volts, 400 cycles, 1 phase.
Output: 0-135 volts, 6.5 amperes, .880 KVA.
Mounting Radius 2 1/2 inches; Overall height 4 3/4 inches.

POWERSTAT Variable Transformer Type 116:
Input: 115 volts, 50/60 cycles, 1 phase.
Output: 0-135 volts, 7.5 amperes, 1.0 KVA.
Mounting Radius 2 1/2 inches; Overall height 6 3/8 inches.

A special POWERSTAT is incorporated in the M-9 Gun Director shown on this page.

POWERSTAT TYPE 116

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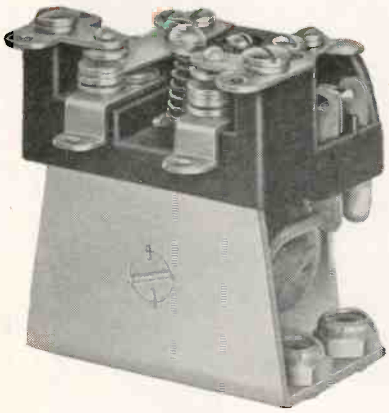
SUPERIOR ELECTRIC CO., 406 Laurel St., Bristol, Conn.

SEND FOR BULLETINS LE

"BO" POWER RELAY

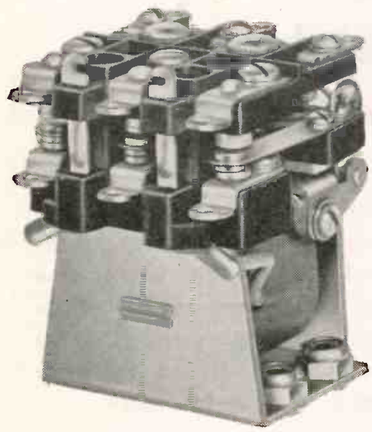


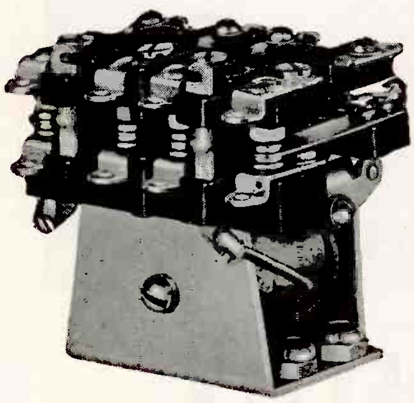
The "BO" relay is an all-purpose double pole power relay. Like other Allied types it is ruggedly designed yet features compactness and minimum weight. This relay utilizes molded Bakelite insulation throughout. Contact rating is 15 amperes at 24 volts DC or 110 volts AC non-inductive. The "BO" relay can be furnished normally open, normally closed or double throw and is available for either AC or DC service. Weighs 4 ounces.

Height 1⅞"; Length 1⅝"
Width 1 13/32"

constant progress
MARKS ALLIED RELAY DESIGN

"DO" TYPES
3 and 4 POLE





The "DO" three and four pole relay is similar in function to the "BO" type described above. It supersedes the old three and four pole type and features such modifications as simplified terminal arrangements, adjustable contacts, and improved mechanical structure. By using molded Bakelite insulation throughout, greater electrical clearance is provided. Contacts are rated at 15 amperes at 24 volts DC or 110 volts AC non-inductive. Can be furnished normally open, normally closed, double throw and for AC or DC service as specified. Weight for three pole type 7 oz., four pole 7½ oz.

Three pole Height 2¼"; Length 1⅝"; Width 1⅞"; Four pole Height 2¼"; Length 2 1/16" Width 1⅞".

Marking time or "resting on laurels" *in no way* reflects Allied's engineering and business philosophy. A specific control does a good job . . . but can it be improved? Allied engineers and field staff check its working performance . . . seek possibilities to better or broaden its usefulness.

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GENERAL OFFICES: 2 East End Ave. (at 79th St.) New York 21, N. Y. *Factories:* New York City (2 East End Ave.)—Plantsville, Conn. *Chicago*—4321 Knox Avenue, Chicago 41, Illinois. *In California:* Allied Control Co. of California, Inc. 1633 South Hope St., Los Angeles 15, Calif.

that the life of gun tubes is much longer than previously assumed. In the past, gun crews discarded gun tubes rather frequently because they had no knowledge of the efficient life of a tube and could not afford to take chances. The electronic calibration units supply data on the condition of the tubes and helps reduce the artillery supply problem so serious in the Pacific.

• • •

Postwar Prospects for Modulated Pulse Transmission

After nine years of research, pulse time modulation (PTM) has been announced by Federal Telephone and Radio Laboratories. The new system makes it possible to broadcast as many as 12 different programs simultaneously from a single radio transmitter operating on one frequency channel.

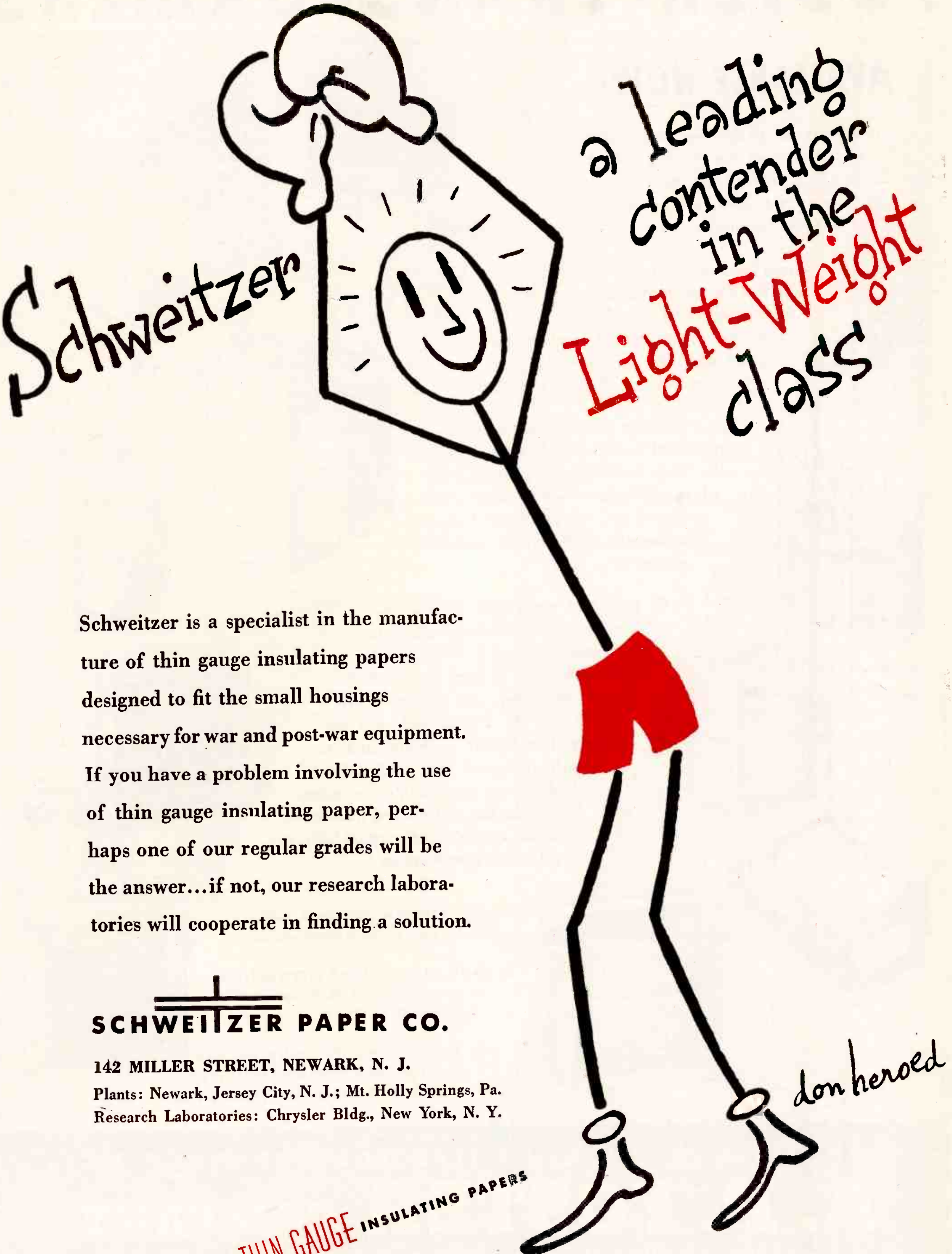
At the same time that it effects economy in transmission and simplifies and improves the efficiency of reception, it provides static-minimized reception of sound broadcasting.

Pulse time modulation receivers receive all radio programs on one frequency channel and are equipped with pushbutton circuits to separate each program after it is received. PTM transmissions differ enough from static to permit a PTM receiver to filter out noise.

The new system has been named PTM because the radio signals are transmitted in the form of short pulses, accurately timed. The time intervals between pulses in the new system, since it operates on very high frequencies, are extremely minute. Insertion of separate synchronizing pulses permits more than one program to be transmitted on a single channel. Reception of a particular program is accomplished by synchronizing the receiver through this pulse. Other programs, transmitted with differently synchronized pulses, are received by readjusting the synchronization in the receiver.

Advantages

Pulse time modulation is expected to have an application in tel-



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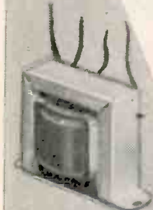
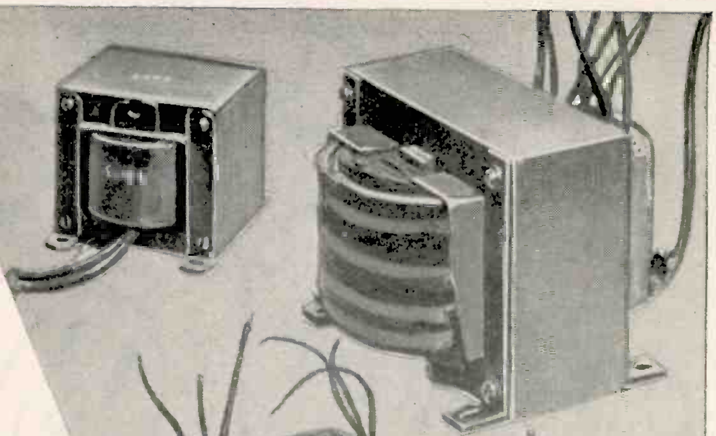
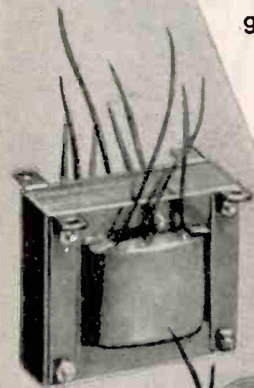
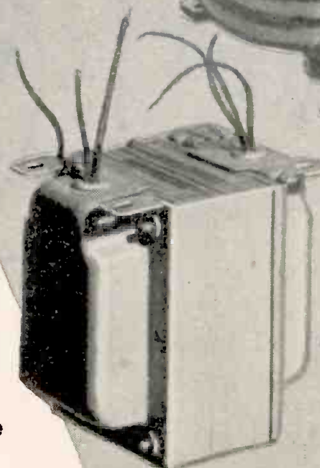


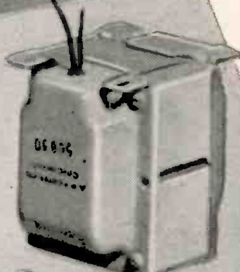


During the war years A. P. Foster has supplied thousands of custom-designed and custom-built transformers to all branches of our armed services, for use in all parts of the world under great extremes of climatic condition.

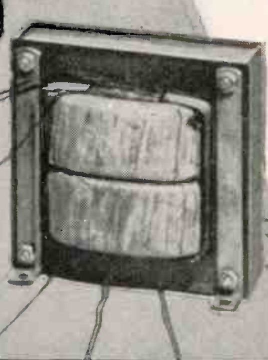


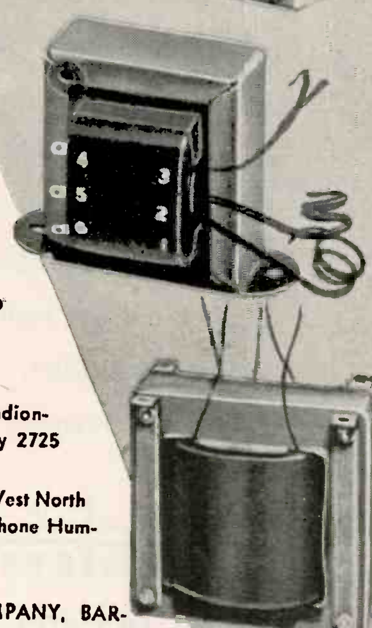


High production schedules have been maintained by advanced Foster manufacturing techniques. High standards of performance were demanded, achieved and will be maintained—to the benefit of America's peacetime economy.



As your own reconversion plans advance from the conference stage to the blueprint stage, it may well be worth your while to bear in mind that Foster engineers and designers are ready *now* to consult with you on every transformer problem and to furnish estimated costs and delivery schedules on experimental or quantity production of standard transformers or special jobs custom-built to your own specifications.





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evision, since both the video and audio signals may be transmitted on the same carrier, thus effecting economy in transmitting equipment and the amount of space occupied in the frequency spectrum. Where radio signals are repeated a number of times—as in network broadcasting—or in long-distance radio relaying—efficiency is improved and operating difficulties are minimized with PTM because signal distortion is not cumulative, as it is with conventional methods.

Deloraine, E. M. and Labin, E., Pulse Time Modulation, ELECTRONICS, p. 100, Jan. 1945.

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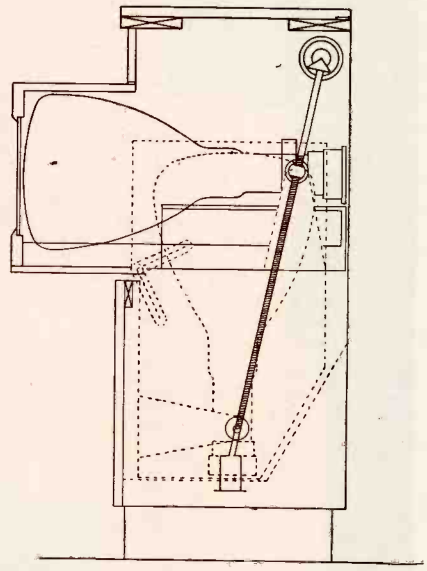
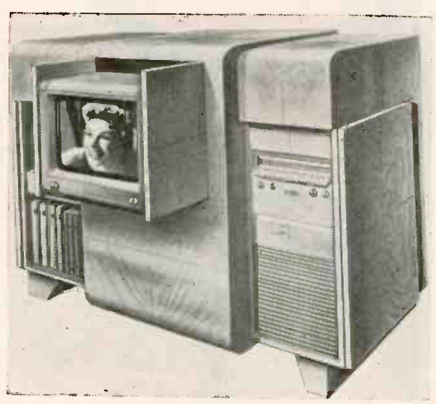


A retractable c-r tube is featured in the television receiver recently announced by Allen B. DuMont Laboratories. It works as shown above, controlled by pushbutton through a motor drive. Appearance of the 20-in. teleset, a-m/f-m, and phonograph combination is as below. Also shown was a projection model of similar design which threw a 3 by 4 ft picture



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Weight, 23 lbs., 11 oz.

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IT WILL be much more than just a "smaller" battery! For the first time, an "Eveready" **"Mini-Max"** B battery will become part of a farm-type radio A-B Pack. As a result, you're going to see a 30% *smaller*, 30% *lighter* "Eveready" "Mini-Max" farm type battery pack *with the same service life* as the conventional pre-war packs, such as our own "Eveready" No. 748 A-B Pack.

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The trade-marks "Eveready" and "Mini-Max" distinguish products of National Carbon Company, Inc.

THE ELECTRON ART

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Calculation of Distortion Due to Phonograph Needle Wear

THE DEGREE OF DISTORTION and loss of highs as a result of phonograph needle wear are discussed in considerable detail by B. B. Bauer of Shure Brothers in the *Journal of the Acoustical Society of America*. for April, 1945. Emphasis is placed on the fact that the needle does not long remain spherical but tends to develop "flat" spots at the point of contact with the record groove. Most theoretical papers on this problem have assumed that the needle has a spherical point which does not change with use.

It is pointed out that a spherical point initially penetrates into the surface of a shellac record to a

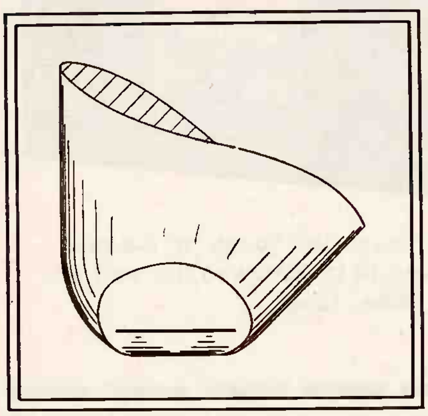

Fig. 1—Side view of worn needle point, showing the flattened portion

depth of approximately 0.0001 inch under a pickup force of one ounce. After a few revolutions of the record, there is considerable abrasion at the portion which presses most deeply into the record and this tends to even out the spherical surface. Because of the pivoting of the tone arm, the flat exhibits a slight curvature.

Difficulty was had in measuring the size of the flat since there is no sharp line of demarcation between the worn section and the spherical portion. The method finally adopted consisted of directing a distant source of light perpendicularly to the flattened portion and observing the needle tip under a medium power microscope (100 to 200×). Light is reflected from the worn surface as a straight line which is measured using a calibrated eyepiece. The width of the flat can be determined with a precision of 0.0002 to 0.0003 inch. The side view of a typical needle point with a 0.0025-inch flat is shown in Fig. 1.

The size of the flat developed on three needles of different types as a function of the playing time is shown in Fig. 2. Popularly priced 10-inch commercial shellac records and one-ounce pickups were used. It was noted that considerable variation existed within a class because of the use of different alloys, jewels, etc.

Method of Analysis

A technique similar to that used by Pierce and Hunt[1] was used for analysis. In this method, the motion imparted to the needled point by each groove wall separately was studied. The results were then combined later to obtain the complete equation of motion. As a result of mathematical analysis, it was found that distortion attains very large values before there is a substantial reduction in the output level of the fundamental component. This contradicts the common belief that the principal effect of needle wear is a loss in high-frequency response.

Fourier coefficients for calculation of needle wear distortion are

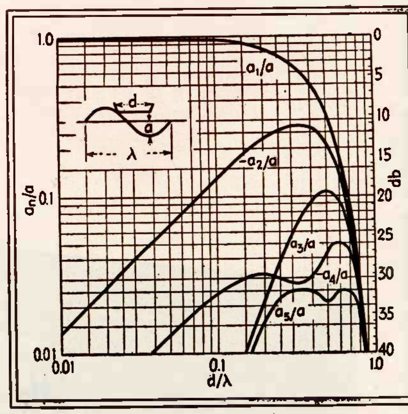

Fig. 3—Fourier coefficients for calculation of distortion due to needle wear

given. These indicate that the distortion due to needle wear in a hill-and-dale system is of the same nature as that which occurs at a single side wall. Similarly, the same

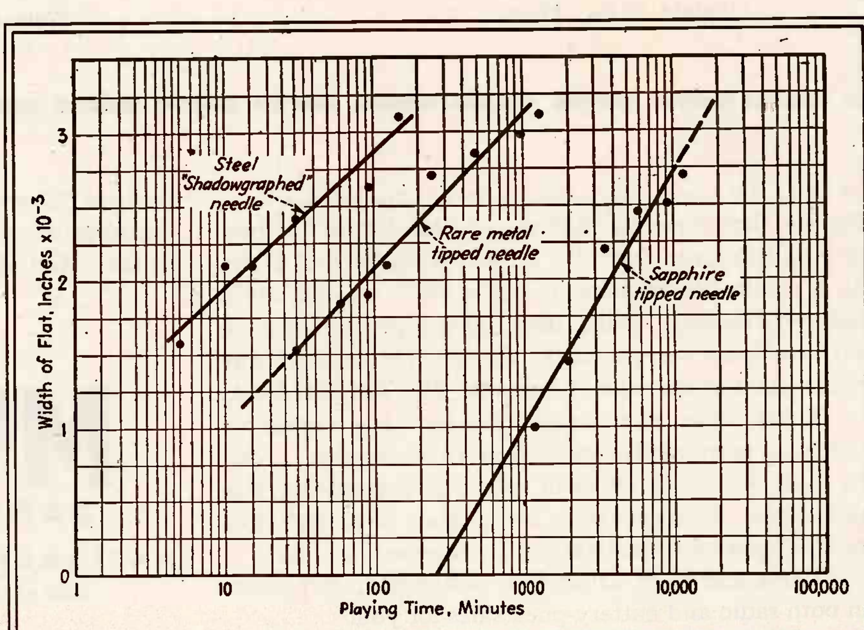

Fig. 2—Needle wear as a function of playing time measured on three different needles

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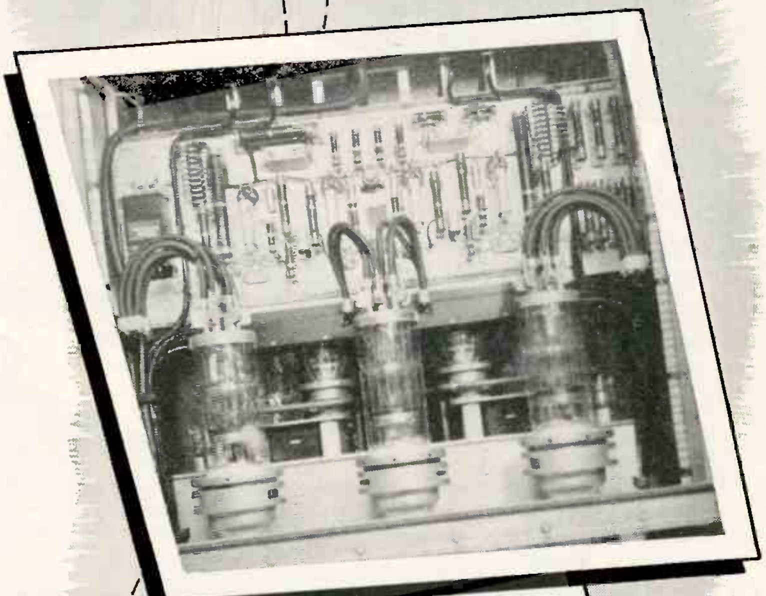
200 KW
Bethany Transmitters



From six of the world's mightiest shortwave stations, the "Voice of America" shoots "bullets of truth" to combat enemy lies. These transmitters, 200 KW each, located in Bethany, Ohio, were designed and built for the OWI by the Crosley Corporation.

The two interior photo-views of one transmitter reveal more than 60 Ohmite Resistors of various sizes . . . and one Ohmite Tandem Rheostat assembly.

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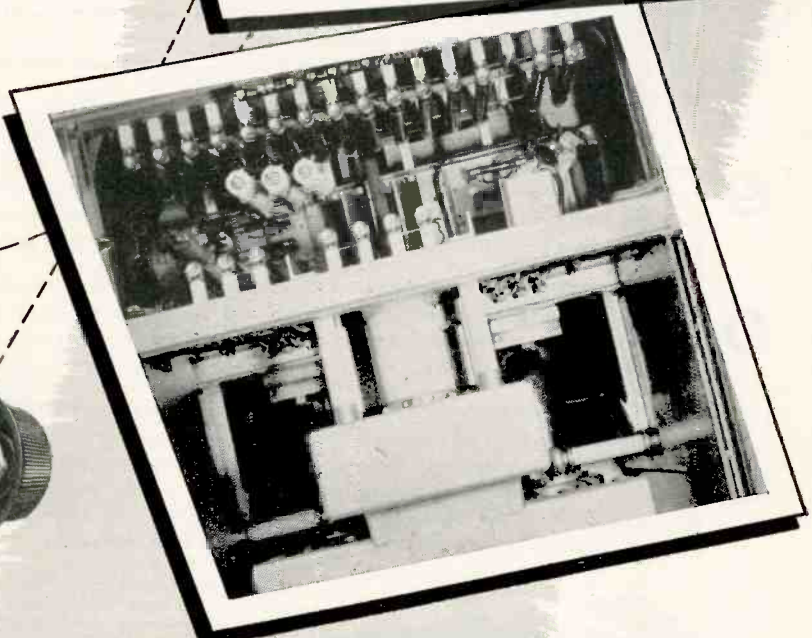

Write on company letterhead for helpful Catalog and Engineering Manual No. 40. Gives valuable data on resistors, rheostats, tap switches, chokes and attenuators.

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type of distortion in a lateral system is like that in a single side wall, except that even harmonics tend to cancel out. Such cancellation could not be perfect unless the two needle flats are identical.

Calculations are carried out in some detail using Fig. 3 in estimating distortion. Measured values of distortion compare favorably with those calculated.

• • •

Subsurface Prospecting for Hydrocarbon Oil Sands

AN INSTRUMENT for determining the presence of hydrocarbon oil sands or oil bearing formations by electronic means is the subject of a patent issued to Donald G. Hare of Houston, Texas, and assigned to Texaco Development Corporation.

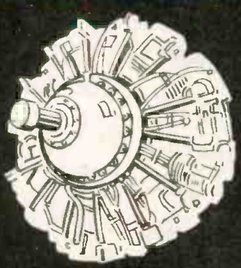
In the proposed method, fast neutrons are caused to be emitted and passed into the formation around a hole drilled in the earth. Some of the neutrons after being scattered in the formation return to the surveying device to cause an indication of the variation in the types of formation through which the hole is drilled. A source of penetrative gamma rays which may be associated with a neutron source is lowered into the hole and these rays are scattered by the formations through which the hole has been drilled, a certain number of these rays then returning to the instrument.

The instrument is provided with a suitable detector such as a Geiger-Muller counter or ionization chamber. The amount of radiation scattered back to the instrument will vary with the type of formation adjacent to the instrument according to well known physical laws and thus by measurement of the intensity of this scattered radiation, information may be obtained as to the nature of the formations.

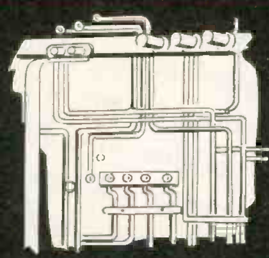
Emission Source

The surveying instrument comprises a substantially closed casing which is arranged to be lowered and raised through the hole. The casing contains a suitable source of gamma rays and neutrons such as a tube in which is sealed a mixture of a small amount

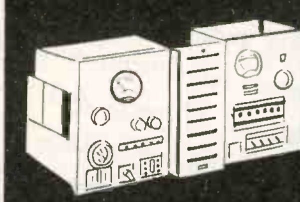
TURBO earns its wings in the Aircraft industry



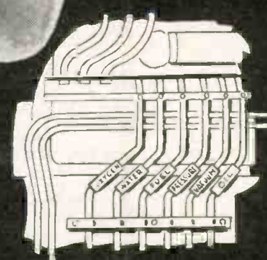
VARNISHED GLASS TUBING: provides a solution for motor wiring and cabling subjected to high ambient temperatures. Dielectric strength is high and mechanical properties are unimpaired in unventilated applications.



TURBO SLEEVINGS: simplify service and repair of complex equipment. A full range of vivid colors are available. Identification and tracing is simplified — service and repair is expedited.



WIRE IDENTIFICATION MARKERS: are available in two types —tab and sleeve—these markers are easily applied and assure permanent legibility. Supplied in any color and marking, they permit instant identification of cables, tubing, and control rods.



EXTRUDED TUBING: is a smooth wall sleeving capable of withstanding the rigors of extreme low temperatures. Immunity to embrittlement at sub-zero temperature assures safety and dependability.

...and proves its outstanding dependability in every type of critical electrical installation!

IT IS TURBO SAFE-GUARDS

The exceptional functional suitabilities of TURBO insulation sleevings are exemplified in airborne installations offering specific characteristics for meeting diversified requirements of altitude and climate. They are available in four types.

Equipment wiring solutions—radio, control, communications, etc. involving sub-zero temperatures—are effected by TURBO Extruded Tubing. This material is immune to embrittlement in severe cold, retains dielectric strength and flexibility. It is unaffected by vibration or mechanical shock, and is available in a diversity of sizes.

Other products importantly utilized in the aviation field are Varnished Glass Tubing for resistance to high heat, and Flexible Varnished Oil Tubing for use in the presence of chemicals, vapor, humidity and moisture. Identification Markers are also widely applicable for visual identification of pipes, tubing, control rods, cables, etc. Thus, by the extensive use of these insulation products for extremely critical requirements, TURBO is recognized for its dependable attribute in all fields of electrical endeavor. Write for the free TURBO Sample Board with specimens and sizes of each.

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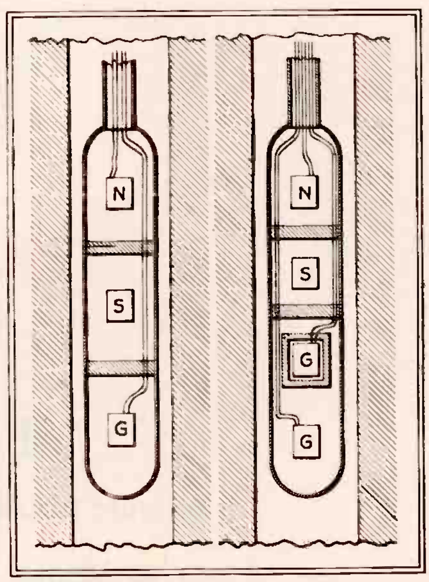
of a radium sulfate or chloride and a considerably larger quantity of finely powdered beryllium metal. A detector for the detection of gamma rays only is also disposed within the casing and is separated from the source by a suitable shield of lead.

The detector used for detecting gamma rays to the exclusion of neutrons may be such a device as a Geiger-Muller tube, operated at a potential sufficiently high so that the electrons emitted by the inter-



Two devices for lowering into bore holes for determining the nature of the surrounding earth formation. A source of gamma rays and neutrons, S, produces emissions which are picked up by detectors *N* and *G*

action of a gamma quantum with the tube wall will cause the tube to discharge. Within the upper part of the casing is a detector adapted for the detection of neutrons only and this detector is also separated from the source by means of a shield. The shields tend to prevent direct radiation from the source from reaching the two detectors. The shield for preventing neutrons from passing directly from the source to the detector may, if the detector is such as to respond to slow neutrons only, be a sheet of cadmium or other substance or a combination of cadmium and boron having a high capture cross-section for slow neutrons.

If desired to have the detector respond to both fast and slow neu-

trons, the shield may consist of 10 to 20 cm of a hydrogenic material such as paraffin, for slowing down the neutrons, followed by a layer of cadmium or other substance as described above. Such a thickness of paraffin will slow down practically all the neutrons to an energy suitable for their capture by a cadmium shield. The detectors may be Geiger-Muller counters, or ionization chambers, and may be connected to suitable amplifiers to actuate indicating or recording instruments at the surface.

Gamma-ray Detector

Since the number of gamma rays scattered per unit volume will depend on certain physical properties such as density and atomic number of the substances making up the formation, by measuring the number of such gamma rays scattered back to the detector we can obtain valuable information concerning the nature of the formation adjacent to the instrument. Thus, as the device is moved along the bore hole from point to point, changes will be noted in the intensity of the gamma rays scattered back to the detector and these changes may be correlated with the types of formations through which the bore hole has been drilled. A continuous survey may be made of a bore hole and, since the gamma rays are little influenced by the presence of iron or steel in the hole, the device can be used with success in the logging of holes containing casing or drill pipe.

Neutron

The neutron detector is included to pick up those neutrons which are scattered and returned to the instrument in a manner similar to that in which the gamma ray detector operates. With this arrangement, additional information may be obtained such as the presence or absence of hydrogenic substances in the structure of the formations. This is particularly true if the detector is capable of differentiating between fast and slow neutrons, thus detecting those which have been slowed down by collision with hydrogen nuclei. Such a detector may be a boron-trifluoride ionization chamber.

A modification of the unit which

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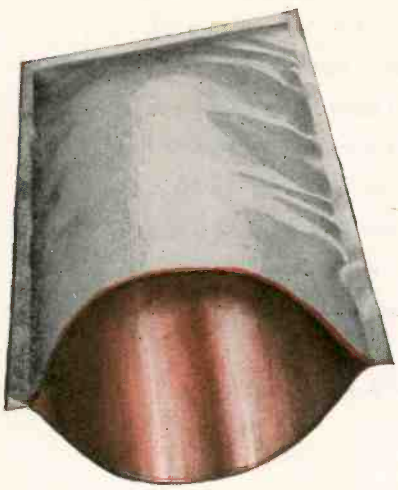

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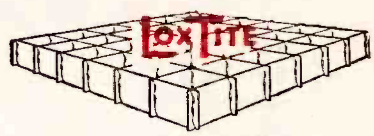

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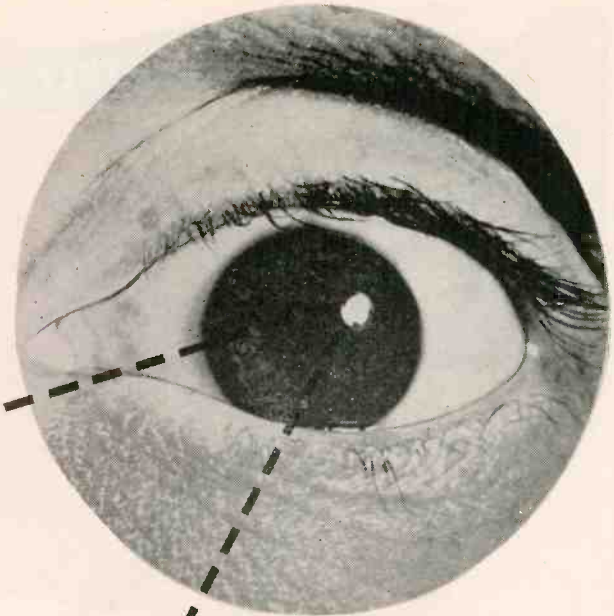

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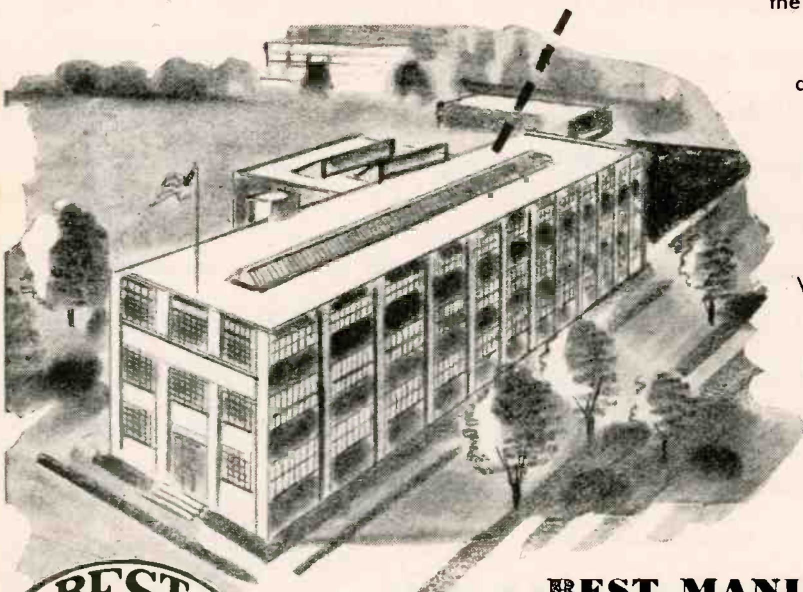

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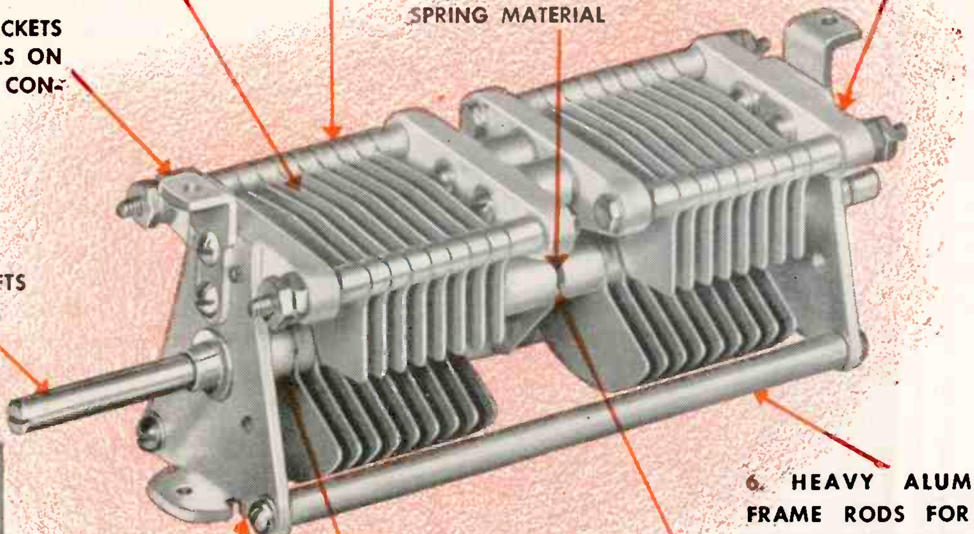

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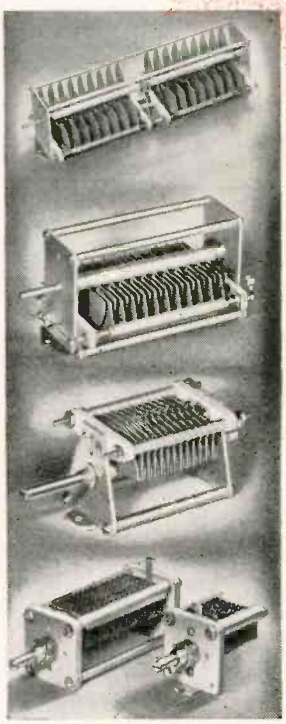

C -	Plate spacing	.125" - .500"
	Maximum frame dimensions	5½" x 5-13 32"
D -	Plate spacing	.080" - 250"
	Maximum frame dimensions	4½" x 4"
E -	Plate spacing	.045" - .125"
	Maximum frame dimensions	2⅜" x 2-19 32"
H -	Plate spacing	.030" & .080"
	Maximum frame dimensions	1½" & 1-9 16"

Type "F" single and dual condensers are stocked with plate spacings of .045 to .075" in 19 different models. Maximum capacity range is from 34 mmf. to 255 mmf. and the ratios of maximum to minimum run from 7:1 to 15:1. Maximum frame dimensions 2-1 16" by 2".

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E. F. JOHNSON COMPANY • WASECA • MINNESOTA employs three detectors is also shown in the accompanying illustration. This arrangement is designed for detecting the change in penetrating power or hardness of the gamma radiation caused by scattering in the formation. Two gamma-ray detectors are employed, one being well shielded to provide selective absorpion as a function of wavelength of the radiation while the other is unshielded. The shield around the detector decreases the intensity of the less penetrating gamma radiation and permits the detector to record principally the radiation which has been least affected by the scattering process. Comparison of the intensity registered by the two detectors provides information regarding the scattering processes and thus of the type of formation doing the scattering.

• • •

Five Radio-Frequency Bridge Circuits

THE FOLLOWING SERIES of radio-frequency bridges have been developed by the British Broadcasting Corporation during the past ten years and a more detailed description of them was given by H. L. Kirke, head of the research department, in delivering the chairman's address for 1945 of the IEE radio section. They are all types that have been well proved by long usage in the field and laboratory.

A short-wave admittance bridge is shown in the schematic of Fig. 1. Reactance balance is obtained by

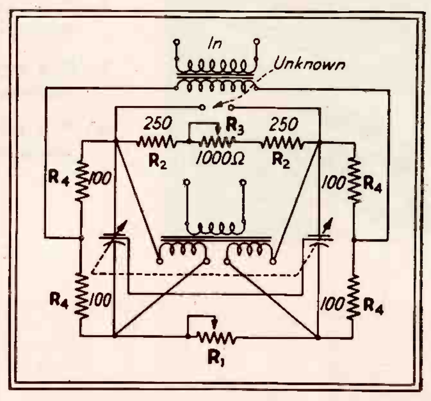

Fig. 1—Short-wave admittance bridge for field use. Resistor R_1 is the standard resistor and resistors R_2 and R_3 are used to balance the maximum value of R_1. Resistors R_4 are the ratio arms of the bridge

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Where the resonate type Voltage regulator can't meet the specs—when you need a regulator not affected by frequency variations—where the output wave form must not be altered by the regulator—call for Sorensen.

For Aircraft applications—400 cycle. Frequency Variation ± 10% Input Voltage 90—140 V. A. C. Output—115 V. A. C. ± ¾ of 1%; 500 Watts. Weight 13 pounds. Meets A. N. Specifications.

50-70 Cycles Input 90 — 140 V. A. C. Output 115 V ± ¾ of 1%; 1200-1750 Watts. Weight 60 pounds.

All transformer components are hermetically sealed and tropicalized throughout.

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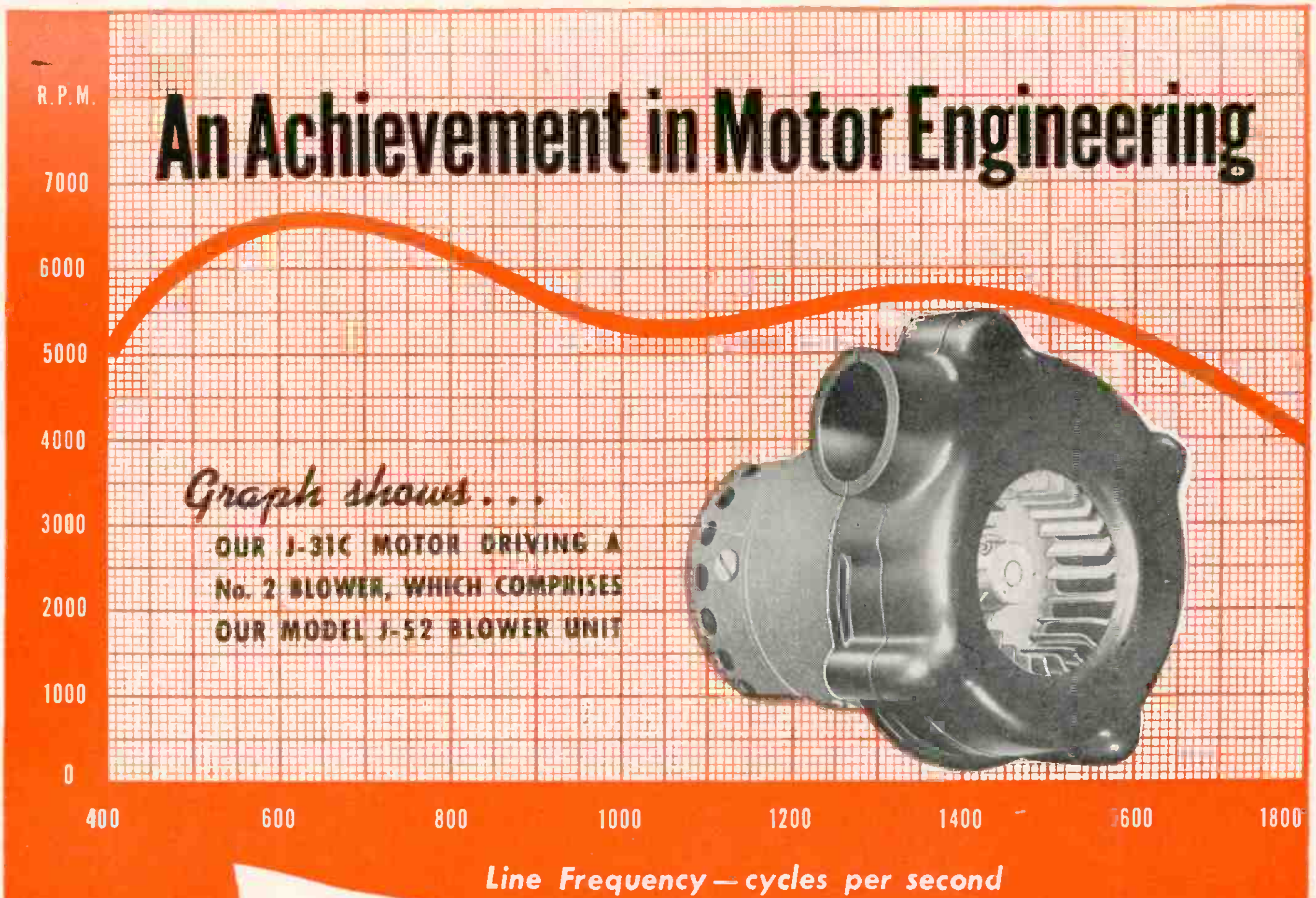

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Dimensions:

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A medium and long-wave admittance bridge is given in Fig. 2. This bridge is somewhat similar to that shown in Fig. 1 but the resistance ratio arms are replaced by

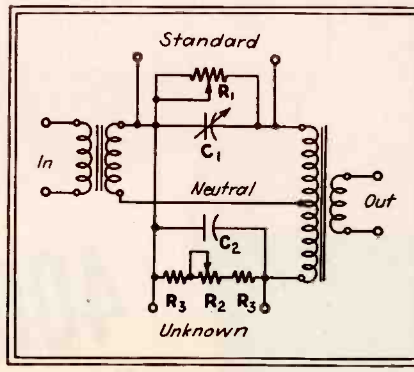
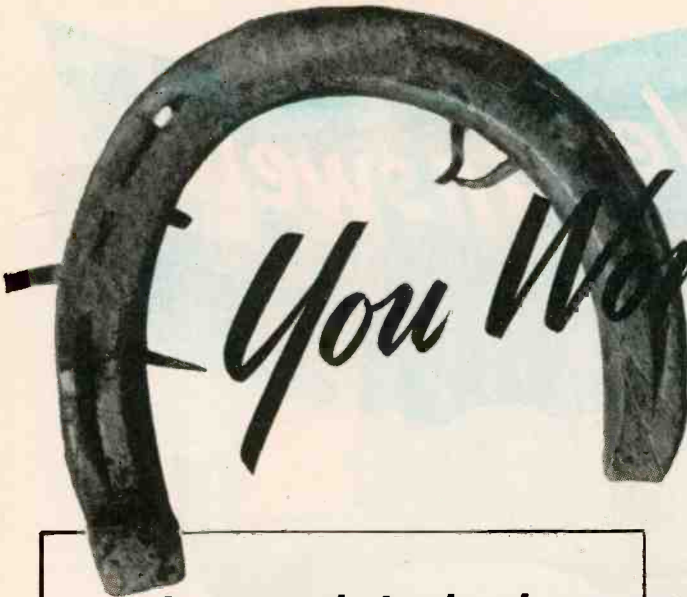


Fig. 2—Medium and long-wave admittance bridge. Capacitor C_1 is the standard and C_2 is a fixed capacitor which is switched in for inductance measurement

the transformer windings used previously for the same purpose. It uses standards consisting of a variable capacitor and a variable resistor in parallel. Normally it measures unbalanced impedances but can handle balanced types when converted to the type of bridge shown in Fig. 1. The change is carried out by means of a switch. Internal standards are provided but external ones can be used.

Multi-Ratio Bridge

A medium and long-wave multiratio admittance bridge is shown in Fig. 3. This form of bridge has been designed for use in the frequency range from 15 kc to 2 Mc and the various ratios are obtained by tapped transformers. As before, a resistor and a capacitor, effec-



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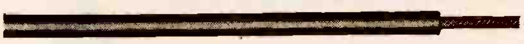
1000 volt in sizes No. 22 to 4 AWG and 3000 volt in sizes No. 16 to 12 AWG with stranded tinned copper conductors insulated with synthetic tapes and felted asbestos, covered with lacquer-finished, color coded glass braid and shielded with a tinned copper braid. Heat, flame and moisture resistant, light weight, small diameter construction; operating temperature range 125°C. to minus 50°C. Also available without shielding and in twisted pair and multi-conductor constructions.

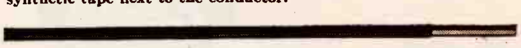
ROCKBESTOS FIREWALL MULTI-CONDUCTOR INSTRUMENT CABLE

This unusually small diameter, light-weight, high-dielectric No. 26 AWG three-conductor cable was designed for an electronic device in which three No. 22 AWG single conductor aircraft circuit wires previously used had proved too bulky. It is made to a nominal diameter of .125" (smaller than a No. 14 AWG single conductor 1000 volt Rockbestos Firewall Radio Hookup Wire). Also in 4 and 5 conductor constructions, in sizes No. 26 to 20 AWG.



ROCKBESTOS ASBESTOS INSULATED LEAD WIRE

Sizes No. 22 to 4 AWG solid or stranded copper, monel or nickel conductors insulated with .031" or .040" of impregnated felted asbestos in black, white or colors. Heatproof and flame-resistant, this lead wire will not bake brittle and crack under vibration, won't rot, swell or flow when in contact with oil or grease, and has ample moisture resistance for most applications. For high dielectric strength and added moisture resistance specify Type CA Lead Wire with synthetic tape next to the conductor.



ROCKBESTOS ASBESTOS INSULATED MAGNET WIRE

Round, square and rectangular asbestos insulated conductors finished to meet varying winding conditions and coil treatment requirements. Designed for Class B windings and also suitable for use as insulated bus wire where high-dielectric strength is not required. The insulation is non-checking and is unaffected by heat or aging.

A few of the 125 different wires, cables and cords designed for severe operating or unusual conditions by Rockbestos.

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EXCESS VOLTAGE DROP ☐	ADEQUATE CONDUCTOR SIZE ☐
WIRE TERMINATIONS ☐	FREE STRIPPING AND SIZE ☐
CONDUIT AND BUSHINGS ☐	MAXIMUM DIAMETERS ☐
EXPOSURE TO MOISTURE ☐	MOISTURE RESISTANCE ☐
OIL, GREASE AND FUMES ☐	RESISTANCE TO ROTTING ☐
OPERATING AND AMBIENT TEMPERATURE RANGES ☐	RESISTANCE TO CONDUCTOR AND EXTERNAL HEATING ☐

Is that job you're working on apt to be used where ambient temperatures climb too high for wire comfort? Is it going to develop considerable heat in operation? Are conduit bends so snug that wire may be abraded when installed? Should thought be given to wire-fire hazards? And how about overloads . . . etc. . . . etc.?

Check and *double-check* these trouble sources . . . and *everything else* you can think of that might open the way for wire-failures that may cause your smooth working models to break down under actual service conditions . . . then *specify* wire that gives you *an ample safety margin* of resistance to heat, moisture, oil, grease, corrosive fumes and flame.

For help in your wire-planning call in our field engineers for recommendations from our line of 125 different *permanently insulated* standard constructions . . . and if your wiring problem calls for something special Rockbestos Research will be glad to go to work on it. Just give us the details or ask us to call. Address the nearest branch office or:

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tively in parallel, form the standard but each can be connected to different transformer taps to provide independent resistance and reactance ratios.

To maintain exact voltage ratio and phase in the standards and unknown values, under different conditions of loading, the leakage reactance of the transformer is minimized by the use of a Mumetal strip wound as a toroid, and also by careful winding.

A radio receiver 2-gang capacitor of 7-250 $\mu\mu$f is used for the standard. It is switched between

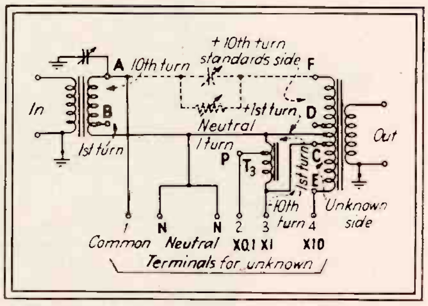


Fig. 3—Tapped transformers are used in this bridge circuit to provide several ranges

taps of the input transformer and taps on the standard side of the output transformer for capacitance measurements, and to one of the taps on the unknown side for inductance measurements.

For resistance balance, a 1000-ohm potential divider (Fig. 4) is connected across appropriate taps

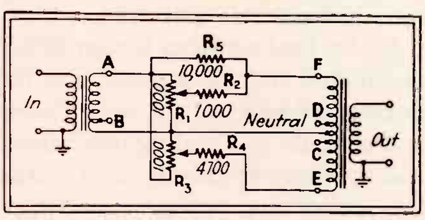


Fig. 4—Resistance balance is obtained by adding R_1 and R_3 to the circuit shown in Fig. 3

of the input transformer and a fixed resistor R_2 from the slider is switched to either tap on the output transformer. The inductance of the potential divider is thus of less importance than if it were used as a variable resistor. The ranges of the bridge are:

Capacitance: 0.01 $\mu\mu$f to 25,000 $\mu\mu$f.

Inductance: Such as will reso-

"Accentuate the Positive"

WITH THIS IRC COAXIAL CONNECTOR

For *positive*, vibration-free contacts, here's a plug that daily is proving satisfactory in many UHF applications. Of Navy design, it is built to meet the rigid standards of both Service branches and can be depended upon for faultless operation where ease and rapidity of making and breaking electrical connections are important. Originally engineered to meet the severe requirements of warfare, it will readily find many uses in commercial fields.

All metal parts of this popular connector are heavily silver-plated. Contact parts are of specially tempered spring-brass and the plug is insulated with low-loss mica-filled bakelite. The connector is designed to take Army-Navy cables Types RG-7/U, RG-8/U and RG-11/U. When ordering specify plug #50.393-1 (Navy Part Number CI-49195, U.S. Signal Corps Number PL-259A.)

For dimensional drawings and information on this and other types of IRC coaxial connectors and receptacles, write for Bulletin #4.

IRC

CONNECTOR DIVISION OF

INTERNATIONAL RESISTANCE CO.

401 N. BROAD ST. PHILADELPHIA 8, PA.

DEPT. 6-1

OKONITE "FIRSTS" FOR THE NAVY

- First to offer a corrosion-resistant lead alloy coating for copper conductors ("Okoloy")
- First to develop a method of assembling conductors to increase resistance against twisting ("Unilay")
- First to supply conductors insulated with a non-flammable synthetic dielectric ("Okoseal")
- First to protect conductors with flame-resistant glass fiber insulation ("Okoglass")
- First to manufacture the synthetic impervious sheath for protecting cables ("Okoseal")

they ALL benefit the ELECTRONICS industry

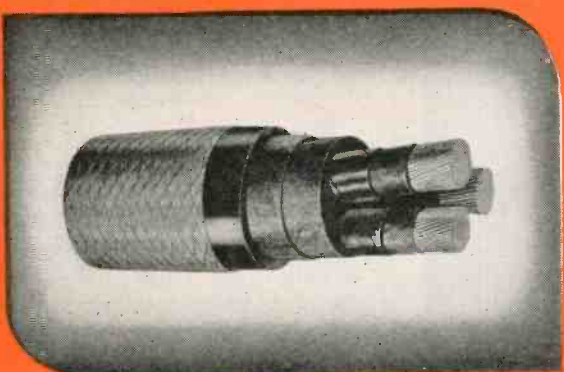
Meeting Navy demands has been more than a challenging experience to Okonite chemists and research engineers. It has helped to introduce better products of greater value to all industry. Among Okonite's pre-war developments in electric cable and insulated wire are many which have been improved and which have found their greatest usefulness in wartime. Some of them whose service advantages have commercial applications are listed and illustrated. Write for further information on any or all of them or for assistance on any specific problem involving the transmission or distribution of electrical power through insulated wires and cables. The Okonite Company, Passaic, New Jersey.

OKONITE

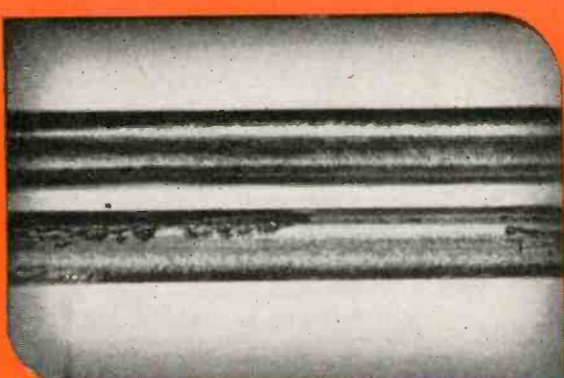
SINCE 1878

insulated wires and cables

OKOSEAL as wire insulation is moisture-tight, non-flammable, resistant to chemicals, oils, and ozone.



OKOSEAL as a flexible sheath, in addition to the above advantages, is light in weight and mechanically strong.



OKOLOY affords a corrosion-proof lead alloy conductor coating that outlasts tinning at least 2 to 1. Okoloy (top) is unaffected by immersion.

OKOGLASS insulation, which cannot burn or give off flammable gases, protects cables in hot locations, as near steam lines.

4009

nate with the above.

Resistance: 10 ohms to 10 megohms.

V H F Circuit

An ultra-short-wave admittance bridge appears in Fig. 5. In this instrument, the input and output transformers both have a ratio of 3:1, giving a total of 9:1. This ratio enables a capacitor of low inductance to be used as a standard, and the value of resistance is also more convenient. Capacitors C_1 and C_2 are the standards, of 60

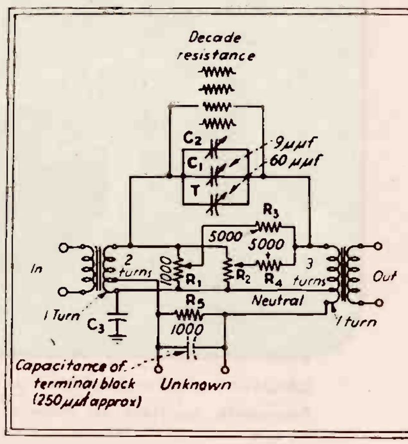


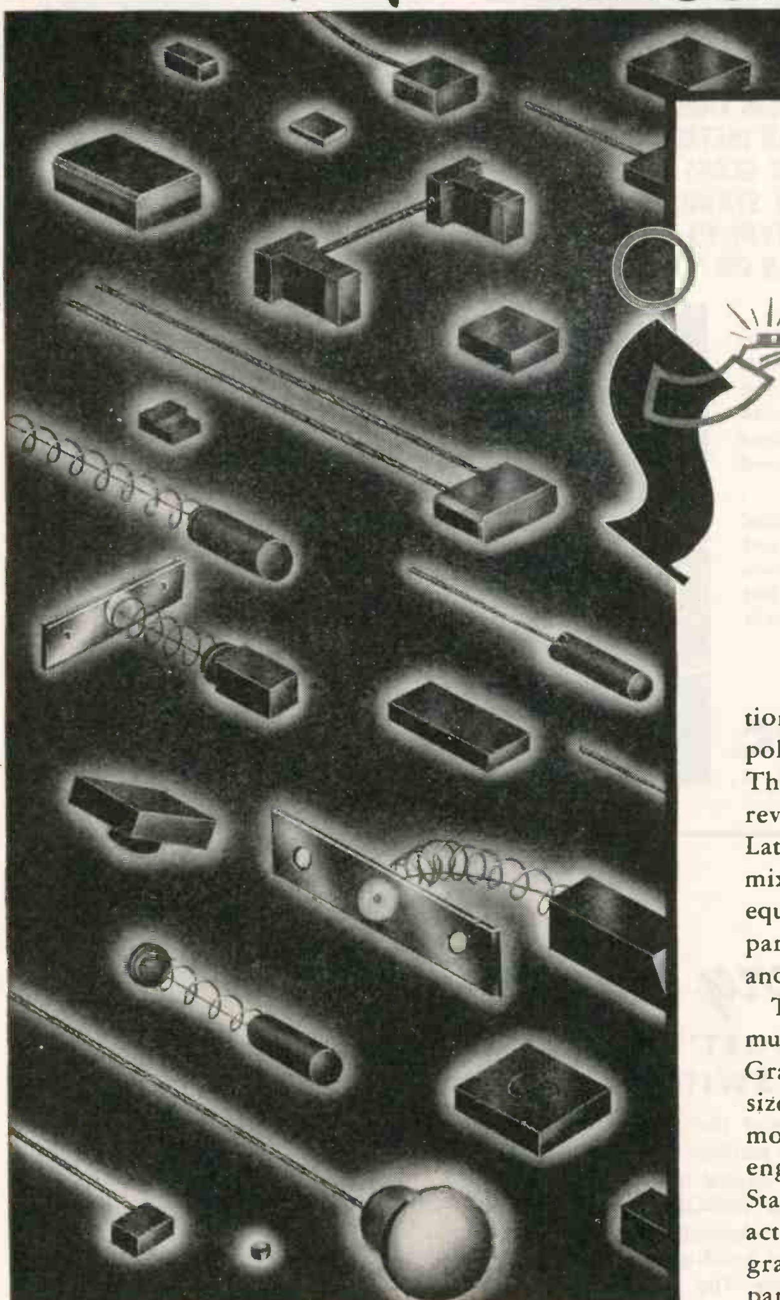
Fig. 5—An accuracy of five percent over a range of frequencies from 100 kc to 100 Mc is claimed for this bridge circuit

and 9 μμf respectively, but the 9-μμf capacitor is calibrated from 0 to 70 μμf (the capacitance which it balances), and the 60-μμf unit is calibrated from 0 to 500 μμf. Owing to the necessity for reducing internal inductance in the bridge, the capacitance of the 60-μμf unit at half scale, plus the zero capacitance of the small capacitor and that of a trimmer, is balanced by the capacitance of about 250 μμf across the unknown terminals, which is obtained by making the leads and the massive terminals in one unit, spaced by a sheet of mica.

Groups of carbon resistors are used for the resistance balance and there is a continuous adjustment of resistance balance with a potential divider. Great care is taken in wiring, to reduce the inductance and stray fields. All leads are of copper tape and external leads are kept very close together.

A 30-ohm carbon resistor is used as the resistance standard, its ends

Silver-Graphite BRUSH HEADQUARTERS



- **LESS RADIO INTERFERENCE**
- **LESS AUDIO AND RADIO FREQUENCY NOISE**
- **LOW CONTACT RESISTANCE**
- **UNIFORM CONTACT RESISTANCE**
- **LONG LIFE**

Twenty years ago, at the suggestion of Westinghouse engineers, Stackpole pioneered silver-graphite contacts, The result was an almost immediate revolution in circuit breaker design. Later, as the advantages of this unique mix were applied to brush engineering, equally important advances were scored, particularly on low-voltage commutator and slip ring motor applications.

Today, the important thing is not so much the fact that Stackpole Silver-Graphite Brushes are supplied in all sizes and shapes. What counts even more is the unsurpassed wealth of engineering experience that permits Stackpole engineers to recommend exactly the correct, "tailor-made" silver-graphite mix for best results on your particular application. Backed with complete details of your equipment, they welcome the opportunity to submit Silver-Graphite Brush (or Contact) samples for test. You be the judge!

STACKPOLE CARBON COMPANY
ST. MARYS, PA.

BRUSHES AND CONTACTS
(All carbon, graphite, metal, and composition types)
RARE METAL CONTACTS
BEARINGS **WELDING CARBONS**
PACKING, PISTON AND SEAL RINGS
CONTINUOUSLY ADJUSTABLE CARBON RHEOSTATS
CHEMICAL CARBONS
CARBON PIPE **POWER TUBE ANODES**
MOLDED SPECIALTIES, etc.

STACKPOLE

MOLDED METAL POWDER AND CARBON PRODUCTS

Thermoplastic insulation specialists . . . producing a complete line from fine wires to heavy power cables . . . serving: Public Utilities, Radio, Electronic, Appliance and Instrument Manufacturers, Telephone Companies and Contractors.

Now

THERMOPLASTIC INSULATION

Nothing is constant but change . . . and in the wire and cable field the "change" to thermoplastic insulation has been tried and proved in the test tube of war. When victory is won you will demand the maximum resistance which these new compounds and constructions offer to heat, flame, oxidation, chemical action, oil, grease, moisture, cold, abrasion, fungus growth and other severe conditions. Write NOW for complete information and samples engineered to your particular requirements. Remember . . . when you're thinking of PLASTIC you're thinking of US!

PLASTIC

WIRE & CABLE CORPORATION

NORWICH CONN

being cased in copper to neutralize inductance. It is non-reactive up to 60 Mc.

To measure the internal inductance of the bridge, a measurement is made of an inductance and a resistance in series. This is provided by a single turn of 46 SWG eureka wire on a 3/8 inch former. The inductance can be calculated and the resistance measured on d-c and calculated for high frequencies.

The accuracy of the bridge is not worse than 5 percent and is considered fairly good for the frequencies covered (100 kc to 100 Mc) and for such a simple piece of equipment. Ranges are as follows:

Capacitance—Up to 300 $\mu\mu$f.

Shunt Resistance—10 to 10,000 ohms.

Inductance—Such as will resonate with the above capacitances.

Inductance Measurements

A medium and long-wave low impedance bridge is given in Fig. 6. This bridge covers the frequency range from 100 kc to 2 Mc and is designed particularly for low-

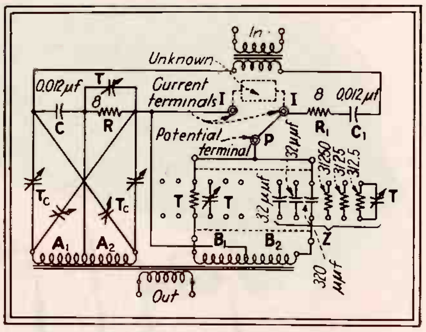
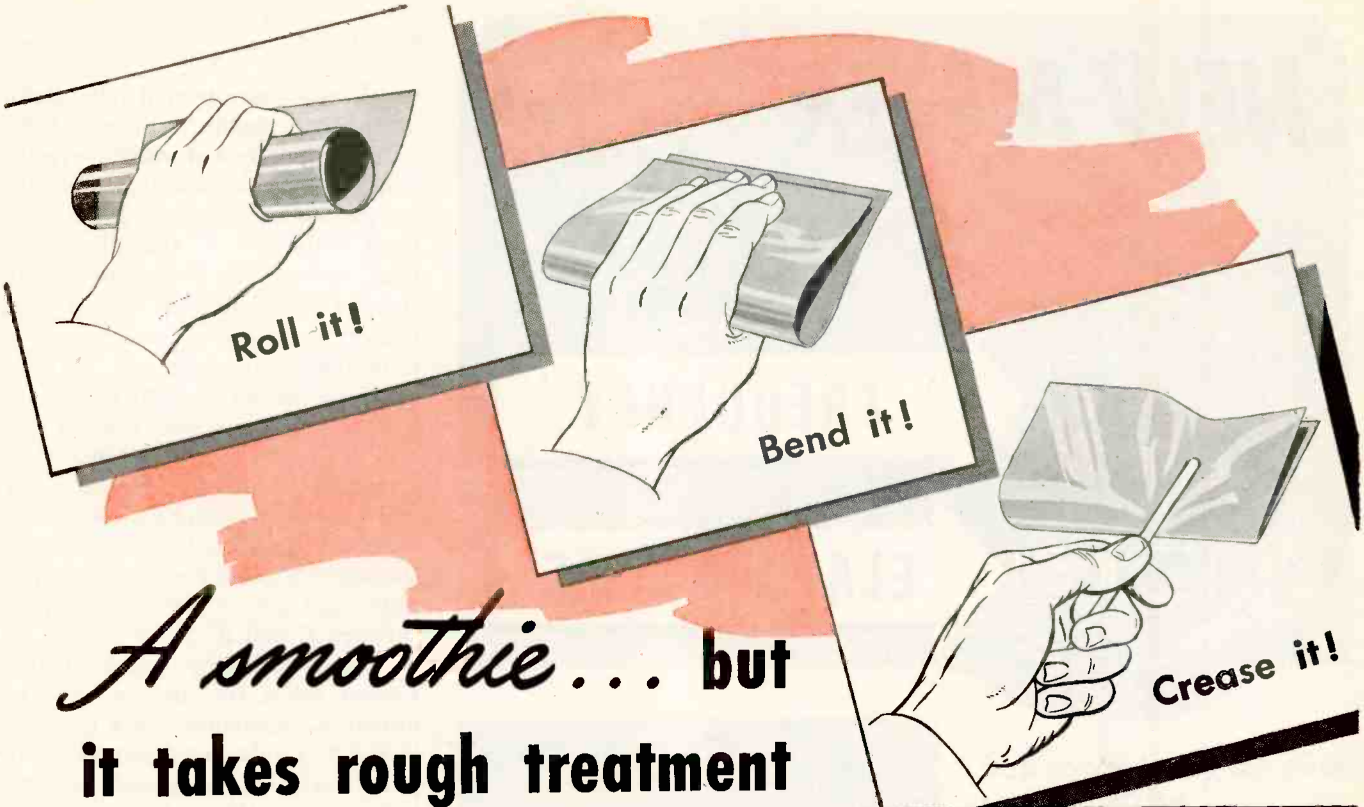


Fig. 6—Low values of inductance as well as the resistive component are measured by this circuit. Capacitance may also be measured by changing the calibration of the dial. Capacitors marked *T* are trimmer types

inductance measurements. It also measures the resistive component. Capacitance measurements can be made but the dial readings are in reciprocal capacitances.

The method is to determine the potential difference across the unknown impedance and to compare this with the current through it. Independence between the circuits is achieved (like the Kelvin double bridge) and this enables mutual inductance to be measured. It also



A smoothie . . . but it takes rough treatment

You can form DOBAR laminated insulation paper into almost any shape without damaging its smooth surface or changing its electrical characteristics. It slides readily into small, confined spaces with minimum pressure and friction, making it quick and easy to handle.

The laminated moisture-barrier of cellulose acetate film increases dielectric strength to 70% better than standard paper, under ordinary conditions. At 85% RH and 85° F., DOBAR tests up to 296% better. Leakage tests under the same conditions show an improvement of 327%. With its high resistance to moisture, solvents, weak acids, mineral oils and similar dangers, DOBAR effectively increases your margin of safety.

These DOBAR advantages apply wherever you use insulation paper. Send for samples to test on your own applications.

7 DOBAR ADVANTAGES

1 High dielectric strength
2 . . . *especially* in high humidity
3 Low current leakage
4 Easy to work, especially in tight spots
5 High resistance to abrasion
6 Noncorrosive
7 Less space required for same insulation efficiency

DOBAR IMPROVES YOUR FACTOR OF SAFETY

DOBAR insulation is a permanent lamination of cellulose acetate film to standard insulation paper. Made by the makers of LEXEL insulation tape.

TRADE-MARK

DOBAR *Insulation*

A new name for an old product of THE DOBECKMUN COMPANY

Industrial Division . . . . Cleveland 1, Ohio

ARMY E NAVY

means that the internal inductance of the instrument is unimportant.

An input transformer supplies current to pass through the unknown impedance, via a 0.125-μf fixed capacitor C and an 8-ohm fixed resistor R. Capacitor C_1 and resistor R_1 balance the circuit with respect to ground. The drop across C is applied to a 400-$\mu\mu$f variable capacitor in series with one winding of a summation transformer, and the drop across R is applied to a second 400-$\mu\mu$f variable capacitor and another winding on the transformer. The resultant core flux is therefore a measure of the amplitude and phase of the current through C and R.

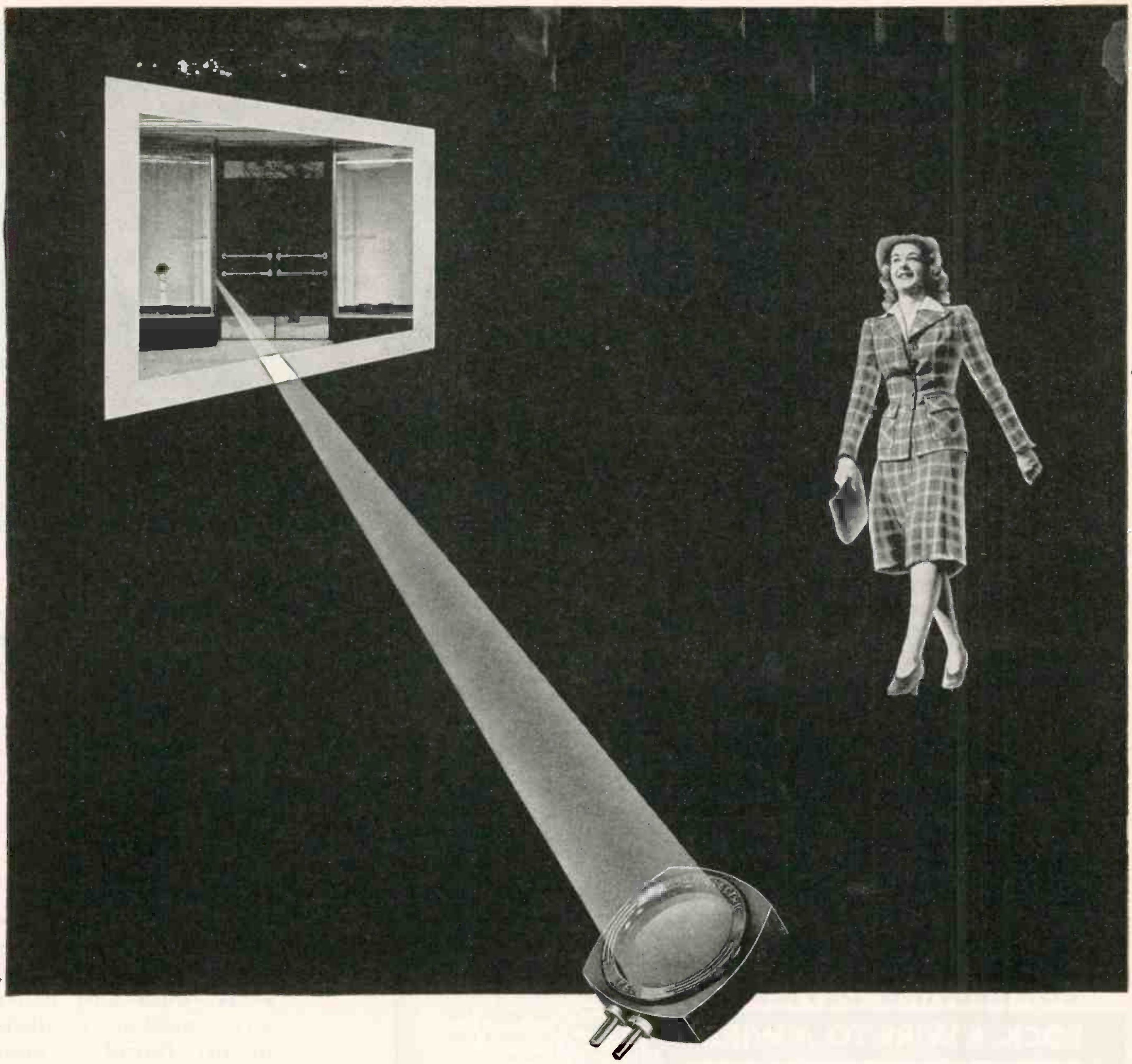
A third winding on the transformer takes the drop across the unknown impedance, via a fixed resistor Z, producing a current proportional to and in phase with the voltage across the unknown. When the two variable capacitors are adjusted so that the amplitude and phase of the currents in the transformer windings produce a flux, equal in amplitude and opposite in phase to the flux from the third winding, the resultant flux will be zero and a null balance will be obtained.

The values of the two variable capacitors and the resistance of Z

• • •

SOUND TRUCK

The psychological warfare branch of the British Army used this camouflaged truck to make announcements in German and Polish to the enemy. Hung in trees, the speakers called upon soldiers to surrender



How to beat a woman—TO A DOOR

One way to startle the lay public into awed pleasure is to show them a door opened by means of a photo*cell.*

The practical beauty of this stunt is that you can do it over and over again without failure, even where shattering vibrations exist as part of normal operating conditions. For the Luxtron* photo*cell* is really rugged.

Another advantage is that Luxtron photo*cells* convert light into electric energy for the direct operation of meters and meter relays without amplification. They are lightweight, too. They are a good way to beat competition to a customer.

If you have any control problem that has defied solution with a simple, durable piece of apparatus, perhaps Bradley can throw some light on it—and make that light do the work for you. Write for literature and samples.

*T. M. REG. U. S. PAT. OFF.

Another "Coprox" Rectifier

This center tap, full wave rectifier for high frequency current is one of a useful group of copper oxide rectifiers developed by Bradley. Illustrated "Coprox" bulletin mailed on request.

PHOTOCELLS—MASTERS OF LIGHT **BRADLEY** MASTER OF PHOTOCELLS

BRADLEY LABORATORIES, INC., 82 MEADOW STREET, NEW HAVEN 10, CONNECTICUT

COAT TURNTABLES and GRILLS

with

Cellusuede FLOCK

Here's the ideal material for coating phonograph turntables and grills! It protects records, eliminates slipping, and provides a rich, velvety finish at low cost. Cellusuede can be applied to almost any surface, easily and economically, by sifting or spraying. Both Rayon and Cotton Flock available for immediate shipment in a wide assortment of eye-catching colors. No rationing . . . no priorities . . . No delay.

Send for Booklet, Color Card, Samples and Prices

CP

Cellusuede Products, Inc.

ROCKFORD, ILLINOIS

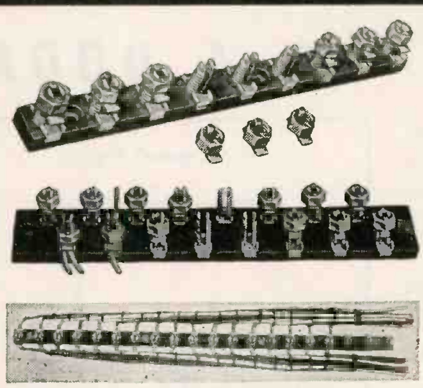
NEW!

The ULTIMATE in

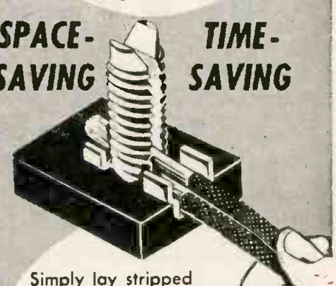
SOLDERLESS CONNECTING DEVICES

LOCK A WIRE TO A WIRE

When the Bee nut is screwed down all the way, its built-in clamp locks a wire to a wire. No danger of loose strands. Assures a vibration-proof, low resistance connection.



SPACE-SAVING **TIME-SAVING**



Simply lay stripped ends of two or more wires into slot. The Bee nut will clamp them together permanently or until you want them apart. No lugs, lock nuts or lock washers required. No soldering, crimping, pressing or insulating.

BEE TERMINAL BLOCKS

LOCK A WIRE TO A WIRE

Write for SAMPLES and data

L. S. BRACH MFG. CORP., Newark 4, New Jersey

Threading the way to progress

Screw Machine Products:

- Screw machine products have now entered the field of electronics in volume.
- Experienced Producers of screw machine products are essential to expedite efficient operation.

Your Source—
Waltham Screw Company because:

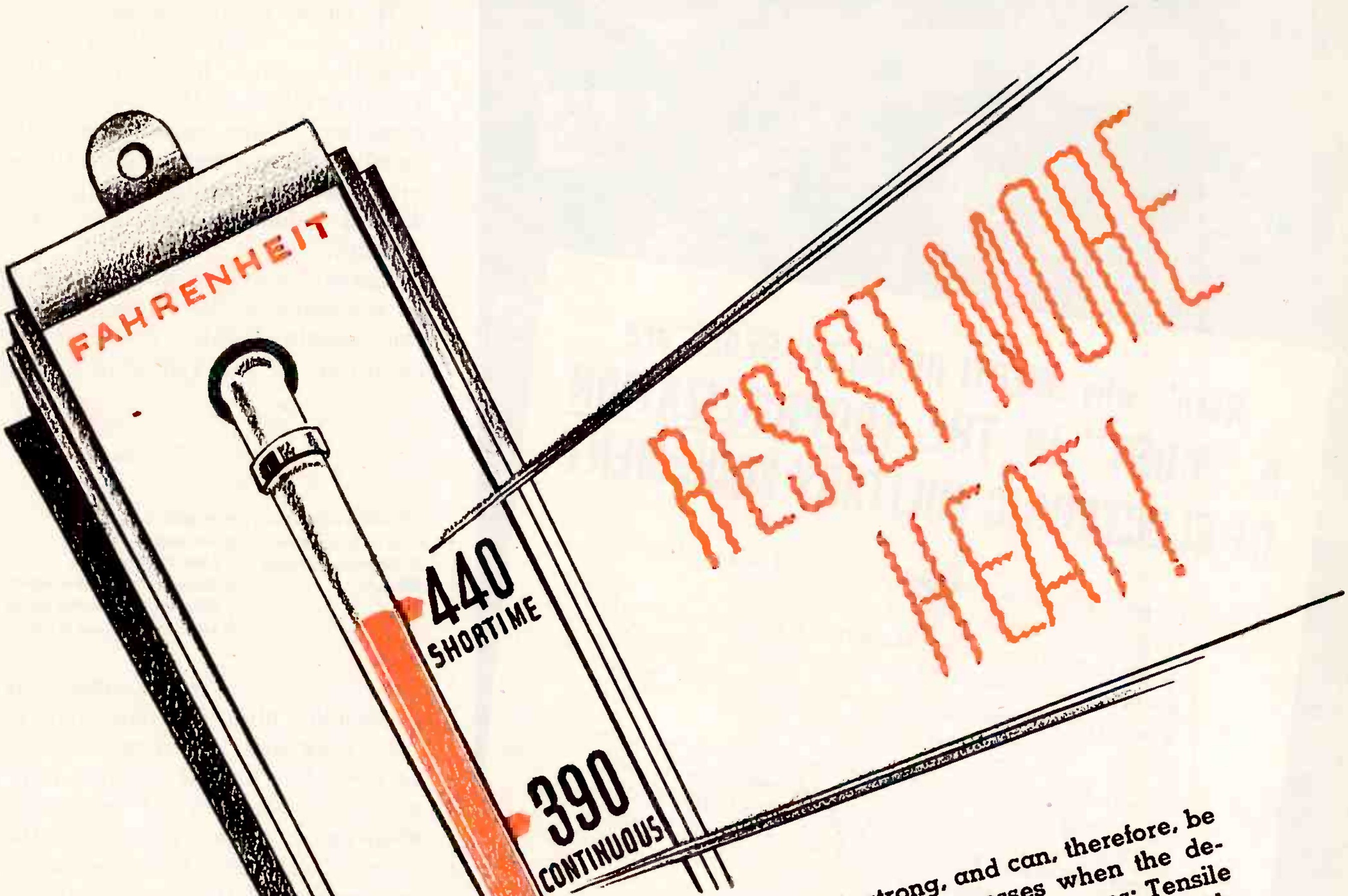
- Of sufficient equipment to produce in any quantity screws, tubes, shafts, inserts, nuts and other screw machine products in any thread to meet close tolerance requirements.
- Our experience gained in over half a century of development and production of screw machine products is now available to you in the electronics fields.

Send for our catalog and call upon our Engineering Staff for solutions to your problems in screw machine products.

WALTHAM SCREW COMPANY

75 Rumford Ave.
Waltham, Mass.

New Formica Grades



PROGRESS has recently provided new resins and new fibre bases that have greatly increased the heat resistance of insulating grades of Formica. They will take without injury about 25 percent higher temperatures.

An example of this improvement is FF-55, produced to conform to Navy Grade GMG made with a glass fibre base and melamine resins. It withstands 440 degrees Fahrenheit for a short period, and 390 degrees continuously.

In this same material Arc resistance reaches a new level — by ASTM test D495-42, it is rated at 185 seconds.

The material is strong, and can, therefore, be used to take structural stresses when the design makes that desirable. Test figures: Tensile strength 25,000 P.S.I.; Compressive strength (flatwise) 90,000 p.s.i.; Flexural Strength (flatwise) 30,000 p.s.i.; Modulus of Elasticity in bending 3,000,000 p.s.i.; Izod impact, 12 ft. lbs. per inch of notch.

This is a new combination of useful qualities, not previously available in one material. Unlike some materials which possess some of these characteristics, the material can be easily punched and machined. It is suitable for rapid fabrication by production methods.

THE FORMICA INSULATION COMPANY, 4661 SPRING GROVE AVENUE, CINTI. 32, O.

FORMICA

will be a measure of the reactance and resistance of the unknown impedance.

Capacitance Measurements

To measure capacitance, the resistor Z is replaced by a fixed capacitor, which interchanges the dial indications of the two variable capacitors. The one which indicated resistance then gives reciprocal capacitance and that which indicated inductance then reads resistance.

Range of the bridge is dependent on the value of the resistor Z (or the capacitor which replaces it), according to the following table:

Standard Z	Range of measurement
312.5 ohms resistance	0–10 ohms; 0–1 μh
3,125 ohms resistance	0–100 ohms; 0–10 μh
31,250 ohms resistance	0–1,000 ohms; 0–100 μh
320 $\mu\mu$f	0–10 ohms; 10,000 $\mu\mu$f to infinity
32 $\mu\mu$f	0–100 ohms; 1,000 $\mu\mu$f to infinity
3.2$\mu\mu$f	0–1,000 ohms; 100 $\mu\mu$f to infinity

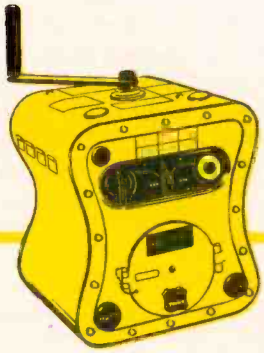
Accuracy of measurement is reasonably high for most laboratory work and the bridge is easy to use. For high-Q circuits, however, the accuracy of resistance measurement is not good, since the range of resistance measured is not independent of the range of inductance measured. This difficulty can be overcome.

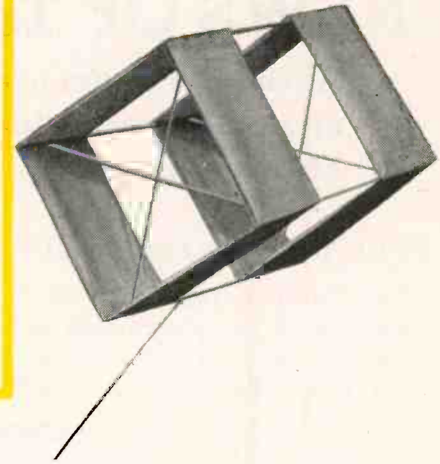
• • •

TESTING WIRE

The insulating value of the enamel coating on fine wire produced at the Dobbs Ferry plant of North American Phillips is checked on this instrument

THEIR FAVORITE BLONDE





THIS IS THE GIBSON GIRL* with her hourglass shape and a bright yellow dress . . . the magic emergency radio transmitter which automatically sends out S-O-S signals by merely turning the hand crank. ☆ Now carried on overwater flights by most military planes, Gibson Girls have snatched back to life many American, Canadian and British crews forced down at sea. ☆ The hand crank generates sufficient power to transmit signals over a 100,000 square mile area, and to light a brilliant signal light. Manual keying on radio transmission is available. The unit is equipped with parachute for release from a rescue plane or before a crash landing. ☆ More than 60,000 Gibson Girls have been produced by Pacific Division since they were developed by this company before Pearl Harbor. Such outstanding radio developments as this demonstrate Pacific Division's unique ability to successfully solve new radio problems. Our engineers—now specializing in VHF communications systems—are available to assist you with your radio problems.

*Trade Mark Reg. U.S. Pat. Off.

All rescued airmen become members of the most exclusive fraternity in the world—the Order of Gibson Girls. They receive this certificate and a gold lapel pin. If you have been rescued or know someone who has, write today to the Order of Gibson Girls, North Hollywood, California, for membership.

Pacific Division
Bendix Aviation Corporation
NORTH HOLLYWOOD 7, CALIF.

NEWS OF THE INDUSTRY

Alien patents; fm-television truce; therapeutic music; fluorescent fungicides; Washington and FCC news; business and personnel activities

FCC Releases Proposed Allocations Below 25,000 Kc

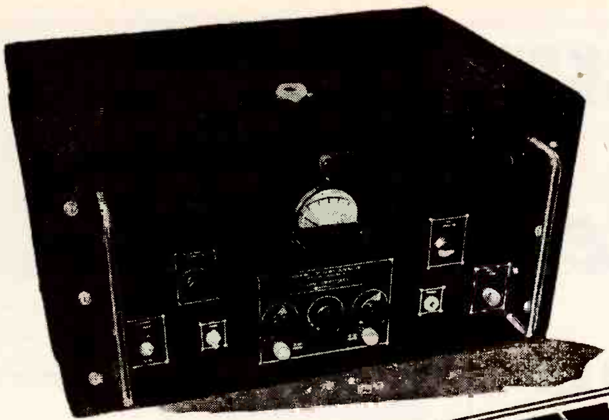
THE PROPOSED ALLOCATION of frequencies to non-government radio services operating in the portion of the radio spectrum below 25,000 kilocycles, as released May 21, is given in the table below. After all oral arguments have been heard, starting in June, the Commission will issue a final allocations report covering non-governmental radio services in this portion of the spectrum.

Highlights of the FCC proposals include addition of another radio channel to the lower end of the present standard broadcast band, at 540 kc; provision of 120 radio channels, some of which will be available to the United States, for direct international short-wave broadcasting; allocation of frequencies for use by radio amateurs and others during

PROPOSED FCC ALLOCATIONS BELOW 25,000 KILOCYCLES

Freq. in kc	United States Allocations	Proposed International Allocation
Up to –100	Fixed	Fixed
100–160	Coastal, marine relay, ship, mobile press, fixed Alaskan	(a) Fixed (b) Maritime mobile
160–200	Fixed (1)	Fixed (1)
200–280	Air navigation aids	Air navigation aids
280–320	Maritime beacons	Maritime beacons
320–415	Air navigation aids	Air navigation aids
415–490	Coastal, marine relay, ship	Maritime mobile (telegraphy)
490–510	Mobile (distress & calling freq. 500 kc)	Mobile (distress & calling freq. 500 kc)
510–535	Mobile (telegraphy) (2)	Mobile (telegraphy) (2)
535–1605	Broadcasting (non-gov.) (3)	Broadcasting (3)
1605–1800	Police, aviation, relay broadcast, special, Alaskan, disaster communication including amateur disaster networks	Fixed, mobile
1800–2000	Navigation aids	Navigation aids
2000–2050	Government (4)	Fixed, mobile (4)
2050–2065	Ship telegraph	Maritime mobile
2065–2075	Mobile (distress and calling freq. 2070 kc) (5)	Mobile (distress & calling freq. 2070 kc) (5)
2075–2100	Ship telegraph	Maritime mobile
2100–2250	Ship telephone, relay broadcast	Mobile
2250–2300	Police point-to-point, ship telephone, aviation, special, relay broadcast	Fixed, mobile
2300–2350	Coastal telegraph, marine relay	Maritime mobile
2350–2495	Police, ship telephone, Alaskan	Fixed, mobile
2495–2505	Government	Standard freq. broadcast on 2500 kc
2505–2700	Coastal harbor telephone, Alaskan	Mobile
2700–2850	Fixed, maritime mobile telephone, police point-to-point, special emergency, relay broadcast, Alaskan	Fixed, mobile
2850–3125	Aeronautical mobile (6)	Aeronautical mobile (6)
3125–3200	Aeronautical fixed (7)	Aeronautical fixed (7)
3200–3330	Government (8)	Aeronautical mobile (8)
3330–3450	Forestry (9)	Mobile, except maritime and aeronautical (9)
3450–3500	Government	Fixed, and mobile except maritime
3500–4000	Amateur	Amateur
4000–4100	Fixed, except aeronautical fixed	Fixed, except aeronautical fixed
4100–4135	Coastal, marine relay, ship	Maritime mobile
4135–4145	Mobile (distress and calling freq. 4140 kc) (5)	Mobile (distress and calling freq. 4140 kc) (5)
4145–4500	Coastal, marine relay, ship, mobile press	Maritime mobile
4500–4890	Fixed, aero. fixed, coastal telephone, Alaskan	Fixed, mobile except aero. (10)
4890–4990	Government (8)	Aeronautical mobile (8)
4990–5010	Government	Std. freq. broadcast on 5000 kc
5010–5300	Fixed, aero. fixed	Fixed
5300–5500	Fixed, aero. fixed, Alaskan	(a) Fixed, and mobile except aero. & maritime
5500–5800	Aeronautical mobile (6)	Aeronautical mobile (6)
5800–6000	Fixed, aero. fixed	Fixed
6000–6200	International broadcast	International broadcast
6200–6300	Coastal, marine relay, ship	Maritime mobile
6300–6450	Fixed, aero. fixed	Fixed
6450–6600	Aeronautical mobile (6)	Aeronautical mobile (6)
6600–6900	Fixed, aero. fixed	Fixed
6900–7000	Government (8)	Aeronautical mobile (8)
7000–7300	Amateur	Amateur
7300–8200	Fixed, aero. fixed, Alaskan	Fixed
8200–8275	Coastal, marine relay, ship	Maritime mobile
8275–8285	Mobile (distress and calling freq. 8280 kc) (5)	Mobile (distress and calling freq. 8280 kc) (5)
8285–8700	Coastal, marine relay, ship, mobile press	Maritime mobile
8700–8900	Aeronautical mobile (6)	Aeronautical mobile (6)
8900–9000	Fixed, aero. fixed, coastal telephone	Fixed, maritime mobile (10
9000–9500	Fixed, aero. fixed	Fixed
9500–9700	International broadcast	International broadcast
9700–9990	Fixed, aero. fixed	Fixed
9990–10010	Government	Standard freq. broadcast on 10000 kc
10010–10200	Government (8)	Aeronautical mobile (8)
10200–11300	Fixed, aero. fixed	Fixed
11300–11500	Aeronautical mobile (6)	Aeronautical mobile (6)
11500–11700	Fixed, aero. fixed	Fixed
11700–11900	International broadcast	International broadcast
11900–12300	Fixed, aero. fixed	Fixed
12300–12415	Coastal, marine relay, ship	Maritime mobile
12415–12425	Mobile 12420 kc (5)	Mobile (calling freq. 12420 kc)
12425–12950	Coastal, marine relay, ship, mobile press	Maritime mobile
12950–13050	Government (8)	Aero. mobile (8)
13050–13250	Fixed, aero. fixed	Fixed
13250–13350	Fixed, aero. fixed, coastal telephone	Fixed, maritime mobile (10)
13350–14000	Fixed, aero. fixed (11)	Fixed (11)
14000–14400	Amateur	Amateur
14400–14985	Fixed, aero. fixed	Fixed
14985–15015	Government	Standard freq. broadcast on 15000 kc
15015–15100	Government (8)	Aero. mobile (8)
15100–15300	International broadcast	International broadcast
15300–16400	Fixed, aero. fixed	Fixed
16400–16555	Coastal, marine relay, ship, mobile press, aeronautical	Mobile
16555–16565	Mobile (calling freq. 16560) (12)	Mobile (calling freq. 16560 kc) (12)
16565–17100	Coastal, marine relay, ship, mobile press, aero.	Mobile
17100–17600	Fixed, aero. fixed	Fixed
17600–17700	Fixed, aero. fixed, coastal telephone	Fixed, maritime mobile (10)
17700–17900	International broadcast	International broadcast
17900–19985	Fixed, aero. fixed	Fixed
19985–20015	Government	Standard freq. broadcast on 20000 kc
20015–20500	Fixed, aero. fixed	Fixed
20500–21000	Fixed, aero fixed, coastal, marine relay, ship, mobile press, aeronautical	Fixed, mobile
21000–21500	Amateur	Amateur
21500–21700	International broadcast	International broadcast
21700–24985	Fixed, aero. fixed	Fixed
24985–25015	Government	Standard freq. broadcast on 25000 kc

(1) Aero. fixed shall have priority in the polar regions.
(2) Not open to public correspondence in the American region.
(3) Lowest and highest assignable frequencies are 540 and 1600 kc.
(4) 500 watts peak power limit for both fixed and mobile.
(5) Calling limited to telegraphy.
(6) Frequencies within these bands are reserved primarily for long-distance overseas air routes and only where the use of frequencies above 30 Mc is impracticable.
(7) Frequencies within this band are reserved for fixed circuits associated primarily with long-distance overseas air routes where other facilities are not available or are impracticable.
(8) Not available to civil aviation.
(9) Power limited to 200 watts peak.
(10) Maritime mobile limited to coastal telephone stations.
(11) 13660 kc is for industrial, scientific and medical. All emissions must be kept within the band 13652.5 to 13667.5 kc.
(12) Limited to telegraphy.



UHF HARMONIC FREQUENCY GENERATOR

PROVIDES output voltages which are multiples of 10 or 40 megacycles with CRYSTAL-CONTROLLED accuracy.

RECOMMENDED FOR: the calibration of receivers, wavemeters, or using internal beat detector for calibration of oscillators and signal generators.

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RADIO ENGINEERS AND MANUFACTURERS

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This letter is your invitation to consult with us on your present or reconversion problems in the UHF field.

Your immediate plans may consist simply of ideas on which you require technical advice - or you may need help in re-design or ways and means to lower production costs.

Regardless of your particular requirements, our specialized knowledge of UHF, plus a plant especially equipped for UHF production, should be invaluable in accomplishing your objective quickly, accurately and economically.

There is no cost or obligation involved in talking it over. Your inquiries will have our prompt and careful attention.

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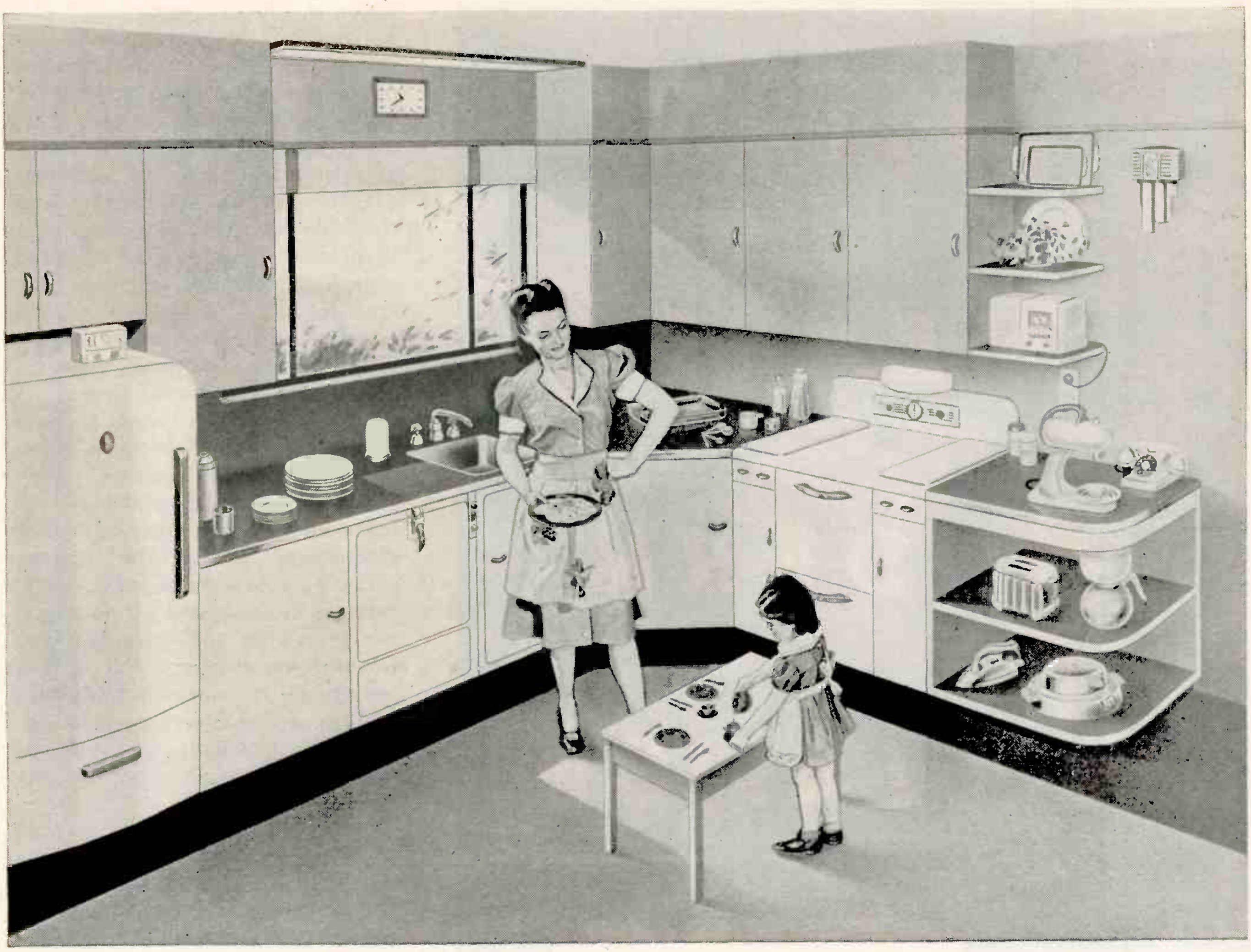
UHF PRECISION FREQUENCY METER

Completely portable Accuracy 0.1%
Battery or AC-Operated

Models available from 100 to 1500 megacycles with 2 to 1 frequency coverage on each model. Available only on high priority.



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● From the floor to the ceiling, your next kitchen truly will represent the modern age of plastics.

There'll be Plaskon Molded Color carrying a range of gay tones throughout the room. Plastic handles, knobs, closures, housings, tableware, electrical equipment and parts, lighting reflectors, telephones—even garment buttons and shoe ornaments—will be of sparkling molded Plaskon. Service requirements of durability, non-conductivity, sanitation and ease of cleaning are adequately filled by Plaskon in these applications.

The kitchen will be lined with handsome, low-cost, prefabricated cabinets of plywood, made with Plaskon Resin Glue. Washable resin-treated paper finishes of attractive colors, and almost impossible to mar or scar, will be bonded to the exterior surfaces with this powerful glue. In any application it is permanent and highly waterproof; unaffected by heat, cold, bacteria or fungi; and its tenacious grip cannot be weakened or broken.

Tough linoleum, treated with Plaskon Coating Resin, will provide a colorful, durable covering for floors, cabinet and shelf tops, and splash surfaces. Special Plaskon resins will assure finishes to meet particular needs for many kitchen surfaces; and will be used for the development of other new utility applications in the kitchen and throughout the house.

The plastics kitchen of tomorrow, with its widespread use of Plaskon materials, is but one indication of the versatility of these modern products of industrial research. Plaskon resins offer you exceptional manufacturing and sales advantages in product development. Our experienced field men will gladly help develop your plans.

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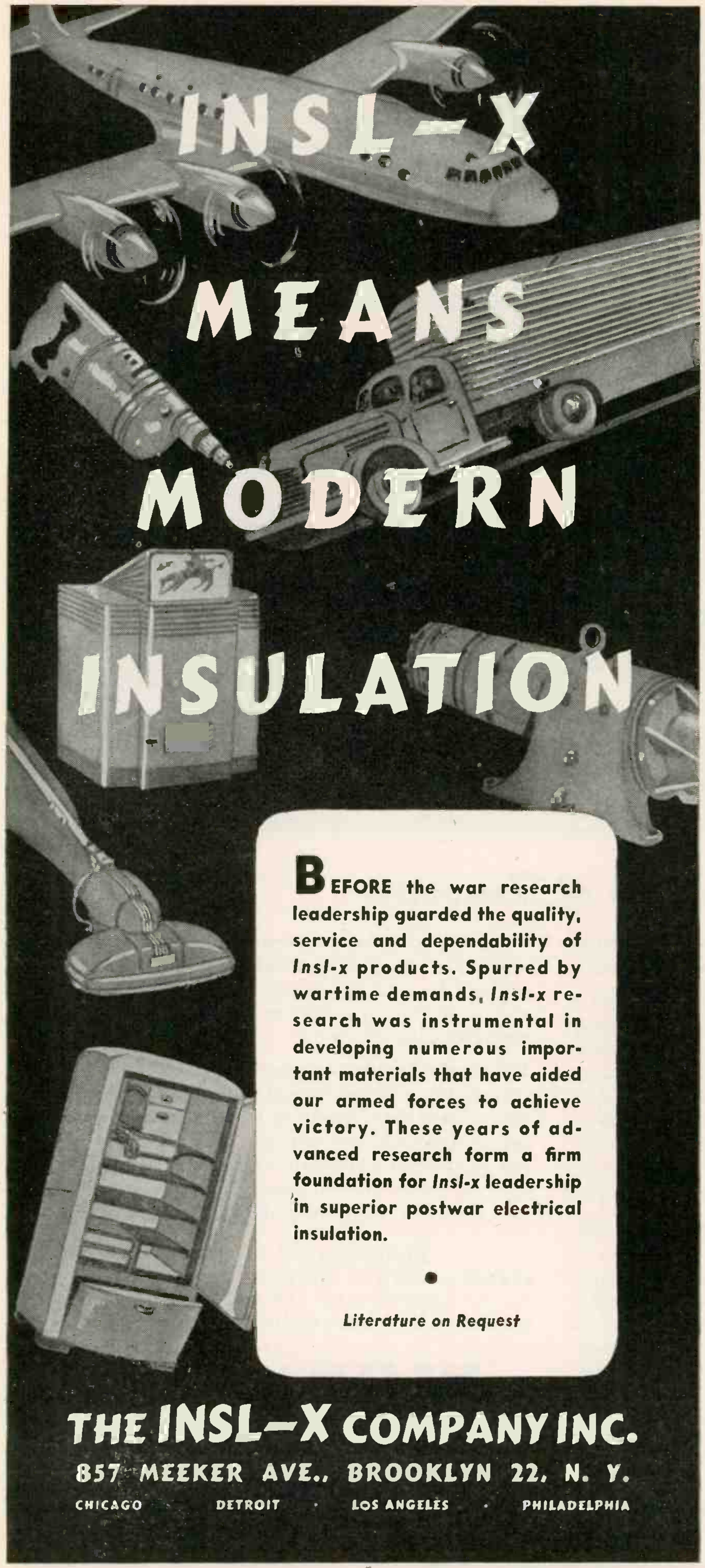
★ ★ MATERIALS ★ ★



times of disaster, such as floods, earthquakes, hurricanes, etc.; increased emphasis on the requirements of aviation radio communications, including navigational aids, after the war; and establishment of a greater number of SOS frequencies for use by aircraft and small surface craft in distress and to provide more reliable coverage over long distances on radio distress calls.

As the commission points out, the radio spectrum below 25,000 kilocycles is so overcrowded that it has been impossible to meet the requirements of all radio services operating in these ranges. However, the FCC has attempted to make an equitable distribution of frequencies among the various services. Wherever possible, radio services are expected to move into the very high and ultrahigh portions of the spectrum and to take advantage of improved equipment and transmission techniques to enable them to make the most efficient use of the spectrum space available to them.

No decision has yet been made as to the number of new stations the new 540-kc broadcast band channel will accommodate or as to whether the channel will be used by local, regional or clear-channel broadcast stations. It is believed that possible interference with auto alarms on the 500-kc distress frequency can be solved by assigning 540 kc for use at appropriate geographical locations and by limiting the intensity of the signals in coastal areas. (There are now 928 standard stations broadcasting and 23 others under construction. The FCC has in its pending files approximately 180 applications to build new standard stations when manpower and materials again become available for civilian radio construction.) About 54 percent of the present receiving sets will be able to receive programs from stations operating on the 540-kc frequency. However, the channel including 540 kc is now used by the government and it is not known how soon it can be made available to broadcasters.

Six bands of frequencies, involving a total of 120 channels below 25,000 kc, are set aside for direct international broadcasting on a worldwide basis.

The bands 3500 to 4000, 7000 to

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7300, and 14,000 to 14,400 kc are being retained for amateur use. The 300-kc wide band between 1750 and 2050 kc is being deleted. In lieu thereof, the Commission is making provision for amateurs to operate a disaster communications network in the band 1605 to 1800 kc. The exact width of this frequency band and its location within the range 1605 to 1800 kc is undetermined at this time. In addition, the Commission proposes to assign a 500-kc wide band between 21,000 and 21,500 kc to the amateurs.

Six channels are included for use by the National Bureau of Standards to provide a highly accurate standard for the measurement of frequencies, and for the transmission of time signals, to be used by scientists, observatories and radio station operators throughout the world to calibrate their equipment.

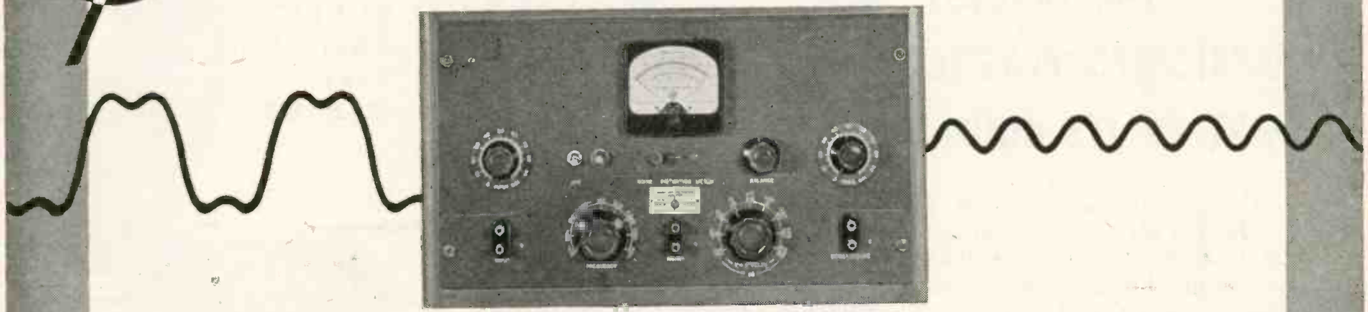
The Commission is not making specific proposals regarding channel widths for stations in the fixed public services at this time. However, in view of the urgent requirement for conservation of frequencies, the Commission will expect licensees to avail themselves of the latest technical improvements looking toward early realization of the use of 2.5 kc, or less, per telegraph communication channel and not more than 5 kc per telephone or facsimile channel. This objective is believed to be reasonable since it is expected that, of necessity, use of such technical improvements will be adopted generally on a worldwide basis.

Total Number of Channels

A comparison between the total number of channels requested, the total currently assigned and the total proposed, cannot be made since (1) no decision has been made as to channel widths; (2) the number of channels to be used by aeronautical and government fixed services cannot be determined at this time; (3) the assignments at the time of the hearing included shared frequencies which are regularly assigned to other services such as coastal harbor and coastal telephone; and (4) the channel requirements of other nations throughout the world are not known.

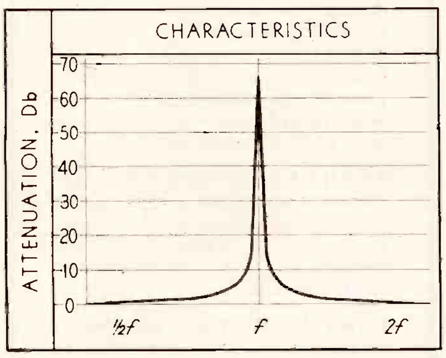
For the fixed public services, the Commission is of the opinion that

LABORATORY INSTRUMENTS FOR SPEED AND ACCURACY



This instrument separates harmonics from a desired frequency

By eliminating the fundamental frequency, this instrument permits accurate measurement of noise, distortion and the harmonics of the wave. At balance its fundamental circuit has almost infinite attenuation at a single frequency and other frequencies are passed with little or no attenuation.



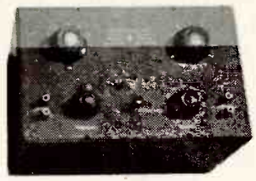
As shown in the chart: the attenuation at the 2nd harmonic (2F) would be in the order of 1/2 db while at the resonant frequency it would be infinite—from 60 to 70 db in practical circuits making it possible to measure distortions as low as 0.1%.

The *-hp-* Model 325B Noise and Distortion Analyzer is really a combination of three separate elements: a frequency elimination circuit, a stabilized 20 db amplifier and a vacuum tube voltmeter, any one of which may be used individually. The amplifier employs inverse feedback and is very stable . . . accuracy is independent of line voltage and tube characteristics. Because the input is to the grid of the amplifier and is equivalent to 200,000 ohms, it will not load down the circuit being measured. The sensitivity of the vacuum tube voltmeter in combination with the amplifier is such that hum may be measured directly and voltage measured as low as .0005.

The *-hp-* Model 325B covers the audio frequency spectrum, supplying frequencies of 30 cps, 50 cps, 100 cps, 400 cps, 1000 cps, 5000 cps, 7500 cps, 10,000 cps and 15,000 cps within ± 5%. These frequencies cover FCC recommendations for checking FM as well as AM broadcast. The meter scale is calibrated in volts and in dbs.

The *-hp-* Model 325B in combination with *-hp-* 200 series Audio Oscillators provides equipment to make most laboratory AF measurements including distortion, power, gain and frequency response. Write for complete information now.

OTHER -hp- INSTRUMENTS



Distortion Analyzer

The Model 320A consists of two fundamental elimination circuits, 400 cps and 5000 cps, together with a calibrated attenuator reading in decibels.

Distortion Analyzer

The Model 320B consists of six fundamental elimination circuits, 50, 100, 400, 1000, 5000 and 7500 cps, together with a calibrated attenuator reading in decibels.

Harmonic Wave Analyzer

The Model 300A consists of a highly selective amplifier which measures the individual components of a complex wave.

Attenuator and Voltage Divider

The Model 350A is a bridged-T attenuator consisting of one 100 db attenuator with 10 db steps and a 10 db attenuator having 1 db steps.

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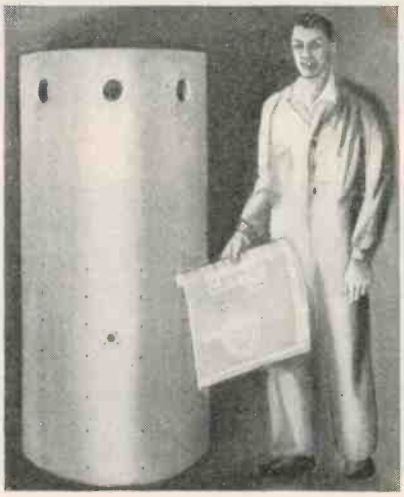

This coil form is one of a production lot fabricated in our shop; drilled with more than one hundred holes, all close tolerance as to size and location.

Of importance to you is our ability to furnish prompt delivery. If you are faced with a tough fabrication problem, or the necessity of fast service, a consultation with one of our organization may help you to meet your own delivery dates.

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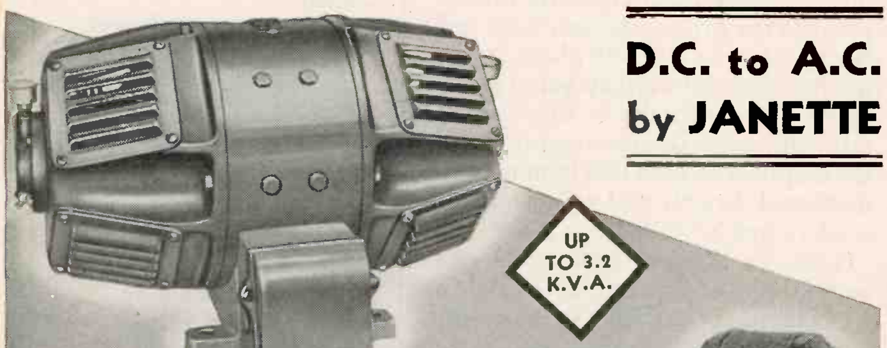
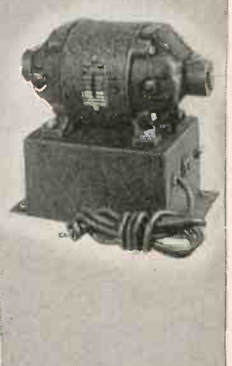


UP TO 3.2 K.V.A.

D.C. TO A.C. CONVERTERS



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For nearly a quarter of a century Janette converters have given dependable service under varied climatic conditions in all parts of the world.

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Janette

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FOR CLEANING SMALL PARTS

IMPROVES EFFICIENCY. Parts to be cleaned are placed on the perforated-metal dasher, which is then depressed so cleaning liquid filters through and covers parts. Dasher is spring-mounted and returns above liquid level when released. Parts drain on dasher and can be placed on open cover to dry. Cover when open forms a horizontal tray with handle as support.

REDUCES EVAPORATION. Through minimum exposure and agitation of cleaning fluid, evaporation from open can is reduced to a minimum. When cover is closed, can is vapor-tight.

LOWERS FIRE HAZARD. Double perforated-metal dasher is an effective fire baffle. Ignition of vapor above dasher is prevented from reaching liquid in can. Fire burns out harmlessly or can be snuffed out quickly by closing cover.

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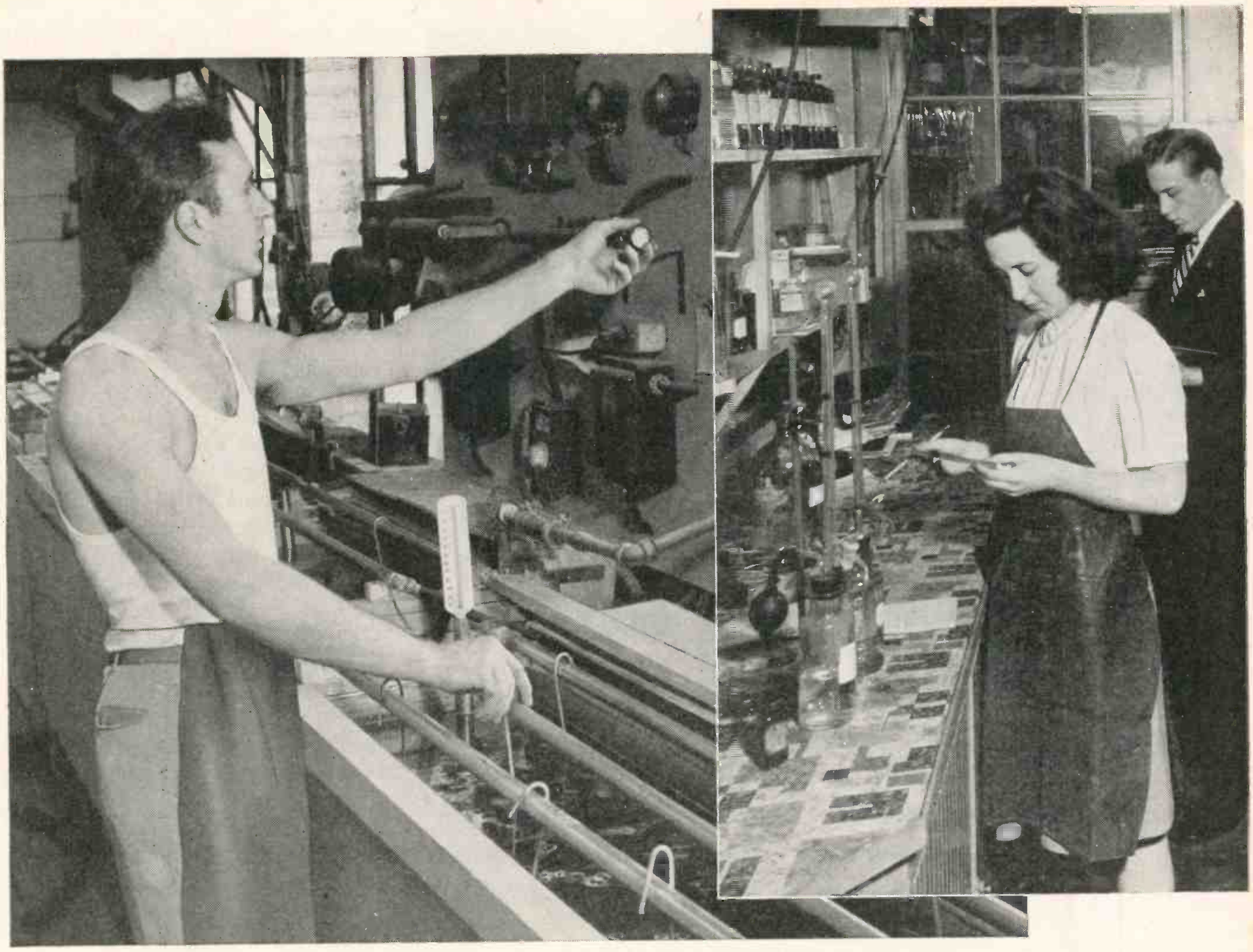

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only through a properly organized system of assigning frequencies, by geographical zones throughout the world, will it be possible to accommodate the post-war requirements of all nations. Under such a zoning plan, a given frequency may be employed in as many as three or more different locations in the world during a period of 24 hours. Such a plan will have the practical effect of increasing the number of channels available to each nation, a consideration of the highest importance when it is realized that many countries will use radio transmission in a post-war era to a far greater extent than they have in the past. The Commission will exert every effort to make such an organized system of assigning frequencies possible.

The provision of shipboard radio direction-finding facilities and a comprehensive maritime beacon system has largely obviated the necessity for shore-based direction finders and has resulted in a decline in their use. For these reasons, it is not proposed to continue the allocation of 375 kc for shore-based radio direction-finding systems.

It is proposed, in view of the improvements in ship station receiver selectivity and transmitter frequency stability, to reduce the guard bands for the 500-kc international distress and calling frequency from 15 to 10 kilocycles.

It is proposed to designate the frequencies 2070, 4140, and 8280 kilocycles as additional international distress and calling frequencies (telegraphy) to facilitate communication between stations engaging in air-sea rescue operations.

Aeronautical Outlook

The requests of civil aviation for radio-frequency bands below 25 megacycles can not be granted in full without seriously affecting the minimum requirements of other services. It is evident that means must be found by which the spectrum space requested can be reduced. This may be accomplished in only one way, namely, by obtaining the most efficient use of the spectrum available to that service. This may be accomplished in several ways: (1) Employ the narrowest band of emission that will satisfactorily transmit the desired intelligence most economically from

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So, if you're specifying molded plastics or small motors, we'd like to work with you. Definite commitments must wait until the end of our military work is in sight, but a start now may help you get to the markets quicker with your postwar products. It will be appreciated if you will address the specific division . . . *molded plastics* or *small motors*.

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THE New Drake No. 75AP is designed for 110 volt circuits. However, the Resistor we can supply readily adapts it for use with 220 volt circuits if desired. This sturdy, rigid, Jewel Light Assembly never needs replacement. Every detail of construction is designed for long, dependable service under the most severe conditions. This is an underwriter's approved unit, for use with Mazda S6, 110 volt, 6 watt, candelabra, screw base lamp. We can ship the 75AP complete, with lamp installed, if so specified. The lamps are easily removed with our S6 Lamp Remover—a real convenience when large numbers of these units must be serviced. You can depend upon DRAKE for any type of standard or custom built unit required. Do you have our catalog handy?

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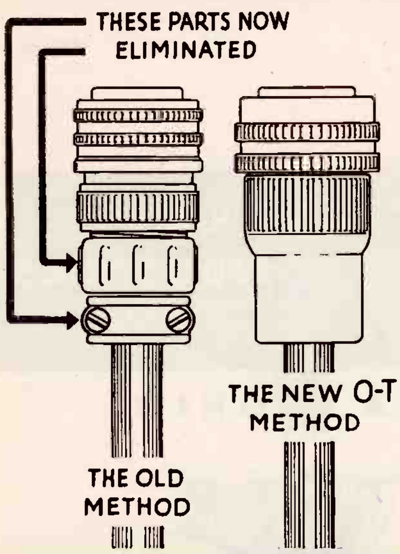

Assembly time and number of parts cut to a minimum by new simple compression type.

- ★ Waterproofs the assembly without extra parts.
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the standpoint of spectrum utilization; (2) Restrict air-ground-air communications and inter-aircraft communications to those pertaining exclusively to the necessities of air navigation and to emergencies involving the safety of life and property; (3) Restrict operating power to the minimum required for satisfactory communications in order to permit duplication of frequencies with a minimum geographical separation; (4) Consolidate all international radio communication facilities under one operating agency; (5) Assign frequencies on an area basis instead of a route basis; (6) Employ the very high frequency spectrum for all communication with aircraft flying over land, and restrict frequencies below 25 megacycles to communication with aircraft flying international overseas routes only; (7) Employ radio only where other satisfactory means of communication cannot be utilized.

Bands for aids to air navigation are being assigned for government use substantially in compliance with the request of the RTPB. The one slight change made is that where RTPB requested 200 to 285 kilocycles, the allocation is 200 to 280 kilocycles. In addition, the band 1800-2000 kilocycles is proposed for navigation aids although not requested by RTPB.

Alien Patents

PATENTS FORMERLY owned by aliens and seized by the United States government for uses that will benefit the nation in general and assist in the war effort in particular are vested in and on file at the Office of the Alien Property Custodian.

Enemy patents not already exclusively licensed to American interests prior to vesting are available to United States citizens under non-exclusive, royalty-free licensing for the remaining life of the patent. Patents from nationals of enemy-occupied countries are similarly available, but carry a reasonable royalty payable to the Custodian. If there is a return of patents to former owners in enemy occupied countries, the licenses will continue valid at the same royalty, unless a former owner is dissatisfied with the rate. In this case the right is reserved for him to negotiate with

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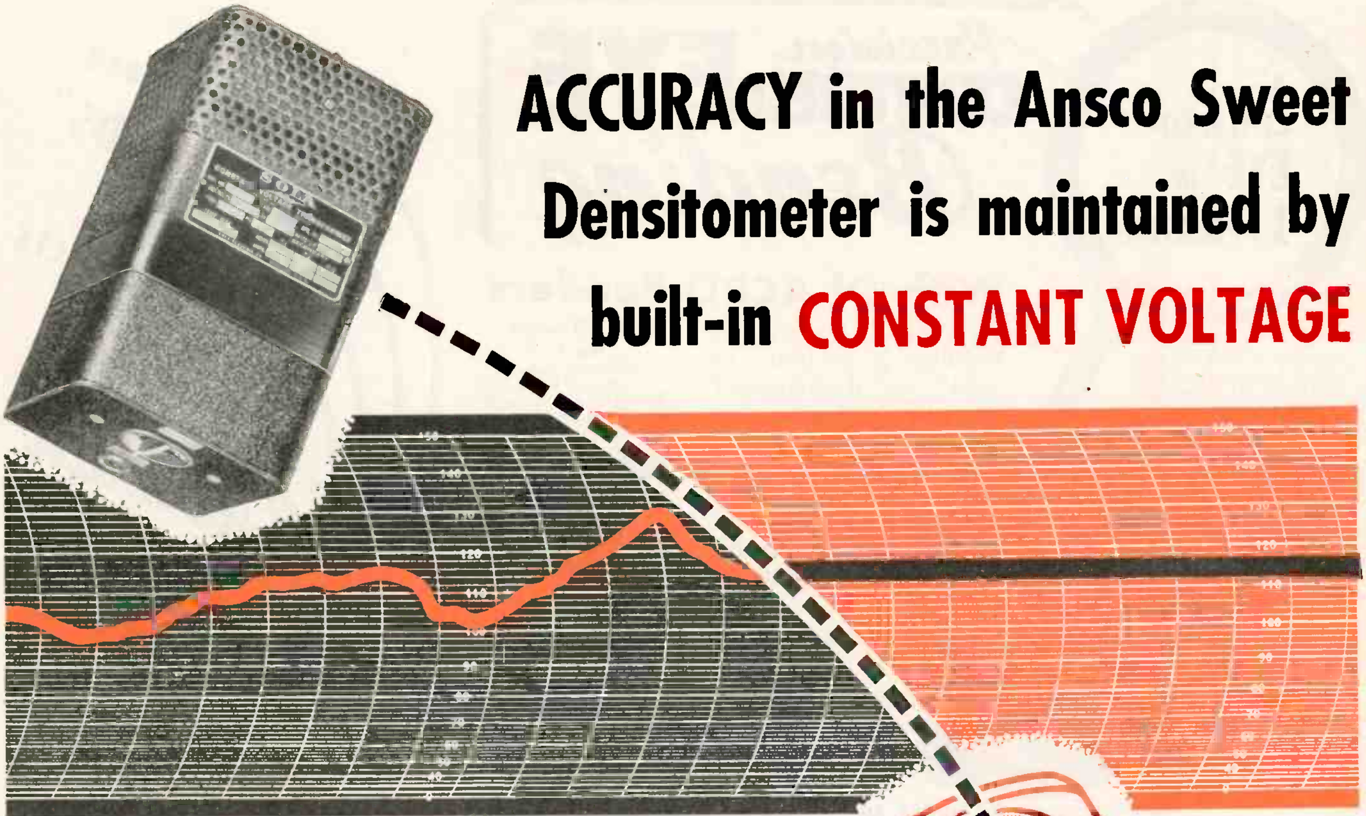

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VOLTAGE VARIATIONS AS GREAT AS ±15% ARE INSTANTLY CORRECTED TO WITHIN ±1% OF THE DENSITOMETER'S PRECISE VOLTAGE REQUIREMENT

The designers of the Ansco Sweet Densitometer realized that the carefully controlled voltage of their laboratory would never be consistently available to their instruments in the field. Yet the operating voltage must be maintained within an allowable tolerance of ±1% of rated requirements if instant and accurate answers were to be obtained in the study of the sensitometric problems for which it was designed.

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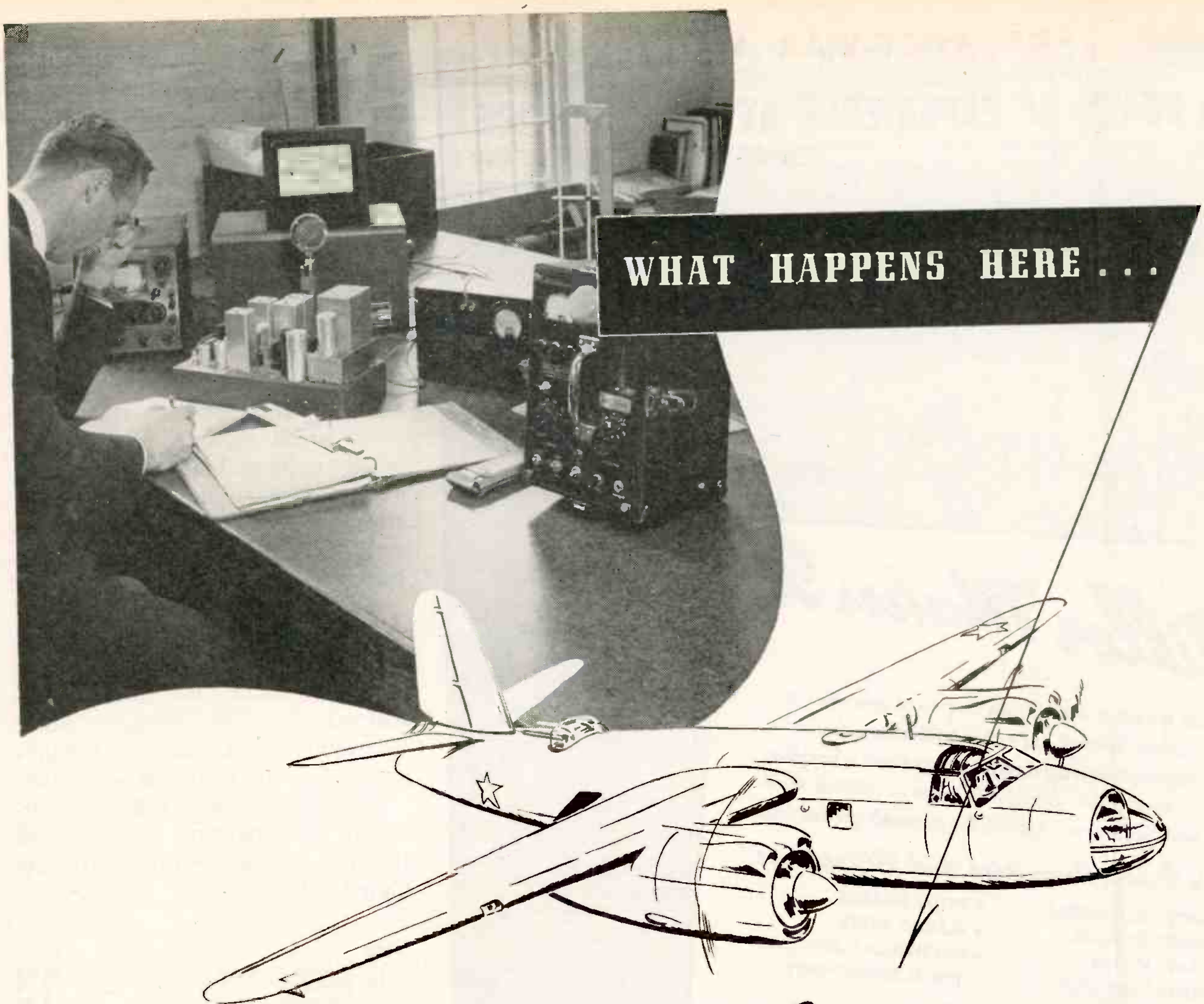

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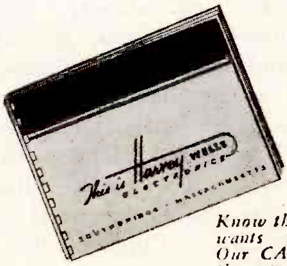

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Licenses on approximately 9,000 patents, including duplicates, have been issued by the Office of Alien Property Custodian to nearly 700 individuals and companies.

Indexes and Abstracts

An index to the abstracts of mechanical and electrical vested patents, which lists the classes into which patents have been divided, describes tersely the content of each class. Patent abstracts from the electrical and mechanical classes have been prepared in usual patent office style. The complete set, covering some 37,000 patents in four volumes, is obtainable for $25. (Abstracts of about 8,000 purely chemical patents are in a separate set of 33 volumes at $25.) Complete classes are also available separately.

Classes most likely to be of interest to ELECTRONICS readers with the class number and price are tabulated below.

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13	Electric Furnaces	$0.10
18	Plastics	0.10
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136	Batteries	0.10
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178	Telegraphy	0.50
179	Telephony	0.50
201	Resistances and Rheostats	0.10
204	Chemistry, Electrical and Wave Energy	0.10
219	Electric Heating	0.25
250	Radiant Energy	1.00
274	Sound Recording and Reproducing	0.10

Class 178 also includes television patents. Class 250 will be of greatest interest to users of vacuum tubes, which subject comprises a great portion of this class.

Reference Libraries

Copies of vested patents and pending applications, classified catalogues, abstracts, special sublists and other cross reference material are available for inspection by the public without charge from 9 AM to 5 PM Monday through Saturday. The APC libraries supplying this service are at: Washington, D.C.; Chicago, Ill.; New York, N. Y.; Boston, Mass.; Portland, Ore.

In addition, public libraries in the following cities have copies of vested patents: Los Angeles, Calif.; Chicago, Ill.; Boston, Mass.;

Gentlemen, we are ready to talk

SPEAKERS

And we are ready to *make* them, too. Not today, of course—we've still got a war job to fiinish. After that we are prepared to break into volume production on those Speakers we have been telling you about for months.

How will they measure up? Well, back of these Speakers are nearly a quarter century of specialized engineering and mass production experience in practically all types of radio components—all to one high standard. So, set manufacturers who are hopefully and logically looking to this line of Speakers for tone superiority and the best in modern design will find their expectations fully realized.

As a matter of fact, we are now ready to discuss orders—big orders—to submit samples on request.

GENERAL ELECTRONIC APPARATUS CORPORATION

A SUBSIDIARY OF THE

GENERAL INSTRUMENT CORPORATION •

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Designers, Detailers, Tracers and Engineers

We Offer
A Permanent Position
A Future with a promise of unlimited possibilities

We have no conversion problem!
There will be no lay offs or set back when the war ends

We are one of the largest manufacturers of a wide variety of communication and electronic equipment in the world, fully prepared and ready to go ahead with a very ambitious, expansion program as quickly as we are permitted. There will be unlimited possibilities for creative, ambitious men to advance to key positions both in research development and production field. At present, we are producing vital equipment for our fighting forces.

Good Starting Salaries—Exceptionally fine working conditions

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The Mfg. unit of the International Tel. & Tel. Corp.
591 Broad St., Newark, N. J.
W M C Rules Observed

"Drop-test" proves

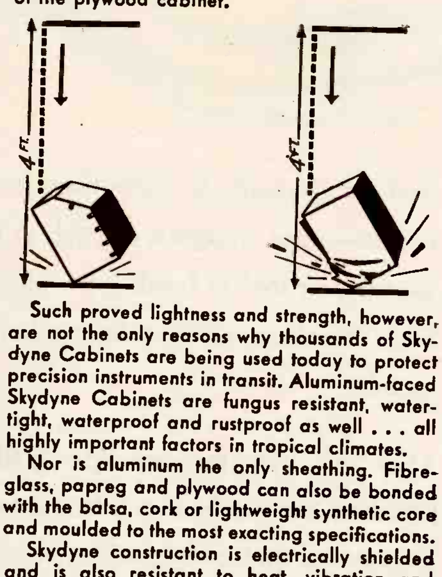
Skydyne CABINETS TWICE AS STRONG FOR HALF THE WEIGHT

From a 48-inch level—the height of the average truck—two chests containing 75 pounds of deadweight were dropped to a concrete floor.

One chest was of fabricated plywood; the other, a Skydyne Cabinet of aluminum-balsa-aluminum "sandwich construction."

Each was dropped, fully loaded, four times . . first on one corner and then another.

At the end of the experiment, the plywood case was smashed. In marked contrast, the Skydyne Cabinet came through intact. The weight of the Skydyne Cabinet itself was only half that of the plywood cabinet.



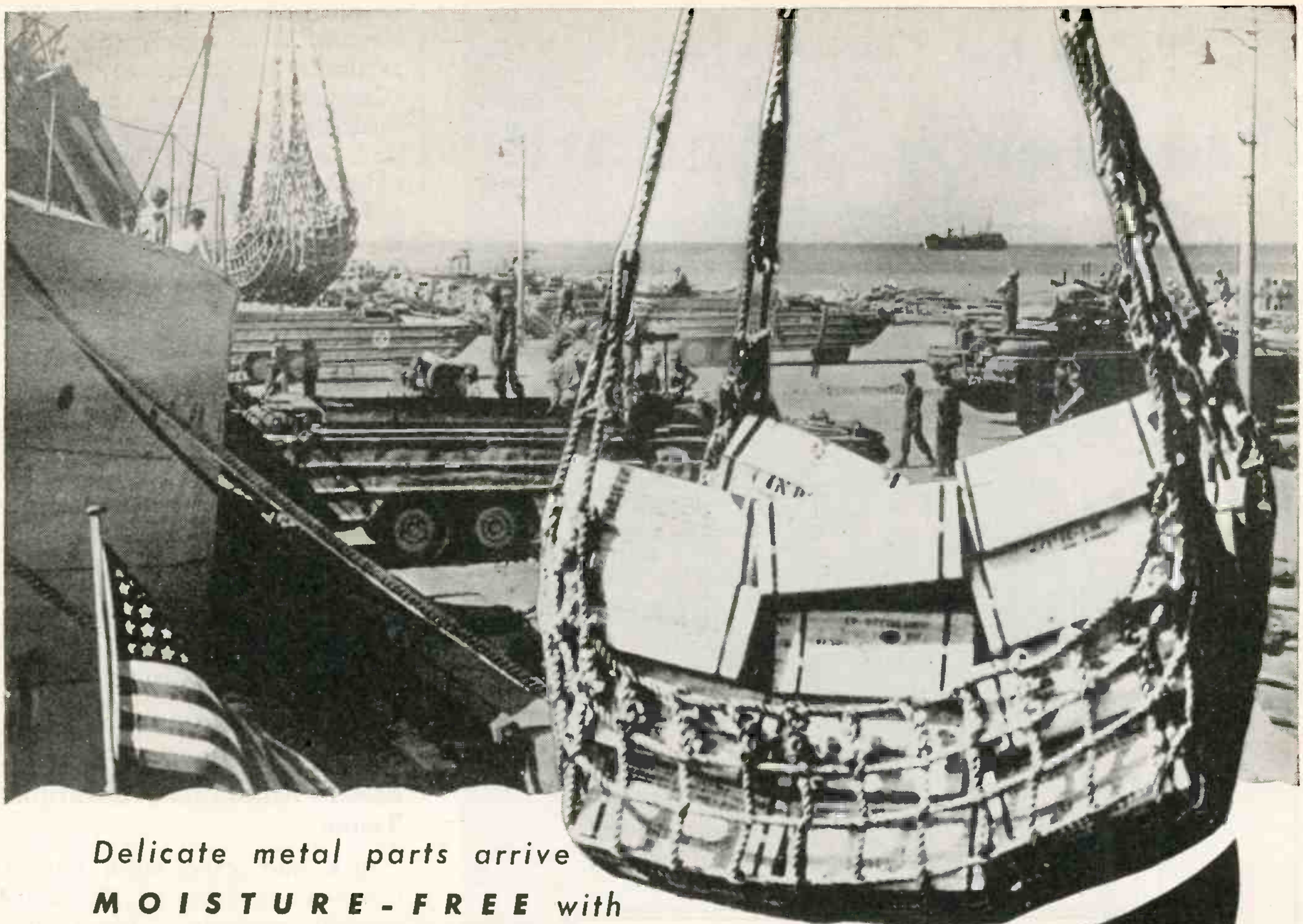
Such proved lightness and strength, however, are not the only reasons why thousands of Skydyne Cabinets are being used today to protect precision instruments in transit. Aluminum-faced Skydyne Cabinets are fungus resistant, watertight, waterproof and rustproof as well . . . all highly important factors in tropical climates.

Nor is aluminum the only sheathing. Fibreglass, papreg and plywood can also be bonded with the balsa, cork or lightweight synthetic core and moulded to the most exacting specifications.

Skydyne construction is electrically shielded and is also resistant to heat, vibration and sound . . . a feature which suggests numerous applications now and after the war.

Get the whole story of Skydyne and learn how it will improve the appearance and serviceability of any product housing in which strength, light weight and special protection are essential. Write for our descriptive brochure.

Skydyne Inc
PORT JERVIS, NEW YORK



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***MOISTURE-FREE** with*

Joliet SILICA GEL

The ideal drying agent...

THOUSANDS OF PACKAGES of delicate, precision metal parts are being delivered to our fighting fronts . . . moisture-free and rust free . . . because of Joliet Silica Gel.

The power of crystalline Joliet Silica Gel to absorb atmospheric moisture within containers is almost phenomenal. Its drying action prevents rust and corrosion. Moreover, it is widely used as a drying agent in cartons and boxes of foods, fabrics, chemicals and other commodities.

Joliet Silica Gel is strictly a quality product. It is clear white; passes a rigid section test; meets exacting government specifications. Write today for full information.

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There are excellent opportunities for jobbers to build profitable business on Joliet Silica Gel in a few territories. Write for details.

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Detroit, Mich.; St. Louis, Mo.; Newark, N. J.; Albany (State Department of Education), Buffalo (Grosvenor Library) and New York City, N. Y.; Cincinnati, Cleveland, Columbus, and Toledo, Ohio; Philadelphia (Franklin Institute) and Pittsburgh, Pa.; Providence, R. I.; and Madison, Wis. (State Historical Society).

Copies of the catalogue and complete sets of abstracts are on file at district offices of Smaller War Plants Corporation and in many Chambers of Commerce.

For further information write to the Office of Alien Property Custodian, 120 Broadway, New York 5, N. Y., or 135 S. LaSalle Street, Chicago 3, Ill. Indexes and abstracts can also be ordered from either of these offices; make checks or money orders payable to the Alien Property Custodian.

• • •

F-M and Television Broadcasters Announce Allocations Truce

In a joint action taken May 31 to speed a decision on the seven-year-old struggle between frequency-modulation broadcasting and television for space in the high-frequency radio spectrum, FM Broadcasters, Inc., and Television Broadcasters Association, the trade associations for the two industries, petitioned the Federal Communications Commission to adopt promptly an allocation plan satisfactory to both.

The plan upon which the two rival groups have finally joined hands is the first of the three FCC proposals concerning frequencies between 44 and 108 megacycles. It would give FM broadcasting 90 channels between 50 and 68 megacycles, a range in which present television stations now operate, and would give television 13 channels between 68 and 216 megacycles.

Prompt granting of the request by the FCC would permit both industries to prepare now for vast post-war expansion. It would enable them to avert unemployment which might result during the design and production engineering of equipment and sets. With cutbacks on war contracts already taking place in the electronics indus-


TUBES
including Rectangular!
For electronic purposes, we supply tubes in all the usual sizes, and in shapes that include not only round, but square, rectangular and special. In certain alloys, for critical electronic uses, we can meet the current high requirements. See this list of Revere tubes:
COPPER AND COPPER-BASE ALLOYS
Seamless Tubes • Condenser Tubes • Copper Tube for Water, Oil and Gas Lines • Dryseal Refrigeration Tubes • Pipe (S.P.S.) • Lock-Seam Tubes • Automobile Tubes • Capillary Tubing • Heat-Control Tubes.
MAGNESIUM ALLOYS
Seamless Tubes • Pipe (S.P.S.) • Rocket Launching Tubes.
ALUMINUM ALLOYS
Seamless Tubes • Lock-Seam Tubes • Pipe (S.P.S.)
STEEL
Electric Welded Tubes • Perforated Tubes • Lock-Seam Tubes.
Remember that Revere is an increasingly-important supplier to the electronic industry, not only of tubes, but of regular and special copper and copper alloys, including a remarkable Free-Cutting copper that increases production rates, decreases rejections. There is a Revere distributor near you. He or we will be glad to answer any question.
REVERE
COPPER AND BRASS INCORPORATED
Founded by Paul Revere in 1801
Executive Offices: 230 Park Avenue, N.Y. 17, N.Y.

"JUST TELL HIM ALBION CAN SHIP ALL THE COILS HE NEEDS... THAT'LL QUIET HIM."

SUPER-QUALITY COILS AT REASONABLE PRICES

More and more every day, the industry is turning to Albion for fast, quality and quantity production of coils, chokes, and transformers. That's because here you benefit from the unbeatable combination of management "know how," skilled workmanship, streamlined facilities, and central location. Your requirements will be given prompt and thoughtful attention.

ALBION
COIL COMPANY

ALBION, ILLINOIS

R. F. AND TRANSMITTING COILS AND CHOKES.
I. F. TRANSFORMERS

try and due to increase as complete victory nears, design and engineering must take place without delay if civilian production is to dovetail with war work.

Music Therapy

USE OF MUSIC from f-m receivers has made it possible for several Chicago dentists to do painful drilling without need for an anesthetic, according to Miss Violet Kmety of Zenith Radio Corp.'s station WWZR.

Speaking during National Music Week in Chicago, she pointed out that music from this station was particularly useful for these purposes since it is largely serious classics and has no distracting commercial announcements.

Other local applications include quieting the nerves and easing the minds of 2,700 donors a week at

At the Helderberg Mountain transmitter site of General Electric Co., near Schenectady, engineer George M. Brown talks with other GE engineers cruising in a 4-w f-m emergency mobile unit. The occasion was a two-day demonstration for members of the New York State chapter of APCO (Associated Police Communication Officers) of Radiotype and v-h-f (161.775 Mc) communications. In the foreground is one of the electromatic typewriters used in the system which involves perforating a tape, passing it over an automatic transmitting head which keys the transmitter with a tone signal, transmitting and receiving the keyed signal and electronically selecting the proper keys on the typewriter at the receiving end

FERRANTI ELECTRIC, INC.

Transformers · Instruments

ELECTRONIC EQUIPMENT

FERRANTI

TELEPHONE CIRCLE 7-0812-3
CABLE ADDRESS FERRATRAN

30 ROCKEFELLER PLAZA
NEW YORK 20 · N · Y ·

July 1, 1945

Mr. Chief Engineer:

We have available immediately, plant capacity for TRANSFORMERS, CHOKES, FILTERS, ETC., ETC. If you have any bottlenecks why not see us at once, as we can be of definite and immediate service to you.

This is a frank letter soliciting immediate business. To date we have had no cutbacks and we have sufficient business to see us well into 1946. However, due to greatly improved efficiency and increased manufacturing facilities, we have cleaned up our backlog at a greater rate than was originally anticipated, i.e. in the month of May, we completed and shipped over forty times as much business as we did in a similar month a few years ago.

Therefore, in the light of the above facts, we can entertain your orders for scheduling during the summer months.

Yours very truly,

FERRANTI ELECTRIC, INC.

W. R. Spittal
Vice-President

METAL STAMPINGS
IN SMALL LOTS

Die cut metal stampings in limited quantities can be produced to your special requirements at 15% to 20% of the cost of permanent type tools. No matter how small your quantity requirements or how intricate your work, we can show you a definite saving. During our twenty-three years of specialized experience in this service, there has been no other method of producing metal stampings in small lots that can equal the process originated by Dayton Rogers.

Our new, illustrated booklet #176-17 will give you full particulars.

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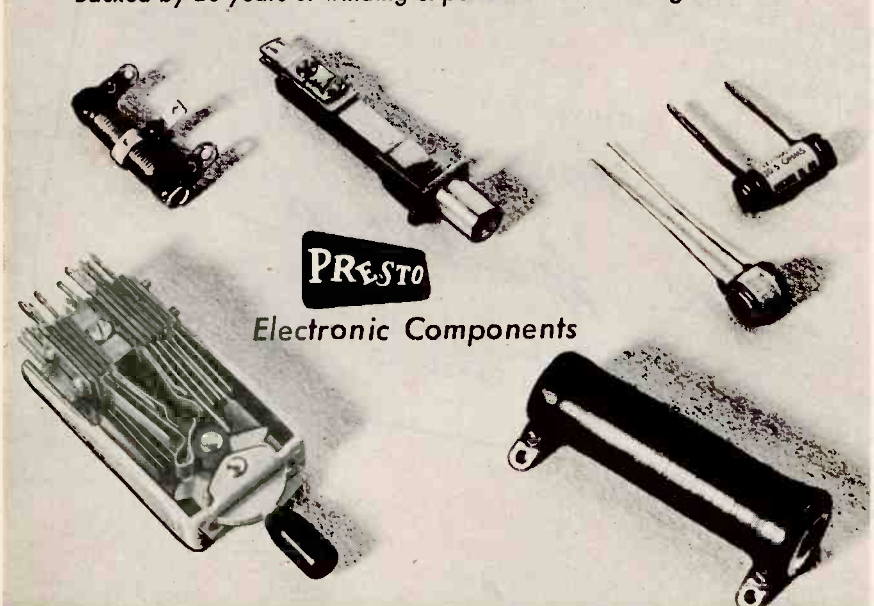
VITREOUS ENAMEL PRECISION WOUND **RESISTORS**

TELEPHONE SWITCH KEYS & JACKS

TELEPHONE COMMUNICATIONS and CABLE ASSEMBLIES

Weather-and-Fungus-Proofed

Backed by 20 years of winding experience. 75 Winding Machines



PRESTO ELECTRIC COMPANY
Manufacturers of Signaling Devices
UNION CITY, NEW JERSEY

For your present and post war electronic instrumentation.

Actual  *Size*

— SERIES VW —

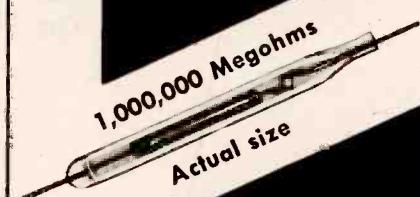
A new 15 ma., 1.5 volt sub-miniature vacuum tube with —peak inverse potential up to several thousand volts— Grid current less than 10^{-14} amperes — grid resistance approximately 10^{16} ohms.

Available as . . .

- Electrometers
- Pentodes
- Tetrodes
- Triodes
- Diodes

. . . or to your specifications.

. . . and hand in hand with this tube development a new Victoreen Hi-Meg vacuum sealed resistor. Values from 1 megohm to 1,000,000 megohms.



Meeting the needs of fine instrumentation with unusual stability.

Write for our technical brochure on tubes and resistors.

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ATR VIBRATORS

FEATURE:

- Longer Life
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INCLUDE ALL TYPES:

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ATR Vibrators, the heart of vibrator-operated power supplies, are proven units of the highest quality, engineered to perfection. They are backed by more than twelve years of vibrator design and research, development and manufacturing—ATR pioneered in the vibrator field.

ATR

Preferred Precision Products

- Vibrators
- Vibrator-Operated and
- Rectifier Power Supplies

ATR LOOKING AHEAD! Though now engaged in vital war work, with the immediate aim of victory, ATR is looking ahead. Our organization is being geared for the postwar requirements of the Radio-Electrical Industry. At present, only priority rated orders are being filled. However, we suggest that your postwar orders be anticipated and placed with us for prompt delivery. Write for catalog number 244. Backed by 14 years of "know how," DEPEND ON ATR.

AMERICAN TELEVISION & RADIO CO.

Manufacturers of Quality Products Since 1931

ST. PAUL, MINNESOTA, U. S. A.

the Chicago Blood Bank and diverting the minds of caesarian mothers under local anesthetic.

Hundred-Watter Sales

SUPPLEMENTING INFORMATION previously released on standard broadcast stations in other power categories, FCC now announces that net time sales for 1944 among 24 of the nation's 33 standard broadcast stations (28 commercial and 5 non-commercial) operating with power of 100 watts, increased 37 percent over the amount reported for 1943. All stations in this category showed increases. The total was $983,639, an increase of $263,-476.

Tropicalization Inspection

AS A RESULT of the increasing pitch of war activities in the Japanese theater of operation, the U. S. Army Signal Corps announces current use of an invisible dye to facilitate inspection of equipment treated for fungus and moisture detection.

This invisible or fluorescent dye is mixed with the lacquer which is sprayed on the equipment. Since the lacquer must be colorless to permit the reading of numbers and identification marks on the surfaces beneath, it is impossible to use visible dyes for determining paint coverage.

Checking is done with a special lamp high in ultraviolet emission and equipped with a deep purple filter.

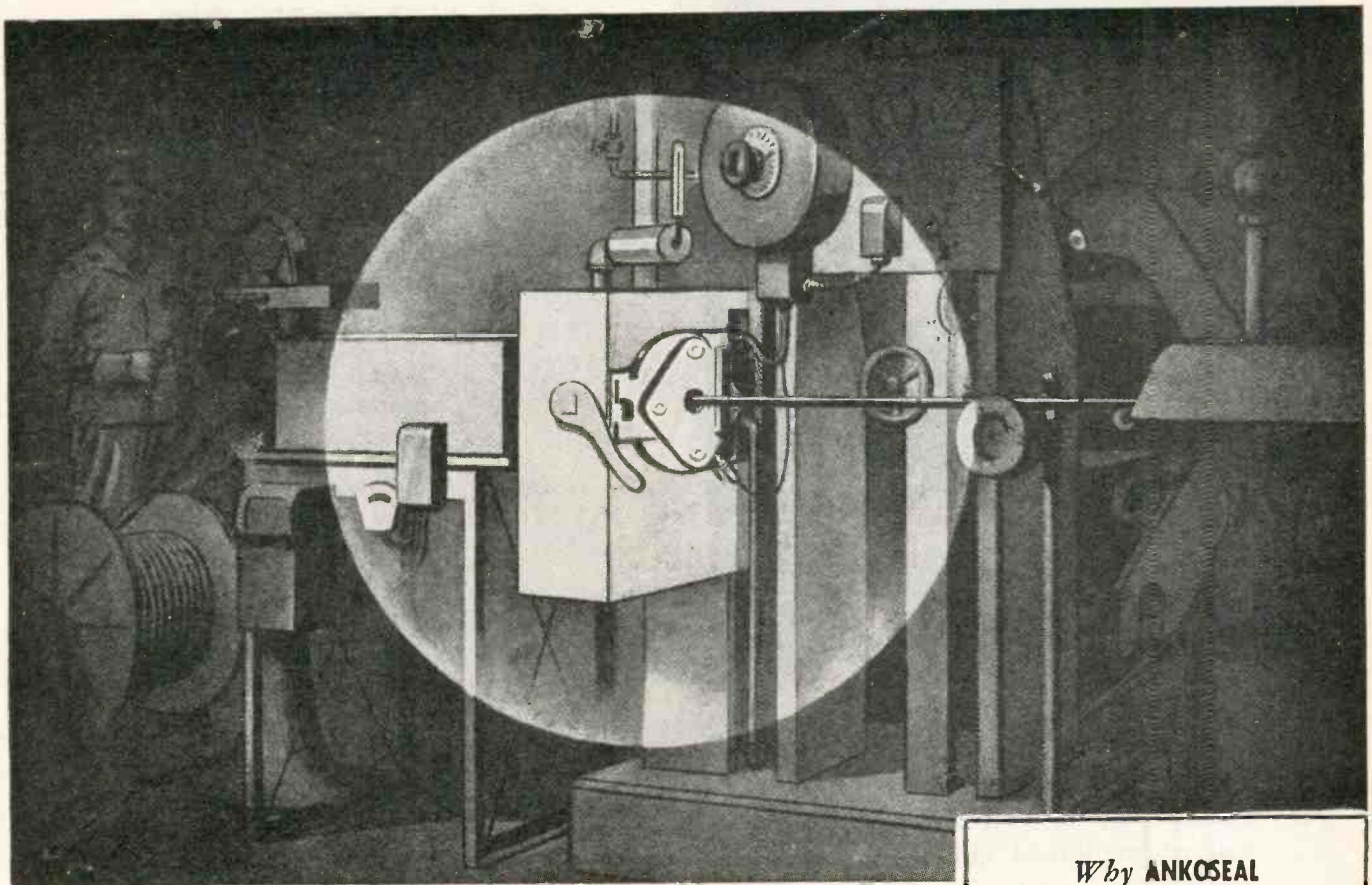
A quick spot check which is sometimes used for the same purpose is executed with an ordinary pencil. Wherever the pencil glides as if on glass the spraying has been adequately done, but if it starts to write this indicates the presence of a weak spot in the covering.

CONVENTIONS TO COME

SEPT. 17-21. AMERICAN SOCIETY FOR MEASUREMENT AND CONTROL. National Instrumentation Exhibit, Hotel William Penn, Pittsburgh, Pa., L. Susany, secretary, 4400 Forbes St., Pittsburgh, Pa.

WASHINGTON NEWS

EXPERIMENTAL MODELS. In line with its announced policy of permitting reconversion as rapidly as



Where's the Engineer in this picture?

THE engineer isn't visible in the sketch—but he's there, behind every step in building Ankoseal cable! For, more and more, cables are engineered *and* manufactured to do particular jobs—especially here at The Ansonia Electrical Company!

Because of the many unusual cable demands of the Army and Navy which we have met, we are able to satisfy equally difficult requirements of other government agencies ...or of private concerns engaged in war work. Once we know what the function of the cable is to be, we take over—and from there to the finished product, in engineering and manufacturing, our organization works to deliver the form and type of Ankoseal cable best suited to that job.

That we stand ready to meet such requirements is indicated by our output record...made possible by "Yankee ingenuity" in manufacturing, implemented by emphasis on *continuing* laboratory research. These same facilities, this same ability, are offered to you.

So—if you have a cable problem—think of Ankoseal—and The Ansonia Electrical Company. We'll be glad to hear from you!

Why ANKOSEAL *solves cable problems*

Ankoseal, a thermoplastic insulation, can help solve many electrical engineering problems, now and in the future. *Polyvinyl* Ankoseal possesses notable flame-retarding and oil resisting characteristics; is highly resistant to acids, alkalies, sunlight, moisture, and most solvents. Polyethylene Ankoseal is outstanding for its low dielectric loss in high-frequency transmission. Both have many uses, particularly in the radio and audio fields. Ankoseal cables are the result of extensive laboratory research at Ansonia—the same laboratories apply engineering technique in the solution of cable problems of all types.

THE ANSONIA ELECTRICAL COMPANY

Specializing in "Ankoseal" a Thermoplastic Insulation

ANSONIA • CONNECTICUT

A Wholly-Owned Subsidiary of

NOMA ELECTRIC CORPORATION

GENERAL OFFICES • NEW YORK, N. Y.

—In peacetime makers of the famous Noma Lights—the greatest name in decorative lighting. Now, manufacturers of fixed mica dielectric capacitors and other radio, radar and electronic equipment.

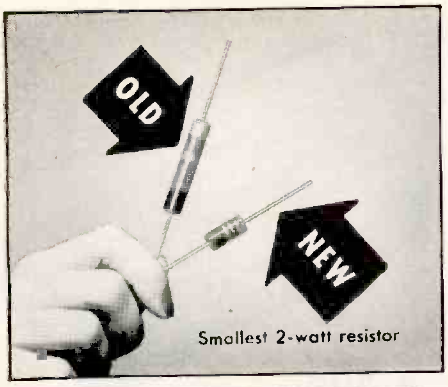
possible, WPB has relaxed restrictions on the production of experimental models. Thus, where WPB authorization was required for the expenditure of more than $5,000 in a single plant in any calendar month in making models, no dollar limitation now exists. The order also removes the restriction on exhibition of models to the trade or to the public and permits distribution of experimental models for the purpose of promoting sales and creating consumer demand.

Sound Equipment. It is reemphasized by WPB that intercommunication systems and public address systems may not be sold on the basis of maintenance, repair and operating. MRO orders can be used to add stations to existing intercommunication systems or to replace damaged amplifiers where repairs are impossible—but can never be used for installation of sound systems.

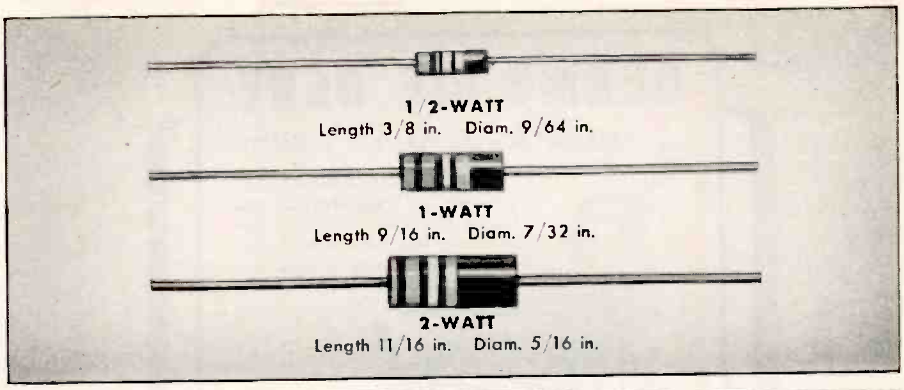
Receiver Price Studies. In anticipation of a return to civilian production, OPA (Office of Price Administration) officials are gathering data on manufacturing costs of radio sets, cabinets, and components preparatory to the fixing of ceilings in accordance with existing reconversion policies. From the point of view of parts, the operation comes under the direction of Earle H. Morse, chief of the electrical section, while sets and cabinets fall under the jurisdiction of Daniel L. Jacobs, chief of the radio and miscellaneous unit of the durable goods price branch.

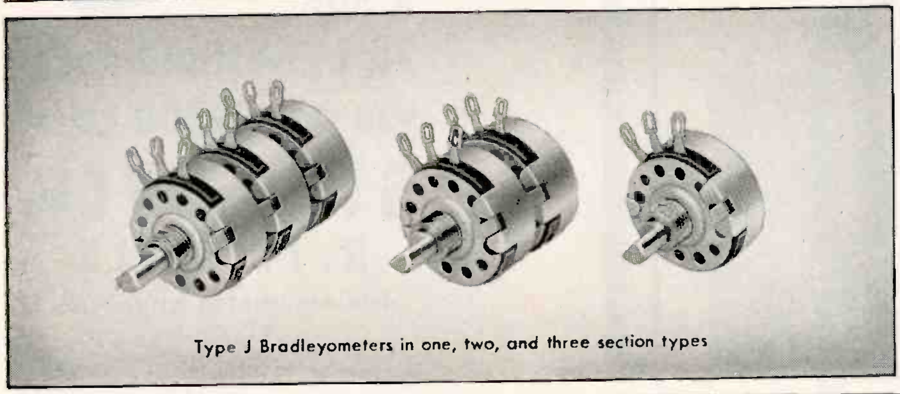
Civilian Products Released. Revocation of Order L-325 releases the production of 35-mm motion picture projection equipment, including sound and amplifying systems, for civilian use. Sixty other limitation orders revoked simultaneously cover a wide variety of types of equipment including resistance welders, electric office machines, motor controllers, and automatic music devices.

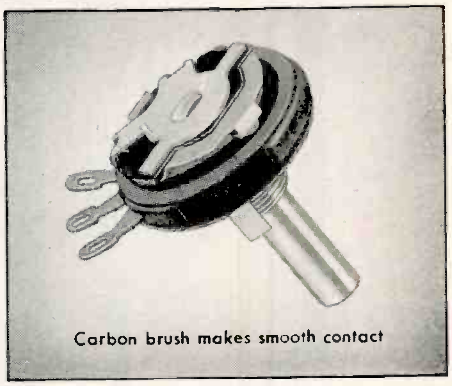
Receiver Market. Preliminary tabulations from the fourth nationwide survey taken by the Office of Civilian Requirements of WPB show that consumer demand for household appliances is far in ex-

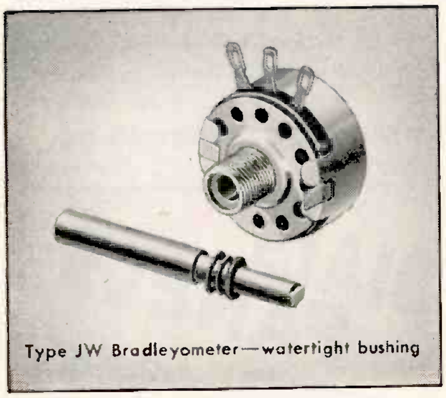


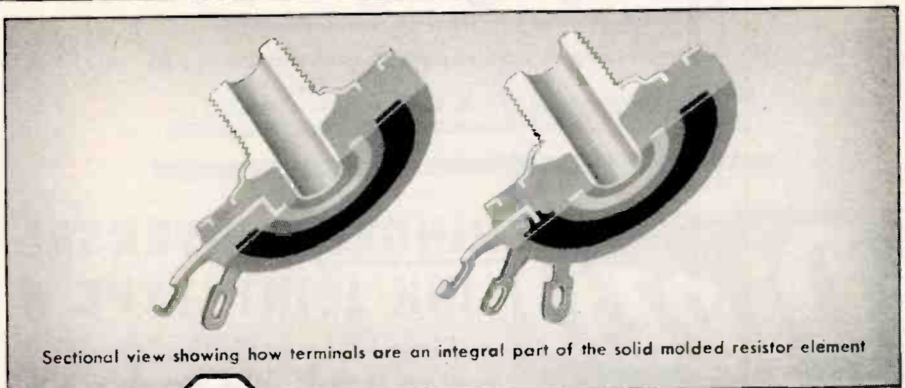
Smallest 2-watt resistor




Type J Bradleyometers in one, two, and three section types


Carbon brush makes smooth contact


Type JW Bradleyometer—watertight bushing


Sectional view showing how terminals are an integral part of the solid molded resistor element

A-B Quality

ALLEN-BRADLEY

FIXED & ADJUSTABLE RADIO RESISTORS

QUALITY

FIXED INSULATED RESISTORS—Bradleyunits are available in 1/2-watt, 1-watt, and 2-watt ratings. They will sustain an overload of ten times rating for several minutes without failing. Wax impregnation is not necessary to pass salt water immersion test. The 1/2-watt and 1-watt units are available in all RMA standard values from 10 ohms to 10 megohms. Two-watt units available from 10 ohms to 1 megohm.

ADJUSTABLE RESISTORS—Type J Bradleyometers are the only continuously adjustable composition resistors having a 2-watt rating with good safety factor. Resistor element is solid molded and has substantial thickness. Not a film, paint, or spray type. Molded as single unit complete with insulation, terminals, face plate, and bushing. No rivets or soldered connections. Any resistance-rotation curve can be provided.

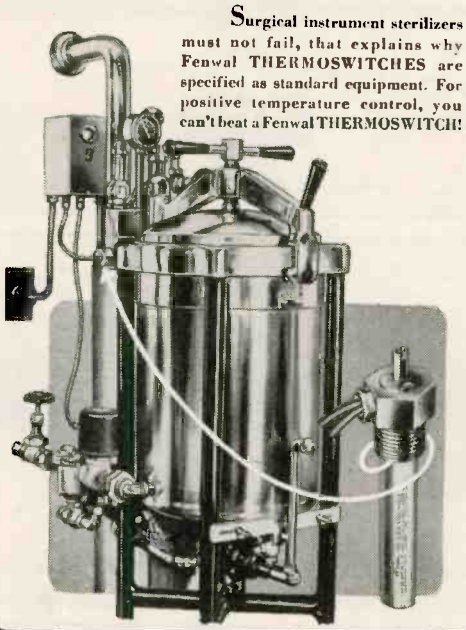
Allen-Bradley Company, 110 W. Greenfield Ave., Milwaukee 4, Wis.

WHEN DEPENDABILITY AND PERFORMANCE ARE "MUSTS"... THE EXPERTS SPECIFY ALLEN-BRADLEY

GERMS DIE HERE

. . . under temperature control!

Surgical instrument sterilizers must not fail, that explains why Fenwal THERMOSWITCHES are specified as standard equipment. For positive temperature control, you can't beat a Fenwal THERMOSWITCH!



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A BOX TO REMEMBER when you want GOOD coils

STANWYCK

R. F. COILS

AND ASSOCIATED ASSEMBLIES

There is a Stanwyck coil for every application in the Radio Frequency Spectrum —coils that have met the requirements of war and which will meet your requirements when the war is won . . . Send for folder describing our line and facilities.

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Piezo

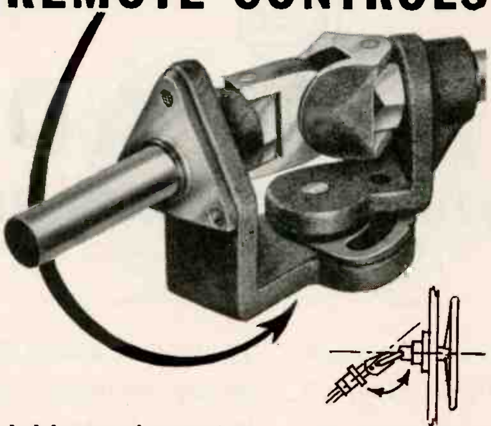
TRADE MARK

HINGED UNIVERSAL LINK JOINT-TYPE "H"

Simplifies installation of

REMOTE CONTROLS

The type "H" hinged Universal Link Joint with solid shafting has three distinct advantages for remote controls. (1) Simplicity of installation (the Universal Link Joint hinges from 0 to 90°). (2) A minimum of backlash. (3) Output shaft turns in exact angular rotation with the input shaft.



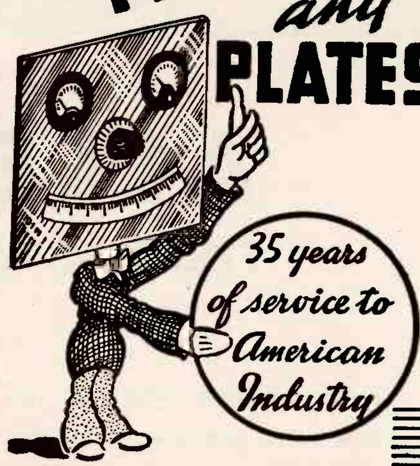
This method is particularly recommended for panel operation of dial and rheostat controls, switches, variable condensers, variable transformers, coils, remote operating rods and other mechanical adjustments.

Write for Bulletin 45B for complete data and specifications.

PIEZOELECTRIC CORPORATION

110 EAST 42nd ST., NEW YORK 17, N. Y.

DIALS PANELS *and* PLATES



DIALS • PANELS • PLATES

made to your precise engineering specifications in etched metals and finishes.

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METAL ETCHING CO.

21-03 44th AVE.

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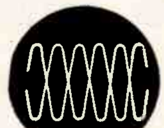
Policing Production

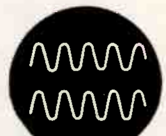
VARIABLE SOUND WAVES



ELECTRICAL WAVES

BROADCAST WAVE

RADIO INTERFERENCE



CHECKING A TELEVISION SET.

with JEROME STILL & MOTION PICTURE CAMERAS

These graphs show what the eye sees on the fluorescent screen of an oscillograph. By using the JEROME Data Camera to photograph these tests at intervals of a few seconds or minutes, as required, you get a permanent record of your tests, and one that may be studied at leisure.

This is only one of many useful tasks on which the JEROME Automatic Still and Motion Picture Camera may be employed.

Changed to a motion-picture camera at the flick of switch, the JEROME makes Time Studies in Electronic Manufacturing. Or — it portrays shop methods, for instructing novice workmen in their training period. See the 28 uses outlined in the table opposite.

This rugged, 35mm camera, with every part strongly built to resist vibration or shock, is extraordinary in so many ways that we may only hint at them here.

For instance, heating equipment, controlled by thermostat, permits motion-pictures at a temperature of 60° F. below zero. For work in the dark, or in shadowy spots the camera provides its own illumination.

There are two shutters, one for each class of work, and mounting for three different lenses, of which two are provided as standard equipment.

Speeds — On Movie Work — approximately 4 to 64 frames per second. On Data Work — intervals of from 15 seconds to 30 minutes. Furnished with substantial tripod, or may be rigidly clamped to bench or fixture. Read all about this unusual Industrial Camera. WRITE FOR FULL INFORMATION.

28 Ways to Use JEROME Cameras

1 Photograph instrument panels, registering instruments, single, multiple frame, at pre-determined intervals.

2 Gun camera — recommended for heavy guns — 35 mm. Superiority over 8 mm., 16 mm.

3 As an Ordinary Camera: Despite special design camera can be used as regular 35 mm. camera.

4 Ground and aerial reconnaissance, surveys.

5 Recording duplications, Maps, Mail, valuable documents.

6 Medical research, fluoroscope screen and microscopic photographic recording.

7 Chemistry, records chemical research & action.

8 Coast Survey, Aerial Reconnaissance. Recording of depth and sounding instruments.

9 Buoy survey and patrol of sea in critical areas.

10 Electronic Research Instrument, photographically records cathode ray, oscilloscope.

11 Detection, automatically photographs objects passing within camera range.

12 Test work, general instrument, recording test performances, techniques.

13 Training Film, all types of school and educational photographs for training purpose, class room.

14 Deck Observation Camera, records deck action or position of ships in convoy.

15 Production Check Camera, checks machine, manual operations, increasing efficiency.

16 Aerial observation. At pre-set intervals will photograph landscape below at high altitudes.

17 Engineering Work. Used in construction of ship hulls, bridges, construction analysis.

18 Performance Guide, manual operation, gun crew action. Recording for future study.

19 Aircraft Landings & take-offs mounted on control tower. Records unusual incidents.

20 Aerodynamics research and flight test operations.

21 Material Testing. Automatic testing characteristics of materials, recording for analysis.

22 Meteorology. Isolated weather instruments and cloud formation and climatic study.

23 Traffic Check. Dangerous road intersections. Tunnel and bridge traffic analysis.

24 Marine observation, underwater photography fluora, fish habitats.

25 Firing Data Recording. Complete gun firing record, corrector range and site.

26 Front Line Warfare. Tank and listening post observation.

27 Restricted Area Detection. Registers pedestrian traffic thru gates, doors.

28 Photoelectric Cell operating camera operating from sound and vibrator detection.

JEROME ENGINEERING CO.

MASSAPEQUA, L. I., N.Y.

ORIGINATORS OF THE AUTOMATIC RECORDING CAMERAS
BUILDERS OF PHOTOGRAPHIC EQUIPMENT
UNIVERSAL CAMERAS FOR EVERY TECHNICAL REQUIREMENT

PHONE: MASSAPEQUA 2100

cess of the demand in any year before the war. Including only households, and not apartments and new housing, the figures represent demands as of the date of the survey, which was shortly before V-E Day. Assuming that supplies were ample, it is projected from the results that 5,085,000 radios were in demand as against only 2,682,000 a year ago. From the second-hand point of view it was brought out that 429,000 households had sought unsuccessfully to purchase radios, while 913,000 found units to buy. 13 percent of these were new. Radios were the only items among household appliances where the number actually bought exceeded the number looked for unsuccessfully.

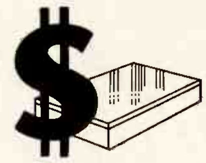
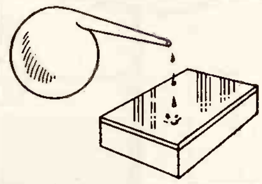
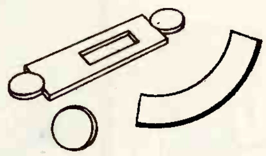
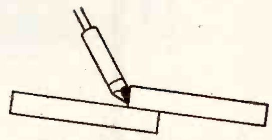
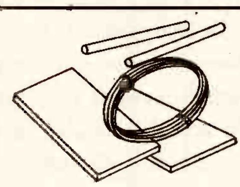
QUARTZ CRYSTALS. An amendment to Conservation Order M-146, issued by WPB, eliminates the provision for application of certain quartz crystal production under the spot authorization plan. Consumers in hardship cases are directed to appeal by letter to the Miscellaneous Minerals Division. The new order allows the use of quartz in the manufacture of research or production instruments on any ratings and also eliminates a former prohibition against fabricating radio oscillator plates and filters from quartz scrap.

FCC ACTS

To permit this station:	To do this:
WJXN Jackson, Miss.	Operate a new station on 1490 kc, 250 w, unlimited time.
WJAX Jacksonville, Fla.	Operate new auxiliary transmitter.
WPAG Ann Arbor, Mich.	Operate a new station on 1050 kc, 250 w, daytime.
W4XAP Birmingham, Ala.	Operate a new developmental broadcast station on frequency to be assigned, 250 w.
W2XCS New York, N. Y.	Extend completion date for new experimental television broadcast station to Nov. 12, 1945.
— — — — Cadillac, Mich.	Construct a new station to operate on 1240 kc, 250 w, unlimited time.
KEUB Price, Utah	Change call letters to KOAL.
WSTN Staunton, Va.	Construct a new station to operate on 1400 kc, 250 w, unlimited time.
— — — — Tulare, Calif.	Construct a new station to operate on 1240 kc, 250 w, unlimited time.
— — — — Milwaukee, Wis.	Construct a new developmental broadcast station at the transmitter site of WMFM. Emission: A0 and special for FM.
WLBG Philadelphia, Pa.	Change call letters to WIBG-FM.
KCRA Sacramento, Calif.	Operate a new station on 1340 kc, 250 w, unlimited time.
WBHD Petersburg, Va.	Change call letters to WSSV.

"When Ordering Please Mention Electronics"

What do you need in metals?

ECONOMY	
CORROSION RESISTANCE	
EASE OF FABRICATION	
EASY SOLDERING	
ELECTRICAL CONDUCTIVITY	
SHEET, WIRE, TUBE	

You'll find the answer in General Plate Laminated Metals

The versatility of General Plate Laminated Metals makes possible the fabrication of parts with exceptional electrical performance . . . corrosion resistance . . . mechanical and structural properties . . . long wearing life . . . and economy.

By permanently bonding precious metals to base metals, General Plate Laminated Metals give you solid precious metal performance at a cost slightly higher than the base metal. Base to base metal combinations provide special performance requirements not found in single base metals.

No matter what your metal requirements in such applications as electronic devices, electrical products, signal control apparatus, chemical equipment . . . anything from peanut radar tubes to giant turbines, it will pay you to investigate General Plate Laminated Metals for present and post-war products.

They are available in sheet, wire and tube form . . . inlaid or wholly covered . . . or as fabricated parts. Many new clad combinations, developed since the war, are also now available. Our engineers are available for consultation. Write for their services.

General Plate Division

of Metals & Controls Corporation

50 Church St., New York, N. Y.; 205 W. Wacker Drive, Chicago, Ill.; 2635 Page Drive, Altadena, California; Grant Bldg., Pittsburgh, Pa.

ATTLEBORO, MASSACHUSETTS

— — — — Massena, N. Y.	Construct a new station to operate on 1340 kc, 250 w, unlimited time, contingent on WPB authorization.
— — — — Santa Maria, Calif.	Construct a new station to operate on 1450 kc, 250 w, unlimited time, contingent on WPB authorization.
KINY Juneau, Alaska	Operate with increase in power, newly installed transmitter, and changes of antenna.
— — — — Columbis, Ohio	Construct a new relay broadcast station to operate with WOSU.
W7XTE Portland, Ore.	Extend completion date of new developmental broadcast station to Dec. 30, 1945.
W3XPA, W3XPC, W3XP Philadelphia, Pa.	Increase power to 40 w, add A3 emission; change antenna and transmitter; and change area to Washington, Philadelphia and New York.
W3XPD, W3XPE, W3XPF, W3XPG W3XPH, W3XPI, W3XPK Portable-mobile	Change power to 40-w (peak) visual, 40-w aural, change type of transmitter and antenna, extend commencement and completion dates of experimental relay station to 60 and 180 days, respectively, change areas to Central Maryland, N. E. Maryland, S. E. Pennsylvania and District of Columbia.
W3XPR New York, N. Y.	Modify construction of new experimental television broadcast station to increase power to 40 w, add A3 emission, change area to Washington, Philadelphia and New York, change transmitter and extend commencement and completion dates to 60 and 180 days, respectively.
— — — — Portable-mobile	Construct new experimental television relay broadcast station to be used with WPTZ.
WGY Schenectady, N. Y.	Operate with decrease in power and changes in transmitting equipment of auxiliary.
WMAZ Macon, Ga.	Operate auxiliary transmitter and move to site of main transmitter with increase in power to 1 kw and use of DA for day and night operation.
WEHS Chicago, Ill.	Extend completion date of new f-m broadcast station to July 8, 1945.
KOB Albuquerque, N. M.	Extend for 6 mo. operation on 770 kc, 25 kw night, 50 kw-ls, unlimited time.
KVSO Ardmore, Okla.	Increase nighttime power from 100 to 250 w.

BUSINESS NEWS

JEFFERSON-TRAVIS RADIO MFG. CORP., makers of communications equipment, and Fonda Corp., manufacturers of continuous sound recording equipment, are merged into the Jefferson-Travis Corp.

RAYTHEON MFG. CO. moves the New York offices of its radio receiving tube division from 420 Lexington Ave. to 60 East 42nd St.—the Lincoln Building, New York, N. Y.

BELMONT RADIO CORP., as agent of Defense Supplies Corp., takes over a plant containing 72,000 sq ft. of floor space to serve as a regional redistribution center for surplus military electronic and radio material.

PHILCO RADIO AND TELEVISION CORP. has formed a new television broadcasting division which brings together all Philco telecasting activities including operation of

"Ring Out, Brave Land"

...LET'S CREATE NEW MARKETS

Only by the creation of new markets, can we, as a nation, keep a high standard of living.

No longer is it sufficient to exploit only the existing markets, many of which are already worn thin. To create new markets should be the goal of all Industry —not only from a sense of duty to the peoples of this country, but from a plain common-sense dollars and cents viewpoint.

One of the best and surest ways to accomplish the most good for the nation—and more sales for the electric appliance industry—is the intensive development of our natural resources.

THE TVA PLAN HAS SHOWN THE WAY

It's hard to put TVA into words. It is not just the generation of electric power, nor flood control alone, or merely soil conservation. All these are a part of TVA—but basically it is the growth of a people and the growth of the soil they live on. It has metamorphosed a stunted region and backward people into a new economy—profitable both from a humane as well as a commercial standpoint.

Cheap electricity, a prime result of TVA, has been one of the important elements that have enabled the people of the TVA region to become prosperous and to lead a life more in keeping with the American way. And inevitably, it *created an entirely new market* for the sale of electrical appliances and machinery.

A market, for instance, that showed a 374% increase in the sale of electric ranges over the preceding year; water heaters by 774%, refrigerators by 329%! This, from a former undeveloped "poor market" area!

Every one of the electric farm machines, washers, refrigerators, ranges, radios and other appliances that went into the Tennessee Valley provided work and income for the dealers, distributors and service men who sold, installed and maintained them; jobs and profits for the workmen and manufacturers who produced them —Yes and for you and us.

ESTABLISH A MISSOURI VALLEY AUTHORITY

Now that TVA has shown the way, what is more logical than to follow up with an MVA? The Missouri River Basin, about one-sixth of the land area of the nation, has problems similar to the Tennessee Valley. It presents a definite challenge to a forward-looking nation. *And an unprecedented profit opportunity for the manufacturers of electric machinery and appliances!*

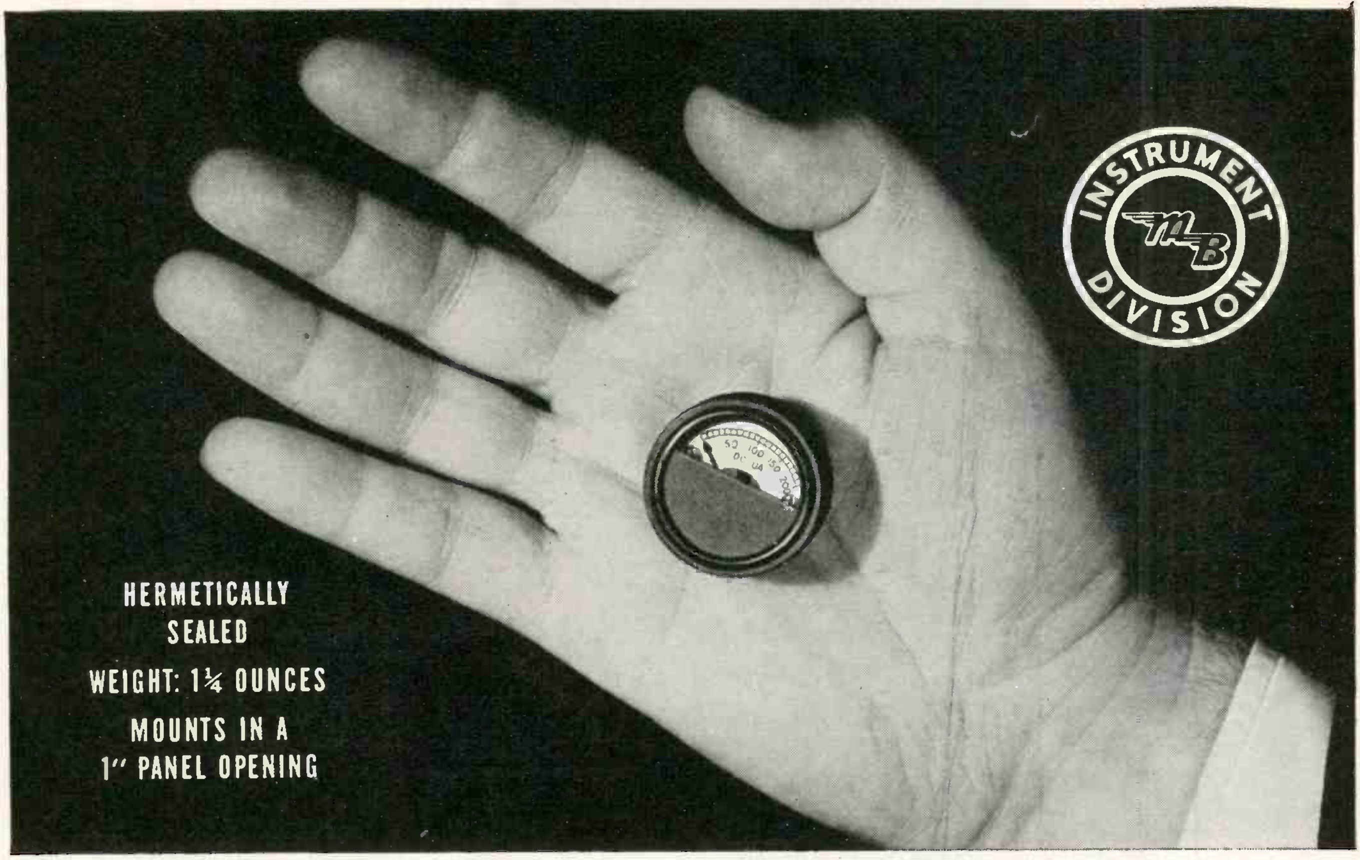
So let us urge Congress to set up a Missouri Valley Authority to develop all the resources of this vast region for the benefit of all the nation. Let us urge Congress to act immediately, so that when the war is over, the plans will have been made, and we can go forward. For further information, send for free booklet.

First of a series of advertisements designed to encourage the creation of new markets

GTC

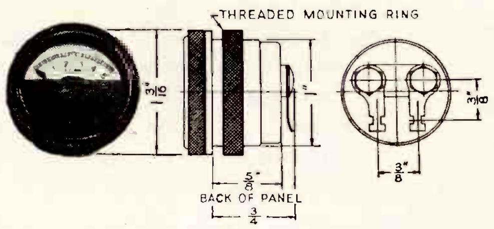
GENERAL TRANSFORMER CORPORATION

1250 West Van Buren Street • Chicago 7, Illinois



MB MAKES THEM . . .

the smallest millivoltmeters — voltmeters — ammeters milliammeters and microammeters



Mounting Dimensions — model 100

MB Miniature Ammeters
—at left, 1 inch diameter, model 100;
—at right, 1½ inch diameter, model 150.

for Aircraft and Portable Equipment

TINY ENOUGH to fit into the smallest space, this unusual new MB series of electrical indicating instruments, will meet most exacting, rigid tests for accuracy, performance and durability. They are hermetically sealed in a rugged anodized aluminum case which, in turn, can be sealed to the mounting panel itself. Wherever space and weight in electrical indicating instruments are at a premium, this new MB series is the answer.

In addition to the one inch meter, MB also makes a one and one half inch meter, weighing one and one half ounces, with the same type of construction and offering the same advantages.

Write for new catalog to Dep't. E, The MB Manufacturing Company, Inc., Instrument Division, 250 Dodge Avenue, East Haven 12, Connecticut.

THE MB MANUFACTURING COMPANY, INC.

INSTRUMENT DIVISION

250 DODGE AVENUE, EAST HAVEN 12, CONN.

Station WPTZ and the new television network between Washington and Philadelphia.

RADIO CORP. OF AMERICA is working under a unique manpower sharing plan with Prudential Insurance Co. at Newark, N. J. RCA has installed a production operation on the premises of the insurance company and employs a group of the

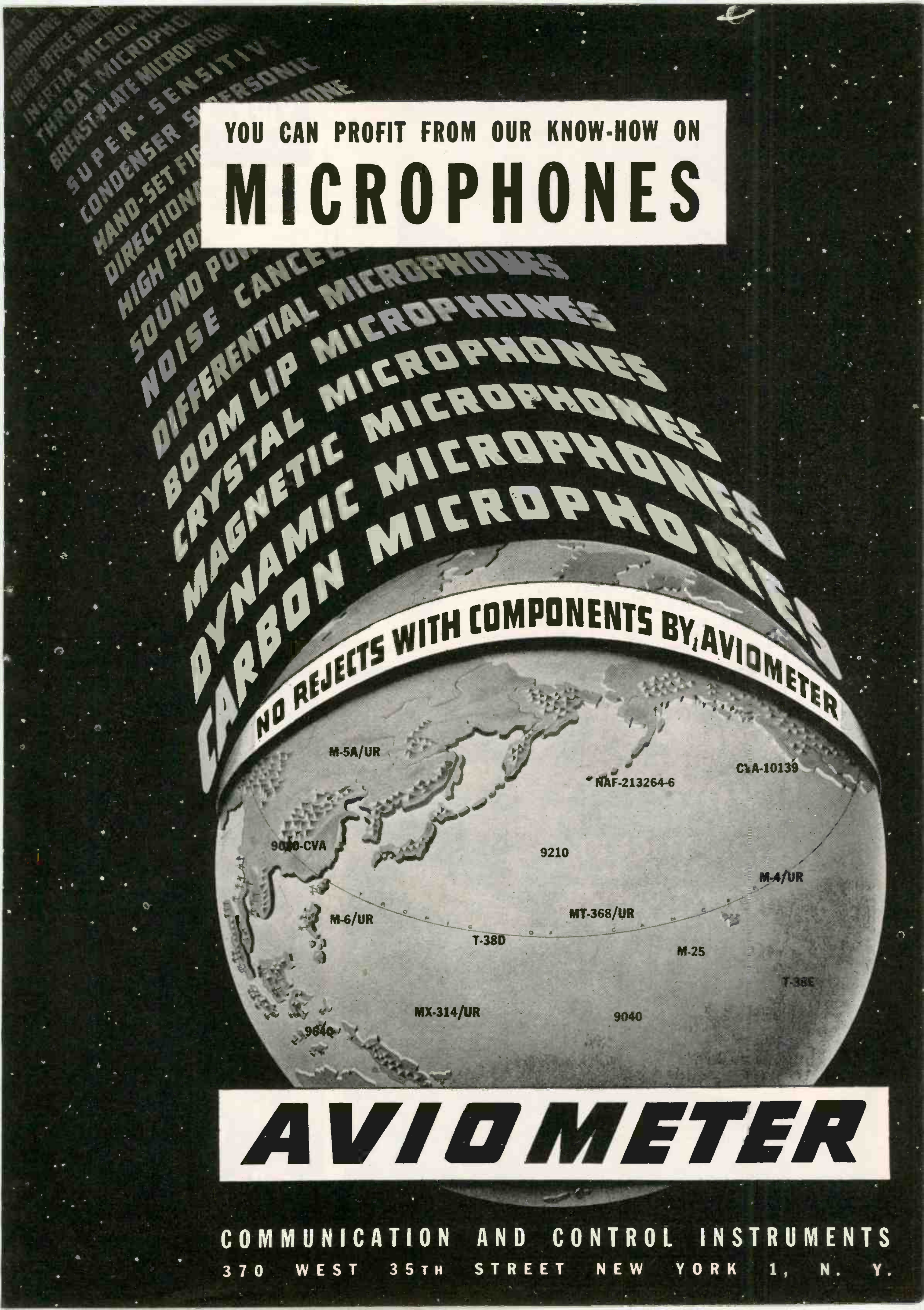
company's personnel for part-time operation. The illustration shows a view of the 40 Prudential girl typists and clerks who are working in two shifts of four hours each on a simple assembly operation for miniature electron tubes.

PERSONNEL

HARRY C. INGLES, major general, Chief Signal Officer of the Army, was presented with an honorary degree of doctor of engineering by the trustees of the University of Nebraska for his outstanding accomplishments in the field of communications engineering.

RALPH R. BEAL, assistant to the vice president in charge of RCA Laboratories and for nine years research director of RCA, becomes vice-president of RCA Communications Inc. in charge of engineering.

GEORGE T. BROWNELL, signal officer and lieutenant colonel in the 11th armored division, is made chief engineer of the Majestic



YOU CAN PROFIT FROM OUR KNOW-HOW ON
MICROPHONES
INERTIA MICROPHONE
THROAT MICROPHONE
SUPER-SENSITIVE
DIFFERENTIAL MICROPHONES
BOOM LIP MICROPHONES
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MAGNETIC MICROPHONES
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T-38D
M-25
T-38E
MX-314/UR
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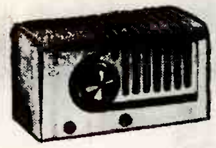
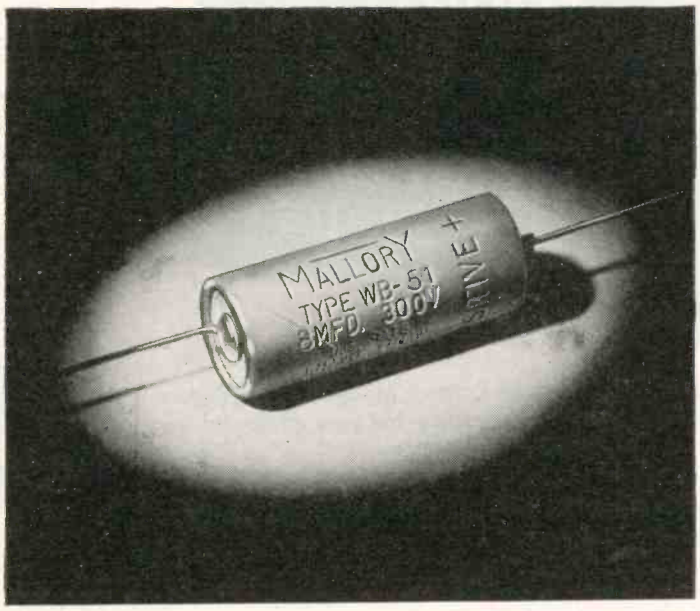
COMMUNICATION AND CONTROL INSTRUMENTS
370 WEST 35TH STREET NEW YORK 1, N. Y.



Save Chassis Space with

MALLORY "WB" CAPACITORS



WHEREVER chassis space has to be figured in fractions of an inch . . . in small AC/DC receivers, for instance . . . you'll be wise to specify Mallory "WB" Capacitors. These dry electrolytics are designed and built to combine top efficiency with minimum size for their capacity rating.

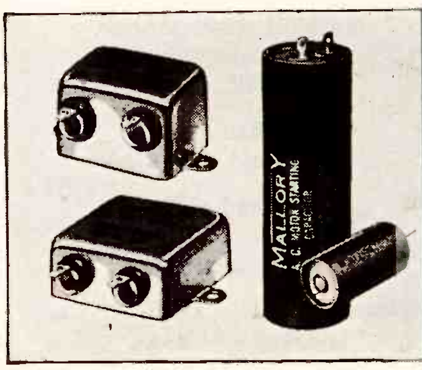
To prevent moisture absorption, loss of electrolytic, and to withstand destructive temperature changes, each "WB" capacitor is hermetically sealed in an aluminum case and is covered with a waxed cardboard tube that avoids shorting in crowded installations.

End-sealing wax has been eliminated to reduce the length still further.

Mallory "WB" Capacitors are available from stock in rated capacities from 10 mfd. at 25 volts to 16 mfd. at 450 volts.

The Mallory catalog, listing characteristics of "WB's" and other Mallory precision capacitors, variable and fixed resistors, switches, vibrators, rectifiers and other electronic parts, is available *free* from your nearest Mallory Distributor. Ask him for a copy, or write us today.

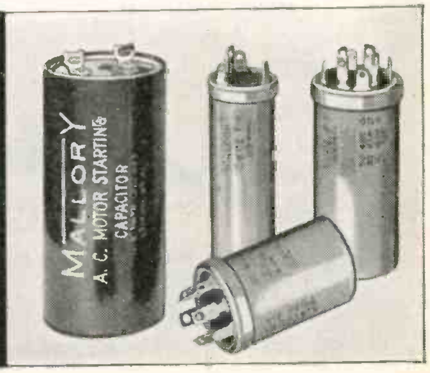
P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA



P. R. MALLORY & CO., Inc.

MALLORY

Electrolytic, Film and Paper CAPACITORS



Radio & Television Corp., St. Charles, Ill.

HARVEY W. SMITH, electrical engineer specializing in transformer design, joins the engineering staff of Glenn-Roberts Co., Oakland, Calif. He will head the research and development activities of the company.

STANFORD C. HOOPER, father of navy radio and consulting engineer for Automatic Electric Co., Chicago, Ill., receives the Franklin Institute's Elliott Cresson Medal for 1945. Admiral Hooper was selected for his pioneering leadership in the field of radio for the United States Navy. In the accompanying illus-

tration he is receiving the award from Charles S. Pelling, president of Franklin Institute, center, who presented at the same ceremony the Franklin Medal to Dr. Harlow Shapley, director of Harvard College Observatories and professor of astronomy, for his work in that science.

AWARDS

Workers of the following concerns in the electronics field have been awarded Army-Navy burgees for excellence in production:

Induction Heating Co.
New York, N. Y.

International Detrola Corp.
Detrola Radio Div.
Detroit, Mich.

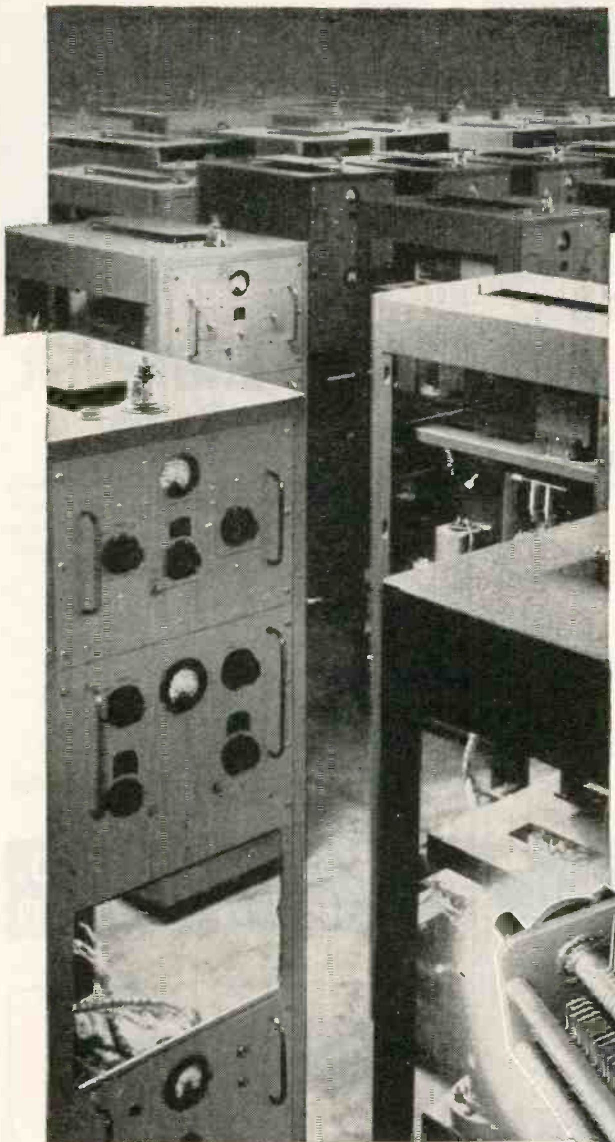
Machlett Laboratories,
Power Tube Division
Norwalk, Conn.

Pilot Radio Corp.
Long Island City, N. Y.

Rauland Corp.
Plants No. 1, 2, 3, and 4
Chicago, Ill.

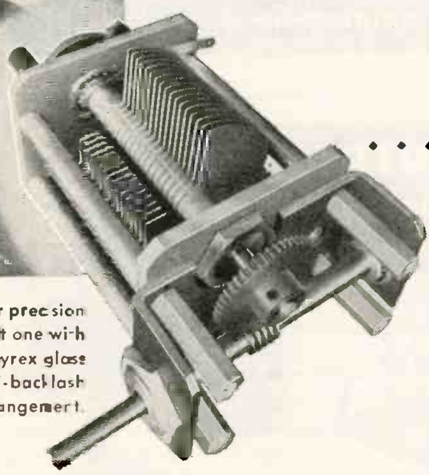
Sylvania Electric Products, Inc.
Wakefield, Mass.

ASSEMBLY LINE OF THE WELL KNOWN T350XM



ONE- TO FOUR-SECTION FIXED CAPACITORS. Designed for the output section of a pi-network, this compact, multiple capacitor eliminates the need for mica-type units. Typical capacities are 20, 40, 120 and 230 mmf. It has mycalex insulation throughout and all sections are common on one side. Complete tooling makes fast delivery possible.

You can break production bottlenecks with these components ...Techrad designed and built them for that specific purpose



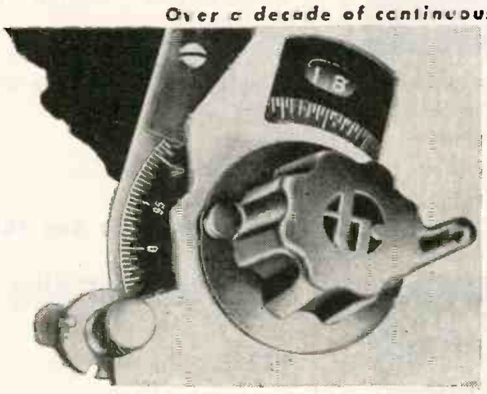
VARIABLE CONDENSER. To fill a need for precision variable condensers, Techrad designed and built one with the following features: ball bearings, pyrex glass insulation, soldered plates, .030" spacing, worm anti-backlash drive assembly and lead-screw stop arrangement.

technical radio company

275 NINTH STREET • SAN FRANCISCO 3, CALIFORNIA

EXPORT AGENTS: FRAZAR & HANSEN, 301 CLAY STREET, SAN FRANCISCO 11, CALIFORNIA, U. S. A.

*Over a decade of continuous **experience***



INTERPOLATING COUNTERDIAL. Swift, sure and accurate calibration. By giving an accurate log of any position it makes possible the exact return to any previously established setting. Mechanically simple, there are no parts to get out of adjustment; no back-lash because the dial is coupled directly to the driven apparatus. Standard stock counters have two digit number (0 to 99). Used by Techrad on variable condensers and roller inductors.

DIAL LOCK, for use with flat disc dials of various thicknesses. Simply constructed, it employs the established right-hand, left-hand thread principle. No dragging or scraping when dial is disengaged. It is impossible to distort or bend the dial scale when locked. Hairline accuracy of setting is maintained when dial is locked because the two locking discs do not rotate.

WRITE FOR COMPLETE INFORMATION AND DATA ON TECHRAD COMPONENTS

FOR QUALITY

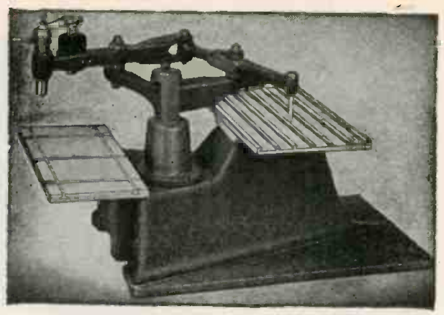
RADELL-BUILT PRODUCTS

• It is easy to recognize the marks of superior craftsmanship in Radell-built electronic products. With a broad basic knowledge and advanced production skill, Radell Corporation is a versatile organization specializing in the assembly and sub-assembly of highest quality electronic products.

COMPLETE FACILITIES FOR AUDIO WORK

RADELL CORPORATION

6323-37 Guilford Avenue, Indianapolis 5, Indiana



DUPLICATING and PROFILING

AUTO ENGRAVER

Accurate Engraving with Unskilled Operators

Unskilled operators will profile or accurately reproduce in smooth lines any design, number, letter, emblem, signature; on iron, brass, copper, aluminum, soft steels and all plastics. Here are some of its other uses . . .

- Drills a series of holes, or profiles small parts.
- Cuts an even channel for wiring on panels. Increases accuracy and production.
- Works from original drawing or templates.
- Etches glass and similar items.
- Will not cause distortion.

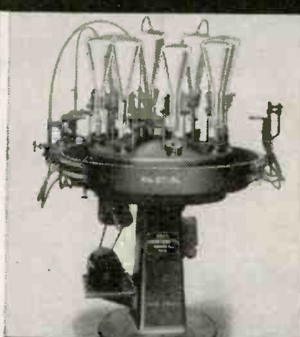
For complete information on this and other models and prices write Dept. K

AUTO ENGRAVER CO.
1776 BROADWAY, NEW YORK 19

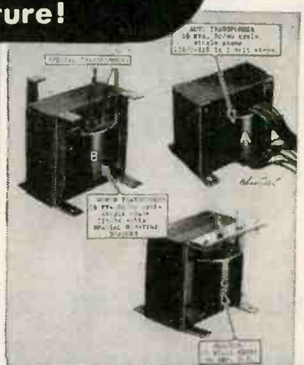
EISLER EQUIPMENT

..complete and diversified for every phase of electronic* manufacture!

(A) No. 600-KC3P, 50 KVA Press Type Spot Welder, 3 Spots, Air Operated, 18" Throat—a high production unit.



(B) No. 57-8L New Eisler 8 head type Tipless Sealing Machine. Adaptable for all types and sizes of bulbs.



(C) EISLER Special Transformers and Reactors — high or low voltage; air cooled, oil immersed or uncased.

The CHAS. EISLER line of specialized electronic tools, machines and devices is complete and diversified. Included are innumerable types of welders — spot, seam, butt, rocker, arm, pneumatic and special types. Also included are hundreds of devices for vacuum tube manufacture — glass tube cutters, slicers, stem and sealing machines as well as an all-inclusive line of transformers for every industrial and general need.

* EISLER serves 99% of American vacuum tube producers today. Write for completely illustrated catalog now—you incur no obligation.

Chas Eisler

Eisler ENGINEERING COMPANY

751 SO. 13th STREET NEWARK 3, NEW JERSEY

ACOUSTIC ENGINEER

TO DEVELOP LOUD SPEAKERS

Familiar with laboratory and measurement devices for checking loud speaker characteristics.

Right hand man to chief engineer. Permanent, post-war position with rapidly-growing loud speaker manufacturer located in New York City

Salary commensurate with qualifications

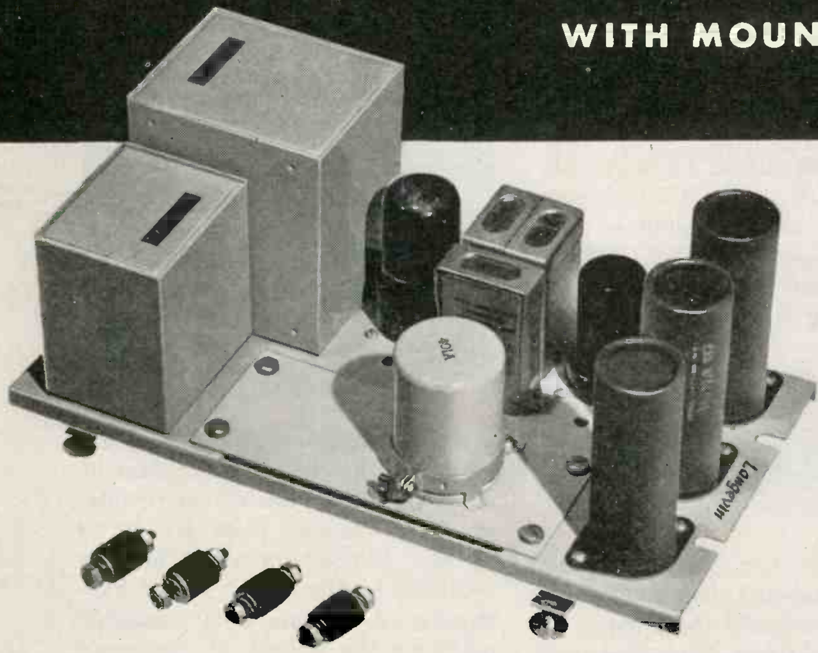
Submit complete resume

Write to Box 354

Cromwell Advertising Agency
INCORPORATED
122 E. 42d St., New York 17

106-A SERIES *Amplifiers*

WITH MOUNTING ACCESSORIES



The TYPE 106-A AMPLIFIER is a two-stage medium fixed gain preamplifier, designed for use in high quality broadcast-speech-input or sound systems. The low noise level generated within the amplifier and its excellent frequency response make it particularly desirable. It is small in size. Three 106 amplifiers can be mounted in a 10½" rack space. It requires an external power supply such as the Langevin 201-B.

ELECTRICAL CHARACTERISTICS

GAIN—Approximately 39 db with provisions for decreasing to 29 or 19 db maximum.

OPERATES FROM — Source impedance of 30/250/600 Ohms.

OPERATES INTO—Load impedance of 600 Ohms.

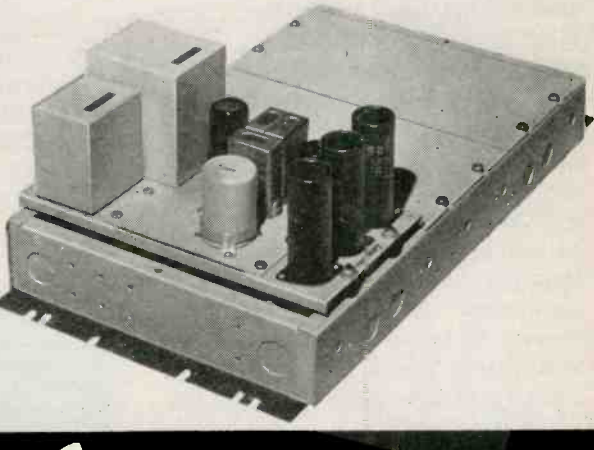
OUTPUT POWER— +16 dbm with less than 1% total R.M.S. harmonic distortion at 400 cycles single frequency.

OUTPUT NOISE—The unweighted noise generated within the 106-A amplifier is equivalent to an input signal of —119 dbm (db below .001 Watts) over a band width of 20,000 cycles.

FREQUENCY CHARACTERISTIC—Production run ±.5 to 1 db over the range 30-15000 c.p.s.

METERING CIRCUITS—Designed for plate current reading on a percentage type meter.

POWER REQUIREMENTS—FILAMENT 6.3 Volts, .6 Amperes. PLATE 275 Volts, 8 Milliamperes.



The type 3A mounting frame, requiring 10½ inches rack space, will accommodate up to THREE 106 Series Amplifiers and is suitable for wall mounting cabinet or rack and panel installations.

The Langevin Company

INCORPORATED

SOUND REINFORCEMENT AND REPRODUCTION ENGINEERING

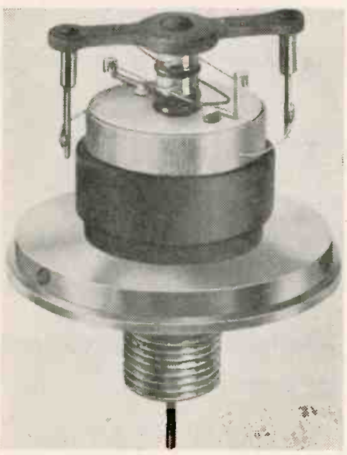
NEW YORK	SAN FRANCISCO	LOS ANGELES
37 W. 65 St., 23	1050 Howard St., 3	1000 N. Seward St., 38

NEW PRODUCTS

Month after month, manufacturers develop new materials, new components, new assemblies, new measuring equipment; issue new technical bulletins, and new catalogs

High-Sensitivity Resistors

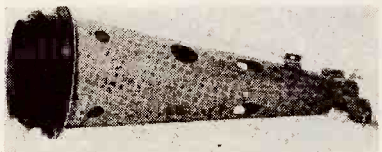
G. M. GIANNINI & Company (161 E. California St., Pasadena, Calif.) state that their autoflight high-sensitivity resistors are the first of their kind to be built in the United States. Overall dimensions of the components are $1\frac{1}{4}$ x $1\frac{1}{16}$ in. diameter and they are capable of producing from a low-torque rotational movement a variable electric resistance. They can be connected directly to sensitive low-torque apparatus such as aircraft flight test



recording instruments and will operate relays or recording systems without the use of amplifiers, and from a simple d-c source. The manufacturer also states that their development is a step forward toward the simplification of delicate circuit measurements, particularly in laboratory or industrial applications where photoelectric cells and amplifiers are required. Units come in various sizes from 100 to 1500 ohms, and from 4 to 15 watts. Only 2 gram-millimeters input torque to overcome friction is required. This low value is secured by use of a jewel-supported shaft, the contact mechanism being made with the accuracy of a fine watch.

Metal Tube-Shield

MODEL J-583 shield, for 5-in. cathode-ray tubes, meets Navy requirements for shock resistance. The shield is constructed of 0.025-in. Mu-metal and is hydrogen annealed at 1100 deg C to achieve magnetic

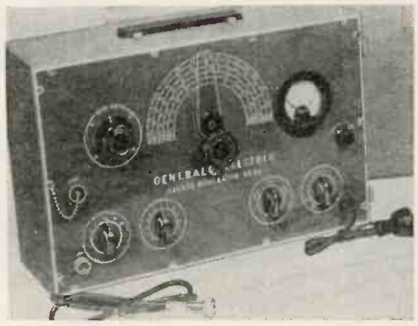


shielding. A rear clamp grips both the tube base and the socket of the tube so as to hold them firmly together at all times. For added shock protection the shields have sponge-rubber linings on the clamp and between the shield hood and the tube face. The shield is easily removed from tubes, when necessary. Metallic Arts Co., 243 Broadway, Cambridge 39, Mass.

Signal Generators

TWO NEW signal generators (Types SG-2A and SG-3A) and a new multi-range measuring instrument (Type UM-4) have been announced by the Specialty Div., General Electric Company's Electronics Department, Schenectady, N. Y. Type SG-2A generator provides a signal source only, the other (SG-3A) gives calibrated output readings. On fundamental frequencies SG-2A covers a range of 100 kc to 32

Mc in five bands which are selected on the front panel. Modulation of the unit (30 percent in accordance with IRE recommendations for receiver testing) is effected by the constant-current method on the plate of the oscillator tube. Changes in line voltage and attenuator settings do not affect the frequency of the instrument. Type SG-3A gives



directly calibrated readings of r-f output, with subdivided readings of signals of 0.5 to 100,000 microvolts, at all frequencies from 100 kc to 32 Mc. Signals up to 64 Mc are available by the use of second harmonics. A vacuum tube voltmeter monitors the output of the modulated oscillator to the attenuator while a panel control is used to maintain a constant level. Five complete reading scales are possible.

Type UM-4 Unimeter can be used

in cathode-ray tube and television high voltage uses, as well as in industrial and radio maintenance where voltage, current and resistance measurements are required. Safety protection on the meter is provided for the operator. On d.c. the unit operates from zero to 10,000 volts at 20,000 ohms per volt. On a-c ranges it operates from zero to 10,000 volts at approximately 5000 ohms per volt. Direct-current ranges extend from 100 microamp

Meet TWO LITTLE METERS THAT DO A GREAT BIG JOB!

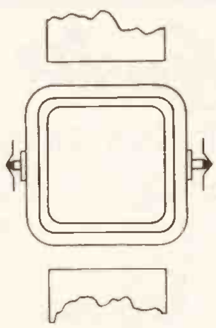
EXTERNAL PIVOT INSTRUMENTS

1½" Square Model 112

Measuring only 1¾" square by 25/32" deep, the 112 is capable of performing a full-scale task in a variety of applications. Made with the precision of all DeJUR larger instruments. It can be immersed in water at a depth of 30 feet for seven days without harm to mechanism. Movement built to forthcoming JAN-I-6 specification for 1½ inch instruments. Quickly and easily installed. Additional information upon request.

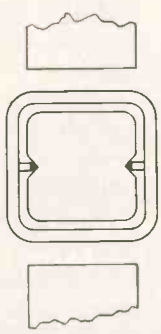
1½" Round Model 120

Another good friend to know. It also is capable of doing a man-sized job in many applications where space is at a minimum. Performs with high efficiency. Uses basically the same carefully designed components as large DeJUR instruments. Built with fine precision. Entirely self-contained, with built-in resistors and shunts. Also, immersion-proof throughout. Conforms to forthcoming JAN–I-6 specifications for 1½ inch instruments. Write for catalog.



External Pivots

EXTERNAL PIVOTS—used in the design of DeJUR 1½ inch Meters provide greater accuracy in mounting the moving element between the jewel bearings. For this reason internal pivots are not used in DeJur instruments.



Internal Pivots

DeJUR engineers are prepared to work with you on special models of DeJUR Products for your present and postwar applications.

DeJUR AMSCO CORPORATION

GENERAL OFFICE: NORTHERN BLVD. AT 45th STREET, LONG ISLAND CITY 1, N. Y

FOR QUICK VISUAL INDICATION

Investigate the Unique Characteristics of G-E Neon Glow Lamps

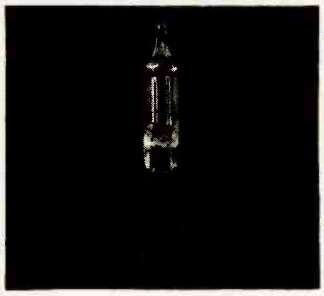
● The unique characteristics of General Electric Neon Glow Lamps recommend them for a variety of uses in radios and electronic devices . . . as indicators, voltage regulators, pilot lights and test lamps.

The uses described at right are typical. If you think G-E Neon Glow Lamps can be useful to you, write or phone the address below. Experienced General Electric Lamp Engineers will be glad to discuss your problems with you.

CONSIDER THESE ADVANTAGES

1. **Distinctive orange-red glow—no colored cover glass needed.**
2. **Dependable performance and long life—rated at 3,000 hours.**
3. **Very low current consumption—less than ½ milliampere for smallest lamp.**
4. **Variety of sizes and wattages.**
5. **High resistance to vibration, shock.**
6. **Normally usable on a-c or d-c.**
7. **Screw base lamps for 105-125 v. circuits; similar lamps available with bayonet bases, but external resistance required.**
8. **Produce practically no heat.**
9. **Nearly flat volt-ampere characteristics.**
10. **Insensitive to voltage variations above critical value.**

NE-51 For general indication, such as showing existence of potential across various parts of electrical circuits.



NE-2 One of the most widely used indicator and test lamps — popular because of compactness and small size. Nominal wattage is only 1/25 watt. This lamp is unbased—has wire terminals.

NE-48 (also NE-16). Indicator lamps. Special volt-ampere characteristics of these lamps indicate use as voltage regulators. Screw base lamp available as NE-45.*

NE-17 Indicator and pilot light lamp that flashes to show condition of B-battery in portable radios. Frequency of flashes decreases as battery runs down.

**NE—16 meets JAN-1A specifications for 991. Special marking JCG-991 supplied for small extra charge.*

ORDER NO.	NE-2	NE-51	NE-17	NE-48	④ NE-16	NE-45	NE-30	NE-32	NE-34	NE-36	NE-40	NE-42
Watts, Nominal	1/25	1/25	③	¼	¼	¼	1	1	2	2	3	3
Volts (Circuit)	105-125	105-125	③	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125	105-125
Starting Voltage ① AC / DC	65 / 90	85 / 90	③	65 / 90	— / ⑤	85 / 90	60 / 85	60 / 85	60 / 85	60 / 85	60 / 85	60 / 85
Base	★Unbased (Wire Terminals)	★S. C. Bay. Min.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	★D. C. Bay. Cand.	Cand. Screw	Medium Screw	★D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.	Medium Screw	★Sk. D. C. Bay. Cand.
Maximum Over-all Length	② 1-1/16"	1-3/16"	1½"	1½"	1½"	1-5/8"	2-1/16"	2"	3-5/16"	3¾"	3-5/16"	3¾"
List Price (plus tax)	$.08	$.10	$.45	$.35	$.42	$.40	$.40	$.45	$.50	$.55	$.60	$.65

① Applies to lamp when new.
② Glass part; wire terminals extend additional 13/16".
③ Designed for DC flashing operation in RC circuit.
④ Meets JAN-1A specifications for 991. Special marking JCG-991 supplied at small extra charge.
⑤ Designed for 67-87 Volts D.C. (D.C. operating voltage at 1.5 milliamperes, 53-65 volts).
★ All Bayonet Base Lamps Need External Resistance.

For further information, write address below for Bulletin 7100

NELA SPECIALTY DIVISION LAMP DEPARTMENT

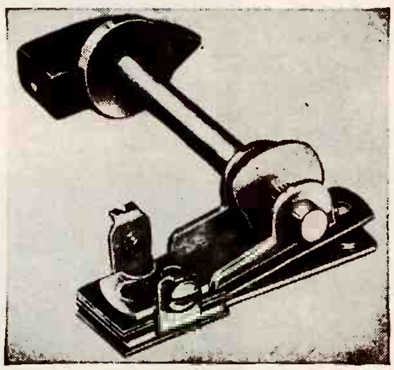
GENERAL ELECTRIC

1 Newark Street, Hoboken, N. J.

to 10 amp in 6 steps, and resistance measurements are provided from 3000 ohms to 10 megohms in 5 steps.

Thermostatic Switch

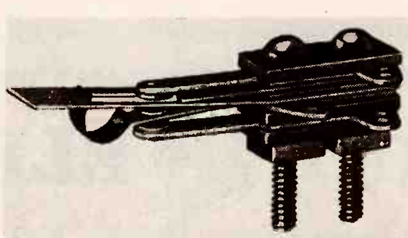
THIS NEW DUAL cam-adjusted thermostatic switch (rated at 1500 watts, 115-230 volts) can be used for either or both a thermostat and a manual switch. It eliminates the necessity of an additional on and off switch and permits instant adjustment of the thermostat. It is designed for mounting on the bottom of electrically-heated equipment such as glue pots, hot plates,

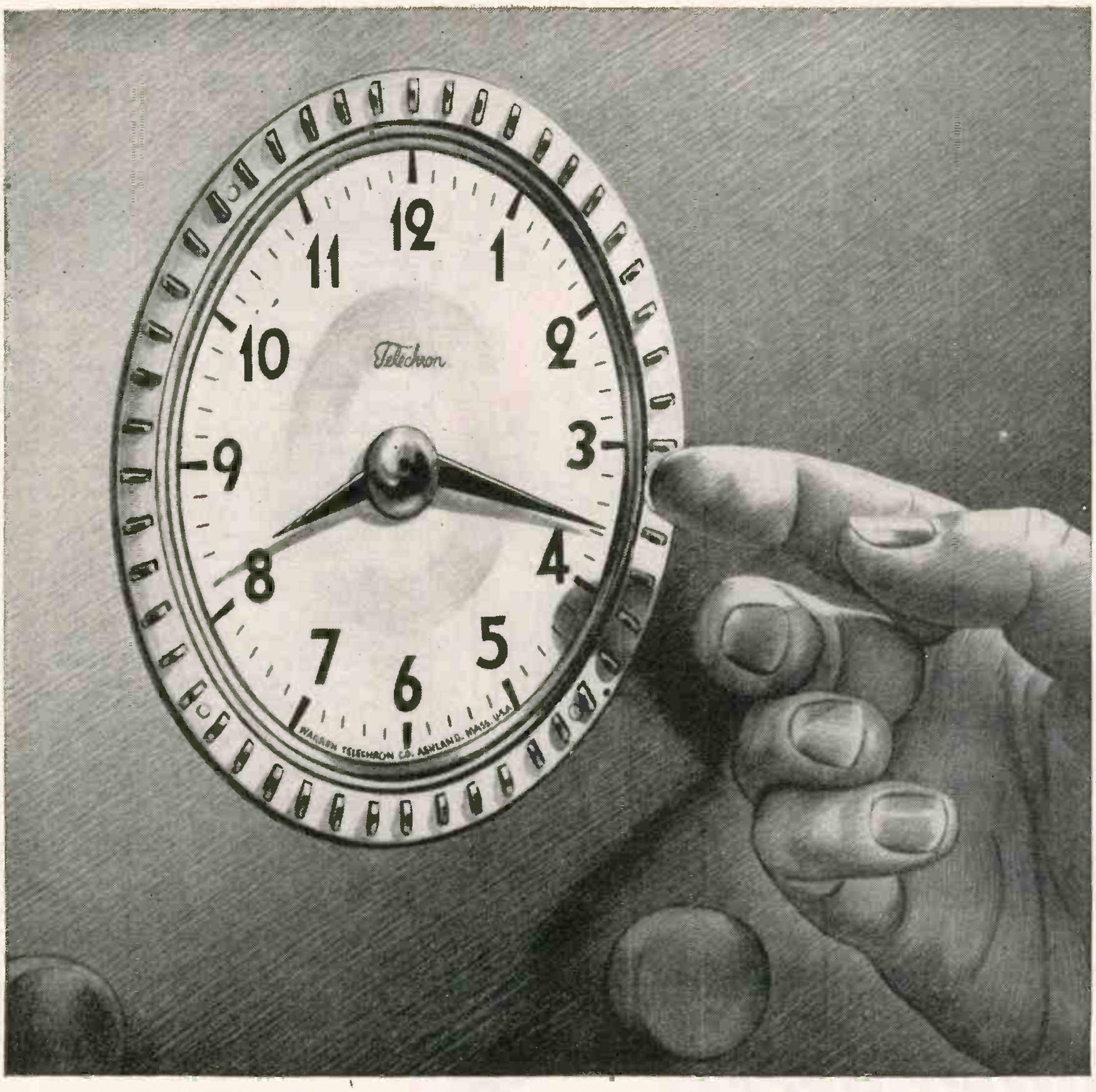


etc., where a manual on and off knob is desired. The knob which controls the temperature setting can be located any distance from the thermostatic element by lengthening the cam shaft. The unit is available in three adjustable temperature brackets: 50 to 300, 50 to 450, and 50 to 700 deg. F. George Ulanet Company, 88 E. Kinney Street, Newark, N. J.

Open Blade Switch

ILLUSTRATED below is a single-pole open-blade switch which is made of berryllium rolling springs. It is rated 15 amp, 115 volts a.c. Overall dimensions are 2 1/32 x 10/16 x 23/64 inches. Contact arrangements are for normally open, normally closed or double throw circuits. Standard operating pressure





A TELECHRON SELECTOR FOR POST-WAR RADIOS

THIS carefully engineered timer gives radio receivers dramatic two-way sales appeal. It's a dependable electric clock that provides the accurate time listeners need. *But it's much more.* It turns on the set automatically at any preselected time in the morning to waken a member of the family—or the whole household—with music. It switches the set on for favorite programs during the day and evening and shuts it off at bedtime.

Set buyers will like the easy finger-tip control of this built-in Selector. There are no knobs to turn, no complicated settings, no difficult calculations. All that's needed to set the timer for any 15-minute period is to flip one of the 48 keys around the large, legible Telechron clock dial. Fifteen minutes after the set has been turned on, it will switch off unless the next key is also pulled. Keys are automatically reset to "off" position after timing periods are passed. Programs can be selected as far ahead as 10 hours.

The cost to radio set builders will be surprisingly low—less than $4. That recommends the Selector for moderate-price receivers.

The Telechron Selector is only one of the full line of automatic timing and control devices we can supply for post-war appliances. All use famous Telechron movements and self-starting synchronous motors.

For full information about this and other Telechron timers, wire or write Automatic Control Division, Dept. K.

WARREN TELECHRON CO. • ASHLAND, MASSACHUSETTS

Telechron
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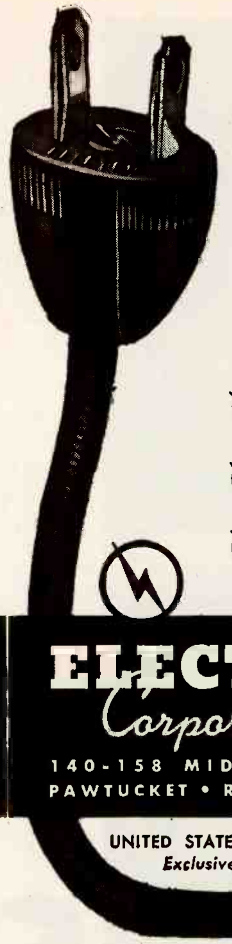

Streamlined

... in appearance
... in assembly

ELECTRIX PLUGS offer

- Superior features of mechanical design
- Quick, easy assembly
- Lowest cost per finished unit

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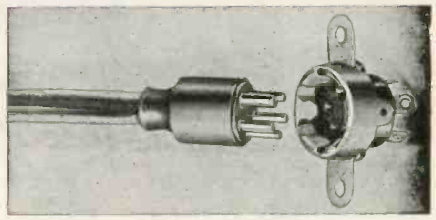
ALDEN

SHIELDED PLUGS & SOCKETS



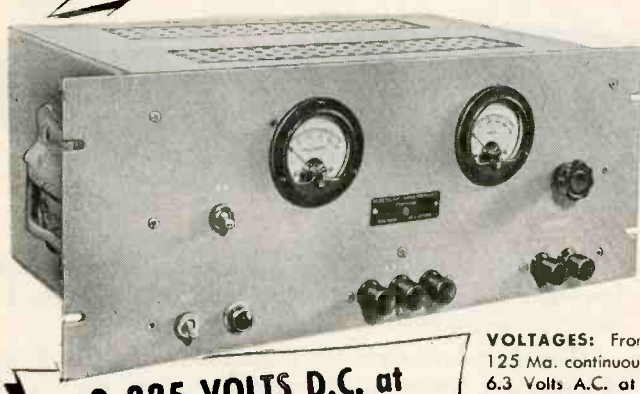
The new automobile set or any commercial requirement for shield grounding socket is going to demand this quality patented socket. Here's what it is and does. It's a metal seal socket that has a rounded edge entrance that grounds the plug upon insertion. The plug has long insulated protection for each lead and was designed to meet all the cable manufacturers' problems of efficient use, as to ease of cutting leads, preparing ends, soldering shield, and applying overbraids. The shield cover seals the plug dust, fungus and moisture tight. Quality—but again, by meeting our design standards, inexpensive with appreciable assembly saving whether supplied by us with the cable or cable is made by others.

Write for the
ALDEN "BLUE-BOOK"
of Electrical Components

ALDEN PRODUCTS COMPANY
BROCKTON (64E) MASS.

MODEL 200-B

POWER SUPPLY



continuously variable voltage *plus* regulation

0-325 VOLTS D.C. at 125 MA. Without Switching

Due to its flexibility and ease of operation the Model 200-B Power Supply has a wide variety of applications in the laboratory and on the production line Write for descriptive technical bulletin.

VOLTAGES: From 0-325 Volts D.C. at 125 Ma. continuously variable.
6.3 Volts A.C. at 6 Amps. center tapped

REGULATION: Within 1% for voltages between 20-325 volts from no load to full load.
Within 2% at 10 volts from no load to full load.

HUM VOLTAGE: Less than 10 millivolts including noise.

METERED OUTPUT: Voltmeter and Milliammeter included to read output voltage and current.

E/M

ELECTRONIC MEASUREMENTS COMPANY
RED BANK • NEW JERSEY

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MECHANICAL
and
ELECTRICAL

Experienced in

ELECTRONICS,
Chassis Design
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CONTROLS

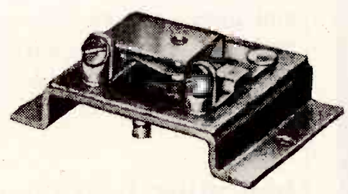
Designers and manufacturers seeking accuracy and efficiency of operation in control or protection devices rely more and more on Klixon Disc-operated Controls.

The Spencer snap-acting thermostatic disc . . . the fool-proof actuating element of Klixon Controls . . . always snaps to a quick, clean break or solid make assuring accurate and dependable operation no matter how often it operates.

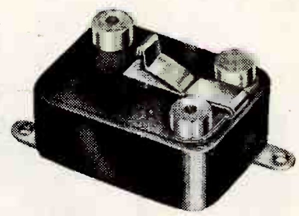
Small, compact, light in weight, Klixon controls meet design and exacting performance requirements in such applications as transformer overheat protection, electrical circuit overload protection, thermal time delays and temperature control for radio equipment. Their reliable operation is unaffected by motion, vibration, shock or altitude.

If you need control or protection, investigate Klixon snap-acting controls. They are available in many standard types to meet most requirements. Write for information, today.

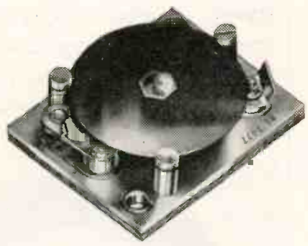
Type RT Thermostat. Adjustable Temperature Control.



Type C-4351 Thermostat. Used for Tube Warming, Tube Cooling, High Limit Controls, etc.



Type C-7220 Precision Snap Switch 12 amps. 30 Volts D. C., 125 Volts A. C.



Type B-3120 Thermostat and Heater, Crystal Dew Point Control

Type C-2851 Thermostat. For such use as Roughing Controls on Outer Crystal Ovens.

Type PM (NAF-1131) Circuit Breaker.

Type ER Series. Ambient Compensated Time Delay Relays.

KLIXON

SPENCER THERMOSTAT CO., ATTLEBORO, MASSACHUSETTS

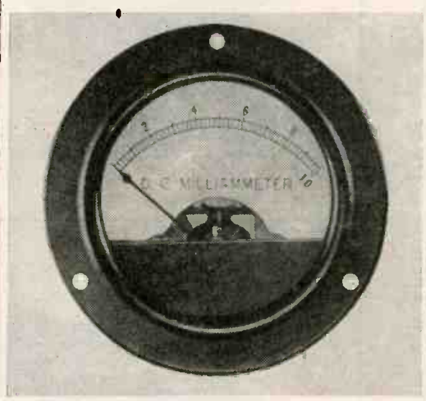
at the end of the blade is from 3 to 6 oz. The manufacturer states that tests of these switches show a mechanical life expectancy of more than ten million operations. Acro Electric Co., 1316 Superior Ave., Cleveland 14, Ohio.

Output Transformers

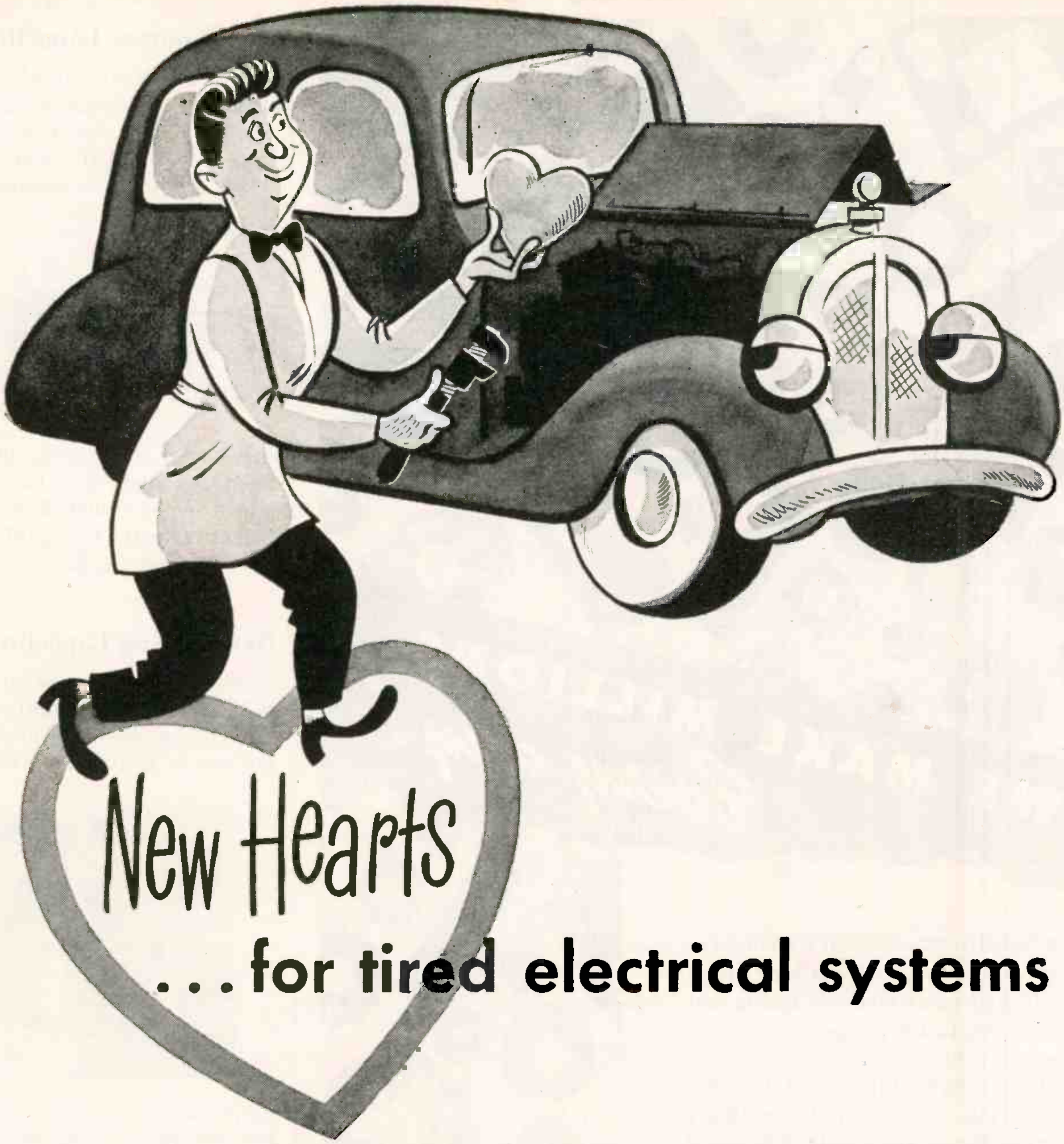
A NEW SERIES of hermetically-sealed aluminum-case output transformers has been designed by The Acme Electric & Mfg. Company of Cuba, N. Y. The manufacturer states the use of annealed steel cores and special vacuum-impregnated coils improves the operating efficiency and over-all performance. Terminals of Pyrex glass with Kovar electrodes and metal collars form a hermetic seal that complies with standards established for 5-cycle immersion tests.

Indicating Instruments

HICKOK ELECTRICAL Instrument Co., 10527 Dupont Ave., Cleveland 8, Ohio, announces new hermetically-sealed electrical indicating instruments with internal pivot construction in 2½, 3½ and 4-inch round styles. Dimensions are in accordance with AWS specifications. The 4-inch types are for radio service equipment where several scale arcs



are required. All three styles include voltmeters, ammeters, milliammeters and microammeters, for both ac and dc. Units can also be sealed with dry air at sea level pressure or inert gas. Glass on the case will withstand 25 lb pressure per sq in. The instruments are vacuum and pressure tested under water. Terminals are special glass soldered-in type using a direct bond of glass to metal.



New Hearts
...for tired electrical systems

Keeping America's aging automobiles, trucks, tractors, and buses rolling is a vital wartime task.

Part of this task is performed by General Products Corporation, of Union Springs, N. Y.

They produce what are often called the heart of the electrical system—replacement ignition coils for many makes and models of vehicles.

Thus, when aging electrical systems develop heart trouble, General Products steps in with coils to give them new leases on life—to keep America rolling.

General Products coils are good coils—fully up to their tough jobs. That's why we at Wheeler Insulated Wire Company are proud to supply the coil windings that go into them.

For the 35 years of its existence, Wheeler Insulated Wire Company has devoted its talents and experience to the manufacture of high-quality windings and other wire specialties.

Our entire capacity has been bought by a comparatively few customers—mighty *good* customers!

After the war, we hope to have many additional customers—for our manufacturing facilities have been greatly expanded in the interest of the war effort.

When that time comes—*Remember Wheeler for Windings!*

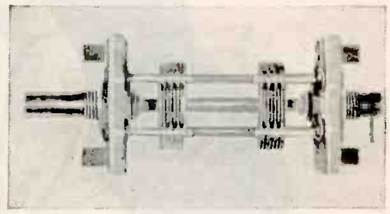
The Wheeler Insulated Wire Co., Inc.

BRIDGEPORT 4, CONN.

Manufacturers of Magnet Wire...Litz Wire...Coil Windings
Transformers...Ballasts for Fluorescent Lighting

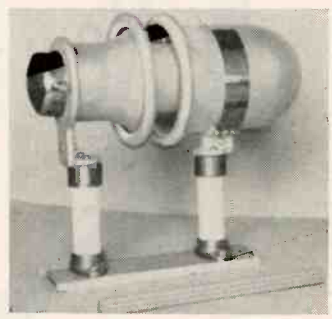
Air-Trimmer Capacitor

UNITS ARE available either single or dual, in capacitance ranges from 5 to 140 mmf, with standard air gaps of 0.012, 0.015, 0.019, 0.030 or 0.045. Units have ceramic mounting bases, with brass plates and mounting studs of either cadmium, silver or nickel plated, as required. Comar Electric Co., 2701 Belmont Ave., Chicago 18, Ill.



Neutralizing Capacitor

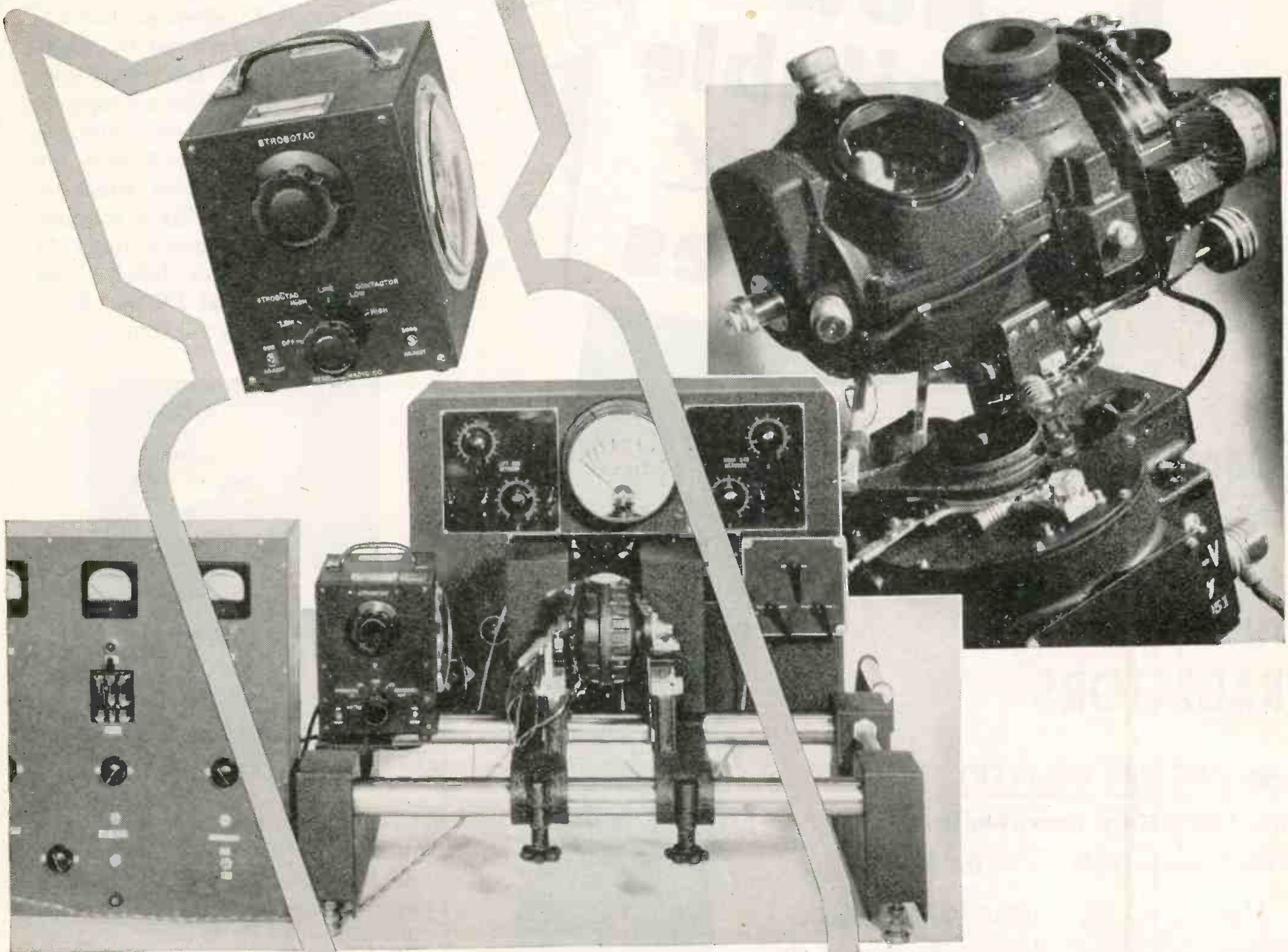
TYPE TN capacitor is an addition to the type N line manufactured by E. F. Johnson Co., Waseca, Minn. for use in neutralizing circuits of radio transmitters. Two sizes available are rated at 45,000 volts and 35,000 volts peak breakdown, respectively.



Portable X-Ray Tube

A NEW X-RAY UNIT, using a shockproof tube (approximately 3 in. in diameter) examines internal structure of welds, rivets and other points of stress in confined spaces (such as airplane wings, fuel tanks, etc.) The tube is coupled to the generator by means of a shockproof cable and two small water hoses. The high-loading anode tubes are available with targets of copper, cobalt, iron, or molybdenum. Ratings range from 10 to 20 milliamp at potentials up to 50 kv, depending on the target material. North American Philips Co., 100 East 42nd St., New York 17, N. Y.

PRECISION *to 0.000070 Inch!*



● One of the mechanical marvels of the war is the famed Norden Bombsight, until recently one of the most secret of military devices. Information on some of its general features has now been released by the Army.

This bombsight is probably the most precise instrument in the world, yet it is being built in mass production by the Victor Adding Machine Company and several other manufacturers.

The heart of the bombsight and its associated stabilizer are two gyros which have to be balanced to almost unheard-of accuracy. When inspected, the rotor must be centered to *70 millionths of an inch.*

To obtain this accuracy, each gyro is carefully adjusted on the balancing machine shown in the illustration. This portable unit is manufactured by the Gisholt Machine Company. General Radio's STROBOTAC is a part of this machine.

The control equipment at the left includes an electronic speed regulator which maintains the gyro at the speed selected by the STROBOTAC. The equipment behind the gyro measures the amount of weight to be removed from the gyro rotor to give balance, while the STROBOTAC again is used to point out the angular position at which unbalance should be removed.

Gradually as the requirements of military security are relaxed, we hope that we can tell you of many other war uses for General Radio equipment.

In the meantime, possibly your interest in the STROBOTAC is associated with the war effort. STROBOTACS are available for top-priority war work. If you'd like detailed information about the STROBOTAC, ask for Bulletin 962

GENERAL RADIO COMPANY Cambridge 39, Massachusetts

90 West St., New York 6 920 S. Michigan Ave., Chicago 5 1000 N. Seward St., Los Angeles 38

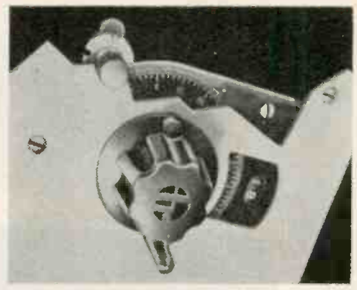
Submersion-Proof Microphone and Headset

"WATER BUFFALO" is the name of a new submersion-proof lip microphone and headset combination developed by Bell Telephone Laboratories and manufactured by Western Electric Co., 195 Broadway, New York 7, N. Y. The microphone is equipped with an especially designed gland which will pass air but exclude water, and which is capable of withstanding a submersion cycle of 25 minutes under 10 inches of sea water followed by baking in an oven at 125 deg F repeated five consecutive times with-

out damage to the instrument. Not much larger than a half-dollar and less than one-half inch thick, the mike employs the differential principle of operation. When it is properly adjusted before the lips of the user, noise enters from the front and rear in phase and cancels out, thereby making the mike relatively unresponsive to unwanted sounds, yet sensitive to speech. Thus the mike and headset can deliver and receive articulate speech under the most adverse noise conditions. The headset, also submersion-proof, is of a flat-response type. It is fitted with soft neoprene ear-cushions to assure high transmission quality.

Interpolating Counterdial

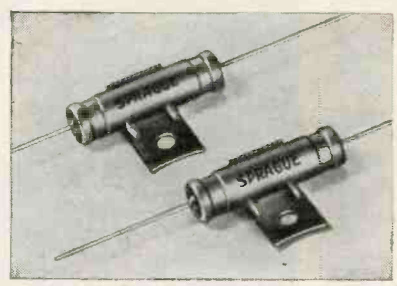
THESE INTERPOLATING counterdials have the dial coupled directly to the driven apparatus to prevent their getting out of adjustment. The scale graduations run from zero to 100 for each revolution of the dial. Each graduation has two marked divisions, making a total of 200 readable parts on the dial, with the



possibility of estimating accurately at least 200 more settings. An additional counting mechanism records each dial revolution, either forward or backward, thereby giving an accurate log of the setting in revolutions and fractions of a revolution. Standard stock units have two digit numbers (from zero to 99) but three digit numbers are available on special order. Technical Radio Co., 275 Ninth St., San Francisco, Calif.

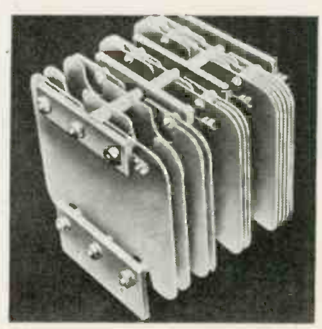
Capacitors

THREE MANUFACTURERS announce new capacitors. The first of these is a non-resonant capacitor called "Hypass" which does not show



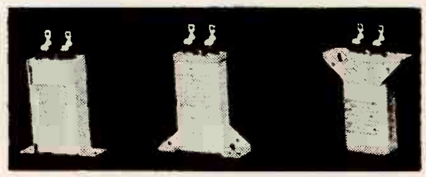
resonance at frequencies as high as 50 Mc, and in instances even up to 300 Mc. Sprague Electric Co., North Adams, Mass.

Technical Radio Co., 275 Ninth St., San Francisco, Calif. has added to their line capacitors with from 1 to 4 sections (20, 40, 120 and 230



$\mu\mu$f). Over-all dimensions of this capacitor are 5⅜ x 5¼ in. It is designed for the output sections of a pi-network.

General Electric Co., Schenectady 5, N. Y. announces two new types. The first of these is a fixed paper-dielectric capacitor which comes in case style No. CP-70 and is for electronic equipment for d-c applications. There are 268 standard ratings, ranging from 0.1 to 15 microfarad, for circuit voltages from 600 to 12,500 volts. All ratings have a capacitance tolerance of plus or minus 10 percent. Complete data is contained in Bulletin No. GEA-4357. The second capacitor types available from G. E. are case styles CP-60, CP-62 and CP-64



fixed paper-dielectric capacitors with glass terminal seals. The glass seals provide resistance to humidity, fungus growths, and termites. All three case styles are available in both single-section and two-section construction. Capacitance values range from 0.05 to 0.50 microfarad, for voltages of 600, 1000 or 1500 volts.

Current and Voltage Unit

MODEL No. 601 voltammeter consists of an ammeter and a voltmeter which comes in a single case measuring 12½ x 9½ x 10 inches. The ammeter measures from 0.2 to 500 amp in 8 current ranges. The voltmeter measures from 30 to 600 volts in 3 ranges. An inserted primary current transformer with

8-ft secondary leads facilitates measurement of current on 0-100, 0-250 and 0.500 amp scales without subjecting the meter to stray magnetic fields. Scales of the units can be easily and quickly read. Associated Research, Inc., 231 S. Green St., Chicago 7, Ill.

What!... Voluntarily lower the price on a contract already awarded?

Don't be silly!

To lower the price on a contract involving a *new* part is one thing. But when you "bid in" at a lower price than anyone else on a contract covering a device that's already history—and still reduce the figure after the deal is closed—it's something altogether different.

Specifically . . . a contract to turn out a special aluminum part for a major company making automatic pilots for Uncle Sam's fighter planes.

We Cut Our Original Bid to Less Than Half.. And On Top of It Broke a Bottleneck

We bid low, at $38.10 per unit. Up until then, each part required 54 inches of intricate welding—and there had been a shortage of welders capable of doing it. Rejects at testing had been 40%. It had been possible to make only 500 a week.

To boost the output, we looked for a better way of doing it. The answer turned out to be "impact extrusion". Heretofore, manufacturers had used it only for small parts, limited to 2 inch diameter and 3 inch draw. In the process, we eliminated all but approximately 9 inches of welding—plus the need for critical aluminum tubing. Rejections dropped to about 2%. Production jumped to 500 a day, instead of 500 a week.

Our contract price $38.10—but we billed $18.85.

So, Uncle Sam gets the automatic pilots he needs . . . the prime contractor cuts his costs (on top of our original low bid)—and we're feeling very good about it.

Perhaps the fact that we have been in the subcontracting business for over 50 years has something to do with our ability to improve part designs, cut production corners and lower costs.

★ ★ ★

Write on your business stationery for 48-page book, "Let Lewyt Do It"—the story of the Lewyt organization in pictures. Lewyt Corporation, 60 Broadway, Brooklyn, N. Y.

ARMY E NAVY

Lewyt

A CONTRACT MANUFACTURER—EXPERTLY STAFFED TO PRODUCE COMPLETE ELECTRONIC AND MECHANICAL ASSEMBLIES, COMPONENT PARTS AND SUB-ASSEMBLIES, TO THE MOST EXACTING REQUIREMENTS

CONTINUE BUYING WAR BONDS

Circuit Tester

THIS NEW multi-purpose circuit tester audibly tests continuity and insulation between wires, or from wires to ground. With a special indicator attachment it also determines visually the polarity of wires.

Operation is accomplished by a regulated hand-cranked generator which develops 500-volts d.c. Great American Industries, Inc., Connecticut Telephone & Electric Div., Meriden, Conn.

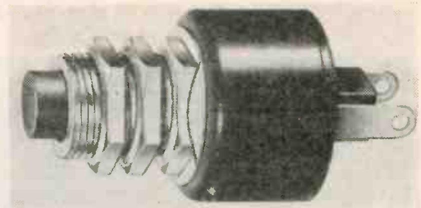
Multimeter

THIS MULTIMETER, designated as Model PB-200 Speed-O-Meter, has a sensitivity of 2000 ohms per volt on both a.c. and d.c. It measures a-c or d-c voltages up to 1500 volts;

d-c current to 1.5 amp; capacitance to 30 mfd; decibels to plus 58; and resistance to 2 megohms. Superior Instruments Co., Dept. W, 227 Fulton St., New York 7, N. Y.

Snap-Action Switch

A SMALL, push-button, snap-action switch called Snapit operates on a 0.0625-in. movement of the push button and carries a current rating of 10 amps at 115-volts a-c., and 2 amp at 115-volts d.c. The fixed contacts are of silver overlay on phosphor bronze. The contact gap is 0.040 in. on each contact. The



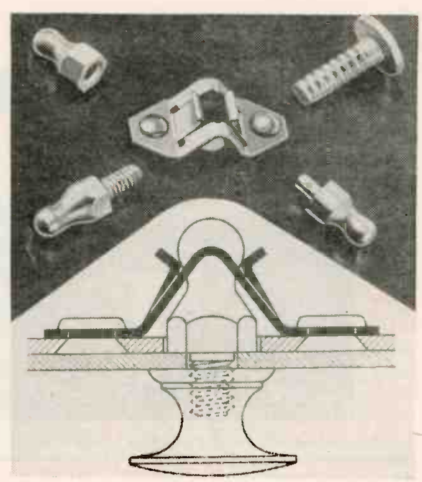
switch has a phenolic body which is round and which measures $\frac{7}{8}$-in. diameter x $1\frac{7}{8}$-in. high. Grayhill, 1 N. Pulaski Road, Chicago 24, Ill.

Adapters for Solderless Wiring

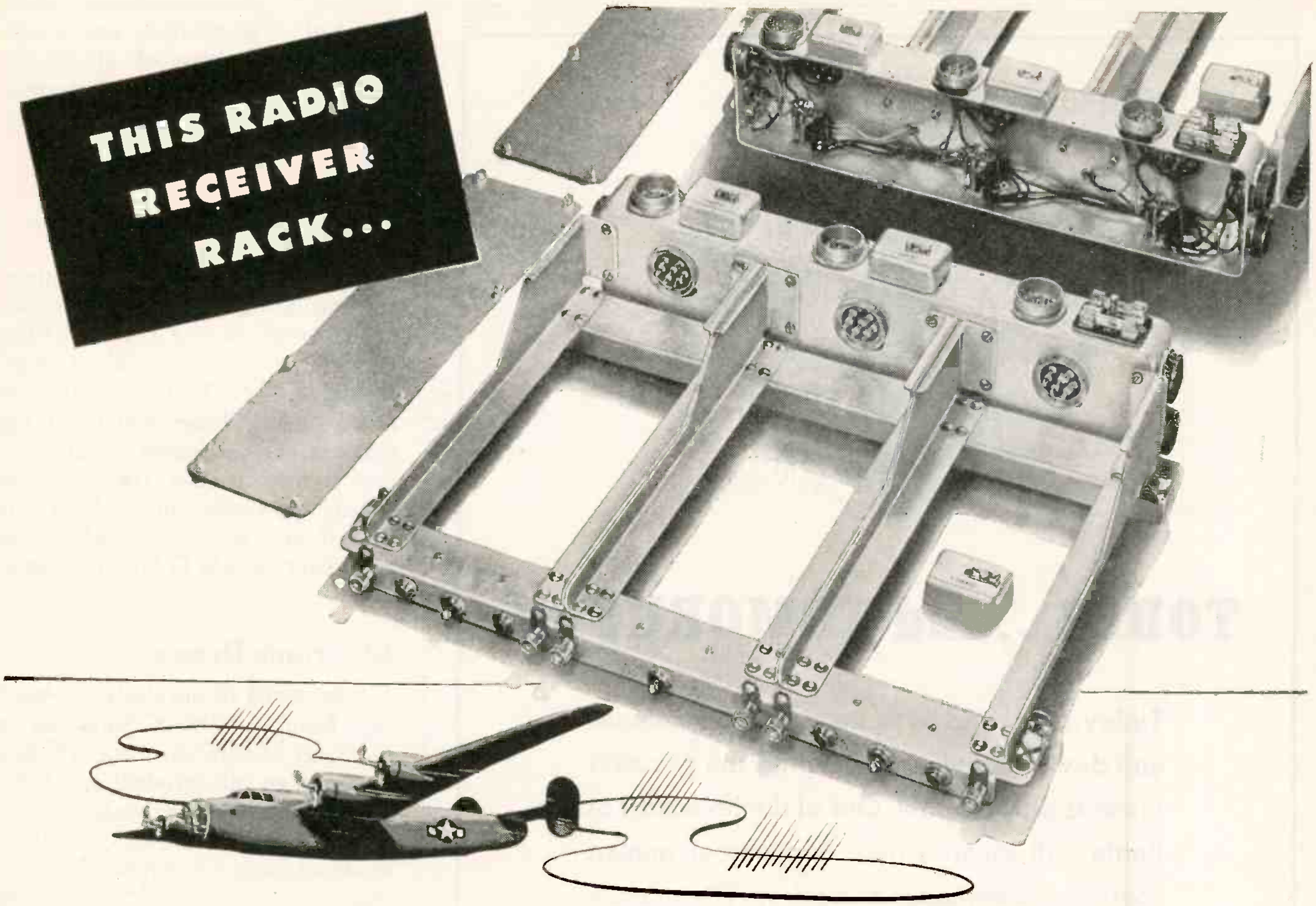
KNIFE-DISCONNECT component parts are manufactured by Aircraft-Marine Products (1591B North Fourth St., Harrisburg, Pa.) for rapid, inexpensive conversion of any existing electrical assembly for use with their knife-disconnect splicing terminals. The adapter is installed in the assembly in the same way as the solder tab it replaces. Adapters for vertical or horizontal conversion for wire sizes from 22 to 10 are available.

Steel Nut Latch

NEW, SPRING-STEEL speed-nut latch, No. 1663, is for instant attachment and removal of box covers, access doors, panels and inspection plates. Three styles of ball studs are available—drilled and tapped for 6-32 screws, threaded shank (632 thread) and plain shank for riveting. These, as well as grooved stud, are provided in various lengths to



suit application requirements. Samples are available but it is necessary to specify pull-out tension required ($3\frac{1}{2}$, 8, 12, 18, or 30 lbs.); thickness



*contains more than 500 Electrōnents**
. . . all made and assembled by Scovill

This three-position, high-frequency radio receiver rack for big bombers . . . one of the most intricate manufacturing and assembling problems ever entrusted to Scovill . . . shows how Scovill's versatile production facilities can meet requirements for electronic components or complete assemblies.

More than 500 individual parts are assembled in this rack. Materials used range from plastics to metal alloys in the form of sheet, rod, wire and tubing. Scovill makes all except glass and plastics components. Methods include forging, stamping, drawing, heading, machining, and wire forming.

Even complicated wiring does not stump Scovill's production engineers. Every wire is cut to length, stripped and soldered into correct position. Relays are manufactured, tested and adjusted by Scovill technicians.

In other words, Scovill engineered the whole job for assembly-line production . . . a service that can help you, too, save time, trouble and money on the production of small electronic components as well as large assemblies. For further details about the scope of Scovill's ingenuity and facilities, send for literature. Fill in coupon below and mail today.

*Electrōnents = Electronic Components

Scovill
MANUFACTURING COMPANY
WATERBURY 91, CONN.

Please send me a free copy of *"Masters of Metal"* booklet describing your facilities. I am interested in the ELECTRŌNENT* applications checked.

- ☐ Batteries
- ☐ Record Changers
- ☐ Clips
- ☐ Condensers
- ☐ Dials
- ☐ Escutcheons
- ☐ Jacks
- ☐ Lugs
- ☐ Panels
- ☐ Sockets
- ☐ Stampings (misc.)
- ☐ Tubes

Other applications..........

SCOVILL MANUFACTURING COMPANY
Electronic Division
22 Mill Street, Waterbury 91, Connecticut

Name ....

Company ....

Address ....

of panel to which speed nut will be attached; type of stud; and length of plain or threaded shank, or length of grooved stud. Tinnerman Products, Inc., 2106 Fulton Road, Cleveland 13, Ohio.

Insulating Grommets

FOUR NEW standard sizes of phenolic insulating grommets have been added to the line of Creative Plastics Corporation, 963 Kent Ave., Brooklyn 5, N. Y. These units are screw-type bushings which will not pop out of the chassis when wires are tightly packed through. For speedy assembly the collars are geared and matte finished. Hole sizes vary from $\frac{1}{8}$ to $\frac{1}{2}$-in. clearance.

Electronic Heater

A NEWCOMER TO the electronic-heating field is Climax Engineering Company of Clinton, Iowa, which is ready to go into production of Climax high-frequency heaters which are designed for quick, efficient, localized heat for surface hardening, annealing and brazing. The

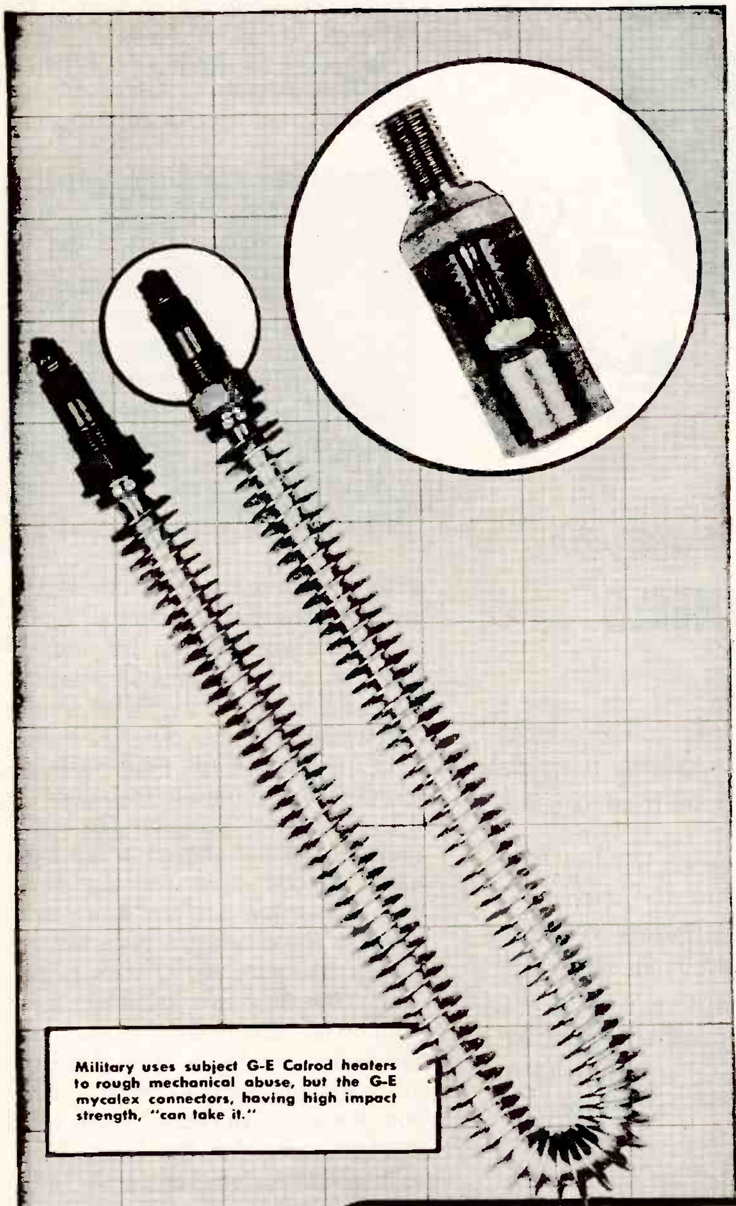
equipment can also be used for such food applications as sterilization, pasteurization, deactivation of enzymes, cooking and heating, baking, destroying infestation, packaging and sealing. Climax expects to produce 12 different models of standard electronic heaters.

Vacuum Indicator

FOR TUBE MANUFACTURERS there is a new type vacuum indicator (designated Tru-Vac) which operates from any 110-120-volt a-c outlet. It is scaled to read pressures of a vacuum system from 0.25 to 250 microns, and is accurate to ± 2 per-

How G-E Mycalex keeps the Calrod dry

AN IDEAL SEAL—IT'S MOISTURE PROOF—IT'S PERMANENT



Military uses subject G-E Calrod heaters to rough mechanical abuse, but the G-E mycalex connectors, having high impact strength, "can take it."

G-E MYCALEX utilizing metal inserts makes this sealed terminal connector for G-E Calrod heaters permanently moisture and oil proof.

AND THE REASONS . . .

(1) Metal inserts can be combined with G-E mycalex during the molding process, and as a result, the metal and the G-E mycalex are fused into an unusually strong bond, locking out moisture, oil and gas.

(2) A permanent seal is assured because of G-E mycalex's unique properties. In this G-E Calrod application it is subjected to temperatures up to 375°C, constant exposure to water, oil and chemical fumes; yet G-E mycalex maintains its dimensional stability and the seal remains unbroken.

Only G-E mycalex was able to solve this tough insulation problem because it has a combination of features not found in any other insulation.

The General Electric Company solved this one and stands ready to put G-E mycalex to work in solving those "impossible" insulation problems of yours.

For further information, write section S-52, General Electric Company, 1 Plastics Avenue, Pittsfield, Mass.

Hear the General Electric radio programs: "The G-E All Girl Orchestra" Sunday 10 P.M. EWT, NBC. "The World Today" news every weekday 6:45 P.M. EWT, CBS. "G-E House Party" every weekday 4:00 P.M. EWT, CBS.

Buy War Bonds

GENERAL ELECTRIC

PD-52

G-E MYCALEX HAS THE FOLLOWING PROPERTIES:

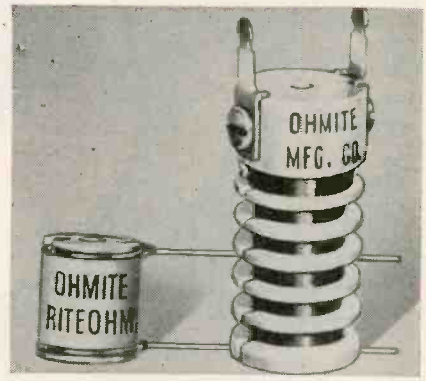
1. High dielectric strength
2. Low power factor
3. Prolonged resistance to electric arcs
4. Chemical stability; no deterioration with age
5. Dimensional stability; freedom from warpage, shrinkage, etc.
6. Imperviousness to water, oil and gas
7. Resistance to sudden temperature change
8. Low co-efficient of thermal expansion
9. High heat resistance

cent throughout the scale, with constant voltage. Meter may be read from a distance, if desired. Gage is unaffected by changes in barometric pressure. Continental Electric Co., Geneva, Ill.

Resistors

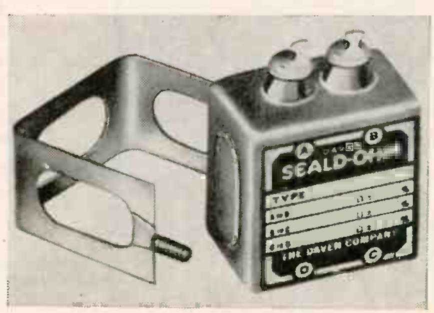
NEW TYPE RESISTORS have been announced by three manufacturers.

The first of these are Riteohm precision resistors, Series 82 and 83, announced by Ohmite Mfg. Co.,



4835 Flournoy St., Chicago 44, Ill. Both types are pie wound to 1 percent accuracy and can be supplied with a fungus-resistant coating. Type 82 measures $\frac{11}{16}$ inches in diameter, and $1\frac{1}{8}$, or $1\frac{7}{16}$, or $1\frac{3}{4}$ inches long for the 2, 4 and 6-pie units respectively. Minimum resistance is 0.1 ohm for all units and the maximum is 400,000 ohms for the 2-pie unit, 750,000 ohms for the 4-pie, and 1 megohm for the 6-pie unit. Type 83 is available in three sizes—$\frac{1}{2}$ inch diameter x $\frac{7}{16}$, $\frac{5}{8}$ or 1 inch long. The first two units are 2-pie while the third is a 4-pie unit. Minimum resistance is 10 ohms for all units, and the maximum is 200,000 ohms for the small 2-pie unit, 400,000 ohms for the large 2-pie, and 800,000 for the 4-pie unit. Bulletin No. 125 describes units in detail.

Wire-wound "Sealed-Ohm" hermetically-sealed precision resistors



A forward-looking American manufacturer offers Advanced Careers to a few qualified engineers and scientists

★ ★ ★

Top salaries plus high royalty earnings

★ ★ ★

Excellent laboratory in fine building located in beautiful Southern New England community

IN order to carry out a highly developed program of growth and expansion, we seek to augment the staff of our creative engineering laboratories with outstanding talent...and are prepared to do the things necessary to obtain it.

Applications are therefore invited from key engineers, research men and physicists experienced in industrial electronics, industrial control equipment, the design of automatic machines and allied fields. There are openings to satisfy the chief engineer, department head, project engineer, research engineer and the basic research scientist.

Salaries will at least equal those paid by other leading companies in the field, *but in addition, each candidate will receive a graduated percentage royalty on the sale of all products he develops. A portion of this royalty continues even if he later leaves the company.*

The conditions under which you will work are ideal. Our laboratory—housed in a splendid building—is well-equipped. You will be furnished with everything necessary to carry out the projects under your direction. The laboratory is located in one of the most charming residential communities of southern New England within commuting distance of New York—fine homes, excellent schools, modern shops and stores.

In order to receive fullest possible consideration, your application should present a detailed and comprehensive account of your experience and accomplishments, with particular emphasis on patents you may have obtained and contributions you have made to the origin or improvement of devices or techniques in your field.

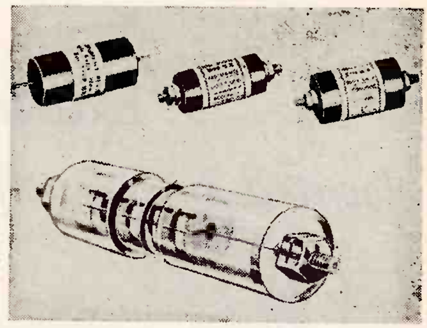
The engagement of any candidate, of course, must be in accordance with War Manpower Commission and wage and salary regulations. If your present status precludes a change in position at this particular time, contractual arrangements can be made for you to join the staff at a later date.

We choose not to reveal the name of this corporation in this advertisement but every candidate interviewed will have the fullest opportunity of learning everything he wants to know about us. Further, your letter of application will be seen only by principals and will be held in the strictest confidence. All our staff knows of this advertisement.

Please address your letter to P-860, Electronics, 330 West 42nd St., New York 18, N. Y.

are announced by Daven Co., 191 Central Ave., Newark 4, N. J. These resistors may be employed as secondary standards, resistor elements in bridge networks, in voltage divider circuits and in attenuation networks. Resistor windings are non-inductively wound—in spool or mica-card types. Resistance range—any desired value, maximum 1,600,000 ohms. Four types of resistance wire of different temperature characteristics are available. Accuracy is rated plus or minus 0.1 percent to plus or minus 10.0 percent.

Five new types of hermetically-sealed resistors are available from Instrument Resistors Co., 25 Amity



St., Little Falls, N. J. These types are: RX, SX, WX, CX and BX. CX and BX units have 2-inch No. 18 copper axial leads while the others are equipped with 8-32 threaded studs capable of mounting several lugs, wires or mounting brackets. All units are tropicalized. They provide a range to 1 megohm maximum, and 2 watts maximum. Tolerance is rated 1 percent.

Dielectric Heater

A NEW DIELECTRIC heater, "Heatmaster" for heating plastics, dehydration, sterilization and other purposes has been introduced by the Thermatron Division of the Radio Receptor Co., Inc., 251 West

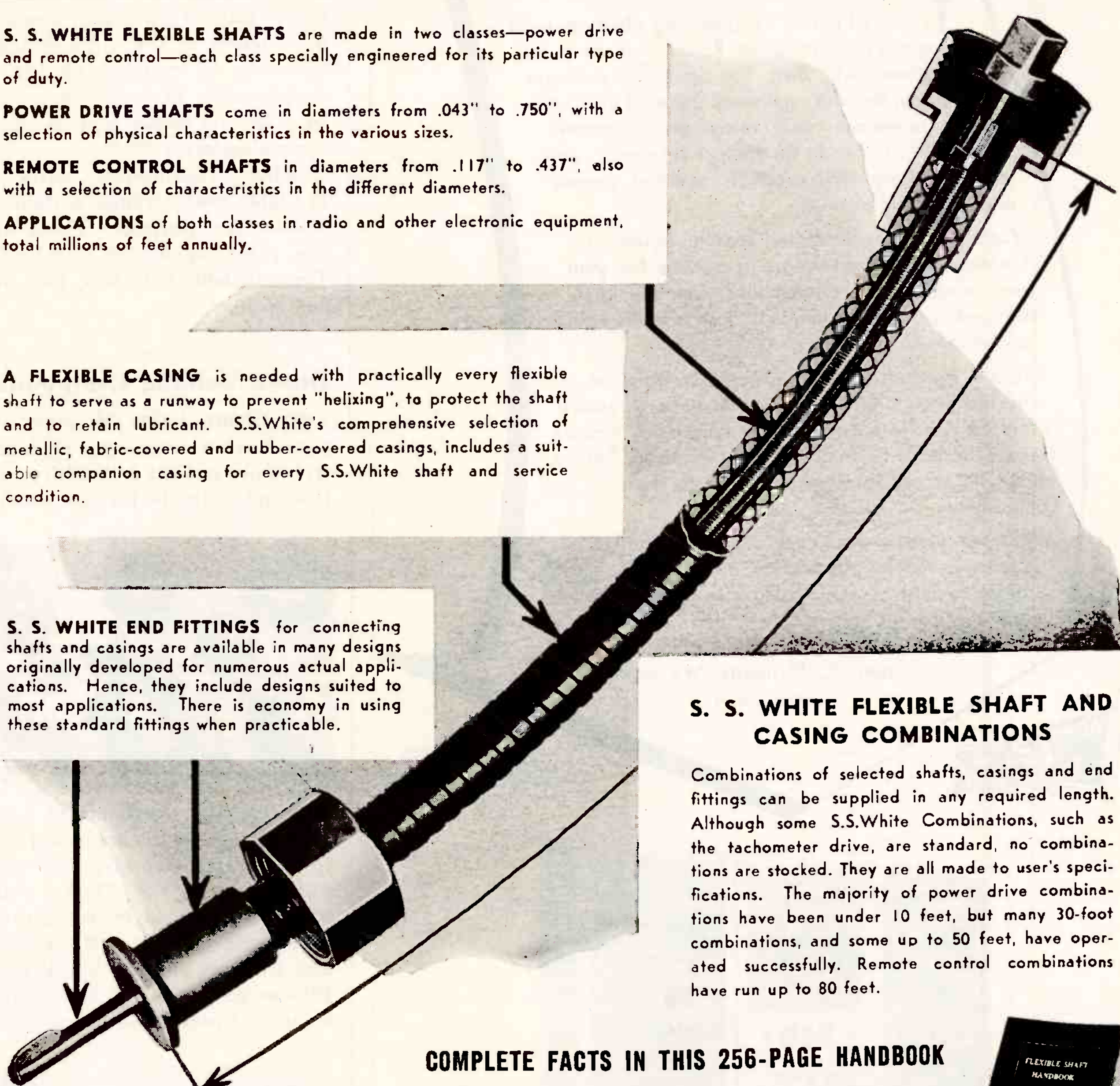
QUICK FACTS FOR ELECTRONIC ENGINEERS ABOUT S.S.WHITE FLEXIBLE SHAFTS

S. S. WHITE FLEXIBLE SHAFTS are made in two classes—power drive and remote control—each class specially engineered for its particular type of duty.

POWER DRIVE SHAFTS come in diameters from .043" to .750", with a selection of physical characteristics in the various sizes.

REMOTE CONTROL SHAFTS in diameters from .117" to .437", also with a selection of characteristics in the different diameters.

APPLICATIONS of both classes in radio and other electronic equipment, total millions of feet annually.



A FLEXIBLE CASING is needed with practically every flexible shaft to serve as a runway to prevent "helixing", to protect the shaft and to retain lubricant. S.S.White's comprehensive selection of metallic, fabric-covered and rubber-covered casings, includes a suitable companion casing for every S.S.White shaft and service condition.

S. S. WHITE END FITTINGS for connecting shafts and casings are available in many designs originally developed for numerous actual applications. Hence, they include designs suited to most applications. There is economy in using these standard fittings when practicable.

S. S. WHITE FLEXIBLE SHAFT AND CASING COMBINATIONS

Combinations of selected shafts, casings and end fittings can be supplied in any required length. Although some S.S.White Combinations, such as the tachometer drive, are standard, no combinations are stocked. They are all made to user's specifications. The majority of power drive combinations have been under 10 feet, but many 30-foot combinations, and some up to 50 feet, have operated successfully. Remote control combinations have run up to 80 feet.

COMPLETE FACTS IN THIS 256-PAGE HANDBOOK

This standard handbook-size volume completely covers the subject of flexible shafts. It gives all essential technical data and explains how to select and apply shafts for specific requirements. A copy will be sent free, if you will write for it direct to us on your business letterhead and mention your position.

ARMY E NAVY

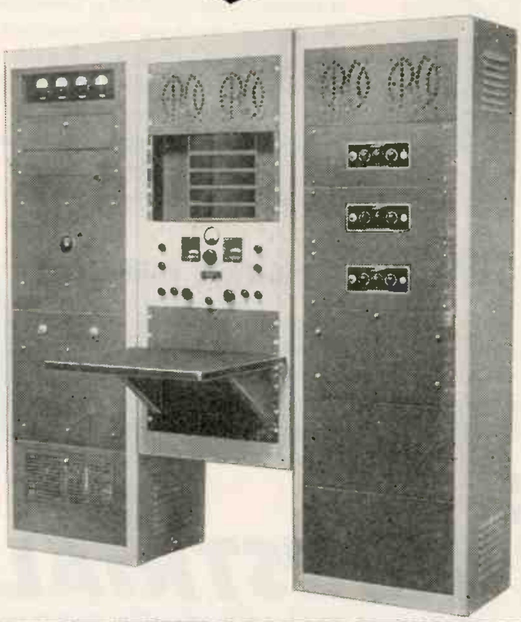
S.S.WHITE INDUSTRIAL DIVISION

THE S. S. WHITE DENTAL MFG. CO.

DEPT. E 10 EAST 40th ST., NEW YORK 16, N. Y.

FLEXIBLE SHAFTS — AIRCRAFT ACCESSORIES — MOLDED PLASTICS — MOLDED RESISTORS — FLEXIBLE SHAFT TOOLS

One of America's AAAA Industrial Enterprises

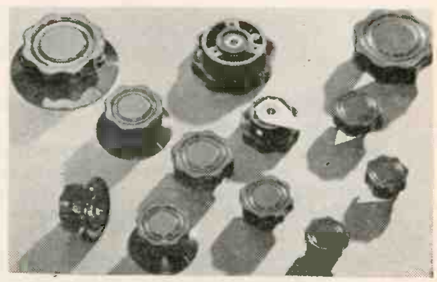


19th St., New York 11, N. Y. The unit is completely self-contained, and is designed particularly for heavy-duty preheating of plastic molded parts. It is capable of heating a 3.3-lb preform in 1 minute or a 5-lb preform in 90 seconds. Output is rated 5 kw plus; input—approximately 8 kva; line voltage—220 volt, 60 cycle, 3 phase; frequency—30, 15 or 5 Mc; size—24 x 28 x 59 inches high; weight—approximately 1000 lb.

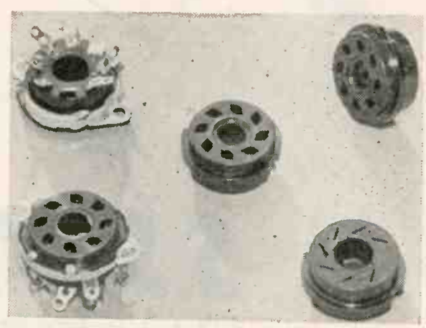
Other Thermatron units are available over a range suitable for almost any purpose. These units are rated at output and include Types K-500, K-1, K-3, K-8, K-15 and K-30.

Durez Molding Compound

THE HARRY DAVIS Molding Company has an extensive line of control knobs molded from Durez plastics and suitable for all standard



requirements. Available in a wide range of styles, the knobs are fluted to permit positive grip for critical calibrations. The Durez plastic used is unaffected by perspiration, greases or oils, is self-insulating, and will not chip or break easily. Illustrated below are National Fabricated Products octal radio sock-



ets, designed to use a minimum of chassis space. Self-aligning contacts float in the Durez plastic insulation and provide the necessary safeguards against fracture of the glass seal of the tube resulting

from possible misalignment of tube pins. Durez Plastics & Chemicals, Inc., North Tonawanda, N. Y.

Synthetic Insulation

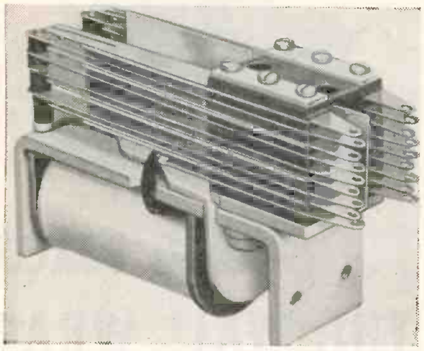
NEW SYNTHETIC insulation called "Flexitube" meets exacting specifications and is suited for use on all wire insulation purposes in radio and communications assemblies. The material has high flexibility, is resistant to abrasion, and has high dielectric strength. At room temperature, Flexitube averages 15,000 volts, with a guaranteed minimum of 12,000 volts for all sizes. Forty-eight hours immersion in tap water results in a reduction of less than 10 percent of its original dielectric strength. The material will not become hard or brittle under temperatures ranging from minus 35 to plus 75 deg C. Walter L. Schott Co., 9306 Santa Monica Blvd., Beverly Hills, Calif.

Speaker

TYPE NF-300 reproducer, originally developed as a talk-back unit in ship intercommunicating systems, is a special-purpose speaker for use in severe weather or difficult operating conditions. Voice coil impedance is 12 ohms, nominal value. Maximum handling capacity for speech is 10 watts. Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago 39, Ill.

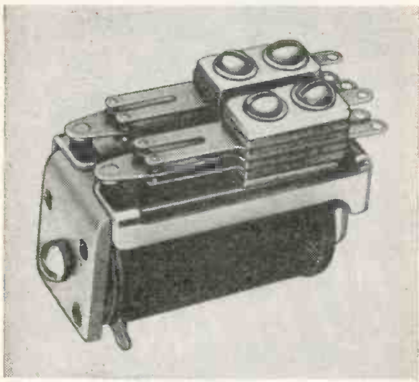
Relays

BOTH POTTER & Brumfield Mfg. Co. (Princeton, Ind.) and R-B-M Mfg. Co., (Division of Essex Wire Corp., Logansport, Ind.) announce new relays. The R-B-M is Type 20000 multi-contact relay for minimum operating currents. Contact spring



assemblies can be furnished in 1, 2 or 3 stacks, with various combinations, up to 16 springs. Coils are fungus treated and are available in voltage ranges from $1\frac{1}{2}$ to 28 volts dc. Two sizes are available.

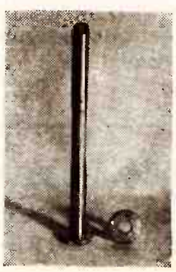
A miniature telephone-type relay known as the "MT" series is offered by Potter & Brumfield. The unit



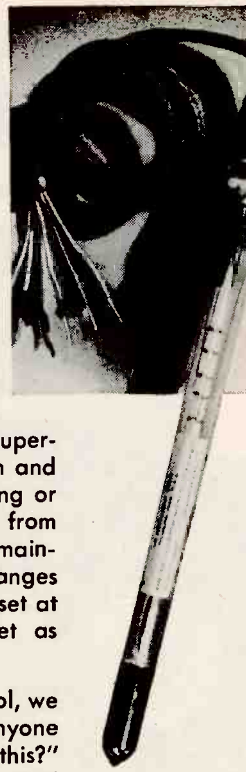
weighs $1\frac{3}{4}$ oz, is compactly constructed for mounting in limited space, and is sensitive enough to operate on minute current. Twin contacts exert high contact pressure. Units are vibration-resistant.

Record Carrier

THIS DEVICE consists of a specially-made spool for loading records on to an automatic phonograph. George Solkover of 2608 E. Marion St., Seattle 22, Wash., is the inventor. To load the records a flange is removed, and when the spool is loaded the flange is replaced. It is



HOW CAN *you* USE AN INSTRUMENT *like this..?*



This H-B Red Top Thermo-Regulator has limitless applications in the field of accurate temperature control. It is used to eliminate guesswork, simplify supervision, increase the quantity or quality of production and aid in hundreds of other ways by holding, controlling or limiting temperatures—*automatically*. Ranges are from minus 35° to plus 350° F. and temperatures can be maintained to an accuracy of a fraction of a degree. Ranges may be set as specified or adjustable units may be set at any temperature point within the range and reset as frequently as desired.

Being specialists in temperature indication and control, we are able to give the benefit of our experience to anyone who asks—"What can I do with an instrument like this?" Why not write us today? H-B Instrument Company, 2524 North Broad Street, Philadelphia 32, Pennsylvania.

THERMOMETERS · THERMOSTATS · RELAYS
THERMO-REGULATORS · HYDROMETERS

DOUBLE H B DIAMOND

MOVING AIR—

15 CUBIC FEET A MINUTE
ONLY 2½" OF SPACE NEEDED

The blower illustrated, No. 1½*, is one of many blower models manufactured by the L-R Mfg. Div. with C.F.M.'s at 8000 R.P.M. ranging from 15 to 270. These blowers will outperform many larger and heavier types formerly in use and where size and weight are factors, they are the answer to cooling problems presented by electronic tubes or circuit components in airborne communication units as well as in many industrial applications.

*WEIGHT: 2 oz.; CAPACITY: 15 C.F.M. at 8000 R.P.M.; CONSTRUCTION: Housing of high impact phenolic plastic. Wheel is turbo-type cadmium-plated steel; SIZE: 2⅝" long x 61/64" wide x 2½" high.

L-R MANUFACTURING DIVISION OF

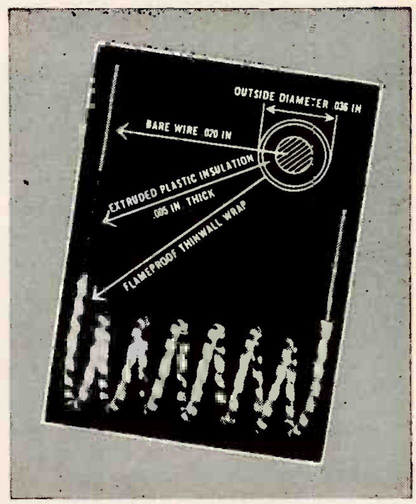
The RIPLEY Company

13 NEW LITCHFIELD STREET
TORRINGTON, CONNECTICUT

THE WESTERN UNION TELEGRAPH CO.

... *installs* SURCO THINWALL WRAP *after Rigid Testing*

..... the first uniformly high quality fine wire, plastic insulated with flame proofed yarn serving.



This photo of typical construction is absolutely unretouched

Voltage Breakdown — 7000 Volts
(For spiraled section shown in photograph after 5 minutes in water)
Insulation Resistance—30 Megs. Per 1000 Ft. at 60°F. (After 72 hrs. in water)

Here are Thinwall's Characteristics:
High dielectric properties, Maximum saving in space and weight, Unlimited coding and identification, High temperature operation, Excellent abrasion resistance and toughness, Maximum protection against damage by soldering iron, Unusual flexibility at below freezing temperatures, Flameproof qualities, Good end and spot-stripping characteristics, Low cost.

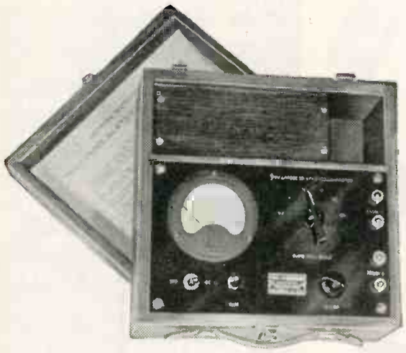
Surco-American Thinwall Wrap is available in a wide variety of formulations finer sizes of wire and thinner insulations than shown above, for use where maximum performance under specific operating conditions is required.

Surprenant
ELECTRICAL INSULATION CO.
Dept. C 84 Purchase St., Boston 10, Mass.

then sleeved over the pin of the phonograph. The pin is slightly reduced in diameter to accommodate the spool. The device saves time in loading a phonograph; enables one to keep pre-selected records together as a unit; prevents marring or scratching of records; and prevents accidental dropping of a record. A special carrying case for extra groups of records (which are held together by the spool) is also available from Mr. Solkover.

Milliohmmeter

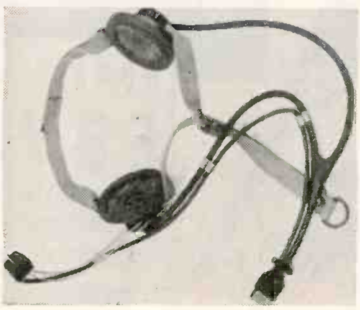
MILLIOHMMETER No. 673-F is a new addition to a line of direct reading resistance measuring test



sets produced by the Shallcross Mfg. Co., Collingdale, Pa. The unit has linear scales. The six scales have ranges of: 0, 0.5, 1, 5, 10, 50 and 100 ohms full scale. This range bridges the gap between the regular Shallcross milliohmmeters used for low-resistance testing and the ordinary ohmmeters used for high-resistance measurements.

Headphone Assembly

DESIGNED FOR comfort, efficiency and convenience is this assembly which consists of headphone (or headband) and a microphone. The lightweight, 100-ohm carbon-type microphone comes in a plastic clo-



THE NEW

SPEED IRON

Patents Pending

THE SUCCESSOR TO THE

ELECTRIC SOLDERING IRON

100 WATTS
115 VOLTS
60 CYCLE

IT'S REALLY

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SOLDERING HEAT IN 5 SECONDS!

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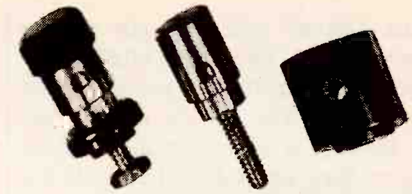

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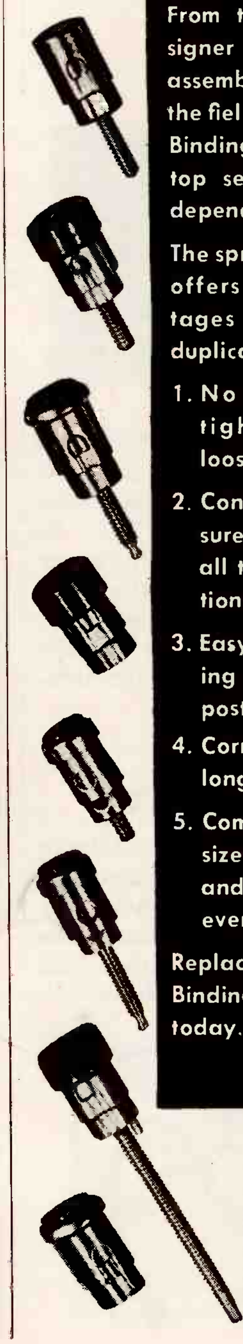

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sure and is assembled with a swivel boom. The complete assembly weighs less than 12 ounces. A chin slide clasp adjusts ear cushions. Aviometer Corp., 370 West 35th St., New York 1, N. Y.

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sition with respect to the gap walls. The manufacturer states such positive positioning of the coil assembly permits using increased magnetic flux density in the gap. Two types of units available include Model PAH rated at 25 watts, 15 ohms impedance, frequency range 100 to 6000 cycles, dimensions 5¼ x 5 in. and weight 9 lb. Model SAH differs only in that its dimensions are 4½ x 5 in. and weight is 5 lb. University Laboratories, 225 Varick St., New York 14, N. Y.

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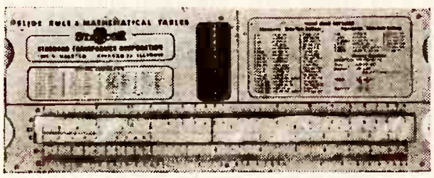

Corp. (1500 N. Halsted, Chicago 22, Ill.) who will sell the rule together with a carrying case at a cost of $1.00. The rule is made of durable stock, clear print and has a transparent plastic indicator.

Literature

GE Literature. Four separate pieces of literature from General Electric Company, Schenectady, N. Y., include: Bulletin GEA-4265 which describes voltmeters, milliammeters and microammeters (types DO-45, DO-46 and DO-55) which are 3½-inch a-c rectifier type electric instruments for panel mountings. Bulletin GEA-4363 describes thickness gages (types A, B and C) which are used to measure thickness of non-mag-

netic materials. Bulletin GEA-3682B is a 20-page booklet which illustrates and describes sintered-alnico magnets which are compact and permanently stable and are available in a variety of shapes and sizes. The fourth and last Bulletin GEA-4324 describes electric tachometers used to measure rotational speeds from 1 to 60,000 rpm, and linear speeds which can be measured in terms of rpm.

Electronic Heaters. Application of Allis-Chalmers vacuum-tube electronic heaters for both induction heating of metals and dielectric heating of non-metallic materials is explained in a 4-page bulletin, No. B6372, issued by Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.

House Organ. Westinghouse Newsfront is the title of a new monthly report on the highlights of Westinghouse Electric Corporation's scientific research, engineering, and production. Vol. 1, No. 1, is available. Write Westinghouse Newsfront, 306 4th Ave., Box 1017, Pittsburgh 30, Pa.

Fastenings. New information has been added on the many types of self-tapping screws, socket screws, and other fastening devices in a new edition of Parker-Kalon's Fastening Catalog Data Book. 204 Varick St., New York 14, N. Y.

Radio Components. A Partial Directory of Radio Components is the title of a 4-page bulletin which lists 500 different items in 30 classifications as manufactured by the Alden Products Co., 117 N. Main St., Brockton 64, Mass.

Liquid Polystyrene. A new technical bulletin contains data on the dielectric constant, power and loss factors, as well as electronic characteristics of No. 912 Polyweld (a pure polystyrene in solution form). American Phenolic Corp., 1830 South 54th Ave., Chicago 50, Ill.

Cable Accessories. Bulletin No. 25-A is a 4-page folder which illustrates and describes cable accessories from Andrew Co., 363 East 75th St., Chicago 19, Ill.

Miscellanea Vol. XIX, No. 10 of The General Radio Experimenter contains the following articles: "High-Frequency Compensation for Amplifiers," "Dynamic Balancing in the Field with the Aid of a Stroboscope," "The Use of Variacs at Voltages Above 230" and "Rubber Glove Tester Uses Variac." General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Tube Manual. A new 1945 Catalog and Manual, available for 25 cents, contains information on all tubes manufactured by Taylor Tubes, Inc., 2312 Wabansia Ave., Chicago 47, Ill. Some 22 pages of the manual are devoted entirely to tube characteristics, and a large portion of the catalog contains technical information on transmitters and tubes.

Reference List of Tube Types. To assist design engineers in the selection of tubes for specific applications there is available a handy "pin up" chart of recommended tube types. Sylvania Electric Products, Inc., 500 Fifth Ave., New York 18, N. Y.

Plastic Molding. A 16-page booklet entitled "A Businessman's Guide to the Molding of Plastics" contains charts and photographs. A good portion of the booklet deals with material selection, design, moldmaking, and production. Also contained in the booklet is data on the facilities, equipment and the production capacity of Kurz-Kasch, Inc., Dept. 7G, 1415 S. Broadway, Dayton 1, Ohio.

Replacement Capacitor Catalog. Catalog No. 195 contains complete data on capacitances, sizes and prices of Cornell-Dubilier (South Plainfield, N. J.) electrolytic capacitors.

Industrial Sound. A 66-page pamphlet has been compiled giving a comprehensive picture of the installation and most efficient use of equipment for transmitting sound as an operational and morale item in war plants. The title of the pamphlet is "Guide to Industrial Sound." It is sponsored by The Industry Advisory Committee for Industrial Sound Equipment and The

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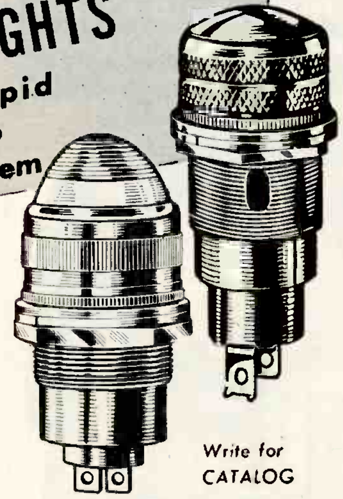

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Radio and Radar Division of the War Production Board and is available for 15 cents from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C.

Resistors. Koolohm type resistors having the "tropicalized"-glazed outer protective shell and new type of moisture-proof end seals are described in a new catalog which also contains data on 5, 10, 25, 50 and 120-watt fixed types, as well as 10-watt adjustable types. Sprague Products Co., North Adams, Mass.

Tropicalized Wax. This 6-page folder discusses tropicalized wax (fungus resistant) and tells about results of tests made on this manufacturer's products. Four pages of the folder show illustrations of Agar test plates of wax heated at 250 deg F. Zophar Mills, Inc., 112 26th St., Brooklyn 32, N. Y.

Research Institute of America. "Rehiring Your Company's Veterans" is the title of a recent Research Institute analysis on the subject. The booklet is timely and authoritative and tends to answer most of the questions pertaining to veterans employment or re-employment. It is an analysis which every employer should read. Four chapters of particular interest are "Your Rehiring Obligations Under the Law," "Where to Get Help in Retraining Veterans," "The Meaning of Changed Circumstances," and "Solving Seniority Questions." Copies may be obtained by writing the Public Relations Dept., Research Institute of America, 292 Madison Ave., New York 17, N. Y.

Electronic Controls. Bulletin No. Z6300 (supersedes Bulletin No. Z6200) is a 12-page bulletin which contains a condensed listing of electronic controls available from Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 1, Ill.

Silicon Steels. Core loss data, magnetization curves and permeability curves are given in a new technical bulletin which confines itself to brief essential data on the several grades of Republic silicon steels most generally used at this time. The bulletin is prepared

for the electrical manufacturing industry and is available from Republic Steel Corp., Republic Bldg., Cleveland 1, Ohio.

Induction Heating. Two separate booklets available on this subject include a reprint from *The Iron Age* entitled "Induction Heating, A History of Its Development" and Bulletin No. 25 entitled "Induction Heating & Melting in Industry." This 28-page booklet contains illustrations and descriptive data on equipment available from Ajax Electrothermic Corp. Ajax Park, Trenton 5, N. J.

Background Data. Alden Products Company (117 North Main St., Brockton 64, Mass.) have issued a 44-page, nicely bound catalog which tells about their facilities for designing, engineering and manufacturing complete sub-assembles and items difficult to obtain. The booklet contains many illustrations.

Radio Parts. Catalog No. U.C.-44 has been prepared essentially to provide the buyer of Utah parts with all of the important technical data pertaining to these products. The catalog is spiral bound and contains 50 pages of illustration and descriptive matter. Utah Radio Products Co., 812-20 Orleans St., Chicago 10, Ill.

X-Ray Diffraction. "X-Ray Diffraction Apparatus and Applications" is the title of a 26-page booklet (Bulletin No. 1245) which contains a section devoted to the application of x-ray diffraction and gives typical diffraction radiographs and their interpretation. Picker X-ray Corp., 300 Fourth Ave., New York, N. Y.

Selenium Rectifiers. Bulletin No. RDP-107 is intended primarily for design engineers who use rectifiers or other sources of direct current in their products. It is an engineering manual and gives standard element specifications. Fansteel Metallurgical Corp., Rectifier Div., North Chicago, Ill.

NEW BOOKS

The Soul of Amber

By Alfred M. Still. *Published by Murray Hill Books, Inc., 232 Madison Ave., New York, N. Y., 1944. 274 pages, $2.50.*

This book will never achieve the heights of popularity held forth by the publishers in the jacket because it is definitely not a "popular" book. However, it is a contribution to the literature on electrical science that could easily become of major importance.

It is a review of practically all of the great, and most of the near-great, names in the history of electricity, including what they contributed to electrical science and what they thought. As such it is of definite value to anyone interested in the background of electricity and electronics. The author has performed a monumental piece of work. He has read, digested and evaluated an incredible amount of literature that deals with the personalities behind electrical engineering down through the ages.

The name of the book is inaccurate, in a sense, because the soul of amber is electricity or an electrical charge. Amber as such is discussed only briefly. It would seem that the title was chosen for popular appeal when the text does not live up to that appeal. Actually, this book would make dull reading for anyone not interested in electricity and the development of this "art" as we know it today.

There are some errors of omission that seem to be serious, whether or not they are intentional. Nothing is said about the contributions of Edison and Tesla. Steinmetz is covered only briefly. Westinghouse and William Stanley are given all the credit for developing alternating current to the point where it was practical, even though Westinghouse paid Tesla $1,000,000 for his patents. None of the living electrical scientists are mentioned at all. Conversely, what seems like an inordinate amount of space is devoted to Faraday, Eddington and others who although they are important seem to have been emphasized too much.

Two indices are provided—one of names and the other of subjects. Both could be considerably ex-

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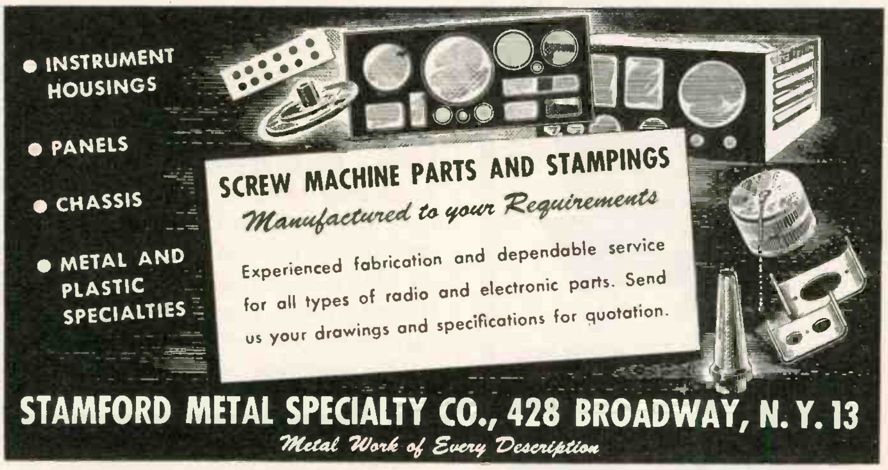

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panded to make the book of greater value to those who want more detail. There is also a too-short chronological table of key dates in the progress of electrical science. Just in passing, it would be interesting to know why the dates for the first steam locomotive and Fulton's steamboat are included in this table.—K.S.P.

• • •

Plastics in Practice

By John Sasso and Michael A. Brown, Jr. *Published by McGraw-Hill Book Co., 330 West 42nd Street, New York 18, N. Y., 1945 185 pages, $4.00*

More than one-half the total poundage of molded and laminated plastics goes into parts and assemblies associated with electrical circuits. Because electronics is a relatively new science, it is only natural that a good portion of this poundage should be found in electronic applications. In effect a handbook of plastic applications, this book offers much of interest to electronic engineers, especially if they are concerned with the development, design or production of components of electronic equipment.

The book consists of a collection of successful case histories of designs of over 100 plastic parts of all kinds. Each application described is covered from all standpoints. In fact, the treatment is such that the specific application is merely a peg on which to hang a discussion of the whys and wherefores of applications of plastics in various fields or for various purposes. In this respect the book is unique in industrial publishing.

Many of the case histories are of direct interest to the electronics field, particularly in view of their background discussions. These include circuit-breaker handle, cold-molded heater plug, standoff insulator, radio cabinets, electrical controller, radio-tube base, fence-control housing, microswitch, cable insulation, molded capacitor, ignition distributor head, name plates, nonmetallic gears, double injection molding, coaxial cable, heat-resistant styrene thermoplastic, styrene elastomer, thermosetting copolymer and silicone resins.

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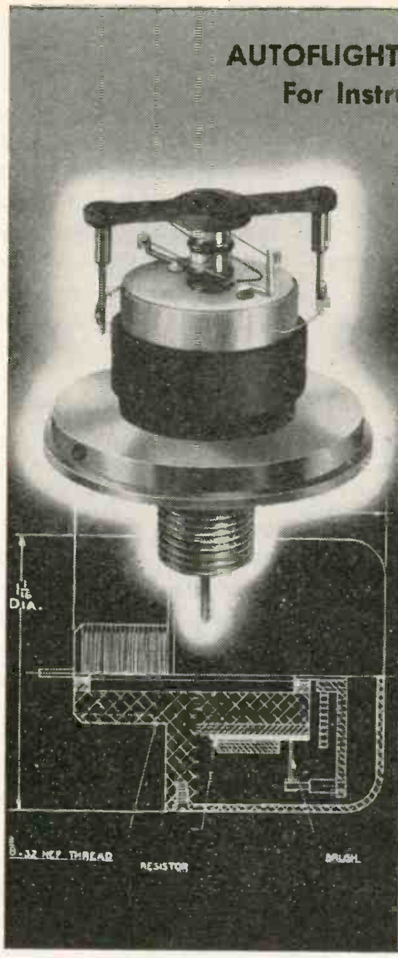

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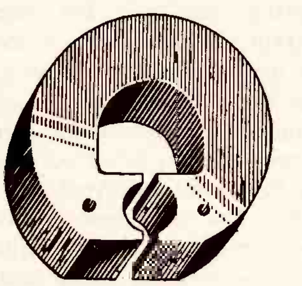

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the various plastic materials, methods of forming, comparative properties, important design considerations and cost factors. Both of the authors have given plastics a good part of their attention for many years and are well-known in this field. The book reflects their wide interests and activities. It should be a valuable aid to any engineer who is interested in plastics.—K.S.P.

• • •

Production-Line Technique

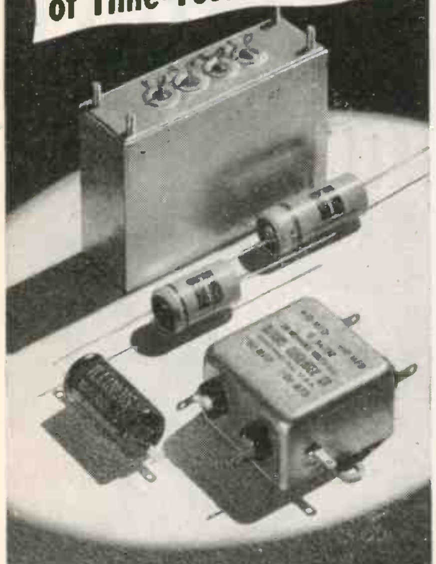
By Richard Muther. *McGraw-Hill Book Co., 330 W. 42nd St., New York 18, N. Y., 1944, 320 pages, $3.50.*

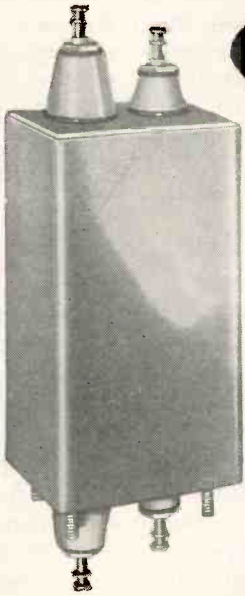
The necessity for turning out large quantities of precision equipment at a fast rate for the armed services forced many companies to turn to line production from job-lot manufacture. The success of this change has been apparent for some time, although at the start it was doubtful whether or not many types of equipment could be produced in this way.

There are certain fundamentals common to all production-line methods. If these fundamentals are thoroughly understood there should be little difficulty in applying such methods wherever they can economically be used. This book, then, was written expressly for industrial executives who are considering the use of line production. It pictures the current state of this art as found in well-established organizations after a two-year study to gain first-hand information. In particular, the book was written for medium-sized plants, which have always been the accepted domain of job-lot manufacture.

Four general sections are provided—advantages and limitations of line production, establishing the line, operating the line and diversification in line production. A chapter of problems is included to help the reader become familiar with production-line techniques.

Manufacturers of electronic equipment all the way from simple parts to complicated assemblies could make good use of this book by studying it to determine whether or not their products are applicable to line production. The final answer may not always be readily apparent, but if the book stimulates thinking along the proper lines it will have served its purpose.—K.S.P.





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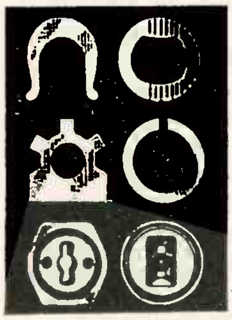

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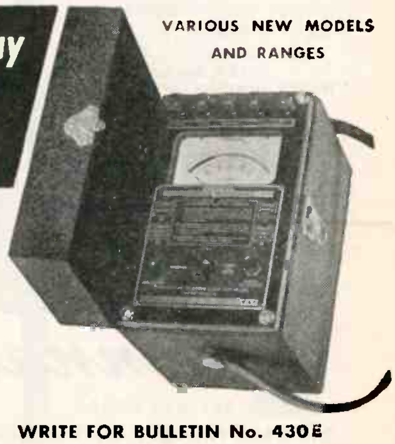


Backtalk

This department is operated as an open forum where our readers may discuss problems of the electronics industry or comment upon articles which ELECTRONICS has published

Dangerous Art

Dear Mr. Henney:

I READ ELECTRONICS pretty carefully, including the advertisements which are a great source of information. Two recent full-page advertisements by commercial organizations have set me thinking about safety. We are all safety conscious, and I am especially so since our laboratories here necessarily must be as safe as possible. Of course, some risk is inevitable.

But to get on: In one ad, the caption reads that the specialist is giving a capacitor a thorough ". . . voltage and capacitance checking." With his right hand the operator practically touches the *hot* side of a transmitting capacitor presumably being tested at several thousand volts; with the left hand he applies the power to the circuit! A perfect arrangement for a serious accident.

The photograph of the testing of a vacuum capacitor in another issue is a second case in point. From the sphere-gap it is evident that the capacitor is being tested at a rather high voltage; one hand of the operator is on the hot circuit and the other on the power switch.

I feel that these examples of unsafe testing methods represent a low order of engineering and should not be given the widespread publicity which their publication in ELECTRONICS will ensure.

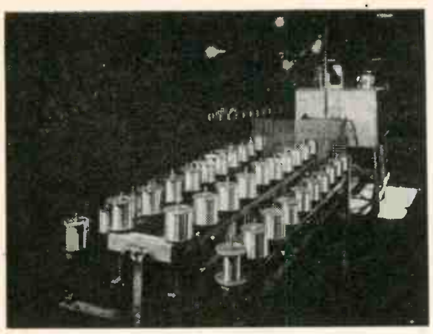
P. M. HONNELL
Lieut. Colonel, S.C.
O-I-C of Laboratories
Dept. of Chemistry and Electricity
United States Military Academy
West Point, N. Y.

• • •

About the Format

Dear Sirs:

ON RECEIVING my November 1944 issue of your publication I was astonished and delighted to find that you had led the way back to common sense in the arrangement of your articles so that one could read the whole article without the irri-



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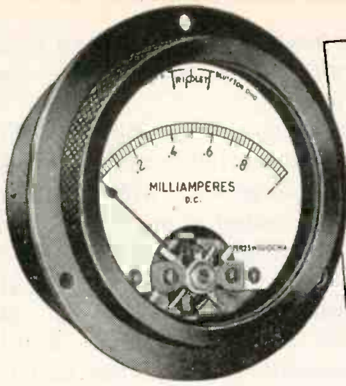

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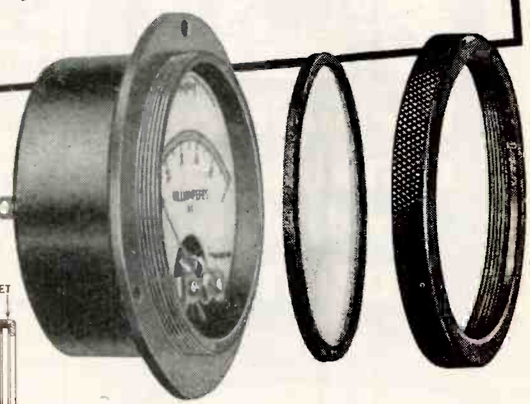

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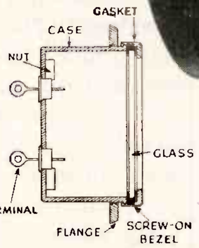

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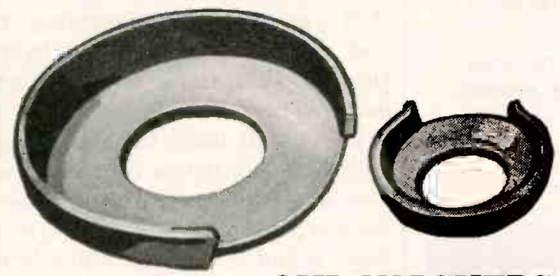

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tating need to chase the tail ends through endless hide-outs in the back pages.

The fashion of insulting the authors of the articles and the readers thereof is very widespread in American technical and trade journals and causes constant irritation to those who are interested enough to pursue the elusive "rest of the article." Apart from this it is also self-derogatory, as if the editors said actually "This is the only part worth reading; if you *must* read the rest, sort it out for your self—it's somewhere in the back of the number." Then begins the schoolboy prank "Turn to page 163" etc., etc. *ad nauseum*.

You have shown now that the articles *can* be arranged in intelligent consecutive fashion, at the expense of a little thought (and possibly some sub-editing) and I am sure the majority of your readers will appreciate the compliment as much as I do.

For those of us who endeavor to maintain files of reference for particular subjects, the added simplicity saves a lot of cross referencing between files to indicate the whereabouts of a page containing the tag-ends of two or more articles on separate subjects. In some cases this involves typing the rest of an article to complete the file record.

I offer my sincere thanks for the saving of time and patience, and the added pleasure of reading the subject matter.

V. HARDING
Wing Commander
Technical Branch
Royal Australian Air Force

• • •

Cathode Followers

Dear Mr. Skeeters:

ACCORDING TO your last letter, (ELECTRONICS, May 1945) I see that you are misinterpreting the end results of my article in the October 1944 issue, entitled Cathode Follower Calculations.

If you will study the article carefully you will notice that there are two impedances mentioned; one is the output impedance, Z out, equations 8 and 9, and the other is the internal impedance of the cathode follower, Z_c, equations 10 and 11. The former is the parallel combination of R_3 (the cathode resistor) and Z_c (the internal impedance).

Therefore, as you can see, the

effect of the cathode resistor is not neglected in the solution for the output impedance, and the only assumption made is that μ is very much larger than 1.

HUMBERT P. PACINI
Wanamassa, N. J.

• • •

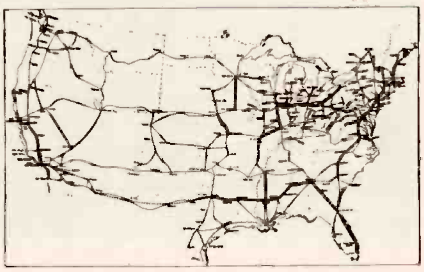
Accentuate the Positive

Dear Sirs:

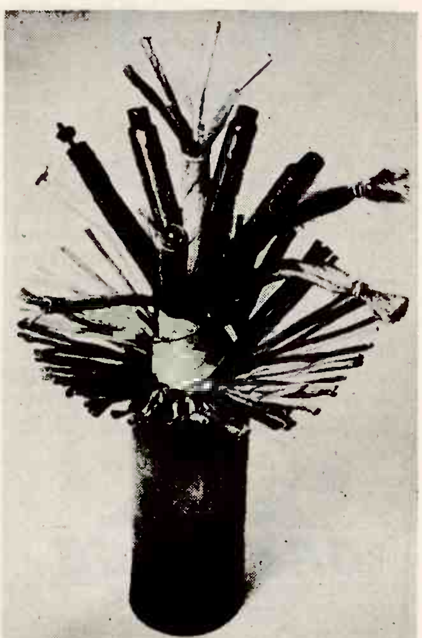
THERE IS AN ERROR in Fig. 5 on page 143 of the May 1945 issue. The large circle represents *maximum* voltage across C_2 instead of *minimum* voltage across C_2. Although this is rather obvious from the text, I thought you would like it called to your attention.

W. B. BRUENE
Collins Radio Co.
Cedar Rapids, Iowa

• • •



Interim report shows status of Bell Telephone coaxialization program in map above where heavy solid line represents cable installed or in process up to the end of 1945, dotted line shows remainder of 5-year program and fine solid line marks existing major toll lines of the system. The end of 1945 is expected to see 2000 miles of the cable (as shown below in full flower) manufactured, and at least 75 percent of it in the ground



(Additional Employment ads on pages 406-408)

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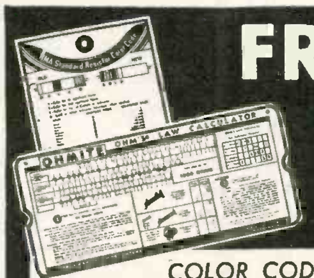

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(Additional Employment Advertising on pages 312, 344, 352, 395, 397, 399, 403 and 404)

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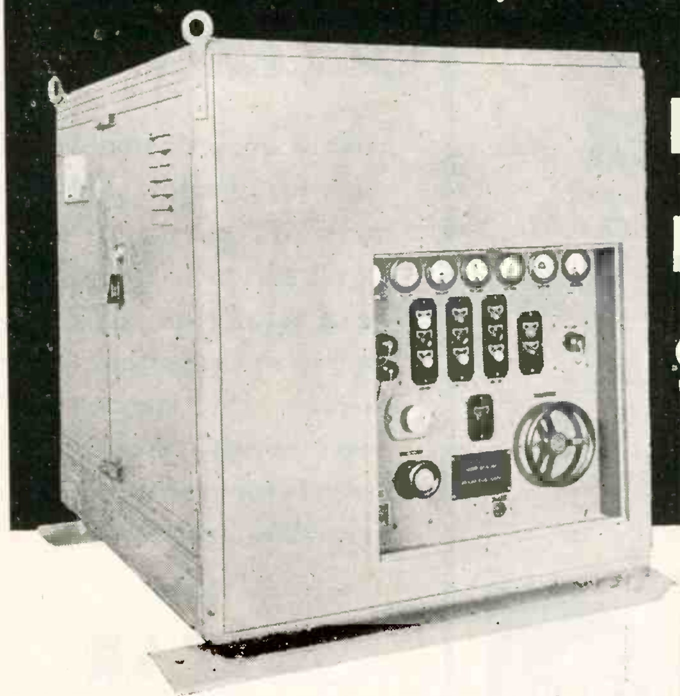

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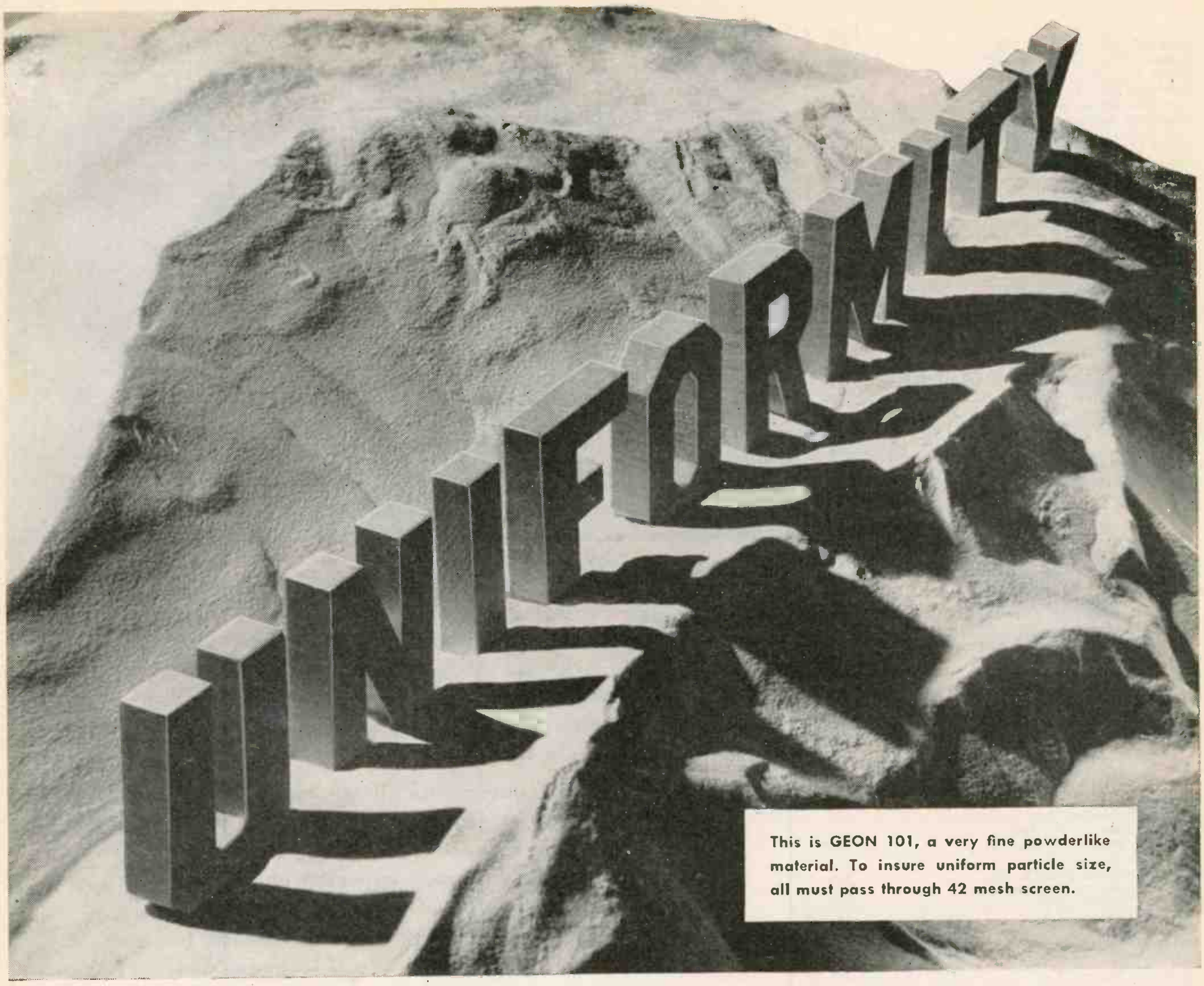

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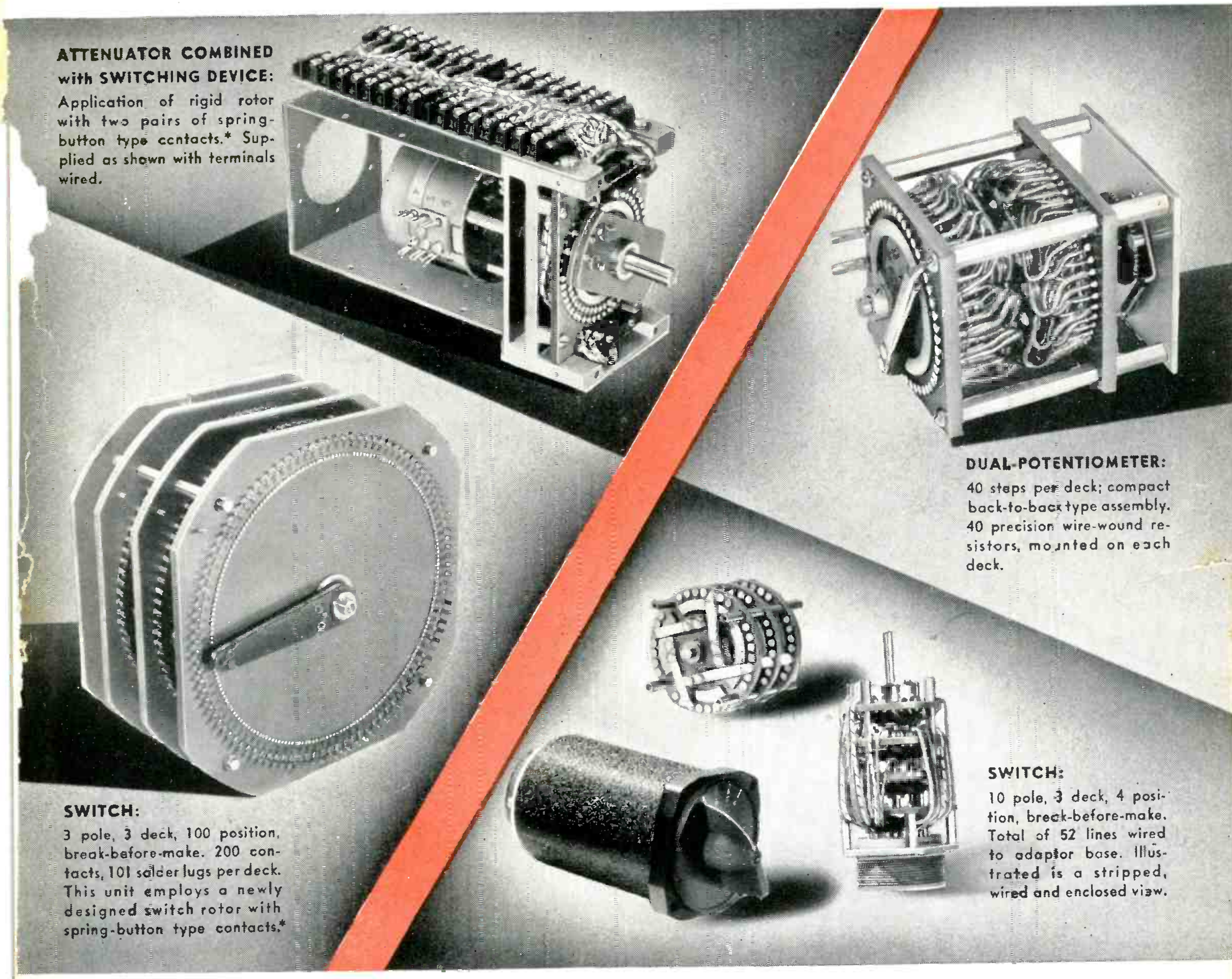

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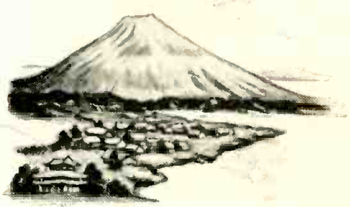

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