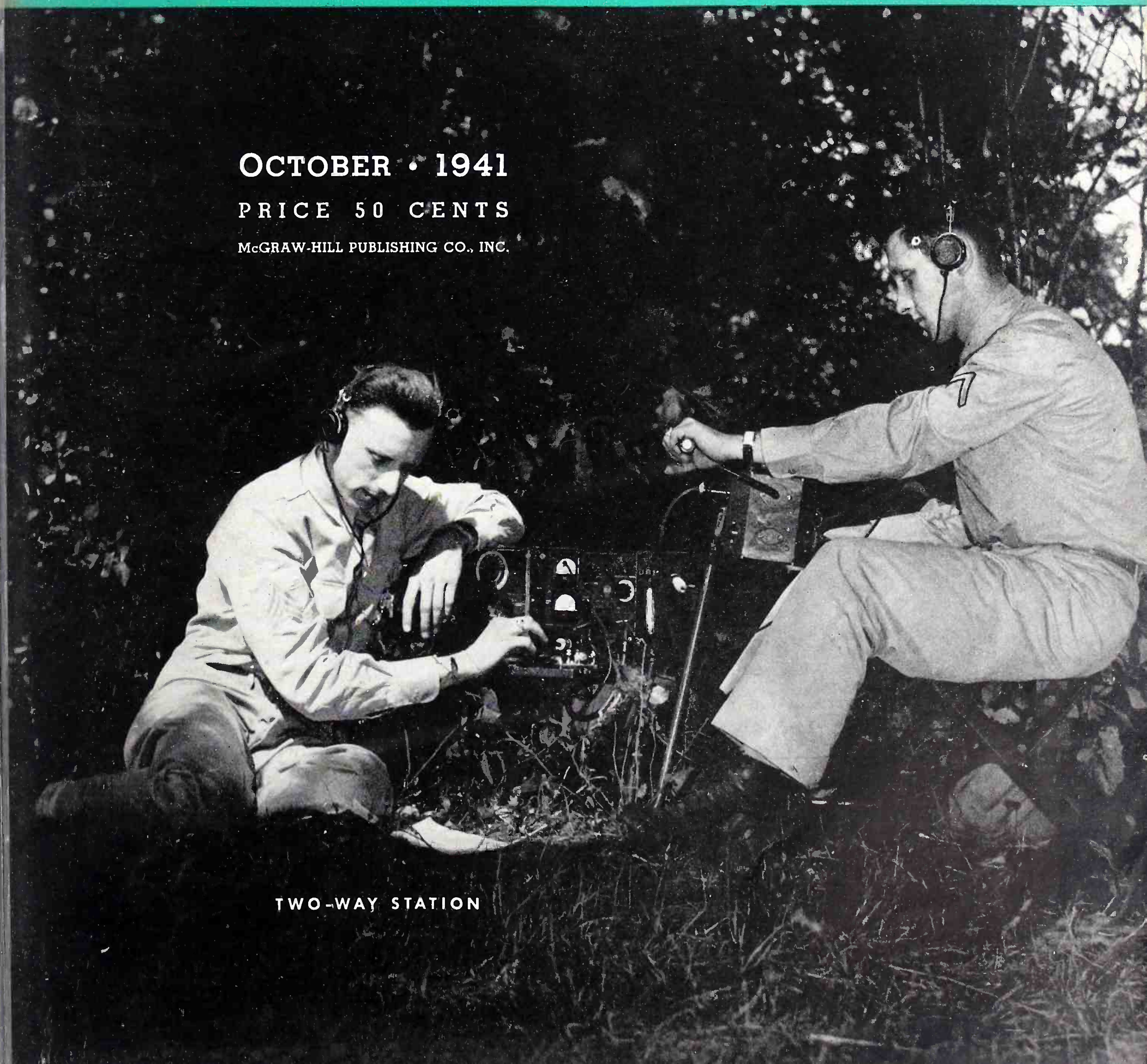
electronics

radio, communication, industrial applications of electron tubes . . . engineering and manufacture



OCTOBER • 1941

PRICE 50 CENTS

McGRAW-HILL PUBLISHING CO., INC.

TWO-WAY STATION

A McGRAW-HILL PUBLICATION

electronics

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Founder and Honorary Chairman

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CONTENTS—OCTOBER, 1941

DEPARTMENTS

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FM's FIRST INDEPENDENT STATION on-the-air with a G-E 1-kw transmitter

Proof That the Public Regards "FM" as More than a Strange Radio Symbol

W47A started operation July 17 with 36 sponsored programs, none less than 15 minutes long. It serves the Capitol District of New York State—covering 6589 square miles—16½ hours daily, 18½ hours Saturdays.

Owned and operated by the Capitol Broadcasting Co., Inc.—devoted solely to FM—it is the first commercial FM station unaffiliated with any broadcast interest.

W47A is also the first station in the country to get a construction permit from the F.C.C. for STL equipment. It will operate on 331 megacycles with W2XEO as the call letters. This studio-to-transmitter equipment is being built by G.E. and will soon be installed.

General Electric offers the only comprehensive line in FM today—broadcast and relay transmitters, receivers, tubes, frequency and modulation monitors, high-gain turnstile antennas, and crystals. G.E. is the only manufacturer of FM broadcast transmitters and receivers operating an FM station as a proving ground. To benefit from actual operating experience look to General Electric for all your FM needs. Just get in touch with the nearest of our 80 offices.

Free!

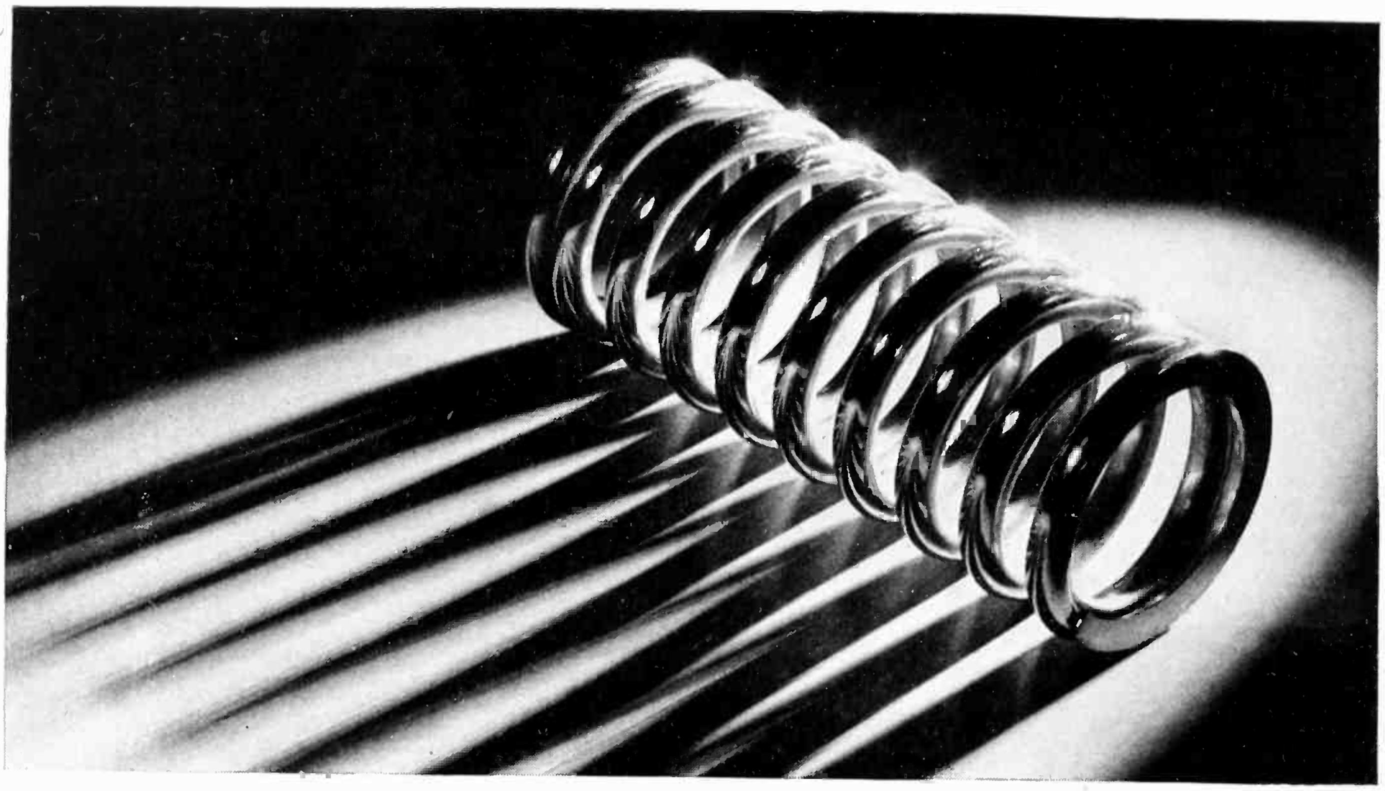
HOW TO PLAN AN FM STATION
HINTS ON OPERATING FM TRANSMITTERS
HOW TO MAKE MEASUREMENTS IN FM TRANSMITTERS

Three valuable guides, written by G-E engineers, to help you in the FM field. Get them from your G-E representative, or write General Electric, Section A160-16, Schenectady, N. Y.

Dwelle S. Hoag, Chief Engineer of W47A, takes readings on the 1-kw FM transmitter

GENERAL ELECTRIC

160-16-6914



Why We're Stepping Up Our Advertising To Bring You News About Springs

IN THE NEXT few months—through the advertisements of this company—you are going to see a series of stories about springs that have never been told, or well told, before. If you design, specify or buy springs, these stories will interest you. They can influence the performance of your product and increase the satisfaction of your customers.

We are going to tell this story because many people still feel that a spring is a "hunk of wire".

The simple truth is that spring manufacturers, with few exceptions, have outgrown the by-guess-and-by-gosh way of making springs. Rule-of-thumb methods have been replaced by scientific formula, scientific manufacturing and scientific testing.

The astronomical number and variety of springs used today, the kinds of wire and finishes, and the functional responsibilities placed on springs make the help of spring engineers not only advisable but profitable.

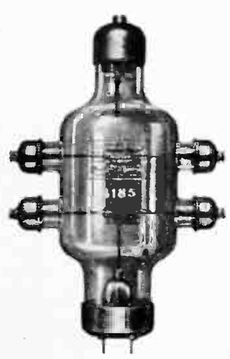
As you run across the next advertisement of this series in this publication, and those to follow—remember that they're worth reading.

HUNTER PRESSED STEEL COMPANY, LANSDALE, PA.

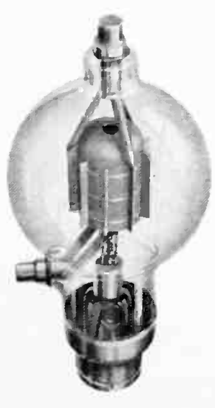
HUNTER
Science in Springs

We are happy to have made this contribution to the electronic art

14 YEARS OF PROGRESS



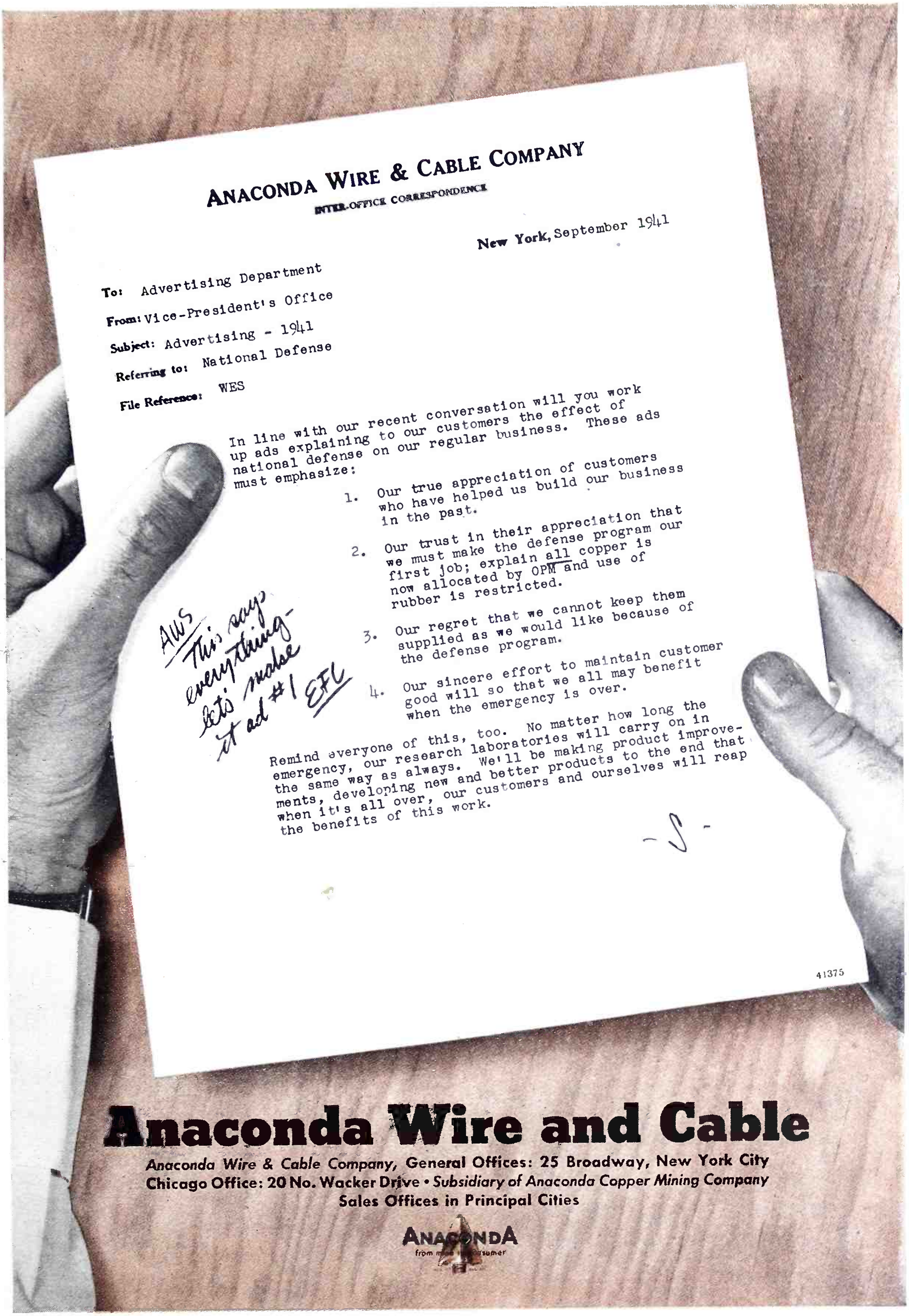
TYPE 255
The first tantalum tube

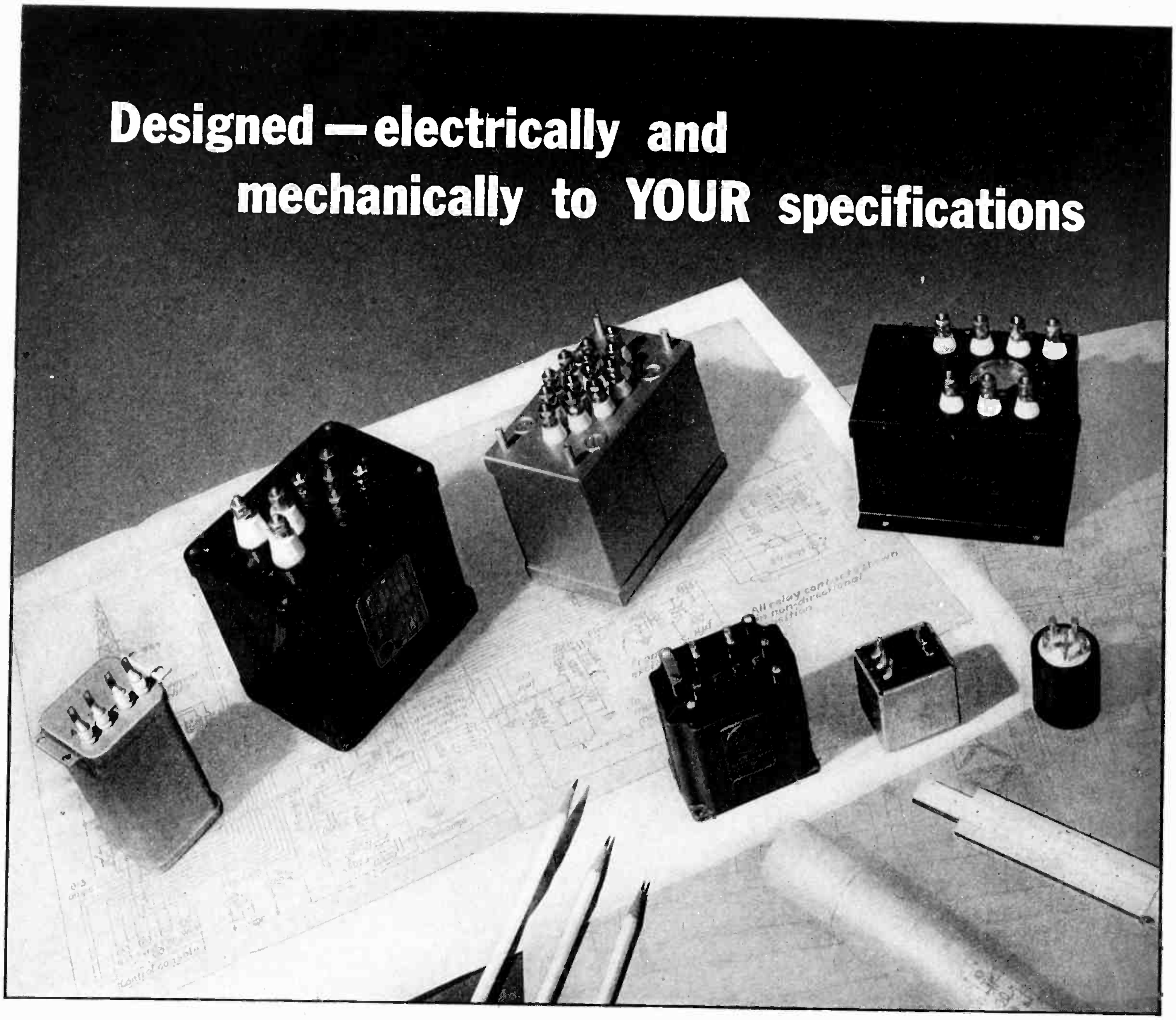


TYPE 854
A new tantalum tube for modern UHF applications

Today tantalum tubes are doing their part in the National Defense program. It is natural that GAMMATRONS play an important role, that designers should turn to the pioneer in the field for new tantalum tube developments. It is natural that when tantalum tubes are considered users all say—

GAMMATRONS of course!


ANACONDA WIRE & CABLE COMPANY
INTER-OFFICE CORRESPONDENCE
New York, September 1941
To: Advertising Department
From: Vice-President's Office
Subject: Advertising - 1941
Referring to: National Defense
File Reference: WES
In line with our recent conversation will you work up ads explaining to our customers the effect of national defense on our regular business. These ads must emphasize:
1. Our true appreciation of customers who have helped us build our business in the past.
2. Our trust in their appreciation that we must make the defense program our first job; explain all copper is now allocated by OPM and use of rubber is restricted.
3. Our regret that we cannot keep them supplied as we would like because of the defense program.
4. Our sincere effort to maintain customer good will so that we all may benefit when the emergency is over.
Remind everyone of this, too. No matter how long the emergency, our research laboratories will carry on in the same way as always. We'll be making product improvements, developing new and better products to the end that when it's all over, our customers and ourselves will reap the benefits of this work.
- S -
AWS This says everything - let's make it ad #1 EFC
41375
Anaconda Wire and Cable
Anaconda Wire & Cable Company, General Offices: 25 Broadway, New York City
Chicago Office: 20 No. Wacker Drive • Subsidiary of Anaconda Copper Mining Company
Sales Offices in Principal Cities
ANACONDA
from mine to consumer



MANUFACTURING transformers for all industrial, electronic and laboratory applications has been our specialized work for 40 years. Today, a very important part of this business is with the electronic industry, and especially with manufacturers who purchase components for refabrication in *their* products. For these customers, AmerTran engineers develop designs to meet exact electrical and mechanical requirements.

While the present needs of National Defense are taxing our expanded engineering and manufacturing facilities, AmerTran quality will not be impaired. The benefits resulting from present experiences will, in the future, place us in a still stronger position to serve our regular and new customers in the commercial field.

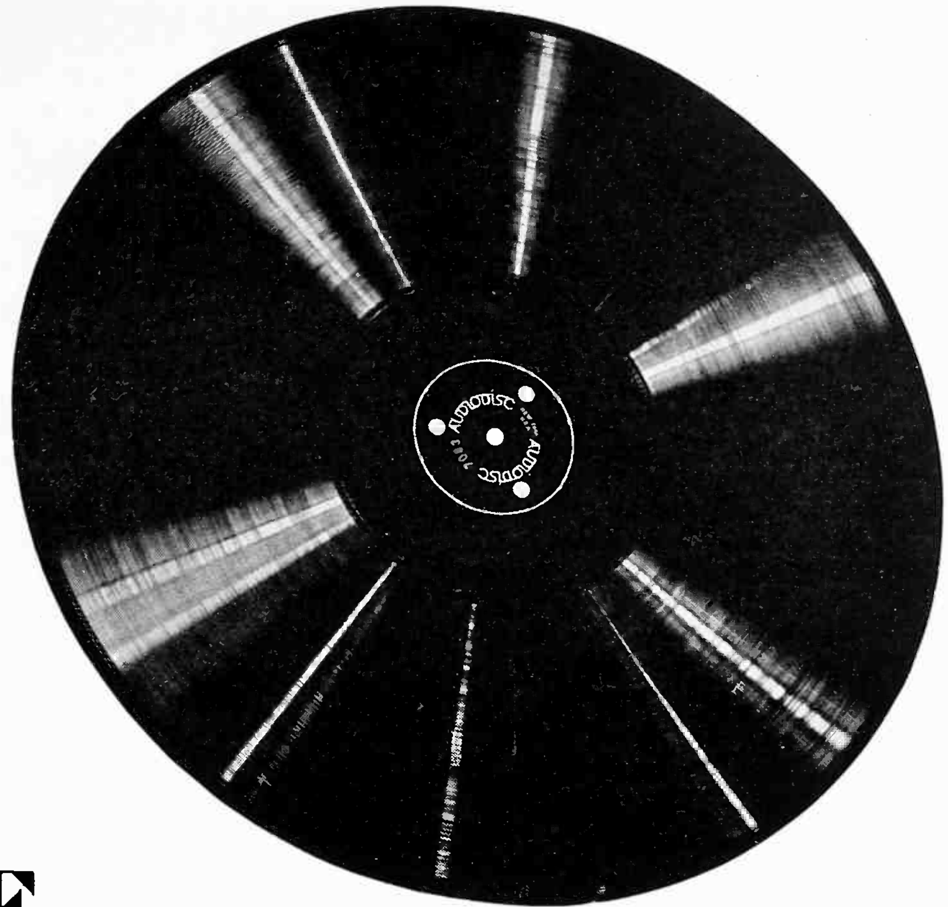
AMERICAN TRANSFORMER CO., 178 EMMET ST., NEWARK, N. J.

Manufacturers since 1901
at Newark, N. J.

AMERTRAN

You asked for it . . .

and here it is!



SENSATIONAL NEW

4 HOLE

GLASS BASE

audiodisc

"Return to Normalcy"

When aluminum vanished as a base material, you looked to AUDIO to engineer a suitable alternative — *in a hurry!* AUDIO promptly made available the first glass base discs. To AUDIO, however, these early models were but a stop-gap, pending development of this sensational new Red Label AUDIODISC.

Here is the answer to your most exacting demands — a brilliant achievement of AUDIO engineers, sparkling with exclusive AUDIO features that carry our industry a giant stride forward.

AUDIO is as grateful for your confident patience as it is proud to lead the way again, out of an era of inconvenience and expense.

LOOK at these EXCLUSIVE FEATURES!

SERIES 6000 — RED LABEL AUDIODISCS

- Thin, flexible glass base, with center hole and *three* drive-pin holes in new type fiber insert.
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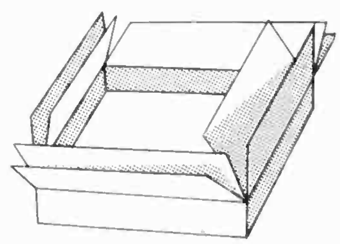
- New strength, the coating being a high percentage of total thickness. Perfect coating-to-glass bond.
- Amazing durability through scientifically correct strength-to-weight ratio.
- Less static charge in cutting.
- Flawless surface, lower surface noise, longer playback life, no deterioration.
- Coating formula and process now acclaimed the industry's outstanding best.
- Safe delivery. All Audiodiscs are shipped in specially designed reusable wood packing cases, approved by the transportation companies.

Safety Package for Re-shipment

Specially designed and equipped safety cartons, approved by the transportation companies, are now available to you *at cost*, for re-shipping 1 to 3 Audiodiscs.



CALL YOUR JOBBER, OR WIRE US FOR COMPLETE INFORMATION TODAY

AUDIO DEVICES
INCORPORATED

1600 BROADWAY
NEW YORK CITY

Motorola

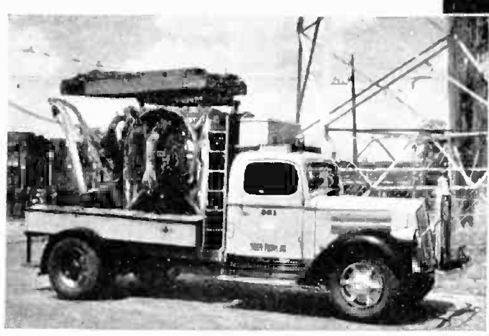
2-WAY F-M RADIO SYSTEM EXPEDITES HANDLING OF ST. LOUIS STREET CAR AND BUS EMERGENCY SITUATIONS

MOTOROLA F-M FREQUENCY MODULATION

With the aid of Motorola F-M 2-Way Radio Communication System, the Public Service Company of St. Louis is now able to speed up the handling of street car and bus emergency situations . . . This modern installation of Motorola equipment was made under the direct supervision of Motorola engineers.

In front of central dispatcher is a map showing car and bus routes and the reverse side shows the radio districts into which the system is divided. A mobile supervisor with radio cruises each district. Headway recorders check up on the spacing of street cars. Impulses generated by cars passing over regularly spaced trolley contactors are transmitted by telephone lines to recording instruments. Delays or disruption to service are immediately apparent.

The map shows the dispatcher the radio district in which emergencies arise. 2-way radio contact is established with the supervisor who is instructed to investigate the emergency and report details. Trouble trucks dispatched to the emergency are equipped with 2-way radio.



The Public Service Company of St. Louis has 3 trouble trucks all equipped with Motorola F-M 2-Way Communication Equipment.

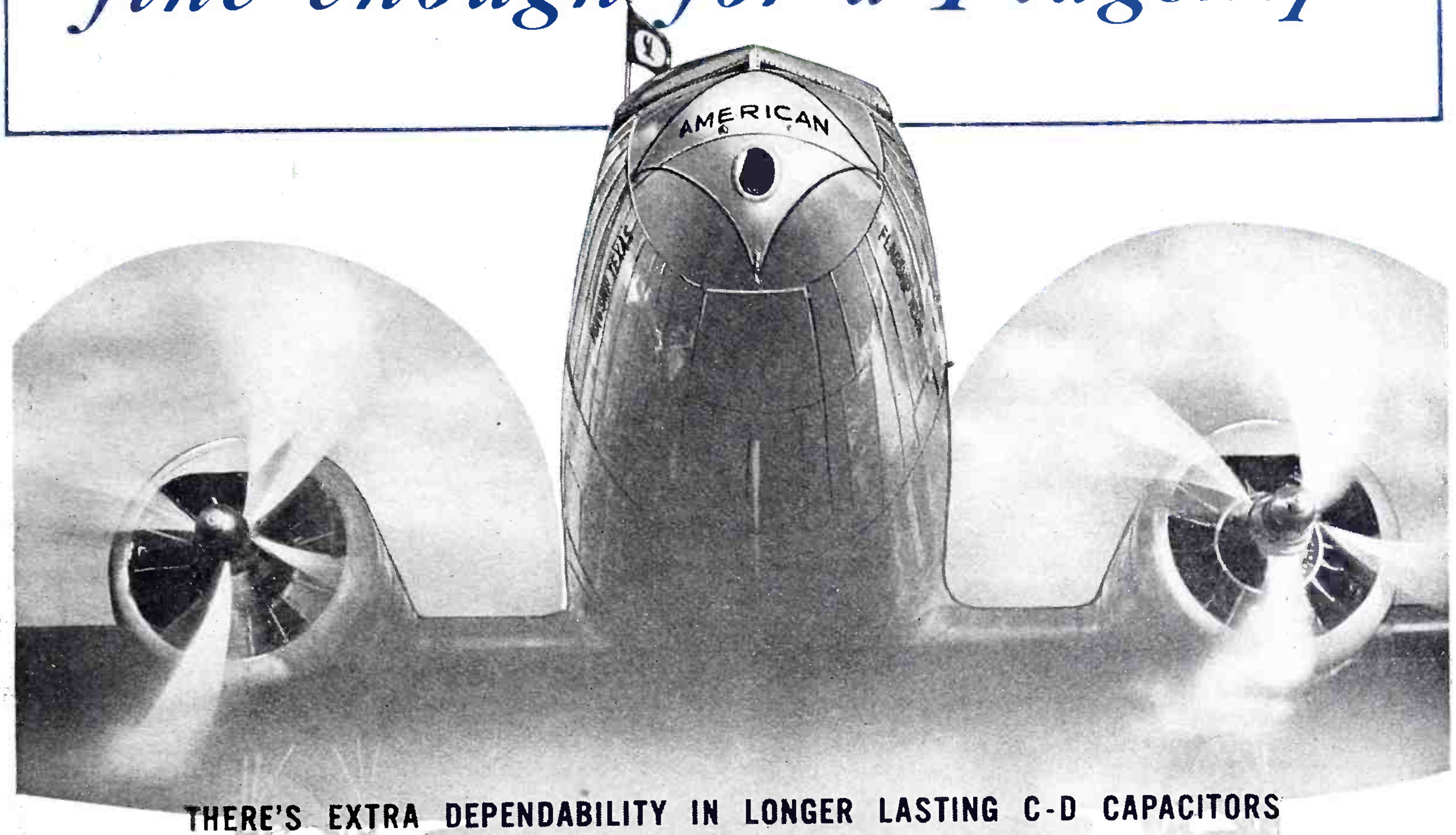
The Public Service of St. Louis has 15 cruising supervisor's cars all equipped with Motorola F-M 2-Way Radio Equipment.

WRITE FOR COMPLETE DESCRIPTIVE LITERATURE AND TECHNICAL DATA

GALVIN MFG. CORPORATION ★ CHICAGO, ILL.

MAKERS OF THE FAMOUS MOTOROLA AUTO AND HOME RADIO

Capacitor performance fine enough for a Flagship



THERE'S EXTRA DEPENDABILITY IN LONGER LASTING C-D CAPACITORS

A good test of capacitor performance occurs along the routes of the Flying Flagships. There's some difference in altitude and a great deal of temperature change between New York and Tucson . . . Toronto and Fort Worth. So it's significant that American Airlines use Cornell-Dubilier capacitors throughout its aircraft and ground transmitting and receiving communication equipment.

But not surprising. For back of today's Cornell-Dubilier capacitor looms the longest engineering experience in the industry—more than 31 years of capacitor specialization. And out of this has come the capacitor "know how" that gives C-Ds their *extra* dependability—an important reason why, today "*it pays to FLY*" . . . and pays you to specify Cornell-Dubilier, whatever your capacitor requirements.

CAPACITORS MAY LOOK ALIKE BUT . . . *There is extra long life, extra uniformity and dependability built into C-Ds. Next time you specify capacitors look for the Cornell-Dubilier seal of experienced engineering. And get the hidden extras at no extra cost. Send for Catalog. Cornell-Dubilier Electric Corporation, 1006 Hamilton Blvd., South Plainfield, New Jersey.*

MICA • DYKANOL • PAPER • WET AND DRY ELECTROLYTIC CAPACITORS

Cornell Dubilier

CORNELL-DUBILIER CAPACITORS CD

SOUTH PLAINFIELD, N. J. NEW BEDFORD, MASS.

. . . MORE IN USE TODAY THAN ANY OTHER MAKE . . .

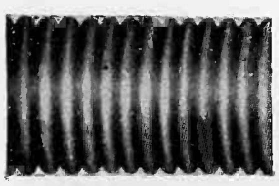
Again! KOOLOHMS LEAD THE WAY with two long-awaited improvements

THIS CONSTRUCTION REVOLUTIONIZED WIRE WOUND RESISTOR DESIGN

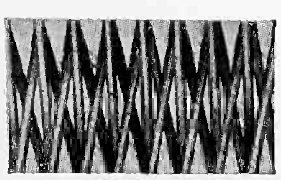
Resistance wire touches but cannot short

Engineers will be quick to appreciate the many advantages made possible in wire wound resistor construction by the exclusive Koolohm process of insulating the wire itself *before it is wound*. This permits layer windings for higher resistance in less space; progressive windings for non-inductive resistors that are truly non-inductive even at 50 to 100 Mc.; larger wire sizes; faster heat dissipation; greater stability; extreme accuracy and greater humidity protection. No secondary insulations such as brittle cements or enamels are needed on the windings. For double protection, however, most Koolohm types are encased in a sturdy outer ceramic shell that will not peel or chip and allows for mounting directly to metal parts. Koolohms are made in a full line of shapes, types and sizes for all needs. Write for the new edition of the Koolohm Catalog.

Koolohm wire with section of ceramic insulation removed.



Single layer winding



Progressive winding

In conformity with standard Koolohm Resistor construction, these new Type MFA and Type MFB Meter Multipliers are made with wire that is insulated *before it is wound* with a tough, 1000° C. heat-proof, moisture-proof ceramic material (U. S. Patent No. 2,213,969). They are further protected by a Pyrex glass high-voltage insulator tube, 1/8" thick and heat-treated. By test and in actual use, they have proved their ability to withstand temperatures as high as 150° C.—considerably higher than any other resistors of this type.

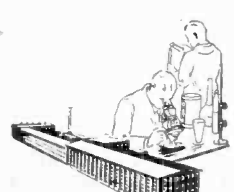
APPROVED FOR NATIONAL DEFENSE

These units are approved for exacting defense applications where they have set new standards of performance under adverse salt water immersion conditions. Complete information gladly sent upon request. Sprague engineers will gladly cooperate in helping you choose the proper Koolohm for greater dependability, longer life on practically any wire wound resistor application.

Type MFA KOOLOHM (9-13/16" long) is available in resistance ratings of 3.5, 4.0, 4.5, 5.0 and 6.0 megohms, with voltage ratings of 3.5, 4.0, 4.5, 5.0 and 6.0 KV respectively.

Type MFB KOOLOHM (5-5/16" long) is available in resistance ratings of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4 megohms, with voltage ratings of 1.0, 1.5, 2.0, 2.5, 3.0, 3.5 and 4 KV.

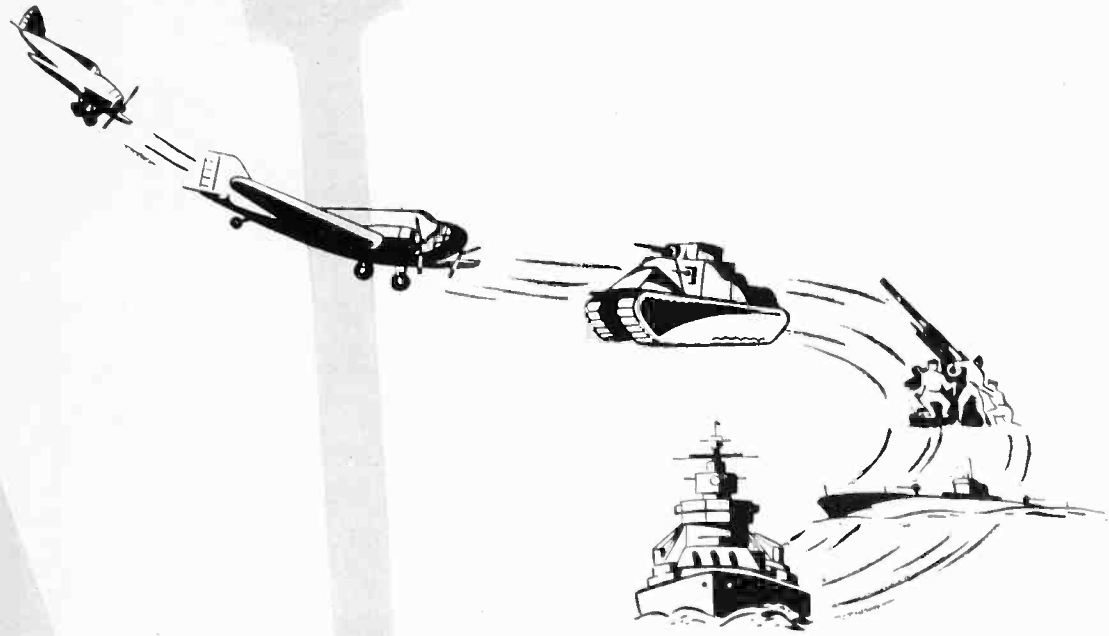
SPRAGUE SPECIALTIES CO., RESISTOR DIVISION
North Adams, Mass.



SPRAGUE KOOLOHM RESISTORS

Greatest Improvement in Wire Wound Resistor Construction in 20 Years


If You Want the Best
... We Recommend these new "Coaxial" Speakers
1 2 3 4
MIN
MAX
HIGH FREQUENCY CONTROL
Ideal extension reproducer for home, club, or institution. Insures full realization of the potentialities of the finest FM or AM receivers.
Excellent "across-the-room" unit for natural, more enjoyable reproduction with chairside tuners and combinations.
Recommended by manufacturers of professional type FM/AM receivers. Be sure you can enjoy FM at its best!
Brilliant Performance plus Complete Versatility with these New Jensen "Coaxial" Speakers
Not one—but two important achievements are combined in these new Jensen Coaxial Speakers and Reproducers! First...extended-range high-fidelity performance that meets the most critical professional requirements. Second...complete versatility, made possible for the first time by the new Jensen High Frequency Control. Now one reproducer covers every listening requirement, instantly adjustable for most satisfactory results on everything from wide range FM to home phono records! And the cost is so low it will surprise you. Data Sheet No. 120 gives complete details. Write for it today.
Four complete reproducer types with 12" to 15" speaker sizes, priced at $75.25 to $118.75 list in striped walnut cabinets. Utility cabinet models down to $64.25 list. Coaxial speakers only as low as $29.50 list.
Smooth, extended-range high-fidelity response eminently qualifies these reproducers for the most exacting service in FM/AM broadcast and recording monitoring.
Jensen
JENSEN RADIO MFG. CO., 6601 S. LARAMIE AVE., CHICAGO
CABLE ADDRESS: "JERAD" CHICAGO

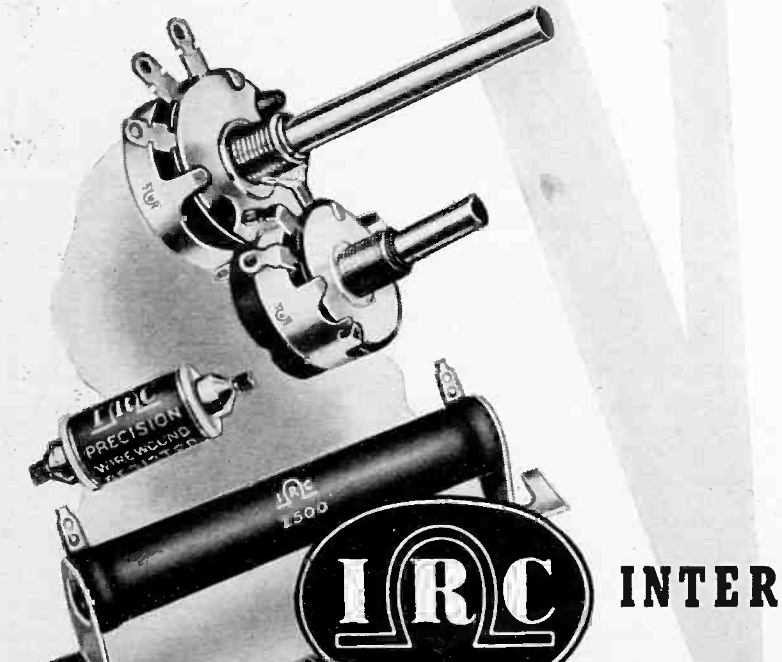


IRC RESISTORS HELP DEFEND DEMOCRACY

ON ALL FRONTS!

From Reykjavik to Singapore, from Murmansk to Sidney, from Tobruk to Chungking; at sea, ashore and aloft; at home and abroad; IRC Resistors are doing their job. In airplanes and tanks, dreadnaughts and submarines, they have been thoroughly tested in the critical laboratory of actual "shooting" war. From the world's hottest and most humid climates, to the coldest and dryest, they are standing the gaff of rigorous service in practically every type of equipment where resistors are required.

This widespread use of many types of IRC Resistors in modern defense equipment is a natural result of IRC's many years of specialization as well as its close collaboration with U. S., British and Canadian defense agencies.

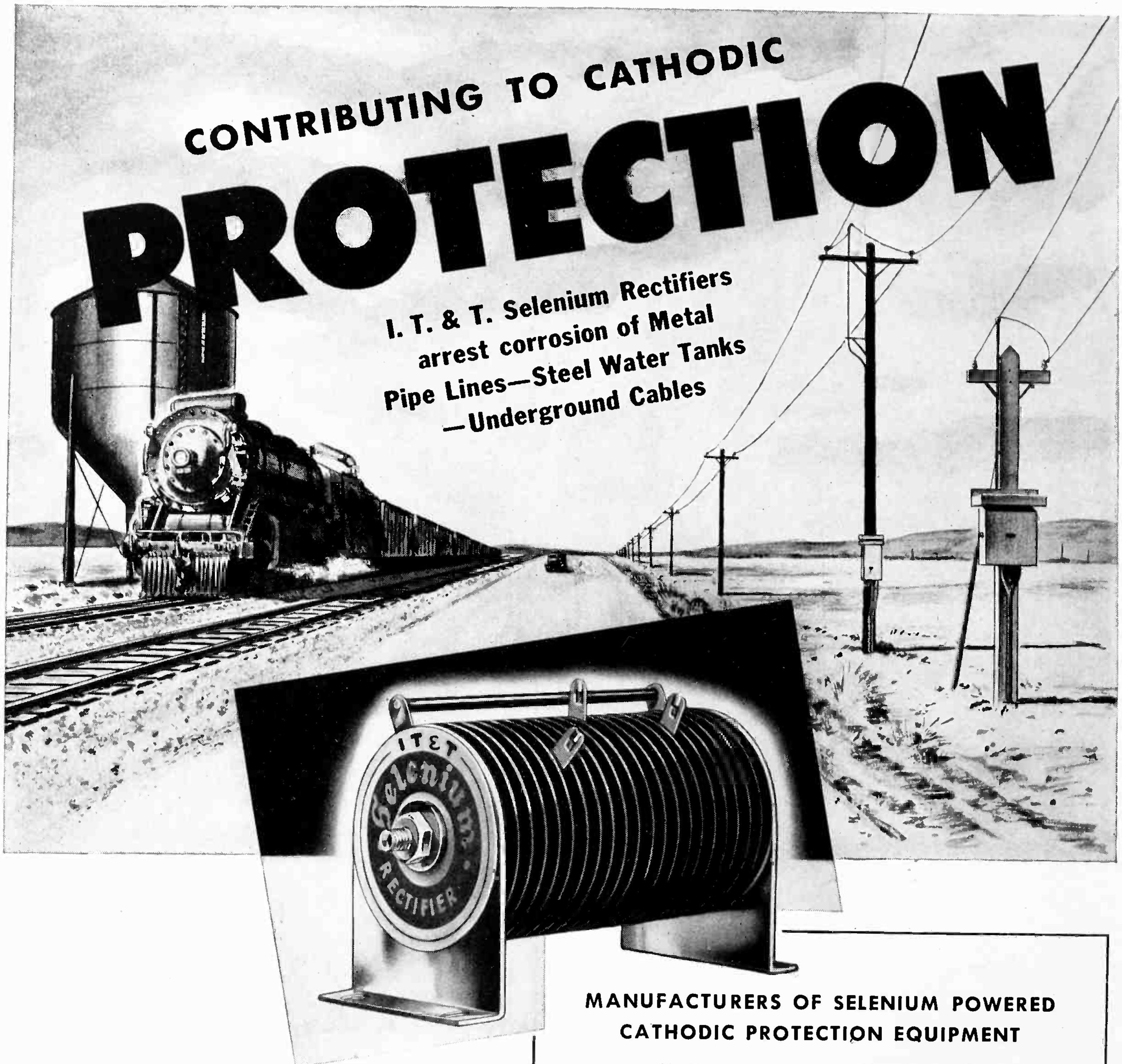


IRC

INTERNATIONAL RESISTANCE CO.

403 N. Broad St., Philadelphia, Pa.

Makers of Resistance Units of More Types, in More Shapes, for More Applications Than Any Other Manufacturer in the World.



MANUFACTURERS OF SELENIUM POWERED CATHODIC PROTECTION EQUIPMENT

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In the everlasting fight against corrosion of metallic pipe lines, underground cables, steel water tanks, etc., the introduction of the Selenium Rectifier as a cathodic corrosion eliminator has met with universal enthusiasm.

The reasons for this acceptance are many, for the I. T. & T. Selenium Rectifier, in addition to being a light weight and extremely compact unit, operates with high efficiency over an exceedingly wide temperature range . . . it has practically unlimited life and, because it is entirely metallic and rugged in construction, it requires no maintenance.

Consulting engineering services available for specific requirements.

Address Rectifier Division for descriptive Bulletin

INTERNATIONAL TELEPHONE DEVELOPMENT CO., INC.

67 Broad Street, New York, N. Y.


YOUR ANSWER
TO A PRACTICAL
replacement
MATERIAL
FOR METALS AND CERTAIN PLASTICS . . .
NATIONAL VULCANIZED FIBRE
WITH emergency shortages of essential metals and certain plastics, replacement with available materials for the purpose, may be your major problem right now. In this replacement role, National Vulcanized Fibre, due to its unusual mechanical and electrical qualities, has proved, and is proving its outstanding ability. (Available in sheets, rods, tubes and special shapes.) Our engineers will gladly work with you on any application. Wire, phone or write us.
NATIONAL VULCANIZED FIBRE CO.
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Offices in Principal Cities
NAME PLATE
TAX TOKEN
WAX PAPER

REACTANCE STABILITY *for...Defense Radio Equipment* through *SIMPLE, ACCURATE,* COMPENSATION

Erie Ceramicons
REG. U.S. PAT. OFF.

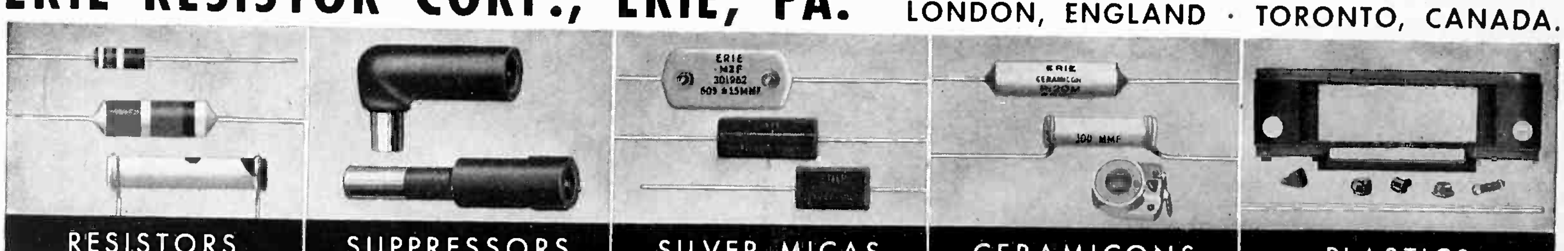
Erie Ceramicon Trimmers
REG. U.S. PAT. OFF.

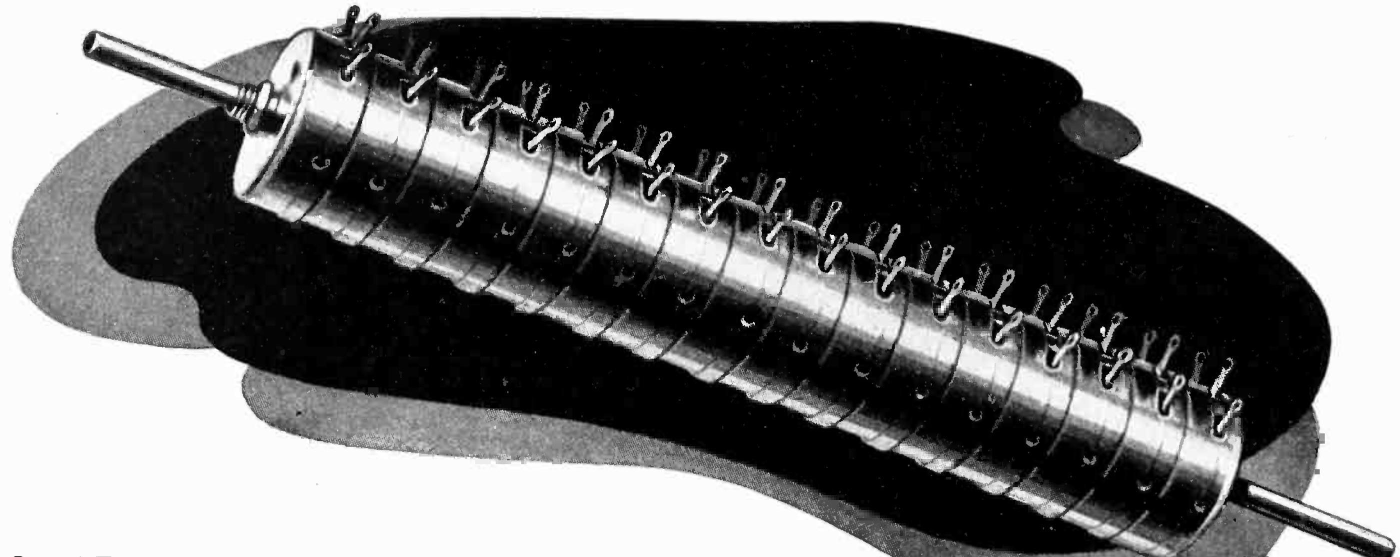
TUNING stability is essential in the many forms of military and defense radio equipment. The extreme temperature variations to which these sets are subjected, can change the reactance of many components widely and result in unstable oscillator frequency.

Such undesirable frequency drift can be accurately compensated for, simply by placing a proper-value Erie Ceramicon in the oscillator, as these small ceramic-dielectric condensers have a definite and reproducable temperature coefficient. Fixed-capacity Ceramicons are made in insulated and non-insulated styles with temperature coefficients between +.00012 and —.00075 per °C. Variable capacity Ceramicon Trimmers are furnished in single and double units with temperature coefficients of zero, —.0003, and —.0005 per °C.

Many exclusive design features of these units particularly adapt them to rigorous mobile uses. For complete description write for a copy of the new, revised Ceramicon catalog.

ERIE RESISTOR CORP., ERIE, PA. LONDON, ENGLAND · TORONTO, CANADA.

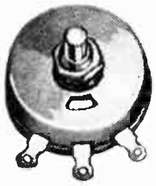




MALLORY Variable Resistors...

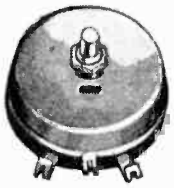
P. R. MALLORY & CO., Inc.

Single Gang... or 16 Gang... It's all in a day's Orders!



M TYPE VARIABLE RESISTOR
Insulated contact arm, dissipates 4 watts. 281° effective electrical rotation.

C TYPE VARIABLE RESISTOR
Grounded contact arm, dissipates 2 watts. 266° effective electrical rotation.



E TYPE VARIABLE RESISTOR
Grounded contact arm, dissipates 9 watts. 304° effective electrical rotation.

A prominent manufacturer of regulating devices needed a special potentiometer of 16 gangs and needed it quickly. The problem was presented to Mallory engineers, the job put into production, finished and delivered *on time* and *right* from every standpoint.

Solve a problem . . . fill a need . . . find a new way . . . They're all in a day's orders for Mallory engineers.

In addition to the standard wire-wound rheostats and potentiometers shown at the left, Mallory also manufactures and stocks high-resistance, carbon element controls in both standard and midget types . . . values from 5000 ohms to 9 megohms. Special construction features insure noiseless operation.

Manufacturers in many fields have turned to Mallory Variable Resistors, potentiometers, rheostats and attenuators for laboratory equipment, test and production devices where quiet action and critical adjustments are needed.

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA
Cable Address—PELMALLO

Send for this catalog

Be sure of a handy reference to the entire Mallory line of approved precision products. It will save time and money.

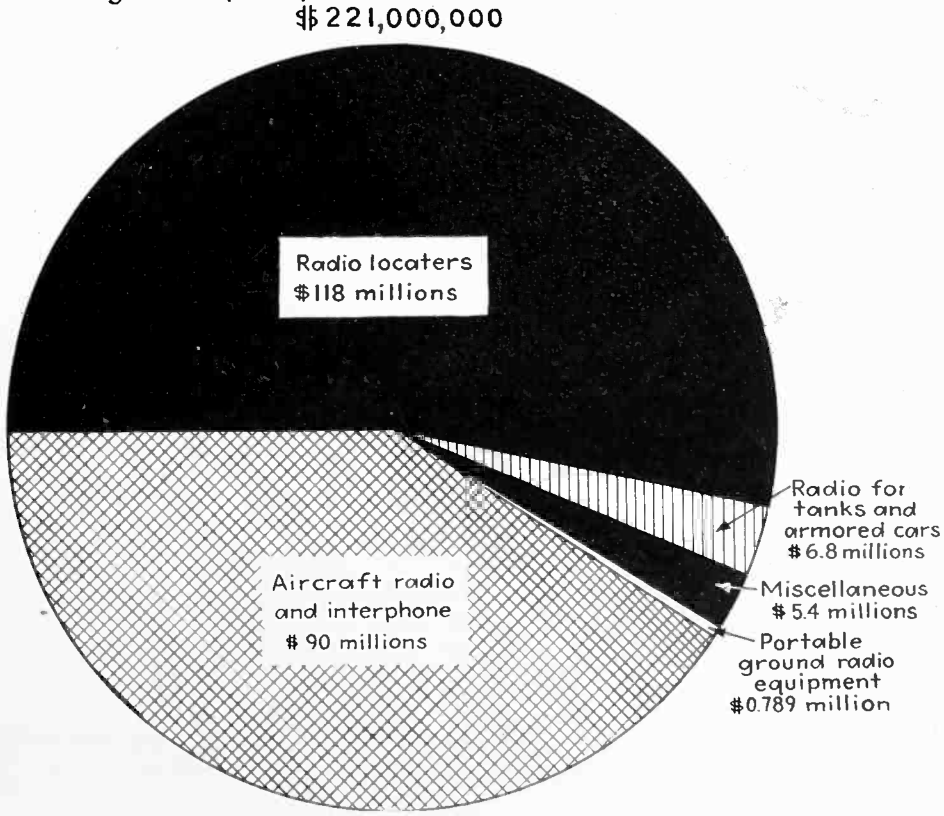
CROSS TALK

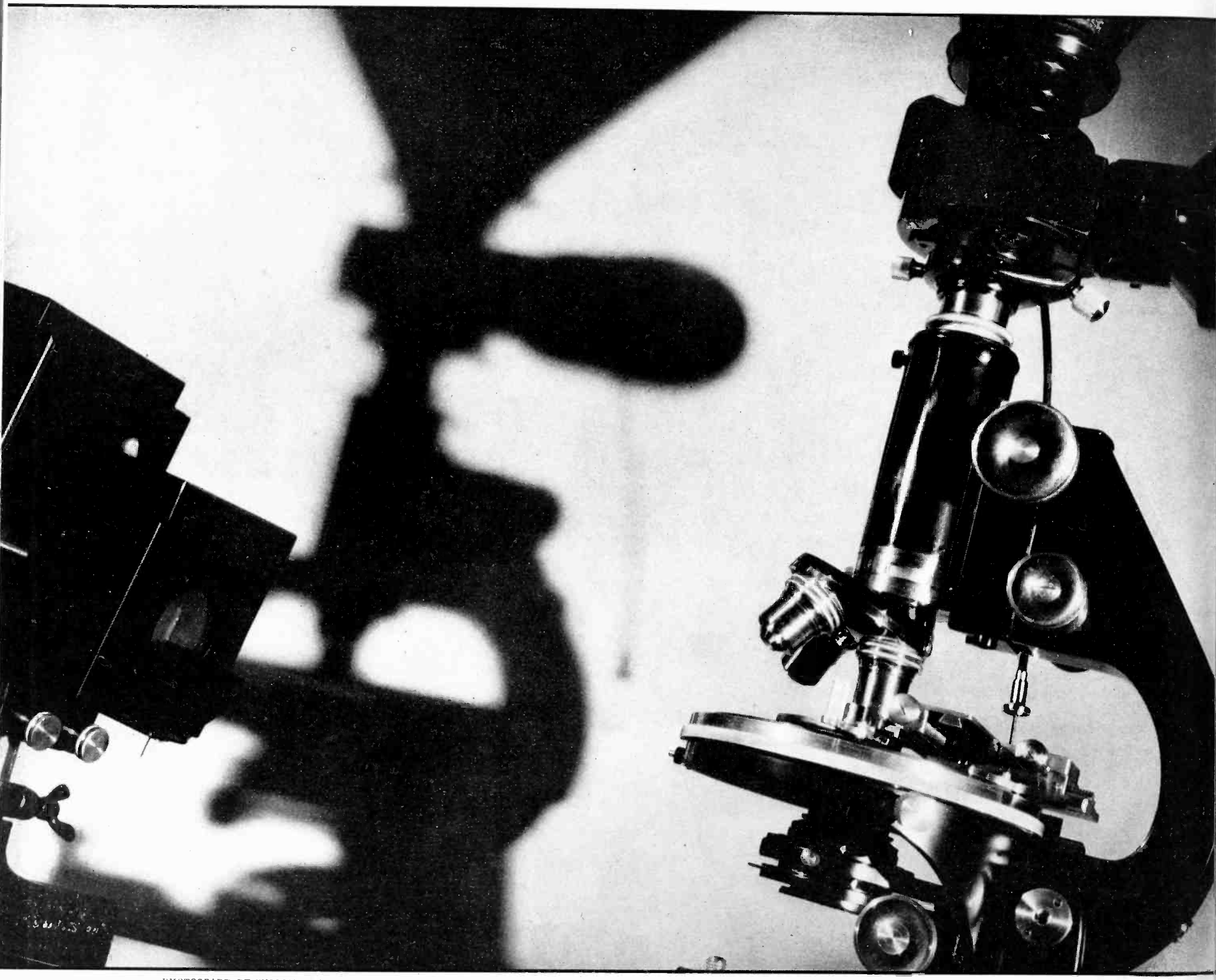
► **SIGNALS** . . . With the pretty complete disruption of the radio industry so far as non-defense products is concerned, and with the vast sums of money being spent, one cannot but wonder how much of the money is going to our industry, and what the country will get for it. Our curiosity along these lines cannot be completely satisfied at the present moment because "to a military expert, disclosure of the amount of the equipment affords a vital source of deduction as to contemplated defensive of offensive measures with a corresponding increased ability to counteract those measures."

So said Under Secretary of War Patterson before the Truman Committee of the United States Senate on July 15, reporting on the actual accomplishment in Army procurement during the fiscal year ending June 30. In his report, however, are some round figures on expenditures by the Signal Corps which give an idea of the magnitude of the effort in which the communications industry is at work.

During the fiscal year 1941 some 103 millions of dollars were to be spent for aircraft communication equipment alone; by June 21, 1941, 11.5 millions had been delivered. During the fiscal year 1941 an expenditure of 38 millions was allocated for portable ground radio equipment, to be carried by man, by parachute, by truck. Radios for tanks and armored cars account for 41 millions; wire and cable (32.5 millions) and miscellaneous purchases of 7.8 millions will bring the total to some 223 millions of dollars. Part of the portable ground equipment money went for radio locaters—but the big money for this material will be spent in 1942 as the pie chart shows.

1942
Total Signal Corps Expenditures for Communication Equipment
$221,000,000





PHOTOGRAPH BY WILLIAM WARD

Research is a very powerful tool in adapting plentiful materials to do the jobs formerly done by materials now unavailable because of National Defense requirements. Mr. LeBel's article describes an outstanding example of the value of such research in that aluminum, in great demand for the production of airplanes, was replaced by readily available glass

RESEARCH BEATS THE PRIORITIES

When recording disc manufacturers were forced to abandon aluminum as a base material the groans were many, but glass is proving that it is a superior material for this purpose. Events leading to the adoption of glass and some of the technique of using it are outlined

By C. J. LeBEL
Audio Devices, Inc.

RESEARCH often takes quite a while to yield useful results, but the preparatory work which has been done may be the saving factor in an emergency. This is the case with the aluminum substitute problem in the instantaneous recording field. For nearly two years proposed materials were studied, more with the idea of improving quality or reducing cost than with any feeling of imminent emergency. Nevertheless, when aluminum priorities were imposed at the end of February, all of this groundwork was a godsend, for it meant not starting completely fresh but completing an almost finished solution. We had found out exactly what should not be done. There was nearly enough aluminum on hand to take up the slack while a new material was put into production.

So the problem was not to decide in which direction to go, but merely to go ahead. Of course going ahead involved carload lots of material and this took some time to secure, perhaps longer than was anticipated. But there was no frantic scurrying around trying to decide what to do.

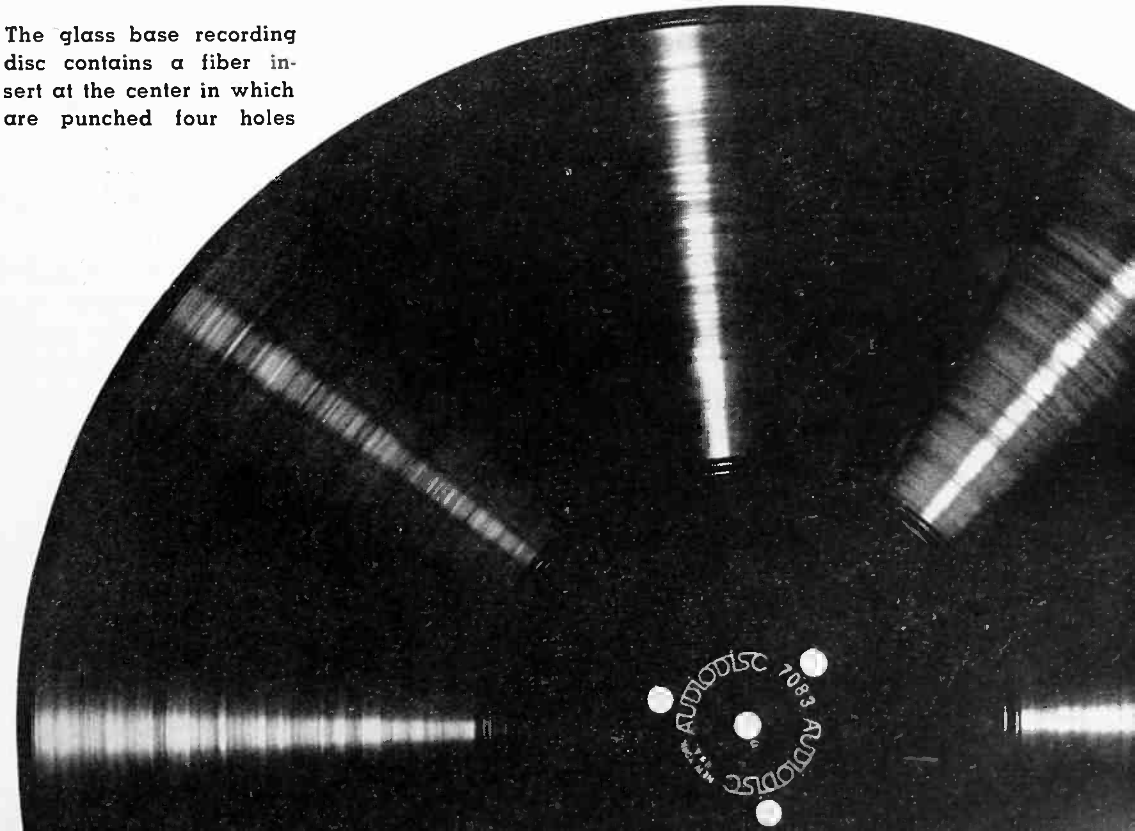
From the *professional* record user's point of view aluminum has been valued as a base material chiefly for its extreme flatness and perfectly smooth surface. To maintain the flatness within its normal range of ±0.005 inch has further involved freedom from warping, considerable strength, fair stiffness, and no softening at moderate temperatures. Maintenance of surface smoothness involves reasonable hardness and absence of surface porosity. The problem has been to find other materials at least equal to and preferably superior to aluminum. Nothing poorer in these respects would satisfy the critical professional user.

The Preparatory Period

Early in 1939 the search for a new base material for professional instantaneous recordings was begun. The first tests were on records made of cardboard, hard fiber and other pressed boards. The porous surface produced a serious grain, but the worst complaint lay in the inherent tendency to buckle and twist. Special lacquer formulas adaptable to cardboard proved soft and seriously lacking in high frequency response; they were suitable for a home quality disc perhaps, but certainly not for a good professional product. Research along this line has been continued to the present day but with identical results.

The next step was in the field of synthetic resin plastics. A thermoplastic resin re-softens every time it is heated. Our experience with thermoplastics was unfortunate. A temperature considerably below the normal softening point would cause the disc to droop gradually in accelerated cold flow. This caused a great deal of difficulty in curing the records, and in fact, long before the end of the curing operation the disc assumed a U shape which made it utterly worthless. The curing operation is vital to production of a good product and so cannot be discontinued. There was a certain amount of warping after the material had cooled off as well and thermoplastics were quickly abandoned.

Thermosetting resins harden upon the application of heat and pressure and never soften up again on further heating. These seemed rather interesting and a great many tests were



The glass base recording disc contains a fiber insert at the center in which are punched four holes

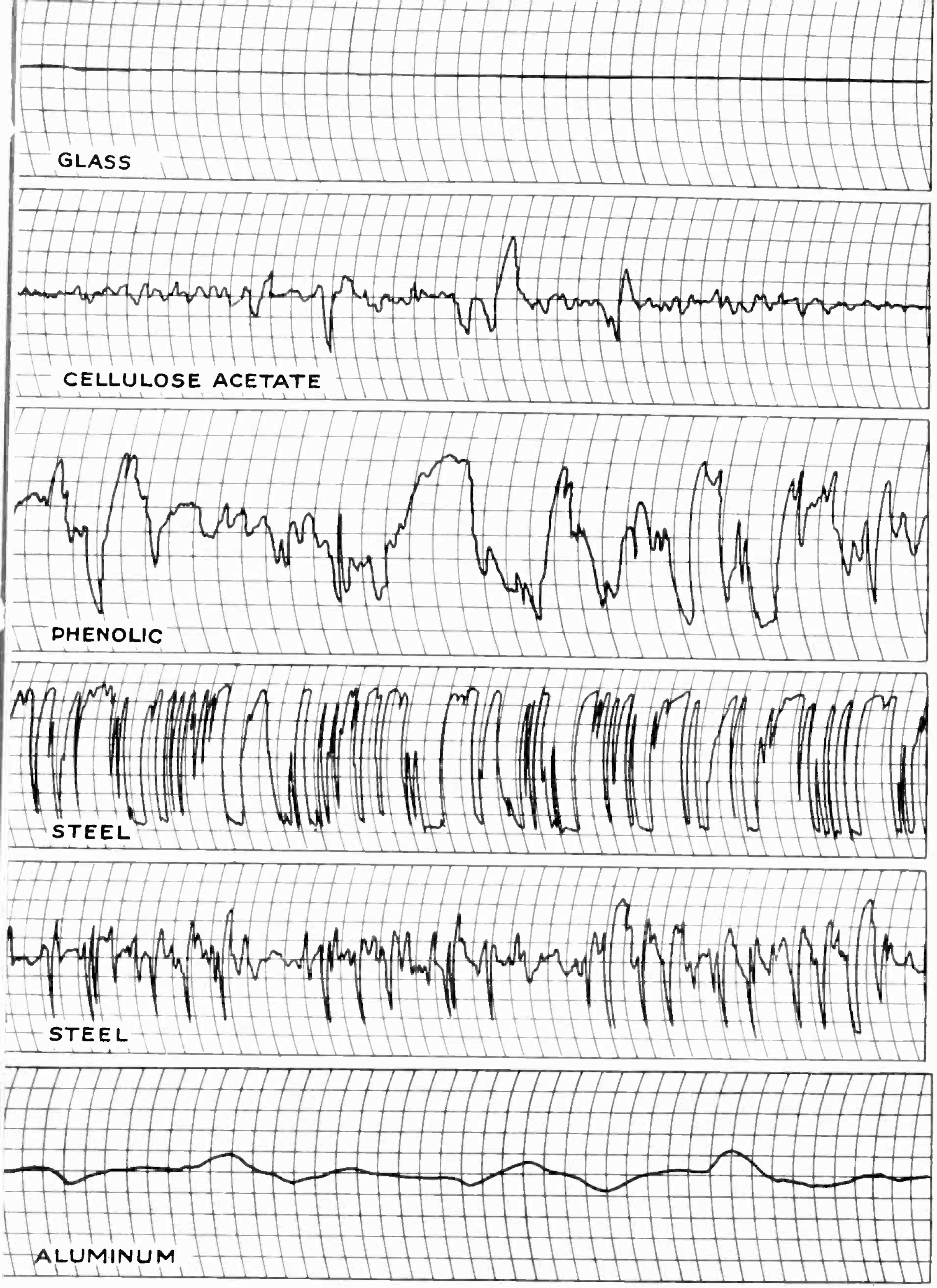


Fig. 1—Surface characteristics of several possible base materials for recording discs. Each vertical division indicates a departure from absolute smoothness of five millionths of an inch. The horizontal distance is eighty times greater than the actual distance traversed

made. However, it soon developed that such materials warp in time. It is hard to say whether this warping tendency is due to the resin itself or whether it is due to the base material, but in any case and seemingly regardless of the character of base material used, severe warping ensues. A further difficulty was the general floppiness of such sheets in any practical thickness. This floppiness could have been overcome at considerable cost by increase of thickness, but serious warping was too much to be accepted and it became necessary to study the metals.

Actually, long after this decision was adopted, tests of new resin samples continued, but always with the same general result. Incidentally, plastics have a rather curious surface grain which varies with the maker, but which is always present in one form or another. This irregularity appears in the coated disc and is rather objectionable.

Metals as Base Materials

Zinc had been used in France as a substitute for aluminum, and our first tests were with this metal. It was soon found that zinc could be made with a very fine surface. However, pure zinc is heavy, but not very strong and the chance of buckling a disc is much too great. The zinc alloys which were tried were quite satisfactory. The discs possessed sufficient strength and had an excellent surface.

Steel was another obvious choice. It has good stiffness, excellent strength, and is the least floppy of the metals tried. On the other hand it is very difficult to get steel free from roll marks. These are produced by minute roughness in the rollers and can be eliminated by polishing the rollers just before use. This is costly and wholly unnecessary for any other customer, so the manufacturers were understandably reluctant to handle such a headache. Nevertheless, it was possible to get good samples. However, when the roll marks were eliminated, it was found that a characteristic grain resembling an orange peel took its place. This was less objectionable except from the appearance point of view, but it did stamp the steel disc with a characteristic appearance. An idea of the characteristics of surface grain on different materials may be obtained from Fig. 1, which is a group of charts drawn by a Brush surface analyzer. The principle of this device is shown in Fig. 2. A diamond point is drawn back and forth over the material to be tested. Roughness of the material vibrates the point, actuating a piezoelectric crystal which converts the mechanical displacement into voltage. The amplified voltage operates an oscillograph producing a graph of the rise and fall of the point. The magnification is such that one division of height (measured at right angles to the length of the chart) corresponds to five millionths of an inch. The speed of travel of the chart is such as to produce a magnification of 80 times along the length. This device is used rather widely for checking surface character. The curves speak for themselves and no particular comment is called for, beyond to point out that the glass curve is virtually as straight as though drawn by a ruler. The other graphs are for other materials, but the magnification and amplification are the same in all cases.

Results were sufficiently interesting to warrant pilot plant tests so several thousand pounds of steel of various thicknesses were ordered. The first discs were cut on a circle cutting machine, but the resulting burr proved objectionable. It became necessary to order die sets for all the standard disc sizes. Seemingly this added trouble was a serious misfortune, but later on possession of the dies at a critical moment proved of enormous help. Good die design and skilled punching technique then turned out quantities of burr-free discs in various thicknesses. Coated discs were tried by representative customers and the optimum steel thickness determined for each diameter, as a compromise between rigidity and weight.

A technique for handling the new material and for coating it properly had to be developed. It was found, however, that even specially rolled, patent levelled, and carefully handled metal was occasionally not very flat according to the recording industry's standards. It was necessary to reject many punchings and even then steel was likely to average somewhat poorer than the aluminum then in use.

The general public's reaction had to be considered. It became evident that it prized the stiff feeling of hard rolled aluminum and that any other material would have to come as close as possible to it. A mathematical study became necessary. For a given thickness and force the deflection of a material is inversely dependent on the value of Young's modulus. The force tending to bend the disc when handled is proportional to the specific gravity so that we may compute an index number which permits comparison of the materials most suitable for the purpose. The consumers figure of merit can be expressed as

$$M_c = 10^{-6} E/G$$

where E is the coefficient of elasticity or Young's modulus, and G is the specific gravity of the material under consideration.

A modification of this equation may be made to allow for the resistance to permanent deformation in factory handling, and the factory or producer's figure or merit may be expressed as

$$M_f = 10^{-10} SE/G$$

where S is the tensile strength of the material under consideration, and the other symbols have the meaning given above.

The cost might be introduced as a factor in the denominator, but it has little importance beside the other three as far as the recording field is concerned.

Some representative values are given in the following table; the values are suggestive only, with no pretense to being definitive:

Material	Users Factor	Factory Factor
Steel	3.9	19.5
Aluminum	3.8	7.6
Glass	3.2	1.3
Copper	2.0	10.2
Laminated Plastic	1.8	1.6
Zinc	1.7	4.1
Zinc Alloy	1.7	8.5
Phosphor bronze	1.6	13.1
Brass	1.1	7.9

It can be seen from this that steel is definitely the best at any given thickness. If we introduce the cost factor it becomes still more superior. A number of miscellaneous factors such as chemical reasons, surface, punching character, and cost ruled out most of the other materials listed.

About the time that we had narrowed down the field to zinc alloys and steel, we found material shortages approaching. Zinc immediately went by the board, because a zinc shortage was one of the first to occur. This left steel as the only metal, and we knew that it had the faults of slight grain and occasional incompletely perfect flatness, but we also knew that it was entirely suitable for a great deal of recording work, and we knew how to process it. Therefore, when aluminum priorities were imposed, the first step was to order sufficient quantities of specially rolled steel from the best manufacturer as shown by the pilot plant tests on about 19,000 discs.

Rapid Start Using the New Materials

With the steel order accepted and the delivery date set we realized how lucky the pilot-plant tests had been for we had complete sets of dies proven and waiting to go to work at a time when dies in a hurry just weren't obtainable. When the steel rolled in the presses were set up and ready to go. Research had paid a dividend.

In the meantime it became evident that no new aluminum would be available, and that with airplane production stepping up daily, even melting and rerolling old discs would soon stop. A new material had to be found for the most critical users: broadcast stations, professional recording studios, and motion picture producers.

This new material had to have ex-

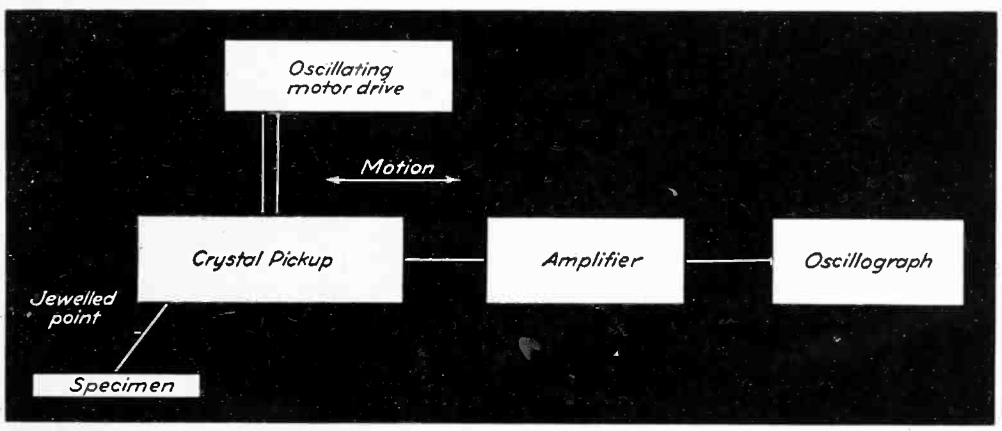


Fig. 2—Block diagram illustrating the principle of the Brush surface analyzer. A diamond point is moved across the surface and any irregularities are shown on the oscillograph

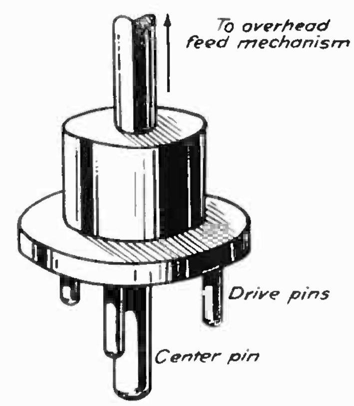


Fig. 3—Some recording machines have the drive pins attached to the flange as shown rather than to the turntable. A rubber pad raises the drive pins above the disc

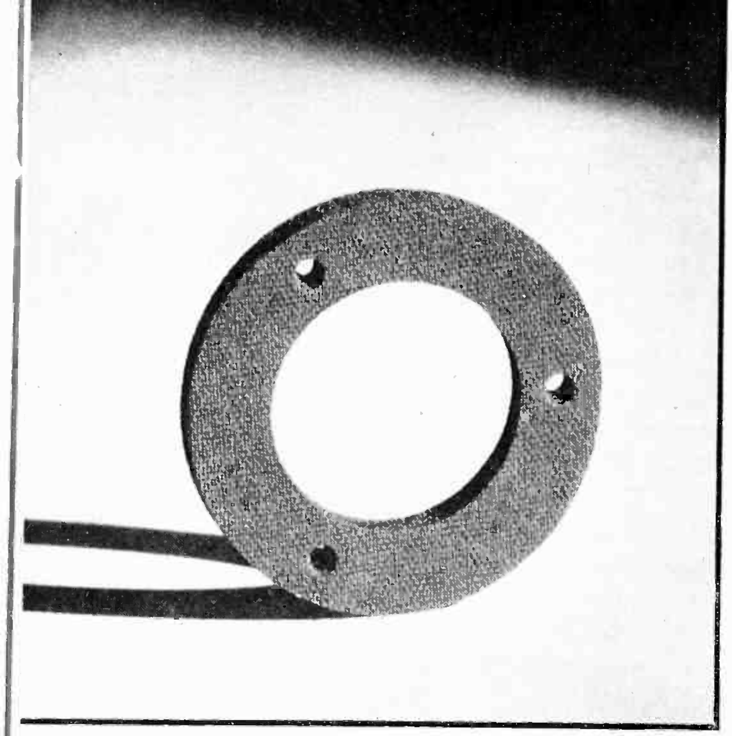


Fig. 4—Rubber pad which is used to prevent the drive pins of Fig. 3 from resting on the glass base recording disc which is not equipped with drive holes to accommodate them

treme flatness, perfect surface, and desirable chemical properties, plus little liklihood of being placed on the list of priorities. The user factor computations pointed a finger at glass, and the hint was sufficient. Glass made by the right process has a flawless surface and is the flattest of any material in its natural state. The factory superintendant sent out for a box of aspirin and work began.

The first problem was the question of thickness. A number of tests soon showed that a base thicker than about 0.065 inch produced a record of excessive thickness; excessive because any recording machine in general use would be thrown out of alignment by the increase above normal. On many machines with an overhead feed mechanism the misalignment of center pin and driving flange shaft produced intermittent change of load, resulting in growl or serious wows; in other cases it changed the cutting angle near the center, producing excessive angle variation from rim to center. This would necessitate realignment of the feed mechanism. On lathe type machines the change of angle was great enough to necessitate readjustment.

A further thought occurred in connection with durability. One's first reaction would be that the thicker the glass, within limits, the stronger it would become. This is not true as regards resistance to dropping, which is of course the chief problem. If a record is made a little thicker, its strength is increased. But at the same time the weight of the record has gone up in direct proportion, so that the force tending to damage the record on impact has also gone up. Hence, the strength to weight ratio is unchanged. Therefore, within reasonable limits an increase of thickness produces virtually no effect on the durability. It is possible that the cushioning effect introduced by the coating and the flexibility introduced by decreased thickness has something to do with this. As a matter of fact it might be better to use a still thinner glass, whose flexibility is quite astonishing.

The question of tempered glass came up. This material is extremely strong, but the flatness is not satisfactory, undoubtedly due to the tempering operation. It was further found that whereas an ordinary glass record would crack at one point when dropped from too great a height, the tempered glass would shatter rather completely when once a break started. Therefore, while ordinary glass when cracked could be re-recorded onto another disc (the coating, of course, held the material together) the tempered glass would be utterly valueless. Also the cost of tempered glass is prohibitive.

The tenacity with which cracked glass holds together is surprising until one recalls that the principle is the same as that of automobile windshield safety glass. Windshield glass is a sandwich of glass-plastic-glass, while a disc is plastic-glass-plastic. Another reason for the enhanced durability lies in the cushioning produced by the outer unbreakable lacquer coating.

So the problems of glass production began. The first morning it was thought that cutting and drilling would present no problems at all, for hadn't glass been cut and drilled for centuries? About noon the superintendant phoned home that he wouldn't be in till midnight—the job was a little hard.

The next morning he brought a large bottle of aspirin as permanent equipment for his desk for it had soon been found that the accuracy with which these operations had been done in the past was not satisfactory for recording purposes. The diameter of the hole at the center had to be controlled to within a very few thousandths of an inch and the circle diameter and concentricity also had to be quite accurate. In addition to that there were severe problems of surface cleanliness to insure good adhesion of the lacquer. Another interesting discovery was made. It was found that a disc with one hole was infinitely stronger than one with two or the usual four. This was traced to an area of weakness around each hole and a line of weakness joining the two holes. The obvious remedy was to use only a single hole. The question then came up of whether a single hole disc could be driven properly on standard machines. Rather gratifyingly it was found that practically all standard commercial machines hold the record between layers of rubber or Corprene and the friction produced by the normal pressure of the machine was sufficient to insure a positive drive. The expression gratifyingly is used because the completed record is worth thirty or forty times as much as the blanks and anything which protects the completed result is worth using. Many tests were made on machines of different manufacture and in different recording rooms and the results always checked; the drive was positive. This is not very surprising when we remember that European practice always used friction and that some of the best recording turntables are driven by friction. As a matter of fact in the old days discs of all sorts were driven by a pressure clamp at the center and no drive pin was even thought of with so slippery a material as waxed aluminum. Perhaps one help is the fact that the coefficient of friction between a lacquer coating and rubber is quite high and a rather small pressure will serve to produce a very great gripping force.

Skeptics should try the finger test. Draw a crayon line on the rim of the disc and another line next to it on the turntable. Start recording, then press on the record with a finger. It is amazing to see how much added pressure is needed before the disc line drops behind the other as the record starts to slip. Then try the crayon lines alone on the next few regular recordings. There is absolutely no evidence of slippage, even on a 15 minute program.

Experience with Glass Base Discs

Heavy production of steel and glass began in early April and from

(Continued on page 78)

Defense Contracts for Small Plants

Small manufacturing plants have a very definite place in the national defense effort. The procedure for fitting a small organization into its proper place by the acquisition of defense contracts or sub-contracts is given in a straightforward manner

By ERNEST O. EISENBERG

Institute of Public Research

ARE you getting your quota of defense contracts? If you feel that you are not, the following paragraphs are dedicated to you, regardless of the fact that you may believe your business is too small, under-capitalized, or inadequately equipped to handle defense work.

Defense is America's biggest business today. As such, it has already established priorities in the field of basic war commodities. As such, it will soon possess the authority to divert skilled labor from non-essential factories to war industries.

As of July 1, 1941, eighteen billion dollars of defense contracts were let out by the United States Army and Navy. Contracts exceeding thirty billion dollars are being planned and the end is nowhere in sight.

Where do you fit in this picture? Is the continued operation of your plant necessary for national defense, or would the interests of this nation best be served by diverting your raw materials and skilled workers to some other factory? This is the question you must ask yourself now! Ask it honestly, and answer it honestly, because if your business is non-essential in this emergency, you have no guarantee that you will remain in operation six months from today.

You can make your business essential, however, by participating in the defense program. And the best way of doing that is by securing a defense contract. The procedure for obtaining defense contracts has been greatly simplified recently. It is not necessary or even advisable for you to travel to Washington to find out what you can do.

Instead, write to your regional office of the Defense Contract Service and describe in detail your facilities for handling defense work. The Defense Contract Service is a Federal Agency set up by the Office of Production Management in cooperation with the Federal Reserve System. Its chief purpose is to help you obtain defense contracts.

Its offices are located in each of the twelve Federal Reserve Banks, and in each of their twenty-four branch banks. These are as follows:

Atlanta, Ga.	Memphis, Tenn.
Baltimore, Md.	Minneapolis, Minn.
Birmingham, Ala.	Nashville, Tenn.
Boston, Mass.	New Orleans, La.
Buffalo, N. Y.	New York, N. Y.
Charlotte, N. C.	Oklahoma City, Okla.
Chicago, Ill.	Omaha, Neb.
Cincinnati, O.	Philadelphia, Pa.
Cleveland, O.	Pittsburgh, Pa.
Dallas, Texas	Portland, Ore.
Denver, Colo.	Richmond, Va.
Detroit, Mich.	Salt Lake City, Utah
El Paso, Texas	San Antonio, Texas
Helena, Mont.	San Francisco, Calif.
Houston, Texas	St. Louis, Mo.
Jacksonville, Fla.	Seattle, Wash.
Kansas City, Mo.	
Little Rock, Ark.	
Los Angeles, Calif.	
Louisville, Ky.	

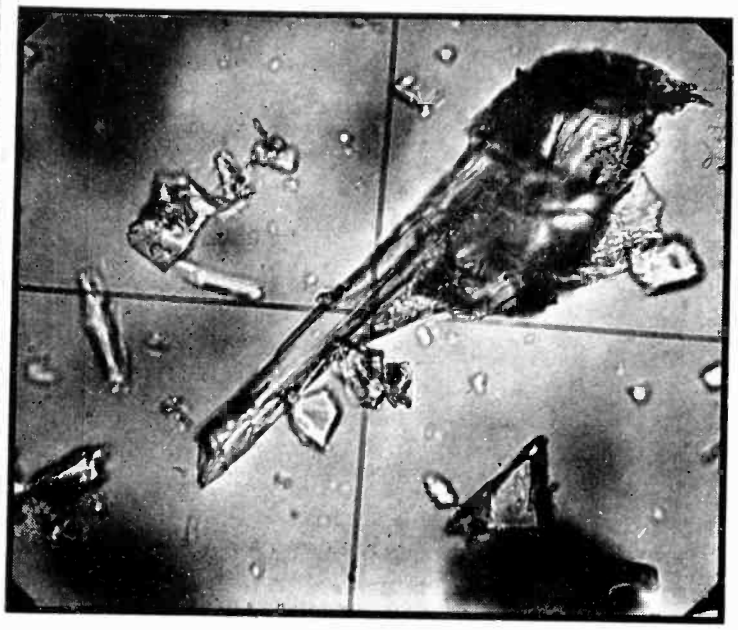
Write to the regional office which serves your area. In your letter enclose photographs showing the interior of your plant. These photographs should be taken from several angles. In addition, supply photographs or complete descriptions of the products you are now making or have made in the past. You should also answer the following thirteen questions:

1. How many employees do you have?
2. How many people could you employ on a one-shift basis, a two-shift basis, or a three-shift basis?
3. How many shifts are now working in your plant, and what is the length of each shift?
4. How many shifts can you work with the labor supply available in your community?
5. Do you have a design and development department?
6. List each of your machines by size, type, manufacturer's name, manufacturer's serial number, the year in which the machine was built. and the tolerances to which it will work.
7. How many machine hours do you have idle per week over and above present commitments? This information should be broken down by types of machines.
8. Is your power source adequate?
9. What are your shipping facilities?
10. Who are some of your regular customers?
11. Have you ever had a defense order and, if so, for what?
12. Have you ever been a sub-contractor and, if so, for whom?
13. Have you ever sub-contracted any of your work and, if so, to whom?

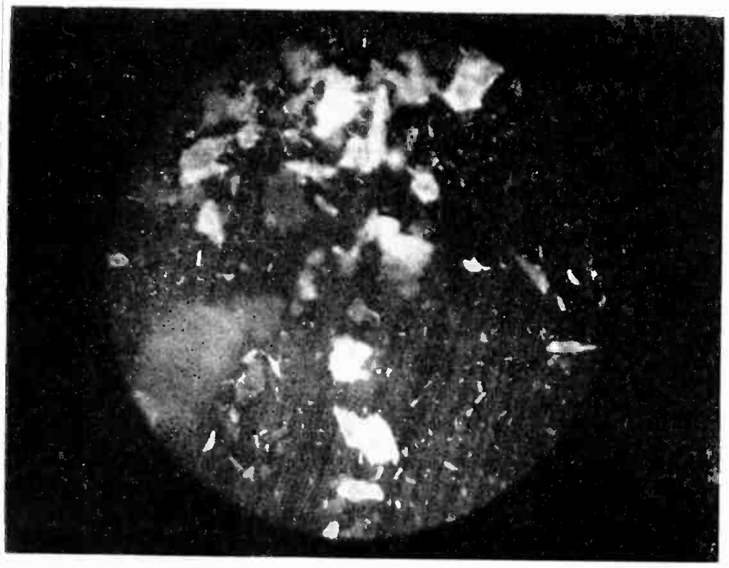
The men staffing the offices of the Defense Contract Service are prepared to give you every possible consideration and assistance. If you feel that your plant is under-capitalized for defense work, they will help you secure the necessary financing once you have been approved as having the suitable facilities and qualifications for defense contracts. If your plant is inadequately equipped to handle any particular job, they will guide you in pooling your resources with other small shop owners so that together you can participate in a contract which none of you could handle alone. If you are a sub-contractor, they will furnish you with lists of defense contracts already let out, so that you will know which prime contractors to approach for work. In short, the Federal government will cooperate to the fullest extent in helping you make your business an essential one. The rest is up to you.

By L. H. STAUFFER
University of Idaho

CHARACTERISTICS OF



Calcium silicate crystals enlarged about 325 diameters. This phosphor will luminesce yellow under electron bombardment. Photographs were made by RCA Manufacturing Co.



Calcium silicate phosphor magnified 80 diameters under the luminescent microscope. The particles were photographed by their own luminescence

WITH the advent of commercial television and fluorescent lighting the phosphors have become the subject of intensive investigation and development. Recent improvements in luminous efficiency and color range have placed these fluorescent materials among the most important light sources now in use. Luminescent crystalline materials have been developed with efficiencies exceeding 70 percent, for ultraviolet excitation, and almost any desired hue, including white, is obtainable. As energy converters the phosphors far outstrip the incandescent filament in efficiency, and in addition they have the advantage of quick response to variations in exciting energy.

Phosphors are made by firing a pure crystalline material with a very small amount of another element known as an activator. The kind of activator, its concentration, and the heat treatment employed have important effects on the behavior of the phosphor. There is a specific activator for each basic crystalline material, although some compounds may be activated by several different elements. Of the matrix materials now in use the metallic sulphides, silicates, and tungstates are of greatest practical interest. The table lists representative phosphors belonging to these groups together with their activators, emission peaks, and persistence times. It will be noted that the tungstates are exceptional in that they require no activator. Also, it will be seen that there is a wide variation in color and persistence time among the phosphors listed.

Fluorescent materials convert the energy of electron beams, ultraviolet light, or x-rays into visible light with widely varying efficiencies. For cathode-ray excitation the efficiency of energy conversion is about 10 percent for most phosphors, while it may be as high as 50 to 70 per cent when the same phosphors are excited by ultraviolet. For x-rays the efficiency is from 1 to 5 percent depending on the hardness of the radiation. The luminescent hue of the phosphor, however, is the same for all exciting agents; it depends only on the chemical make-up and the compounding process.

Because of the variation of eye sensitivity with color the luminous efficiency of a phosphor will depend on the amount of energy it can throw into those regions of the spectrum which give the maximum visual stimulus. Figure 1 shows the response characteristic for the normal human eye.[1] This characteristic is peaked in the yellow-green region which explains why willemite and other green and yellow emitting materials show such high luminous efficiencies. Some of the blue phosphors, although they are good energy converters, are not efficient from a visual standpoint because they throw too large a portion of their emission into the violet and ultraviolet regions. Since most spectral distribution curves for phosphors are now plotted on an energy basis it is necessary to multiply their ordinates by the corresponding ordinates of the eye sensitivity curve to estimate visual efficiencies. The area under the resulting curve gives a measure of the total visual effect, corresponding to the response of an eye-corrected Weston photocell.

The spectral distribution curves of Figs. 2, 3, and 4 show how some of the phosphors distribute their emitted light over the spectrum.[2] The effect of different activators on zinc sulphide phosphors is illustrated in Fig. 2. Each activator has its effect on the luminous efficiency and color as shown by the table accompanying Fig. 2. The effect of varying the amount of manganese activator in willemite is shown by the emission curves of Fig. 3. The emission peaks for the tungstates, shown in Fig. 4, are displaced too far toward the blue to show high luminous efficiencies.

In some cases changes in activator concentration as small as one part per million will produce a detectable change in the emission of a phosphor. Variations in heat treatment have an effect on the crystal structure which in turn affects the shape of an emission curve. For these reasons careful control of production processes is essential to insure uniform characteristics in commercial phosphors.

When a particular application demands a luminescent hue that cannot be efficiently secured by the use of any single matrix material a mechanical mixture of two or more powdered phosphors may be used.

FLUORESCENT MATERIALS . . .

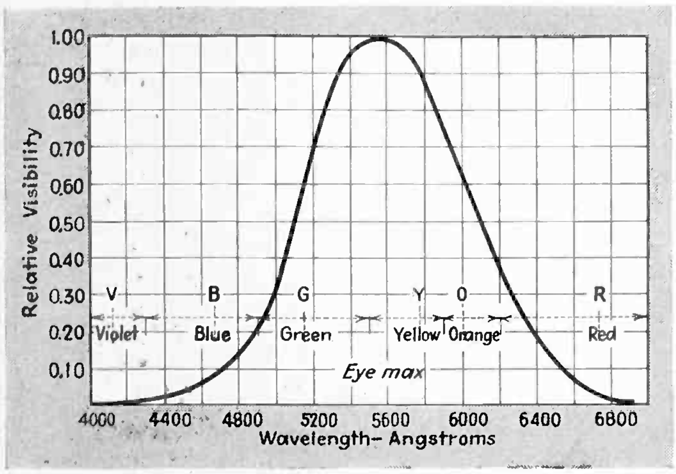


Fig. 1—Relative sensitivity of the eye to light of various wavelengths

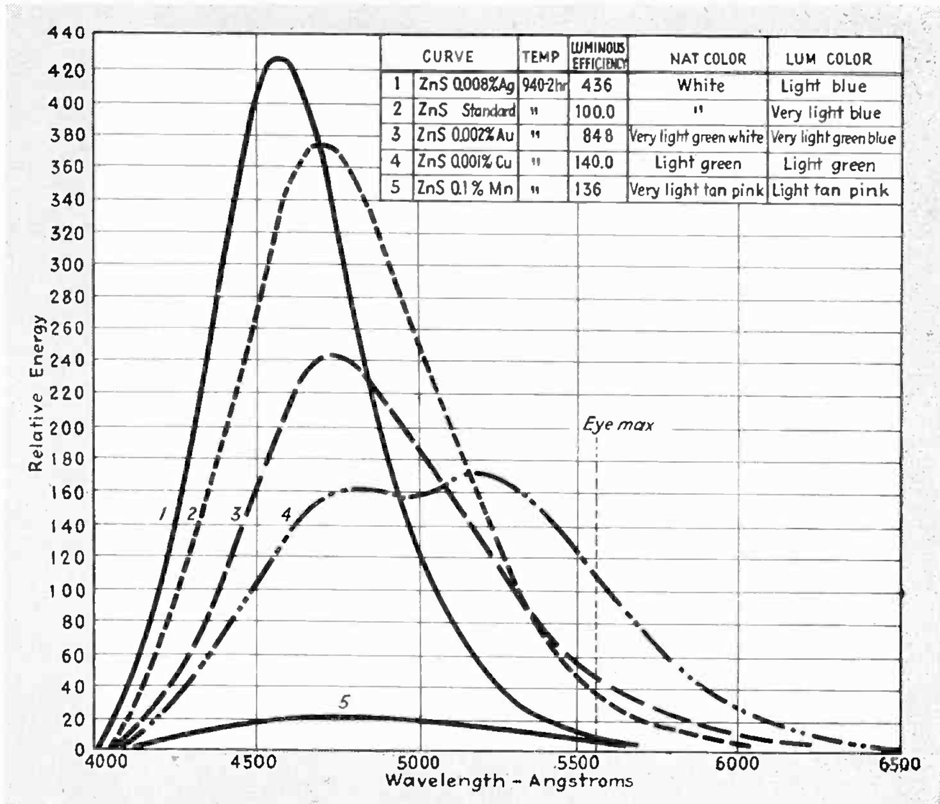


Fig. 2—Emission curves of several zinc sulphide phosphors. Pure zinc sulphide is used as the standard for comparison

This gives a practically unlimited choice of colors without unduly sacrificing luminous efficiency. These mixture phosphors find their most important uses in fluorescent lamps and television screens where intense white luminescence is required.

The emission curves of Fig. 5 show the results obtained by mechanically mixing zinc sulphide and cadmium sulphide phosphors activated by silver.[1] As the mixture proportions are varied from pure ZnS-Ag to pure CdS-Ag the emission changes from light blue, through green, yellow, and orange, to red for the pure CdS-Ag phosphor. The column headed Weston gives the comparative illuminometer readings under identical excitation conditions in a cathode-ray tube. It will be seen that the 50-50 mixture best fits the eye sensitivity curve and, therefore, gives the highest luminous efficiency. Relative visual response curves for ZnS-Ag and for the 50-50 and 20-80 mixtures are shown in the upper part of Fig. 5. These were constructed with the help of the eye sensitivity curve. Good quality white emitting screens usually employ a three component mixture of

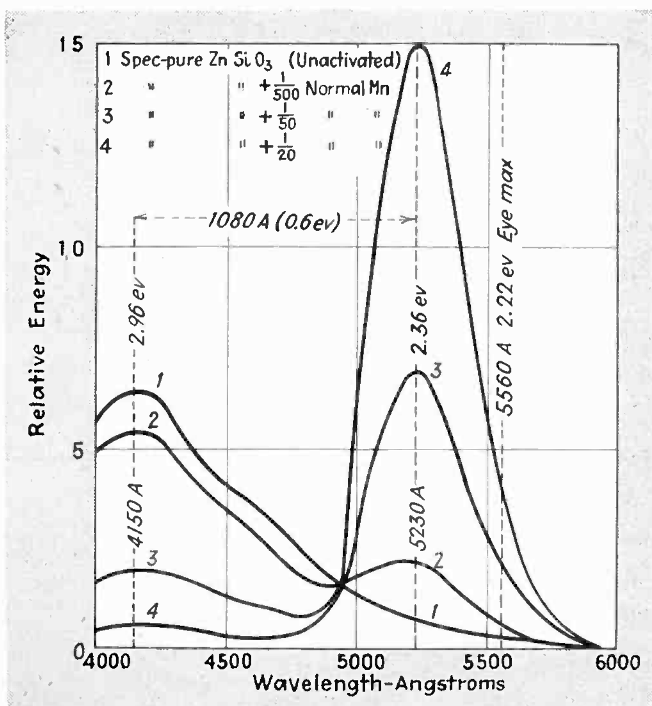


Fig. 3 — Curves showing the effect of varying concentration of manganese, used as an activator, on alpha willemite

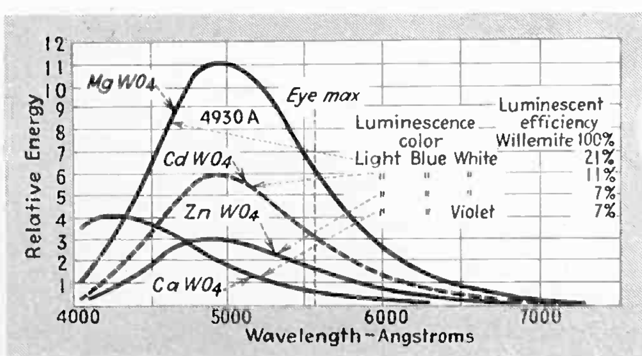


Fig. 4—Emission curves of several tungstate phosphors. The peaks are too far from the maximum eye sensitivity for high efficiencies

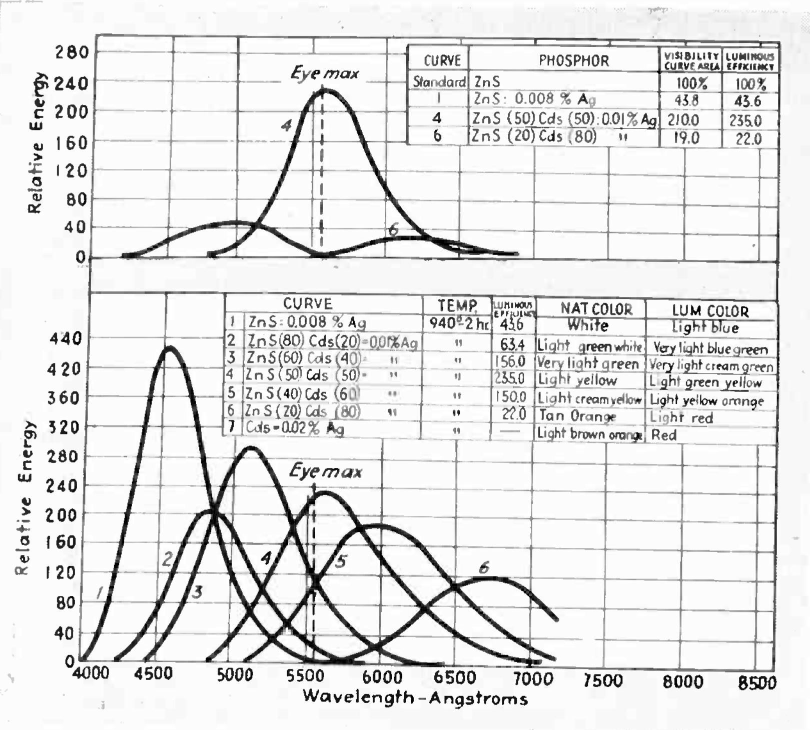


Fig. 5—Relative visibility curves and emission curves of several mixtures of zinc sulphide and cadmium sulphide phosphors

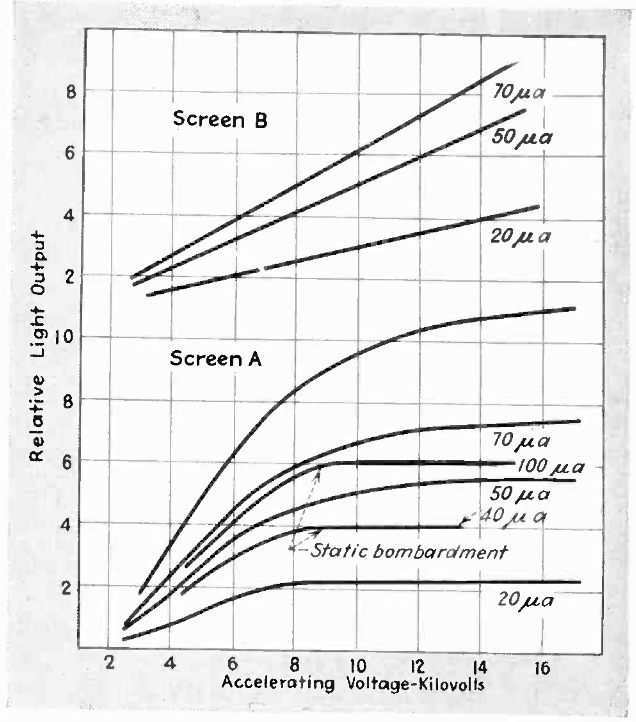


Fig. 7—Relative light output of willemite screens as a function of acceleration voltage

blue, green, and yellow emitting phosphors.

In selecting phosphors for use in cathode-ray tubes other properties that must be considered, in addition to emission characteristics, are: (1) stability under electron bombardment and exhaust temperatures; (2) the persistence time; (3) the limiting accelerating potential.

Sustained high temperatures may affect the emission of a phosphor by permanently altering its crystal structure. Screen materials must withstand exhaust temperatures approaching 500 deg. C and should outgas easily. Under operating conditions high instantaneous temperatures may be encountered which might not permanently alter the phosphor, but which may reduce the luminous efficiency. The luminous efficiencies of all phosphors decrease with increasing temperature, and at a limiting temperature, usually below the melting point, luminescence ceases. For some materials the luminous efficiency is fairly constant up to 150 deg. C or higher while for others it begins to fall off at temperatures below 100 deg. C. Many materials showing little or no fluorescence at room temperature are strongly luminescent at low temperatures.

Most phosphors continue to emit light for a measurable period after excitation ceases. This lag or afterglow is known as phosphorescence, and the time required for the luminescence to drop to a given fraction of its initial value is called the persistence time. In the tungstates phosphorescence is negligible, but the sulphides and silicates show ap-

(*Continued on page* 117)

APPROXIMATE CHARACTERISTICS OF TYPICAL PHOSPHORS

PHOSPHOR			Color of Fluorescence	Wave-length of Maximum Emission — Angstroms	Persistence Time* — Seconds
Crystal Matrix	Formula	Activator Concentration			
Pure zinc sulphide	ZnS	None	Light blue	4700	10^{-3} approx
Zinc sulphide—silver	ZnS-Ag	Ag—0.032%	Blue	4550	10^{-3}
Zinc sulphide—copper	ZnS-Cu	Cu—0.001%	Light green	4700-5300	5×10^{-2} approx
Cadmium sulphide—silver	CdS-Ag	Ag—0.02%	Red	8000 approx	10^{-3}
Zinc—cadmium sulphide—silver	4ZnS:6CdS-Ag	Ag—0.01%	Yellow-orange	6000	10^{-3}
Alpha—zinc silicate—unactivated	Zn_2SiO_4	None	Pale blue	4100	2.0 approx
Alpha—zinc silicate—manganese	Zn_2SiO_4-Mn	Mn—1.9%	Green	5300	5×10^{-2}
Beta—zinc silicate—manganese	Zn_2SiO_4-Mn	Mn	Yellow	5600	10^{-1} approx
Zinc beryllium silicate—manganese	ZnO BeO SiO_2	Mn	Green to orange	5250-6000	5×10^{-2}
Cadmium silicate—manganese	$CdSiO_3$-Mn	Mn	Yellow-pink	5950	....
Magnesium tungstate	$MgWO_4$	None	Blue-white	4900	10^{-5} approx
Cadmium tungstate	$CdWO_4$	None	Blue-white	4900	10^{-5} approx
Zinc tungstate	$ZnWO_4$	None	Blue-white	4900	10^{-5} approx
Calcium tungstate	$CaWO_4$	None	Violet	4200	10^{-5} approx

* The persistence time is the time required for the luminescence to fall to 1 percent of its initial value.

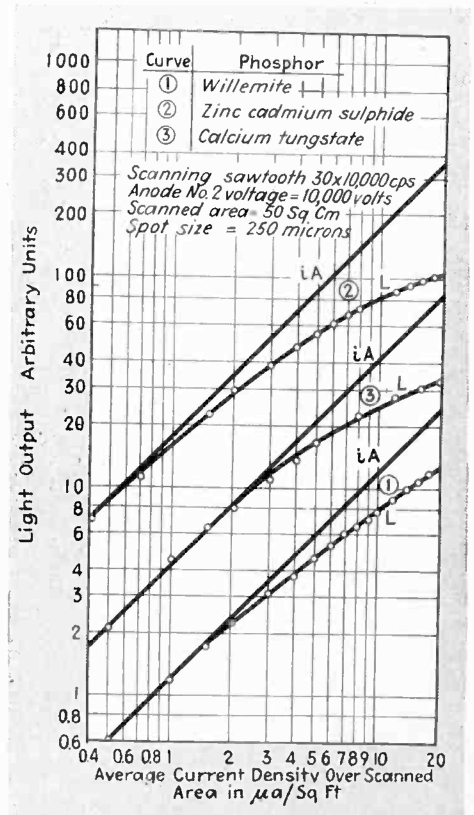


Fig. 6—Light output curves for phosphor screens uniformly scanned by an electron beam

Direct Reading Interpolation Oscillator

A standard frequency generator and interpolation oscillator are used in combination to provide a rapid and accurate method of determining the frequency of received signals

Front view of frequency standard (upper panel) and interpolation oscillator

By D. REGINALD TIBBETTS

Moraga, Calif.

IN many instances when accurate frequency measurements are to be made delay due to slide rule calculations and figuring is experienced. In order to overcome this, a frequency measuring unit was developed to enable even the inexperienced to perform interpolations. No calculations at all are necessary, and very rapid measurements can be made directly from the dial. Accurate calibration can be quickly and easily made at any time. The interpolation oscillator and frequency standard is composed of two units. The upper panel contains a secondary frequency standard with 100 kc quartz bar and multivibrators giving strong outputs at every 100, 50 and 10 kc interval. The lower panel contains the interpolation oscillator which allows precision readings between the 10 kc points given by the secondary frequency standard.

Secondary Frequency Standard

The 100 kc bar is mounted in a plug-in dustproof shielded case. The bar is a thick crystal with two sides silver-plated and mounted between two wedge-shaped electrodes. The temperature coefficient is very low and, by means of a variable condenser built into the circuit, adjustment of the crystal frequency to exactly 100 kc is easily and quickly possible.

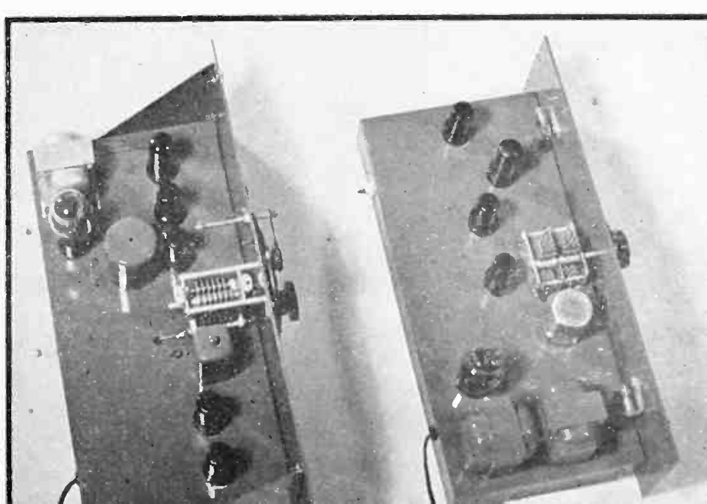
The oscillator is a 6SJ7 with the screen of the tube acting as the plate. The circuit gives some feedback to aid crystal oscillation and also provides variation of the oscillator frequency over a range of approximately 16 cycles by means of the tuning condenser. The frequency can therefore be brought exactly to 100 kc when an accurate checking source such as Station WWV is available.

Since the oscillator alone will produce harmonics useful to only about the fiftieth harmonic or 5000 kc, amplifiers are needed to get strong harmonics up to 60,000 cycles per second. The output of the oscillator is capacity-coupled to another 6SJ7 as an amplifier. For 100 kc harmonics this amplifier is in turn coupled to an 1852/6AC7. For the 50 kc harmonic series, a multivibrator is incorporated in the unit. This stage uses a single 6N7, and follows the 6SJ7 first amplifier. The 10 kc series of harmonics are similarly secured. A three position rotary switch is used to switch the output of the first amplifier to the desired harmonic output. The 1852/6AC7 second amplifier is used in all cases and serves to isolate the multivibrator from the output circuit. The first amplifier not only serves as an amplifier, but also as a buffer stage to isolate the oscillator from the multivibrator. The output circuit is coupled to the receiver antenna post through a built-in attenuator using a 500,000 ohm potentiometer. This attenuator is necessary to effect a balance between the harmonic being used and the signal observed. Otherwise the output of the unit swamps the signal observed and observation of the beat note would be difficult.

Interpolation Oscillator

The interpolation oscillator is similar to an accurate highly stabilized beat frequency oscillator of a good receiver. The frequency range of the unit is somewhat more than 5000 cycles per second plus or minus the intermediate frequency of the receiver. One of these units has been

Interior views of the interpolation oscillator (left unit) and frequency standard, below, show no wiring above the chassis



adjusted to 455 kc although this can be changed to any exact intermediate frequency between 450 and 470 kc. When set for 455 kc the dial of the unit tunes from a little less than 450 kc to a little more than 460 kc.

Stability is very high and no provision for regulated power supply is necessary. The stability is high mainly because the interpolation oscillator operates at a comparatively fixed low frequency instead of the usual variable high frequency. Calibration is linear, i.e., dial spacings are equal for the same frequency increments.

The unit must be used with and in fact is, an integral part of any unit that will supply stable 10 kc harmonics. Interpolation is accomplished between adjacent 10 kc multivibrator marker points by means of a variable oscillator operating at the receiver intermediate frequency. Thus, in reality frequency measurement is simply determined merely by measuring the beat frequency between the unknown signal and the nearest 10 kc point after both have been converted to the i-f channel frequencies.

The low frequency oscillator tunes a little more than 5000 cps either side of the receiver i-f channel and is based on the transitron. This oscillator is very stable and can be compared to a crystal oscillator.

The 455 kc oscillator is tuned by means of a combination of a silver mica condenser whose stability is very high, especially with respect to temperature, and a variable iron core inductance. These two in the plate circuit of the 6SJ7 oscillator in combination with the 100 $\mu\mu$f air padder, and interpolation condenser complete the basic parts of the interpolation oscillator. By means of the variable air padder and the variable inductance the range of the interpolation oscillator may be precisely adjusted while keeping the middle frequency the same as that of the intermediate frequency of the receiver.

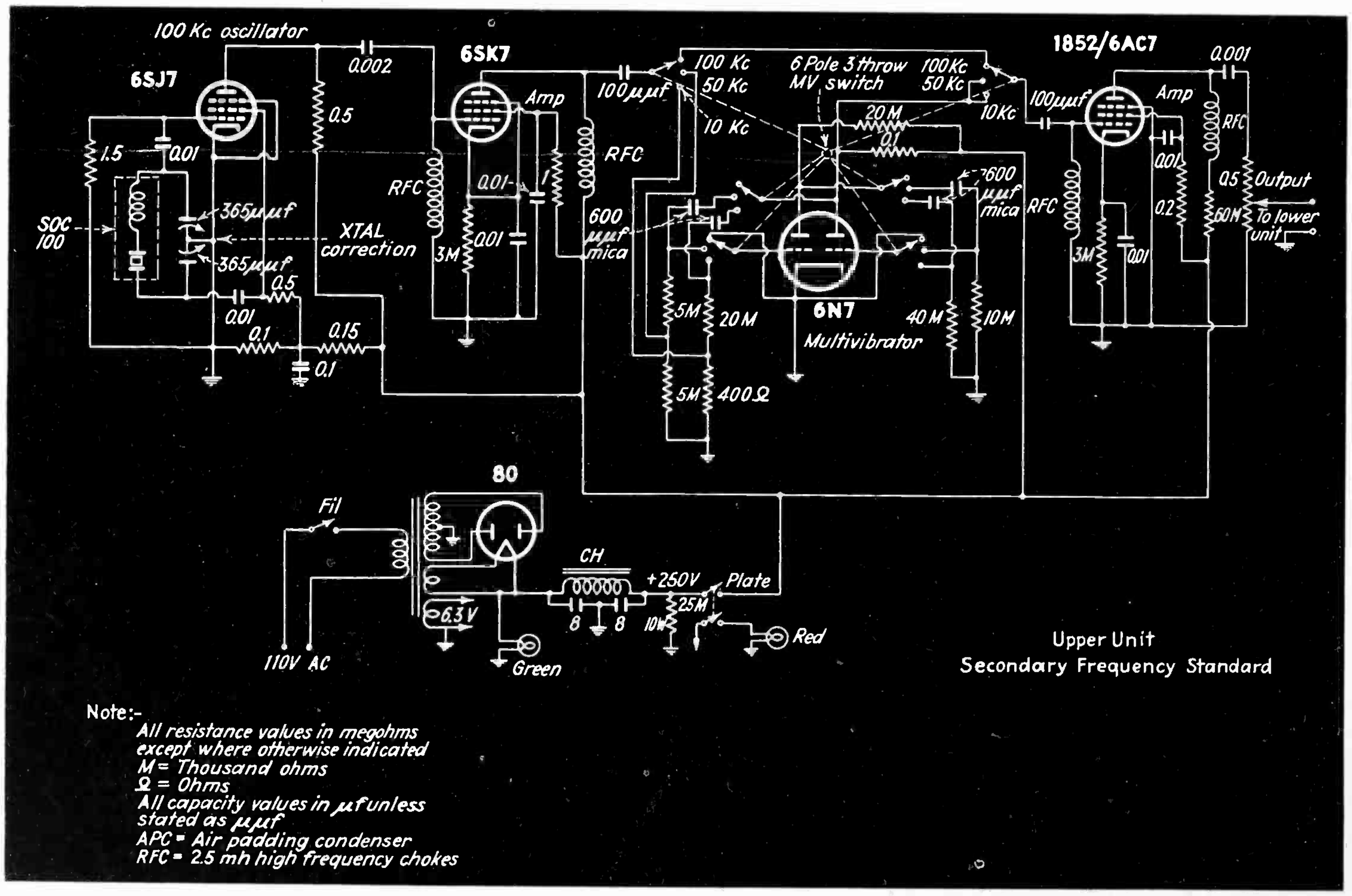
1000-Kilocycle Oscillator

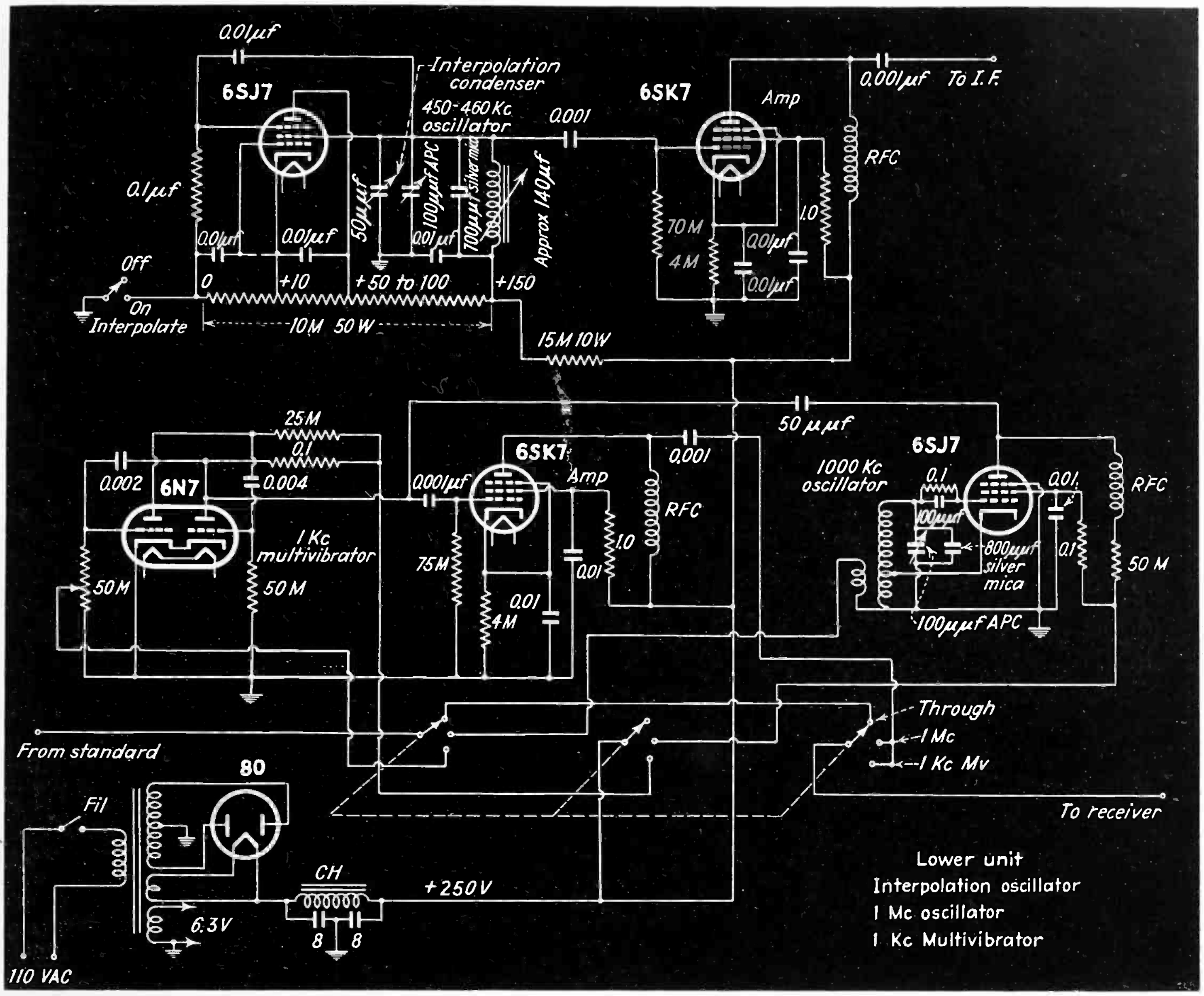
As an added feature a 1000-kc oscillator is built into the interpolation oscillator. Since the 100-kc points are very close together at the very high frequencies, i.e., those above 20,000 kc, a 1000-kc (1 Mc) self-excited oscillator is used for checking. This oscillator is arranged so that it is exactly controlled by the 100 kc crystal. This portion of the standard is operated by turning the upper multivibrator switch to the 100-kc position with output at maximum and the lower selector switch to the 1 Mc position. Output will then be secured at exactly integral multiples of 1 Mc over the entire range of the receiver. Adjustment of this 1 Mc oscillator is made by means of the trimmer located next to the type 80 tube on the lower chassis.

Procedure in Measuring Frequency

To check the 100-kc crystal bar to the exact point, the operator should first find either WWV or 5000 kc or select any station, broadcast or commercial, whose frequency is known. Nearly all broadcast stations keep their frequency deviation within a few cycles per second and many keep to within a single cycle per second. In any case broadcast stations are required to keep within 20 cps. The station selected is tuned in on the receiver. Next turn on the secondary frequency standard and switch to the 10 kc multivibrator. This assumes the frequency of the station to be divisible by 10 kc. Of course if the frequency is divisible by 50 or 100 kc these multivibrators can be used as well. A beat note will be

Circuit diagram of the secondary standard of frequency





Connections and circuit components are given in this diagram for the interpolation oscillator

heard between the station observed and the multivibrator output. By adjustment of the output a balance can be secured. The correction dial is moved until the beats can be counted and brought to zero beat. If the receiver has an "S" meter, the beats can actually be seen. The actual number of swings a second is the precision to which the correction is set. From a practical standpoint, once the correction is made, good measurements can be made without the necessity of the correction. The temperature coefficient of the bar is so low that often the correction will be found to be at zero beat with a primary station. The correction is provided for better precision and any drift due to temperature, humidity or circuit changes can be corrected very easily. This can be checked both before and after measurements for accuracy.

As an example it is assumed the receiver dial can be read to within reasonable limits and that the approximate frequency of the station to be measured is known. For instance a station is known to be operating on about 2512 kc. The station is tuned in and the 10 kc multivibrator is switched on. The dial of the interpolation oscillator is set at mid-scale, and the interpolate switch is thrown on. A beat note will be heard in the receiver. The receiver is tuned to exact zero beat at 2510 kc with a harmonic of the multivibrator. During this operation it is desirable to remove the incoming signal to avoid confusion of beat notes. The plate switch is thrown off and the station is received again. A beat note will be heard. This zero beat will be the exact difference between 2510 and the operating frequency of the station measured. This difference can be measured by tuning the interpolation oscillator to zero beat. If the station is on exactly 2512 kc the dial will read +2 kc (100 degrees). Each division of the dial is 40 cps. If the frequency should happen to be 2508.5 kc the dial would read −1.5 kc or (187.5 degrees). To check back, turn off the received signal, turn the multivibrator on and see if the zero beat checks back at 150 degrees or the zero calibration mark of the interpolation oscillator. A convenient means of reading measurements is to read the dial in degrees. Let this dial reading be n. Then, the exact frequency in cycles per second to be added the marker frequency of the multivibrator is

$$f = 40\ (150 - n).$$

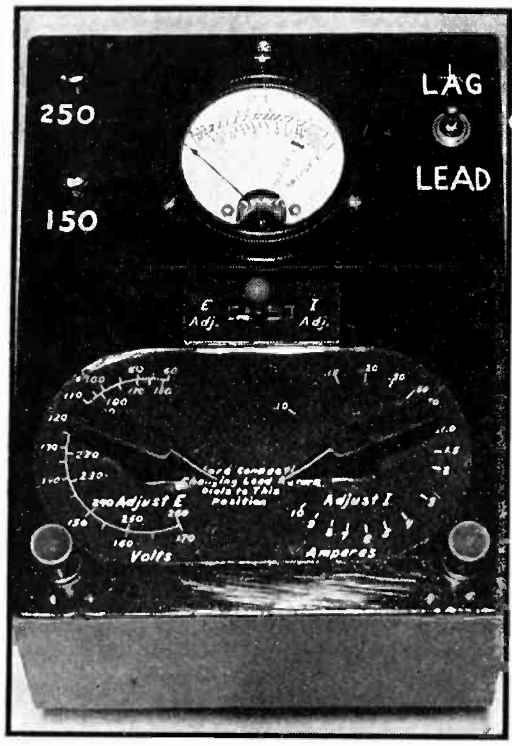
For example if zero beat is obtained when the dial reads 200, then the frequency which must be added to the multivibrator marker frequency is $f = 40\ (150–200) = 40\ (-50) = -2{,}000$ cycles per second. Since the sign is negative, we must subtract 2 kc from the multivibrator marker frequency.

POWER FACTOR METER

Based on the phase control operation of gas tubes, a direct reading power factor meter has been designed for either 150 or 250 volt circuits and for currents of from 0.1 to 10 amperes. All errors are less than those in reading the indicating meter

By ALEXANDER B. BERESKIN

University of Cincinnati



Photograph of the power factor meter which reads leading or lagging power factor directly on 150 or 250 volt circuits

THE determination of power factor has always been an important consideration in the utilization and distribution of power but with the advent of fluorescent lighting, with its attendant low power factors, the importance of the problem has been materially increased. The following article deals with the application of the D'Arsonval type meter movement and the thyratron tube, to the direct measurement of power factor. As a by-product the instrument is also capable of indicating amperes and volts in the circuit.

The D'Arsonval type meter movement is sensitive, reliable, and inexpensive but its indication depends upon the average value of unidirectional current flowing through its coil. For this reason, in the measurement of a large number of electrical phenomena, it is desirable to provide a suitable circuit arrangement which will produce a unidirectional flow of current having an average value which is a function of the phenomenon being measured. It is also desirable that the measurement circuit introduce a minimum amount of disturbance into the circuit being measured.

Review of Thyratron Principles

In view of the intimate relation existing between the theory of the power factor meter and that of the control tube, a review of the gas tube theory seems advisable to facilitate the explanation of the power factor meter.

In the gas tube, with positive plate some of the electrons flowing from the cathode to the plate will strike gas molecules and, if these electrons happen to be going fast enough, ionization by collision will occur. All of the free electrons formed will continue to go to the plate and, en route, may collide with more gas molecules. The positive ions (atoms lacking one or more electrons) will go to the negative cathode and grid.

The positive ions arriving at the cathode will unite with free electrons and, having formed neutral particles, will disperse within the envelope of the tube. Due to the great concentration of positive ions close to the cathode, the space charge will be greatly reduced and the removal of electrons from the cathode will be facilitated, thus making available a large supply of free electrons. Because of the practically complete neutralization of the space charge, the potential that will appear between the cathode and plate of the gas tube will be approximately the ionization potential of the vapor or gas for the particular operating conditions involved. The positive ions arriving at the grid, however, will not find any free electrons to combine with and will form a positive ion sheath around the grid which will completely shield it from the cathode.

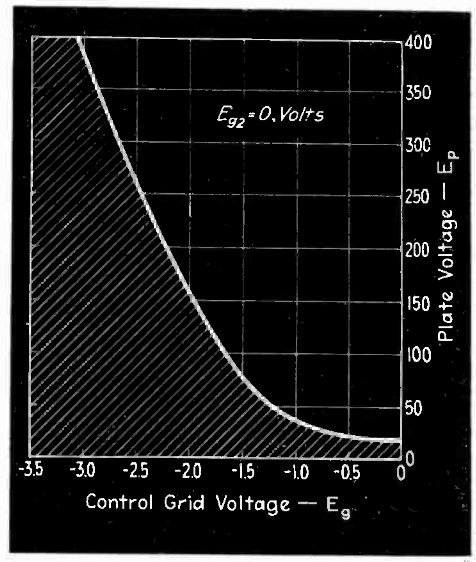


Fig. 1—Control grid characteristics of the RCA-2051 gas tetrode. Conduction cannot occur in the cross-hatched region

Due to the shielding effect of the positive ion sheath the grid has no control over the current flow in the gas tube after ionization has occurred. This means that the grid will be effective only in preventing or permitting current to start in the tube and therefore has a trigger-like effect but has no effect after ionization takes place. The magnitude of grid voltage required to prevent current flow will naturally vary for various values of plate voltage and a characteristic curve, such as shown in Fig. 1 for an RCA-2051 tube, can be plotted. Any combination of grid and plate voltage in the cross-hatched region will not produce current flow in the tube, while

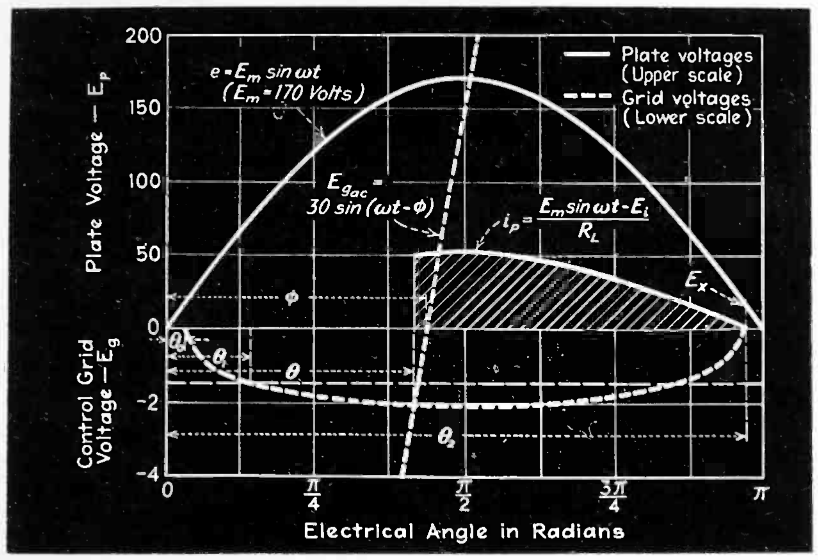


Fig. 2—Grid and plate voltage wave forms illustrating the operation of gas tetrodes. Conduction occurs for that part of the cycle which is shown cross-hatched

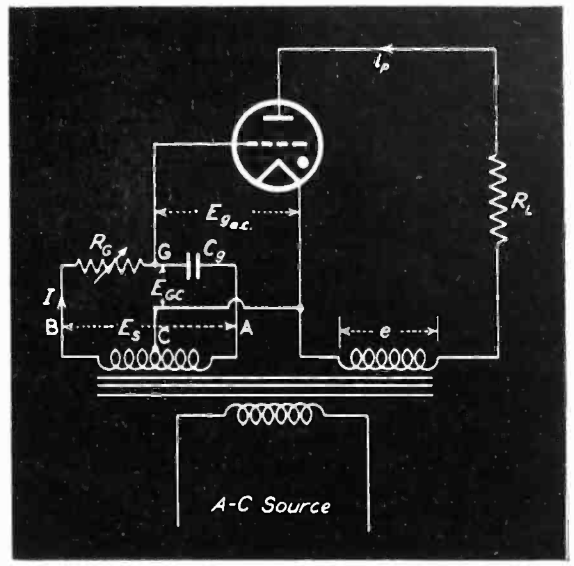


Fig. 4—Circuit diagram illustrating phase control of the conduction of a gas control tube

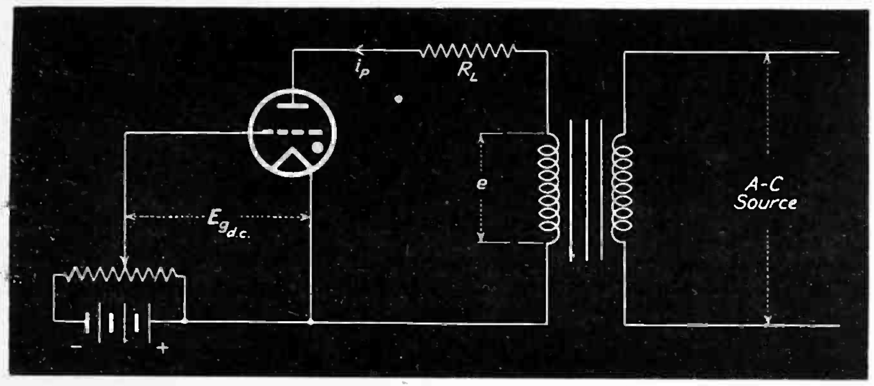


Fig. 3—Simple circuit diagram illustrating amplitude control of the conduction characteristics of gas control tube when plate is fed by alternating current

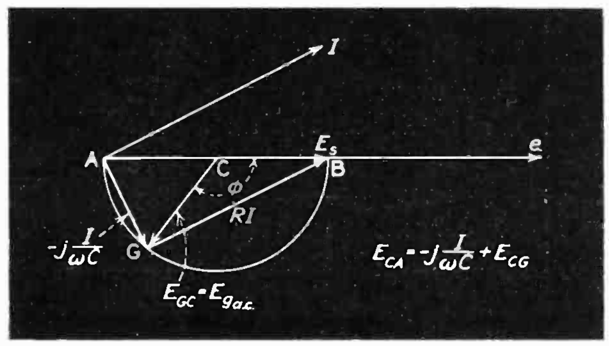


Fig. 5—Vector diagram showing the relations of current and voltage in phase controlled tube

any combination of grid and plate voltage in the clear region will produce current flow. The grid can be made to regain control only if the positive ion sheath surrounding it is destroyed, and this can be done only by reducing the voltage across the tube below the extinction potential of the gas. If an alternating voltage is applied in the plate circuit of the tube, it can be seen that it is possible for the grid to regain control once in every cycle.

If the positive half of the voltage sine wave, $e = E_m \sin \omega t$ is plotted as a function of time, and for each value of this wave a corresponding value of grid voltage is taken from the curve in Fig. 1 and plotted to its own scale, the curves e and E_c indicated in Fig. 2 will be obtained.

There are two possible methods of control by which a tube may be made to start conducting at a predetermined time in the positive half of the cycle and to continue conducting for the remainder of that half cycle. The first method is known as amplitude control and the second method as phase shift control. In amplitude control a direct voltage E_{gdc} is applied between the cathode and grid, as indicated in Fig. 3, and the magnitude of this voltage will determine the point in the cycle at which E_c and E_{gdc} will intersect and therefore the angle θ_1 of Fig. 2 at which conduction will commence. Conduction will continue until the potential e, in Fig. 2, drops below the extinction potential of the tube E_x and this point will determine the angle θ_2. It is obvious that with fixed grid voltage the tube can not be made to conduct for less than a quarter of a cycle by this method and also that the point of intersection will not be very definite on the portion of E_c which is relatively flat.

In the phase shift control method, an alternating voltage E_{gac} of constant magnitude is applied between the cathode and grid and provisions are made for shifting the phase angle between this voltage and the voltage e in the plate circuit. Referring again to Fig. 2, if the peak value of E_{gac} is large compared to the maximum value of E_c their point of intersection will be very clearly defined. By proper phase shifting, the tube may be made to conduct over any portion of the positive half of the voltage wave e. A convenient method of obtaining the phase shift of the grid voltage is indicated in Fig. 4. The vector diagram for this circuit indicated in Fig. 5, shows that E_{gac} will be the radius vector of a semicircle and the angle, ϕ, which it makes with e will be determined by the relative magnitudes of R_g and X_g.

If we call the drop in potential across the tube E_t then the instantaneous current that will flow, after conduction commences, will be $i_p = (e - E_t)/R_L$ as long as the numerator is positive but will be $i_p = 0$ if the numerator becomes negative. The value of i_p averaged over a complete cycle will be

$$I_p = \frac{1}{2\pi} \int_{\theta_2}^{\theta_1} \frac{(E_m \sin \omega t - E_t)}{R_L} \, d(\omega t)$$

where θ_1 is the point at which conduction starts and θ_2 is the point at which conduction stops. In practice θ_2 will be very nearly 180 deg. but will actually be the value of (ωt) at which $E_m \sin \omega t - E_t = 0$. The tube drop potential, E_t, depends on the amount of current flowing in the tube and is ordinarily a few volts less than the ionization potential of the tube for zero grid voltage.

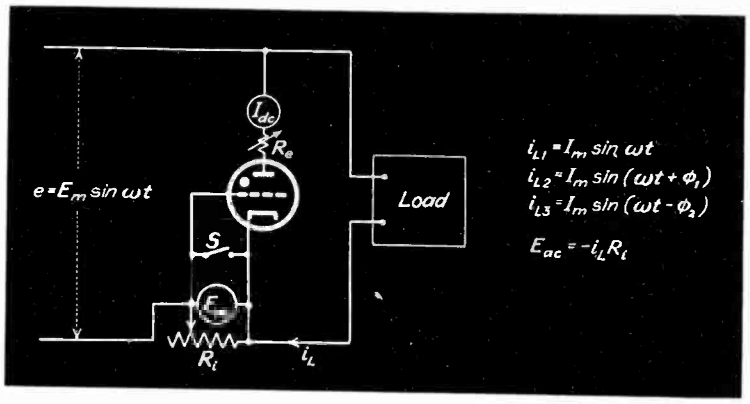


Fig. 6—Elementary schematic wiring diagram of circuit for power factor meter

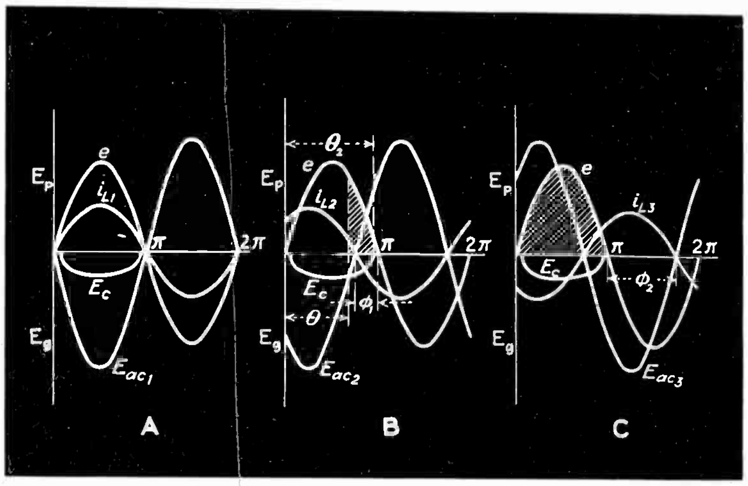


Fig. 7—Current and voltage wave forms illustrating method of operation of simple power factor meter

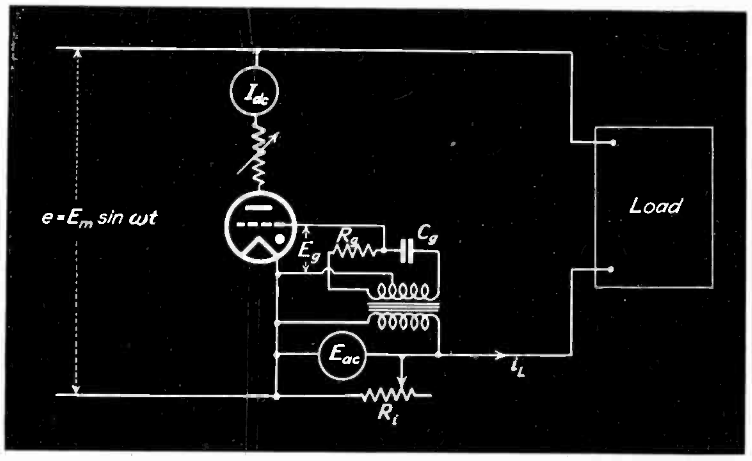


Fig. 8—Basic circuit of a somewhat more convenient and practical power factor meter

The Power Factor Meter

The measurement of power factor must of necessity involve a circuit in which the response is independent of the relative magnitudes of the voltage and current waves but is dependent on the phase angle betwen the two waves. Referring to Fig. 6, if the gas tube is connected as indicated in the circuit and switch S is closed, the grid of the tube will be at zero voltage and conduction will occur over the maximum possible time interval. With S closed, if for any voltage, $e = E_m \sin \omega t$, the rheostat R_e is adjusted until the d-c ammeter, I_{dc}, reads full scale deflection, the current wave in the plate circuit of the tube may be almost exactly reproduced for any reasonable range of input voltages e. If switch S is now opened and the rheostat R_t is adjusted until E_{ac} reads some predetermined value of voltage, then the period of conduction, and therefore I_{dc} will depend on the phase angle between the current wave, i_L, and the voltage wave, e. As indicated in Fig. 7A, if the current wave i_{L1} is exactly in phase with e no conduction will occur since E_{ac1} will at all times, in the positive half cycle of e, be more negative than E_c and therefore I_{dc} will read zero. If the current wave i_L should lead the voltage wave e then conduction will occur for a portion of the half cycle determined by the intersection of E_{ac2} and E_c. The d-c meter reading in this case would be

$$I_{dc} = \frac{1}{2\pi} \int_{\theta}^{\theta_2} \frac{(E_m \sin \omega t - E_t)}{R_e} \, d(\omega t)$$

where θ is the angle at which E_{ac2} intersects E_c and θ_2 is the angle at which conduction ceases as indicated in Fig. 2. It is obvious from Fig. 7C that if the i_{L3} wave were to lag the e wave, conduction would occur through the full half cycle for which e is positive and I_{dc} would read full scale as previously adjusted.

For various reasons the elementary circuit in Fig. 6 is neither practical nor convenient. In the first place if E_{ac} is to be much larger than E_c (which may have a value of 3 or 4 volts for the 2051 tube) the voltage drop across the variable shunt R_t would be too large a percentage of the load voltage. In the second place the large amount of power dissipated as heat in R_t would be difficult to get rid of. Finally, no measurement of lagging power factors would be possible since all such factors would all read the same amount on the meter.

The current requirements in the grid circuit of the tube are very small and therefore the obvious step is to use a small voltage, E_{ac}, (approximately 0.5 volt) and to use a step-up transformer to obtain the higher grid voltages required. It would also be convenient to use a phase shifting network of the type indicated in Fig. 4 in order to be able to use any desired point in the cycle as a unity power factor reference point. These changes are shown incorporated in Fig. 8. The combination of R_g and C_g could be made such that E_g would intersect E_c at the time when e was at its maximum value as indicated by E_{g1} in Fig. 9. In this case unity power factor would be indicated by an I_{dc} reading of 0.5 of full scale deflection. Lagging power factors would be indicated by I_{dc} readings less than 0.5 of full scale deflection and leading power factors would be indicated by I_{dc} readings greater than 0.5 of full scale deflection.

It is obvious from Fig. 9, however, that the greatest changes in I_{dc} per unit change in phase angle would occur in the 90 deg. region between $\pi/4$ and $3\pi/4$. This means that a more convenient arrangement would be to have the phase shifting network give a unity power factor reference point at $\pi/4$ for lagging power factors and at $3\pi/4$ for leading power factors. In this manner a theoretical 70 percent of full scale I_{dc} deflection can be used for leading power factors and the same percentage of full scale deflection in the opposite direction can be used for lagging power factors. Another possible scale arrangement would be to have the unity power factor reference point at 0 for lagging power factors and at π radians for leading power factors. This arrangement would produce two linear power factor scales which would meet at the middle of the meter scale. The actual scale chosen, as indicated in Fig. 10, was a compromise scale which tends to have both a large scale utilization factor and a good amount of linearity.

It is also inconvenient to have an additional a-c voltmeter E_{ac} and to avoid the use of this instrument a copper oxide rectifier, in conjunction with the meter I_{dc} and suitable switching arrangements, can be used. The complete circuit diagram, with all modifications and refinements, is shown in Fig. 11. In actual operation, with the switch thrown in the E_{adj} position, the I_{dc} meter is in parallel with the 1-ohm shunt and the grid is shorted to the cathode. With the switch in this position the rheostat in the plate circuit is adjusted till I_{dc} reads full scale deflection. With the switch in the I_{adj} position the I_{dc} meter is connected with the proper polarity across the copper oxide rectifier cell and the variable shunt is adjusted till the meter assumes some position which indicates a predetermined voltage drop across the variable shunt. This last adjustment is not at all critical for if the instrument is used on a 120-volt line and calibration was made with an rms voltage of 21 volts on the grid, doubling the grid voltage would cause an error equivalent to only 2 deg. while halving the grid voltage would produce an error equivalent to only 5 deg. If the switch is now released to its normal center position, the I_{dc} meter is again placed in parallel with the 1-ohm shunt and the reading on the meter indicates the power factor of the load. Whether readings should be taken on the lead or lag scale is determined by the position of the lead-lag switch.

Several interesting problems arise in the design of the component parts of the power factor meter. If a 2050 or 2051 gas tetrode is used, it is desirable to have a grid voltage of about 20 volts rms. On the other hand the alternating voltage across the variable shunt should not exceed 1 volt and was arbitrarily chosen to be 0.5 volt. Since only a half of the grid transformer second-

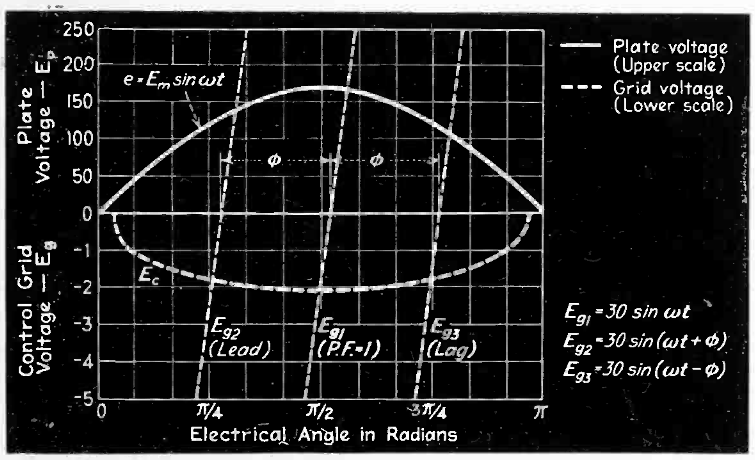


Fig. 9—Voltage and current wave forms showing how the indication of power factor meter depends upon point of cycle at which conduction begins

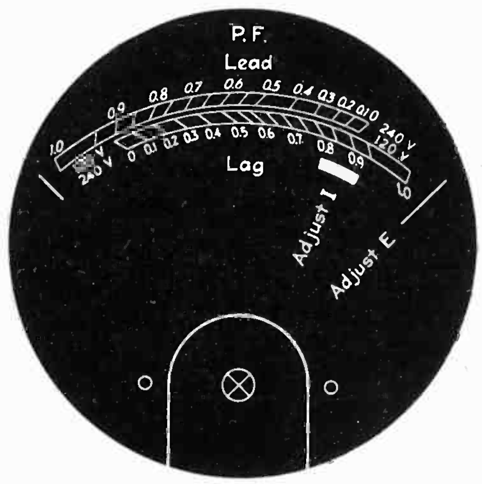


Fig. 10—Meter scale for power factor meter with lagging and leading factors for 150 and 250 volt circuits

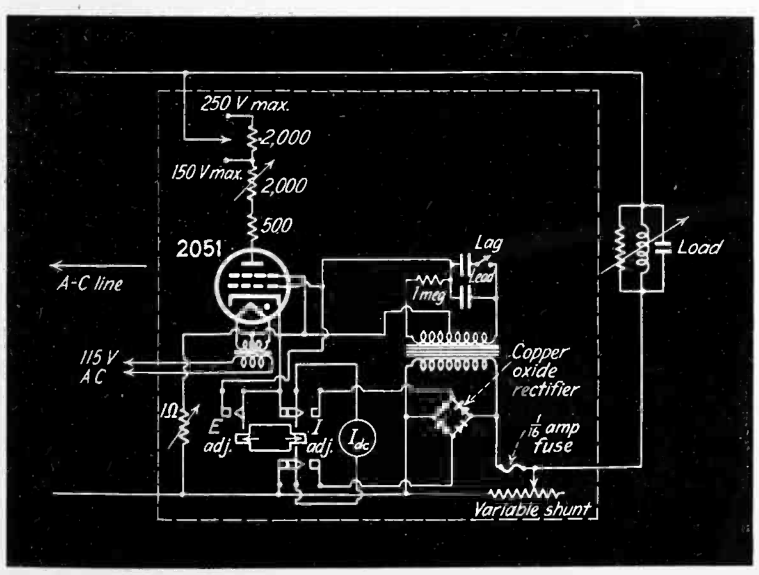


Fig. 11—Detailed wiring diagram of the complete power factor meter

ary voltage appears between cathode and grid, due to the phase shifting network used, a transformer with a center-tapped secondary and a ratio of transformation of about 1 to 80 was required. In addition to the above requirements it was also essential that the magnetizing current of the transformer should be very small in order that the primary voltage of the grid transformer should be very nearly in phase with the load current even at small values of load current. To satisfy these conditions the primary winding was designed to have 150 turns and it drew a magnetizing current of 7 milliamperes at 0.5 volt rms. The secondary of the grid transformer has a total of 12,000 turns and an equivalent secondary impedance of about 90,000 ohms, most of which is due to leakage reactance. For this reason the transformer requires a large value of load resistance R_g and load reactance X_g. A load resistance of 1 megohm was used. The 2050 and 2051 tubes are admirably suited for this application because of their low grid current requirements.

The design of the variable shunt presents another problem, for a constant voltage must be developed across it within the full operating load current range used. In this instrument a minimum operating current of 0.1 ampere and a maximum operating current of 10.0 ampere were chosen. This required a minimum resistance of 0.5 ohm and a maximum resistance of 5.0 ohms, all on the same control and with approximately uniform variations of voltage all along the control. This naturally dictates a tapered rheostat giving small changes of resistance at the large current end and large changes of resistance at the small current end. In order to protect the meter, the copper oxide rectifier, and the grid transformer from damage in case of failure of the variable shunt a 1/16 ampere fuse was installed as indicated in Fig. 11.

It is interesting to note that if calibrated dials are attached to the rheostat in the plate circuit and to the variable shunt, it is possible to determine the voltage and current in the circuit, and, knowing the power factor, the power in watts drawn by the load can be easily determined. The instrument therefore serves as a combined voltmeter, ammeter, power factor meter, and wattmeter.

Limitations of the Power Factor Meter

With the grid shorted to the cathode, the point in the cycle at which conduction will commence (θ_1) will vary slightly for various values of applied voltage. In a like manner, the point at which conduction stops (θ_2), (at $E_m \sin \omega t - E_t = 0$), will vary with the magnitude of E_m. For these two reasons and because the resistance in the plate circuit is adjusted to give an average value of I_{dc} equal to the full scale deflection of the meter, the wave shape of the current wave through the tube will vary slightly for various voltages in the plate circuit. This difference becomes negligibly small when the voltage in the plate circuit exceeds 230 volts rms. This condition can be taken care of by either calibrating the power factor meter for two common values of voltage desired such as 120 and 240 volts, as indicated in Fig. 10, and interpolating between the two values or else by using a potential transformer to supply the plate circuit. If a potential transformer is used then it would be desirable to use a base voltage of about 230 or 350 volts on the secondary and variations of plus or minus 25 percent in this voltage could be accommodated with negligible error with a single calibration of the scale on the power factor meter.

Since the grid transformer draws a small amount of current which lags the current in the variable shunt by approximately 90 deg. and the sum of these two currents is equal to the load current, the voltage across the primary of the grid transformer will not be exactly in phase with the load current. In the case of the transformer used, with a magnetizing current of 7 milliamperes, the error is negligible until the load current decreases below 0.1 ampere. If the power factor meter is calibrated for a load of 0.5 ampere the error involved in using 0.1 ampere would be that due to 3° 12′ lag. At 1.0 ampere this error would be that due to 0° 24′ lead and at 10.0 amperes the error would be that due to 0° 36′ lead. In practice, all of the errors except that due to the 0.1 ampere load current would be less than the reading accuracy of the meter employed. The obvious way to decrease this error, or to extend the current range to lower values if it should prove desirable, would be to decrease the magnetizing current requirements of the grid transformer by either increasing the number of primary turns, decreasing the primary voltage, or both.

The power requirement in the shunt of the power factor meter is but a small portion of the total volt amperes involved. If measurements are made on a 120-volt circuit then the power required in the shunt is $(0.5 \times 100)/120 = 42$ percent of the total volt amperes involved. Measurements on a 240-volt line would require 0.21 percent of the total volt-amperes involved. The current drawn in the potential circuit is highly variable, depending on the power factor being measured. In the case of this particular instrument the peak value of this current is 62 milliamperes, its r-m-s value is 31 milliamperes, and its average value is 19.7 milliamperes.

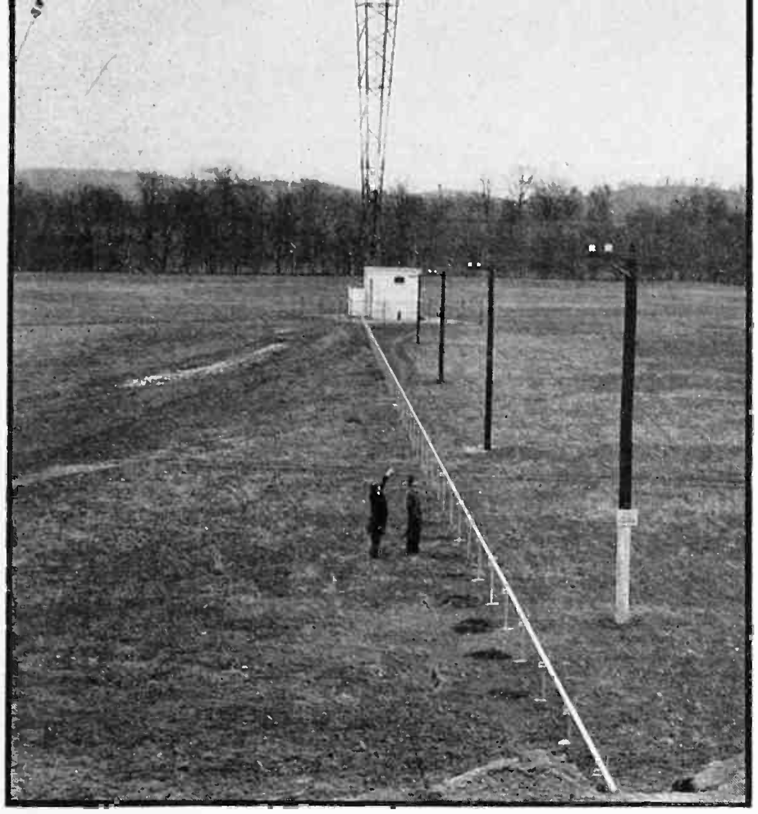
In the design and calibration of the instrument sine waves of both current and voltage are assumed. If harmonics are present small errors will be introduced.

Since the grid voltage E_g, is much larger than the critical voltage E_c and the tube drop E_t is only a small portion of the total voltage involved, similar types of tubes can be substituted in the power factor meter without recalibration since the error involved would be entirely negligible.

Conclusion

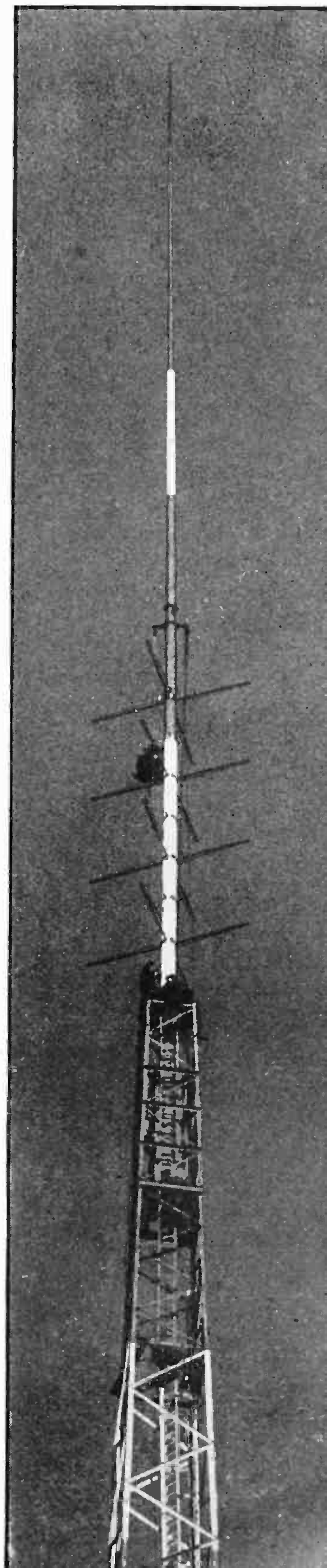
In the present power factor meter the 2051 gas tetrode was used since it had several characteristics which were very desirable in this application. The use of this tube, however, required a 6.3-volt source of power for the filament and therefore a filament transformer. The current requirements of the plate circuit of the power factor meter are considerably lower than the current rating of the tube used and therefore it would be desirable to have a tube with lower maximum emission and which could be supplied with filament power from a 1.5-volt dry cell in the case.

A photograph of the completed power factor meter is shown. It can be seen that the power factor meter could easily be adapted to use with current and potential transformers.

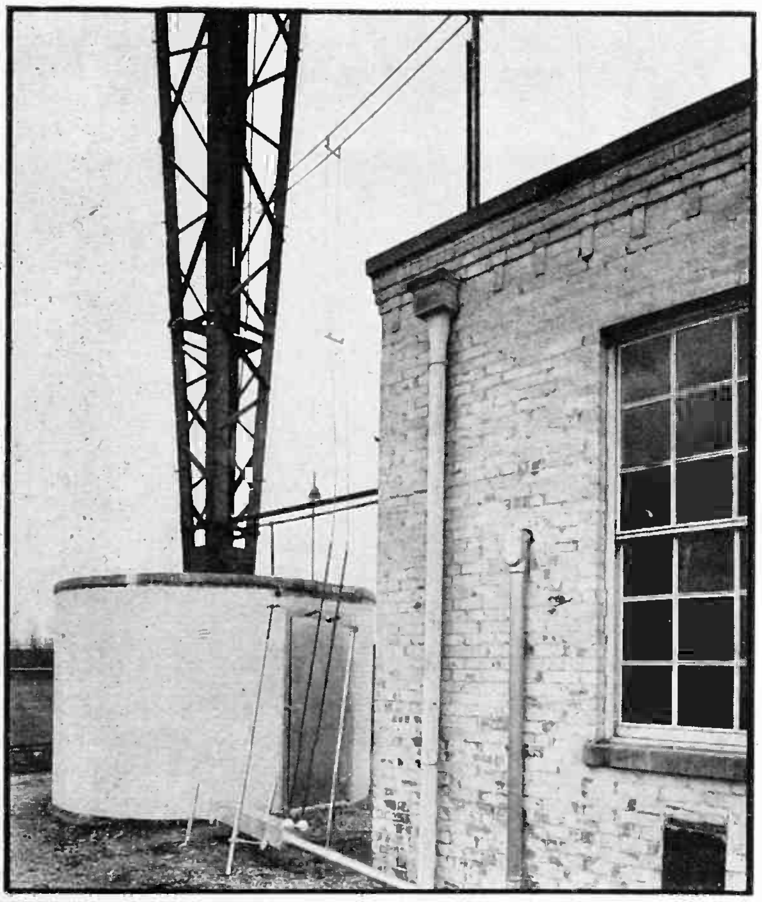


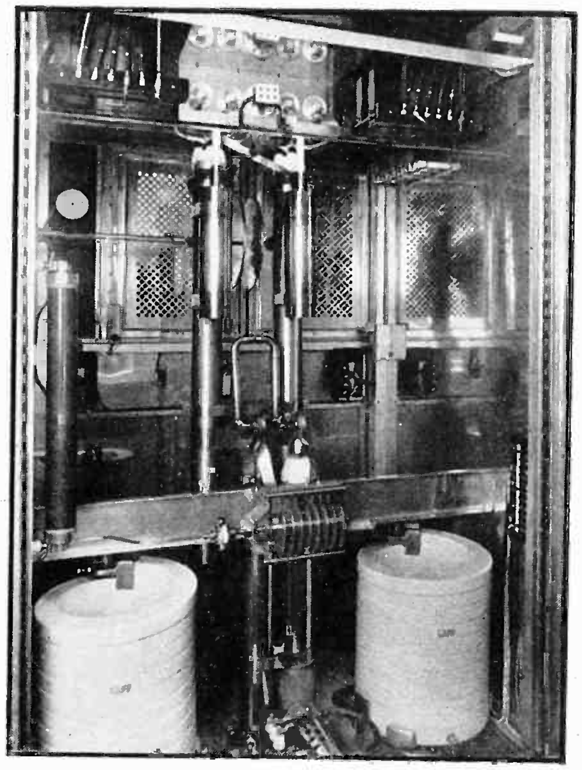
W47NV NASHVILLE

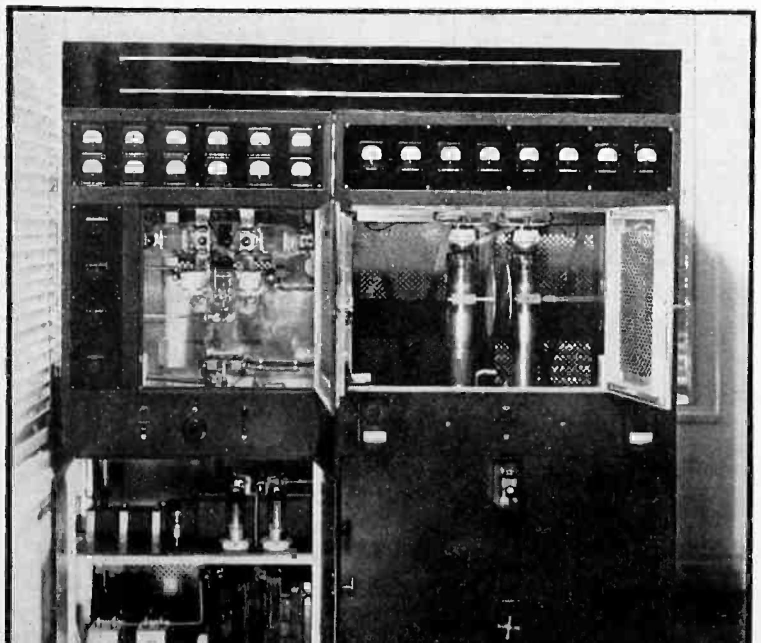
Features of the first f-m station to operate on a commercial basis. The turnstile antenna is located on top of WSM's 758-foot antenna tower which is the tallest in this country



RIGHT, the antenna is a four-bay turnstile in which each element is folded back to the supporting pole where it is connected to the transmission line feeder. This permits close spacing of feed lines thereby reducing their radiation effects . . . LEFT TOP, the coaxial transmission line which serves W47NV as well as WSM







LEFT CENTER, close-up of the base of the tower showing the matching and feed circuits. . . .

LEFT, BOTTOM, the transmitter in which a 450-kc oscillator is frequency modulated by a push-pull reactance tube circuit. At maximum volume the 450-kc signal is swung 18.7-kc, one-quarter of the allowable swing of the carrier. The modulated signal is mixed with the 10.725-Mc output of a crystal-controlled oscillator, and the sum of the two frequencies is multiplied four times to give the carrier frequency which is 44.7 Mc. . . . ABOVE, rear view of the 20-kw power amplifier showing two GL-889 water cooled tubes which are used in the final stage

Equipment Failure Alarm for Communication Networks

By

E. G. COOK
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and A. H. PETERSEN

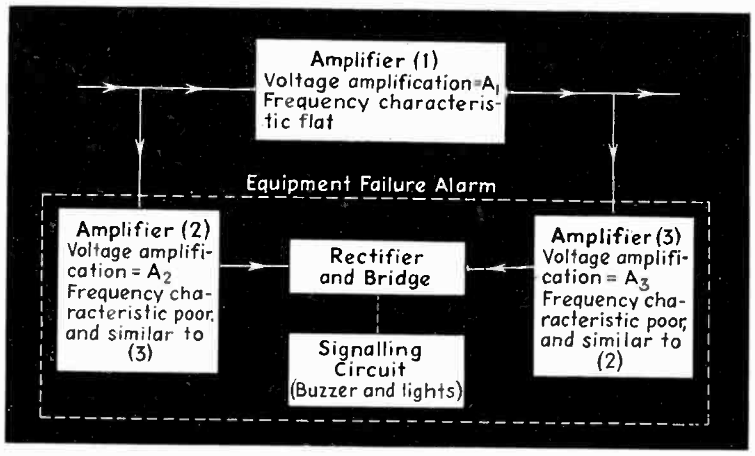

Fig. 1—Block diagram of the equipment failure alarm. Under normal conditions the output voltages of amplifiers 2 and 3 are equal. Abnormal conditions will upset this equality

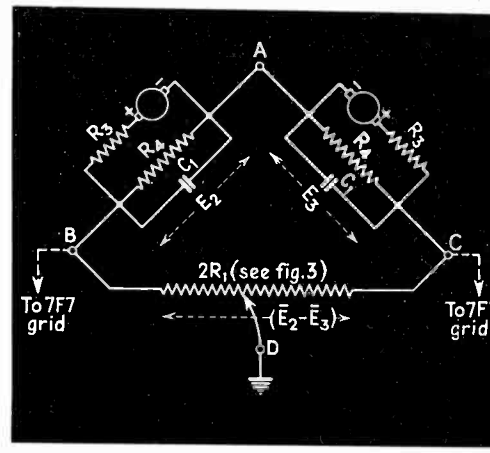

Fig. 2—Equivalent circuit of the alarm. The characteristics of the components of the two upper arms should be identical

THE sharp increase in the use of two-way facilities in communication networks during the past few years has resulted in greater complexity in these circuits to such an extent that the use of an equipment failure alarm is highly desirable. Such instruments placed at strategic points in the network insure a minimum loss of time in restoring normal service.

Generally speaking, the equipment failure alarm is an inexpensive and practical way of monitoring between any two points in an audio chain when the difference in level between these two points is normally constant. For example, it may be used with any type of constant-gain amplifier as a failure or trouble indicator. With a limiting amplifier, in addition to warning of equipment failure, it may also serve as a warning signal for excessive limiting action. Connected across the modulation monitor rectifier output and the modulator input of a radio-frequency transmitter, it readily betrays any appreciable change in amplification between these two points, as well as pronounced hum or noise originating therein. Connection of equipment failure alarms with a central board may be made so that all amplifiers are monitored from the operating position. Moreover, in the case of an amplifier whose function is of the utmost importance, relay switching arrangements are easily made whereby a spare unit is automatically placed in service when the regular unit fails.

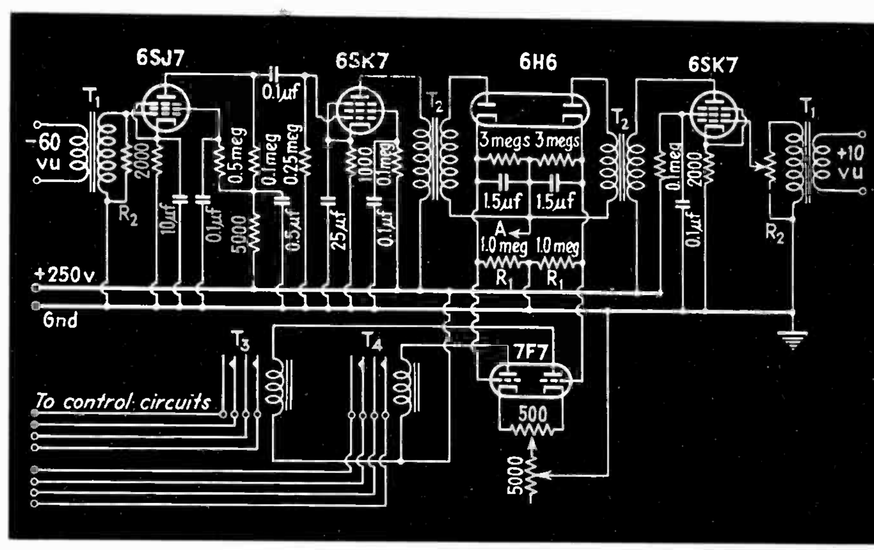

Fig. 3—Circuit diagram of the alarm. The common cathode resistor of the 7F7 increases the sensitivity of this tube as a push-pull d-c amplifier

Method of Operation

Fundamentally, the idea is to bridge off the input and output terminals of an amplifier, and bring the signal which is present at the input terminals up to a usable level. The signal present at the output terminals is treated in the same manner, naturally requiring less amplification in order to bring it to the same usable level. Each of the two resulting matched signals is then impressed upon its individual rectifier and filter, and the d-c outputs (E_2, E_3, Fig. 2) are compared in a bridge. When the d-c voltage thus derived from the original input terminals approximately equals that obtained from the output terminals at all frequencies to be transmitted, the system in balanced. If trouble should develop within the amplifier causing either a rise or fall in amplification or a large amount of hum or noise, the system will fall out of balance, causing a resultant voltage, E_2-E_3 to appear on the bridge (Fig. 2) and be impressed on the signalling circuit. Polarity of this resultant voltage depends upon whether the amplification has increased or decreased, and determines which of two indicating panel lamps will light.

In addition, a buzzer may be connected to operate on any unbalance without regard for polarity. If the fuse blows or power supply fails the buzzer will sound and both lamps will light. Perhaps most important of all, the equipment failure alarm monitors itself in the same way in which it monitors the amplifier in question. Only failure of the type 6H6 tube heater, or sudden and total failure of two of the three amplifiers (Fig. 1) can occur without energizing the signalling circuit. This latter possibility is certainly negligible. The 6H6 possibility suggests an occasional check during maintenance rounds to see that this tube is operating, or a relay and pilot lamp may be placed in the heater circuit.

Referring again to Fig. 1, it will be seen that across the input of the amplifier to be monitored (1) is bridged another amplifier (2) of whatever gain is necessary to bring the gain up to a usable level, say +10 vu. Across the output of (1) is bridged another amplifier (3) of low gain for isolation purposes, so adjusted that its output is at the same level as that of (2). These outputs are rectified and impressed upon a bridge (Figs. 2 and 3) in such a way that with an unbalance of predetermined magnitude a signalling system is actuated. Obviously, the frequency response characteristics of (2) and (3) must match each other closely, or false alarms will take place. In practice, however, the high and low frequency content of most audio signals is fairly low with reference to the middle range frequencies. Therefore some aberration of frequency characteristics at the two ends of the spectrum is not likely to be troublesome. Furthermore, the frequency response of (2) and (3) may be considerably poorer than that of (1). This assumes that (1) is intended to have an essentially flat characteristic. If in (1) there is included a line equalizer, recording filter, or other frequency discriminating network, then the frequency specifications for (2) and (3) must be especially designed. They must satisfy the fundamental requirement that within some reasonable tolerance, such as 2 vu, $A_1 + A_3 = A_2$ for the entire frequency range expected at the input.

In Fig. 4 it will be seen that the frequency characteristics of (2) and (3) although quite similar are exceptionally poor. One convenient way of accomplishing this is to use the same type of poorly designed transformer in both amplifiers. Fortunately, due to rectifier time constant, phase shift and amplitude distortion is of no significance, except that care should be taken not to operate (2) and (3) very far above the overload point.

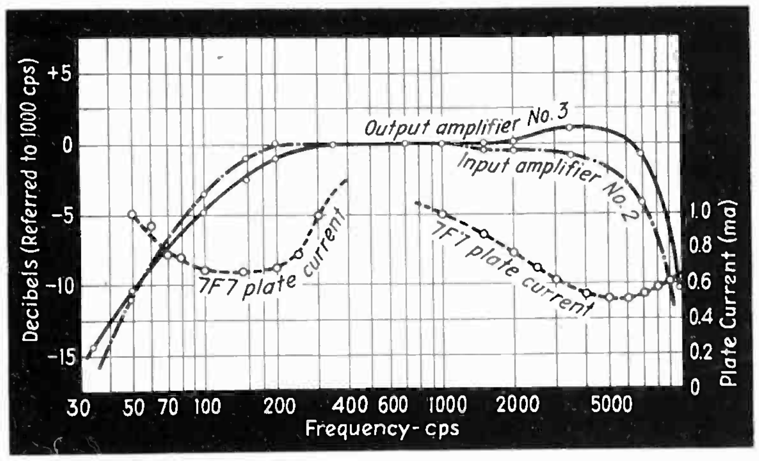

Fig. 4 — Characteristic curves of the two alarm amplifiers. Because of the low energy content of the very low and high frequencies, small discrepancies between the two characteristics are not serious

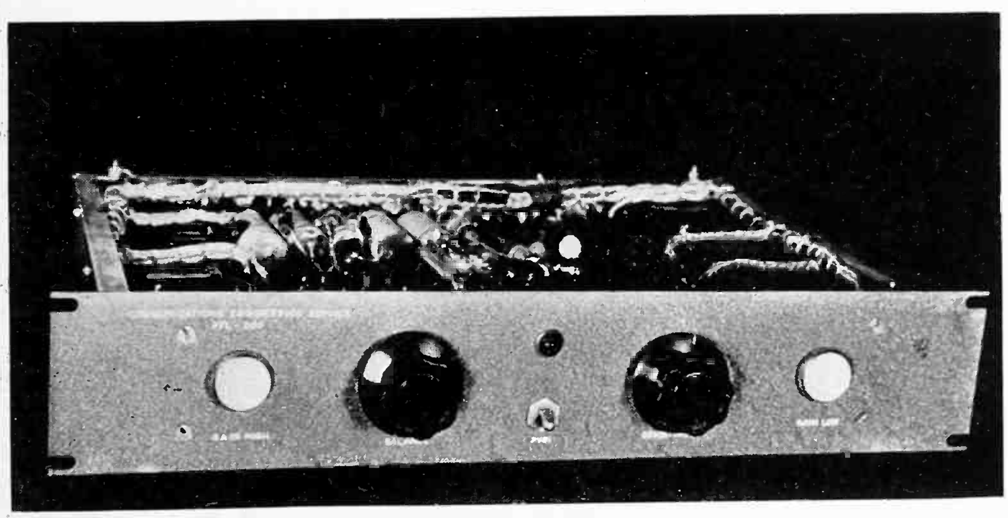

Fig. 5—The unit is accommodated in a standard rack panel 3½ inches high. The tubes are located in the rear for accessibility

Adjustments for Operation

In building the equipment failure alarm, some difficulty may be experienced in adjustment of the bridge and associated circuits. The circuit constants shown in Fig. 3 are not inflexible. In general the lower the bridge impedance is, the easier it becomes to adjust. However, the lower this impedance, the more gain and driving power is required. Hence, the problem becomes an economic compromise. The time constants of this bridge, determined by R_1, R_3, R_4, and C_1, are important in the successful operation of the alarm. When an unbalance occurs an indicating signal is certainly wanted as soon as possible. With too high a value of R_3, due to the low average power content of some program material, several seconds may elapse before the alarm takes place. On the other hand, once an alarm sounds on intermittent trouble it should continue at least until the operator has had a fair chance to locate the difficulty. For this reason R_1 and R_4 should be kept as high as possible with respect to R_3. Any dissimilarity between the two upper arms of the bridge with respect to circuit values is bound to cause false alarms. It is convenient to use a potentiometer (Fig. 2) instead of the two separate fixed resistors, R_1, (Fig. 3). In this way the ground point of the bridge may be arbitrarily set at the point which gives the best balance on extraneous noise caused by the high impedance 6H6 cathodes.

A 500 ohm potentiometer will be found in the 7F7 cathode circuit (Fig. 3) to allow compensation for

(*Continued on page* 105)

STORAGE in TELEVISION RECEPTION

. . . . Successfully used in television transmission, the principle of image storage may also be used with benefit in receivers. Some Scophony developments along this line are discussed

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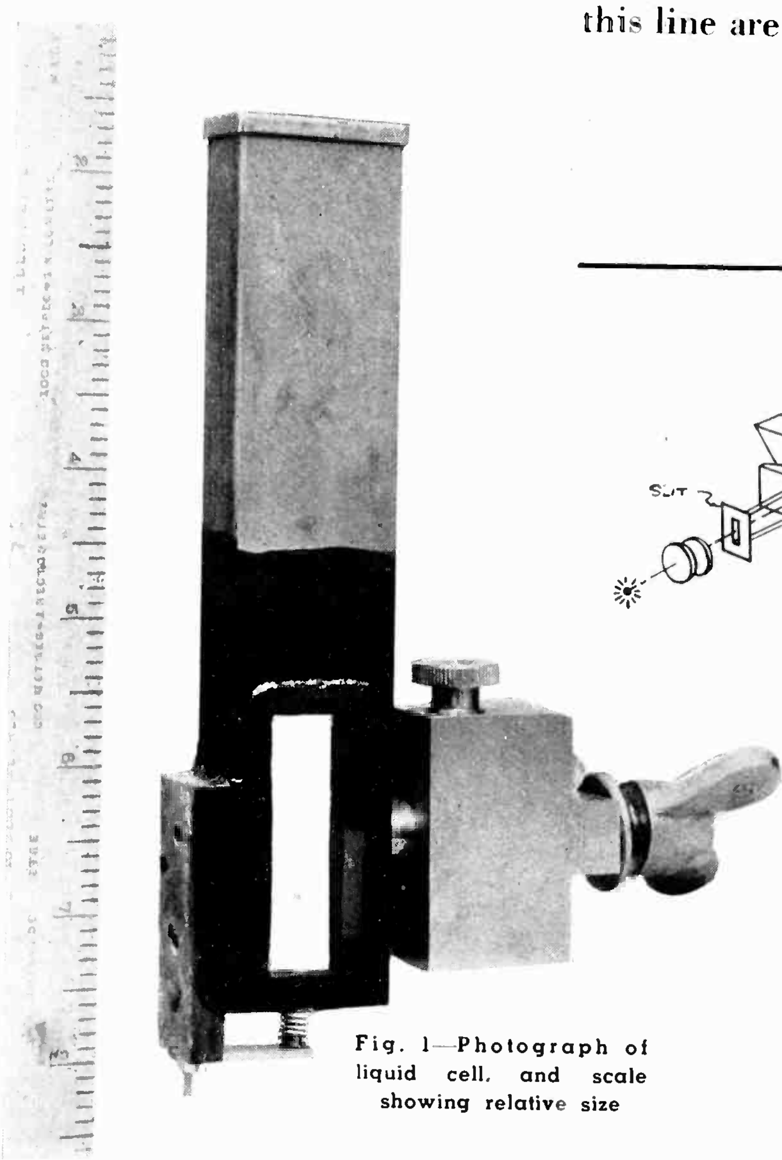


Fig. 1—Photograph of liquid cell, and scale showing relative size

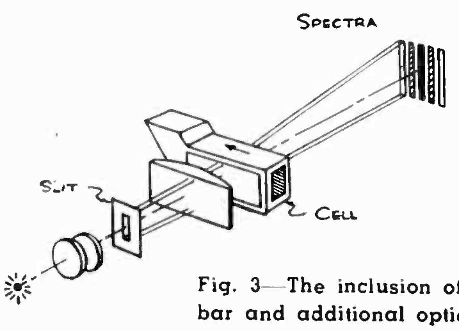


Fig. 2—Diagram illustrating construction of the liquid cell system

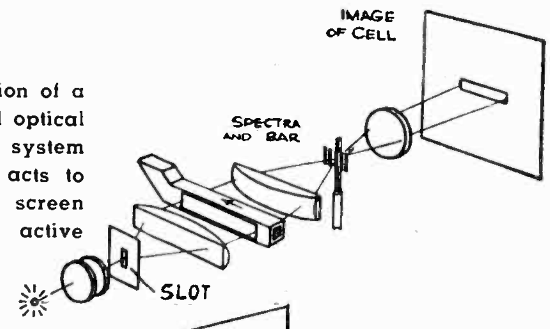


Fig. 3—The inclusion of a bar and additional optical elements to the system shown in Fig. 2, acts to remove light from screen when cell is not active

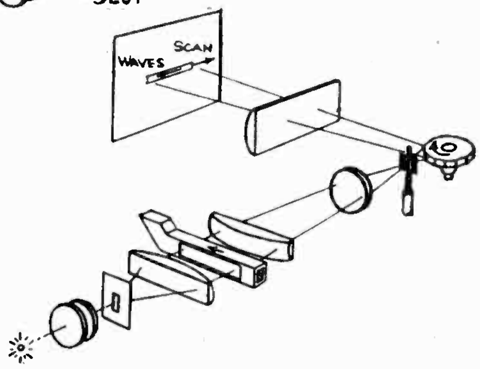


Fig. 4—The elements of Fig. 3 are combined with a multiple mirror rotating wheel to produce a line image whose intensity can be varied with time or with the position of the spot

THE recent progress of television technique has been characterized by a steady increase in definition with a consequent increasing difficulty due to the extreme shortness of the time interval available for scanning one picture element. At the transmitting end, the introduction of electrical storage over a substantial fraction of the frame period has made possible modern high-definition transmission.

A similar principle may be applied at the receiving end by introducing an optical storage of the picture elements over a substantial part of the frame period. The retention of the illumination of each element amounts to the simultaneous illumination of a considerable fraction of the total picture area, which results in a proportional increase of the total light energy available for each picture.

The Supersonic Light Control

The principle of optical storage is inherent in the supersonic light control, developed in the Scophony Laboratories.[1, 2, 3] This light-modulating device makes use of the diffraction of light by a grating consisting of supersonic waves in a liquid. This optical effect which has played an important part in various scientific researches,[4] has been applied as a simple and effective means of light modulation.

The supersonic light control consists of a cell having two opposite transparent walls, filled with a transparent liquid. A piezoelectric quartz crystal having a natural frequency between 10 and 20 Mc is arranged in such a way that it can transmit its vibrations to the liquid of the cell creating travelling waves therein. A photograph of such a cell is shown in Fig. 1, while the cell system is shown in Fig. 2. The crystal is excited by electrical oscillations which are amplitude-modulated by the video frequency signals received from the transmitter and transmits those modulated oscillations to the liquid of the cell in the form of compression-supersonic waves of varying intensity. These supersonic waves represent periodic compressions and rarefactions of the liquid, producing similar variations in the refraction index of the liquid which act on light transmitted through the cell like a diffraction grating.

By a lens system adjacent to the supersonic cell the optical arrangement shown in Fig. 3 forms an image of the light slot, from which the light beam traversing the cell issues, on a bar of such a size and position that practically all the light is stopped when the cell is not active. As soon as supersonic waves are excited in the liquid a certain amount of the light is diffracted but the diffraction spectra have a position outside the intervening bar. Thus, an amount of light can pass this bar in proportion to the intensity of modulation of the supersonic waves, which is in turn proportional to the intensity of the television signal.

Adjacent to the bar, or at the position of the diffraction spectra, a lens is arranged of such an aperture as to accommodate the more intense of the low-order diffraction spectra. On the picture screen of the receiver this lens forms an image of the wave-train in the supersonic light control. The supersonic waves carrying the signal modulations in the liquid, travel away from the exciting crystal with the velocity of elastic waves of sound of these frequencies, which is in the order of 1 kilometer per second. Since, for high definition television standards, the time duration of one picture element is of the order of one quarter of a micro-second, the length of a wave train corresponding to one element is about one-fortieth of a centimeter in the cell. Such an "element train" contains about 5 waves if the crystal frequency is 20 Mc. A wave train ten centimeters long will accordingly contain the successive modulations of about 400 picture elements, corresponding to approximately one complete picture line.

If the image of a wave train of such a length is projected onto the picture screen the image of nearly a full picture line appears simultaneously on the screen. A wave train of such a length does not show a noticeable attenuation, provided a suitable liquid is used. In order to simplify the optical system about one-third to one-half of a line is simultaneously active.

This application of the supersonic light control thus enables the simultaneous projection of 200 to 300 picture elements onto the viewing screen. We may also express the performance of the supersonic light control by saying that each picture element is actively illuminated for the scanning duration of 200 to 300 elements. An "optical storage" of the picture for this duration corresponding to one third to one half of a line is thus effected by the supersonic light control.

A further advantage of the supersonic light control over earlier light modulating devices, for instance the Kerr cell, is the excellent high frequency response obtained as consequence of the very low capacitance between the electrodes of the quartz crystal and the very low power consumption of the device (5 to 10 watts). Special damping means and output bandpass characteristics serve to obtain a flat frequency response of 5 Mc wide, which easily accommodates a high definition single-sideband image.

Mechanical Scanning System

The light modulations projected on to the screen would move along the lines with a velocity corresponding to the velocity with which the supersonic waves travel in the cell. However, a mirror polygon called the "high speed scanner," having 20 or 30 faces serves to sweep the light beams across the picture screen with a speed exactly opposite to that of the movement of the waves on the screen, and of such a magnitude as to compensate this movement as shown in Fig. 4. Thus each element is immobilized on the screen.

Using a 20-mirror polygon, a motor (Fig. 5) running at 47,250 rpm is required for reproduction of a 525-line image. Using a 30-mirror high speed scanner, the same result will be obtained at 31,500 rpm.

The bearings and balancing of the rotor must be of high quality to achieve service-free operation for a time comparable with the life of standard receiving tubes. The driving mechanism consists of an asynchronous three-phase motor which

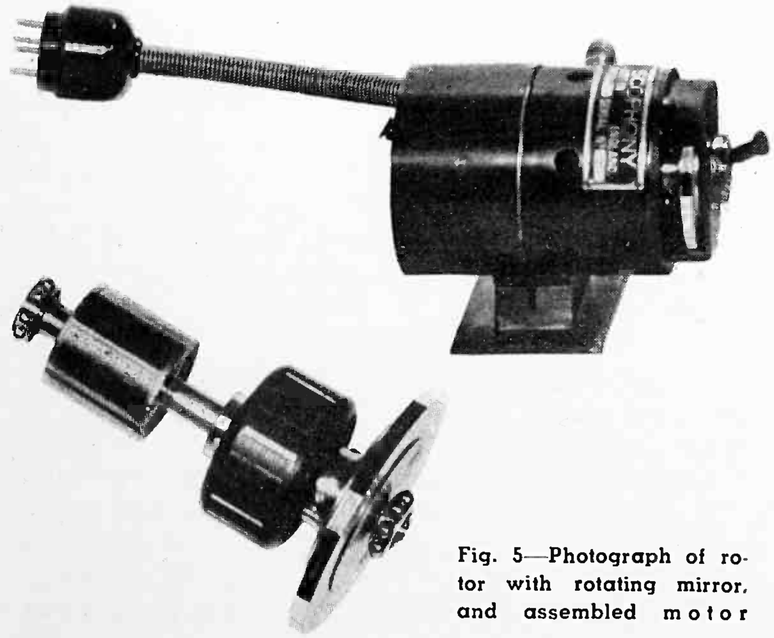
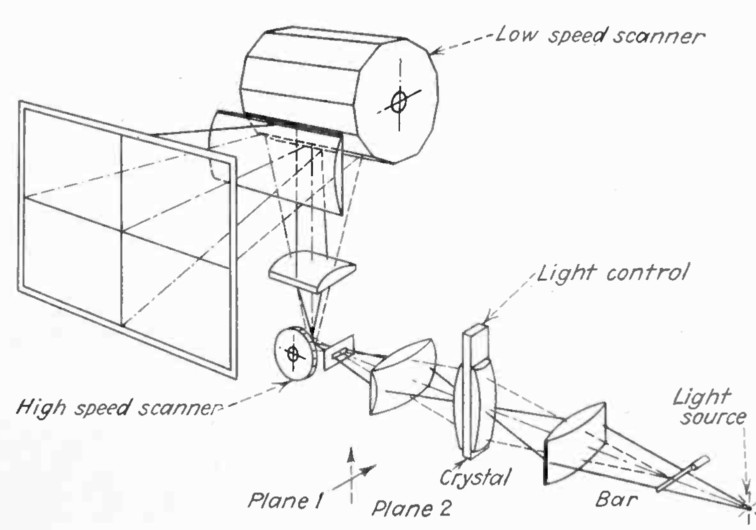


Fig. 5—Photograph of rotor with rotating mirror, and assembled motor

Fig. 6—Schematic optical diagram of Scophony receiver for home use, showing arrangement of split focus and light control



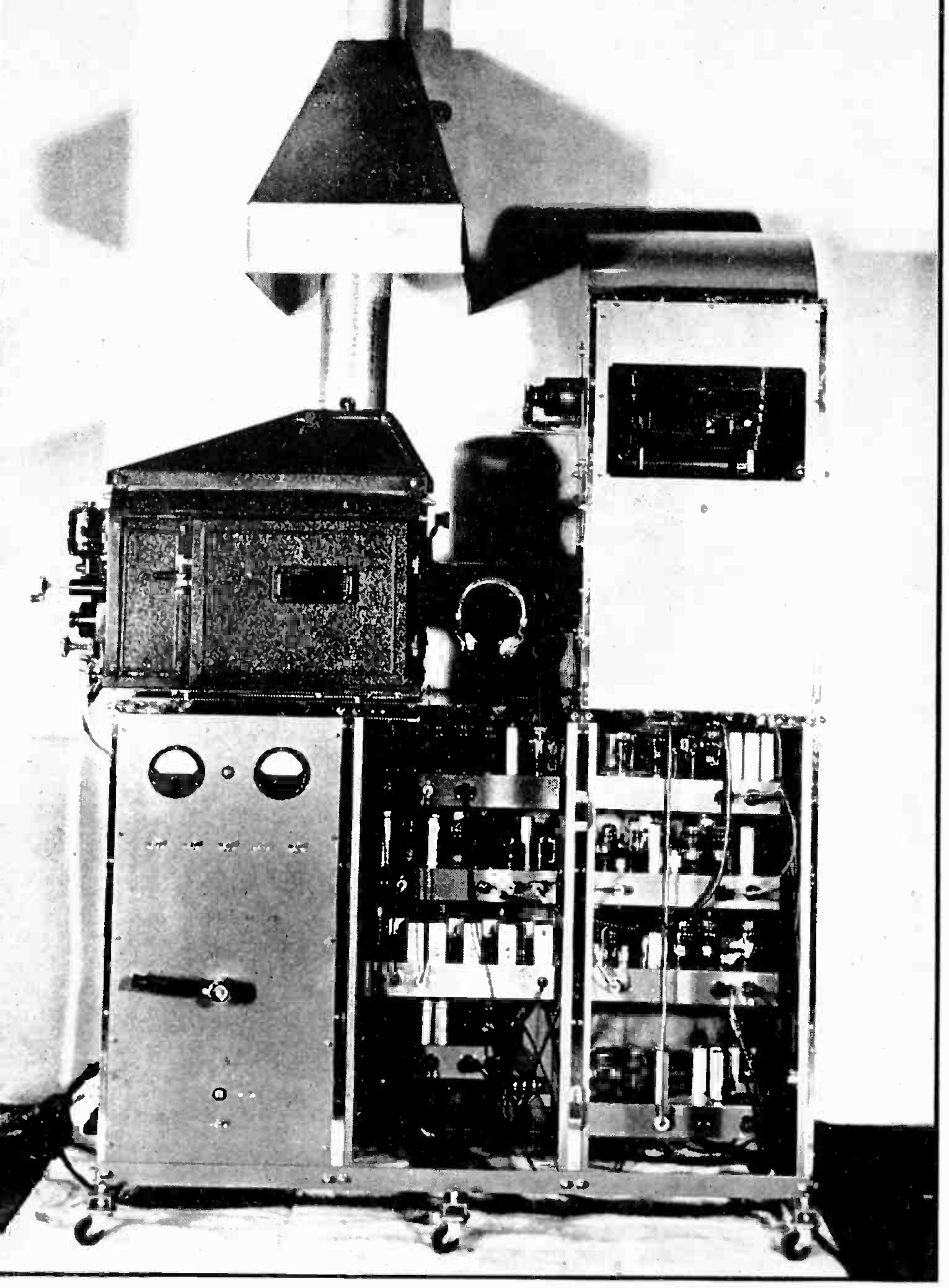


Fig. 7 Complete projector for theater use, based on the principles outlined in this article

supplies the power, and on the same shaft a phonic-wheel synchronous motor to the stator of which are fed the synchronizing signals from the receiver.

The frame-scanning movement is achieved through the use of a slow-speed scanner, a 20-mirror polygon driven at 180 rpm by means of a synchronous motor. The alternating current to drive this motor is obtained by amplifying the frame synchronizing pulse transmitted as a component of the signal radiated by the transmitting station. Figure 6 shows a schematic diagram of a Scophony receiver using this system.

Optical Focussing System

In order fully to utilize the advantages of optical storage made possible by the supersonic light control, and to reduce the size of the high speed scanner, optical principles have been developed which are new in the art of television. A suitable combination of spherical and cylindrical lenses effects an intermediate imaging of the width of the picture line. This "split focus" arrangement (Fig. 6) focuses the beam of light from the supersonic cell in two different planes, in such a way that the light energy is concentrated on a narrow band near the surfaces of the high speed scanner. Thus, the split focus principle permits a substantial reduction in the active apertures of the high speed scanner, and, consequently, in the size of this component making possible the use of a small driving motor and correspondingly easy synchronization.

It may be remarked that receivers based on the principles described above can be easily adapted to color television using a small rotating filter arrangement placed where the beam has a minimum cross section, preferably near the slot or high-speed scanner. A theater projector is shown in Fig. 7.

Combination of Supersonic Light Control with Electronic Scanning

The main limitation of the projection cathode-ray tube is caused by the saturation of the fluorescent screen, which limits both the brilliancy obtainable and the life of the tube. If instead of exciting only one element of the picture screen at a time, many elements could be excited, it would be possible to obtain with a smaller current density a far brighter picture, and still operate below saturation. By combining the light-storing properties of the supersonic light control with an electronic image converter, such a storage excitation of the fluorescent screen can be effected. Such a tube will act like a multi-beam cathode-ray tube.[5] The multi-beam however is produced automatically in a type of electronic image converter tube. In this tube an optical image of the supersonic light modulations of the light control is projected onto the photoelectric screen and is there transformed into an electron image. The image is at the same time amplified, and immobilized by electronic scanning means, and utilized to ex-

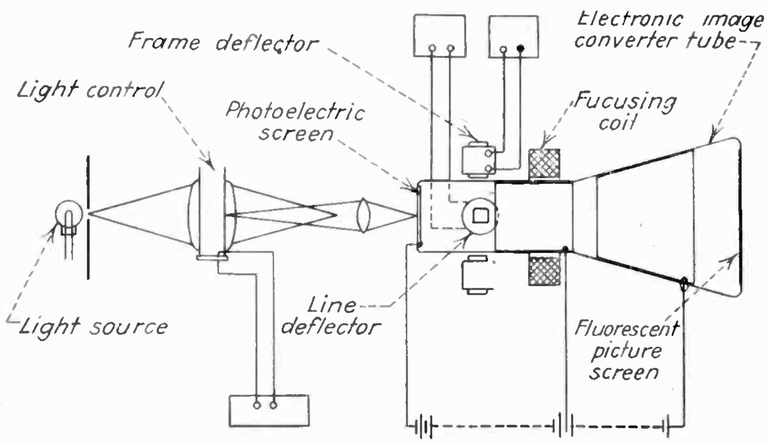


Fig. 8—Diagram illustrating principles of electronic supersonic television projection receiver

cite, in the form of a multiple cathode-ray beam on the fluorescent screen of the tube as many elements as the supersonic light control can handle. That means several hundred elements (Fig. 8). The system has not yet been fully developed since Scophony has been primarily interested in the development of another device, the Skiatron.

The Skiatron

Various effects have been proposed to obtain a modulation of the light transparency of a screen by scanning it with a cathode-ray beam. The cathode-ray, for example, has been used to operate small mechanical shutters, to cause the orientation of small colloidal particles or to produce birefringence in suitable substances.[6]

The advantage of such a system can be utilized efficiently only if the varying transparency values of the picture elements can be retained between maximum and minimum illumination in the picture, and the decay constant must be chosen so that during one frame period the intensity has fallen at least to a fraction equal to r. With an exponential decay according to

$$J = J_o \epsilon^{-at}$$

this would require a decay constant not smaller than $\alpha = (1/T) \log_\epsilon r$ where J and J_o are the intensities at the beginning and the end of the frame period T.

The intensity-time integral I, which represents the apparent element brightness equals

$$I = J_oT/g$$

where

$$g = \frac{r \log_e r}{r - 1}$$

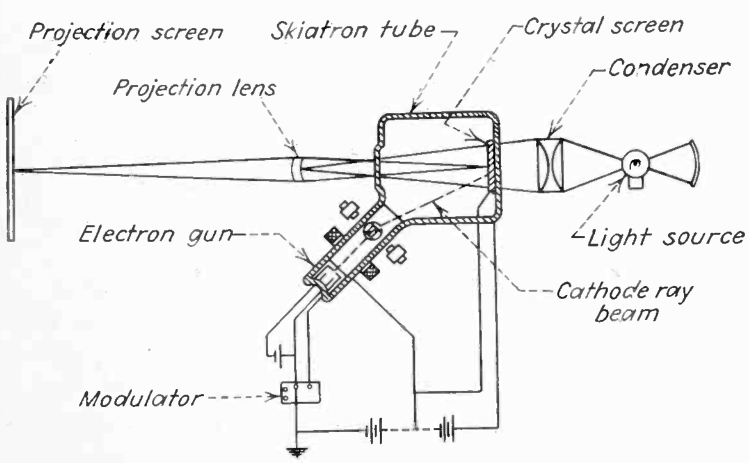
is a gain factor representing the ratio of the apparent brightness of a full storage system with a rectangular intensity-time curve to that of a system with an exponential decay and intensity ratio r. In such a system the element intensities would be retained at a constant value during the whole frame period and would fall off suddenly at the end of it. The decay curve of such a system would have a rectangular form. The accompanying table shows values of g for various intensity ratios r:

r	g
5	2.0
10	2.6
30	3.5
100	4.7

An electronic television system which inherently offers the possibility of a full storage, that is, possesses a rectangular decay curve, the Skiatron[7], has been developed in the Scophony laboratories.

As shown in Fig. 9 the Skiatron consists of a cathode-ray tube device in which a crystalline screen is exposed to the modulated and deflected cathode-ray beam. The screen material exhibits the property of "electron opacity" that is, it can be rendered opaque by being scanned by a cathode-ray beam. By subjecting the screen to a suitable electric field and temperature it is possible to cause the opacity to remain constant for substantially the whole frame period and to disappear then quickly when the beam returns to produce the opacity for the following frame.

This effect occurs in the following way: If an alkali halide crystal such as sylvine, or rock salt, is subjected to an electric field and to a cathode-ray beam, the electrons travel as free



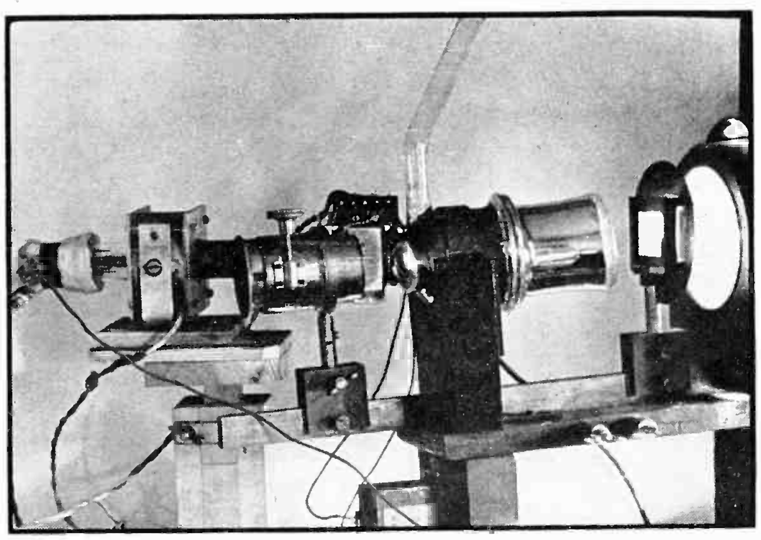


Fig. 9—Schematic diagram of the Skiatron and its associated circuits. Fig. 10—Right, demountable cathode ray tube for Skiatron making use of principle of signal storage

practically unchanged over substantially the full picture period. However, in all the above-mentioned phenomena, as in self-luminous fluorescent screens, the intensity time relation of the elements is represented by a decay curve, usually of exponential type. Hence in order to obtain as large as possible a storage of the element illumination and on the other hand to prevent an appreciable carry-over of movement from one frame to the following one, a compromise must be chosen with regard to the decay constant.

The carry-over of movements depends upon the intensity ratio r be-

electrons toward the anode producing the electric field, through the crystal lattice. After a certain time however an electron is captured by a positive alkali ion, resulting in the formation of a so-called color center which causes absorption in the visible spectrum. After a certain time these color centers are split up again by the thermal oscillations of the lattice into alkali ions and electrons, the latter ones proceeding further towards the anode until a subsequent capture by an ion. Thus the effect of the impact of the cathode-ray on to the crystal is the formation of an

(*Continued on page* 115)

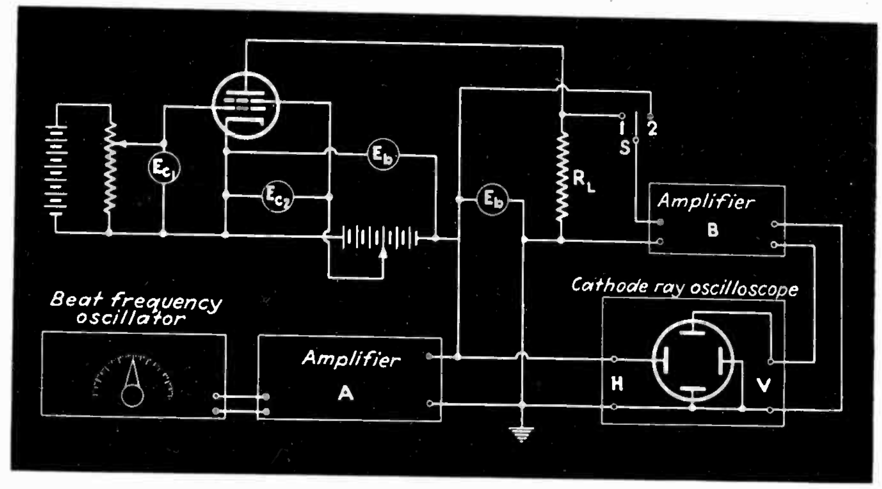
TECHNIQUE for TUBE DATA

A versatile and simple method of taking tube characteristics as a trace on the screen of a cathode ray oscilloscope is described. Advantages of this method are the small amount of equipment required and the speed and accuracy with which desired results can be obtained

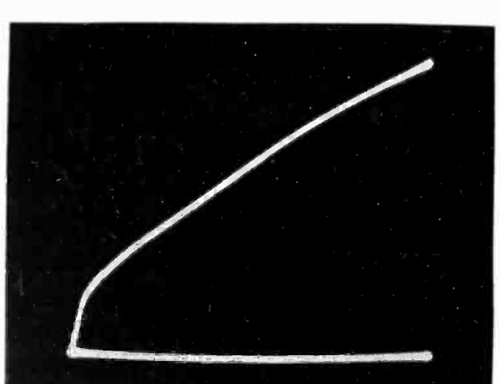
By C. C. STREET

Providence, R. I.

THE time spent in taking the characteristics of vacuum tubes is something which is dreaded by most laboratory technicians. In any case the usual point-by-point determinations are tedious, and errors in meter readings cannot be checked easily until the characteristic curves are drawn when it is often impossible or inconvenient to make a check reading. In some tube applications, the characteristics of a particular tube must be known more accurately than one can rely on the published data, and in other cases it is desirable that the transfer characteristics of the same electrode, or between two different electrodes, have some specified shape, as determined by the voltages applied to them or the impedances in their circuits. Under the conventional procedure a characteristic of prescribed form and scale, within the limitations of the tube in question, can be obtained only by successive approximations, that is, by taking point by point readings, plotting the results, altering some circuit constant or electrode voltage, and obtaining other characteristic data in this time-consuming manner. A family of curves is finally obtained from which the desired electrode voltages or circuit impedances required to produce the desired characteristic can be selected.



Suitable connections for determining the plate characteristics of a tetrode are indicated in the above schematic diagram

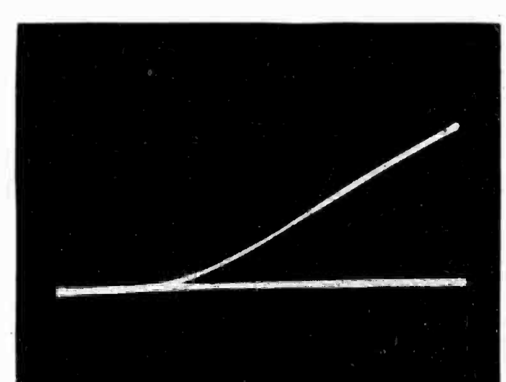


Photograph of trace on oscilloscope. Typical plate characteristics of 1G6 tube with control grid at +4 volts

To eliminate this laborious and time consuming procedure, the method outlined here was developed and has been found to be of considerable utility within its limitations. With this method it is possible to obtain the characteristic curves of the tube in question as the trace on the screen of a cathode-ray tube. This method differs from certain other methods of tracing the characteristic curves on the screen of a cathode-ray tube in that it gives the instantaneous conductance relationship of the same electrode, or between two electrodes so long as the electrodes for which the characteristic is being determined can be connected so as to have a common junction. For example, with this method the plate-voltage plate-current characteristics of a triode, or the screen-voltage plate-current characteristic of a pentode can be reproduced as a curve on the oscilloscope for given values of the control grid bias as a parameter. By inserting the plate voltage immediately adjacent to the plate, the grid-voltage plate-current characteristics can be obtained for various values of the plate voltage as the parameter. Other possibilities could be worked out as the need for them arises. The purpose for which this method was first worked out was to determine the operating conditions resulting in a linear characteristic between the plate voltage and the plate current in the 1G6 double triode, but the method has since been used in many other measurements. It may be pointed out here that the determination of the most suitable electrode impedances may be as important, in some applications, as the determination of the static characteristics, and this method lends itself admirably to such work.

The principle of this method has

(*Continued on page* 96)



Relation between screen grid voltage and plate current for a 6J7 with control grid at —2 volts

Frequency Deviation Measurement of F-M Transmitters

The frequency deviation can be determined by noting the constant amplitude modulating frequencies for which the carrier disappears. A graph relating the frequency deviation with the modulating frequency for zero carrier simplifies this calculation

By L. N. HOLLAND and L. J. GIACOLETTO

University of Michigan

FROM the theory of frequency modulation it is known that the generation of a frequency-modulated signal produces a carrier and side frequency terms. For a sinusoidal modulating signal, the amplitude of the carrier is directly proportional to $J_0(Z)$ where $J_0(Z)$ is the Bessel function of zero order and argument Z. The argument Z is usually called the modulation index and is defined by

$$Z = mf_0/f_1 \qquad (1)$$

where f_0 is the carrier frequency, mf_0 is the frequency deviation to either side of the carrier, and f_1 is the modulating frequency. The Bessel function, $J_0(Z)$, goes through variations having a close resemblance to a damped cosinusoidal function as is shown in Fig. 1. For certain values of Z, the carrier goes through zero or null points. The values of Z for which $J_0(Z) = 0$ are denoted by Z_i and are tabulated in Table I.* If the point at which the carrier disappears is known, the frequency deviation can be found because at this point

$$mf_0 = Z_i f_1 \qquad (2)$$

There must also be known the order of the zero, that is, the value of i.

In order to use this method of frequency deviation measurement, there is first required an audio signal generator with a calibrated output. This generator is connected to the transmitter a-f input. A selective a-m type receiver capable of receiving c-w signals is used to ascertain the presence of the carrier. In order to make the measurements, reduce the transmitter a-f input to zero and tune in the carrier on the receiver obtaining an audible beat or heterodyne note. Slowly increase the transmitter a-f input (analogous to increasing m in Eq. (1)). The audible beat note should gradually decrease in intensity and finally disappear entirely when the amplitude of the carrier reaches zero. At this point the frequency deviation is $mf_0 = 2.405\ f_1$. If the a-f input is again increased, the carrier beat note will return, increase to a maximum, decrease, and again disappear. For the second null point the frequency deviation is $mf_0 = 5.520\ f_1$.

* If additional zeros are desired, note that the difference approaches π units as i increases.

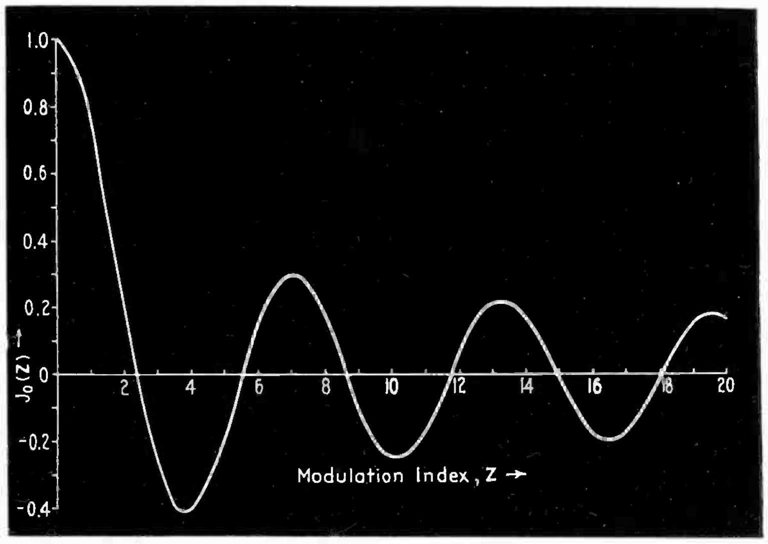


Fig. 1 — Graph of Bessel function, $J_0(Z)$, plotted as function of modulation index, Z

TABLE I

i	Z_i	i	Z_i
1	2.4048	11	33.7758
2	5.5201	12	36.9171
3	8.6537	13	40.0584
4	11.7915	14	43.1998
5	14.9309	15	46.3412
6	18.0711	16	49.4826
7	21.2116	17	52.6241
8	24.3525	18	55.7655
9	27.4935	19	58.9070
10	30.6346	20	62.0485

In general, the receiver will not be selective enough to admit the carrier alone, but will admit the carrier and several of the side frequencies. For this case if the receiver is tuned to give an audible beat note, f_a, it is quite possible that there will also be heard the frequencies $f_1 \pm f_a$, $2f_1 \pm f_a$, etc. This may lead to some confusion in determining when the carrier disappears. Considerable improvement can be obtained by introducing a low pass audio filter between the receiver output and the speaker or headset. The filter should be designed to admit f_a and to attenuate the other frequencies. If the cut-off frequency for the filter is chosen as f_c then f_1 must be greater than $2f_c$ in order that the other heterodyne notes fall outside of the filter pass band.

In order to facilitate the measurement of frequency deviation, the chart has been prepared. The radial lines are a plot of Eq. (2) (the dashed curved lines are used with another method of measuring deviation described below). Each radial line when numbered counterclockwise corresponds to the value of i in Table I. As an example of how the chart may be used, suppose that the modulating frequency is 5 kc. The deviation when the carrier disappears for the first time is found by following along the lower edge of the chart to the 5-kc ordinate and moving upward along this ordinate until it intersects the first radial line. The deviation, 12 kc, is read from the scale on the left. For the second null point continue upward along the 5 kc ordinate to the second radial line where the deviation is found to be 27.6 kc. In this manner the deviations may be determined for successive null points.

The above method of measuring deviation follows closely the method described by M. G. Crosby† A slightly different method has been used by the authors with success. For this method the a-f input is held constant and the modulating frequency varied. If this is done, the carrier will disappear for several values of f_1. Any two successive modulating frequencies which cause the carrier to disappear will uniquely determine the frequency deviation. Suppose in this method that a modulating frequency of 7.8 kc gives a carrier null, and the frequency is decreased until another null is obtained with a modulating frequency of 5.0 kc. Then the intersection point of the ordinate at 7.8 kc (upper frequency) and the dashed curve at 5.0 kc (lower frequency) indicates a frequency deviation of 43 kc. The intersection point of the lower and higher frequency must always fall on a radial line. Also the interpolation between the dashed curves for lower frequency values is linear along any radial line.

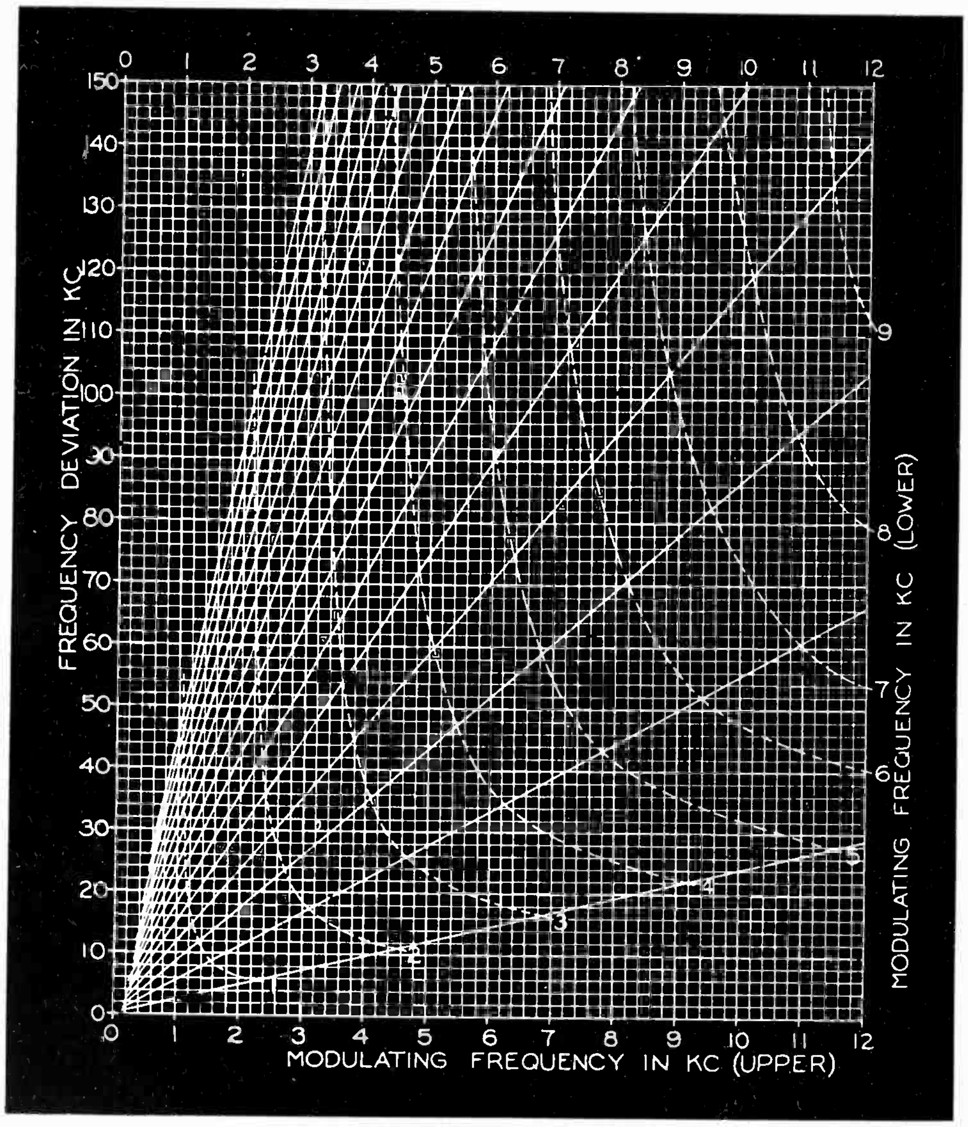


Fig. 2—Graph relating frequency deviation of f-m transmitter and modulating frequency for zero carrier

While these methods of frequency deviation measurement are basic in that they are independent of all circuit parameters, they have certain shortcomings which limit their usefulness. First they presuppose a linear relation between input voltage and frequency deviation. A departure from linearity means that the carrier null points are no longer null points but minimum points. If the departure from linearity is very serious, it may be impossible to detect even a carrier minimum point. The carrier frequency must also remain reasonably constant. If the carrier frequency changes considerably as the input level or modulating frequency is changed (depending on which method is being used), no carrier null points will be obtained. Even a small change in carrier frequency may be bothersome in that the carrier heterodyne note will change, possibly to such an extent that the heterodyne note will move outside of the filter pass band. For this reason the filter cut-off frequency should not be too small. Also for this reason the modulating frequency should be kept at as large a value as is feasible so that the carrier heterodyne note will never be confused with the sideband heterodyne notes. In this connection, from the nature of the carrier zeros, it will be necessary to decrease the modulating frequency for measuring smaller deviations. This factor must be given additional attention when making measurements on mobile f-m transmitters where the maximum deviation is usually only 15 kc. A filter with lower cut-off may prove useful in such cases, and the receiver should be returned to the same note if the carrier shifts.

In using the first method for making deviation measurements, care must be taken to count every null point. If a null point is overlooked the deviation measurements will be incorrect. The second method is an improvement in this respect since the deviation is uniquely determined. On the other hand the second method is useless when there is appreciable variation of deviation with audio frequency. Such a situation will arise in any transmitter if either audio pre-emphasis or uncorrected phase modulation is present.

† Murray G. Crosby, "A Method of Measuring Frequency Deviation," *RCA Review*, Vol. IV, pp. 473–477, April 1940.

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TUBES AT WORK

Portable transmitter, remote amplifier with pre-emphasis, phase reversal amplifier, and Wheatstone bridge voltage regulator are discussed this month

Automatic Voltage Regulator

By E. J. Casselman

Mellon Institute, Pittsburgh, Pa.

The increasing attention being given by laboratory workers to electrical and electronic methods for a wide variety of measurements has resulted in many applications for automatic voltage regulators. The inexpensive regulator tubes such as type VR-105 cover the field of very small direct current loads of the order of 30 milliamperes. The field of the much more expensive constant voltage transformers begins at 25 watts of alternating current. Between these groups there is a field that is in part covered by the device to be described. The instrument is inexpensive and can be made with few purchased parts. It is not new, but inquiry indicates it is not commonly known or used, possibly because no one has shown how simple it is in design. The principles of this instrument were first outlined by Campbell[1] and further elaborated by Lewis[2]; Walsh[3] proposed their use in preparing a standard light for photometry.

The device takes advantage of a characteristic of tungsten filament lamps, namely, that the resistance is proportional to the square root of the applied voltage. A bridge circuit is arranged as shown in Fig. 1. In this circuit

R, R are fixed resistors,
nR, nR are operating resistances of the lamps,
mR is the resistance of the load, which carries
i, the constant current,
E is the nominal line voltage, and
v is the voltage ratio mRi/E

The letters m and n of course are ratios of the other resistances to that of the fixed resistors R, n always being less than 1. The voltage across mR is the difference in potential of points A and B. A change in line voltage E will result in a smaller proportional change across the lamps than across the fixed resistors and consequently the potential difference between A and B tends to remain the same.

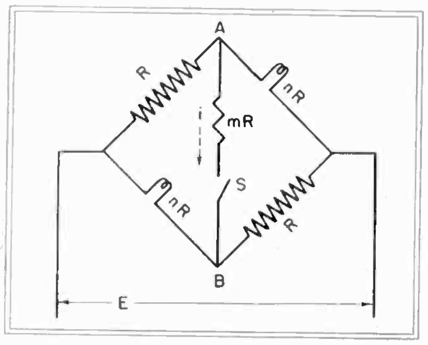


Fig. 1—Schematic diagram of Wheatstone bridge used as voltage regulator

It can be shown from Kirchhoff's laws that

$$i = \frac{E\,(1 - n)}{R\,(m + mn + 2n)} \qquad (1)$$

Replacing E by e^2, and assuming the lamp filaments to have the characteristic resistances $nR = ke$, then

$$i = \frac{e^2 - ke^3}{R\,(m + kme + 2ke)} \qquad (2)$$

The condition for a constant value of i is that $di/de = 0$, that is,

$$\frac{2e\,(m - mn - mn^2 + n - 2n^2)}{R\,(m + mn + 2n)^2} = 0 \qquad (3)$$

This condition follows where

$$m = \frac{n\,(2n - 1)}{1 - n - n^2} \quad \text{and} \qquad (4)$$

$$v = 2n - 1 \qquad (5)$$

If these conditions were critical, the only acceptable designs would be those that happened to fit in with the available commercial tungsten lamps, between the adjacent ratings of which fairly large intervals exist. The real possibilities are shown in Fig. 2, in

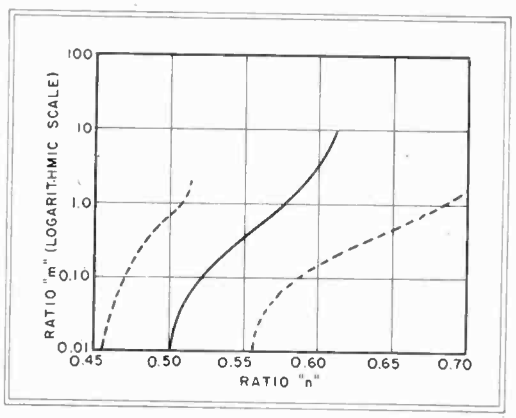


Fig. 2—Ratio of load resistance m to arm resistance n for perfect regulation (solid curve) and good regulation (dotted curves)

which the full line represents the relation between m and n for perfect volttage regulation. The broken lines show the condition for

$$di/de = 0.05e/R,$$

which is sufficiently close control for many purposes. Considerable latitude is indicated in the selection of the tungsten lamp resistors and the approximations in the derivation of the formulae are also justified. For values of n to the right of the solid line, the instrument overcorrects, that is, reverses the effects of line voltage changes.

One example will be given beside those reported by Lewis and Walsh. It is desired to operate a 6-volt light at 5.3 volts. Tests show the lamp to have a resistance of 21.2 ohms at this voltage. The line voltage is pute $R = 89/0.523 = 170$ ohms.

$v = 5.3/117 = 0.0453$;
$n = 1.0453/2 = 0.523$ (Eq. 5);
$m = 0.10$ (from Fig. 2.);
$R = 21.2/m = 21.2/0.10 = 212$ ohms;
$nR = 0.523 \times 212 = 111$ ohms.

On one side of this value for nR lies the estimated operating resistance at 55 volts of 121 ohms for the 75-watt lamp, and on the other side the resistance of 89 ohms for the 100-watt lamp. We select two 100-watt lamps and compute $R = 89/.523 = 170$ ohms.

In an actual trial the voltage across the load was only 4.7 volts instead of the 5.3 that was wanted. Resistance R was then changed to 190 ohms and the voltage across the load then became 5.3 as desired. As a result of the change, however, n had become by estimation $89/190 = 0.47$, a figure that was still inside the limits for excellent regulation. Tests revealed that the voltage across the lamp remained within the range 5.2 to 5.3 volts for all line voltages from 93 to 117.

A few practical points must be noted as follows.

1. The switch S should never be closed until after the line voltage has been applied, otherwise the surge of current through the cold lamps may damage the load mR.
2. A few minutes must be allowed to warm up the various parts of the circuit before the voltage across mR becomes constant.
3. The electrical efficiency of the device is quite low in most designs.
4. As it may not be advisable to ground any part of the load, the latter will be "hot", and hence adequate insulation should be provided.

(1) A Campbell, *Proc. Inst. Elec. Eng.*, *30*, 889 (1901).
(2.) F. G. H. Lewis, "An Automatic Voltage Regulator", *Proc. Phys. Soc.*, *34*, 17.
(3.) J. W. T. Walsh, "Photometry", Constable & Co., Ltd., London, 1926.

• • •

Compact Portable Transmitter

By E. F. Kiernan

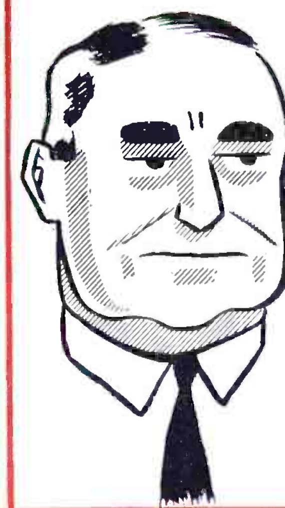
Bendix Aviation, Ltd.

At the time the writer designed this unit he was doing considerable traveling by air transport and had in mind the limitations on weight which baggage restrictions impose.

Although a great many so-called midget transmitters have been built, most of them either required bulky battery or other power supply equipment, or their output was limited to fleapower proportions. Desiring a reasonable amount of power without straining either the weight or dimensional limitations, an output of 10 watts was decided upon. With reasonable efficiency (66 per cent) this would require

I was worried

when I realized our production was not geared to meet delivery dates. New business had come our way, spurred by national defense. Were *we* going to lag behind?



But determined

I studied every operation . . . consulted time-and-motion experts . . . went through the plant for the hundredth time, and *there* on the assembly line . . . was a major cause of delay.

Slow work?

"Yes," said one foreman, "our screw-driving *is* slow. Can't use power drivers, for fear of driver slippage. Hand driving is hard work . . . screws go in crooked . . . screw heads split."

THE CAUSE . . .

"Old-Fashioned Fastening"

I began to notice. Screws fumbled. Driver wobbling. Help needed to steady the parts. Everywhere — waste resulted because I had insisted, *incorrectly,* that slow-driving screws *cost less!* I decided —

Don't Be Old-Fashioned

Phillips Screws Will End Slow, Wasteful Fastening

It's just good sense, I found out. The driver can't slip from the Phillips recess — so pneumatic or electric drivers can be used. No more screw driver accidents — no more delays — no more unnecessary worker fatigue. No wonder so many industries are standardizing on Phillips Screws.

Don't forget—it isn't the *price* of the screws that counts. It's the cost of *using* them. Thousands agree — *Phillips Screws cost less to use!*

PHILLIPS RECESSED HEAD SCREWS . . .

WOOD SCREWS • MACHINE SCREWS • SHEET METAL SCREWS • STOVE BOLTS
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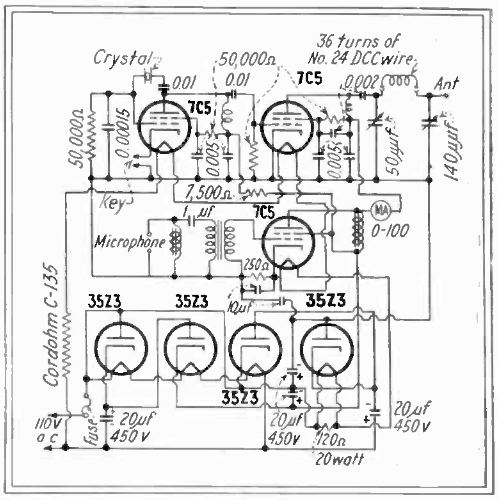
Speed Product Deliveries by Cutting Assembly Time

U. S. Patents on Product and Methods Nos. 2,046,343; 2,046,837; 2,046,839; 2,046,840; 2,082,085; 2,084,078; 2,084,079; 2,090,338. Other Domestic and Foreign Patents Allowed and Pending.

American Screw Co., Providence, R. I.
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.
International Screw Co., Detroit, Mich.
The Lamson & Sessions Co., Cleveland, Ohio
The National Screw & Mfg. Co., Cleveland, Ohio
New England Screw Co., Keene, N. H.
The Charles Parker Co., Meriden, Conn.
Parker-Kalon Corp., New York, N. Y.
Pawtucket Screw Co., Pawtucket, R. I.
Pheoll Manufacturing Co., Chicago, Ill.
Russell, Burdsall & Ward Bolt & Nut Co., Port Chester, N. Y.
Scovill Manufacturing Co., Waterbury, Conn.
Shakeproof Lock Washer Co., Chicago, Ill.
The Southington Hardware Mfg. Co., Southington, Conn.
Whitney Screw Corp., Nashua, N. H.

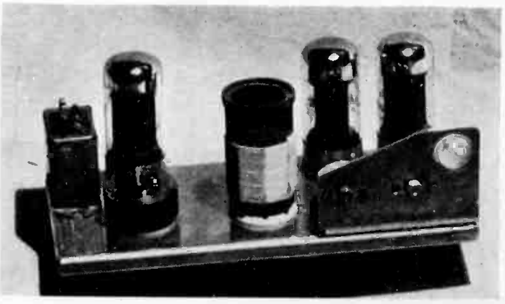
an input to the final of 15 watts. The loctal type tubes appeared to offer the greatest possibilities; the preliminary breadboard setup utilized two 7C5's in parallel in the final with two 7B5's in push pull as modulators. It was found that a single 7C5 would take the 15 watts input and that another would give adequate modulation. The power supply was originally set up with two 117Z6's in parallel, in a voltage doubling circuit. The plate voltage was 200 volts at a drain of 135 ma. The maximum input to the final, with satisfactory results, at this voltage was 6.6 watts, less than half the desire figure. The 117Z6's were then rearranged in a voltage quadrupling circuit, but the



Circuit diagram of the transmitter described by Mr. Kiernan. Note quadrupling arrangement of the 35Z3's

current drain at the required input to the final gave extremely short life from the rectifiers. The use of 35Z3s in the quadrupling arrangement solved the power supply problem very nicely. At a total drain of 100 ma the voltage is 310 volts. It might appear from the circuit diagram that the filtering was inadequate. Nevertheless the hum level was entirely satisfactory.

In order to eliminate the heat liberated by the main filament dropping resistor, use was made of the combination power-cord-resistor commonly used in midget ac—dc receivers. To further simplify the equipment, no a-c switch was installed, the cord being simply plugged in and out as required. Three miniature Jones plugs provide connections to key, mike, and a-c cords. All three are plugged in whenever the transmitter is used. The key acts as a push-to-talk switch on telephony, while the modulator and final are left on



The r-f section, which comprises the top shelf of the transmitter

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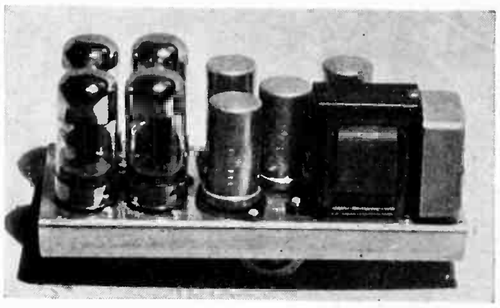
during key-up intervals to insure better regulation of the plate voltage. Mike current is obtained by running the cathode return of the modulator through the coupling choke and mike. Parallel feed to the mike transformer was necessary as this unit was of the hi-permeability core type. Doubling was provided for in the final stage to eliminate the necessity of neutralizing. There is very little difference in efficiency between straight through and doubling operation of the final. This is generally true of beam power tubes. Their power gain is so high that it is difficult to obtain stable operation without neutralization. A simple remedy is to double, with little or no loss in output.

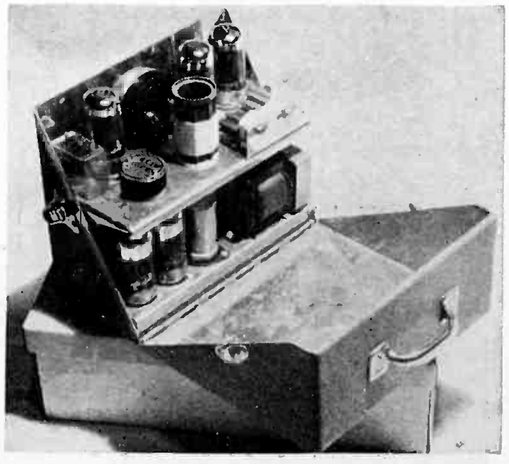


The power supply, modulation choke, coupling choke-condenser, and fuse

The pi coupler gives little trouble provided the antenna attached to it does not approach too closely a quarter wave, or a multiple of the carrier frequency. It is generally an easy matter to adjust the physical length of the antenna so that it will fall within the matching capabilities of the coupler.

The construction of the case requires the ability to get at and use sheet metal working machinery. The cutting and bending to shape is not an insurmountable task. However, the welding of the corners is a job for a professional welder. Care should be taken that a flux is used that will not continue to flake off long after the weld is made. The diagonal break at the ends of the case makes for sturdy construction, at the same time, affords considerably accessibility. If the hinge-pin is removable, the two halves of the case may be readily separated.

The transmitter is wired up in two sections. The power supply, modulation



The two sections of the transmitter mounted in the carrying case

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TRY Formex magnet wire after using any wire with a fabric protection which has been very tightly applied. You'll find Formex wire is not so stiff and is much easier to bend. Also, the outer surface of the film is much smoother.

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The outstanding property of Formex magnet wire is the physical toughness of its film. Tests have proved that this film is at least three times tougher and more flexible than the film on conventional oil-type enameled wire. It is also much more abrasion-resisting. These are the reasons why Formex wire is so well-suited for modern high-speed winding machines. Definitely, it cuts down rejects and lowers winding costs. That means savings—but with safety.

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Also—as compared with fibrous-covered enameled wire—it has a much higher space efficiency. It resists many solvents. It has high dielectric strength and long life. And, though a premium product, it is not high priced.

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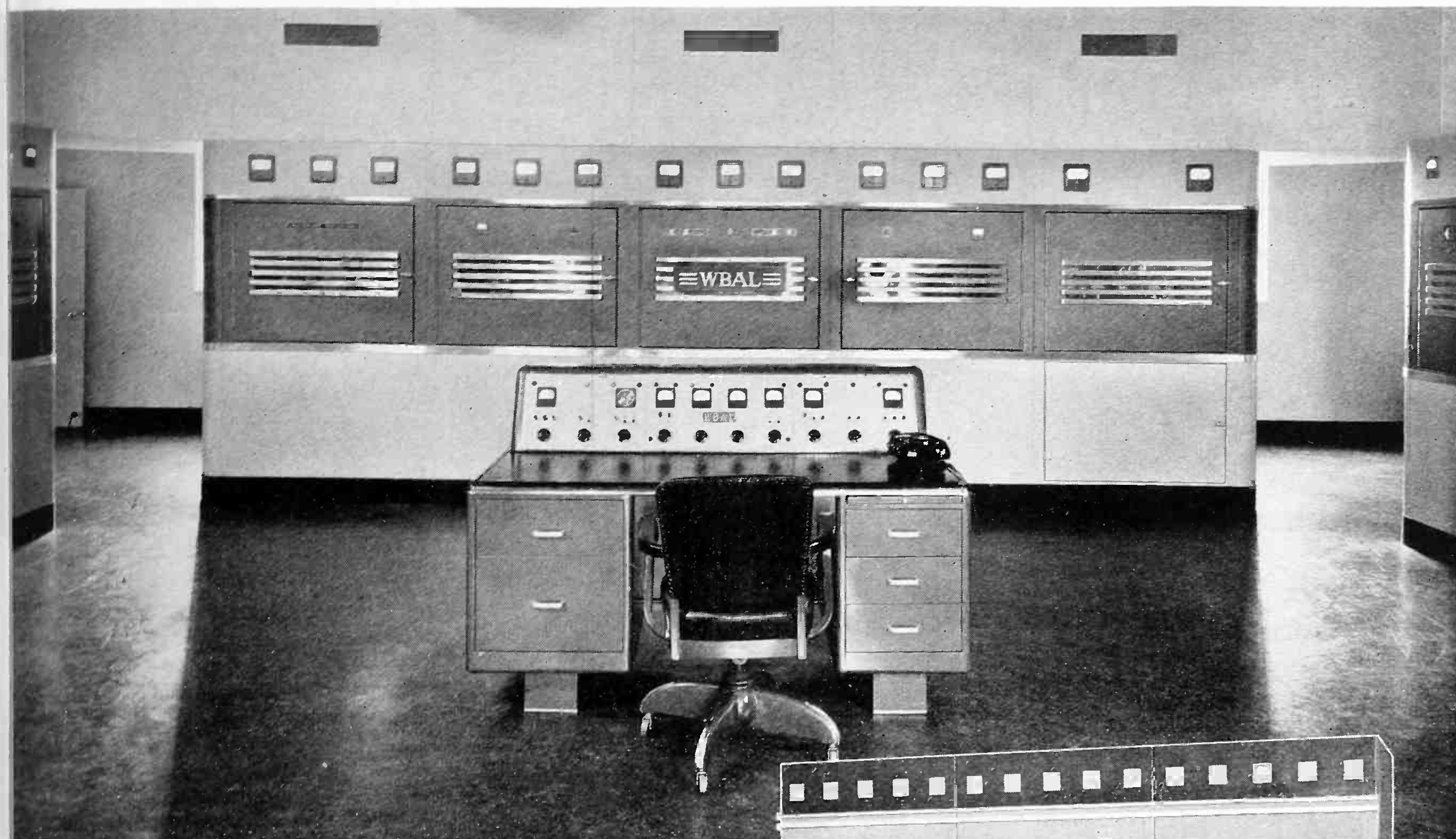
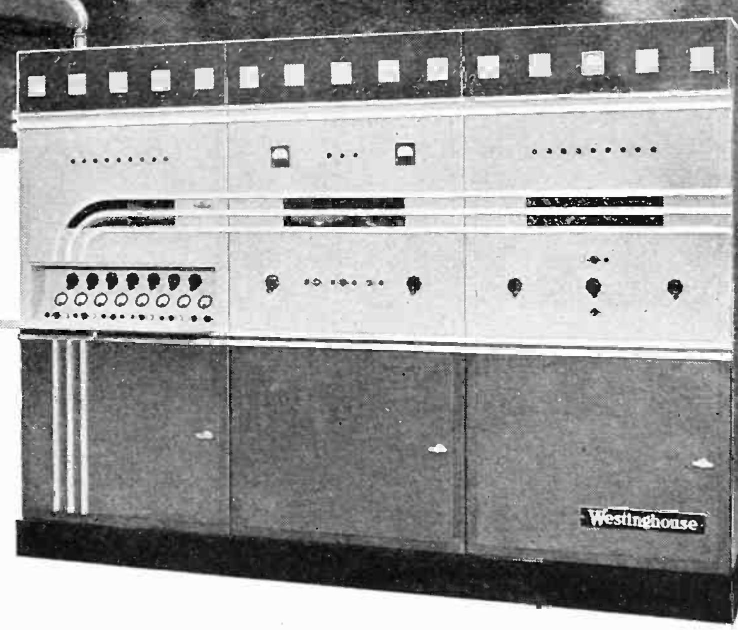
As a means of disseminating vital information, radio today is more important than ever before. High-powered, more efficient broadcast equipment improves these facilities—and we are gratified that we already have put into service an important number of our advanced 50-HG sets—and that we are still in a

WESTINGHOUSE

Westinghouse





position to make prompt delivery of such equipment.

Because defense production is an intensified laboratory of radio developments, out of it may come some of the most important improvements in commercial equipment of the future.

Our experience in manufacturing commercial as well as military radio equipment plus our experience in the operation of commercial broadcasting stations since the earliest days of radio puts us in a position to know the peacetime value of new developments—and to apply them effectively in meeting the requirements of commercial broadcasting.

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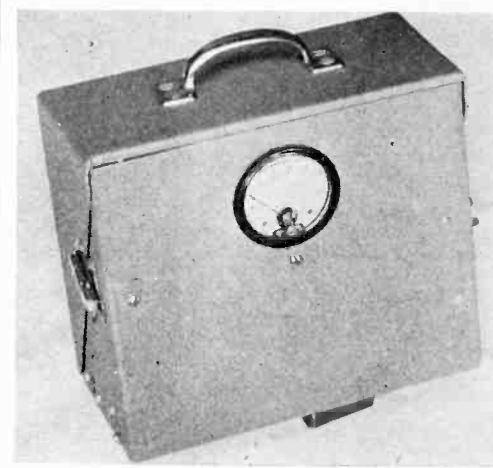
Top—Westinghouse 50-HG transmitter in station WBAL, Baltimore, Maryland.

Above—The 5-HV for 5000-watt operation provides the same advantage as the 50-HG.

J-08038

BROADCAST EQUIPMENT

choke, coupling choke-condenser, and fuse are located on the bottom shelf. The majority of the connections are sub-base. The leads to the plugs and to the upper shelf should be left long enough so that the shelf may be removed from the case by withdrawing the two six thirty-two machine screws (flat head) from the diagonally opposite bottom corners of the case. These screws thread into holes in the shelf corners which have been tapped to receive them. The top shelf is fastened on by means of the three screws through the front of the case; the majority of the leads having been fastened in place before the shelf is mounted. The details of construction and assembly are pretty well covered by the diagrams and photos. The connections between the two shelves are cabled together and brought up through a hole as marked in the sketch. The wiring does not appear in the photos as they were taken before the sections were wired.



The appearance of the transmitter closed, showing the plate current milliammeter

The three 7C5's are mounted in a row next to the case on the top shelf and plugged into low-loss sockets. The inductance and crystal holder plug into four and five prong ceramic sockets, respectively. The four 35Z3's plug into bakelite sockets on the bottom shelf together with the filter condensers which are also mounted on bakelite to insulate both terminals from ground. The mike coupling condenser is mounted on the Thordarson T-57C51 choke; one lug under the screw holding the adjacent end of the choke, the other bent over and soldered to the choke itself. The mike coupling choke was made from a partially defunct Leach relay by soldering the armature to the pole faces. The milliammeter is permanently connected in the plate supply lead to the final amplifier. It has a 0.5 ma scale, and is shunted to read 100 ma full scale. The microphone used was a single button 'airplane' type with the push-to-talk switch shorted out.

The plate currents are, oscilator; 12 ma; final, 50 ma; modulator, 40 ma. The final grid current varied between the limits of 2 and 3 ma. The rig was voice tested on 75 meter phone, and received an R-7 report at 135 miles in the middle of the afternoon.

Automatic Phase Reversal Amplifier

By R. P. Crosby
Vincennes, Ind.

The phase reversal amplifier which forms the basis of this article depends upon the unsymmetrical waveforms which are characteristic of much speech and music. Since the peaks in the positive direction often exceed those in the negative direction or vice versa, it is desirable that the peaks having the greater magnitude should modulate the carrier of the transmitter in the upward direction. This permits the greatest possible coverage by the station short of introducing distortion by over-modulation.

Previously cathode-ray oscillographs have been used to determine the waveform of the sound program and the operator has manually switched the two input wires so as to carry out the upward modulation indicated above. The improvement in this type of operation is approximately equivalent to an effective gain of 6 db without causing any additional distortion. The automatic phase reversal amplifier was devised to carry out this operation automatically. An amplifier of this type has been constructed and has been in operation quite satisfactorily for more than a year.

The circuit rests fundamentally on the fact that Fig. 1 represents the simplest possible manual switching system for reversing the phase of the peak input to a transmitter. Such a

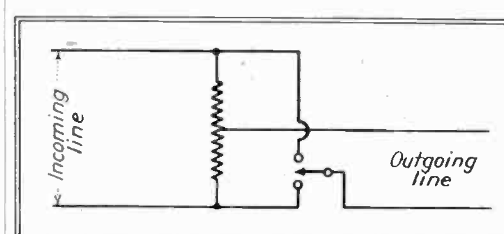


Fig. 1—Simple manual switching arrangement for reversing phase of signals in the outgoing line

manual switching arrangement of course causes a 3 db loss, but this is not a great disadvantage since the gain of any amplifier following it can be turned up by that amount.

Perhaps the operation in the diagram may be more fully considered in detail through the use of Fig. 2. Essentially this circuit consists of a normal line amplifier, a switching tube, and a push-pull amplifier whose function is to operate the switching tube in accordance with the polarity of the voltage at its output terminal. First consider the operation of the line amplifier with the 2A3 switching tube and push-pull amplifier disconnected. The signal voltage across the input of the line amplifier is e_g and for the instantaneous voltages as marked the signal voltage at the grid will be negative with respect to that of the cathode. Now assume that the 2A3 switching tube is connected. For the moment we shall disregard the grid or input circuit and shall merely assume that plate current

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Defense requirements have the right of way in this plant. Neither you, nor we, would have it otherwise. Daily we come nearer our goal of being able to supply defense requirements and your requirements. We believe the day is close at hand when once more we will be able to care for your needs with the speed and competence that won us so many friends throughout the nation.

The cornerstone of this organization is a policy of continued improvement through research and development. The Engineering and Production Staffs of American Lava Corporation contain representatives of many of the leading technological institutions of this country. Thus it is only natural that four completely equipped new laboratories sweep across one floor of this new building. These four laboratories, electrical, chemical, mechanical and testing, are in charge of men whose skill is favorably known to leading engineers in this country and abroad. They are ready to work for you on any problem involving technical ceramics.

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flows through this tube. The flow of plate current will set up a steady voltage across the resistor R_1, which will give a somewhat more positive bias to the line amplifier, but the signal voltage will remain unchanged. Thus, the effect is the same as if the bias control were at the point M instead of at N so far as the instantaneous voltage on the input of the line amplifier is concerned. The function of the push-pull amplifier is merely to provide a convenient and automatic switching arrangement for the 2A3 switching tube. For zero signal on the input of the push-pull tubes, the terminals A and B are at the same potential and consequently the 2A3 tube has zero negative bias.

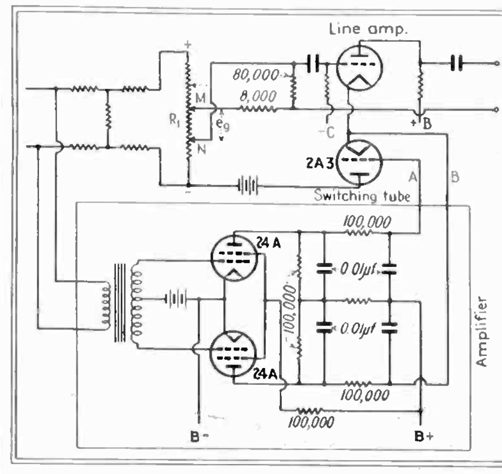

Fig. 2—Circuit diagram of automatic phase reversal amplifier

When a signal voltage is applied, one of the terminals becomes negative with respect to the other. If the terminal A is relatively negative, the 2A3 tube is biased to cut off since only a low voltage is used on the plate of the 2A3. By means of this mechanism we can automatically reverse the circuit so that the higher peaks will always modulate the transmitter upward, although for proper operation the position of the terminals A and B may have to be reversed.

Several practical points are of importance in the construction of this type of amplifier. The input circuit of the two type 24A tubes must be a transformer to obtain proper operation of the push-pull amplifier. Although type 24A tubes were chosen because of their high plate impedance, other and more modern tubes having approximately equivalent characteristics could likewise be employed. It should be noticed that the screen grid of these tubes is not at ground potential and no bypass condenser from screen to ground should be provided. The plate battery of the 2A3 tube should be of as low a voltage as possible so that a very small grid voltage will cause the tube to conduct current or to produce cut-off. The type 24A tubes are biased approximately to cut-off. The design of the optimum value of the voltage divider, R_1 following the H pad probably would not be critical and perhaps 600 to 1,500 ohms would be about right. The H pad reduces the voltage to the tube and voltage divider network so that switching is done at a low audio level.

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As is always the case—year after year—our November IRE-RMA issue will be read eagerly by the important men of the industry in convention at Rochester—and by more than 16,000 subscribers in radio, communication and a spread through every kind of industry.

Each year this issue is a broad index of product source, described in bigger space and greater quantity, because advertisers long ago realized that it is the catalog for a new season of activity. Certainly, *this* year is the banner one for you. Plan ample, competitive space now and get your reservations in early.

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330 W. 42nd Street

New York, N. Y.

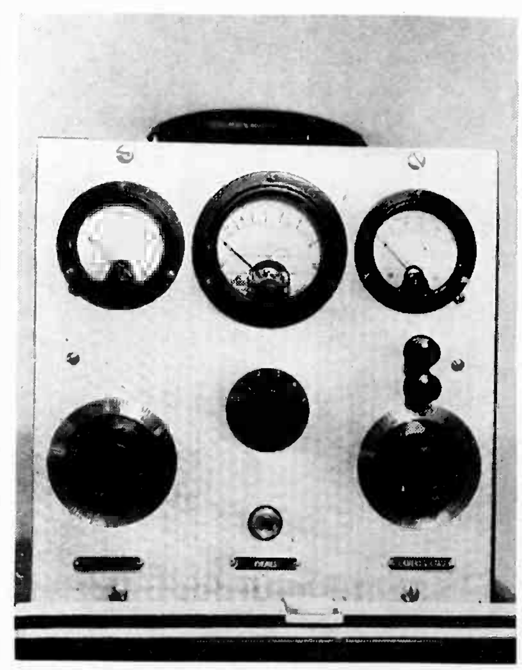
Remote Amplifier with Selective Pre-Emphasis

By Nathan Wilcox
Chief Engineer KTUL
Tulsa, Okla.

THERE ARE MANY IDEAS about remote amplifiers, for nearly every station engineer has his own opinion as to just how large a remote amplifier should be, what level it should put out, and so on.

After traveling around the country and listening to a great number of remote broadcasts from the smaller stations (and some of the larger ones) it was evident that very little, if any, equalization was being used. The idea came to mind that a simple switch on a pick-up amplifier would allow the operator to select a high frequency response curve which, if not absolutely technically correct, would at least give sounds a little more pleasing to the ear. Boosting the high frequency response of the pick-up amplifier will also materially aid in overcoming unwanted line noises. Thus we have a reason for a remote amplifier with selective pre-emphasis. It is to be understood that the effects of the line being used will compensate for the amount of pre-emphasis in use and that the net result will be a flat response with considerably less equalization than would otherwise be required. In this respect the word, pre-emphasis, is not used in its true sense.

No revolutionary claims are made for the unit about to be described, either in design or application, but the amplifier is small, light, and has reasonably good performance characteristics. The complete unit with batteries weighs 22 pounds. Two Burgess 4FH



Front panel view of remote amplifier. Switch in center controls pre-emphasis

batteries are used in series for the three volt filament supply and three Burgess type M-30's are used as the 135 volt plate supply. The amplifier is built in a case 10 inches wide, 10 inches high and 8 inches deep. The performance curves, pictures and diagrams

are more or less self explanatory and require little comment. The three meters shown in the front view of the amplifier are the filament voltmeter on the left, the output meter in the center and the plate current meter on the right. With the addition of another switch the output meter could be used in place of the other two meters, although three meters are desirable if it is necessary to know the entire circuit operation at a glance.

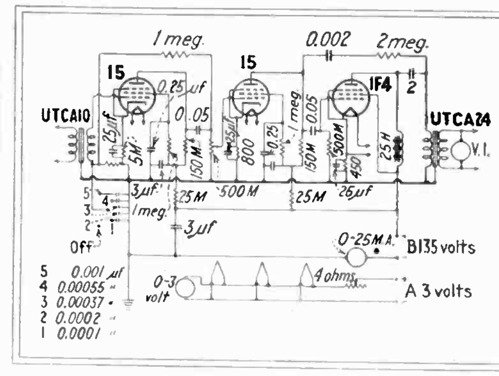


Fig. 1—Schematic circuit of amplifier using two feedback circuits

Don't forget that the performance of an amplifier with a 500 ohm resistor tied across its output will not be the same as it will be when you put a line across it—especially if the line has a doubtful impedance and has multiples tied across it all the way from here to there. Since this particular amplifier is often used to feed open wire lines of considerable length, a 500-ohm output is used. To feed short unequalized cable circuits perhaps a 150-ohm output would be more practical. A pad may be used between the output transformer and the line if desired. The use of such a pad will materially reduce the impedance vs frequency variations reflected into the plate circuit of the output tube by the line and thus minimize amplitude and frequency distortion which might otherwise occur.

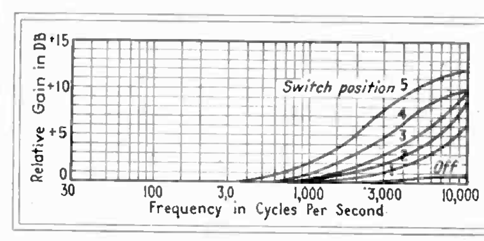


Fig. 2—Gain-frequency characteristics for various adjustments of the pre-emphasis switch

The transformers used are of the midget variety. Usually when these transformers are combined with various resistors and tubes a straight line frequency response is seldom obtained. This then, indicates the desirability of the use of negative feed-back. Two different feed-back circuits are used in Fig. 1. One is in the first stage and contains the pre-emphasis part of the unit. The second feed-back circuit is from the plate of the output tube to the plate of the second tube. The amount and design of this arrangement has a lot to do with the low frequency response of the unit as a whole.

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Machines designed and built in our own plant have accelerated production, and this special equipment has made our service even better than we ourselves expected to attain.

Our latest forward move, that of membership in the RMA, we feel will make us still more helpful to the Industry.

WE AIM TO KEEP IN STEP

SUPERIOR TUBE COMPANY
NORRISTOWN, PENNSYLVANIA

If the expected frequency response is not realized try juggling the size of this condenser-resistor combination. Don't forget what happens to the reactance of a condenser at low frequencies when you change its size and remember that you want some output left, so use as little feed-back as is consistent with the apparatus at hand.

The pre-emphasis is obtained from the feed-back loop in the first tube. The feed-back loop in the first stage has a number of condensers and a switch connected across the return resistor on the input transformer. In the front view of the amplifier this switch is located just under the output meter. By selecting a condenser which effectively short circuits the feed-back at the higher frequencies an overall rise in high frequency response is obtained. Curves for the various positions of this switch are shown in Fig. 2. Distortion vs output is shown in Fig. 3.

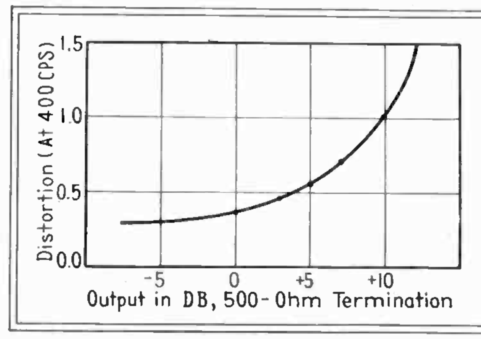


Fig. 3—Distortion plotted against output for the remote amplifier

Possibly one condenser and a variable resistor could be used instead of the switch arrangement. However, preliminary experiments indicated that it would be simpler to use the arrangement shown. If the curves do not come out to suit your particular desires, a fixed resistor can be placed in series with each condenser and the curve made to fall anywhere within the limits of the amount of feed-back being used, or a resonant circuit may be used. This should be placed in the feed-back loop since incorporating it in the plate circuit would introduce complications. If no feed-back were used then it could properly be placed in the plate circuit.

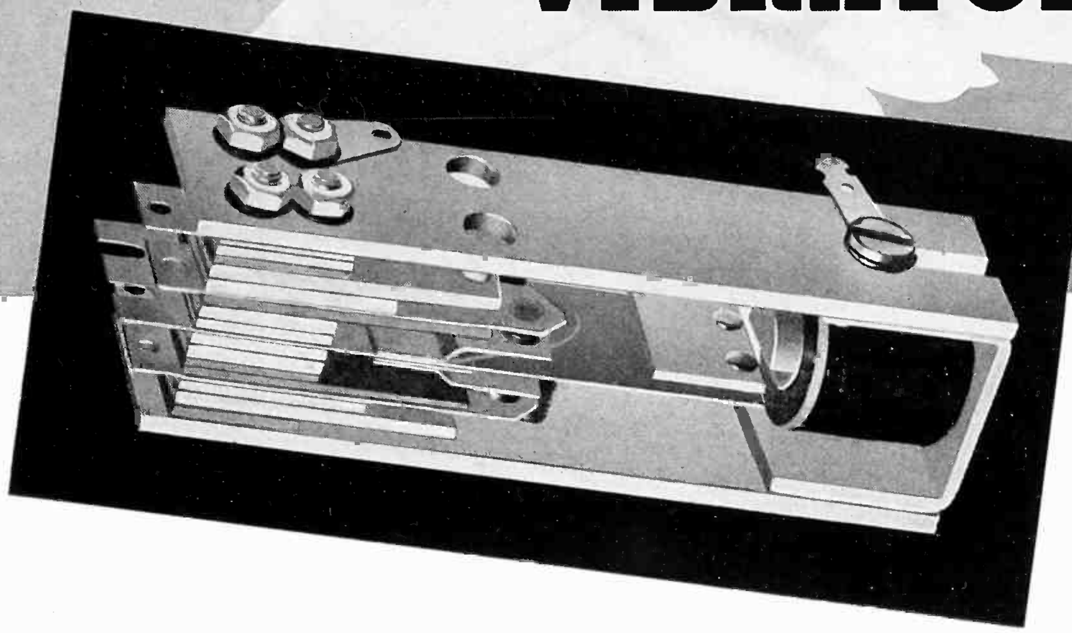
• • •

Cathode-Ray Recording of Transients

THE RECORDING OF TRANSIENTS from the screen of the cathode-ray tube is usually accomplished by using a moving-film camera, or, with a still camera, by opening the shutter, impressing the transient signal on the fluorescent screen, and then immediately closing the camera shutter. In either case the signal occurs only once, permitting one trace of the spot to give the required negative density, and therefore limiting the maximum writing-rate which may be recorded by the emulsion speed, the magnification of the lens system, the speed of the lens system, and the

Military and Civil Aircraft

. . . rely on ELECTRONIC VIBRATORS



Electronic Vibrator . . . heart of Electronic Converters . . . as used in Sperry Directional Compass.

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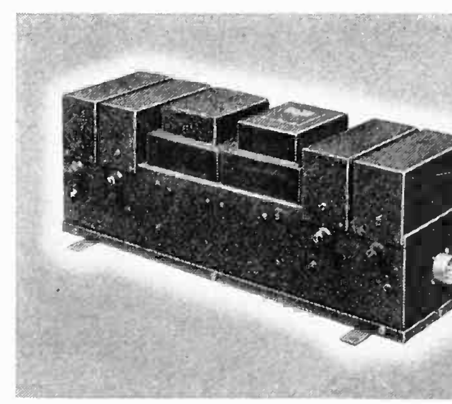

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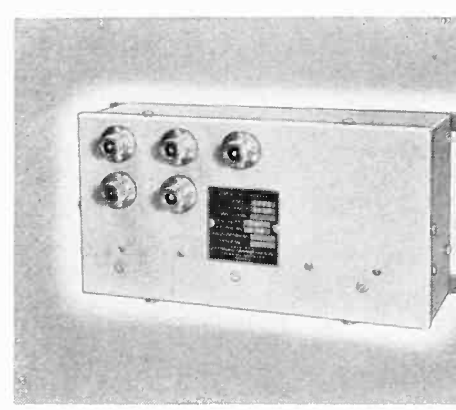

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AIRCRAFT DIVISION, INDIANAPOLIS, INDIANA accelerating potential and the beam current of the cathode-ray tube.

In a report from the Allen B. Du Mont Labs. it is pointed out that their engineers have determined empirically that with a lens opening of $f/4.5$, accelerating potential of 1000 volts, willemite screen, magnification of 0.5, and with a panchromatic emulsion having a Weston speed rating of 24, writing-rates as great as 1500 inches per second will give satisfactory negative density. From this empirical data it should be possible to calculate the maximum writing rate which may be photographed under any conditions.

• • •

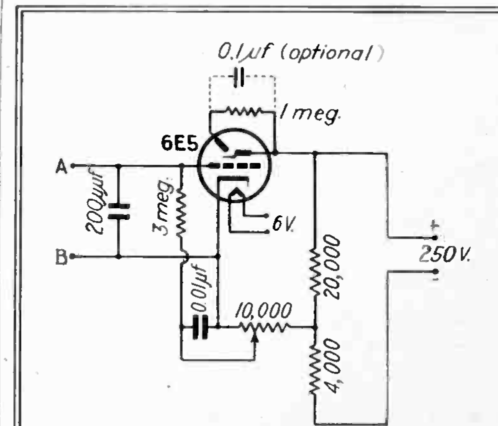
An Electronic Electroscope

By Esten Moen
Fosston, Minn.

A CONVENIENT AND SIMPLE electrical circuit for making certain tests of polarity and voltages (within certain ranges) is shown in Fig. 1. The device may be considered somewhat analogous to the old type electroscope and has been found to be useful in experimental work. The circuit utilizes the operation of the shadow angle of 6E5 electron ray indicator or similar tube.

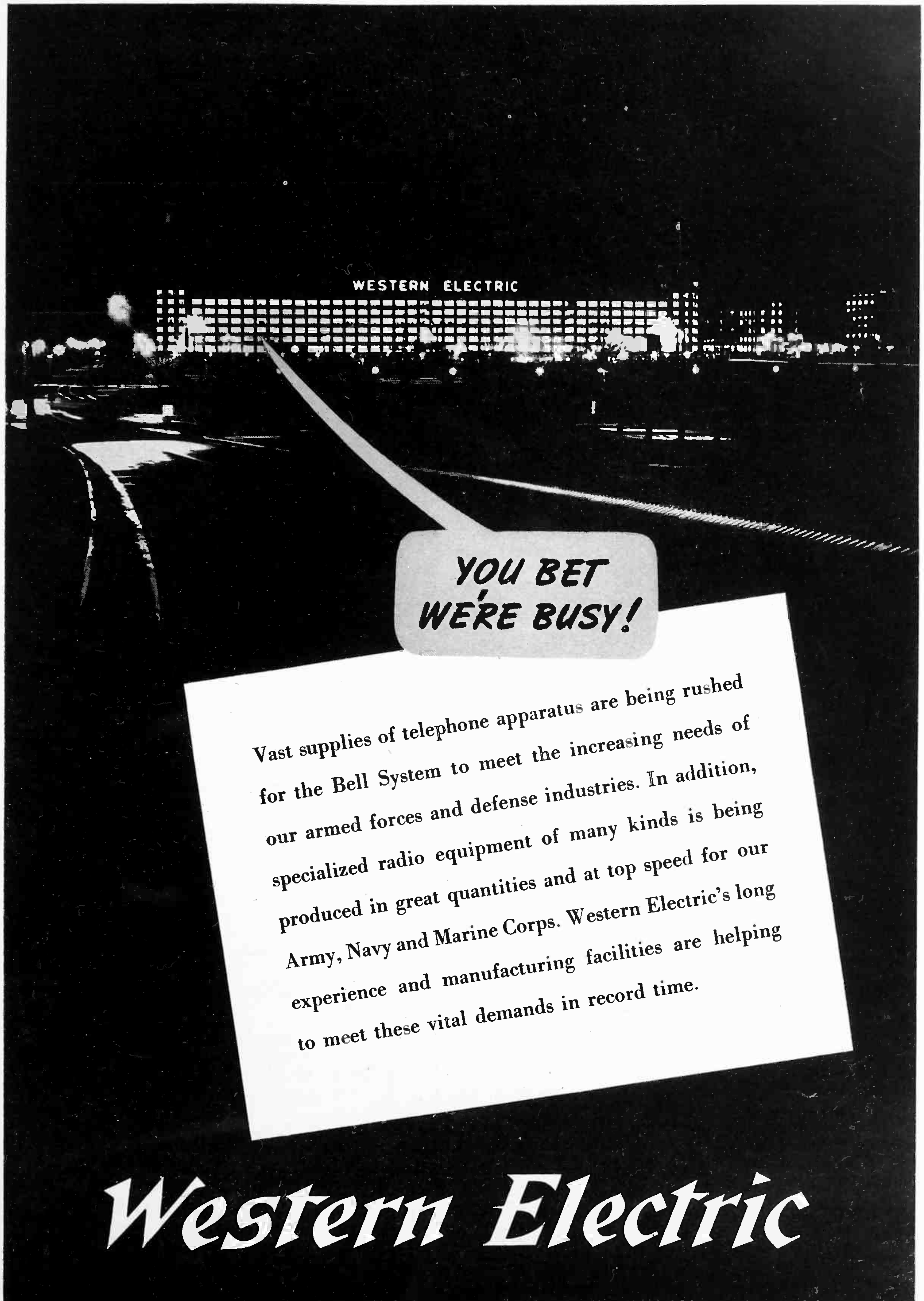
The circuit is shown for operation of the tube from a 250-volt supply. The 10,000-ohm variable resistor is adjusted to provide a suitable bias on the grid of the tube. It may be adjusted so that if the grid goes negative, the shadow angle will close, while if the grid goes positive thee angle will open.

If the circuit is to be used in connection with low impedances, the 200 $\mu\mu f$ grid condenser may be eliminated. The purpose of this condenser is to build up and maintain a charge for an appreciable time for those applications in which the tube is used as an electroscope. If a negatively electrified substance is brought near or into contact



An electron ray indicator tube, connected as indicated above, is useful as a form of electroscope and polarity indicator

with terminal *A*, the shadow angle will close, whereas when the electrified substance is removed the shadow angle will return to its initial position. Without the use of this grid condenser, the response of the electron ray tube will not be sufficiently prolonged to be readily apparent.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1941 Rochester Fall Meeting

Sagamore Hotel,
Rochester, New York
November 10, 11, 12, 1941
Program of Technical Papers

MONDAY, NOVEMBER 10

9:30 A. M.—12:30 P. M.

"A Method of Introducing Good Synthetic Bass Response Into Small Receivers" (with demonstration) by F. H. Shepard, Jr., Revelation Patent Holding Corporation.

"The Design of Solid Dielectric Flexible R-F Transmission Line" by Harner Selvidge, American Phenolic Corporation.

"Some New Aspects of Radio Engineering Economics" by E. L. Hulse, General Electric Company.

2:00 P. M.—4:00 P. M.

"Design Considerations For a Video Signal Generator With Monoscope Signal Source" by O. H. Shade and H. De Ryder, RCA Mfg. Company, Radiotron Division.

"The Skin Effect and The Depth of Penetration" by H. A. Wheeler, Hazletine Service Corporation.

"A 300-kv Electron Microscope," by V. K. Zworykin, J. Hilliar and A. W. Vance, RCA Mfg. Company

TUESDAY, NOVEMBER 11

9:30 A. M.—11:30 P. M.

"Annual Message of RMA Director of Engineering" by W. R. G. Baker.

"Discussion of Tube Noise Phenomena" by W. L. Krahl, Hygrade Sylvania Corporation.

"Design of a F-M Signal Generator" by C. J. Franks, Boonton Radio Coproration.

2:00 P. M.—4:00 P. M.

"New Magnetic Materials" by W. E. Ruder, General Electric Company.

"Design of a Modern 400 Mc. Signal Generator" by John M. Van Buren, Measurements Corporation.

"New Advances in Iron Cores" by W. J. Polydoroff, Consulting Engineer.

WED., NOVEMBER 12

9:30 A. M.—12:30 P. M.

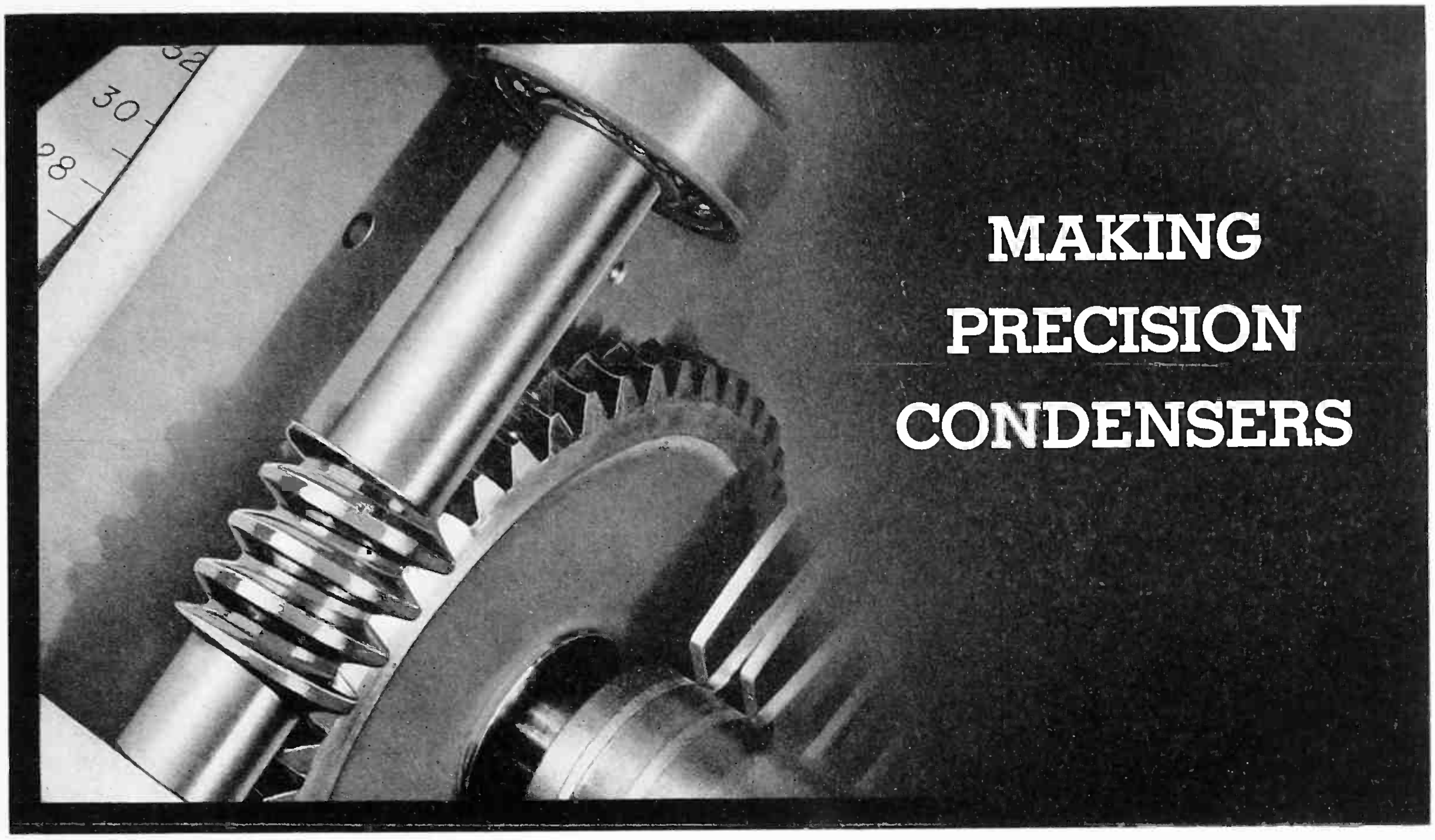
"Some Observations Concerning The Transient Behavior of Radio Noise Meters" by C. M. Burrill, RCA Mfg. Company, Victor Division.

"The Use of Plastics In The Radio Industry" by H. M. Richardson, General Electric Company.

"Civilian Receiver Design, 1942" by Dorman D. Israel, Emerson Radio & Phonograph Corporation.

"Alternate Carrier Synchronization In Television" by F. J. Bingley, Philco Corporation.

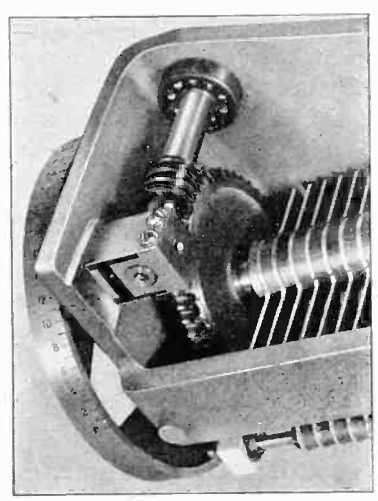
"Receiver Controlled by Transmitted Signal —Alert Receiver" (with demonstration) by S. W. Seeley and H. B. Deal, RCA License Laboratory.



MAKING PRECISION CONDENSERS

ILLUSTRATIVE of the precision employed in the mechanical design of GENERAL RADIO products is the popular Type 722 Condenser series. In the manufacture of precision condensers the mechanical design has considerable bearing upon the ultimate accuracy obtainable.

The Type 722 Condensers can be reset to 1 part in 25,000, an accuracy comparable to that obtained only in the finest type of precision machine. To secure this accuracy of setting, exceedingly close mechanical tolerances are held.



A 50-to-1 worm drive, equipped with a 3½ inch dial, is used for the fine setting adjustment. Backlash in the drive is kept very low (less than one-half worm division) by cutting the worm and worm shaft from an integral steel shaft, thus eliminating eccentricity due to setscrews and misfit.

The worm shaft is held to a tolerance of 0.0004 inch; the radial eccentricity of the worm gear is held to less than 0.002 inch. The main rotor shaft is held to a radial tolerance of 0.0005 inch and its bearing surfaces to 0.0002 inch. Ball bearings are used on the worm and main rotor shafts.

To take full advantage of the mechanical refinements of the worm drive, correspondingly important electrical and mechanical design features are incorporated in the other parts of these condensers. The main shaft, rotor and stator plates, tie rods and heavy cast frame are all fabricated from aluminum alloy. A remarkably low temperature coefficient of capacitance of only 0.0022 per cent per degree C. (22 parts per million) results from this construction.

Small, properly placed waxed Isolantite bars insulate the rotor and stator plates. A figure of merit ($R\omega C^2$) of 0.04 x 10-12, which is constant over the audio-frequency range and remains unchanged up to 75% relative humidity, is thus secured.

After assembly, the completed condensers pass through a number of aging cycles to relieve strains set up . . . strains which otherwise would not appear until years later. The condensers are then calibrated in our laboratories to an accuracy considerably better than that to which they are rated.

General Radio variable condensers have been used throughout the radio industry for years as the standard of variable capacitance. These condensers typify the care used in the electrical and mechanical design, production and testing of many General Radio instruments.

GENERAL RADIO COMPANY
CAMBRIDGE, MASSACHUSETTS
Branches in New York and Los Angeles

Research Beats the Priorities

(*Continued from page* 30)

the beginning steel ran just about as pilot runs had shown. Flatness was a little better than had been anticipated, but steel is not yet of best broadcast standard.

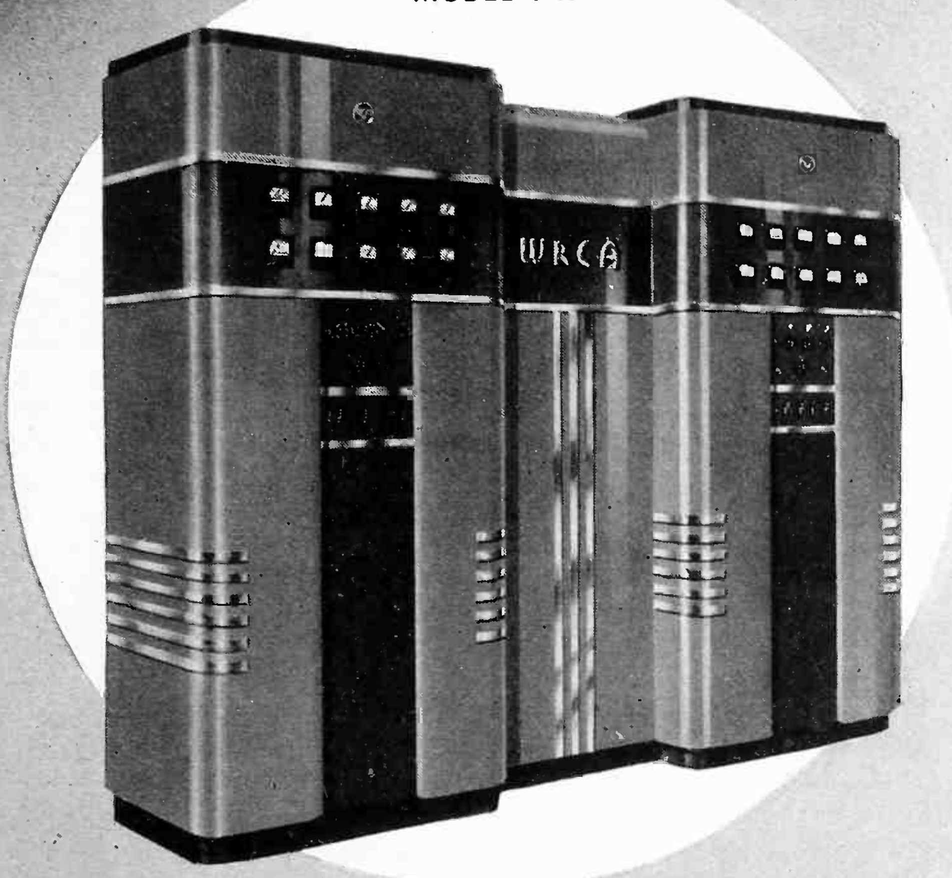
From the start glass was a prodigious headache for the factory and a delight for the customer. The flatness ran very close to ideal, within ± 0.002 inch, which is about two-thirds the thickness of a human hair. The surface was ideally smooth; after all, there is nothing as smooth as glass. The production problems were such that a glass disc was either all good or all bad and so while the factory had its troubles, they never reached the customer. It is possible that this is the reason for the remarkable reputation that glass base discs have developed in the intervening months.

One little but important development occurred after a few weeks of production. It was noticed that the sharp edge of the glass was scraping recording machine center pins, and a bushing arrangement for the center hole became necessary. The obvious thing was to try a metal eyelet or grommet, spun over. This ran into several snags. First, the control of spinning pressure was too critical. Too little would make a loose, rattly center. Too much would leave heavy residual strain in the glass, which became an invitation to future trouble. Then there was the question of hole size—how closely could it be controlled? There was some doubt. Finally, and most important with a metal shortage, what was the use of standardizing on a brass or kindred metal indispensable in cartridge cases and certain to be unavailable all too soon? It was found possible to devise a special non-metallic bushing with a punched center hole. The design made it self-locking, the material did not interfere with defense activities, and the

High Fidelity at Low Cost!

RCA 1,000 Watt Transmitter

MODEL 1-K



- Flat within 1.5 db., 30-10,000 cycles
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SIMPLICITY and accessibility... extended frequency-response and low distortion . . . with extremely low overall operating costs ...make the RCA Type 1-K Transmitter your logical choice when you go to 1,000 watts!

Excited by the famous RCA 250-K transmitter unit, the 1-K offers unusual flexibility, operating at 1,000 watts, 500 watts, 500/1000 watts, 250/1,000 watts, and 250/500 watts. Stations already equipped with the 250-K can increase their power to a maximum of 1,000 watts simply by the addition of the amplifier unit (RCA Type MI-7185), and power unit. Write for complete story, yours on request.

The RCA Model 1-K consists basically of the Model 250-K transmitter plus a matching amplifier unit. 250-watt stations with Model 250-K can increase power to 1,000 watts easily and at very low cost.

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In Canada: RCA Victor Co., Ltd., Montreal

New York: 411 Fifth Ave. Chicago: 589 E. Illinois St. Atlanta: 530 Citizens & Southern Bank Bldg. Dallas: Santa Fe Bldg. San Francisco: 170 Ninth St. Hollywood: 1016 N. Sycamore Ave.

punched center hole could be controlled with great accuracy. Incidentally, accuracy of center hole diameter is rather important. If the hole is too small, the disc will not fit on the machine, if too large the disc may be slightly off center when played back on another turntable and produce objectionable wows.

A rather puzzling observation was made by many rather prominent recording engineers. The glass base discs sounded better, clearer. Ordinary instrument tests gave no clue. Distortion tests were made at various frequencies up to 7500 cps and in no case was there any measurable difference between glass base and aluminum base discs. Frequency response also was identical. The question, therefore, arose and still remains, what makes the disc better?

The mere fact that instruments show no difference is not a proof that there is no difference; it is merely a proof that the instruments cannot recognize one. This is no new situation in the recording field, experienced recordists have known for many years that a cutter may have a marvelous characteristic curve and yet may sound so bad as to be utterly unusable. We seem to have something of the same sort of situation in connection with glass. It is possible that the improvement may be due to the better internal damping of vitreous material. Perhaps when a coating is cut, waves are propagated in the base; these waves may reverberate and blur ensuing recording just as excessive reverberation in a studio is objectionable. A number of tests have been made in an attempt to analyze this factor, but like many problems of dynamic characteristics, the difficulties are great. It is hoped that some crackerjack experimental technician will find a way of detecting the differences.

Handling the discs has not proven the difficulty that it was thought to be. Properly handled shipments of standard quantities suffer virtually no breakage. The first week or two there was a little trouble until expressmen learned proper handling but since then breakage had dropped to a figure very close to zero. Experimental shipments across the continent and back had revealed the proper packing structure. Shortage of steel undoubtedly will compel a change to wooden boxes as current stocks of cans are exhausted. Ship-

CALLING ALL CARS...
...CALLING ALL CARS

ANYONE who has ever seen a police car tear over a bumpy road at high speed may well wonder how such delicate equipment as radio tubes can stand the pounding, jarring and impact. That's why, in this and many another application, Sylvania's new Lock-In Tubes are indispensable.

Once in place . . . they STAY in place—upsidedown, sideways or in any position.

The solid LOCK-IN contact improves the efficiency of car and home sets too, of radio reception in airplanes, tanks, jeeps, anywhere they are used on land or at sea . . . an advantage that pays handsome dividends in customer satisfaction and confidence.

Sylvania Radio Tube Division

HYGRADE SYLVANIA CORPORATION

EMPORIUM, PA.

500 FIFTH AVE., NEW YORK · SALEM, MASS. · ST. MARYS, PA. · IPSWICH, MASS. · TOWANDA, PA.

Also makers of Hygrade Lamp Bulbs, Hygrade Fluorescent Lamps and Miralume Fluorescent Light Fixtures ping individual records also looked like a problem, but proved to be none whatever. By using a floating or cushioned inner box enough flexibility was provided so that there was simply no breakage at all.

Single hole driving has proven a problem easily overcome by application of this simple principle. Gripping the record between layers of live rubber under reasonable pressure will provide adequate friction. If trouble results nevertheless, it is well to search for difficulties in the equipment. For example, a number of complaints were traced to the use of turntable mats nearly five years old, and as slippery and hard as age could make them. Of course, the hardness had raised the disc noise level several decibels, but that had hitherto been neglected. Wax type machines have no inherent provision for applying pressure to the record center, for they rely on a drive pin for instantaneous discs and on the weight of the blank for wax. The answer is to use a center weight. One borrowed from a transcription turntable will do nicely.

In the case of only one machine has any trick been necessary. A relatively small number of overhead feed machines have been made using a center pin and three drive pins attached to the flange rather than the turntable, as illustrated in Fig. 3. The drive pins are fastened in irremovably. To avoid dismantling the mechanism and sawing off the pins it is possible to slip on the rubber pad shown in Fig. 4. Enough of the center pin protrudes to insure good centering. It is necessary to lift the outer support of the overhead feed mechanism (by loosening the appropriate screws) a bit to keep proper alignment.

In a pinch a small strip of scotch tape between the outer rim of the disc and the turntable will compensate for any equipment deficiencies. While the writer knows of no case where it has been necessary, it is a good thing to keep in mind. If the rubber mat has been made slippery by the manufacturer, try washing it off with carbon disulfide.

A Psychological Problem and a New Remedy

In spite of this there was a definite mental problem. The recordist would worry about disc slippage, whether or not it ever happened. It became desirable to change to a much larger diameter non-metallic center with all four holes punched simultaneously, just as with aluminum. This overcame the multiple line of weakness problem which would have resulted from drilling more than one hole in the glass. At the same time it gave the recordist a disc which handled exactly like aluminum on the machine.

Summarizing, the search for a substitute has, instead, developed a new and superior professional material with improved flatness, surface, and tone quality, a material whose use will long outlive the events that caused its adoption.

Experience with glass base may be taken as a good proof of the value of long range research. Furthermore a moral may be pointed. Don't complain about substitute materials. Do your best to use them. We are entering an era of more and more substitutes, and we can't reverse the trend. Instead of grumbling, do your best to get adapted and you will find the problem nowhere as hard as the anticipation. Your manufacturer will help you as much as he can, but in the last analysis there is no substitute for the natural ingenuity of the engineering user.

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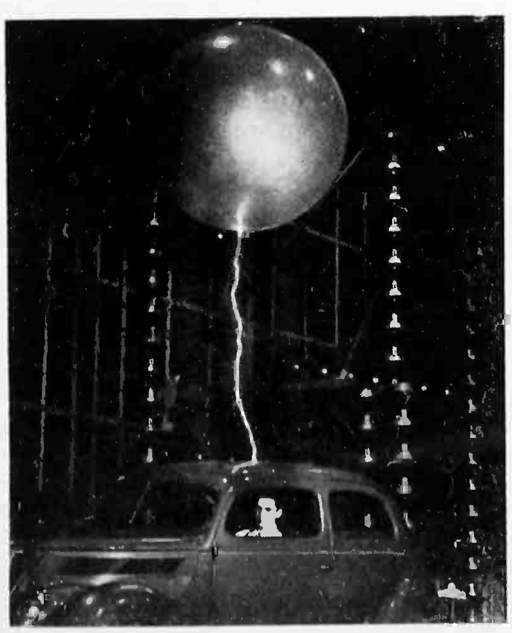
LIGHTNING LEAVES AUTO UNDAMAGED



3,000,000 volts of man-made lightning failed to damage an auto or injure its driver in a recent test at the Westinghouse high voltage laboratory at Trafford, Pa.

THE ELECTRON ART

The use of mathematics in industry, characteristics of vacuum tubes in feedback circuits, method of measuring currents of short duration, a 150- to 600-Mc oscillator, and the strength of cellulose insulation are reviewed

Industrial Mathematics

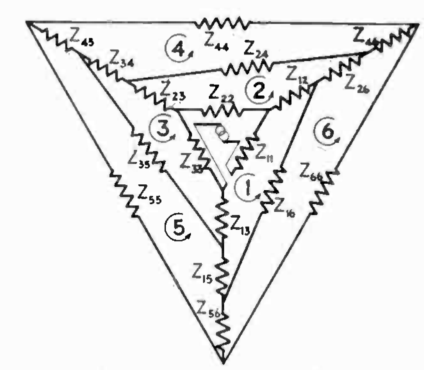
A VERY INTERESTING PAPER on this little publicized side of industry appears in the July 1941 issue of *The Bell System Technical Journal*. It is called "Industrial Mathematics," and is written by Thornton C. Fry, Mathematical Research Director of the Bell Telephone Laboratories. This discussion was prepared for the National Research Council *Survey of Industrial Research*, a survey undertaken at the request of the National Resources Planning Board.

Mr. Fry points out that not everyone who uses mathematical technique in solving a problem can be classed as a mathematician. He adopts a definition of a mathematician which is based on the character of a man's thinking rather than the ultimate use to which his thinking is put. The typical mathematician feels great confidence in a conclusion reached by careful reasoning, more so than one arrived at by experimental evidence. His argument is perfect in every detail or it is wrong. This is "rigorous thinking" for him, and "hair splitting" for the engineer. The mathematician tends to idealize situations, calling gases "ideal", conductors "perfect", and surfaces "smooth". The engineer or physicist is likely to call this "ignoring the facts". About the most predominant characteristic is the tendency to generalize. As a general rule, the mathematician is interested in solving a whole class of problems rather than one or two individual cases.

Bearing these characteristics in mind, it is easy to see that the industrial mathematician occupies a unique place in industry. He is not the sort of man to carry on an industrial project. Necessarily, he is a consultant. In this capacity, he must possess certain qualities which will assure his success as well as the success of his methods. He must be practical enough to make certain approximations which are mandatory even in the theoretical treatment of practical problems. He must be gregarious, cooperative, unselfish, and versatile. These traits make for the good relations so necessary in consulting work. Lastly, he has to be a man of outstanding ability for no one wants the advice of mediocrity. Among industrial mathematicians there is no place for the average man. The job of hiring men with such qualifications is difficult indeed, yet it is of utmost importance that none of these be overlooked. Mathematical ability is easy to determine by referring to scholastic records. However, the other desirable traits should not be ignored, or the lack of them excused on the grounds that "all mathematicians are queer".

The supervision of the right man is not difficult. The broad objectives must be to avoid barriers which would tend to keep his associates from seeking his services. Such barriers are jealousy, red tape, and unavailability. A salary policy should be based on the size, character, and satisfaction of his clientele, and not upon the commercial importance of the work he was consulted on. It should be made easy for anyone to consult him on all problems large and small. If his value to industry is greater as a project man than as a consultant this need not be cause for regret; but to turn a good mathematician into a poor engineer, or an irre-

Determinants



$$D = \begin{vmatrix} Z_1 & -Z_{12} & -Z_{13} & 0 & -Z_{15} & Z_{16} \\ -Z_{12} & Z_2 & -Z_{23} & -Z_{24} & 0 & -Z_{26} \\ -Z_{13} & -Z_{23} & Z_3 & -Z_{34} & -Z_{35} & 0 \\ 0 & -Z_{24} & -Z_{34} & Z_4 & -Z_{45} & -Z_{46} \\ -Z_{15} & 0 & -Z_{35} & -Z_{45} & Z_5 & -Z_{56} \\ -Z_{16} & -Z_{26} & 0 & -Z_{46} & -Z_{56} & Z_6 \end{vmatrix} ; \; Z_j = \sum_{k=1}^{6} Z_{jk}$$

Driving point impedance in mesh $j = Z_{(jj)} = \frac{D}{D_{jj}}$

Transfer impedance between mesh j and mesh $k = Z_{(jk)} = \frac{D}{D_{jk}}$

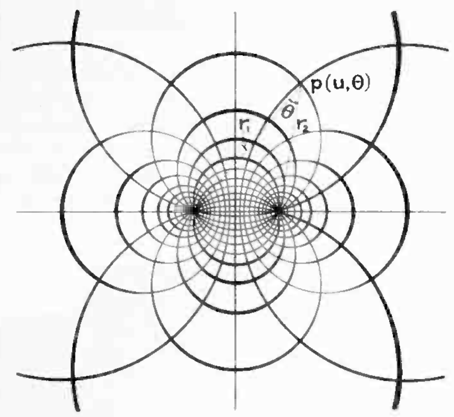
(D_{jk} = the first minor of the element Z_{jk} in D)

Many properties of the complicated networks studied at Bell Telephone Laboratories are most conveniently expressed by means of determinants. Above are shown a six-mesh network, its "circuit discriminant," *D*; and some formulae which illustrate how simply the properties of the system can be found from *D*. Note that, since $Z_{jk} = Z_{kj}$, *D* is symmetrical

R.A.F. OPERATIONS ROOM

In underground rooms like this, officers and girl plotters work day and night recording movements of enemy planes over Great Britain from information supplied by scattered detecting stations

Bicircular Coordinates



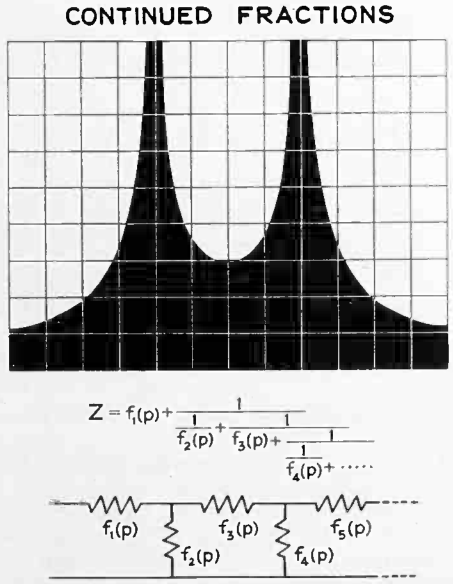
$$(x+\coth u)^2+y^2=\operatorname{csch}^2 u$$
$$x^2+(y-\cot\theta)^2=\csc^2\theta$$
$$u=\log\frac{r_2}{r_1}$$

Using the bicircular system of coordinates facilitates finding the distribution of electric charge on two parallel conductors, and thence their capacity. Rotating the bicircular system about the vertical axis generates a toroidal coordinate system which facilitates determining the capacity of a torus

placeable mathematician into a replaceable engineer is unfortunate for both employer and employee.

Mr. Fry estimates that the number of mathematicians in industry is about 150. This does not include actuaries and statisticians. He says that though the demand for mathematicians will increase in the future, their number will never reach that of physicists, chemists, or engineers. Based on this estimate he predicts a demand for 10

CONTINUED FRACTIONS

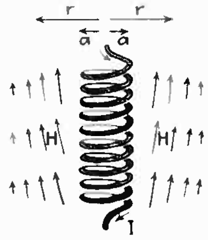


A mathematical method of systematically designing a circuit of predetermined impedance has been developed in Bell Telephone Laboratories. The given impedance, as a function of frequency, is expanded in a Stieltjes continued fraction, whose terms give the electrical constants of the desired network men a year. Though this figure seems small it should be remembered that these must be exceptional men. The difficulty in getting these men is that there is no school in this country which offers the training needed to produce this type of individual. At the present time, the engineering schools seem to be the best source of men who may be further trained in industry later.

Next the subject of mathematics in industry is discussed. The subjects used, their relative usefulness, and the types of service performed by mathematics are cited with interesting illustrative examples. Some of these are

Elliptic Integrals

$$H=\frac{4I}{r}\left[\frac{1}{1-k^2}\int_0^{\pi/2}\sqrt{1-k^2\sin^2\lambda}\,d\lambda-\int_0^{\pi/2}\frac{d\lambda}{\sqrt{1-k^2\sin^2\lambda}}\right]$$



Some simple engineering problems require advanced mathematics in their solution. This is true, for example, in the computation of the magnetic field outside the spiral grid of a vacuum tube. If the grid is closely coiled, the current can be treated as a continuous cylindrical sheet of radius a. Then the component of the magnetic field parallel to the axis of the grid at a distance r from the axis is given by the above function of two Elliptic Integrals whose "modulus" is $k = a/r$

shown in the accompanying illustration. How mathematics aids and even inspires research in communications, electrical manufacturing, the petroleum industry, and aircraft manufacture are also broadly covered. The role of statistics in industry is discussed, and here also examples of the application of this branch of mathematics are given.

The conclusions reached in this report are thought provoking enough to warrant their quotation: ". . . (1) Because of its general significance as the language of natural science, mathematics already prevades the whole of industrial research. (2) Its field of usefulness is nevertheless growing, partly through the development of new industries such as the aircraft business, and partly through the incorporation of new scientific developments into industrial research, as in the application of quantum physics in chemical manufacturing and statistical theory in the control of manufacturing processes. (3) The need for professional mathematicians in industry will grow as the complexity of industrial research increases, though their number will never be comparable to that of physicists or chemists. (4) There is a serious lack of university courses for the graduate training of industrial mathematicians. (5) Management, which is already keenly alive to the importance of mathematics, is also rapidly awakening to the value of mathematicians and the peculiar relationship which they bear to other scientific personnel . . ."

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Determining Feedback Characteristics Graphically

A GRAPHICAL METHOD of determining the effects of feedback on the characteristics of a vacuum tube amplifier is described in the July 1941 *RCA Review*. The article, called "The Equivalent Characteristics of Vacuum Tubes Operating in Feedback Circuits" by John H. Pratt, describes a method of constructing a set of characteristics in which is embodied the feedback effect. The author points out that although conventional mathematical methods of treating feedback are quite simple and are probably more convenient to use when it is desired to calculate the performance of a feedback amplifier under a single set of conditions, where several sets of conditions have to be tried to arrive at a desired result, the "feedback characteristics" are very useful. With them it is possible to judge distortion by the shape of the dynamic characteristic without going to the trouble of expressing it as a number and then applying it in an equation for the reduction due to feedback. Gain is also obtained directly from them without calculation.

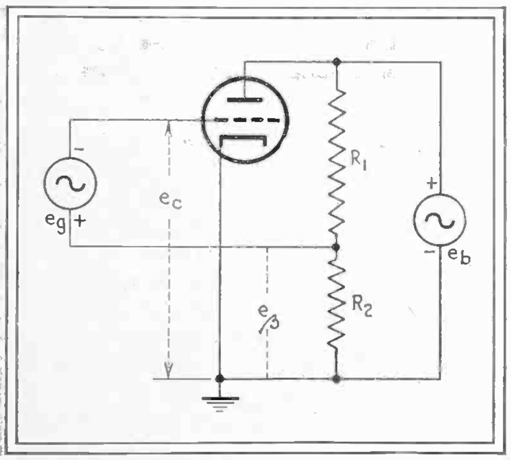

Fig. 1—Simplified circuit of inverse feedback amplifier

The method described is most generally applicable when feedback is over one stage only and when the phase of the fraction of the output voltage applied to the input is assumed exactly 180 or zero degrees. However, the method can be extended to cover the case of feedback over several stages and also to take into account a phase angle associated with the feedback factor although the graphics become somewhat complicated and tedious in the latter cases.

A common type of inverse feedback circuit simplified to show a-c components only is shown in Fig. 1. For this circuit the following relations hold true:

$$\beta = -\frac{R_2}{R_1 R_2} \quad (1)$$

$$e_\beta = \beta e_b \quad (2)$$

$$e_c = e_g - \beta e_b \quad (3)$$

where β is the feedback factor, e_β the voltage fed back to the grid circuit for any instantaneous value of plate voltage e_b, e_g the instantaneous signal voltage, and e_c the instantaneous grid-cathode voltage for any combination of instantaneous signal and plate voltages. By taking various values of e_g as parameters, and allowing e_b to vary, an equivalent family of plate characteristics may be obtained where the grid-cathode voltage is replaced by the instantaneous signal voltage.

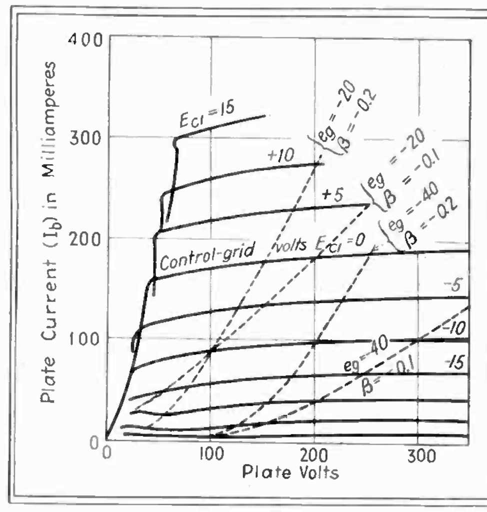

Fig. 2—Static curves of 6L6 (solid lines) with dotted construction lines for various feedback ratios and bias

For example, take the type 6L6 tube, with β as —0.1, and assume e_g equal to —40 volts. From Eq. (3) it is seen that when e_b is 100 volts e_c becomes —30 volts, when e_b is 150 volts e_c becomes —25 volts, when e_b is 200 volts e_c becomes —20 volts, and so on. From these calculations points could be plotted to give a curve for the signal voltage of —40 volts. This procedure could be repeated for different values of signal voltage and a whole family of curves could be drawn. However, it will be noted that the grid voltage increases by intervals equal to $-\beta$ times the plate voltage so we can write:

$$\Delta E_b = \frac{\Delta E_c}{-\beta} \quad (4)$$

We can now resort to the following procedure. Given a set of plate current-plate voltage characteristics whose feedback equivalent characteristics we wish to determine, we note the increments in which the grid voltage has been plotted. Substituting this value in Eq. (4) gives the plate voltage steps which will permit the plotting of the feedback characteristic by advancing one grid voltage curve for every plate voltage step taken, without having to calculate each point separately. The grid curves shown in Fig. 2 are plotted in steps of 5 volts. If we take β as -0.1, Eq. (4) shows that the plate voltage steps have to be taken in steps of 50 volts each. If β is taken as -0.2, ΔE_b becomes 25 volts. The dashed lines are the resulting feedback characteristics

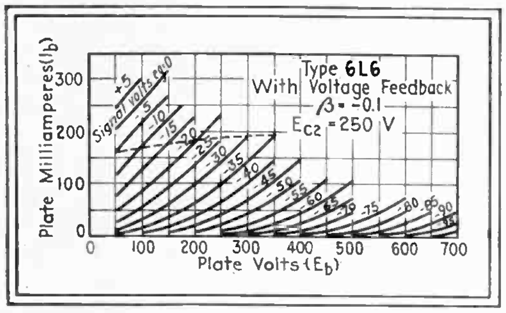

Fig. 3—Equivalent plate characteristics for type 6L6 with 10 percent voltage feedback

plotted by the method outlined above. By varying the signal voltage a whole set of equivalent curves may be obtained. In order to obtain the d-c operating point from the equivalent characteristics, Eq. (3) may be used to find the grid bias corresponding to particular values of e_g and e_b, or the desired plate voltage plate current point may be transferred to the normal characteristics and the corresponding grid bias voltage obtained from them.

A complete family of "feedback characteristics" for the 6L6 with β equal to -0.1, as obtained by this method is shown in Fig. 3. The article also discusses negative current feedback and

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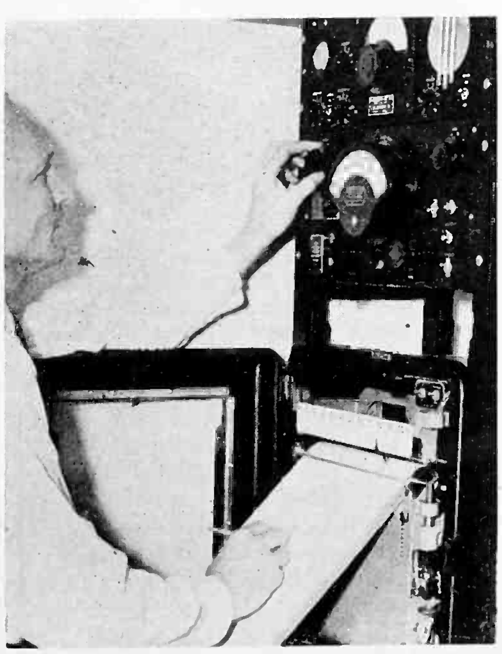
WEATHER BALLOONS AT SEA



The radiosonde ground equipment on the S. S. Exeter, which is releasing weather balloons at sea for the first time describes a similar method of obtaining feedback characteristics for this condition. Feedback over several stages is mentioned also, and the author outlines a procedure for applying the method to this problem.

Editor's Note. The curves and construction shown in Fig. 2 do not appear in the original article. They were drawn to assist in explaining the graphical method outlined by Mr. Pratt.

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Measuring Currents of Brief Duration

POINT-BY-POINT MEASUREMENTS of volt-ampere characteristic of substantially resistive circuit elements at currents and voltages well above the rated values of the elements is discussd in an article called "A Simple Method for Measuring Steady Currents of Brief Duration" which appears in the June 1941 *Review of Scientific Instruments*. The usual point-by-point measuring methods are not feasible because of the destructive amount of heat developed. The method devised permits such measurements to be made with ordinary indicating instruments, but it requires current durations brief enough to avoid dangerous heating effects.

The measuring circuit is shown in Fig. 1a. T is the device under test, and R is the resistance which must carry the current to be measured. An ammeter A measures ballistically the charge accumulated in the condenser C as the current in R rises to a steady value when the switch S is closed. The relay K disconnects the ammeter from the circuit after the current has reached a steady value, and also provides a discharge path around A for the condenser C. Resistor R_1 and condenser C_1 may or may not be necessary depending on the relay voltage rating and the natural speed of operation. Relays which normally operate in a few milliseconds serve the purpose well. If the circuit under test is highly reactive the operation of the relay can be delayed a fraction of a second without resorting to cumbersome values of R_1 and C_1.

For most purposes, the duration of

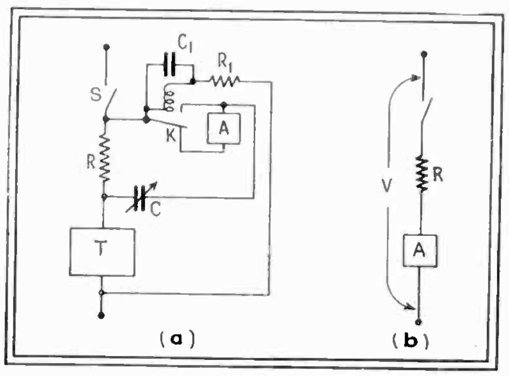

Fig. 1—Basic circuits for measuring currents of short duration

the current which is determined by the period of closure of the switch S is adequately controlled by hand operation. Periods of 0.15 second were convenient, easy, and fairly reproduceable by using an ordinary knife switch to open and close the circuit. The times of closure were measured by means of the circuit shown in Fig 1b. By a choice of a series resistor appropriate to the instrument which was used ballistically, and the times being measured, the instrument may be made to indicate by maximum deflection of the needle the duration of the closure in decimal fractions of a second. If the duration of closure must be controlled very accurately a second relay whose contacts open when the coil is energized may be used with an appropriate RC delay circuit. Precautions

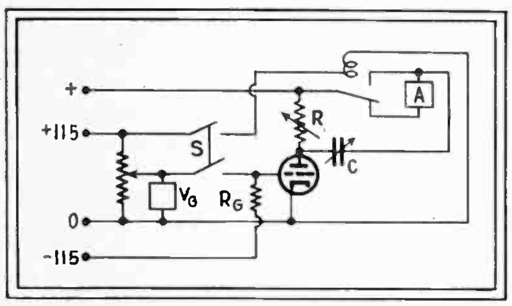

Fig. 2—Circuit for measuring characteristics of a triode

should be taken for quenching the arc by means of a series RC circuit in parallel with the contacts of the relay. If the source of direct voltage is not adjustable it is convenient to get different applied voltages by adjusting R to various known values, then adjusting C in each case to give an appropriate deflection. Thus, with a constant voltage source a whole series of points on a characteristic may be run by varying R. The instrument indicates the charge accumulated in C, and from the known value of C the voltage across R may be computed, and this voltage enables the calculation of the current in R. Subtraction of the voltage across R from the total line voltage gives the voltage applied to the device under test.

The indicating instrument may be any kind of a galvanometer, including the type commonly used in d-c indicating instruments. If R and C of Fig. 1a are large, small values of current can be measured. Large values of current may be measured by making R or C or both small. The magnitude of the resistance R must be known, and the most convenient form for this circuit element is a decade box. For receiving tube testing where the currents range up to one ampere, R may be a 3 or 4-dial decade box, C a 3-dial decade condenser, and A a microammeter having a range of 30 microamperes. The ballistic calibration for the instrument is also necessary.

The volt-ampere characteristic of a diode may be measured by inserting the diode at T in Fig. 1. To measure triode characteristics a more complicated circuit is needed. This is shown in Fig. 2. The voltage divider which supplies V_G should have a current carrying capacity large enough so that the value of V_G is not altered appreciably by the grid current plus the current in R_G when S is closed. At the same time R_G should be small enough to keep the tube from blocking when S is opened. The plate voltage applied is calculated from the quantity of electricity indicated by A and the values of R and C.

A power source of good regulation is needed for obtaining an E_g-I_p characteristic at constant plate voltage. We can compensate for a poorly regulated power supply by resorting to the following procedure. Adjust the source voltage to a value in excess of the voltage to be applied to the plate by the amount V_x. Then adjust R for some convenient value of V_G so that the drop in R is just equal to V_x. The drop in R is determined by the value selected for C and the quantity going into C as indicated by A with the aid of its calibration. Once C and the corresponding deflection of A have been established, as new values of V_G are selected, R is adjusted to give the same deflection of A with C kept fixed. Thus the drop in R which is V_x, is always the same, and the plate voltage is always the same. Knowing the value of R, the plate current can easily be calculated.

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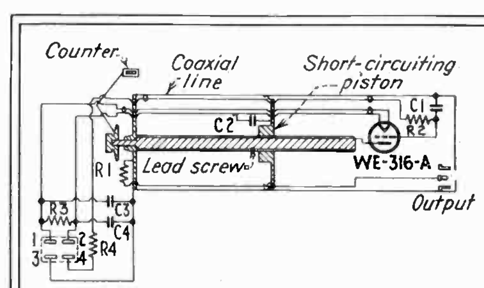
UHF Oscillator

A DESCRIPTION OF AN ULTRAHIGH frequency oscillator whose range is from 150 to 600 Mc (200 to 50 cm wavelength) appears in the August 1941 *General Radio Experimenter*. The accompanying diagram shows the essentials of the circuit. The frequency is



Circuit diagram of 150 to 600 Mc oscillator

varied by rotating the lead screw which drives the short-circuiting piston along the length of the coaxial line. The pitch of the lead screw and the ratio of gearing to a counter at the drive end are adjusted to make the counter indicate the approximate value of the wavelength. A conversion chart is fastened to the top of the oscillator, and by its use the wavelength can be converted into frequency values.

The power output of this generator is approximately 4 watts up to 400 Mc, and this drops down to one watt at 600 Mc. In order to have the full output of the oscillator available at the output terminals no isolation means have been used. The result is that a reactive load coupled directly to the oscillator shifts the frequency of oscillation, but for the usual conditions of loading this shift is generally less than 2 percent. The power supply required must supply 2 volts at 3.65 amperes, and 450 volts with a maximum plate current of 80 milliamperes. The plate supply must be one which permits grounding of the positive side, since the positive side of the high voltage circuit is connected to the outer brass container.

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Cellulose Insulation

"FACTORS INFLUENCING the Mechanical Strength of Cellulose Insulation" by F. M. Clark appears in the July 1941 issue of *Electrical Engineering* and is an article of considerable value to engineers making use of cellulose insulation. Various factors having an effect upon the life of cellulose are covered in detail and a number of experimental curves are shown. The summary which appears at the end of the article is as follows:

1. Cellulose insulation will deteriorate in mechanical strength at a rate which increases with the increasing temperature of exposure. Deterioration will occur in the absence of an oxidizing atmosphere.
2. The rate of cellulose deterioration at a fixed temperature varies as the heat treatment is continued.
3. The mechanical deterioration of cellulose insulation at elevated temperature is the result of oxidation and pyrochemical decomposition.
4. When heated, cellulose passes through a "stable period" during which the mechanical properties are maintained. The presence of oxygen is chiefly effective in reducing the duration of the "stable period".
5. The single effect of oxidation is restricted to the initial periods of treatment at temperatures lower than approximately 120 degrees C. At higher temperatures, pyrochemical decomposition occurs. Even in the most favored temperature range, the effect of cellulose oxidation merges into the effects produced by pyrochemical decomposition as the deterioration progresses.
6. Heated under conditions which favor oxidation or pyrochemical change, the unimpregnated cellulose insulation deteriorates more rapidly than the same insulation after oil treatment and immersion.
7. The effect of oxidation is accelerated when pure oxygen gas is in contact with the insulation. No substantial difference in the rate of mechanical deterioration is observed when the oil-treated and oil-immersed insulation is aged in contact with nitrogen gas as compared to aging in contact with air.

Photoelectric Door Opener Saves $30 Per Day

An installation of a photoelectric control on the doors of the shipping and receiving departments of the Brown and Williamson Tobacco Company, Louisville, Ky., are described in the July 1941 issue of *Timely Ideas*. The doors were previously operated manually at comparatively high cost both in actual operating expense and in time lost in signalling for the doors to be opened. The expense of heating these departments was also very high because the doors opened directly to the outer air and slow manual operation allowed much heat to be lost. With the installation of the photoelectric equipment incoming and outgoing shipments of tobacco approaching the doors interrupts light beams focused on the phototubes. The doors remain open only long enough for the truck to pass through. As a result not only are operating time and costs cut to a minimum, including heat loss, but also comfortable working temperatures for employees are easily maintained. It is estimated that this installation saves as much as $30 a day in operating costs.

Photoelectric door opener saves many times its cost of installation

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Telemetering and Supervisory Control

"Telemetering, Supervisory Control, and Associated Circuits" is the title of a special publication of the American Institute of Electrical Engineers. In recognition of the ever-widening field of application for telemetering equipment, the publication has been prepared in such form and terminology as to make it readily useful to engineers in any branch of industry likely to be concerned with problems of remote measurement and control. Extensive tabulations giving comparative data are designed to enable a user of telemetering or supervisory-control equipment quickly to determine the type of apparatus best suited to his needs.

Maintenance and Servicing of Electrical Instruments

DURING THE PRESENT NATIONAL emergency the repair departments of the manufacturers of electrical instruments are very much overcrowded and are therefore not in a position to repair instruments as quickly as the customers, even those with priorities, would desire. In this case the user of electrical instruments must do the repair job himself. A series of articles by James Spencer describing the design and operation of various types of instruments is currently appearing in *Instruments.* The first two articles appeared in the August and September 1941 issues and several additional articles are contemplated. Engineers using electrical instruments of any type cannot be urged too strongly to read these articles. They are written from the very practical viewpoint of helping the reader maintain and repair instruments. Time spent studying this series will be well repaid.

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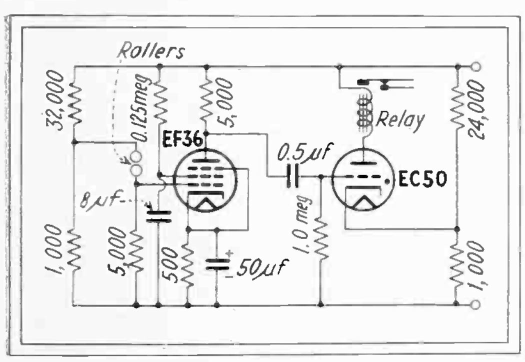
Pinhole Detector

AN ELECTRONIC MEANS of detecting pinholes in rubberized canvas is discussed in the July 1941 issue of *Electronic Engineering*, a British journal, by A. W. Russell. Since rubberized canvas is used extensively under conditions where it must be impervious to gas, it is important to know whether the layer of rubber has taken evenly or whether minute holes have been left. These holes are difficult to detect by the human eye, even when a strong source of light is used behind the material.



Circuit diagram of pinhole detector

The circuit shows an electronic method of detecting these holes. The rollers are saturated with some conducting liquid, and as the material passes between them any hole will permit the liquid to seep through thus shunting an extra resistor across the biasing resistor. This reduces the grid bias, causing a positive impulse to be fed to the grid of the gas triode which will fire. The firing of the triode actuates the relay which can be made to operate a bell or some marking device to show the approximate location of the hole. Though the circuit shown incorporates British tubes, any pentode and gas triode with their proper grid, cathode, and plate resistors and condensers can be substituted.

Vacuum Tube Characteristics

(*Continued from page* 50)

its origin in the fact that if $y = Af(t)$ and $x = Bf(t)$, where A and B are constants or scale factors, then $y = Ax/B$. By comparing this with the standard equation for a straight line, $y = mx + b$, it is evident that the equation we have developed is of the form of a straight line in which $m = A/B$ and $b = 0$. Moreover, it is apparent that the time function, indicated by $f(t)$ above, has disappeared from the expression relating x and y.

Fundamentals of Circuit Operation

Physically, this means that if we apply a time varying voltage to a linear resistance and measure the voltage across this resistance and the current through it, and apply these electrical quantities appropriately to the vertical and horizontal deflecting plates of a cathode-ray tube, the resulting plot will be a straight line with slope A/B.

To extend the reasoning to electron tubes or other non-linear conducting devices, assume that the applied varying voltage, E_s, is given by

$$E_s = E \sin \omega t$$

and that the resulting electrode current is given by

$$i = s\, E_s \sin \omega t$$

where s is the conductance of the electrode (or the transconductance of the two electrodes) in question. By combining these two equations we find the result to be

$$i = s\, E_s$$

which indicates that the curve traced on the cathode-ray screen will have the shape determined by the electrode conductance. This is just the condition which is desired, so that by applying a varying signal voltage to an electrode and one set of plates of a cathode-ray tube, and by applying the electrode current to the remaining pair of deflecting plates, the resulting curve will trace the electrode conductance or transconductance no matter what form the applied voltage may have. Thus, so long as any amplifiers which may be required do not produce too much distortion, a time varying voltage of any wave shape can be used in tracing the characteristics.

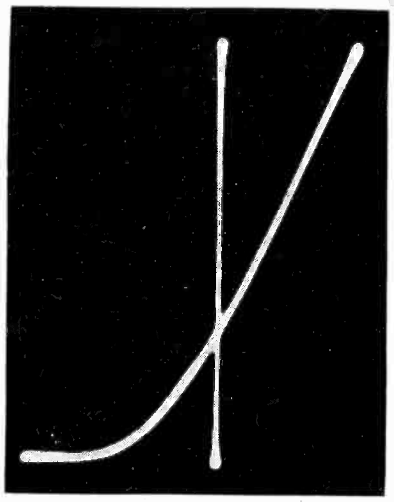
An electrical circuit which is in conformity with this basic treatment and which shows one application of the fundamental principal outlined is shown in the diagram. This circuit is shown connected for the measurement of the plate characteristics of a beam tetrode, although other arrangements are possible. Fundamentally, the circuit consists of the tube whose characteristics are to be determined, the appropriate quiescent operating electrode voltages and suitable meters for determining these voltages, a time varying voltage, E_s, covering the magnitude of voltages over which tube operation is desired and preferably whose peak amplitude is measured, two variable gain amplifiers, and the cathode-ray oscilloscope and its associated power supply circuits. All of this equipment is usually available in even the smallest of communications laboratories, which is a decided advantage of this method. In place of the variable gain amplifier *A* and the beat frequency oscillator as indicated in the diagram, a transformer and voltage divider or autotransformer operating from the a-c power line may be used if measurements at a single frequency will suffice. In this case, the equipment required is even less than that already listed.

In the circuit diagram illustrating the measurement of the plate characteristics of a tetrode, the quiescent electrode voltages are indicated by the meters E_{c1}, E_{c2} and E_b. The time varying voltage, E_s is of such magnitude that when used in series with the d-c plate voltage, the instantaneous voltage varies from zero to twice the d-c value. In other words, if E_s has symmetrical wave shape, its peak value is equal to the quiescent voltage, E_b. In the original set-up, an audio oscillator was used as the source of the time varying voltage so that the effect of frequency could be observed. It is not, of course, imperative that one use a beat frequency oscillator, but this is a convenience.

Since the cathode-ray tube is a voltage operated device, it is necessary to convert any current which is to be measured, into an appropriate voltage which can be employed to operate the deflection circuits. This is done by applying the voltage drop across a non-reactive resistance in the circuit measuring current to the appropriate deflecting plates. In the diagram shown, the resistor, R_L, is provided for this purpose. To obtain the usual static characteristics of a tube, this resistor should have as small a resistance as possible. In this case the voltage drop across R_L will be rather small, and the amplifier, B, will be required to have high gain and high output with low distortion. The exact value for the resistance of R_L will depend upon the tube under measurement, but in general this resistance should be of the order of tens of ohms rather than thousands of ohms. On the other hand, if the dynamic characteristics are required, R_L may have much higher resistance—equal to the external load resistance for example.

Connections for Oscilloscope

Since the tube characteristics are usually plotted with voltage as the independent ordinate and currents as the dependent variable, the cathode-ray tube was connected so that the horizontal displacement of the beam represented voltage variations, whereas vertical displacement of the beam represented current variations. By turning the gain of the amplifier B down to zero, a base line, which acts as an axis of reference from which currents can be measured, will be traced on the oscilloscope. The base line can be used to determine the deviation from linearity of the $E_p - I_p$ (or



Grid voltage-plate current characteristic of 1G6 tube with plate voltage at 90 volts other) characteristic. Since the voltage applied to the amplifier *B* is identical with the voltage applied to the horizontal deflection plates, a straight line, whose slope depends upon the gain of the amplifier *B*, will be obtained when switch *S* is thrown to position 2 if the characteristics of the amplifier and oscilloscope are ideal. In oscilloscope amplifiers, there is often a certain amount of distortion and therefore what represents a linear response characteristic might appear as a slightly curved line on the oscilloscope screen.

The illustrations show some photographs made from the screen of the oscilloscope and indicate the type of traces obtained. Of course with this system the scale of voltage and current variations in the horizontal and vertical directions depends, respectively, upon the magnitude of the voltages applied to the horizontal and vertical deflecting plates. Since these are fed from variable gain amplifiers, it is necessary to calibrate the amplifiers and cathode-ray tube circuits so that the voltages and currents resulting in a given trace will be known. This can be done easily by applying known voltages to the input of each amplifier and measuring the resultant displacement of the spot on the screen. If such calibration is carried out with alternating voltage applied, the peak value of the applied voltage must be used rather than the root-mean-square value which is the calibration of most electrical measuring instruments.

To fully appreciate the advantages of such a system of making tube characteristics, it must be remembered that the results of any change in circuit constants or electrode voltages are instantly apparent on the screen of the oscilloscope. Any changes in the tube operation can be made, and the results will be immediately recorded. The method is, therefore, not only suitable for determining tube characteristics in the usual manner, but is likewise useful for determining circuit constants to produce a desired voltage-current relation in any electrode combination. In early work with this circuit, the method was used to good advantage in determining the circuit constants required to produce a linear $E_p - I_p$ characteristic of a 1G6 double triode.

TUBES

Characteristics of phototubes are presented in addition to the data on receiving tubes registered by the R.M.A. Data Bureau during August

Tube Registry

Tube Types registered by R.M.A. Data Bureau During August 1941

Type 6SH7 (M)

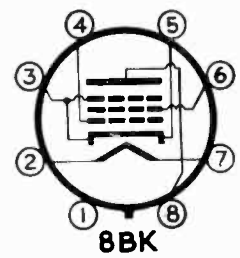
PENTODE voltage amplifier sharp cut-off, heater type, MT-8 metal envelope, seated height 2 1/16 inches (max), small wafer 8-pin octal base.

RATINGS

E_h = 6.3 v
I_h = 0.3 amp
E_b =300 v
E_{c2} = 150 v (max)
E_{c1} = 0 v (min)

TYPICAL OPERATION

E_b = 250 v
E_{c2} = 150 v
E_{c1} = − 1 v
I_b = 10.8 ma
I_{c2} = 4.1 ma
g_m = 4900 μmhos
r_p = 0.9 megohm (approx)
E_{c1} = for plate current cutoff = −5.5 v
Basing 8BK-1-1



Type 7K7 (GL)

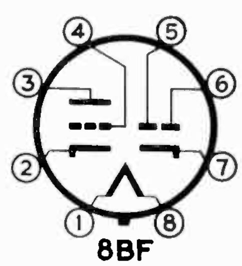
DOUBLE diode high-mu triode, heater type, T-9 integral glass envelope-base, seated height 2¼ inches (max), 8-pin locking-in base.

RATINGS

E_h =7.0 v
I_h = 0.32 amp
E_b = 250 v (max)

OPERATION

Triode Section
E_b = 250 v
E_c = −2 v
I_b = 2.3 ma
μ = 70
r_p = 44,000 ohms
g_m = 1600 μmhos
Diode
E_b = 10 v (dc)
I_b = 0.6 ma (min)
Basing 8BF-0-7



Type 12SH7 (M)

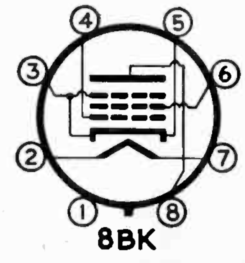
PENTODE voltage amplifier sharp cut-off, heater type, MT-8 metal envelope, seated height 2 1/16 inches (max), small wafer 8-pin octal base.

RATINGS

E_h = 12.6 v
I_h = 0.15 amp
E_b = 300 v (max)
E_{c2} = 150 v (max)
E_{c1} = 0 v (min)

TYPICAL OPERATION

E_b = 250 v
E_{c2} = 150 v
E_{c1} = −1 v
I_b = 10.8 ma
I_{c2} = 4.1 ma
g_m = 4900 μmhos
r_p = 0.9 megohm (approx)
E_{c1} plate current cutoff = −5.5 v
Basing 8BK-1-1

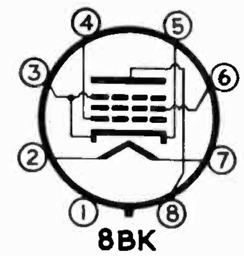


THE BASING ARRANGEMENT of types 6SG7(M) and 12SG7(M) as published in the April 1941 issue of ELECTRONICS (basing 8BC-1-1) has been modified as shown below. The suppressor grid formerly was terminated at Pin No. 1.

Type 6SG7 (M)

R-F PENTODE, semi-remote cutoff; heater type; MT-8 metal envelope; seated height 2 1/16 inches max; 8-pin octal base.

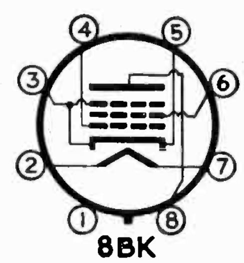
E_f = 6.3 v
I_f = 0.3 amps
E_b = 250 v
E_{c3} = 0 v
E_{c2} = 150 v
E_c = − 2.5 v
I_b = 9.2 ma
I_{c2} = 3.4 ma
g_m = 4000 μmhos
r_p = 1 (+) megohm
@E_{c1} = − 17½ v
g_m = 40 μmhos
C_{in} = 8.5 μμf
C_{out} = 7.0 μμf
C_{gp} = .003 μμf (max)
Basing 8BK-1-1



Type 12SG7 (M)

R-F PENTODE, semi-remote cutoff; heater type; MT-8 metal envelope; seated height 2 1/16 inches max; 8-pin octal base.

E_f = 12.6 v
I_f = 0.15 amp
E_b = 250 v
E_{c3} = 0 v
E_{c2} = 150 v
E_c = − 2.5 v
I_b = 9.2 ma
I_{c2} = 3.4 ma
g_m = 4000 μmhos
r_p = 1 (+) megohm
@E_c = − 17½ v
g_m = 40 μmhos
C_{in} = 8.5 μμf
C_{out} = 7.0 μμf
C_{gp} = .003 μμf (max)
Basing 8BK-1-1



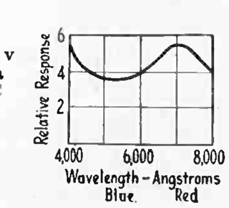
Phototubes

Type 53AWB

G-M Laboratories

GAS-FILLED phototube, cathode area 0.48 sq in, seated height to center line of cathode 1⅜ inch, overall height 2¾ inches, diameter of bulb ⅝ inch, supplied without base.

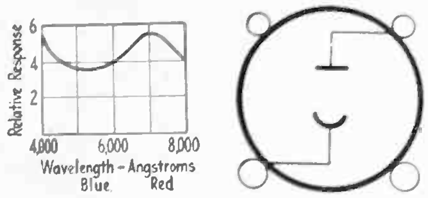
Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100°C



Type 58-A

G-M Laboratories

GAS-FILLED phototube, cathode area 0.62 sq in, seated height to center line of cathode 1¾ inch, overall seated height 2½ inches, diameter of bulb ⅞ inch, 4-pin base.

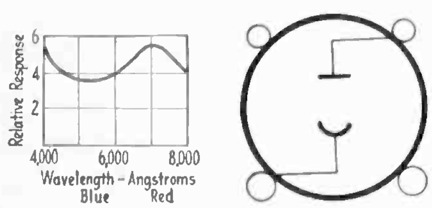


Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 58AV

G-M Laboratories

VACUUM phototube, cathode area 0.62 sq in, seated height to center line of cathode 1¾ inch, overall seated height 2½ inches, diameter of bulb ⅞ inch, 4-pin base.



Sensitivity = 30 μa/lumen
Max Operating Voltage = 150 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

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ATTENTION GIRLS!

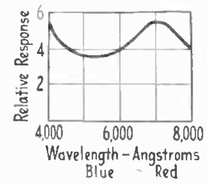
Before accepting the marriage proposal of Harold Dehnisch, Vera Pitts applied the lie detector and asked him, "Was it love or the draft which led you to propose?" A girl can't be too careful these days

Type 58AWB

G-M Laboratories

GAS-FILLED phototube, cathode area 0.62 sq in, seated height to center line of cathode 1¼ inch, overall height 2 inches, diameter of bulb ⅞ inch, supplied without base.

Sensitivity = 130 μa/lumen
Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

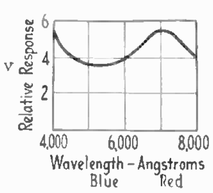


Type 58AVWB

G-M Laboratories

VACUUM phototube, cathode area 0.62 sq in, seated height to center line of cathode 1¼ inch, overall height 2 inches, diameter of bulb ⅞ inch, supplied without base.

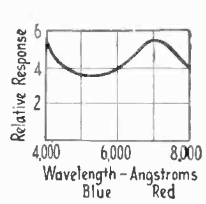
Sensitivity = 30 μa/lumen
Max Operating Voltage = 150 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

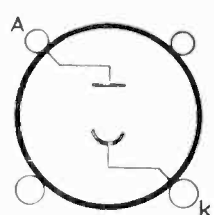


Type 59A

G-M Laboratories

GAS-FILLED phototube, cathode area 0.62 sq in, seated height to center line of cathode 2 5/32 inches, overall seated height 3 9/32 inches, diameter of bulb 1 inch, 4-pin base.



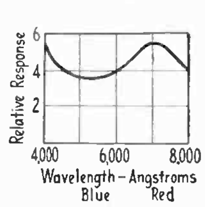


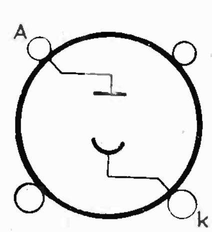
Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 59AV

G-M Laboratories

VACUUM phototube, cathode area 0.86 sq in, seated height to center line of cathode 2 5/32 inches, overall seated height 3 9/32 inches, diameter of bulb 1 inch, 4-pin base.



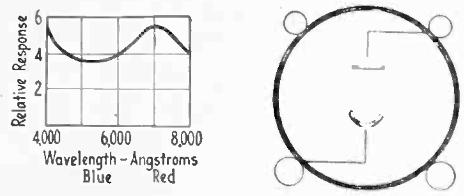


Sensitivity = 30 μa/lumen
Max Operating Voltage = 150 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 71-A

G-M Laboratories

GAS-FILLED phototube, cathode area 1.25 sq in, seated height to center line of cathode 1⅜ inch, overall seated height 2$\frac{31}{32}$ inches, diameter of bulb 1½ inch, 4-pin base.

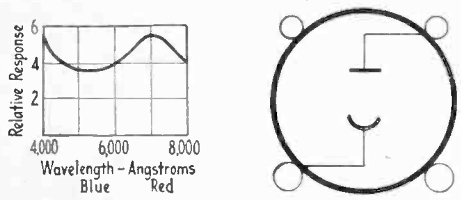


Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 71AV

G-M Laboratories

VACUUM phototube, cathode area 1.25 sq in, seated height to center line of cathode 7⅜ inch, overall seated height 2$\frac{31}{32}$ inches, diameter of bulb 1½ inch, 4-pin base.



Sensitivity = 30 μa/lumen
Max Operating Voltage = 150 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

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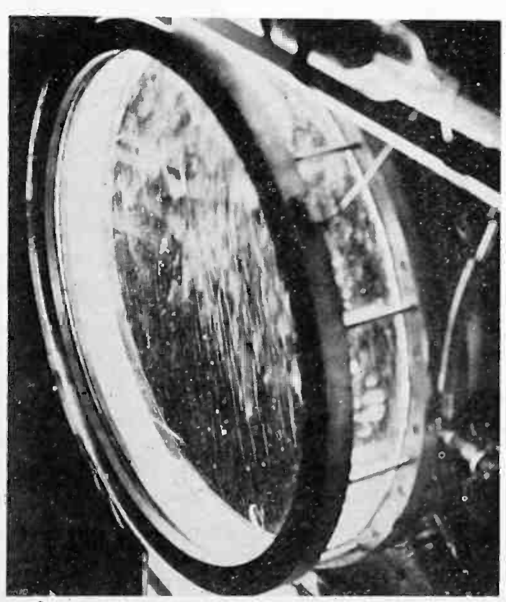
COSMIC RAY CHAMBER

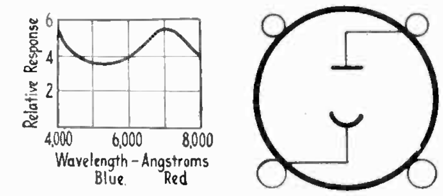


Closeup of cosmic ray cloud chamber showing the paths of the rays as they pass through vapor

Type 71-TA

G-M Laboratories

GAS-FILLED phototube, cathode area 1.25 sq in, seated height to center line of cathode $1\frac{7}{8}$ inch, overall seated height $3\frac{1}{4}$ inches, diameter of bulb $1\frac{1}{2}$ inch, 4-pin base.

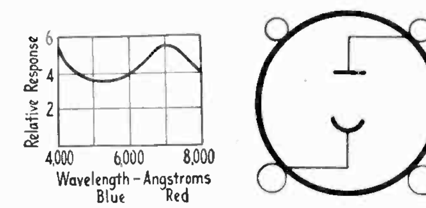


Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 73-A

G-M Laboratories

GAS-FILLED phototube, cathode area 1.25 sq in, seated height to center line of cathode $1\frac{7}{8}$ inch, overall seated height $2\frac{7}{8}$ inches, diameter of bulb $1\frac{15}{16}$ inch, 4-pin base.

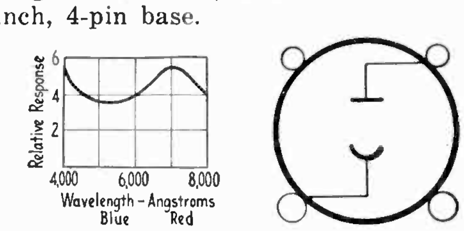


Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 75-A

G-M Laboratories

GAS-FILLED phototube, cathode area 1.87 sq in, seated height to center line of cathode $2\frac{19}{32}$ inches, overall seated height $3\frac{13}{16}$ inches, diameter of bulb $1\frac{3}{4}$ inch, 4-pin base.



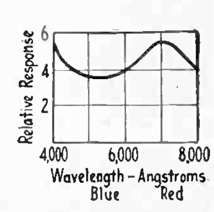
Sensitivity = 130 μa/lumen
Max Operating Voltage = 99 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C

Type 79-A

G-M Laboratories

GAS-FILLED phototube, cathode area 1.87 sq in, seated height to center line of cathode 3 inches, overall seated height $4\frac{1}{4}$ inches, diameter of bulb $2\frac{5}{16}$ inches, flexible leads.

Sensitivity = 130 μa/lumen
Max Operating Voltage = 90 v
Max Anode Current = 25 μa
Max Ambient Temp = 100° C



Equipment Failure Alarm

(*Continued from page* 45)

non-uniformity of the two sections of the 7F7. The variable 5000-ohm common cathode resistor is used to adjust the signalling circuit sensitivity to the desired tolerance. By means of this control the equipment failure alarm may be made to tolerate only a 2 vu aberration from normal gain in the monitored amplifier, or it may be backed off to a tolerance of at least 15 vu. Both of these controls are brought out at the front panel.

An important feature of the equipment failure alarm is its ability to distinguish between rise and fall in monitored amplifier gain as well as power supply failure. Plate voltage for the alarm is best obtained from the same d-c source which supplies the amplifier to be monitored. The relays T_3 and T_4 are of such a ype that they are normally energized holding the alarm signalling contacts open. An increase or decrease in gain of the monitored amplifier will cause a correspondingly positive or negative unbalance in the bridge circuit. This will in turn make one or the other of the 7F7 grids become more negative until the relay associated with that section of the tube drops out, closing the signalling circuit. Failure of the plate voltage supply will permit both of these relays to close, energizing all signalling devices. Adjustment of these relays is best made so that they hold open at 1.0 ma, and fall out to close the signalling circuits at about 0.2 ma. For initial adjustment of the relays and associated bridge circuits, plate current meters for the 7F7 may be found necessary.

There is still another reason for the use of a common source of plate voltage. Some amplifiers and most transmitting equipment have means f automatically regulating the power supply voltage so that it is independent of any but very large changes in the a-c supply. Inasmuch as the gain of some types of amplifiers varies with the plate voltage, the common supply in indicated. In this same connection, the on-off switch, if any, should operate on the signalling circuit as well as the plate-filament supply, lest an alarm be given when the equipment failure alarm is turned off.

The entire equipment failure alarm including filament transformer is easily accommodated on a 3½-inch rack panel. Placement of tubes at the rear of the chassis is permissible due to the use of all cathode type tubes. Heat is then more readily dissipated, and tube replacement facilitated. Gain controls for amplifier (3) and also, if one is needed, for amplifier (2), are located at the rear of the chassis for semi-permanent adjustment.

Due to the possibility of buzzer or signal lamp failure it is always advisable to have both audible and visual indicators in the signalling system. Usually when an entire a-c circuit fails, the operator can be depended upon to recognize the nature of the trouble at once. Any secondary relaying used in conjunction with the alarm, such as might be required for automatic throw-over to spare equipment, will usually have to be of the lock-out type, requiring a manual reset. Otherwise, when the secondary relays are energized, the audio signal causing unbalance in the rectifier bridge might be removed from the input terminals of the equipment failure alarm allowing the 7F7 relays to close out again.

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RUSSIAN RADIO

Portable radio equipment used on the battlefield of the current conflict by the Russian Army

THE INDUSTRY IN REVIEW

News

✦ "Communications in Air Defense" will be the subject of the first meeting of the Communications Group, New York Section of the American Institute of Electrical Engineers. The speaker will be Capt. W. C. Talbot, Signal Officer, Interceptor Command, First Air Force, now based at Mitchell Field, L. I., N. Y. The meeting will be held at the auditorium of the Western Union Telegraph Co., 60 Hudson St., New York, at 7:30 P. M. on October 30 and will be preceded by a showing of selected British defense films at 7 P. M.

Capt. Talbot will discuss in some detail the plans, methods, and organization of the elaborate communications systems and facilities essential to the efficient direction and operation of the most recently developed technique of protecting the country or specific areas from raids or bomber attack. He will discuss such topics as the methods of rapidly collecting information on the approach of hostile aircraft, methods of compiling and displaying this information on the "operations board", methods of disseminating this information to the people, methods of using such information by the Interceptor Command of the U. S. Air Corps, and direct operation of planes. He will also describe the organization and mission of the Interceptor Command and Army maneuvers which have developed or proved the efficiency of this elaborate communications organization.

The films will show war action and life in certain phases in the defense of England. The lecture will be followed by comments from men who have recently witnessed the operation of defense communications in Great Britain.

✦ The importance of National Defense lends added value to a course of lectures on communication networks to be given by the American Institute of Electrical Engineers this Fall. The series of seven lectures, entitled, "Wave Filters and Other Networks in Theory and Practice" will be co-ordinated to make a complete but concise presentation, emphasizing the practical design, use, and theory of filters and related networks. The speakers are all men of international repute in their respective fields and are particularly well qualified to select and impart to an audience the pertinent information on this timely subject. As practicing engineers, several are qualified to stress the practical limitations of theory and aspects of their construction and use.

The lectures will be heard in room 502 at the Engineering Societies Building, 33 West 39th Street, New York from 6:30 to 8:30 P. M. Registration for the course should be made in advance to H. E. Farrar at this address.

The dates, subjects and speakers are as follows:

October 20, "Functions of Filters and Other Networks" by H. A. Affel, Bell Telephone Laboratories

October 27, "General Network Theory" by Prof. E. A. Guillemin, Massachusetts Institute of Technology

November 3, "General Network Theory" by Prof. E. A. Guillemin, Massachusetts Institute of Technology

November 10, "Filter Design Practices" by A. J. Grossman, Bell Telephone Laboratories.

November 17, "Crystal Elements in Wave Filters" by A. R. D'heedene, Bell Telephone Laboratories

November 24, "Attenuation and Phase Equalizers" by A. J. Grossman, Bell Telephone Laboratories

December 1, "Coaxial Line Elements Applied to Filters or Networks" by C. W. Hansell and P. S. Carter, RCA Communications.

✦ A saving of more than five million pounds of metal vital to defense needs, including enough aluminum to build more than 275 fighter planes, is being effected by the Bell System this year through a program of material substitution. The Western Electric Company is now saving 65 tons of aluminum annually by replacing aluminum with steel on dial telephones. Other points in this conservation program will release 1,700,000 pounds of aluminum, almost a third of a million pounds of nickel, more than 3,000,000 pounds of zinc and 8,300 pounds of magnesium. . . . D. C. Prince, president of the American Institute of Electrical Engineers has appointed Dr. Edward E. Minor, Jr., research and development engineer of the Glenn L. Martin Co. as chairman of the Committee on Air Transportation of the American Institute of Electrical Engineers. Others assisting on this committee are V. H. Grant, U. S. Navy, T. B. Holliday, U. S. Army Air Corps, E. E. Johnson, General Electric Co., W. J. Clardy, Westinghouse Electric & Mfg. Co., W. J. Morrill, General Electric Co., C. F. Savage, General Electric Co., H. A. Campbell, Solar Aircraft Co. and J. W. Barker, Columbia University.

✦ A new service shop and warehouse in Pittsburgh, and ranking among the most complete in use in this country, has recently been put into operation by the General Electric Co. The shop has 16,000 square feet of floor space allocated to the warehouse and 34,000 square feet to the service shop and office. Features of the building include dust and fume elimination systems, a 15-ton crane to handle large jobs, a 300-ton hydraulic press, and a copper reclaiming roasting oven. Fluorescent lighting is used throughout the shop and office . . . According to J. G. Mann, treasurer, the Consolidated Wire & Associated Corporations moved all production and general office facilities to new and larger quarters at 1635 S. Clinton Street, Chicago, Ill. on September 1. The move was made to facilitate the handling of orders for the numerous products of the company and will bring under one roof the handling of such items as radio, electrical and automotive wires, aerial wires and kits, resistors, volume and tone controls, test equipment and similar electrical accessories. . . Philadelphia's first television station, W3XE, owned and operated by Philco Radio & Television Corporation, has been granted a commercial license for 60 days which began September 1, pending completion of installation of full power. The station is now transmitting a minimum of 15 hours of program each week, as required by the FCC regulations. W3XE operates on channel 3, having a wavelength of 66-72 Mc. Present power is 3 kw although this will shortly be increased 10 kw.

✦ The National Broadcasting Company has added 14 stations in six Central American Republics to its Pan American network, according to Frank E. Mullen, vice president and general manager of the company. . . . Station WWVA, Wheeling, W. Va., has recently been granted a construction permit to increase its power from 5 kw to 50 kw, unlimited time, and to move its transmitter to St. Clarisville, Ohio, about seven miles west of Wheeling. . . . The fifth frequency-modulated transmitter has recently been approved for Philadelphia when the Seaboard Broadcasting Corporation of Glenside, Pa., was granted a construction permit for an f-m transmitter. Call letters will be W81PH.

✦ According to Dr. R. H. Harrington, metallurgist in the General Electric Research Laboratories in Schenectady new American plants are extracting magnesium from sea water in such quantities that the United States and England are now equalling and will surpass Germany in production of this strategic metal. Present production points to a yield of 30,000,000 pounds for 1941 and nearly 90,000,000 pounds for 1942. . . . George E. Smith, vice president and treasurer of The Crosley Corporation, has been appointed by Brigadier General Dawson Olmstead, civilian adviser and counselor to aid in the reorganization and systematization of certain Signal Corps activities with a view to expediting the delivery of critical defense materials.

✦ Plans for a new building to be erected by the General Electric Company for the manufacture of industrial and radio tubes in Schenectady have been announced by Dr. W. R. G. Baker, manager of the company's radio and television department. The building is expected to be ready for operation by February. A single story manufacturing section will contain 120,000 square feet of floor space while 15,000 square feet of floor space will be available in a two-story office section. . . . The appointment of W. M. Ballenger to the position of assistant district engineer of the General Electric Company's central district has been announced by W. O. Batchelder, commercial vice president. Mr. Ballenger has specialized in the application of engineering to industrial problems. . . . Price reductions on shipments of aluminum made after September 30, 1941 are announced by the Aluminum Company of America. After that date the price of ingot aluminum will be reduced from 17 cents to 15 cents per pound. The company also announces completion of negotiations for the construction and operation of an alumina plant in the State of Arkansas with an annual capacity of 400,000,000 pounds, the construction of three aluminum smelting plants, one at Massena, N. Y., one in the Portland Oregon district and a third in Arkansas having a combined capacity of 340,000,000 pounds per year.

✦ Harry A. Turner has been appointed production supervisor at the Universal Microphone Company, Inglewood, Calif. Mr. Turner is an expert on time and motion study and has a background of 40 years experience in die tool design in typewriter and automobile factories. . . . Bob Barbley, sales manager of National Recording Supply Company, Hollywood, resigned in August to enter the Naval Reserve as a chief petty officer. He was assigned as chief photographer in the sound unit being formed in Hollywood. . . . Construction of a new $1,275,000 building for the assembly and testing of radio equipment for the Army and Navy has been started in Schenectady according to Charles E. Wilson, president of the General Electric Company. The building, to be equipped at an additional cost of $1,000,000, is part of a $2,400,000 project of the Defense Plant Corporation for expansion of radio manufacturing facilities. It is anticipated that the single story wooden structure, 1,000 feet long and 200 feet wide will be finished by October 1 and all equipment installed by next June.

✦ The Electrovox Company has recently moved their general office from NewYork City to the company's large New Jersey plant at 356 Glenwood Avenue, East Orange. . . . G. E. Richter, Jr., vice president in charge of sales, announces the completion of a new plant of the American Lava Corporation, which will provide a 300 percent increase in capacity.

Literature

General Catalogue. The Macquire Broadcasting Network, Sydney, Australia, has issued the second edition of its general catalogue which covers land line costs, the rates of the entire network, and the 22 individual stations grouped by states and also by capital cities. The 100-page book is indexed and contains maps, charts, diagrams, and photographs.

Catalogue. The new Engineering Standards Catalogue, listing the various standard shapes and sizes of Speed Nuts made by Tinnerman Products Inc., 2038 Fulton Road, Cleveland, Ohio is available on request.

Test Oscillators. The Aerovox Research Worker, available from Aerovox Research Corporation, New Bedford, Mass., contains in two separate issues a discussion on "Application of the A.F. Test Oscillator."

Communication Equipment. A booklet is available which describes marine radio telephone systems, amateur transmitters, army, navy, police, fire, forestry, and other types of emergency communication equipment made by TEMCO, Transmitter Equipment Mfg. Co., Inc., 36-01 35th Avenue, Long Island City, N. Y.

Intercommunicators. The various types of office and industrial intercommunicators manufactured by Webster-Rauland, 4245 North Knox Avenue, Chicago, Ill., are described in catalogue No. 241. Diagrams of the station connections, and a price list is also included.

Temperature Measuring Instruments. Two booklets outlining the principles of operation and the constructional features of temperature measuring devices are available from the Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, Pa. One describes the Brown Optimatic, an optical pyrometer, and the other covers the features of the Brown Continuous Balance Unit which replaces the conventional galvanometer and maintains continuous balance in the measuring and recording of temperatures.

Communications Receiver. Folder 108 covers the Howard Model 445 ac-dc Universal communications receiver made by the Howard Radio Company, 1735 West Belmont Avenue, Chicago, Ill.

Transmitting Capacitors. The second edition of the Transmitting Capacitor catalogue has been issued by Aerovox Corporation, New Bedford, Mass. This is a looseleaf book which is kept up to date by new pages issued from time to time. It is available to those engaged in designing, building, and maintenance of commercial radio and electronic equipment.

Radio Catalogue. The new 1942 radio catalogue of the Allied Radio Corporation, 833 West Jackson Boulevard, Chicago, Ill., is off the press. It covers communications receivers, sound systems, test equipment, fluorescent lighting apparatus, and amateur equipment, and may be had on request.

Aircraft Transmitters. AVT-110 which operates on a dry battery power supply, and AVT-111 which operates on a storage battery power supply are two aircraft transmitters described in leaflet 1V4295 of the RCA Manufacturing Company, Inc., Aviation Radio Section, Camden, N. J.

Mycalex. The nature properties, advantages, and applications of G-E Mycalex are presented in a 10-page booklet illustrated with photographs and charts. It may be had from the plastics department of the General Electric Company, Pittsfield, Mass.

Solenoid Operated Valves. This catalogue lists the specifications on various types of solenoid operated valves which are used for automatic and remote control of air, gas, steam, or liquids. The booklet is published by the manufacturer, the Automatic Switch Co., 41 East 11th St., New York City.

Westinghouse Bulletins. No. 41-291 gives the distinctive features, construction, and operation of voltage relays. Styles and prices for 25- and 60-cps relays for operation on 115- or 460-volt circuits are listed. No. 43-330 describes miniature a-c and d-c voltmeters and ammeters. Style numbers, ratings, scale divisions, and list prices are given also. These bulletins may be secured from Dept. 7-N-20, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa.

General Electric Bulletins. Fractional horsepower motors for machine tools and other industrial applications are described in leaflet GEA-3579. The sizes and applications of a shielded-arc electrode for cast-iron welding are listed in bulletin GEA-3493. Notes on cast-iron welding procedure are included. These bulletins may be obtained from the General Electric Company, Schenectady, N. Y.

Fibre Handbook. This handbook contains technical and descriptive data on National Vulcanized Fibre. It covers general properties, different types, typical uses, and notes on forming and machining the products of the National Vulcanized Fibre Company, Wilmington, Delaware. Copies are available on request.

Aluminum References. The first of a series of service bulletins on aluminum has been issued by the Aluminum Company of America, Pittsburgh, Pa. This pamphlet lists 100 references on aluminum of special interest to defense manufacturers. All of these are publications by engineers of this company.

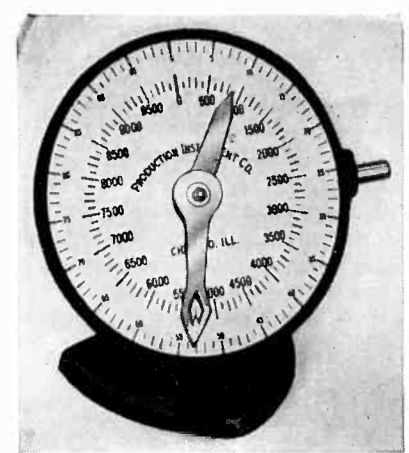
New Products

Beam Tetrodes

Two INSTANT HEATING r-f beam tetrodes have been added to the tube line of the Hytron Corporation, 76 Lafayette Street, Salem, Mass. The HY65 comes with a ceramic octal base, is completely shielded for rf, and is intended to replace the 6V6 and the 6L6 type tubes in low power stages. The filament draws 0.8 amps at 6 volts, and the amplification factor is 100. The HY67 is an all-purpose, graphite anode r-f beam power tetrode with a rugged four-way support making it well suited for aircraft applications where the equipment is subjected to excessive vibration. With 1250 volts on the plate, 300 volts on the screen, and a driving power of 1.5 watts the power output is about 152 watts. This tube is also shielded for rf.

Coil Winding Counter

A HIGH SPEED COIL WINDING counter called the Clipper, designed for direct connection to the motor shaft or for operation through a flexible shaft is available from the Production Instrument Co., 710–12 W. Jackson Blvd.,



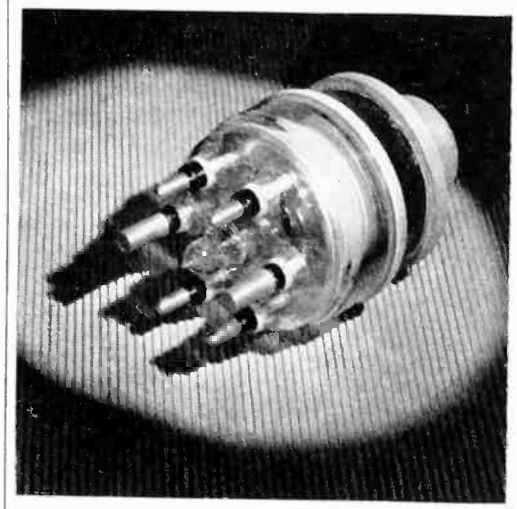
Chicago. In actual service it counts at speeds as high as 9000 turns per minute. The figures on the dial read up to 10,000 turns. Reset to zero is accomplished with one motion, and turns taken off the coil are automatically deducted. An adjustable base permits easy alignment with motor.

DK-3 Transceiver

ANNOUNCED BY ABBOTT INSTRUMENT, Inc., 8 West 18th Street, New York City is their new Model DK-3 transceiver having an effective operating range of up to 30 miles, depending upon terrain. The unit uses three 45-volt B batteries, which are self-contained for portable use, or from 135 to 180 volts d.c. from a power supply used in a circuit employing one 6G6G in the audio and modulator positions, and one 6J5GT as the super regenerative detector and r-f oscillator.

High Frequency Power Tube

A NEW RADIO TRANSMITTING tube, especially designed for high frequency application, has been announced by the Vacuum Tube Department, General Electric Company, Schenectady, N. Y. This is a water-cooled tube known as Type GL-8009, and can be used as a Class B modulator, a radio frequency amplifier, and as an oscillator. Lead inductance is minimized through the use of a six-pole terminal mount. Although primarily designed for television service, the tube is suitable for any high-frequency broadcast application, and may be used at small power rating up to 25 Mc. At reduced output it may be used for frequencies as high as 100 Mc.



Deltabeston Wire

A NEW STANDARD Deltabeston wire was announced recently by General Electric's appliance and merchandise department at Bridgeport, Conn., but should be of interest to radio and communication engineers especially where high temperatures are likely to be involved. The wire is available in sizes from No. 20 to No. 8, is insulated with a synthetic film and a highly compressed covering of felted asbestos, and may be obtained in black, white, red, blue or green. The asbestos insulation is thoroughly saturated with a moisture and heat-resistant finishing compound.

Time Base Generator for Oscillograph

ENGINEERS OF THE Allen B. DuMont Laboratories, Passaic, N. J. have developed the type 215 linear time base generator for facilitating studies of low-frequency phenomenon such as vibration studies, strain analysis, physiological applications and similar usages.

The generator has a frequency range of from 0.2 to 125 cps with a maximum undistorted output voltage of 500 volts d.c. Signal blanking facilities are provided. The instrument is housed in a metal case, measuring 14x8x17¾ inches. It is provided with a leather carrying handle and weighs 35 pounds.

Wide Range Signal Generator

A NEW SIGNAL GENERATOR covering a frequency range of from 50 to 400 Mc in one range, with an output voltage continuously variable from 0.2 microvolt to 0.2 volts, has been developed by the Measurements Corp., Boonton, N. J. The output of the impedance is a 36-ohm balanced network with an impedance to ground of 18 ohms. Continuously variable modulations up to 50 percent from 400 and 1000 cps internal oscillator or from an external source is available. The modulating amplifier is built into the equipment. The frequency band is directly calibrated and has a spiral scale approximately 5 feet in length in addition to a linear scale having 6,000 divisions. A motor driven tuning dial is employed to cover the complete range. The unit is completely operated from the power line, the rectifier and filter being equipped with a built-in voltage regulator. The heater of the oscillator to operate on direct current, and a 6-step 120 db balanced resistance attenuator offers constant output impedance over the whole frequency and output range. The overall size of the unit is 14x24x14 inches and the generator weighs approximately 90 pounds. The price is $1700.

Mallard Speaker

ORIGINALLY DEVELOPED for the Navy the new waterproof speaker developed by Cinaudagraph Speakers, Inc., 921 W. Van Buren Street, Chicago, will be known under the trade name of "The Mallard." These speakers are of the permanent magnet type and range in size from 3½ to 12 inches. They are particularly suitable for marine and outdoor installations and were originally developed with the rigid requirements of the Navy in mind. The cone and the spider were made of water-resistant material and a non-soluble cement is used in fastening them together. All metal parts of the unit are first plated and then treated with a water-repellant coating. Except for the greater power required to activate the unit, these speakers are said to operate as well under water as in the air. The cone action was the same in either medium, but the voice coil withstood 300 percent greater power when the speaker was completely submerged, because of the weight of the water present against the assembly.

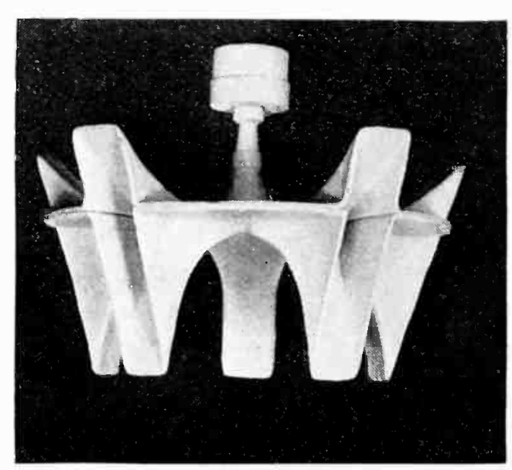
F-M Monitor Speaker

A NEW HIGH FIDELITY loudspeaker and high-fidelity amplifier for use in monitoring f-m broadcasts has been announced by the radio and television department of the General Electric Company, at Schenectady, N. Y. The high fidelity is achieved with the use of the single speaker, thereby departing from the previous practice of using a low-frequency speaker or "woofer" and a high-frequency speaker or "tweeter" to cover the complete audio range.

The speaker is mounted in a cabinet of walnut veneer and may be used on either a table or desk top. It is recommended for use on a special base designed as a companion unit, the base being about 18 inches high and having provision for mounting the high-fidelity amplifier.

All-Way Speaker Baffle

A LOUDSPEAKER BAFFLE of new design, and projecting sound uniformly over an angle of 360 degrees through five evenly spaced apertures arranged in a horizontal plane, is announced as a new development of the Commercial Sound Division of the RCA Manufacturing Company, Camden, N. J. The unit is intended primarily for use in paging and announcing in industrial plants.

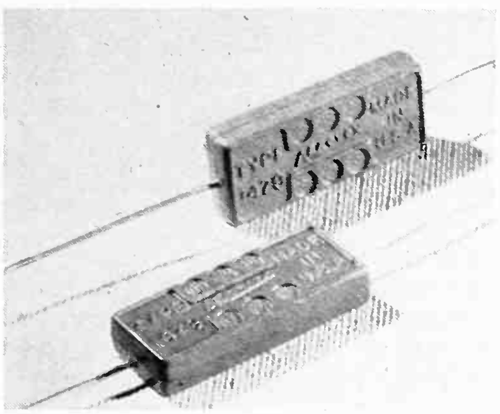


The new baffle distributes sound pressure uniformly over a radius of 50 feet. It is designed for operation with 5, 10, 12, or 15-watt loudspeaker mechanisms, all of which are interchangeable. Only one speaker driving mechanism is required. The baffle is constructed of non-metallic, non-vibratory acoustic material, which it is claimed has been especially developed for this purpose. The baffle is 20 inches high, 20 inches deep, and weighs 10 pounds.

New Aerovox Products

THREE NEW PRODUCTS have recently been announced by the Aerovox Corporation, New Bedford, Mass. One of these is a new and smaller insulated molded carbon resistor available in ½ and 1-watt sizes. These units are considerably smaller than previous ones bearing the same ratings and type numbers, and the reduction in size is attributed to improvements in the resistance elements which in no way reduces the low-handling properties of the units.

A still wider choice of terminals has also recently been announced by Aerovox for their popular bathtub oil-filled non-inductive paper condensers. The terminals are constructed of "double-rubber" bakelite, permanently riveted to the case. The fixed, riveted lug type terminal is standard, but stud-and-nut terminals with movable lugs can be had on special order.



Type 1478 is the catalog number of new postage-stamp molded bakelite receiving condensers shown in the illustration. The same molded casing is used for the Type 1479 condensers with silvered mica section. Both types have working voltage ratings of 500 volts.

F-M Antenna Coupler

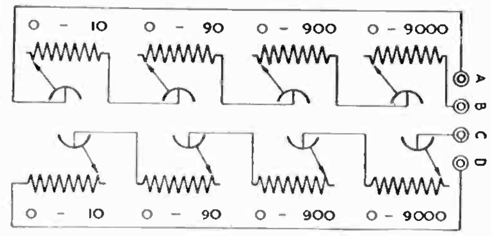
THE INCLUSION OF F-M reception along with the already well-known features of all-wave reception and minimized noise, marks the latest development in the multicoupler antenna system for apartment houses and other multi-radio buildings, according to Amy, Aceves & King, Inc., 11 W. 42nd St., New York. The new type system usually employs a doublet of two wires, one 45 feet long and the other 15 feet long. Transmission lines from the antenna connect with the outlet couplers. As many as 20 couplers can be served with a single aerial and transmission line. No switching or other changes are required in making the outlet instantly available for satisfactory broadcast, short-wave, or frequency modulation reception.

The principles of antennas for f-m reception were discussed by Mr. Aceves in the September issue of ELECTRONICS. Unfortunately in this article, the captions for Fig. 4 and Fig. 5 were inadvertently transposed.

Precision Voltage Divider

DECADE VOLTAGE DIVIDERS in any capacity and calibration desired are available from the Shallcross Mfg. Co., Collingdale, Pa. The standard design of the Shallcross rotary instrument switches and decade resistance boxes permit this flexible arrangement in an entirely practical manner.

The diagram shows a unit having four dials. Resistance is between AB and CD and may be used independently as



a resistance box. When the dials are rotated clock-wise, resistance between A and B will be increased, while that between C and D will be decreased. By connecting the link between terminal B and C, the instrument may be used as a voltage divider with the resistance between A and D constant at all settings of the dial. Voltage ratios of 0.0001 to 1.0 may be obtained although other ranges are available on special order.

Voice Model Unidyne

SHURE BROS., CHICAGO, announce that their Unidyne dynamic cardioid microphone has now been made available in a series of "voice" models for police and commercial radio use as well as for public address, paging, broadcasting and recording applications. No response is obtained immediately from behind the microphone, and low impedance models permit practically unlimited cable to the microphone and its associated amplifier. Three models are available. Model 55AV is for circuits having an impedance of 35 to 50 ohms, and lists at $47. Model 55BV is provided with an internal transformer and operates from 200 to 250 ohms circuits and lists at $49.50. The Model 55CV, also at $49.50 is a high impedance unit with internal transformer.

Decade Inductance

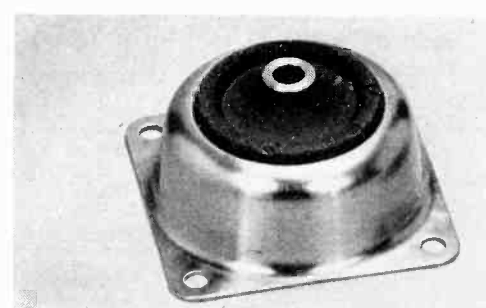
A LABORATORY UNIT which will be especially appreciated by the engineer setting up experimental filters, equalizers, tuned amplifiers, phasing networks, and the like, is the decade inductance manufactured by the New York Transformer Company, 480 Lexington Avenue, New York City. These decade inductances are available in decades from 0.001 henry per step to 10 henries. The precision of adjustment is ±5 percent. The units are intended for use between the frequencies of 50 to 20,000 cps, and for operating levels up to 30 db. The instrument can be obtained in either two or three decades in any of the inductance ranges desired.

Tracing Cloth

GOOD, CLEAR BLUE PRINTS are made from pencil tracings on the new white tracing cloth, Whitex, manufactured by The Frederick Post Company, Box 803, Chicago, Ill. Whitex takes colored pencils sharply and plainly, and produces a jet black on a deep blue background in the final print. Erasures are clean.

Vibration Dampers

TO MEET THE INCREASINGLY important problem of vibration elimination, anti-vibration mountings manufactured by the Lord Manufacturing Company,



Erie, Pa., are finding extensive use. One of their important applications is as an integral part of recording equipment where noise and vibration must be reduced to a minimum.

Storage in Television Reception

(*Continued from page 49*)

opaque deposit which travels in the direction of the electric field through the lattice toward the anode and ultimately disappears there.

The total time of travel of the deposit through the crystal, or in other words the persistence of constant opacity at one element, depends upon the strength of the electric field and temperature and certain crystal constants. A simple calculation shows[8] that with a sylvine crystal one mm thick and a potential of 600 volts at its ends, the deposit would move through the crystal, or remain in visible existence, within 1/30 second, equal to the frame period of present television standards. At the same time when the deposit at a certain element enters the anode, thus disappearing, the scanning cathode-ray beam returns to this element and creates a new deposit of a value belonging to the following frame, at the cathode side of the crystal. This deposit starts on its travel through the crystal toward the anode which it reaches at the end of this frame period. It is thus possible to retain the elemental intensity values constant over the entire frame period, and change them at the end of this period to the values corresponding to the following frame, in other words to attain full storage television reception.

This system has been developed to a certain extent in England, using microcrystalline crystal screens obtained by vacuum evaporation, in demountable cathode-ray tubes, and projecting the pictures by a conventional lantern-slide-projection arrangement on a white screen. Reception results of television transmissions from the London transmitter in Alexandra Palace were very promising both regarding definition and representation of movements. These experiments led to the expectation that, through more extended research on the various physical conditions governing electron opacity effects the system might produce an excellent solution of the large-screen television problem.

When fully developed the Skiatron will permit the projection of a steadily changing opacity picture onto a screen of full theater size using a standard cinema arc lamp. The system offers itself to color television of the type of subtractive color mixture with an optical efficiency equal to the subtractive methods of color photography (or movies) as embodied for instance in the Technicolor or Kodachrome processes.

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8. A. H. Rosenthal, *Proc. I.R.E.*, vol. 28, p. 207, 1940.

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RADIO CONTROLLED TARGET BOAT

A radio controlled target boat was recently used in a test of the coast defenses against mosquito type boats at Fort Story, Virginia. Anti-aircraft weapons and their range-finding equipment were used against this horizontal target which was controlled from an army mine-layer

Fluorescent Materials

(Continued from page 34)

preciable phosphorescence. The rate of decay of luminescence varies with the type and concentration of the activator as well as with temperature. In general the rate of decay increases with increasing temperature. The table gives the approximate persistence times for a number of typical phosphors. This is the time required for the luminescence to drop to 1 percent of its initial value. Materials which show phosphorescence require a measurable time after excitation begins before reaching their full luminescent output. For willemite this built-up period is approximately 0.03 second.

In television kinescope screens phosphorescence must be kept to a minimum to avoid trailing afterglows behind rapidly moving image highlights. However, in fluorescent lamps operated on alternating current a long persistence time is advantageous since it reduces stroboscopic flicker. For cathode-ray tubes used to observe transient effects a luminescent screen with a memory is often an advantage.

Of primary interest in cathode-ray screens is the light output of the screen material as a function of the energy and current density of the electron beam. For low current densities the light output increases linearly with current density, but begins to show saturation at higher current densities. This departure from linearity is shown by the separation between the light output curves and the 45-deg. lines shown in Fig. 6. Each material shows a different degree of departure from linearity.

For a given current density, the energy of the electron beam as it strikes the screen is determined by the screen potential. This in turn depends upon the voltage applied to the accelerating electrode and upon the secondary emission of the materials making up the screen. The screen floats at a potential such that electrons leave it at the same rate at which they arrive. If one or more secondary electrons result from the impact of each electron in the beam the screen potential will not differ greatly from the potential of the accelerating electrode, but if the accelerating voltage is such that less than one secondary electron results from each impinging electron, the screen potential becomes negative with respect to the accelerating electrode. When this latter condition sets in the light output per unit increase in accelerating voltage begins to decrease. Most phosphors are good secondary emitters, but there is considerable variation in this property from one phosphor to another.

Figure 7 shows how the light output from two willemite screens varies with the accelerating voltage.[4] Screen A is composed of particles averaging 2 microns in diameter sprayed on glass to a density of 5.37 milligrams per sq. cm., while screen B is composed of particles 1-2 microns in diameter, and of surface density 0.77 milligrams per sq. cm. The thick screen begins to show saturation effects at 6000 volts for all values of current density, but the thin screen shows no such effects even at 15,000 volts. For static bombardment it will be noted that saturation is complete at 9000 volts.

For accelerating potentials below saturation the light output, for most phosphors, can be expressed by a law of the form $L = Af(i)V^n$, where A is a constant, $f(i)$ is a function of the beam current density, and V is the accelerating potential. The exponent n varies from a value less than 2 for willemite and other zinc silicates to approximately 2 for the sulphides. For some mixture screens it may exceed 2. For Screen A of Fig. 7, n has the value 1.84 and for the thicker Screen B the value 1.23 for dynamic bombardment.

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