MARCH · 1941
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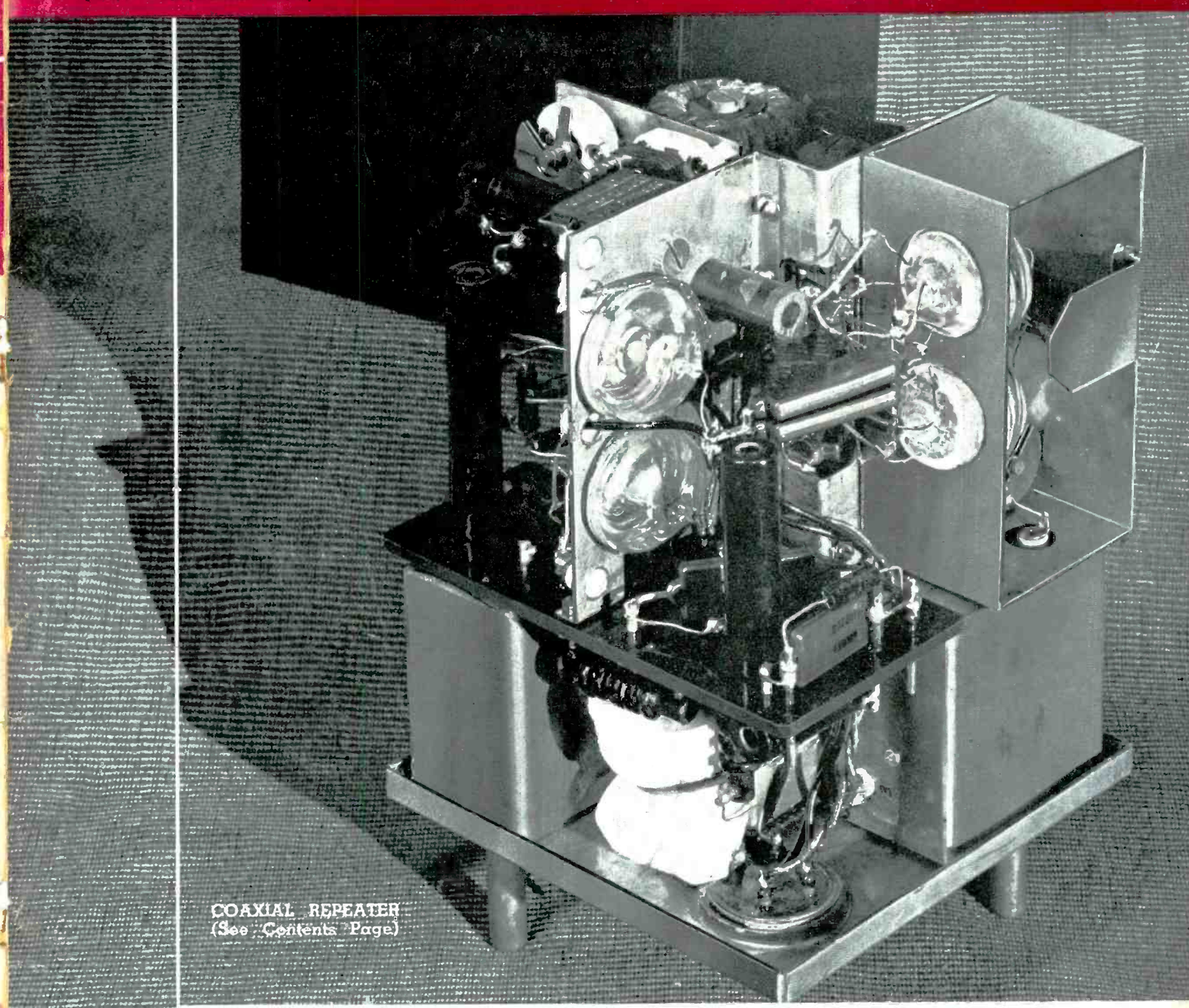
electronics

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



COAXIAL REPEATER
(See Contents Page)

Variable Voltage

FOR YOUR LABORATORY, YOUR PRODUCT, OR YOUR PRODUCTION LINE

UTC

VARITRAN

- ★ SMOOTH CONTROL
- ★ EXCELLENT REGULATION
- ★ HIGH EFFICIENCY
- ★ RUGGED CONSTRUCTION
- ★ WIDE RANGE (0-130 V.)
- ★ LOW TEMPERATURE RISE
- ★ ROLLER CONTACT
- ★ NO DISTORTION

VARITRAN CONTROL UNITS

For Controlling: Rectifier output, Motors, Heaters, Lights, Line voltage

METHOD OF OPERATION The UTC Varitran is a simple autotransformer with turns arranged on one layer so that every exposed turn may be used as a tap. A special non-fusing contact can be moved to any position on the winding, permitting the exact voltage desired to be obtained. The regulation and efficiency are excellent and no distortion of wave form occurs. The output voltage is independent of load.

Type	Input Voltage	Output Voltage	Watts	Max. Amps.	Figure	Net Price
V-0	115 volts	0-130	230	2	A	$7.50
V-0-B	230 volts	0-260	230	1	A	9.50
V-1	115 volts	0-130	570	5	B	10.00
V-1-M	115 volts	0-130	570	5	C	15.00
V-2	115 volts	0-130	570	5	A	9.00
V-2-B	230 volts	0-260	570	2.5	A	11.50
V-3	115 volts	0-130	850	7.5	A	14.00
V-3-B	230 volts	0-260	850	3.75	A	18.00
V-4	115 volts	0-130	1250	11	A	20.00
V-4-B	230 volts	0-260	1250	5.5	A	25.00
V-5	115 volts	0-130	1950	17	A	32.00
V-5-B	230 volts	0-260	1950	8.5	A	37.00
V-6	115 volts	0-130	3500	30	A	60.00
V-6-B	230 volts	0-260	3500	15	A	70.00
V-7	115 volts	0-130	5000	44	A	87.00
V-7-B	230 volts	0-260	5000	22	A	95.00

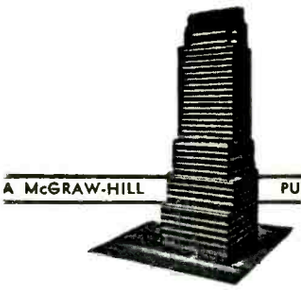
VARITRAN RATINGS

Standard Varitrans are designed for 115 or 230 volt service. The respective output voltages are 0-130 and 0-260 volts. The Varitran autotransformer current and wattage rating is based at 115 volts. The maximum current can be taken at any point from 0 to 20 volts and from 95 to 130 volts, tapering off to 50% of maximum at the 65 volt point.

UNITED TRANSFORMER CORP.

150 VARICK STREET ★ NEW YORK, N. Y.

EXPORT DIVISION: 100 VARICK STREET NEW YORK, N. Y. CABLES: "ARLAB"



electronics

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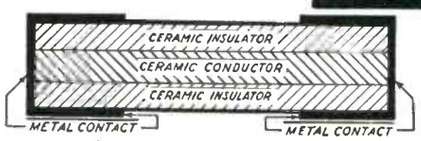
AXIAL LEAD RESISTORS



Magnified cross section showing the important and exclusive Centralab features:

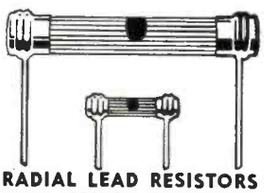
Note center core of resistance material surrounded by a dense shock-proof ceramic providing strength and protection against humidity.

Both core and jacket are fired together at 2500 degrees F. into a solid unit . . . hard and durable as stone.

Pure copper covers the resistor ends for contact.

AXIAL LEAD RESISTORS
Completely insulated

Designed to fit into limited space without danger of shorting to the chassis or other parts. Same resistor bodies are used as in Radial Lead units, millions of which are now in use . . . only difference is in method of making end contact. End leads brought through bakelite insulation. Will withstand five times rated load without permanent change.



RADIAL LEAD RESISTORS
90% Insulated

The ceramic body of all Centralab resistors is in itself an insulator of the highest quality. Only the radial leads where attached to the body are uninsulated. Electrical characteristics of the Axial and Radial lead types are identical.

Old Man Centralab continues to score a bulls eye with the millions of Fixed Resistors that are doing duty in new and replacement jobs the country over. Manufacturers, experimenters, hams and service men continue to believe (and justly so) that Centralab's unique method of uniting the resistance material with the ceramic body makes for a resistor of unusual strength and efficiency under any and all conditions. Available in either Radial or Axial Lead . . . color coded (R.M.A.) in convenient sizes and ratings.

Always insist on CENTRALAB.

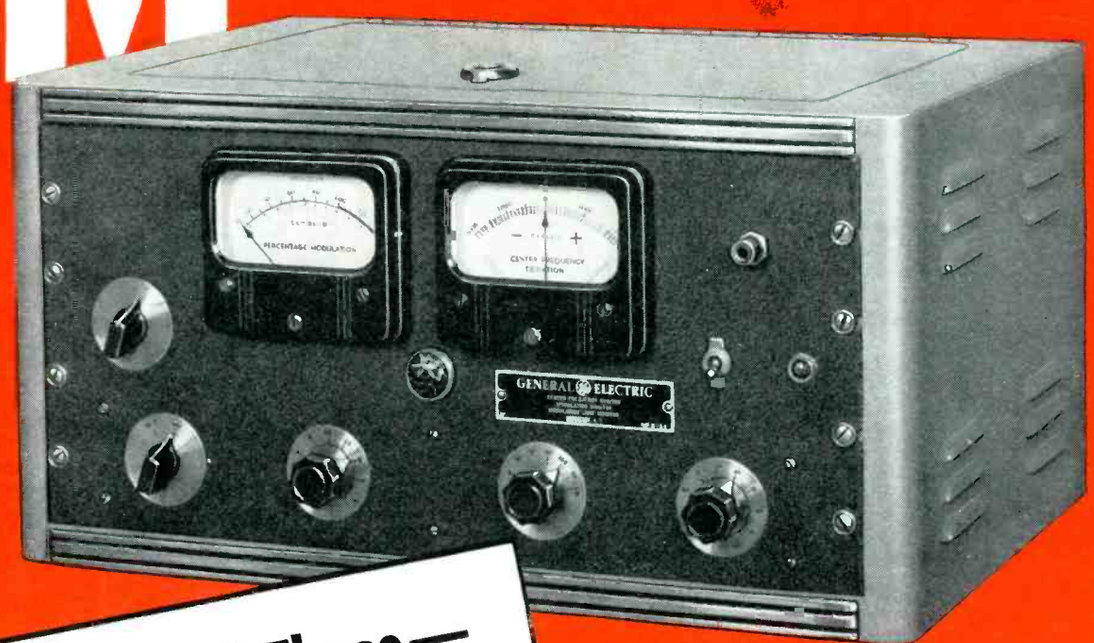
CENTRALAB: Division of Globe Union Inc., Milwaukee, Wis.

by **Centralab**

The Monitor

FM HAS WAITED FOR!

Again G.E. LEADS THE WAY



Here's everything you need in an FM broadcast monitor. It's completely self-contained, with built-in voltage-regulated power supply and hermetically sealed precision crystal units. It stole the show at the IRE Convention in New York.

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1. Direct reading of center-frequency deviation (with or without modulation)
2. Direct reading of modulation percentage
3. Instant calibration against a precision crystal standard
4. Adjustable modulation-limit flasher
5. High fidelity output for audio monitor

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Your BEST INSURANCE Against

Speed-killing "Doubtful" Screws

Guarantee
OF HIGHEST QUALITY

To assure satisfactory performance, Parker-Kalon Fastening Devices are made to exacting specifications covering dimensional and physical characteristics which are checked at every stage of manufacture, and passed upon by Parker-Kalon's Quality Control Laboratory. Should this product prove faulty in any way, replacement will be made without charge.

PARKER-KALON CORPORATION
NEW YORK, N. Y., U. S. A.

A Guarantee that's backed by Parker-Kalon's Unique Quality-Control!

Only a handful of "doubtful" screws may lower the quality of a full day's output of a product. Besides, consider how screws which fail to function properly can slow up production and bring up costs.

That's why Parker-Kalon's Guarantee against "doubtful" screws – *screws that look all right but of which a percentage fail to make satisfactory fastenings* – is vitally important to you. This Guarantee is your assurance that the Parker-Kalon Screws you use have met the rigid tests imposed by the Parker-Kalon Quality-Control Laboratory. From raw material through the various processes of manufacture, inspections and tests guard against "doubtful" screws.

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Types, sizes, head-styles for every assembly of metal or plastics

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Wing Nuts-Cap Nuts-Thumb Screws
Cold-forged . . Neater, Stronger

SOLD ONLY THROUGH RECOGNIZED DISTRIBUTORS

Quality-Controlled **PARKER-KALON Fastening Devices**

SUPERIOR SMALL TUBING *in the hands of the* DESIGNER...

Superior Tube Company fills the need of the man who puts small metal tubing to work on paper—the design engineer. We fit into his plan perfectly. With our highly specialized production facilities, laboratory control, and our experience which has been concentrated in this previously neglected field—the doors have been opened for new tubing applications, use of new metals, and the assurance that there is a dependable source of supply always available. There is practically no limit to our ability to produce the exact tubing in any metal to meet your exact specifications. Think first of Superior, the BIG name in small tubing.

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The most effective use of small tubing (max. OD 5/8") involves factors which at first glance may seem unimportant or may be overlooked entirely. Superior engineers are fully conversant with the metallurgical, physical, chemical and production problems that must be integrated to assure thoroughly satisfactory tubing application. Do not hesitate to bring your problems to us. If it's small tubing, we are prepared to help you.

SUPERIOR TUBE CO.

["*Small Tubing is our only business, and we know it.*"]

NORRISTOWN, PENNSYLVANIA

Tubing from 5/8" OD down . . . SUPERIOR Seamless in various analyses. WELDRAWN Welded and drawn Stainless. BRAWN Welded and drawn "Monel" and "Inconel". SEAMLESS and Patented LOCKSEAM Cathode Sleeves.

"FOR FINE SMALL TUBING"

THERE CAN BE NO FAILURE!

above: famous painting by Fred J. Hoertz of "The S.S. AMERICA" which is linked with other vessels, ports and cities in every part of the world by means of eight transmitters, nine receivers, direction finder, automatic distress alarm, thirteen antennas — all the products of Radiomarine Corporation of America.

DURING 4 decades, Radiomarine Corporation of America has grown to a position of pre-eminence in rendering faithful, reliable communications over the Seven Seas. Its proud place of Leadership will ever remain secure so long as "men go down to the sea in ships that do business in great waters."

Kenyon is honored to have been entrusted with an important share of the responsibility in making so great a service possible.

Day by day — the name Kenyon grows like a legend and gains in stature wherever the great names of Radio are gathered. Informed men everywhere have come to realize that the trademarks of the Leaders is the best assurance that there can be no failure.

We are ever at your service.

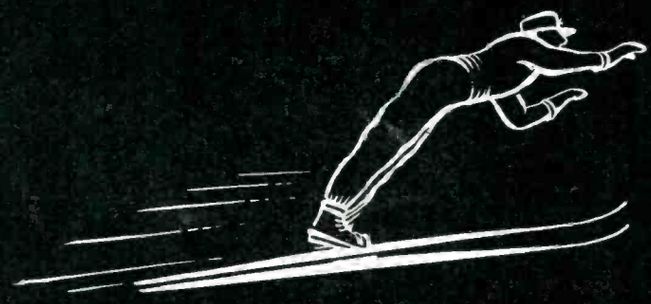
A group of Radiomarine telegraph transmitters installed on the "S.S. America."

Interior view of Radiomarine 200 w. transmitter which utilizes dependable Kenyon Transformers to assure trouble-free service.

KENYON TRANSFORMER CO., INC.

840 BARRY STREET • NEW YORK, N. Y.

ANOTHER GREAT JUMP AHEAD!



...the successor to the famous 110A Amplifier ...now available

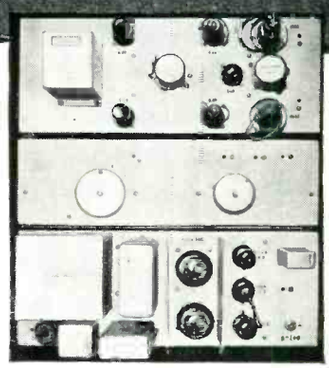
NEW Automatic Governor of Program Level

Western Electric's new 1126A Program Amplifier brings you an entirely new level controlling circuit with far faster operation. It gives you complete freedom from overmodulation as well as increased TRANSMISSION EFFICIENCY with better quality! By governing even instantaneous program bursts it is capable of eliminating:

1. Splash or short interval adjacent channel interference due to overmodulation of AM transmitter.
2. Overswing in FM transmission.
3. Instantaneous overload effects in other program transmission systems.

Where the 110A gives 3 db, the 1126A will give 5 db increase in average signal level for high quality transmission. The 1126A is mechanically and electrically interchangeable with the 110A.

For information about the many other new features that your operators will appreciate, and which will pay you listener dividends, write or call Graybar.



Front and back views of the 1126A. *Top Panel:* **126A Amplifier;** *Middle Panel:* **298A Control Panel;** *Bottom Panel:* **20A Rectifier.**

Western Electric

Distributed by Graybar

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To the Metal-Consuming Industries:

To eliminate bottlenecks in defense production, the National Defense Commission has directed two important requests to metal-consuming industries:

1. *Magnesium producers should allocate their entire stocks to defense industries for the time being.*
2. *Non-defense industries should give attention to means for replacing aluminum in their products with other materials . . . including plastics.*

Production experience indicates that in addition to magnesium and aluminum, defense industries will also have increasing demands for brass and zinc, as well as for stainless and thin gauge steel.

At a time when national defense needs priority metals, Monsanto Chemical Company is placing its broad experience in plastics at the disposal of those non-defense manufacturers whose present product designs call for these vital defense materials. There are ample supplies of six basic Monsanto Plastics which can be successfully used to replace cast or stamped metals in a wide variety of large scale uses.

Already defense metals have been replaced with plastics in cases, cabinets or housings for business machines, radios, scales and vacuum cleaners. Sizeable quantities of strategic metals have been saved for national defense through the use of plastics for kitchen utensils, flashlight cases, cameras and many other consumer goods items. On the production lines, as well, plastics are bringing new advantages in speedier manufacturing, high dimensional accuracy, elimination of hand finishing operations. There is no bottleneck in plastics molding facilities such as already exists in many types of metal fabricating equipment, notably screw machines.

To assist the manufacturer who is presently using metals necessary in any degree for defense work, Monsanto has prepared a special Report on Plastics as Replacement Materials. Your copy will be sent on request, together with names and addresses of capable plastics molders and fabricators.

MONSANTO CHEMICAL COMPANY
PLASTICS DIVISION • SPRINGFIELD, MASSACHUSETTS

"DON'T JUDGE A BOOK by its cover" is a proverb as shrewd as it is ancient. The true worth of any volume is found in its pages, not in the binding. So, too, with capacitors, quality lies hidden. Look to the ingredients always for extra value in capacitors.

IT'S THE EXTRAS!

in Cornell-Dubilier Capacitors...

EXTRA PERFORMANCE, EXTRA LONG LIFE, EXTRA CAPACITOR *VALUE* THAT APPEALS TO ENGINEERS

IN the hidden ingredients of Cornell-Dubilier capacitors lies their difference. The important reason why there are more C-Ds in use today than any other make. It's extra quality! Finer materials and finer engineering, because Cornell-Dubilier, with the broadest capacitor experience in the industry, knows how! That's why so many engineers demand C-Ds today for every capacitor use. They know Cornell-Dubilier builds in the kind of quality — finer performance, longer life, surviving soundness — that means extra capacitor service.

Only Cornell-Dubilier Electrolytics offer all these EXTRA FEATURES!

- Special high voltage paper separator
- C-D etched plate
- Special C-D electrolyte
- Special high formation process

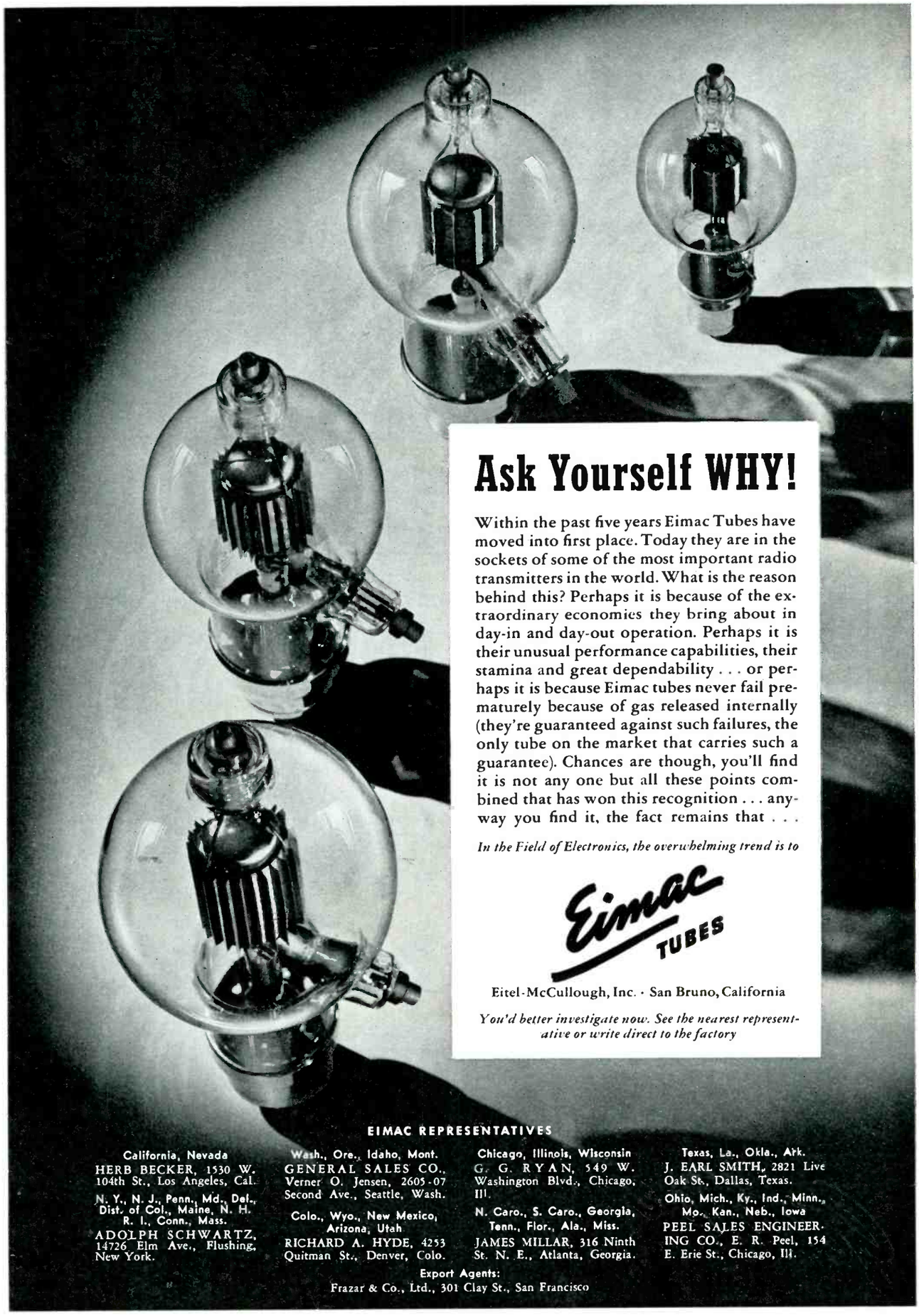
★

For complete technical information, write for Catalog 185A.

CORNELL-DUBILIER
ELECTRIC CORPORATION
1006 HAMILTON BLVD. • SO. PLAINFIELD, N. J.

REMEMBER! Only C-D union-made capacitors give you the EXTRAS at no extra cost.

Get the extras — WITH CORNELL-DUBILIER CAPACITORS!



Ask Yourself WHY!

Within the past five years Eimac Tubes have moved into first place. Today they are in the sockets of some of the most important radio transmitters in the world. What is the reason behind this? Perhaps it is because of the extraordinary economies they bring about in day-in and day-out operation. Perhaps it is their unusual performance capabilities, their stamina and great dependability . . . or perhaps it is because Eimac tubes never fail prematurely because of gas released internally (they're guaranteed against such failures, the only tube on the market that carries such a guarantee). Chances are though, you'll find it is not any one but all these points combined that has won this recognition . . . anyway you find it, the fact remains that . . .

In the Field of Electronics, the overwhelming trend is to

Eimac TUBES

Eitel-McCullough, Inc. · San Bruno, California

You'd better investigate now. See the nearest representative or write direct to the factory

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COMPARE AlSiMag 196 *with any other known material*

If you require a material of low dielectric loss, good electrical characteristics and high mechanical strength, we suggest that you compare any known material with AlSiMag 196.

*General Characteristics	AlSiMag 196	Other	Other	Other
Complies with Government Specifications for Grade G	Yes			
Low Water Absorption	Yes			
High Softening Temperature	Yes			
Uniform Linear Coefficient of Thermal Expansion	Yes			
High Tensile Strength	Yes			
High Compressive Strength	Yes			
High Modulus of Rupture	Yes			
Excellent Resistance to Impact	Yes			
Absolute and Permanent Rigidity	Yes			
Great Dielectric Strength	Yes			
Low Loss Factor	Yes			

*Exact engineering data shown on Property Chart. Free on request.

AlSiMag 196 is one of many AlSiMag ceramic compositions. A new Property Chart giving complete and detailed physical data on all AlSiMag materials will be sent on request. AlSiMag pieces are custom-made in the size, shape and form indicated by your requirements.

AlSiMag

Trade Mark Reg. U. S. Pat. Off.

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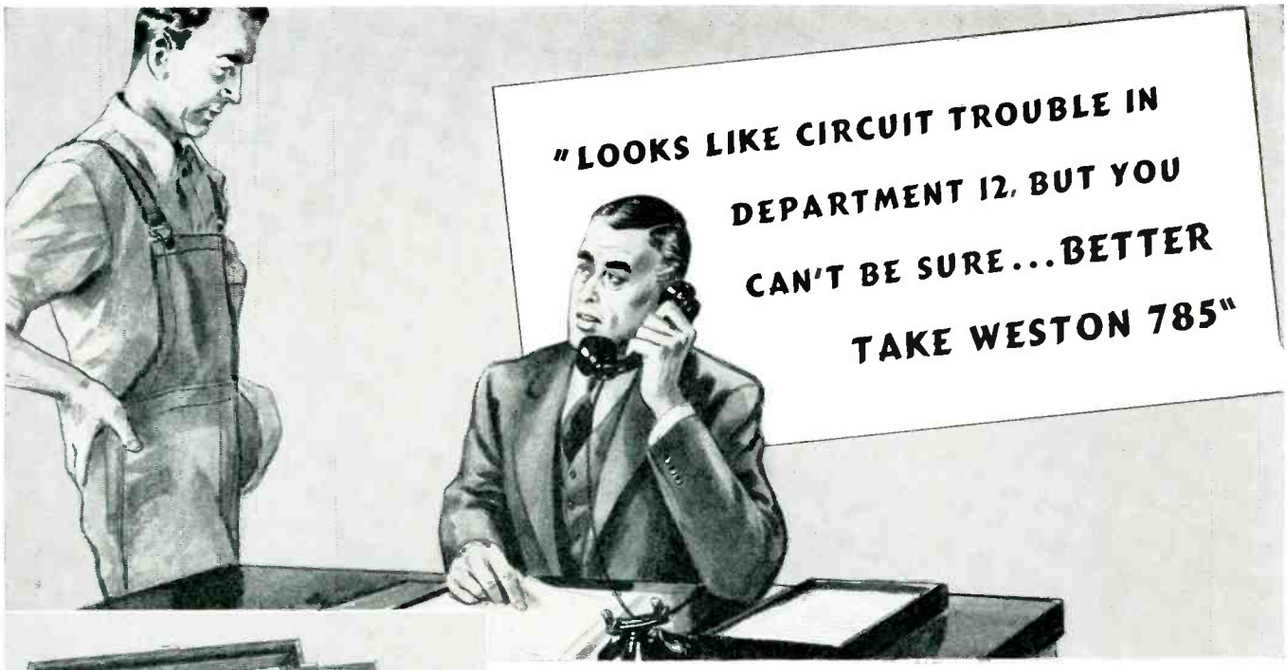

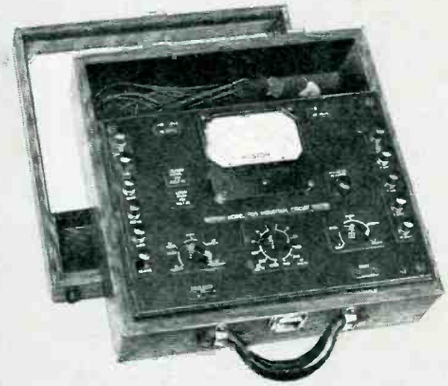

WESTON MODEL 785
Industrial Circuit Tester

VOLTAGE RANGES

DC Volts—0-1/10/50/200/500/1000 volts—20,000 ohms per volt

AC Volts—0-5/15/30/150/300/750 volts—1000 ohms per volt

CURRENT RANGES

DC Current—0-50 microamperes, 1/10/100 milliamperes, 1 ampere and 10 amperes

AC Current—self-contained ranges 0-.5/1/5/10 amperes. (Higher ranges with an external current transformer.)

OHMMETER RANGES

0-3000, 0-30,000, 0-300,000 ohms, 0-3 megohms, 0 to 30 megohms (self-contained batteries).

...this one *multi-purpose* instrument handles 90% of plant emergency calls!

Here's a maintenance chief who handles "trouble" in an efficient, practical manner. True, he has a complete set of standard WESTON electrical instruments for periodic maintenance checking. But on emergency calls, where quick action is needed, and where the cause of the trouble is unknown, he uses the WESTON Model 785 Industrial Tester... a multi-purpose instrument with voltage, current and resistance ranges specifically for this service. For with the compact Model 785 alone, he can check motor and control circuits... lighting circuits... sensitive relay circuits... and even communications and electronic circuits. And in addition to wide adaptability, Model 785 also provides the ruggedness and dependable accuracy which is typically WESTON. Remember, too, that Model 785 is but one of many time-saving, cost-cutting, *multi-range*, *multi-purpose* instruments in the WESTON line. Why not have all the facts? Phone your nearest WESTON representative, or write to... Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transformers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

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Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters...Aircraft Instruments... Electric Tachometers...Dial Thermometers.

FOR OVER 52 YEARS LEADERS IN ELECTRICAL MEASURING INSTRUMENTS

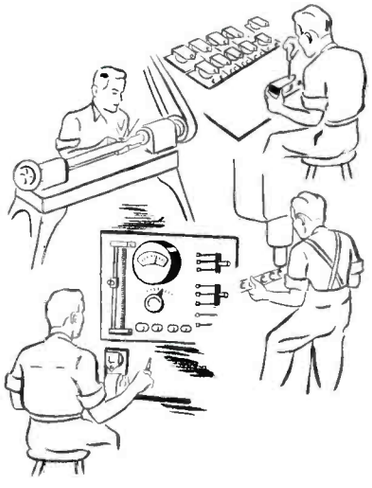
RELAYS FOR SPECIAL USES

If the Dunco Catalog Doesn't Describe *Exactly* the Relay You Need . . . . . DUNCO CAN MAKE IT!

Dozens of standard Dunco Relay types—many of them completely or partially assembled in stock—provide the basic designs from which hundreds of adaptations may be obtained. Each one can be "tailored" to your specifications economically, efficiently and rapidly.

Whether you require an ultra-sensitive midget relay for a temperature control job operated from a vacuum tube, or a husky, vibration-proof unit designed and fully tested for aviation service, Dunco has the answer just as we have the answer for countless other applications. Or, if you require a "different" relay for a new or unusual application, Dunco engineers will welcome the opportunity to make suggestions based on an exceptionally broad experience in the relay field.

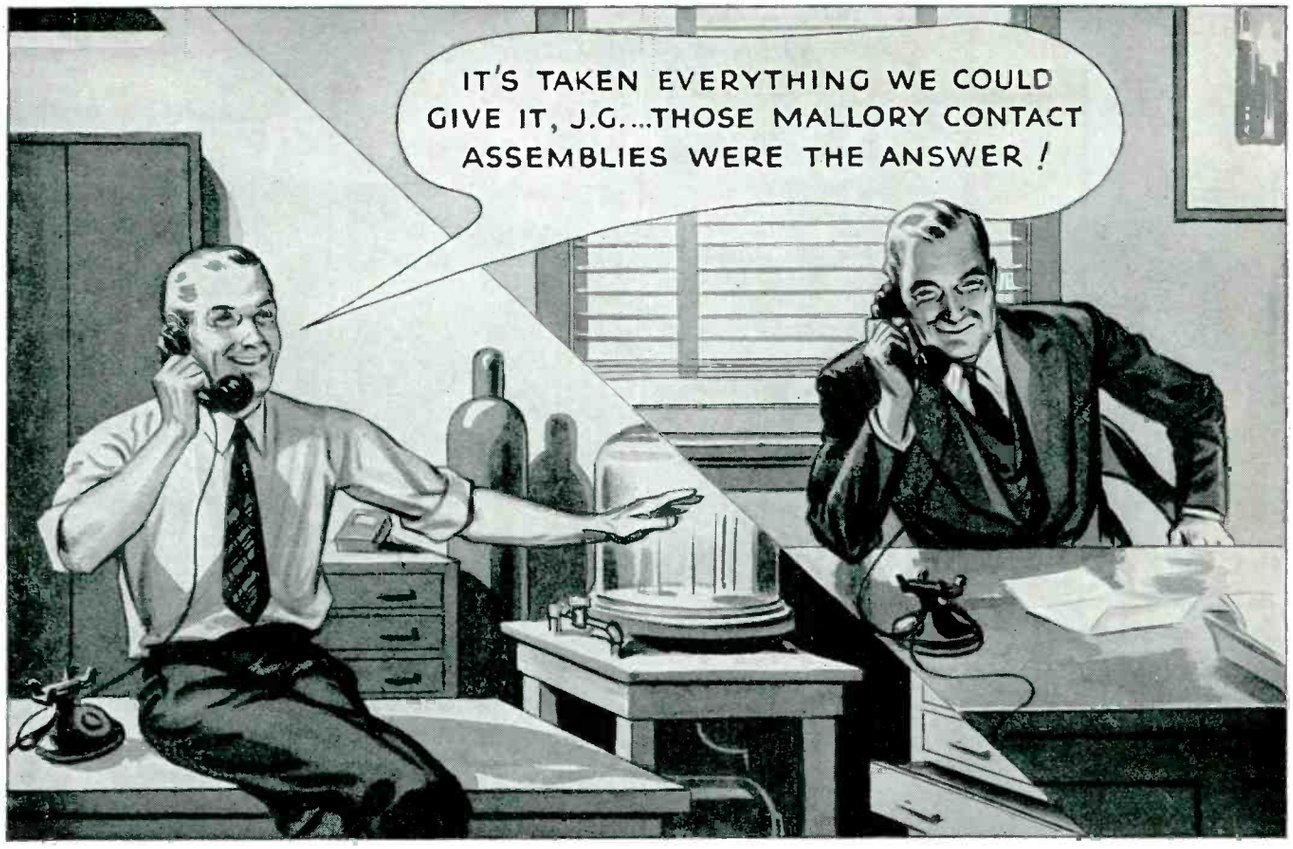
Catalog free upon request. Let us quote on your next relay specifications.



DUNCO RELAYS AND SOLENOIDS

A Complete, Quality Line—Individually Adapted to Your Specific Needs

STRUTHERS DUNN, INC., 1326 CHERRY ST., PHILADELPHIA, PA.



P.R. MALLORY & CO. Inc.

MALLORY Complete Contact Assemblies

May Have the Answer for You, Too !

Years of specialization in the development of electrical contacts have made it apparent that often the selection of the right contact material . . . even the proper design of the contact itself supplies only a partial answer to certain problems.

The composition and design of the contact member often requires the same specialized attention and experience in order to attain adequate efficiency.

With a staff of experienced metallurgists and design engineers, it is only natural that Mallory should undertake to provide this further service. Proper tension . . . contact attachment . . . corrosion resistance . . . simplified action . . . alloy selection . . . resistance reduction . . . better heat dissipation . . . these and a host of other problems are typical of those solved through Mallory complete contact assemblies.

No matter what type of contact you are using . . . be sure to have your Mallory representative give you all the facts about this most advanced Mallory contribution.

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

CROSS TALK

▶ **MISCELLANY** . . . Electronics industry is now reaping the benefit of a policy of hiring only "experienced" men during the last few years. Few companies had a training course; some hired many new graduates with the definite purpose of keeping only a few; after the weeding-out process these men were out of luck. Hardly a day goes by, now, but that ELECTRONICS staff receives call for trained men, but there are no such men.

Subscribers to McGraw-Hill publications drafted into the service may, if they desire, interrupt their subscriptions while in service. These subscriptions will carry on again after the reader's national defense stint is over.

The University of Illinois is planning a radio interference conference to be held in Urbana, Saturday, May 10. The purpose of the conference is to inform radio service men, radio amateurs, public service interference trouble shooters, and radio engineers of the sources of radio interference and their correction. Topics to be discussed include the generation of combination frequencies in a non-linear element, diathermy interference, receiver design to minimize strong signal interference, panel discussion on interference between radio amateurs and the broadcast listeners, the adjustment of transmitters to reduce spurious emissions, reduction of appliance interference.

A slight saving in cost and a possible improvement in tone quality may result in manufacturing ac-dc sets if a direct connection is made between one side of the power supply circuit and the chassis, and a few manufacturers do make such connections. These are not eligible for listing by the Underwriters' Laboratories, Inc., since there is a very materially increased hazard to the user.

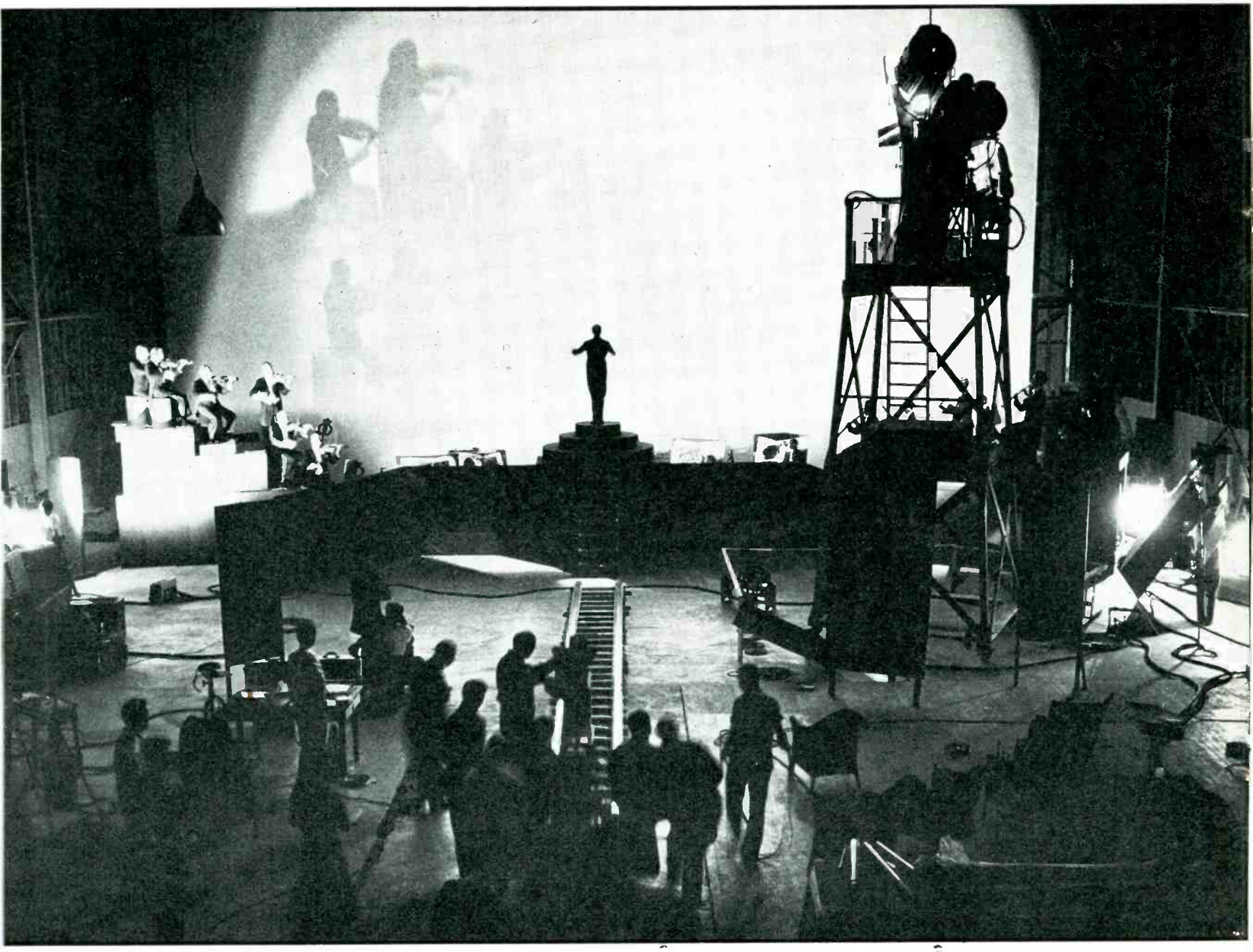
A project for the computation of mathematical tables has been in operation by the Works Projects Administration since January 1938. The aim is to compute tables of fundamental importance in mathematics, physics, chemistry, engineering, statistics and related sciences. Certain tables have already been published, but the Project is now looking for suggestions for additional tables to be computed. Communications should be addressed to Oliver A. Gottschalk, Works Project Administration, 70 Columbus Ave., New York City. Copies may be obtained from the National Bureau of Standards, Washington, D. C.

▶ **SYMPOSIUM** . . . For quite some time a collection of papers on "Temperature—Its Measurement and Control in Science and Industry" has been in the process of publication by the Reinhold Publishing Co., 330 West 42 St., New York City. This results from a symposium on the subject sponsored by the American Institute of Physics with the cooperation of the National Bureau of Standards and the National Research Council. The book will be a monumental volume, some 1375 pages, and with over 100 authors. The original papers have been edited, supplemented and indexed. Anyone wanting the last word on the subject of temperature control and measurement should find it in this volume.

▶ **YAHODI** . . . In December ELECTRONICS Anthony Lamb of Weston described certain new fields for magnetic relays illustrating his article with drawing of "little men" instead of more conventional drawings. Two letters have been received commenting on the use of this type of illustration. A reader in Summit, N. J. says:

"I have read with interest the informative article by A. H. Lamb on the application of sensitive relays in your December issue. You ask for reader's comments on the use of the 'little men' in the illustrations. I believe that the repeated use of such devices would tend to lower the standing of ELECTRONICS among professional engineers. However, if your object is to produce primarily a trade paper, it may expand circulation."

Another reader, this one in Ardmore, Pa., states that he has a friend named Yahodi and that this friend Yahodi, is much upset because Mr. Lamb's pictures look like him and he doesn't like being taken for a ride. Mr. Lamb, however, assures us that through an oversight a statement was not included in his article as published. The statement should have read: "The characters in these illustrations are purely fictitious. Any resemblance to real persons living or dead, or to Yahodi, is purely coincidental." We hope that holds Ardmore, Pa.



Almost as fantastic as the scene it records is this battery of lights and cameras employed by Mr. Disney for the photographic portion of his film. The double-track sound with its auxiliary control is recorded in another place, at another time, and reproduced in the theater on a separate film

WHEN stereophonic reproduction of sound was demonstrated some time ago (see ELECTRONICS, May 1940), many engineers felt that here was a valuable addition to the technique of reproducing sound for entertainment purposes. But at the same time they wondered how it could be applied to a practical entertainment system. They had heard rumors for several months that the new system was being applied to motion pictures. These rumors bore fruit when Walt Disney's "Fantasia" appeared on Broadway, where it has been showing for four months.

Fantasia consists of a number of musical selections played by a symphony orchestra, recorded and reproduced with stereophonic technique. The visual part of the program consists, for the most part, of a series of interpretations of the music as visualized by the Disney staff. The interpretations range from a series of vari-colored lines and curves which are induced in the interpreter's mind by the music, to the telling of a complete story, such as the "Sorcerer's Apprentice" starring Mickey Mouse. The visual phase of the program has no more than passing interest to the electronics engineer, hence further discussion will embrace the electronic aspects of the system.

The sound system in Fantasia makes use of three audio channels. There are three loudspeaker units in front of the audience, and to give a further feeling of directivity in certain parts of the program there are a number of loudspeakers along the side and rear walls of the theater. The three stage speakers are fed from separate sound tracks. The "house" speakers are fed by the sound tracks of the two side stage speakers and are put into use at desired times in the program by

FANTASOUND

In Walt Disney's animated symphony concert "Fantasia", the resources of the sound reproduction engineer have been called upon to immerse and surround the audience with stereophonic sound, at times with several hundred stupifying watts of it. Herewith is the technical story of a significant advance in sound presentation

the operator. Thus, the sound as heard by the audience appears to originate in more than one spatial location. The source can be made to shift with the action on the screen or to fill the entire width of the proscenium opening with different sounds originating at different points, as it would if a living orchestra were present.

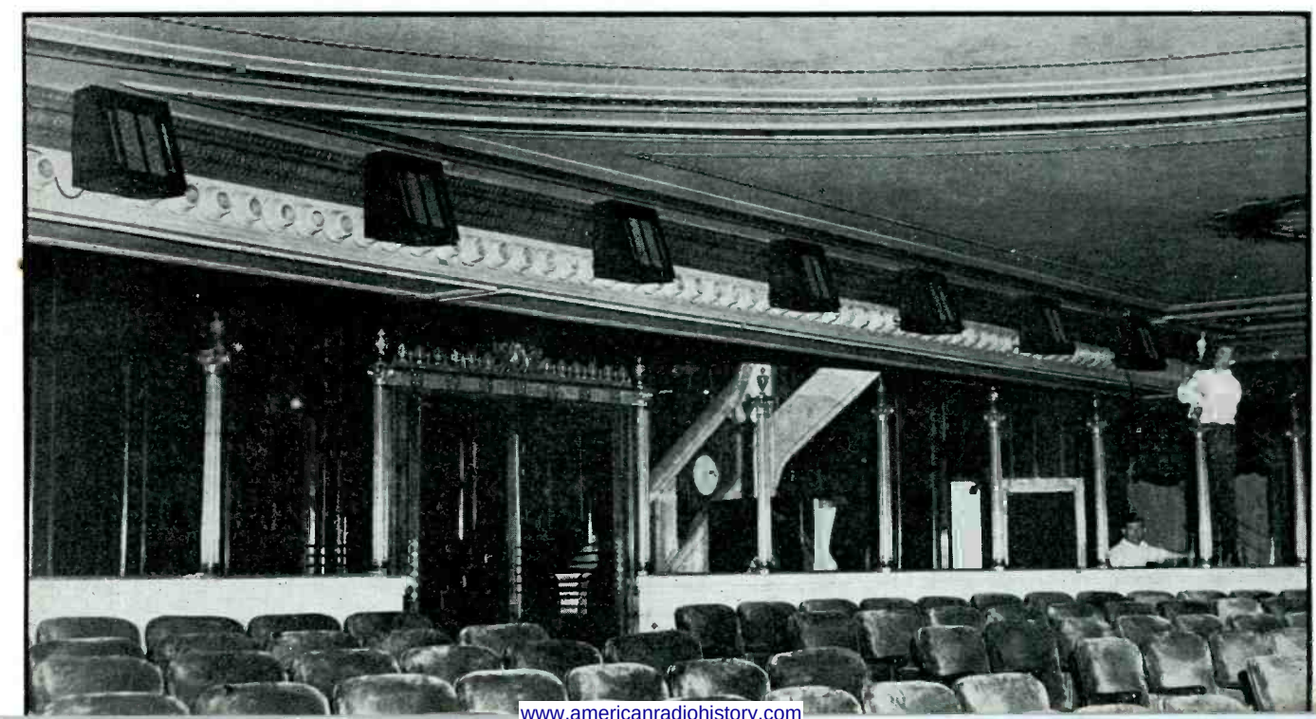
In Fantasia two standard 35-mm films are used simultaneously. One contains the visual part of the program and is run through a conventional projection machine. The other film contains the three sound tracks and a fourth track which controls the automatic volume expansion, and is passed through a multiple sound head which contains four phototubes and associated circuits, one for each sound track including the control track. The two films are run through their respective machines synchronously with each other so that the sound will be heard at the correct time relative to the picture.

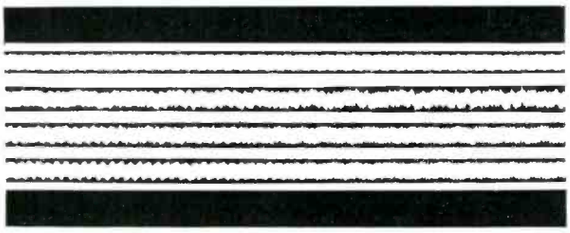
The method of obtaining automatic volume expansion is relatively simple and increases the dynamic range of the sound system by a very considerable amount. As the program is being recorded each audio channel contains a compression circuit to limit the modulation on the sound track to reasonable figures. At the same time each compression circuit causes to be recorded, on the control track, a signal whose amplitude is dependent upon the degree of compression for that signal. Three different frequencies are used and during reproduction the signal from the control track is split three ways by suitable frequency filters. Each of the three alternating currents thus obtained is rectified and is used to control the gain of the three amplifiers feeding the loudspeaker system. In addition to the compression of the recorded signal to comply with the limitations of the recording system, the musical director of the production also determines the volume levels of the signals in the three different channels to suit his interpretation of the music. Thus the music as heard by the audience may be considerably different from that originally played by the orchestra.

Each of the three speaker units on the stage includes both high and low frequency speakers to give the program the wide frequency range necessary in high quality sound reproduction. The high frequency trumpet clusters are mounted on top of the low frequency volume baffles. These speakers have a maximum audio input capacity of 320 watts, quite adequate to fill a theater seating approximately 3000 people with all the volume the audience cares to take.

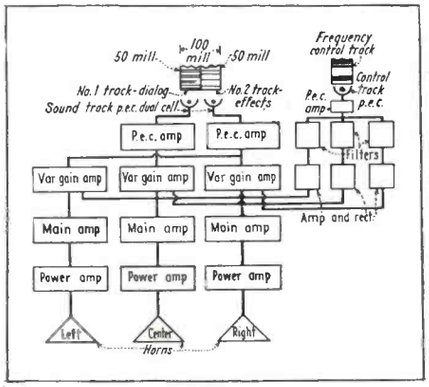
Sound is also brought out into the body of the auditorium by means

To give the audience the illusion of being immersed in the action on the screen, loudspeakers are placed at intervals on the walls of the theater, around the audience, and fed at appropriate times during the performance

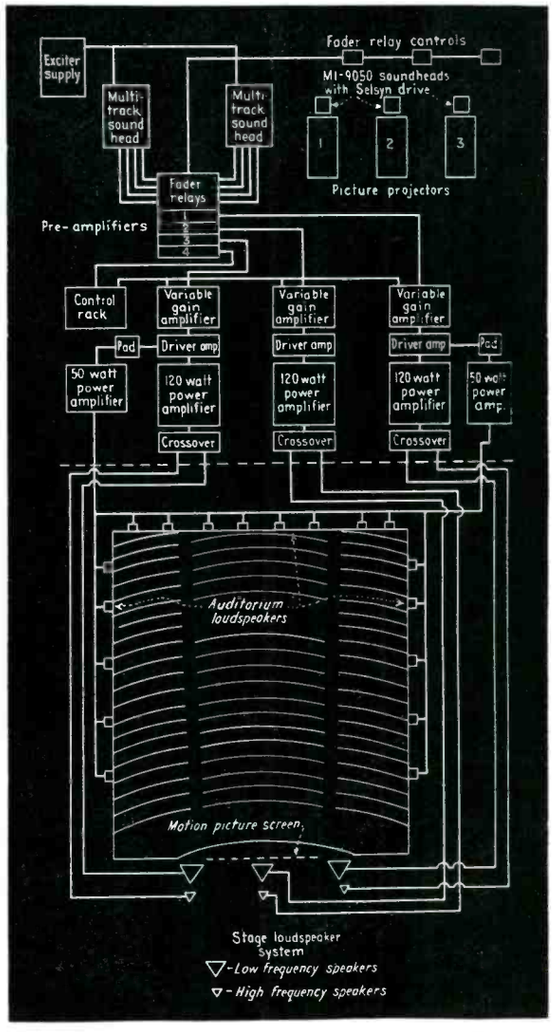




Sample of quadruple push-pull track record



Compromise reproducing system utilizing three channels in projection room



Block diagram of the reproducing system used for reproducing Fantasia

of supplementary units of the permanent magnet type located along the side and rear walls of the theater. These speakers are wired in two circuits, one for each side of the theater, the two groups being poled 180 deg. out of phase with each other. They are electrically substituted for the left and right banks of stage speakers by manual operation of a simple switch thrown by the projectionist according to cue. No appreciable trouble from standing waves appears to result; whatever dead spots may be created are possibly masked by the simultaneous operation of the center bank of stage speakers.

The house speakers give the audience the sensation of being in the action, with sound coming from all around them. The enormous audio output of 320 watts imparts convincing realism to the scene showing a volcanic eruption. Both realism and dramatic value are enhanced by a volume range of 75 db, of which 25 db is recorded in the sound tracks and 50 db more made available by the action of the automatic expander circuits. The audible source of sound shifts from side to side of the screen on appropriate occasions. For orchestra reproduction, the sound appears to come from the full width of the stage with the different instruments located as they would be in reality. The three results last mentioned are impossible with ordinary theater equipment and recordings; the first two have never before been used in commercial motion picture work.

For production of the quadruple push-pull record, the first step was to make eight simultaneous recordings of the Philadelphia Symphony Orchestra under the baton of Leopold Stokowski. The orchestra was divided physically into six sections —violins, cellos, violas, brasses, wood-winds and percussion instruments. Each section was grouped around its own microphones. Branch lines from each of these six recording channels were also fed into a mixer, and the mixer output recorded as a seventh track. The eighth track was obtained from a microphone located at a distance, which picked up the sound of the orchestra as a whole. The arrangement is shown in the block schematic on page 21, which includes one complete recording channel (across the top of the diagram). Six such channels were used, the output from each being carried to its own recording machine, to the mixer at the left of the diagram and also to the monitor mixer at the right. The close-mix recording (the seventh) channel is shown connected to the mixer at the left. The eighth, or distant pick-up channel, is not in the drawing.

The eight tracks thus made were combined into three sound tracks through mixing and re-recording under the direct supervision of the conductor, whose judgment also governed the respective levels of the

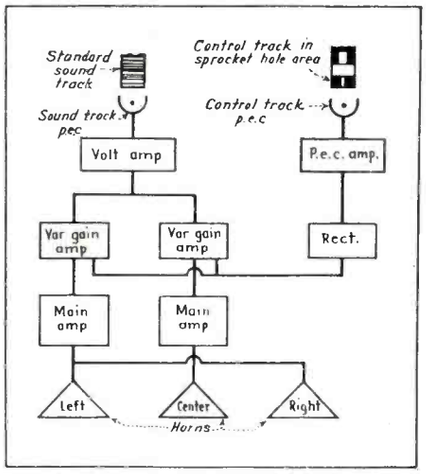
three control frequencies recorded on the control track.

The schematic on page 20 shows the theater reproducing system used for Fantasia. The three control frequencies derived from the fourth track on the film are separated from each other by filters and rectified in the control rack drawn at the left center of the diagram. Although the maximum simultaneous output power of the three channels is shown as equal to 360 watts the amplifiers were held down to a total of 320 watts in practice.

A number of the "Fantasound" systems have been built, and are being installed in theaters throughout the country on a temporary rental basis for the showing of Fantasia. They will be moved from theater to theater with the film. The necessity for using a separate film for the sound tracks, and the cost of this reproducing equipment, have led to efforts to obtain the same results (or some approach to them) through simpler means.

Rival Systems

A rival and much simpler arrangement is now being used at the Strand



Simplified theater reproducing system used at the Strand theater

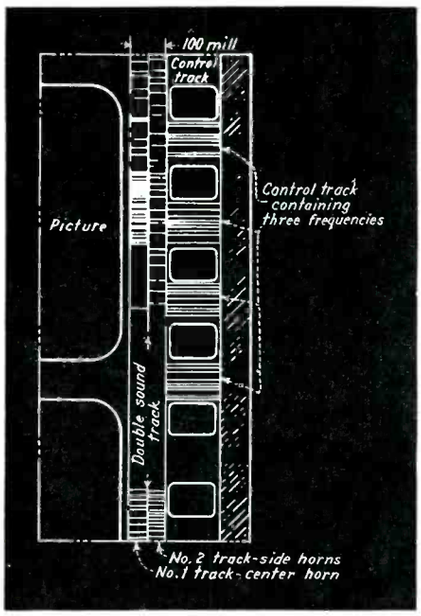
Theater, New York, for the showing of Warner Brothers' pictures. The arrangement requires only a single film (which carries a control track as well as a sound track) and only two amplifying channels. It does not yield all of the results obtainable from the more elaborate arrangement.

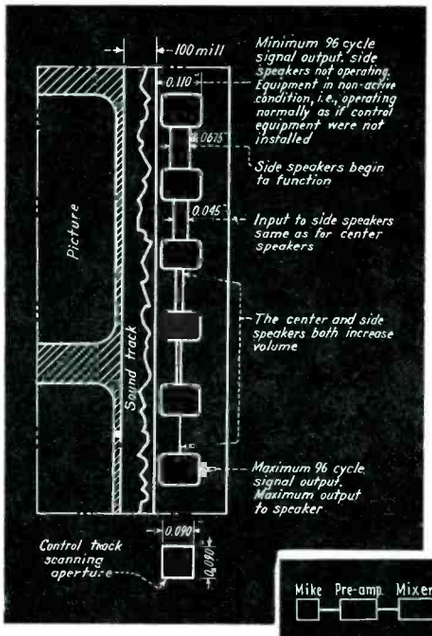
The control track is so designed that the sprocket holes are utilized as a source of 96-cycle current through a separate phototube. A simple variable-area record is placed between the sprocket holes. When this area is entirely opaque the 96-cycle signal is at maximum strength; it is at minimum strength when the area between sprocket holes is entirely translucent. The soundtrack on the same film is entirely conventional.

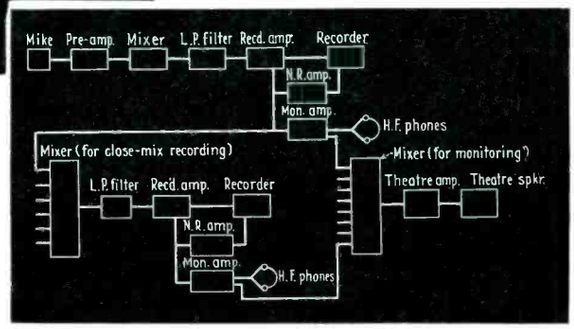
Since this arrangement has only a single sound track it cannot produce different sound from different sources simultaneously; nor can it produce sound from one side of the screen only. It does possess the advantages of expansion, and of utilizing the entire width of the proscenium opening as a source of sound, but in this case the sound heard from any point is identical in nature with that heard from any other point.

A compromise arrangement is a system which uses three channels in the projection room, two sound tracks and a control track, but needs no separate reel of film for the sound record and no separate sound heads for its reproduction. The two sound tracks are each half the ordinary width; they are located side by side in the usual sound track area and reproduced by a dual phototube. One side of this tube excites the channel leading to the central speakers, while the other supplies sound to both the side channels.

Some details concerning this arrangement have not been revealed and are understood not to be fully decided. The control track is located in the sprocket hole area; it consists of three pure-tone frequencies, but the method of dealing with the 96-cycle result of sprocket-hole modulation is still under consideration. Band-stop filters have been mentioned in this connection, but there is also some hint of an entirely new development of film recording which will embody the principle of frequency modulation.







To compete with Fantasound, several simpler systems have appeared designed to fit conventional projection systems with a minimum of modification. Above, right, control track between sprocket holes, as used in the Strand Theater. Above, left, another sprocket hole system. Right, a single recording channel as used in the Philadelphia Academy of Music

Muscular Paralysis Caused by Electric Currents

The values of electric current at which muscular paralysis occurs in humans have been investigated in this important study. The frequency was varied from direct current to 10,000 cps, checking the threshold of muscular non-control for a large number of subjects

By CHARLES F. DALZIEL
University of California
and JOHN B. LAGEN
University of California Medical School

THE danger from electric shock is self-evident when one considers how small are the electric currents which can be withstood with impunity. There is a natural tendency for man to overlook his frailty and take chances he would never consider if he gave the matter a moment's thought. Other important factors which are often responsible for fatal accidents are ignorance, carelessness, and the tendency for familiarity to breed contempt. The latter may assume increased significance in cases where the rated output of the equipment is low. These reasons are also believed applicable in explaining the many recorded fatalities on ordinary 115-volt lighting circuits. Perhaps an effective method of emphasizing the necessity for continued caution when handling energized circuits is to consider the currents that man can release by the use of his muscles only. Details of extensive experiments conducted at the University of California by the authors have recently been published.[1, 2]

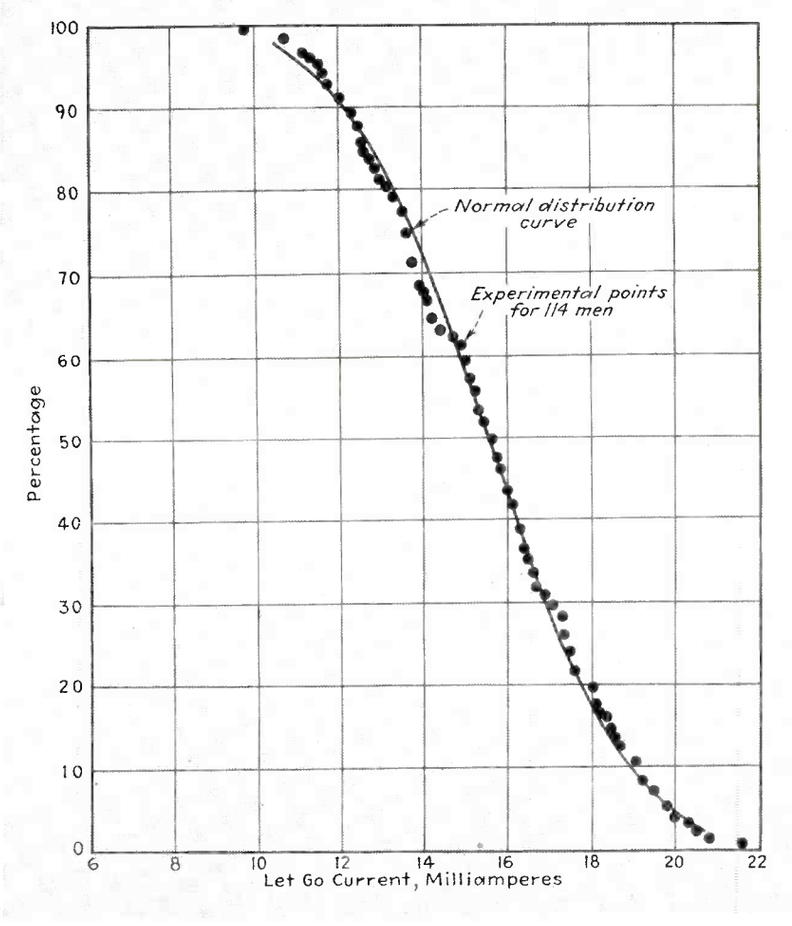


Fig. 1—Curve showing the threshold of non-control of muscular activity, or let go current, for currents at 60 cps

Tests were made to determine the threshold of muscular non-control, or the let-go current, of a group of normal men on direct current and on alternating currents from 5 to 10,000 cps. In these tests the subjects grasped and released a convenient length of No. 6 copper wire. The circuit was completed by placing the other hand or foot on a flat brass plate. This was done in the interest of safety and permitted the subject to break the circuit at any time he desired. With the subject grasping the wire, the current was gradually increased to permit him to become familiar with the sensations and muscular contractions produced by the current. After one or two preliminary trials, the current was increased to a predetermined value and the subject was told to drop the wire. If he succeeded, the current was increased to a higher value and the test repeated. The current values were gradually increased until the subject could no longer drop the wire due to the muscular contractions in the hand and wrist. Several trials were made to determine the let-go current with certainty and the number of trials per day were limited to minimize the effects of fatigue.

The results of tests made on 114

men using commercial 60 cps alternating currents are shown in Fig. 1. Because of the greater practical importance, a larger number of men were used at this frequency than in the other tests. The results of similar tests indicated that the let-go current was independent of the electrode size, moisture on the hands, and the current pathway through the body. The possibility of developing immunity to electric shock was investigated by repeated trials on successive weeks. It was concluded that the slight increase in the let-go current during the nine week test period was insignificant from a practical viewpoint. The effect of waveform was also investigated and it was found that muscular response was proportional to the peak or crest value of the current and not the effective value. However, to avoid confusion, effective values were used in preparing the curves.

Tests on 28 subjects were made using direct current. Steady direct currents produced sensations of internal heating rather than severe muscular contractions. Noticeable muscular contractions were produced by sudden changes in current magnitudes and severe shock was experienced when the circuit was interrupted. In contrast to the tests on alternating current, no subject had difficulty in releasing the test conductor. The maximum values obtained were termed release currents and represent the limit of physical endurance rather than the limit of muscular control. Test values for the group varied from 61 to 83 milliamperes.

For tests on other frequencies the number of subjects in a group varied between 25 and 30. For frequencies less than 60 cps, two alternators mounted on the same shaft were driven at the proper speeds to generate 5, 10, and 25 cps. The machines were connected in series and the stator of one was shifted with respect to the other to minimize harmonics in the output. For the higher frequencies, a beat frequency oscillator, power amplifier and vacuum tube measuring instruments were used, and let-go currents were obtained for 180, 500, 1000, 2500, 5000, and 10,000 cps. The wave form was constantly monitored using a cathode ray oscillograph, and the equipment was adjusted to maintain a sine waveform for all load conditions. A

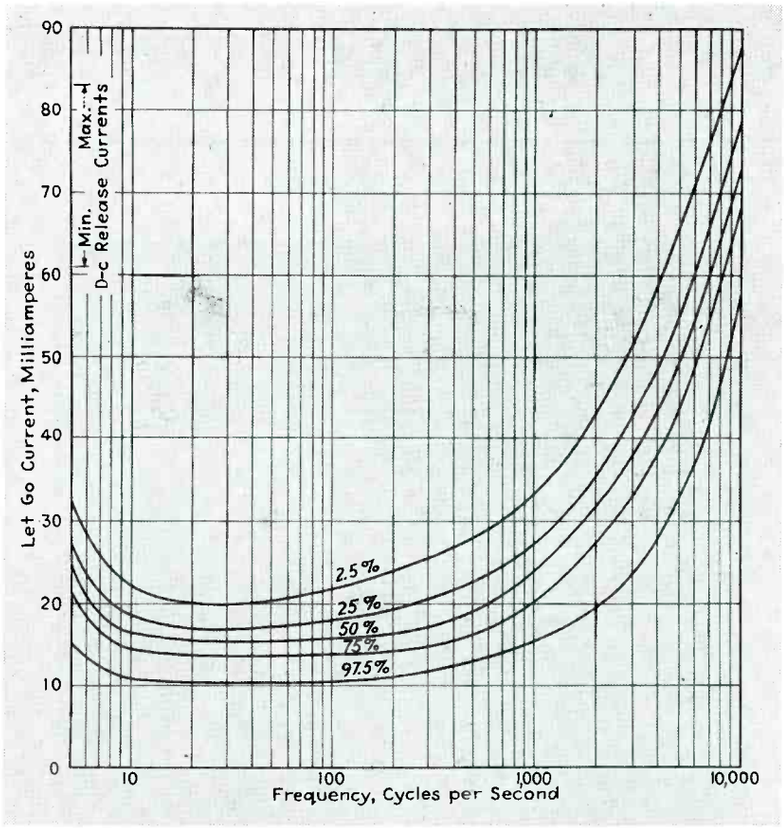


Fig. 2—Curves of let-go current vs frequency. The d-c values are shown in the upper left corner

curve of experimental points and a normal distribution curve similar to that of Fig. 1 was prepared for each frequency. The let-go current curves vs frequency shown in Fig. 2 were then constructed from the data obtained on the various frequencies. Direct-current values were also inserted in an attempt to give a graphical picture showing the range covered in the investigation. The curves indicate that there was considerable variation in a group as to the let-go current of an individual, some having much higher values than others. However, this is not particularly significant when one compares the maximum let-go currents with the amount of current likely to result in accidental contact, especially when the chief current limiting factor is body and contact impedance. It is interesting to note the relatively high values obtained on direct current in comparison with those on 60 cps. It is apparent that man is most sensitive to currents of the usual power frequencies.

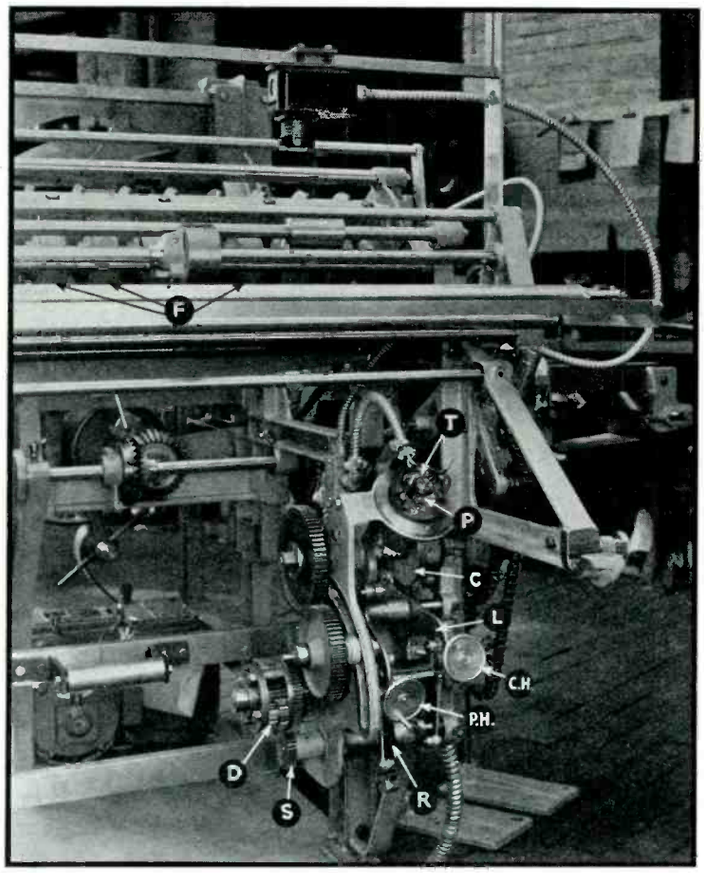
The ultimate aim of this research is prevention of accidents. Investigation and analysis of many fatalities indicate that ignorance or the lack of appreciation of the hazards by the victim, his family, or his associates is responsible in innumerable instances. Certainly one of the most practical and effective methods of reducing the accident rate is education and a better understanding of the dangers which accompany the use of electrical machines and apparatus. It should be emphasized that extreme caution must be exercised when working equipment "hot". In accidental contact, serious results may be expected from a firm grasp once established on an electrified object if the currents are above the individual's let-go value. Although in many cases an individual may release himself by using muscles little affected by the current, or may aid himself using body weight, interruption of the current is problematical and values in excess of the victim's let-go current must be considered dangerous. It is much better to be safe than sorry, especially when human life is at stake.

[1] Electric Shock, by Charles F. Dalziel, John B. Lagen, and Joe L. Thurston. A.I.E.E. Paper No. 41-7. Presented at the A.I.E.E. Winter Convention, January 28, 1941, Philadelphia, Pennsylvania and scheduled for publication in A.I.E.E. Transactions.

[2] Effects of Electric Current on Man, by Charles F. Dalziel and John B. Lagen. *Electrical Engineering*, Vol. 60, No. 2, February, 1941.

ELECTRONICS APPLIED

By E. F. CORNOCK
Package Machinery Company



Mechanical details of the register control: *F*, cork feed rolls; *T*, grid-circuit timer points; *P*, plate circuit points; *C*, cam for correction; *L*, lever driven by *C*; *CH*, hand wheel for correction adjustment; *PH*, wheel for adjusting permanent feed; *R*, ratchet driving *S*; *S*, spur wheel driving *D*; *D*, differential gear

FOR the last twenty-five years there has been a continual increase in the demand for practically all types of goods, household and otherwise, to be put up in individual containers rather than in bulk and this, in its turn, has led to a demand for the use of an individual printed design for each unit.

In the past an "overall" or closely repeated design was used but this was largely due to the expense involved in producing a printed design registered with the edges or panels of the package. In such cases where the design was registered the common practice was to use printed stock which had been cut into sheets before these were used on the package wrapping machine.

To produce these individually printed sheets the paper manufacturer could either use a flat bed press which prints each sheet separately or a rotary press which prints the paper in a continuous web. This latter method necessitated cutting up the continuous web into individual sheets before they could be used on the wrapping machine. This was generally accomplished on a separate unit or sheeting machine. With these sheeting machines a separate operator was required to work a manual control mechanism which would cause the paper to be cut in the right place and, as might be imagined, watching a continuously running sheet was a tiring process. About three hours seems to be the stint during which an operator can maintain good efficiency, so that at least two people are required to alternate.

Purely normal errors in human observation of the moving printed web required frequent correction in the length of paper fed to maintain the printed matter in the right place. These changes in the length of paper cutoff led to a further operation.

After the paper had been cut into sheets they generally had to be trimmed to the required size, for it will be recognized that sheets of varying size could hardly be piled in a stack for use on a machine. This trimming was an added expense, but was endured for many years while paper or paper-backed foil were the most common wrapping materials. When cellophane came into such widespread use a further problem confronted both the wrapping machine manufacturer and the users of this and similar materials. In the trimming process the sheets block together making the separation of the sheets difficult and practically necessitating the use of a continuous roll of printed web on the machine. This same problem of separation frequently arises in hard surfaced papers where the ink is slow to dry, causing the sheets to stick together.

If the printing and folding are both done on the same machine, it is a comparatively simple mechanical problem to cut the final printed sheets in the correct place, just as is done on a newspaper press. Where the printing is done on one machine and wrapping is done on another, frequently many hundred miles apart, there is a new problem in keeping the printed matter in register with the cutter.

The Register Problem

Almost all materials are affected to some extent by atmospheric conditions, particularly humidity, and will shrink or stretch accordingly.

TO PACKAGING MACHINERY

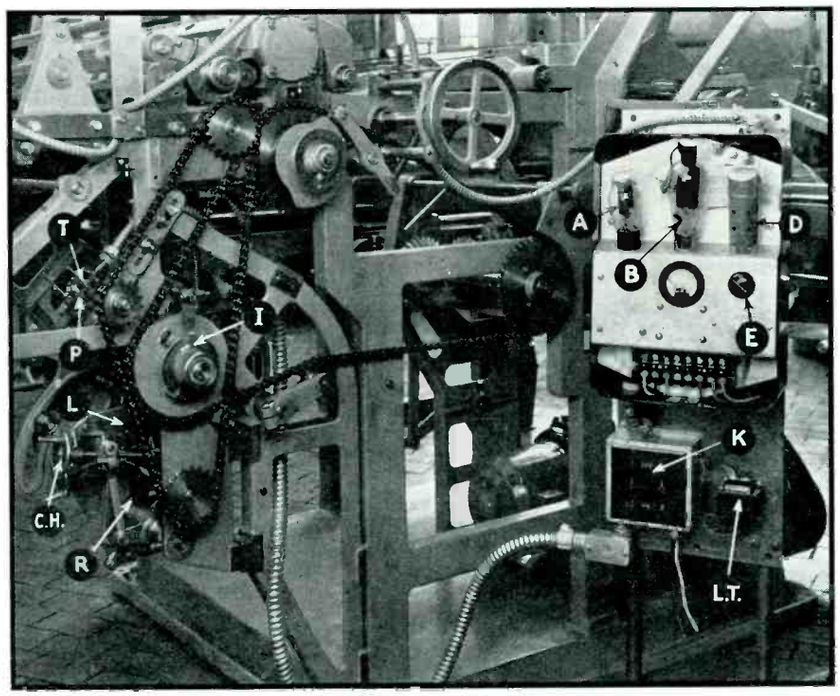
Therefore it may happen that the distance between the printed impressions on the web has changed considerably by the time the roll of stock is used. This change in length must be recognized by the wrapper feeding means on the wrapping machine and correction made accordingly.

The web feeding means on the wrapping machine is generally a combination of metal, rubber or cork rolls that pull from the roll of stock and deliver the web to a cutting device. Such feeding means are prone to error. If a ten-inch length of feed is required and the feed rolls deliver ten inches plus one one-hundredth inch error, then in one hundred sheets the design is one inch out of place. Add together any error made in the printing, any shrinkage or stretch of the sheet and any error in the feeding of the web and quite a large total error may result. It must also be noted that these errors are cumulative so that if there is a total error of two one-hundredths inch per sheet, then in one thousand sheets the error has amounted to twenty inches. Therefore, some control must be exercised over the feed of the web to maintain the cut in the proper register.

Intermittent vs Continuous Feed

Basically there are two ways in which the wrapper may be fed. It may be fed out intermittently and cut off, or it may be fed continuously and cut off while still running at full speed. In the first method the problem is generally of placement only. The wrapper is fed out and brought to rest before it is cut off, and while it is at rest it may be observed to see if it is in the correct position. On continuous feed, the problem is one of timing the arrival of the printed matter with the time of cutoff.

As the intermittent paper feed is the simpler this is the first one that will be described in a little more detail.



The electronic elements of the register control: *A*, rectifier tube; *B*, thyratron tube; *D*, pentode tube; *E*, sensitivity adjustment; *K*, main switch and time delay switch; *LT*, light source transformer; *I*, position indicator. The other letters refer to the mechanical gear and correction system illustrated on the opposite page

The roll of wrapping material is placed in a convenient location on the machine and from here the sheet is led over a slackener device which will maintain a more or less constant tension on the web as the feed rolls pull it out. The feed rolls themselves are driven by means of a jam-roller type of silent pawl which can transmit a crank motion into an intermittent rotation of these rolls. The advantage of the jam-roll type of pawl is not only that it is quiet, but particularly that it can give a very accurate feed because it is not dependent upon any ratchet tooth spacing. If nicely made and with fine limits of accuracy it can pick up and nip almost instantaneously. Presuming a crank is used to generate the motion, the crank pin can be connected to a lever by a link, producing an oscillatory motion of the lever. This lever will have a constant throw but if this lever is tied to a second lever by a spring, then some form of stop or latch can be thrown in to shorten the stroke of the second lever. From the second lever a rotary motion can be imparted to the jam-roll unit by means of a rack and pinion. When no stop is in the way of the second lever it can impart maximum rotation to the jam-roll unit and hence to the feed rolls, but when the stop is introduced the swing of the lever is shortened and hence the feed rolls rotate slightly less, thereby shortening the feed. The jam-rolls are used purely to translate a reversing rotary motion into a uni-directional rotary motion and from then on may be forgotten. We now have a means of varying the amount of rotation of the feed rolls and all that is required is to observe whether the printed matter on the sheet is in the correct location and if it is not, to correct accordingly.

To make this observation a phototube is mounted behind the web and a light source is placed on the other side of the sheet. Either a part of

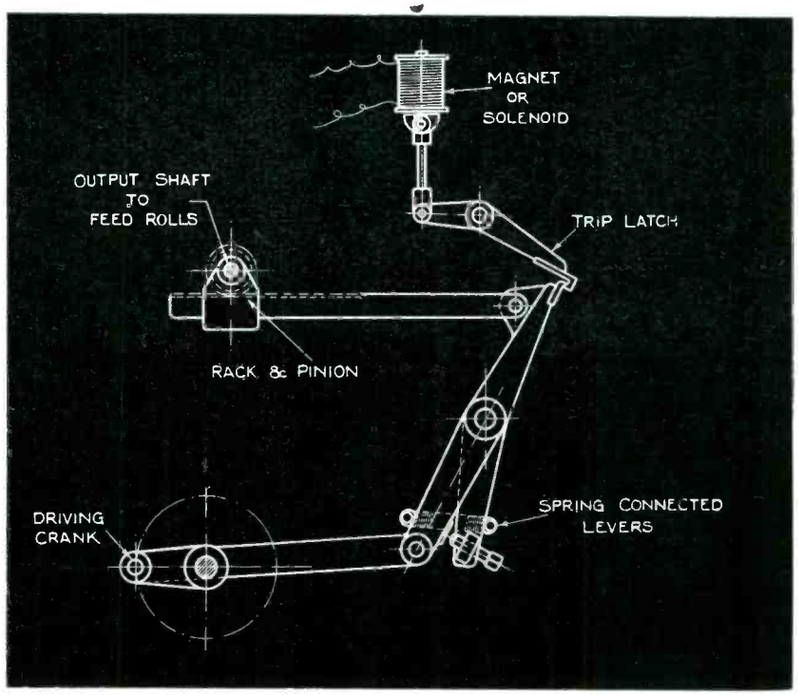
the printed design itself or a "spot", printed on the sheet at the same time as the design, is used to cover a narrow aperture in front of the phototube.

While the feed rolls are rotating and delivering the sheet, a pair of contact points are kept open, thereby preventing any reaction from the phototube amplifier unit, but when the sheet has come to rest these points close and complete the circuit. If the printed spot or design covers the aperture and prevents the light from falling on the phototube, then no reaction will take place. But if the sheet has fallen back so that the spot does not exclude the light, then reaction will take place and a correction should be made. This is done by a phototube amplifier which operates a magnet or solenoid which in turn throws the latch which controls the stroke of the second lever mentioned previously. It is now standard practice with the Package Machinery Company to adjust the length of wrapper fed by the feed rolls so that it is just *less* than the average distance between the printed impressions of the design. In this way we are assured that the printing steadily falls back so that correction need be made only in one direction —forward.

In high speed web feeds handling long lengths of sheets, it is advisable to use a two-way correction so that the feed may be made longer or shorter as required. It is of interest to note, however, that Package Machinery Company equipment successfully operates at speeds as high as twelve hundred sheets per minute using one-way correction only. This high speed work is done with continuous web feed.

When one-way control is used the printed design is always hunting. Due to the short feed it drops back a pre-determined amount until the aperture is not covered by the spot and then the sheet is given a boost forward a definite amount when the correction is made. It will be noted that the correction is made in the next feed after one sheet has been observed slightly out of place. In practice the hunting is limited to a very small amount and the width of the aperture, which actually controls the accuracy, is held as low as one thirty-second of an inch.

With the intermittent paper feed the time for observation is comparatively lengthy so that ac may be used throughout the phototube circuit. Ac can be supplied to both the grid and the plate of a thyratron so that the phase relation between the grid and the plate voltage determines the point in the cycle at which current begins to pass. The phototube acts as a phase-shifting device in conjunction with a capacitor, thereby causing the grid to become positive during the time the anode-cathode voltage is above the breakdown voltage across the tube.



Mechanical feed system employing a drive crank operating through a rack and pinion connected to the feed rolls. The magnetic solenoid operates the trip latch whenever the feed gets out of register

Continuous Feed System

So much for the slow speed machines which use the intermittent paper feed.

On the machines where the paper feed runs continuously the means of control is entirely different and, as mentioned previously, is a matter of timing.

On a wrapping machine it is naturally necessary to synchronize the various operations and this in its turn means that the arrival of the sheet at the station where it is to be folded around the article to be wrapped must have a definite time relation to the machine cycle. The cutter is driven one-to-one by the machine and the time of arrival of the spot must, therefore, be positively tied up to the time at which the sheet is cut. Due to this fixed sequence of operations the arrival of the spot must be controlled to the cutter of the machine and not the cutter controlled to the spot.

Of course the cutting time could be varied but this in its turn would require that the arrival time of the sheet at the wrapping station would have to be variable and obviously the choice of only one variable is better. The point of this explanation is that the *position* of the sheet at the time of cut must have a definite relationship to the machine time, or, as expressed above, it is a problem of timing the arrival of the printed matter with the time of cutoff.

Assume that a sheet 12-inches long is required at a speed of one hundred sheets per minute, also that the register spot is one sixteenth inch wide. We have then a paper velocity of 1200 inches per minute, or 20 inches per second. The time taken for the spot to pass a fixed line is 1/320 second. The phototube equipment must be capable of completing its cycle within that time plus a good safety margin. In addition the phototube must respond in such a form that some *mechanical* device can make use of it. It is here that we find the immense value of the hot cathode thyratron.

Once this tube has been "fired" it continues to pass current until the plate circuit is broken, and this "holding" action allows time for the mechanical parts to come into operation. The actual firing control, however, is practically instantaneous.

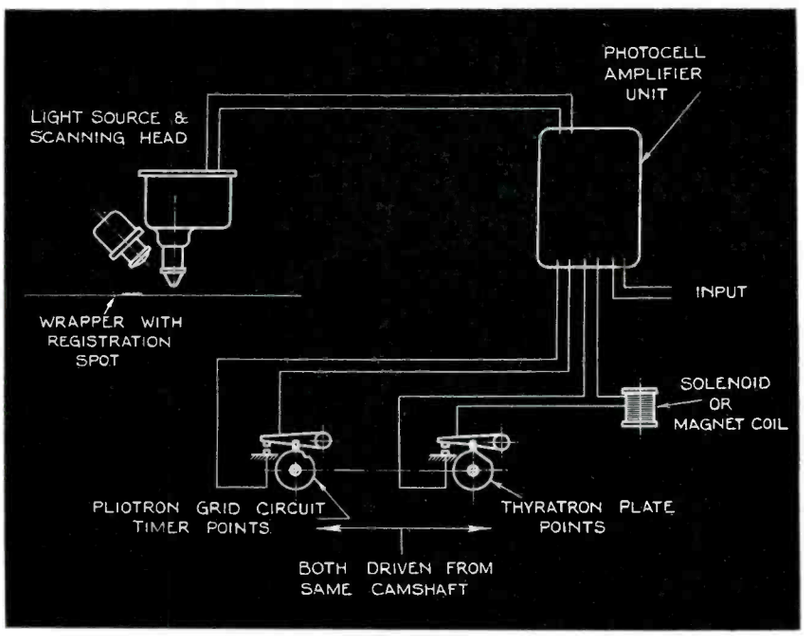
On the continuous type of web feed the sheet is cut off while still in motion by means of a rotary knife. The web feeding means are a set of feed rolls but in this case a differential gear is inserted into the paper feed drive. Picture the planet wheels of the differential being carried by the outer case of the complete unit. The main drive is applied at one end through the central shaft at that end and transmitted through the sun and planet wheels to the other central shaft at the opposite end. If the outer case is held still, the sun and planet wheels act as a regular train of gears. Once the outer case is rotated, the differential action comes into play and the amount of rotation of the output shaft is either increased or decreased depending on the direction of rotation. The paper feed rolls can be pictured as being mounted on the output shaft end, hence the amount of paper fed can be increased or decreased by rotating the differential housing, and this can be done while the rolls are running. We have, then, a means for adjusting the length of feed while the web is in full flight. All we need is a cam motion to operate a lever which will rotate the outer casing of the differential by a ratchet and pawl. This cam can be made to run one-to-one with the wrapping machine so that at each cycle it is possible for the paper length to be increased. If a timing means is supplied a phototube can observe to see if the spot arrives on time, and if it does not, a correction can be made.

Again it should be mentioned that after considerable experience and experimentation Package Machinery Company has adopted as standard the scheme of feeding the wrapper shorter than the average distance between the printed designs and feeding added length to correct the position when required.

The timer used is simply a pair of automobile timer points, running one-to-one with the machine. If the printed design is in correct register then at the instant the spot cuts across the aperture above the phototube the timer points are open, the circuit is not completed and no correction is made. If the spot is out of position it must be *late* in arriving over the aperture because the normal feed is slightly short. When the spot is late on arrival the timer points are still closed so that the circuit is complete and a magnet or solenoid can be energized. Briefly the sequence is as follows: When the spot is on time the points have opened the instant before the spot cuts the light beam. When the spot is late the points have not yet opened at the instant the spot cuts the light beam.

With such a form of timing it is necessary to operate the tubes on dc. The observation by the phototube is, therefore, instantaneous and as has been noted earlier, the firing of the thyratron is also instantaneous, but once fired it maintains its flow of current even after the spot has passed and light is again falling on the phototube. This allows almost one complete cycle of the machine for the mechanical correction to be made.

If a correction is required the current passed by the thyratron is used to energize a solenoid or magnet which in turn throws a latch. This latch being out of the way, the cam lever can follow the cam and rotate the differential casing. If the spot is on time the magnet is not energized and the latch prevents the cam lever from following the cam and no correction is made. It is, however, necessary to open the thyratron plate circuit each cycle of the machine to permit the grid to regain control, so that a second set of points is required. Once again, automobile timer points are used and as the firing and the breaking of the plate circuit have to maintain the same relationship the two sets of points are arranged as one unit. If for any reason the position of the cut has to be changed in relation to the printed matter, this is easily done by rotating the complete timer unit the desired amount. This method has the great advantage that the timer unit can be rotated the full 360 degrees permitting the cut to be made anywhere along the sheet.



Photoelectric scanning system for operating the magnetic solenoid. Periodic interruption of the grid and plate circuits through the timer points causes the thyratrons to operate in conjunction with the impulse from the phototube amplifier

Choose Spot Color Correctly

The sensitivity peak of the cesium-oxide-silver tube used is in the deep red end and causes the response to be particularly interesting in connection with paper registration. In the case of one application, in which the phototube unit was nominally operating on a decrease of light due to a spot of red ink intercepting the light beam, it was actually discovered that the output of the photo-

(Continued on page 82)

Receivers for the Tropics

Although manufacturers of radio receivers have for years taken precautions with equipment designed for tropical climates, the problem remains far from solved. The author, an American living in Panama, reviews the situation and makes pertinent suggestions

WELBY E. STEWART
Assistant Radio Engineer, Panama Air Depot

RECEIVERS sold in the tropical Americas are advertised, almost without exception, as being "tropic-proofed", "built for the tropics" or "specially treated against humidity". It would seem that these receivers could be expected to give a reasonable life to their purchaser. But, an inspection of the long rows of receivers awaiting repair in service shops contradict this assumption. Observation indicates that "tropic proofing" may consist of anything from an extra coat of varnish on the cabinet to a sincere job of impregnation against moisture, heat and insects.

To study the use of receivers and the cause of their failures in the tropics, it is necessary to look to the weather conditions encountered. None of the wide variety of climates found in the United States closely approximates those found farther south. Hence, few radio designers in the United States have a clear conception of the climate and its effect on radio equipment.

The area covered by what is generally known as tropical America naturally embraces a wide variety of climates, but the greater portion of this region is warm and very humid. Colon, at the Atlantic entrance to the Panama Canal, experiences some of the most severe conditions of humidity to be found in the whole region. Hence, it is an excellent place to observe the action of the climate on radio equipment, and the notes below are largely based on experience in this locality.

Colon, in common with nearly all of tropical America, enjoys a wet and a dry season. During the dry season, of about three months, there is a brisk trade wind from the Caribbean Sea. The rains are few and light. The sun shines much of the time, and the temperature does not vary greatly from its mean value of 80 degrees F., but the humidity stays at a comparatively high figure.

During the wet season, the trade wind drops to a light and variable breeze. It rains frequently and hard, an average of 128 inches falling each year. The sun shines infrequently. The temperature seldom varies more than five degrees from the mean value of 80 degrees F. The humidity continues very high. The relative humidity remains high even during the dry season. The most marked quality of the temperature is its monotonous constancy. Most of the failures in broadcast receivers may be attributed to the high humidity. As mentioned above, the conditions in Colon are near the extreme. A study of Central America and northern South America reveals that the coastlines and much of the interior experience a similar climate. Only where comparatively high altitudes are encountered is the climate drier and more temperate. In general, where the humidity and rainfall are less, the temperature varies more. However, the temperature seldom varies anywhere in this region as widely as is expected in any part of the United States.

A study of population densities indicates that the greater portion of the people living in these areas live in the tropical zones rather than in the higher, drier places. There are notable exceptions to this statement; for instance, Bogota, the capital city of Colombia with a population of 350,000, is at an altitude of 8,600 feet and has a moderate climate. Nevertheless, a radio receiver shipped to the Latin Americas has a very good chance of being used under extremely humid conditions.

One other special condition might be mentioned. In Colon, Panama, and its twin city Cristobal, Canal Zone, the entire population of forty thousand lives within a half mile of salt water. A large portion of the receivers are within reach of the fine salt mist thrown up from the sea when a heavy breeze blows. The tropical custom of building houses without glass in the windows leaves many receivers vulnerable to this additional corrosive agent. Since the islands and countries surrounding the Caribbean abound with port

(*Continued on page* 66)

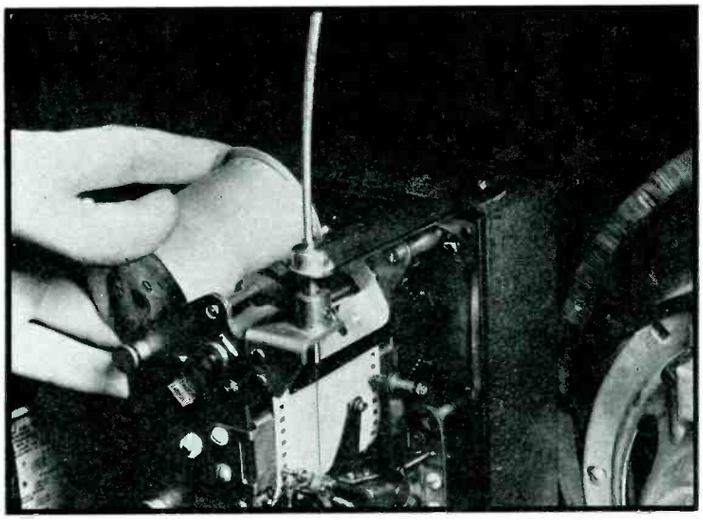
Tropic Radio Field

"EXPORT OF radios to Latin America have grown smaller, declared W. A. Coogan, foreign sales manager for a United States radio manufacturing concern, on July 18th, on his return to New York City from a tour of the field which took him well through Central and South America. This is due, he thinks, because American makers of radios fail to produce sets especially designed to withstand tropic weather conditions, adding that some of the South American countries have resorted to their own ingenuity in overcoming the defects. In parts and accessories, he says, the trade was as brisk as ever.

"Now if such a report was turned in to European manufacturers, whether radios or anything else, an inquiry would be set on foot promptly to supply what was lacking. Whether the American radio manufacturers will act on Mr. Coogan's hint or not remains to be seen. But they should if they hope to hold the trade when the race for business is again on."—Quoted from an editorial in *Star and Herald*, Panama.

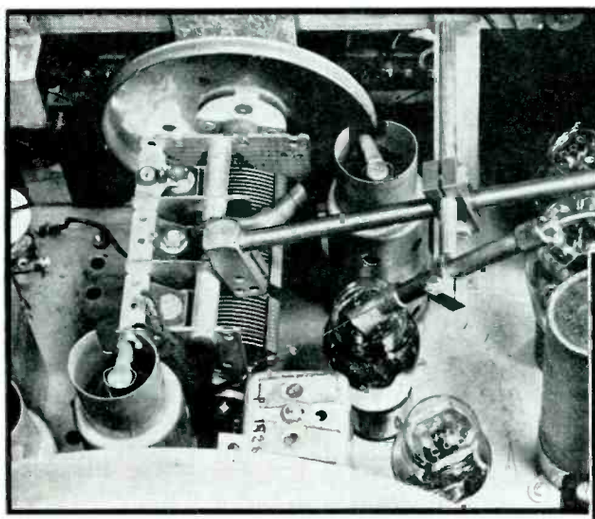
MEASURING THE PUBLIC TASTE

By means of a recording instrument attached to the shaft of the tuning condenser of a radio receiver, the listening habits of a family can easily be determined. The Nielson Radio Index uses this method to find out what people listen to, when, and how long.

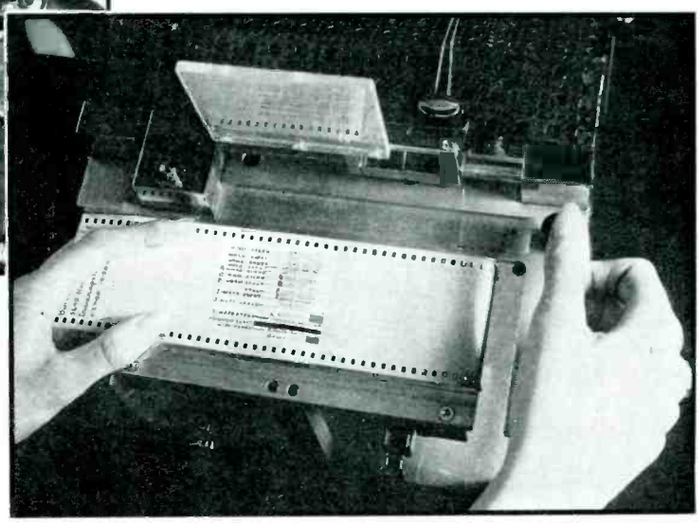


The Audimeter recording unit is placed inside the cabinet of the receiver and is connected mechanically to the tuning condenser by a stiff wire. The displacement of the recording stylus across the tape is directly related to the tuned frequency. The motion of the tape provides a record of the time each station is tuned in

Sufficient tape is provided for a full month's record of the operation of the receiver. This record gives a minute by minute history of what programs were listened to, when they were tuned in, when they were tuned out, and when the receiver was turned on or off



(Above) The wire connecting the Audimeter to the condenser is controlled by a cam attached to the condenser shaft. As the shaft is turned the wire moves longitudinally and changes the displacement of the recording stylus



Each record is decoded by comparison with a calibrated tape and the information is transferred to a perforated tabulating card. The curve at the top is a timing curve with a cycle of five minutes to obtain the length of listening periods

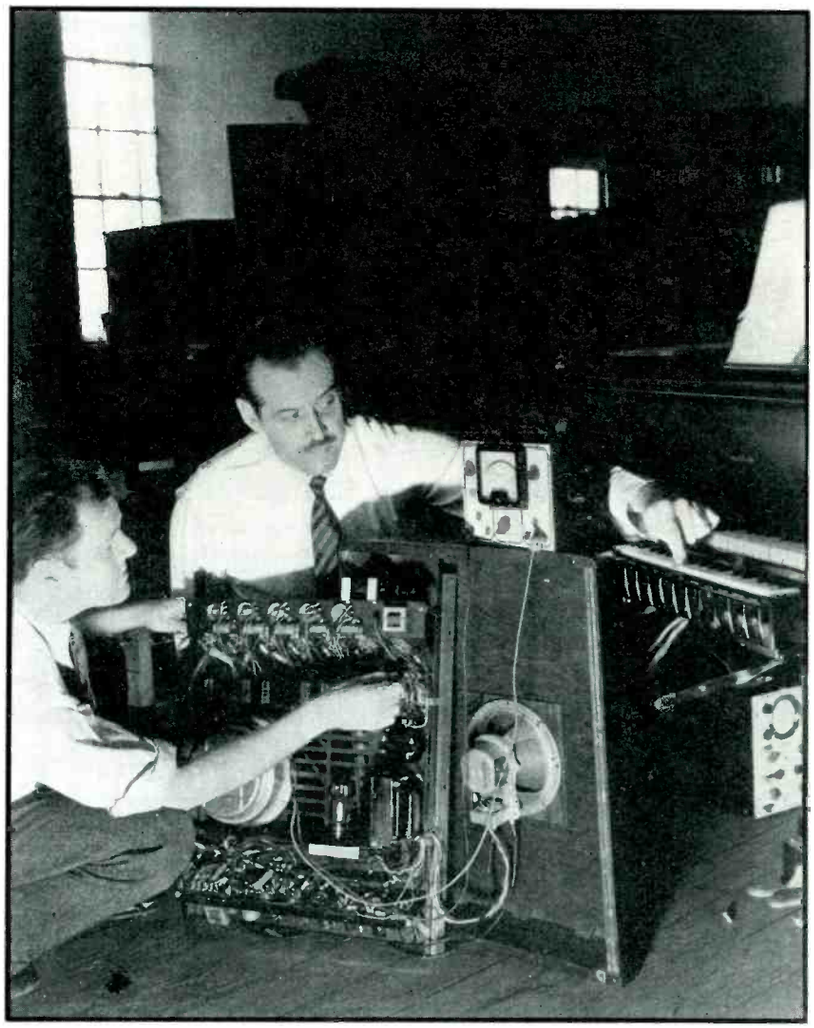
THE SOLOVOX

For less than two hundred dollars, the music enthusiast can now add to his piano a simple electronic music generator, with an auxiliary keyboard on which he may play solo passages with the right hand while accompanying with the left

By FREDERICK D. MERRILL, Jr.

FOR many years there has been a need for a really small, compact, portable musical instrument which would permit single tone solo performance with versatility of timbre, pitch range and tone envelope. Although such a device would preferably use a standard keyboard playing technique, conservation of width necessitates cutting down the number of keys. Early commercial models in this field received scant attention because either a new playing technique had to be learned or the range in timbre was too limited.

The Solovox manufactured by Hammond Instrument Company represents a new approach to this problem. Although it may be played independently, the combination with a piano is particularly appropriate because the organ quality furnishes a pleasing contrast to the percussive attack of the piano strings.



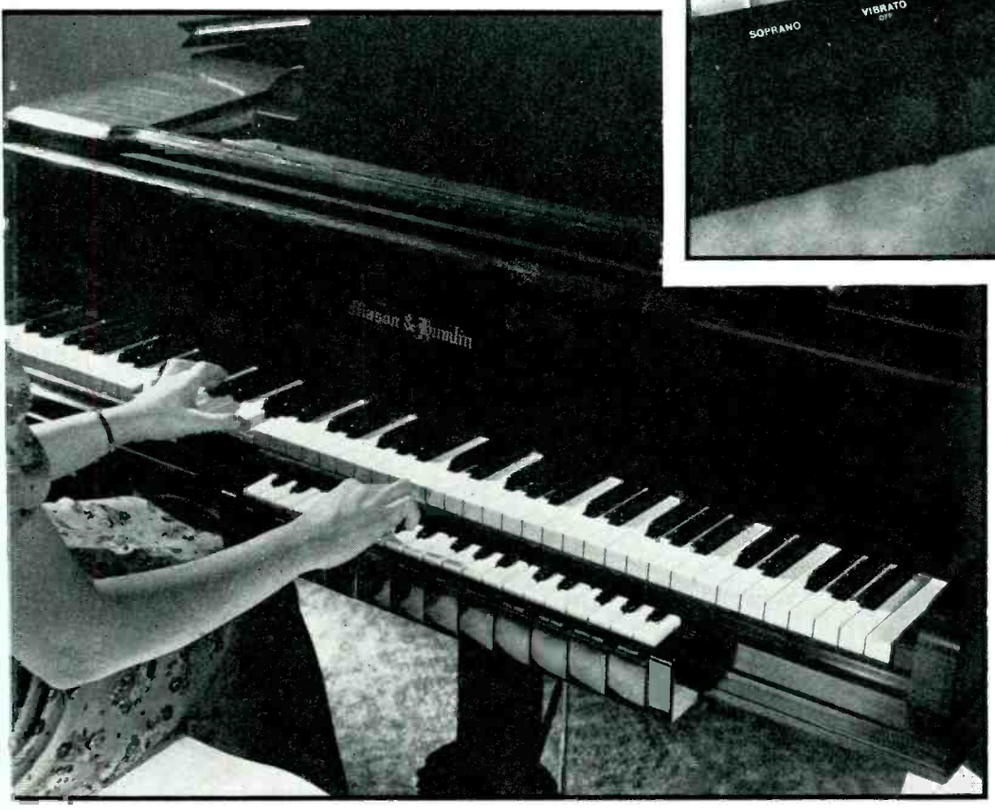
Mr. Laurens Hammond, right, displays the interior of his Solovox in the Hammond Laboratories. The tone-generating circuits are housed in a shallow cabinet which fits under a grand piano or at the side of an upright

General Principle of Operation

The principle of operation resembles that of the Novachord (ELECTRONICS, Nov., 1939) in some respects. A single master oscillator feeds into a cascaded series of frequency dividing circuits. Unlike the Novachord, however, the master oscillator frequency is varied according to the key being depressed. For this reason only one tone may be played at a time and chords are not possible except where these frequencies are related by octaves. The frequency dividers themselves are really controlled oscillators and not simply frequency divider tubes as in the Novachord. Tuned resonant or "formant" circuits provide a wide range of timbre. The attack or envelope is regulated by the grid bias variation of the control tube when a key is depressed. There are only three octaves of keys available but nevertheless six octaves in pitch range are present since five divider oscillator tubes operate. This represents a spread of 65.4 to 3951 cps. The register controls (bass, tenor, contralto, soprano tablet switches) choose the desired range or ranges of frequency at which the instrument operates. The block diagram outlines the functions of the various sections of apparatus.

The Generator Section

The frequency of the master oscillator is adjusted to any of the



Views of the auxiliary keyboard and tone selecting tablets. Since only one master oscillator is used, only one note may be played at a time

twelve chromatic tones of the highest octave range of the instrument (2093 to 3951 cps) by depressing any of the 36 keys. The actual octave pitch at the loudspeaker may be the same as the master oscillator or one or more octaves lower, depending on the number of divider stages chosen jointly by the key octave position and the register control.

The first controlled oscillator (buffer) is stabilized by the master oscillator and operates at the same frequency. Each succeeding tube is essentially a frequency dividing oscillator unit and its output tone is consequently of one-half frequency. In all there are six tone outputs separated by octave intervals always available.

The second controlled oscillator is tuned to approximately one-half that of the frequency of the buffer oscillator. Its frequency is stabilized to be exactly one-half that of the buffer oscillator by applying a "locking" signal from the buffer oscillator to its grid circuit through a potentiometer. These controlled oscillators are of the relaxation type and their frequency may be adjusted by altering the grid bias. Thus, all the controlled oscillators are tuned simultaneously to their approximate sub-octave frequencies by employing tuning resistors (in parallel with the master oscillator tuning condensers) for the appropriate grid bias. The amount of bias varies with the different keys.

The oscillators all operate at their top pitches when no key is depressed. When a key other than *B* is depressed, all oscillators simultaneously shift to the frequencies corresponding to the key. The master oscillator is accurately tuned by the tuning condensers and the controlled oscillators by the tuning resistors.

The particular oscillator output which the loudspeaker reproduces is determined by a second contact under each key, called the control contact. Three relays are connected to the respective control contacts of the keys in the separate upper, middle, and lower octaves. Each relay has a contact to connect the grid of the preamplifier tube to the desired oscillator through the register controls. For example, if the "Soprano" control is actuated, and the *G* key in the middle of the keyboard depressed, then the tuning contact under the key will tune all the oscillators to the *G* tones of the various octaves and the control contact will operate the middle octave relay. This relay completes a circuit from the output of the second controlled oscillator through a register control resistor to the middle octave relay contact, and then to the preamplifier tube. Thus, the register controls shift the pitch range of the keyboard as a whole to four different positions. In addition, by simultaneously depressing two or more of these controls, a composite tone will be heard consisting of the outputs of several oscillators sounding simultaneously in their octave relations.

Other contacts associated with each of the relays serve to prevent undesirable tones from occurring when two keys are depressed simultaneously in adjoining groups. If two keys are depressed within one of the three octave groups then the lowest pitched of the two will be automatically selected for sounding through the speaker.

There are two main divisions to the timbre control methods. First there is a "mute" tube which operates nonlinearly to suppress the sharp curvature of the input signal waveform, and thus weakens the higher overtones. When this more mellow timbre is not desired, the mute switch is used to by-pass the signal around the tube.

The second section of the timbre control circuits alters the frequency characteristics of the amplifier. The "Deep Tone" switch allows a condenser to by-pass the highs. The "Brilliant Tone" switch connects an inductance between high side and ground so as to furnish a comparatively low impedance path to ground for the low frequencies, resulting in their removal from the following stage. "Full Tone" retains both the high and low frequency components. The "First Voice" and "Second Voice" consist of resonant circuits tuned to respectively the 500-cps zone and the 1000-cps zone. These tone control circuits are connected in series so each may be used independently of the others. This timbre control method relies on the extreme richness of harmonics from the output of the preamplifier tube.

Envelope Control

Complete control over the tone envelope is not provided in this instrument. However, the tone onset may be adjusted to slow or fast, the former being used particularly for the organ, orchestra wind instrument and string simulation. The rate of decay cannot be adjusted except by using the knee operated volume control. There is provision made to eliminate decay transient thumps.

A gradual buildup of the volume from an individual tone to produce an organ or wind instrument effect is obtained as follows. The control contacts under the playing keys serve to remove the cutoff bias from the control tubes as well as to operate one of the three relays. This is brought about by dropping the bias to below cutoff for these variable mu control tubes. The time constant of the grid-cathode circuit slows up the tone beginning and ending so as to eliminate loudspeaker keying clicks. To speed up the attack a 0.1 μf condenser connected between the control tube cathodes and grids may be disconnected by operating the "fast attack" switch.

The Vibrato

The vibrato effect is produced by a small piece of powdered iron moving in and out of a coil connected to a tap on the master oscillator tuning coil so that the oscillator frequency varies. The iron itself is supported by a magnetically driven reed which is first set into motion when the volume control lever is pulled forward in starting the instrument.

Volume Controls

There are two volume controls provided in the instrument. The first limits the maximum volume obtainable from the instrument and is located under the keyboard compartment so that adjustment may be made for the particular room being used. Normally it is not operated during the playing of the instrument. A knee swell used by the player for volume expression moves a switch connected to seven fixed resistors. These form a part of a voltage divider circuit which varies the grid bias to the remote cutoff control tubes, so as to change the gain.

Tuning

The Solovox is tuned once to put it in agreement with the piano or other instruments it is accompanying and no additional retunings are necessary. Since but one master oscillator is used, the entire operation is accomplished by adjusting the frequency of the master oscillator alone by turning a knob located on one corner of the tone cabinet. This results in moving a powdered iron core in or out of an inductance in the master oscillator circuit. The controlled oscillators can also be readjusted to correct pitch should one attempt to alter the master oscillator greatly from its normal frequency, but this is seldom necessary.

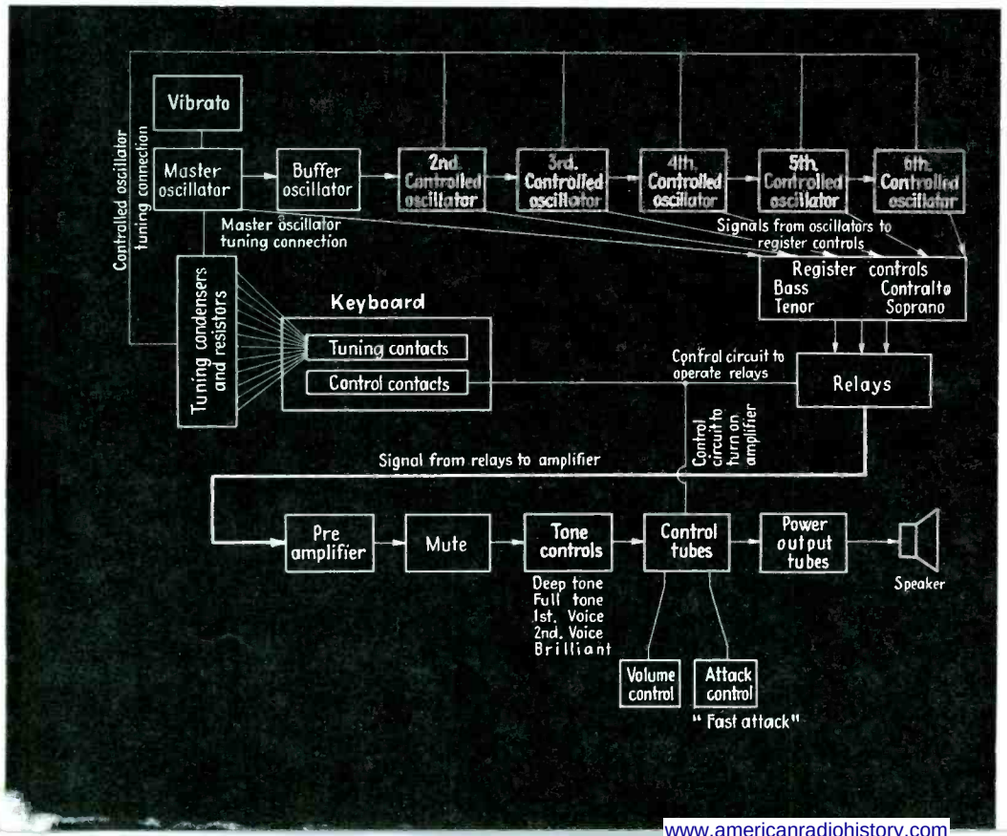
An interior view of the generator and amplifier chassis as well as the loudspeaker cabinet is shown in the accompanying photograph. The large round container at the left protects the relays from dust, etc. This assembly is so shallow that it may be attached to either side of an upright piano or to the bottom of a grand piano.

In the belief that the instrument would find particular application with pianos to provide a wind instrument solo part, the keyboard with the associated control tablets is designed to be attached to the front edge of the piano as shown in the illustrations. The lowest *C* is placed opposite the middle *C* of the piano so that the thumb of the right hand can play the Solovox and the remaining fingers simultaneously depress the piano keys for accompaniment similarly as is often done by organists.

The wide range of tone colors, frequency, and organ-like attack with optional vibrato provide a small solo keyboard instrument of great versatility.

Readers are referred to United States Patents: Re 20,831; Re 21,137; 2,099,204; 2,117,002; 2,142,580; 2,203,432; 2,203,569 for background information on this electronic musical instrument.

Block diagram of the electrical circuits of the Solovox. The keys control the frequency of the master oscillator and controlled oscillators, whereas the tone tablets connect various tone-modifying auxiliary amplifiers and filters



An Electronic Integrator for Counting Circuit Contacts

Devised for indicating the average number of relay closures per minute in an ultraviolet radiation recorder, this circuit is applicable to a wide variety of industrial control applications requiring supervision or measurement of repetitive circuit operations

By G. W. KENRICK

University of Puerto Rico

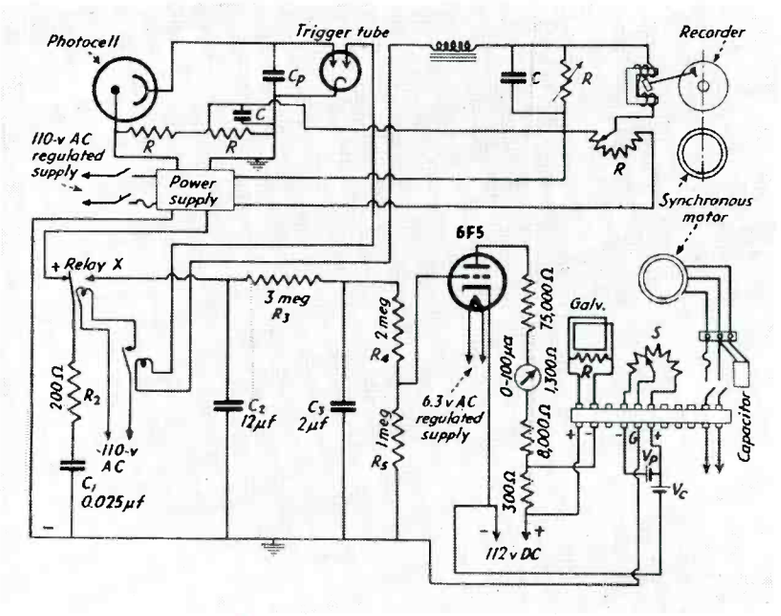


Fig. 1—Circuit diagram of ultraviolet recorder and associated electrical integrating circuit

IT is the purpose of this article to describe an electrical counting and integrating circuit which was developed for use in connection with an ultraviolet solar radiation record using a gaseous tube. It is believed, however, that this circuit is adaptable to many counting processes and is in no sense confined to the particular application for which it was evolved.

Some time ago the writer was asked to supervise a series of ultraviolet solar radiation measurements at the School of Tropical Medicine of the University of Puerto Rico, under the auspices of Columbia University. The equipment available consisted of a Westinghouse type W-6095 photoelectric recorder[1]. The original circuit of this recorder is shown at the top of Fig. 1. This circuit avoided the use of a three element vacuum tube amplifier by the use of a gaseous trigger tube shown in the figure. The phototube, which has a response curve peaking in the ultraviolet and cutting off sharply toward the visible, is used to charge the small condenser C_p which finally assumes a sufficiently high voltage to produce a discharge in the gaseous trigger tube. The ionization thus produced permits the discharge of the large condenser C which in turn causes a click to be recorded on the circular type chart recorder shown at the right of the figure. Thus the phototube current, by controlling the rate of charge of the condenser C_p, produces discharge clicks at a rate proportional to the intensity of the ultraviolet light falling on the cell. The number of breakdowns of the trigger tube per minute can be used as a measure of the average intensity of the ultraviolet light falling on the photocell during this period[2]. In order to translate this record into a graph of the intensity of the ultraviolet radiation as a function of time, it was necessary to count the number of clicks per unit time during the entire duration of the record, and in order to secure a continuous record extending over a period of an entire day it is necessary to have an operator change the chart every three hours.[3]

It seemed of interest to develop a device giving a direct instantaneous reading of ultraviolet intensity as a function of time on a chart capable of following, in reasonable detail, short period variations in intensity which are not evident from a casual inspection of the click-type record. It was thought that such a development would eliminate much of the laborious work associated with counting the numerous clicks appearing on the chart obtained from the continuous operation of the equipment during daylight hours, eliminate the necessity for frequent changes of the charts, and produce a record on which short period variations of ultraviolet can be readily noted while the recording was in progress.

A vacuum tube amplifier might have been used to replace the trigger tube, inasmuch as a considerable

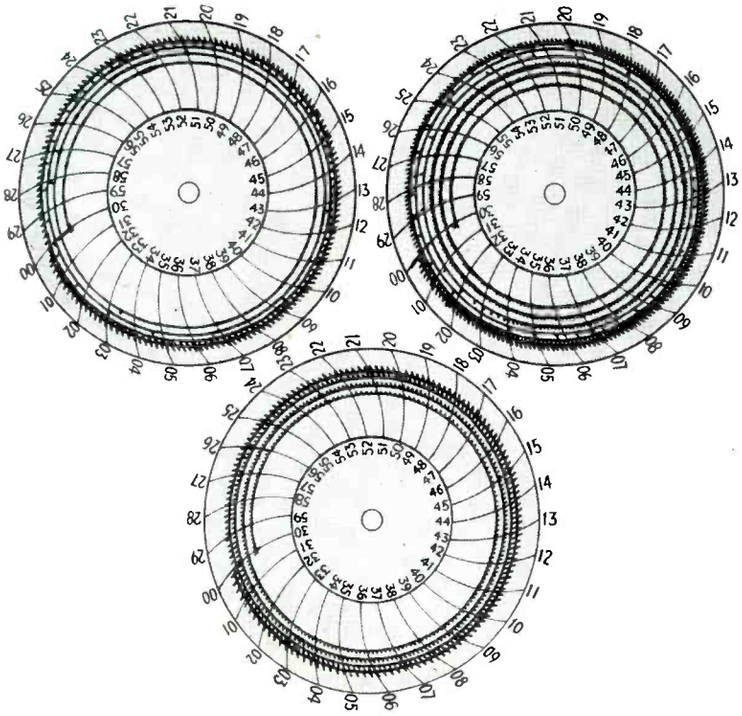
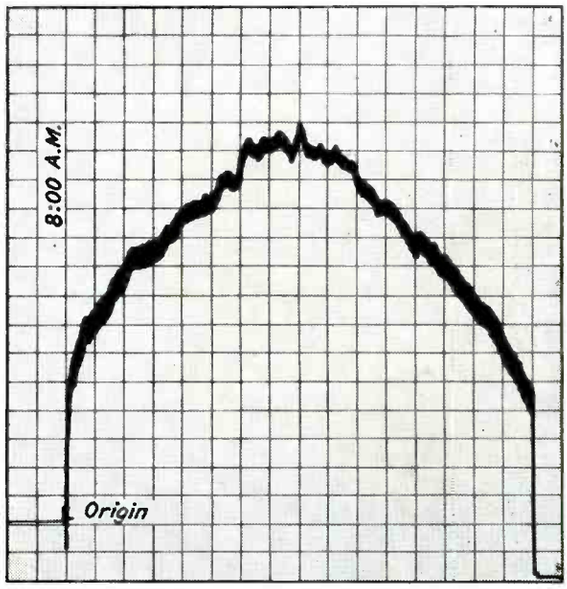


Fig. 2—Comparison of chart record and corresponding Leeds & Northrup graph taken with integrating counter recorder



amount of data already existed using the trigger tube and condenser combination. It seemed preferable, however, to evolve a solution which would not necessitate extended recalibrations of the recorder, thereby removing any doubt as to comparability.

It was decided to seek a solution which would not interfere with the continuity of operation of the recorder and its normal chart record assembly and at the same time provide a supplementary record on a recording galvanometer. Attention was directed to a development which would permit the number of clicks per minute to be averaged, and the average plotted continuously on a Leeds & Northrup recorder which could be operated continuously with little or no attention. It is believed that the circuit evolved is appropriate for recording the average number of impulses occurring per unit time whenever these impulses can be used to actuate a counting relay, therefore, it may have numerous applications other than that to which it has been put in the reduction of ultraviolet solar radiation data.

Further details of this electrical counting and averaging circuit are shown in the lower section of the Fig. 1. An additional relay is connected in series with the condenser discharge circuit of the recorder. When this is actuated by a click discharge, it energizes another relay X which must be maintained at a high insulation with respect to ground to prevent errors due to a minute leakage current across its contacts which might contribute to the charge on the tank condenser C_2.

A small counting condenser C_1 is normally maintained charged to a relatively high well-regulated voltage. For convenience this is derived from the power supply of the photoelectric recorder. It was found desirable to maintain a high constancy in this voltage. This was accomplished by the use of a Raytheon voltage regulator (W1525) used in conjunction with an output potentiometer to permit the maintenance of other than normal regulated output voltage (115 volts). When the counting relay X closes, the counting condenser C_1 is temporarily placed in shunt with the large reservoir condenser C_2. Voltage equilibrium between condensers C_1 and C_2 is thus attained during the brief period of closure of relay X. Since C_1 is very small with respect to C_2, the change of potential of C_2, due to the charge transferred from C_1, will be only a fraction of a volt.

The charge on the reservoir condenser C_2 then leaks off very slowly through high resistances R_3, R_4 and R_5 which are adjusted to values appropriate to make the R-C time constant comparable with the period desired for the "counting" (two or three minutes). A secondary smoothing reservoir condenser C_3 is introduced to minimize recorder oscillations, which might otherwise predominate, at low click-rates. In general, the time constant of (C_3) $(R_4 + R_5)$ need only be long compared to the closure time of the relay X and the marking circuit movements of the recorder, while the time constant (C_2) $(R_3 + R_4 + R_5)$ must be long compared to the interval between counting clocks.

As numerous clicks (i.e. closures of relay X) occur at a rate determined by the intensity of the ultraviolet, an equilibrium is gradually established in which the average voltage on C_2 approaches a well defined low value nearly linearly proportional to the average click-rate of the counting relay. Some of the causes of departures from linearity have already been suggested in connection with the values of the circuit time-constants; they will be discussed in greater detail later. Insofar as they cannot be made negligible, they can be made partly compensatory, and finally checked by an overall calibration.

When a quasi-steady state has been reached, the discharge current of C_2, passing through R_3, R_4 and R_5 is nearly linearly proportional to the number of clicks per minute of relay X since each of these clicks transfer

about the same charge to condenser C_2.

This would be rigorously so if the difference of potential of C_2 and C_1, were always constant; actually, of course, the C_2 potential varies slightly with the click rate. However, since this potential is seldom more than about ten per cent of that of C_1, the charge transfer per click is nearly constant. There is only a slight "saturation" effect at high click rates.

Therefore, we have only to measure the extremely small leakage current in R_5 in order to determine the click rate averaged over a period comparable to the time constant of the $(C_2 + C_3)$ $(R_3 + R_4 + R_5)$ circuit.

This is conveniently done by introducing the voltage drop produced by this current in passing through R_5 as part of the grid voltage of vacuum tube 6F5. If the grid of this tube is maintained negative by battery V_c, the grid load will not appreciably affect the voltage developed across R_5 due to the small R-C leakage current. This current is so small, and the circuit impedance so high, that ordinary meters cannot be employed.

The voltage variations in the plate circuit of the vacuum tube could be adapted to record on a Leeds & Northrup recorder with the aid of an appropriate network. However, this would introduce the grid voltage-plate current characteristic of the vacuum tube 6F5 which cannot be assumed to be linear.

It was considered preferable to utilize a voltage substitution method in the grid of the vacuum tube, that is, a circuit designed to maintain the total grid potential at a constant level. Under these conditions the plate current of the vacuum tube also remains invariable. This was accomplished by the circuit indicated in Fig. 1 in which the Leeds & Northrup recorder is utilized in an application somewhat different than its conventional role of a recording potentiometer or voltage divider.

In the conventional application of the Leeds & Northrup recording potentiometer the deflections of the galvanometer G from its equilibrium position are utilized to move the contact on the slide wire S in such a direction as to reduce the current through the galvanometer. In these applications, the appropriately shunted galvanometer and slide wire contact form part of the central arm of a Wheatstone bridge or voltage-divider circuit and the galvanometer is balanced for zero current, so under null conditions it produces no motion of the sliding contact P which it controls by its deflections.

In the modified application, that of a voltage compensator, the pointer is adjusted to a coordinate origin point on the chart which is usually a few divisions from the edge of the paper (to check plus and minus balance changes). Then with no click input, a bias voltage V_o (plus a small residual from V_p) is sufficient to produce nearly, but not quite, zero plate current with an appropriately chosen plate voltage of about 100 volts. The galvanometer shunts are adjusted so that this corresponds to approximately full scale (but not overload) deflection, the suspension of the galvanometer is then adjusted so that it is in tension by the appropriate amount to bring the needle back to its center position. The recorder, when started, should then record a straight origin line with zero click input.

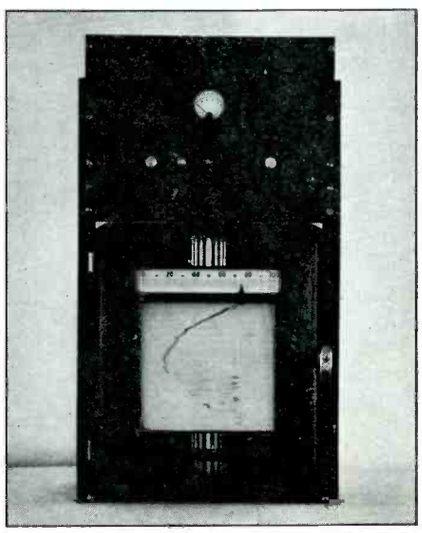
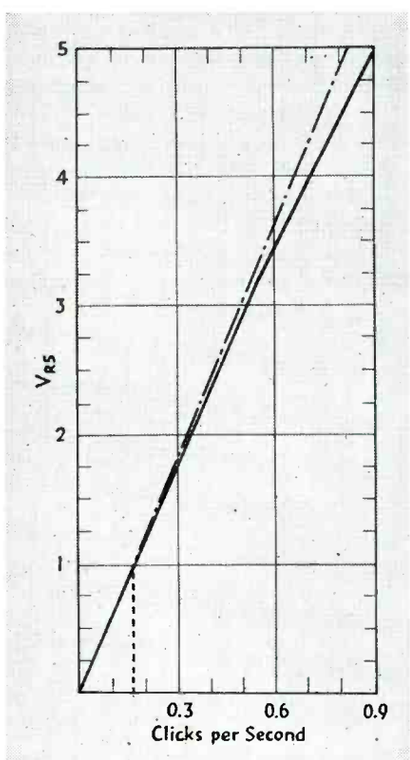


Fig. 4—Physical appearance of integrating circuit and Leeds & Northrup chart recorder

Fig. 3—Theoretical curve obtained from equation on page 74 indicating the linearity and experimentally determined points over working range



However, if clicks are introduced by an input from the ultraviolet recorder to relay X, a voltage appears across R_5 which reduces the negative grid bias of tube 6F5 and hence increases its plate current. This deflects the galvanometer needle from its false equilibrium position and this in turn results in an upward movement of pointer P. This movement can be made upward by appropriately choosing the initial polarity in the connection of the galvanometer G. The motion of the pointer S changes the grid bias voltage derived from the slide wire and this voltage is in a direction to oppose the voltage introduced by the action of the clicks, that is, it is in a direction to make the grid more negative. By an appropriate choice of the polarity of the voltage V_p, it is always possible to make the grid negative with an upward movement of the slide wire.

The upward motion of the pointer on the slide wire stops when the voltage derived from this circuit is equal to the voltage across R_5, that is, the voltage under measurement. This voltage is linearly proportional to the position of pointer P along the slide wire. Should the pointer move further up on the scale, the direction of deflection of the galvanometer from its equilibrium position is reversed and the pointer moves back down again toward the equilibrium position. It is essential to adjust the speed of motion of the pointer and the galvanometer damping and shunting so as to reach equilibrium.

When this equilibrium is reached, the voltage recorded by the Leeds &

(*Continued on page 74*)

Tracing Tube Characteristics on a Cathode Ray Oscilloscope

This dynamic method of determining tube characteristics permits higher values of current and voltage to be used without damage to the tube under test. A simple technique, using d-c coupled amplifiers with equal phase shifts, permits accurate delineation of the curves

By JACOB MILLMAN and SIDNEY MOSKOWITZ

College of the City of New York

THE observation of volt-ampere characteristics of vacuum tubes by means of a cathode ray tube has many advantages over the static point by point method[1]. Chief among them are the speed with which the characteristics are obtained and the safety with which the upper limits of operation are observed. The dynamic method allows higher voltages to be applied for short periods of time which are insufficient to cause damage to the tube whereas a constantly applied voltage of the same magnitude as used in the static method would be detrimental in the time necessary to observe the current values and to record them. The oscillographic observations are of great value for rapid testing of tube characteristics since the operation of the tube over its entire range of voltages is observed at a glance.

The most important characteristic of a vacuum tube is its plate current as a function of plate voltage with grid voltage as a parameter. The fundamental method of observing this characteristic on a cathode ray tube would be to apply a periodically varying voltage to the plate of the tube and the horizontal deflecting plates of the oscillograph, as in Fig. 1. A voltage which is proportional to the plate current is applied to the vertical deflecting plates. This voltage is obtained by inserting a resistor R in the plate circuit of the tube, the voltage drop across this resistor being proportional to the plate current flowing through it.

However, in order to keep the error in the determination as small as possible, the inserted resistor must necessarily be made as small as possible. It then becomes necessary to apply the voltage drop to the vertical plates through an amplifier in order to give an adequate voltage deflection.

Phase Shift

One of the chief difficulties encountered in attempting to obtain volt-ampere tube characteristics on an oscillograph is that the trace often appears in the form of a "loop" instead of a line. This is due to phase shift, as can be seen from the following considerations. If two equal sinusoidal voltages are applied to the plates of a cathode ray tube, then a straight line at an angle of 45 degrees will appear on the screen if the voltages are in phase. If, however, there is a phase shift between the two voltages so that the horizontal voltage is expressed by $x = E \sin \omega t$ and the vertical by $y = E \sin (\omega t + \theta)$ then an ellipse will appear on the screen (since by eliminating t from these equations an expression between x and y results which is the mathematical equation for an ellipse). In the limiting case of θ = zero, the ellipse degenerates into a straight line as noted above and for small values of θ, the ellipse appears as a narrow loop. It may be shown from the above equations that the maximum vertical "opening" of the loop is $2\ E \sin \theta$. For a trace covering the three-inch cathode ray screen, it follows from the above that even for a phase shift of only 0.5 degree, the opening is 0.7 mm which is enough to be very annoying to the eye. This numerical illustration shows how extremely careful one must be to avoid even a very small amount of phase shift between the horizontal and vertical voltages. The phase shift is due to interelectrode or stray capacities. It can be introduced at three places in the circuit, namely: at the cathode ray

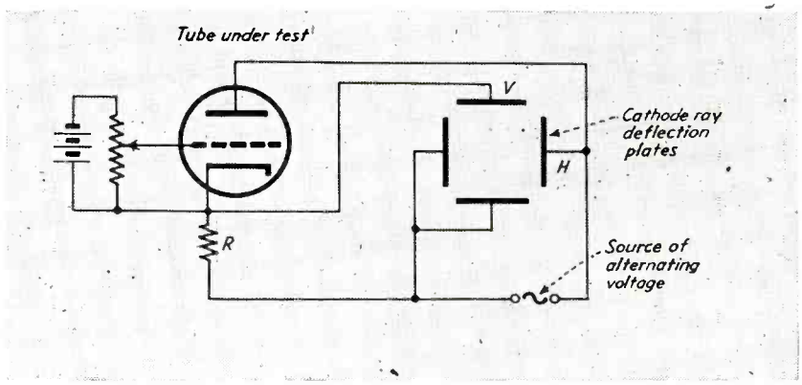


Fig. 1—Basic circuit for measuring tube characteristics oscillographically

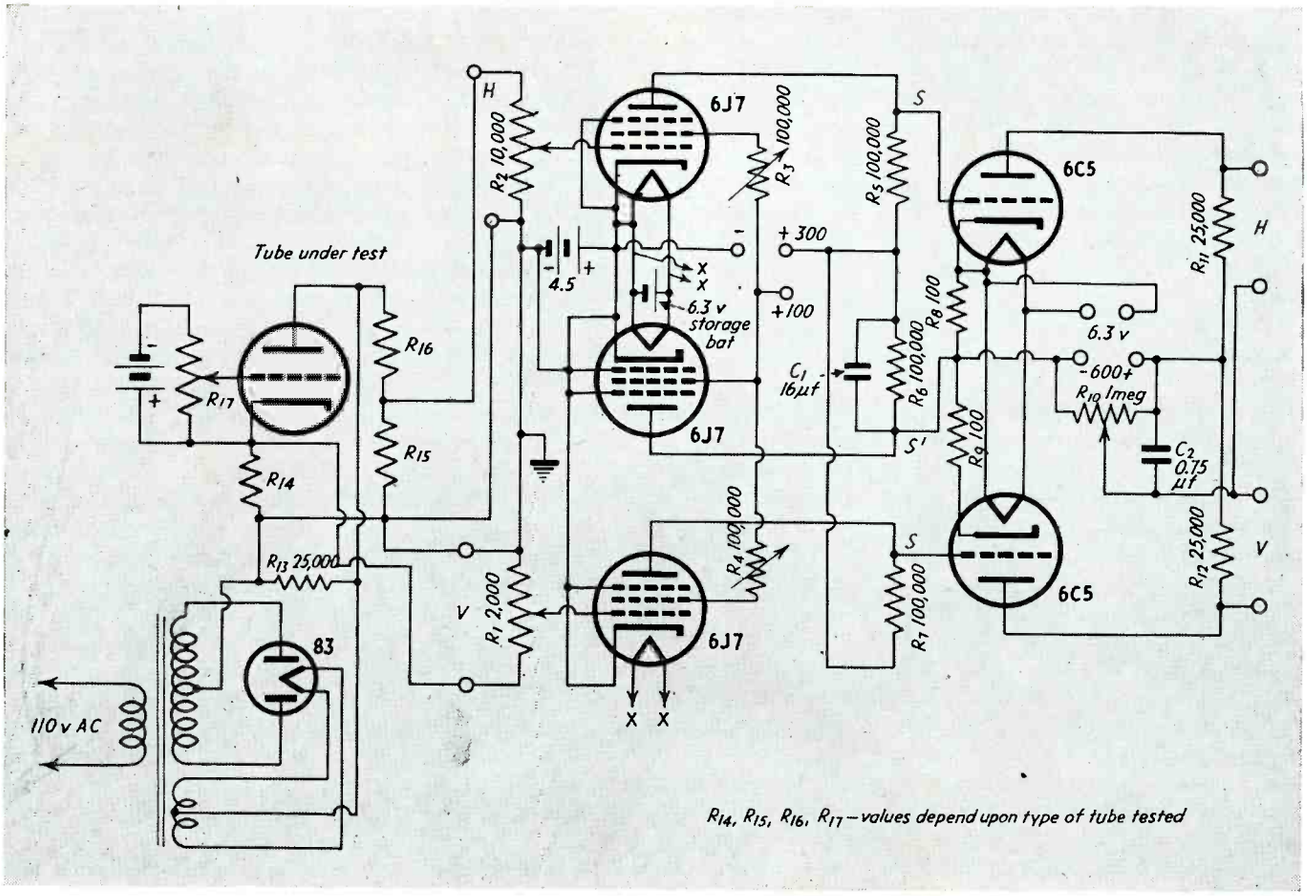


Fig. 2—Complete circuit diagram of the amplifiers used to develop the deflection voltages for the oscilloscope

tube plates, in the amplifier or in the tube under test. Each of these must be considered.

At first it would seem improbable that the tube interelectrode capacities, which are of the order of magnitude of micromicrofarads, would cause noticeable phase shift at 120 cps[2]. However, a simple calculation shows that a capacitance of 10 micromicrofarads when shunted by a one megohm resistance introduces a phase shift of 0.5 degrees which, as noted above, is excessive. This means that the resistance which shunts the cathode ray tube plates must be much smaller than a megohm in order not to produce a noticeable loop. It may be shown that the parallel combination of the load and the tube plate resistance determines the phase shift introduced at the cathode ray tube plates. By using the 6C5 triode with a load resistance of 25,000 ohms this parallel resistance was made less than 10,000 ohms which thus assured negligible phase shift.

The gain of this triode amplifier is only about 15 and hence it was preceeded by a high gain pentode (6J7) so that an overall gain of about 1000 was obtained. The grid voltage swing employed in obtaining transfer characteristics is usually too small to be applied directly to the plates of the cathoderay tube, hence an amplifier was used for the horizontal plates as well as for the vertical plates. Furthermore, by designing identical horizontal and vertical amplifiers there can be no relative phase shift between amplifiers. This was demonstrated by applying the same signal to both amplifiers. A straight line (without the slightest trace of a loop) was observed for all frequencies up to 20,000 cps.

In only a very few cases was a loop observed in measuring volt-ampere characteristics and in each case it could be traced to the tube under test. Usually by rewiring to eliminate stray capacities the loop disappeared. However, if the tube possessed large interelectrode capacities and if these were shunted by high (dynamic) plate resistances, then some phase shift was inevitable. If this phase shift was small and increased linearly with frequency, then it could be compensated for by introducing an equal phase delay into the other amplifier. This was accomplished by putting a variable capacity of the order of 1000 $\mu\mu$f across points *SS'* (Fig. 2) of the appropriate amplifier. Of all the tubes tested, only in one, (a phototube), was it found impossible to remove the loop. This was due to the extremely high dynamic and non-linear plate resistance of the tube which could not be compensated.

The Amplifier

If the plate volt-ampere characteristics are to be obtained at various grid voltages, the d-c component of plate current must be amplified together with the a-c component and its harmonics. If the d-c component is not amplified, the trace observed on the oscillograph screen tends to orientate itself so that the average value of deflecting voltage is zero

about an axis lying along the diameter of the screen. When the grid voltage of the tube under observation is changed, the d-c plate current changes and the trace is therefore shifted from its true position relative to the trace observed at the previous value of grid voltage. This condition therefore dictates the utilization of a directly coupled amplifier.

The circuit diagram of the amplifiers, together with the tube under test is shown in Fig. 2. To permit the amplification of d-c voltages, there must be no condensers or transformers for coupling between stages. Decoupling of the quiescent d-c voltage of the preceding stage may be obtained by the use of a battery or a voltage drop across part of the power supply bleeder. However, a much more stable system results if a third tube is used to obtain the d-c decoupling voltage. This tube is used to decouple the first stage of both amplifiers as shown in Fig. 2. If all three 6J7's had identical characteristics and had equal load resistances, the grid signal voltage on the second stage would be zero when the input signal to the amplifier is zero. However, it is very difficult to obtain perfectly matched tubes and resistances so that provision is made for balancing by varying the static plate current of each 6J7 amplifier tube, by means of the screen voltage, until the voltage drop across its load resistance is equal to the drop across the balancer tube load. In practice, this is accomplished in a very simple manner. The outputs of the amplifiers are connected to the respective plates of the cathode ray tube and a spot is obtained on the screen. The point S on one amplifier is then shorted to S'. If the amplifier is not balanced, the spot is deflected. The screen grid potentiometer is then adjusted until no deflection is observed upon shorting S to S'. This procedure is then repeated for the other amplifier.

When obtaining plate volt-ampere characteristics, the amplifier is balanced as outlined above. The 6C5 tubes operate at approximately -1.5 volts bias (15 ma passing through the 100-ohm biasing resistor). This adjustment requires that the grid signal voltage of the 6C5 increase only in the negative direction to prevent the flow of grid current. The input signal voltage must therefore increase in a positive direction. The polarity of the input connections must be correctly maintained when amplifying voltages having a d-c component. If it is desired to amplify signals containing only a-c components, the 6C5's are biased at a convenient value. This is done when observing mutual transfer characteristics, as explained below.

The voltage applied to the tube under test may be of either of two forms. Since only positive voltages need be applied, the voltage may be a sinusoidal voltage having a d-c positive bias equal to the maximum a-c value, or the un-filtered output of a full wave rectifier. The latter form has been used in obtaining the pictures shown here. The method of obtaining mutual transfer characteristics is shown in Fig. 3. For this procedure, the 6C5's are biased to about -9 volts in a manner similar to the method of balancing except that a battery of 9 volts is used, maintaining the proper polarity, instead of shorting the points SS'. When a balance is reached, the battery is removed.

The traces on the cathode ray tube screen are centered by means of the potentiometer, R_{10}. By this control,

The oscillograms shown at the right were taken with a Kodak view camera, f/4.5 lens with Kodak Ortho Press Plates. The exposure varied between 1/5 and 1/10 second. A DuMont 34-XH tube was used

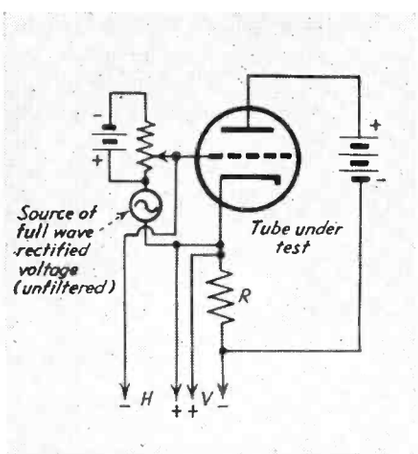


Fig. 3—Method of measuring mutual transfer characteristics

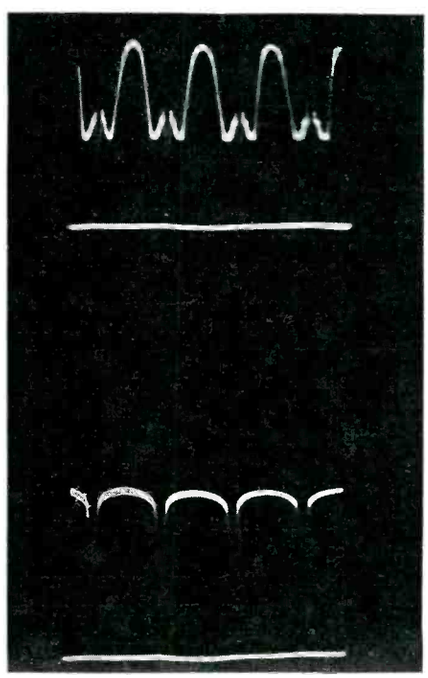


Fig. 4—Top, waveform of plate current of tetrode. Bottom, waveform of plate current of pentode. Secondary emission in the tetrode gives rise to the lower "hump," absent in the latter case

Fig. 5—Plate volt-ampere characteristics of a kenotron rectifier (type FP89), at various filament voltages

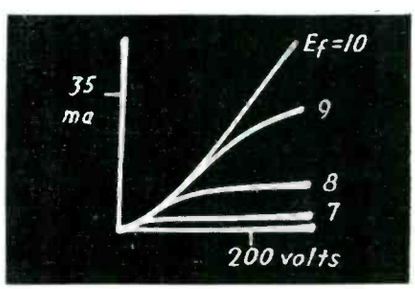
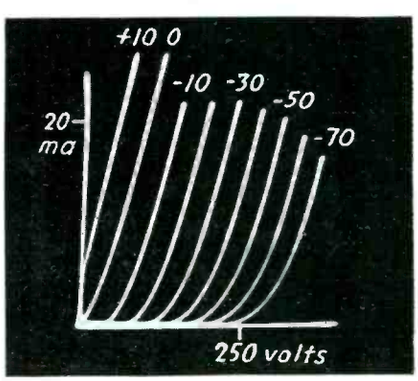


Fig. 6—Plate characteristics of type 89 tube connected as triode



the beam spot is moved across the screen at a 45-degree angle and the origin of the characteristic curves may therefore be easily placed at a corner of the screen.

The 300-volt power supply for the first stages is electronically regulated and built on the same chassis as the amplifiers[3]. However, the 600-volt supply is external and need not be regulated, although a well filtered supply is in order. All input and output cables are shielded to prevent pickup from stray fields. Because of the high gain of the amplifier, a storage battery was used as the heater voltage supply for the 6J7's. With ac on the heaters a noticeable ripple was observed on the cathode ray tube screen.

Frequency Response

In order to obtain a true characteristic curve, the amplifiers must meet the following specifications: They must be linear, must have very little frequency and phase distortion up to about the fiftieth harmonic and both amplifiers must have the same amount of phase shift and distortion. By phase shift is meant a displacement in phase angle of the output voltage relative to the input voltage, for a sinusoidal input. By phase distortion is meant the lack of proportionality between frequency and phase shift of the output voltage relative to the impressed voltage. Tests on the amplifiers described show that they meet these specifications.

The plate current of the tube under test is usually far from sinusoidal. The wave shapes for the plate current in a tetrode and pentode (with applied rectified a-c plate voltage) are shown in Fig. 4. In the extreme case of the pentode, the wave shape is close to being square. It has been experimentally determined by means of filters that all harmonic frequencies up to the fiftieth should be reproduced in order to preserve the original wave shape with accuracy.

The amplifiers proved to have a flat frequency response up to 2000 cps and the gain dropped off 7 per cent at 6000 cps, the voltage gain of each amplifier being 1000. The fundamental frequency used in plotting the curves was 120 cps and the fiftieth harmonic is therefore 6000 cps. The magnitude of the fiftieth harmonic for a square wave is a very small percentage of the fundamental magnitude, so that the decrease in gain is negligible relative to the fundamental.

If a flatter frequency response were desired, it can be obtained easily at the sacrifice of gain. Changing the load resistances of the 6J7's to 20,000 ohms instead of 100,000 resulted in a voltage gain of 230 and a frequency characteristic which dropped 8 per cent at 20,000 cps.

The photographs shown in Figs. 4 to 10 were obtained by taking one exposure for each parameter. This simplifies the procedure, since only one trace is obtained at a time. In order to obtain all the traces at once it would be necessary to use either a rotating or an electronic switch[1].

Calibration of the photographs is an easy matter. If the vertical voltage is removed a horizontal axis is traced whose length corresponds to the maximum value of the voltage used. To obtain the current calibration a voltage is fed into the vertical amplifier and the horizontal voltage is removed, resulting in a vertical trace whose length corresponds to the voltage input. Since the value of resistance inserted in the test tube circuit is known, the vertical axis is calibrated in terms of current.

An alternate method of calibration is to determine a point on the volt-ampere characteristic for a given value of grid voltage and a d-c value of plate voltage equal to the maximum a-c value used. The plate current is noted and the end point of a trace for the given grid voltage is located. All other points can be found by proportion.

The value of this technique cannot be overemphasized. Its application to vacuum tube research and design has been recognized by many. The method is also a convincing test of the characteristics of tubes and their adaptability in circuits.

The authors wish to acknowledge the invaluable aid of Messrs. William Fane, Harold Schneider, John S. Hickey, Jr. and Benjamin Solow in the preparation of this work.

Fig. 7—Plate characteristics of type 6J7 tube connected as tetrode

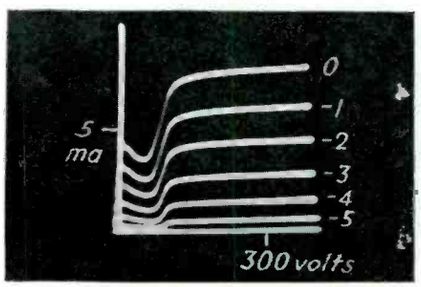


Fig. 8—Plate characteristics of type 6J7 pentode

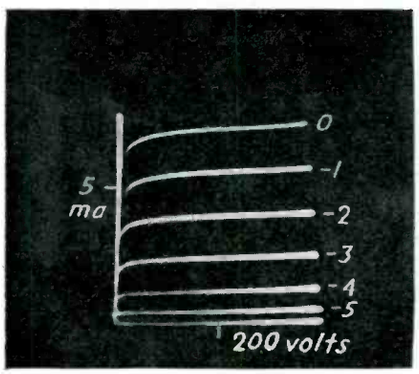


Fig. 9—Mutual transfer characteristics of 6J7 and 6K7. Plate voltage is 250

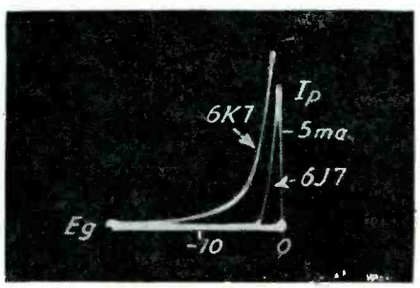
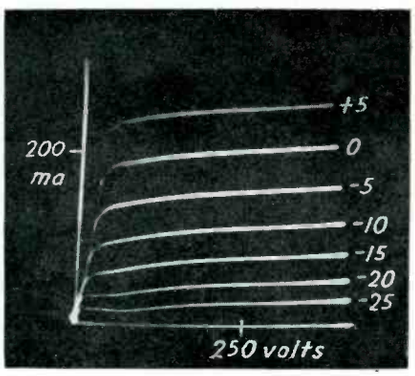


Fig. 10—Plate characteristics of beam power tube, type 6L6



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T. J. Douma and P. Zijlstra, 4, 56, (1939).
A. J. Heins van der Ven, 5, 61, (1940).

[2] "Theory and Applications of Electron Tubes"; Reich, H., McGraw-Hill, New York, page 605.

[3] "The Radio Amateur's Handbook," American Radio Relay League, Hartford, Conn., page 195.

EMERGENCY RADIO COMMUNICATION

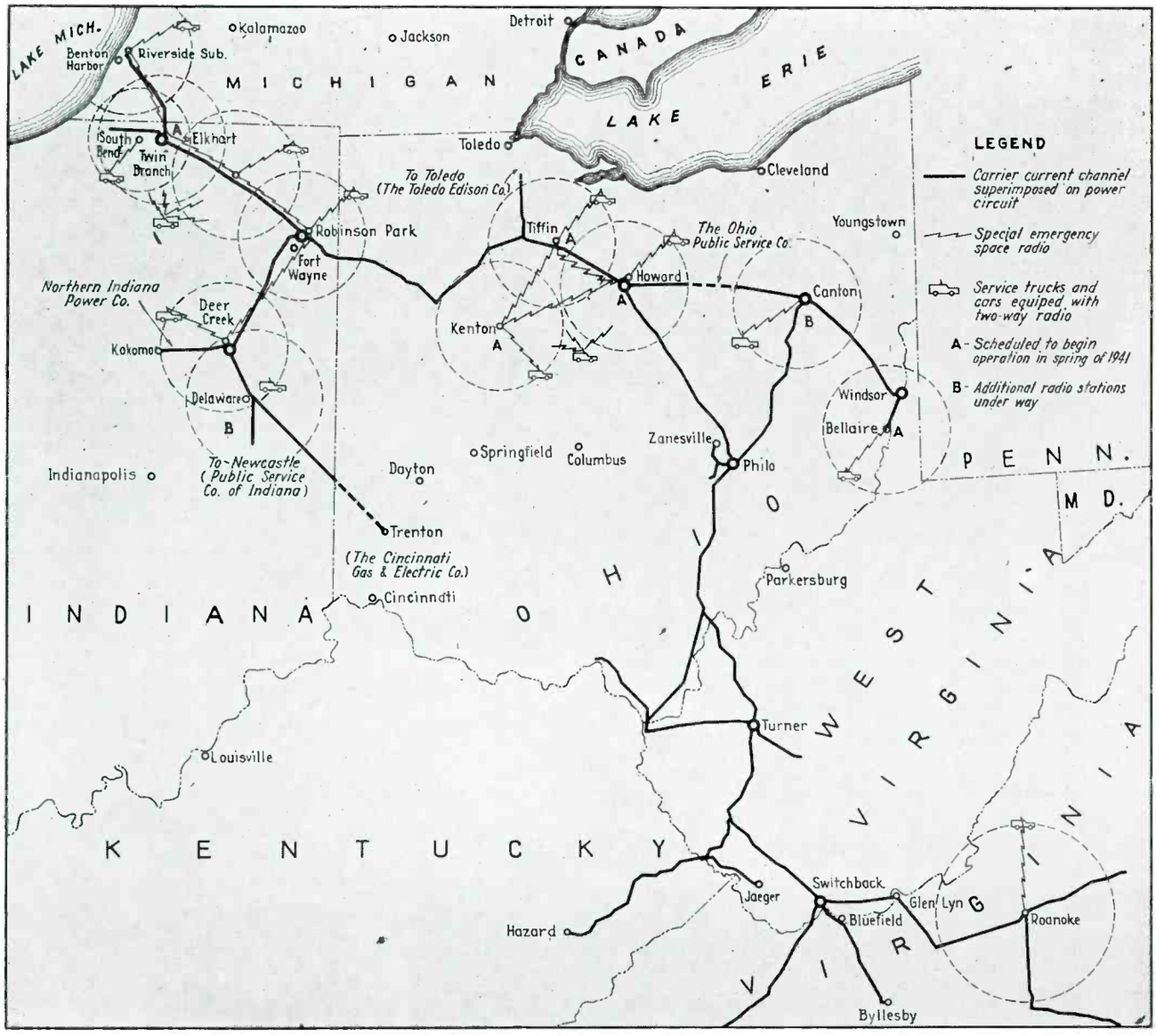


Fig. 1—The communication network, showing carrier telephone connections as well as the emergency radio equipment, of the central system of the American Gas and Electric Company

SPECIAL emergency radio communication found very limited application on power systems until after June 1938 when the Federal Communications Commission made new allocations in the u-h-f band, but since that time its use has grown at a rapid pace. The systems of the American Gas and Electric Company have always recognized the importance of emergency communication to the operation of large interconnected power systems and were the first to install a comprehensive carrier telephone system for this purpose.[1] In the latter part of 1938 the Indiana & Michigan Electric Company placed in operation a 15-watt fixed station and two mobile units at South Bend where terrain is relatively level. Shortly afterward the Appalachian Electric Power Company made a similar installation at Roanoke, Virginia where terrain is mountainous. The technical and the operating aspects of special emergency radio under widely different field conditions were investigated. Although the choice of uhf for these installations was contrary to the advice and recommendations of representatives of probably a majority of the recognized manufacturing and engineering groups, who at that time advocated the use of medium frequencies for this type of service, operating experience with the above trial installations showed very promising results and among other things demonstrated the following with respect to u-h-f mobile communication:

(1) The effect of natural static is negligible in the 30 to 40 Mc band. Even local lightning storms did not seriously interfere with communication. This consideration is probably more important to electric com-

FOR AN ELECTRIC POWER SYSTEM

An extensive u-h-f communication system, using frequency modulation as well as amplitude modulation, has been set up by the American Gas and Electric organization in Ohio and the surrounding states. Mr. Langdon reviews the equipment and its operation record

By G. G. LANGDON

American Gas and Electric Service Corporation

panies, where emergency conditions are created by lightning and other storms accompanied by lightning, than in other fields of emergency radio communication.

(2) U-h-f transmission was found to be particularly consistent day or night, summer or winter. Interference experienced was man-made and therefore could eventually be controlled.

(3) Two-way range obtained between main station and cars did not fully meet the requirements on the American Gas and Electric Company system, but it appeared likely that this range could be increased by advances in the art.

(4) Mountainous territory does not necessarily prevent entirely satisfactory two-way coverages up to 20 miles or more.

(5) Equipment was found to be reliable and easy to maintain.

(6) Two-way rather than one-way communication proved to be necessary in most instances, although one-way communication could also be used to advantage.

(7) Operating departments found the system very valuable for the speedy handling of emergency and hazardous situations brought about by storms, fires, accidents, etc., particularly as affecting the widespread power lines and substations.

As may be seen from the above, the results obtained using uhf justified the original confidence in it as regards its fundamental suitability for emergency purposes on a power system.

While far from perfect, the overall results were so promising and met the fundamental requirements of emergency mobile communication so well that at the present time there are a total of 6 main stations and 40 mobile units in operation, 4 main stations and 44 mobile units are under construction, and several additional stations are being considered. The locations of existing and proposed installations, together with their relation to the existing communication system are indicated in Fig. 1. At four locations antennas of a semi-permanent nature, as shown in Fig. 2, were installed pending a better evaluation of such factors as antenna height, design, and location upon performance. Typical mobile installations are shown in Figs. 3, 4 and 5. Some of the considerations and problems which arose in connection with the growth of the above system, including the question of frequency modulation, are discussed below along with the solutions adopted.

Fig. 2—The radiator of the Robinson Park substation, a 70-foot wooden pole surmounted by a 50-foot steel pole and a vertical coaxial radiator

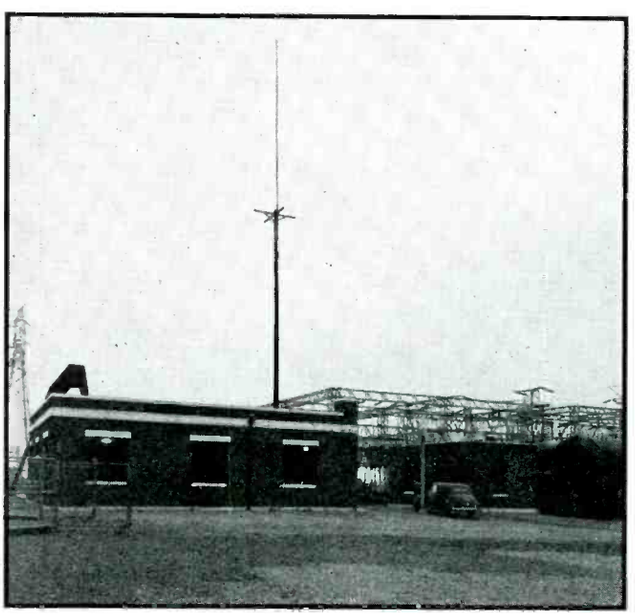


Fig. 3—Radio-equipped line truck. The transmitting and receiving equipment are mounted on the steel cabinet at the side. The whip antenna is raised from inside the truck

Fig. 4—Line supervisor's radio-equipped car. The loudspeaker at the rear is used to give orders to crews or to caution crowds

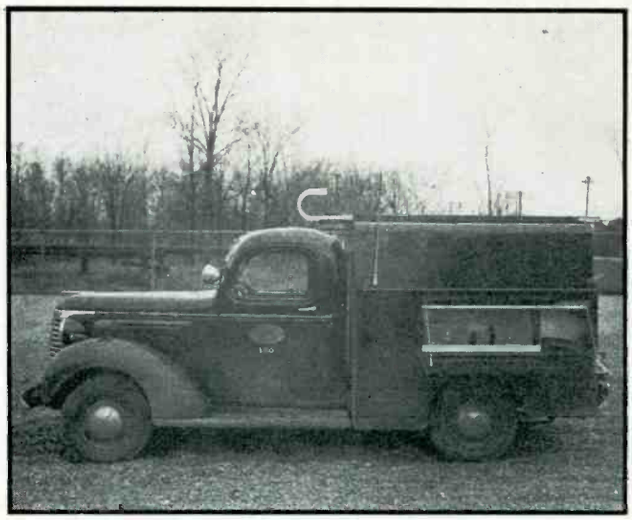


Fig. 5—A light service truck equipment with u-h-f two way equipment mounted in the side compartment

Fig. 6—The system load supervisor at the Twin Branch plant using the radio system. Interlocking prevents interference from other supervisors

General Considerations

In any comprehensive application of special emergency communication to a system like the Central System of the American Gas and Electric Company it is desirable that cars in one district be capable of giving aid during severe emergencies to adjoining districts with a minimum of delay. For this reason the same operating frequencies have been duplicated throughout the system. The radio system should also be coordinated in so far as possible with the existing communication system and it will be noted that main radio stations have been located for the most part at key points equipped also for carrier communication by wire. Figure 6 showing one of four load supervisors positioned at Twin Branch Plant illustrates a coordinated arrangement of all communication facilities within easy reach of the system load supervisors.

The extensive carrier current telephone system (See Fig. 1) provides point-to-point communication of a high order of reliability not only during normal times, but also in emergencies. It was felt therefore that the radio system should be laid out primarily for mobile communication, although communication between fixed stations and between mobile units is desirable for back-up during severe or unusual emergencies.

Frequency Modulation

In 1939 the problem had to be faced whether to install immediately a total of 4 main stations and 27 mobile units using amplitude modulation, or await the development and proving in of fm on a practical basis, which might take from one to ten years. A plan was worked out to permit the immediate installation of a-m equipment and changing it over to fm at a later date with a minimum amount of trouble and expense if found advantageous. This arrangement made it possible to expand the system with reasonable assurance that advances in fm would not make the existing am equipment obsolete at an early date. As it turned out, the development of practical mobile fm equipment was accomplished in record time for the Connecticut State Police (ELECTRONICS, November and December, 1940). Two mobile transmitters and a fixed station receiver, similar to those being installed in Connecticut at the time, were placed in operation by the Indiana & Michigan Electric Company in June 1940 to determine their performance and evaluate their advantages and disadvantages. Operating experience with these units over a six-months period showed the following results as compared to a-m transmitters in the same territory and using the same main station antennas and frequency:

(1) The average area covered with fm was about 80 per cent more than with am under the same conditions.

(2) Under no conditions encountered was fm inferior to am.

(3) Within the normal range of the equipment the interfering noise present was much less with fm than with am, the signals were much

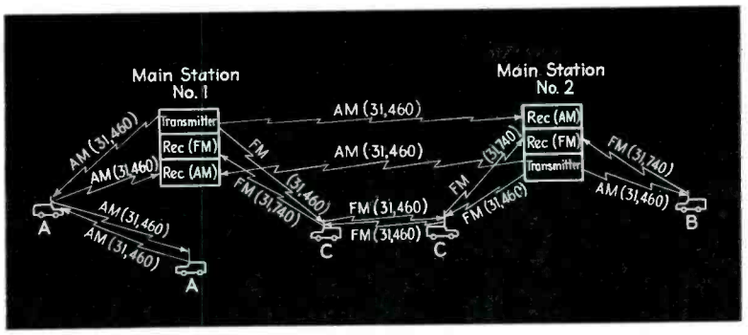


Fig. 7—The three types of mobile communication, used during changeover from a-m to f-m systems: A, a-m sets; B, unit changed to fm; C, all fm

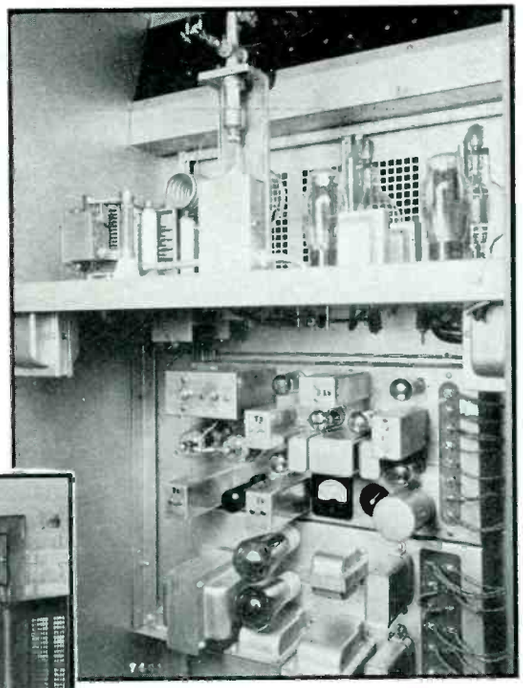


Fig. 8—Rear view of the modualtor-exciter unit used in the fixed f-m stations

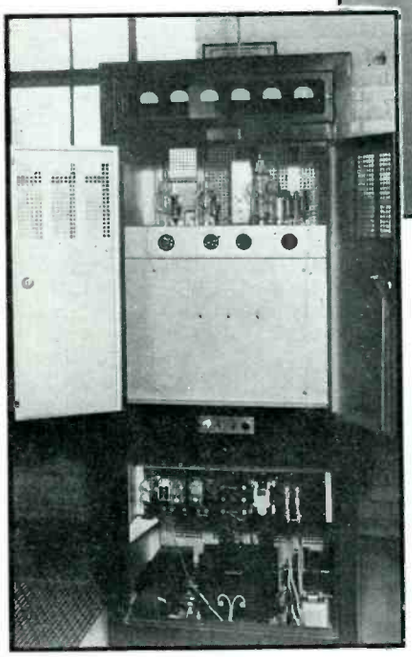


Fig. 9—Front view of am-fm equipment after changeover. The only visible evidence is the changeover relay

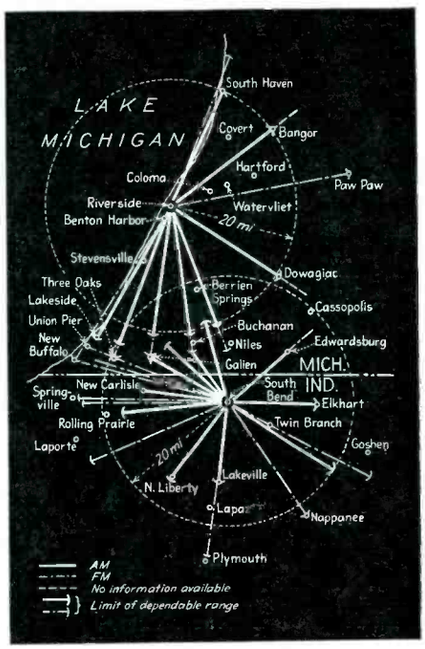


Fig. 10—Map showing dependable two-way coverage of f-m and a-m equipment. These ranges obtain in the absence of severe interference (diathermy)

cleaner, or as one engineer expressed it "fm will transmit silence."

(4) Long distance code interference, which was often very severe during the day on 31460 kc, was only slightly less with fm than with am.

(5) Maintenance required on the more complicated f-m equipment was, to our surprise, less than on a-m equipment.

The above actual operating experience, together with confirming field data from other sources, convinced us that fm was unquestionably far superior to am for general application on our system and the previously conceived plan for changing over to fm was therefore put into effect immediately. Since others operating in the emergency services may also be considering a change from am to fm the method used is described in detail below.

Changing From AM to FM

The plan adopted was influenced by the fact that several main stations and 33 mobile units were in operation using am, and that long range code interference on 31,460 kc and other factors made it desirable to change the cars over to a strictly mobile frequency at the first opportunity. Stated briefly the plan called for the following:

(1) Alter main station transmitters for fm-am operation. The simple method of accomplishing this is detailed later in the text.

(2) Add f-m receiver tuned to 31,740 kc at the main stations.

These two steps permitted main stations to communicate either with existing a-m mobile units operating on 31,460 kc or with new f-m mobile units operating on 31,740 kc. Figure 7 indicates the communication provided.

(3) All new mobile installations to employ fm using 31,740 kc transmitters and 31,460 kc receivers.

(4) Existing a-m mobile units to be changed over in part or completely whenever the improved performance justifies this move.

(5) Main station a-m receivers to be replaced by f-m receivers after all existing mobile transmitters have been changed to fm. Main station transmitter power may be raised 60 per cent or more simply by returning after full f-m operation has been achieved.

The above plan provides a very flexible arrangement well suited to a gradual changeover without disrupting existing communication to any great extent and it results in an f-m system coordinated with any new f-m systems which may be installed over the rest of the territory.

There were a few objections to the plan which have not proven serious in practice. First, main stations

(Continued on page 83)

New Books

Applied X-Rays

By GEORGE L. CLARK, Professor of Chemistry, *University of Illinois. Third Edition. Published by McGraw-Hill Book Co., New York, N. Y., 1940. 674 pages, 342 illustrations. Price $6.00.*

WORKERS IN COMMUNICATION are apt to forget that progress in x-ray technology in recent years has kept pace with the sister arts of electronics. In the eight years since the appearance of the second edition of this book, a multitude of improvements in apparatus and technique, as well as great broadening of the range of application, have taken place in this field. This progress, as well as the fundamental material of older vintage, has been faithfully and completely set down in this new edition of a book which has come to be known as the outstanding practical treatment of the subject. The book is not a complete handbook but rather, as the author states, "an outline of information for the intelligent inquirer". The "outline" is, however, as complete as any 600-page book can be. Some idea of the research which lies behind the volume can be gained from the fact that the author's file on the x-raying of cellulose, papers collected since 1932, is nearly two feet thick.

The present edition contains 23 chapters, beginning with a brief historical survey, followed by descriptions of x-ray tubes and power supplies, methods of measuring intensity and wavelength, techniques of x-ray spectrum analysis in chemistry and physics, x-ray absorption and its applications in radiography, x-ray photochemistry and biological effects. The second part of the book is concerned primarily with x-ray crystallography and the determination of the ultimate structure of materials. Crystal analysis methods are first introduced, followed by applications to crystal chemistry, silicates, alloys, structure of organic compounds, glasses, liquids, etc. Interpretation of x-ray diffraction patterns and applications in metallurgy, and the study of giant molecules (polymers) conclude the volume.

This book is an exceptionally fine piece of work. It is a fitting corollary to Professor Clark's outstanding career of teaching and research in the field.—D.G.F.

M.K.S. Units and Dimensions

By G. E. M. JAUNCEY and A. S. LANGSdorf, *both of Washington University. The Macmillan Company, 1940. 62 pages. Price $1.00.*

THE FOREWORD of this little book explains exactly what the book is: "The International Electrotechnical Commission (I.E.C.), meeting at Schevingen, Brussels, in June 1935, adopted the meter, kilogram and second as the basic units of length, mass and time, this action becoming effective in January 1940.

"The purposes of this volume are to acquaint electrical engineers, physicists, and teachers and students . . . with the properties of the new M.K.S. system of basic units; to describe methods for changing from one set of basic units to another; to give reasons for the adoption of the ohm as the fourth basic unit, . . . to describe a proposed M.K.S.O. system of basic units; and to discuss the difference between magnetic flux density (B) and magnetic strength (H)."

Many engineers are not aware of the advantages of this new system, one of which is the ability to stick to one set of units throughout a piece of paper work; furthermore these units are practical units, with which we deal every day.—K.H.

Radiologic Physics

By CHARLES WEYL, S. REID WARREN, JR. and DALLETT B. O'NEILL, *all of the University of Pennsylvania. Charles C. Thomas, publisher, 450 pages, 1941. Price $4.50.*

ALTHOUGH THIS IS A TEXTBOOK written by teachers and aimed at the student in medical radiology, it will also serve the needs of practicing x-ray men who wish a grounding in the theory and applications of radiation physics with reference to x-ray diagnosis and x- and gamma-ray therapy.

The first half of the book (some 200 pages) is taken up with the theory and practice of electrical engineering as applied to radiological apparatus. It is really a small text on electrical engineering, with chapters on measuring instruments, a-c theory, transformers, generators, distribution systems, electronics etc, and ending with a chapter on electromedical apparatus.

The second half is concerned with radiant energy and its interactions with matter. A short history leading to our present views on the constitution of matter, the wave and corpuscular theories of light, quantum theories, x-rays, and radioactivity are followed by chapters which are very clearly up the alley of the medical man. They deal with the measurement and control of x- and gamma-radiation, measurement of dosage, the use of the fluoroscope, intensifying screens, and the techniques of handling electro-medical equipment. Finally in an appendix are the elements of mathematics through calculus, and log tables, so that the reader who is not scared by an equation can equip himself to read the literature with good effect.—K.H.

The Nature of Crystals
By A. G. WARD

The Nature of the Atom
By G. K. T. CONN

The Wave Nature of the Electron
By G. K. T. CONN

The Cyclotron
By W. B. MANN

Published by Blackie and Sons, Limited, London. Distributed by the Chemical Publishing Co., New York. 114 pages, 52 illustrations; 115 pages, 15 illustrations; 78 pages, 17 illustrations; 92 pages, 31 illustrations, respectively. Price $1.50 each.

THESE FOUR LITTLE BOOKS make excellent sources of background material for electronic engineers who profess to know something of the physical background of their chosen field of work. The first three constitute a brief review of the nature of matter from the modern viewpoint, the last of one of the most important electronic tools in the hands of the physicist. While in no sense a required part of the professional equipment of electronic specialists, they nevertheless make worthwhile additions to a technical library.

Mr. Wards monograph reviews in simple but not popularized language the history and present status of crystalline structure theory. He suggests a very interesting hobby in the study of crystal forms. The two books by Mr. Conn are excellent reviews of the atomic and electronic entities. The "Wave Nature of the Electron" is especially interesting in that it gives a clear picture of wave mechanics in simple terms. Mr. Mann's description of the cyclotron gives considerable information on construction, high frequency oscillator circuits, and operation procedure hitherto available only in periodicals—D.G.F.

Insertion Loss in Filters

By J. KRITZ and E. L. GRUENBERG
Signal Corps Procurement, U. S. Army

WHERAS the determination of the elements of a filter section is fairly simple when carried out in terms of the significant cutoff frequencies (see "Filter Design Charts" by John Borst, ELECTRONICS, August, October and November, 1940), the determination of the shape of the attenuation characteristic is a much more complicated problem, depending not only on the L and C values, but on the Q values of the elements. This reference sheet presents a nomographic method of determining the attenuation constant of low- or high-pass filters. The total insertion loss of a filter is composed of this constant plus interaction losses and reflection losses. The interaction losses may usually be neglected in commercial practice. The reflection loss, which depends only on the termination, may be determined by the methods outlined in "Transmission Characteristics of Electrical Wave Filter" by O. J. Zobel, *B.S.T.J.*, Oct. 1934.

The attenuation constant α of any pi or T filter configuration is given by the relationship

$$\cosh \alpha = 1 + \frac{2m^2}{(1 - m^2) - 1/a^2}$$

where $m = \sqrt{1 - 1/a_i^2} = f/f_c$ (low pass) or f_c/f (high pass), $a_i = f_i/f_c$ (low pass) or f_c/f_i (high pass), $f =$ frequency at which attenuation constant is to be computed, $f_c =$ cutoff frequency, and $f_i =$ frequency of infinite attenuation. This equation is the basis of the nomogram (Fig. 1) printed herewith. This chart gives the attenuation constant of a single pi or T section, high pass or low pass, in terms of a and a_i or m, previously defined. The attenuation scale is divided into two sections, above and below infinity. The lower portion represents attenuation below the frequency of infinite attenuation, whereas the upper portion represents attenuation above this frequency. The chart is used by laying a straight edge on the values of two of the variables, the intersection with the third scale giving the value of the third variable.

The chart applies to filter elements having no dissipation. When the coils have dissipation, the attenuation at the frequency of infinite attenuation is reduced, although the effect at other frequencies is not so marked. Figures 2 and 3 have been plotted to permit taking the Q value into account, in calculating the attenuation at the frequency of infinite attenuation. On the assumption that the Q values of all of the coils are the same, a "Q factor" may be found from Fig. 2, in terms of the given Q value, and an "infinite attenuation factor" from Fig. 3, in terms of the frequency ratio a_i. The sum of the Q factor and the infinite attenuation factor is the value of the attenuation constant α at the frequency of infinite attenuation. Figure 4 may be used to determine the attenuation constant at the cutoff frequency f_c in terms of the Q value of the coils, for a constant-K filter. For the m-derived type, the attenuation constant may be taken as approximately $1/m$ of the value for the constant-K type.

As a practical design problem consider a low pass filter and solve for the attenuation constants at various frequencies. The filter is composed as follows:

1—A constant-K prototype $f_c =$ 1000 cps

2—An m-derived type $f_i = 1400$ cps ($m = .7$)

3—Two terminating half sections of $m = .6$ ($a_i = 1.25$)

The Q of all coils is taken as 20. The frequencies at which the constants are required are: 1000, 1100, 1250, 1400, 1800 cps.

Constant-K Prototype:

1000 cps—From Fig. 4, at a Q of 20, the factor is 2.75 db

1100 cps—From the nomogram, the line joining $a = 1.1$ and $a_i = \alpha$ gives 7.8 as the attenuation constant.

1250 cps—With the same procedure as for 1100 cps but $a = 1.25$, $\alpha = 12.2$ db

1400 cps—$\alpha = 15.2$ db

1800 cps—$\alpha = 21.0$ db

M-Derived Type:

1000 cps—$\alpha = \frac{1}{m}(2.75) = 2.93$ db

1100 cps—$a = 1.1$, $a_i = 1.4$, $\alpha =$ 13 db on the lower scale.

1250 cps—$a = 1.25$, $a_i = 1.4$, $\alpha =$ 22.6 db

1400 cps—On Fig. 2 for $Q = 20$, $a_i = 26$ db

On Fig. 3 for $a_i = 1.4$, $a_2 = 11.5$ db, $\alpha = 26 + 11.5 = 37.5$ db

1800 cps—$a = 1.80$, $a_i = 1.40$, $\alpha =$ 21.1 db on upper scale.

Terminating Sections:

For one terminating section α is one-half that of a full section. Since we have two sections, we may use the full values given by the charts.

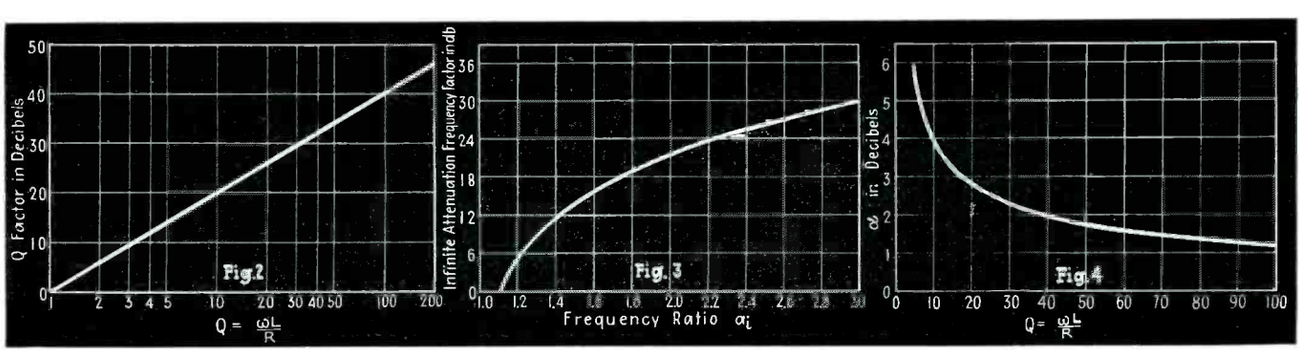
1000 cps—$\alpha = \frac{1}{m}(2.75) = 4.6$ db

1100 cps—$a = 1.1$, $a_i = 1.25$, $\alpha =$ 15 db

1250 cps—$a_1 = 26$ db $a_2 = 7$ db $\alpha =$ 33 db

1400 cps—$a = 1.4$. $a_i = 1.25$ $\alpha =$ 22.1 db

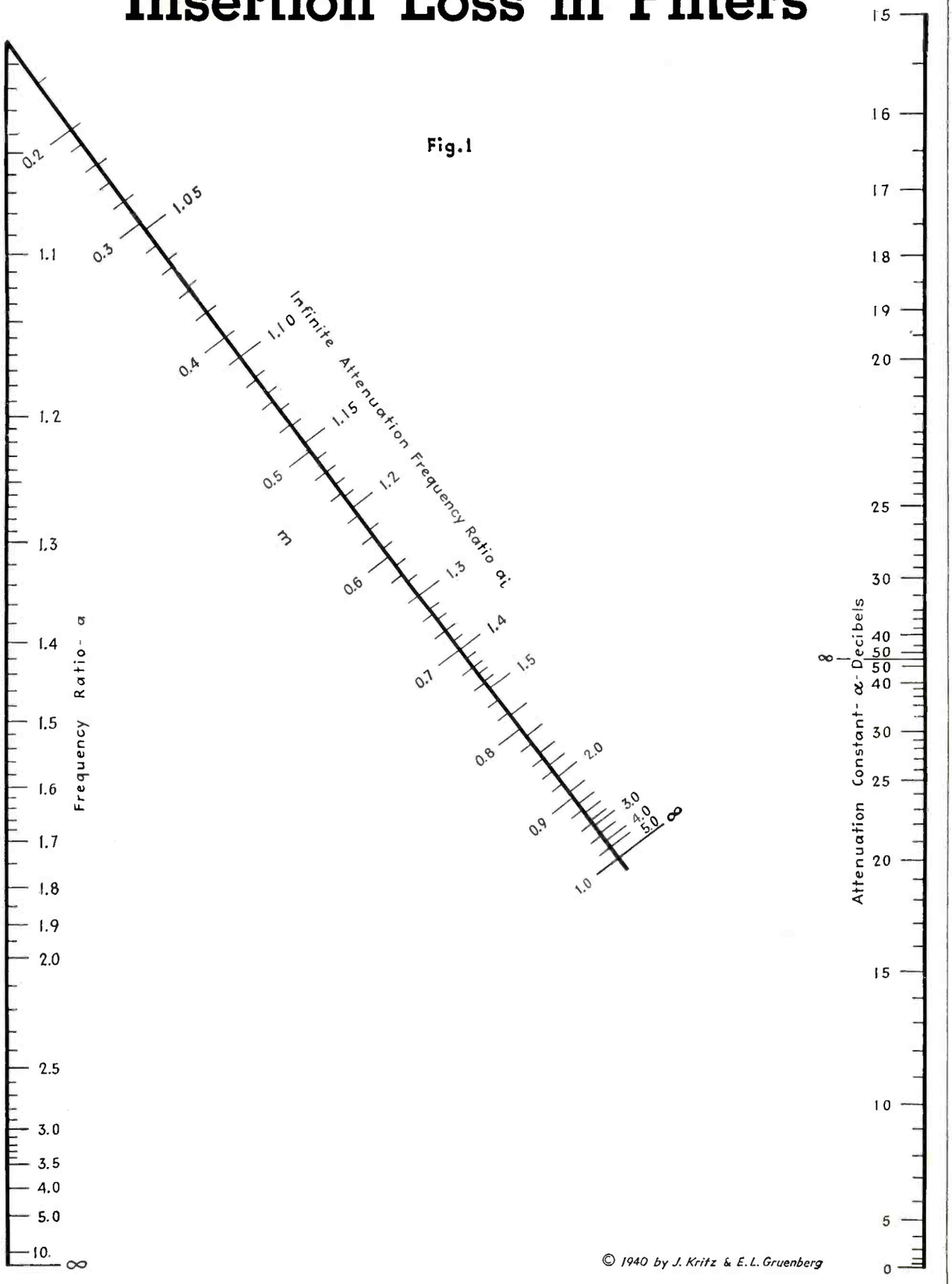
1800 cps—$a = 1.8$, $a_i = 1.25$, $\alpha =$ 15.8 db



ELECTRONICS REFERENCE SHEET

Insertion Loss in Filters

Fig. 1



ELECTRONICS REFERENCE SHEET

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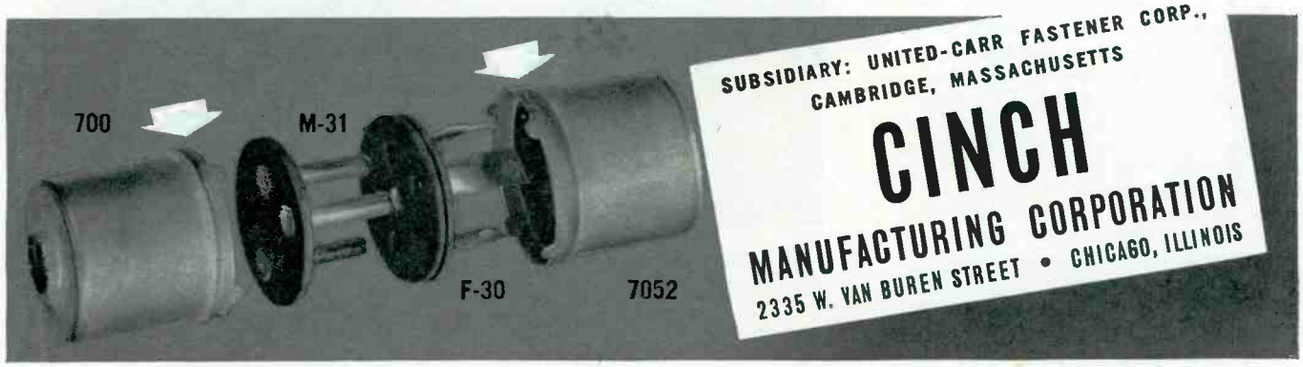


TUBES AT WORK

A bridge-type circuit for stable indication of light flux in a linear densitometer, and a simple method of calibration are described, together with an improved method of protecting the filaments of mercury vapor rectifiers

A Linear Densitometer

BY JOHN A. TIEDMAN
Woman's College of the University of North Carolina

MANY TYPES OF DENSITOMETERS have been proposed in the last few years. They are in general of two kinds: the optical, in which the eye makes a comparison between the area to be measured and an area of known density; and the electrical, in which the light passing through the area to be measured is caught by a photoelectric cell, and the current through the cell is measured by a meter which is calibrated in terms of density.

In addition to the low cost, and the elimination of eye strain, one of the advantages of the electrical method is that it can be calibrated without film strips of known density. The simple electrical circuits, however, give extreme sensitivity in the regions of low density, and low accuracy for high densities. This is a disadvantage if it is desired to balance separation negatives at densities of 2, for example. The densitometer described by George Hartley[1] is of this type.

Several densitometers have been proposed which have a linear density scale. One[2] is particularly mentioned as the present author is indebted to it for some of the features of his instrument. A logarithmic scale is obtained with this instrument by impressing the voltage drop across a high resistance in series with the phototube on the grid of a super-control tube, which gives an approximately linear plate current for logarithmic changes in potential of the grid.

An article by R. E. Meagher and Edward P. Bentley[3] suggests an entirely different principle, which the present author hastened to apply to the measurement of photographic density.

The principle of the Meagher and Bentley circuit involves the energy distribution of the electrons liberated by a hot cathode. If the grids of a vacuum tube are maintained at a high positive potential, only the electrons having high velocity will reach the plate. If the plate and cathode of the tube are connected in series with the current to be measured, logarithmic changes in current will produce linear variations in potential from plate to cathode. This potential can be impressed from cathode to grid of a second tube, which serves as a linear amplifier.

However, since the amplifying tube must be operated linearly, current in the plate circuit cannot be made zero, and about one-third of the plate meter scale is not useful in measuring density. The plate current might be balanced out very simply by means of a battery and a resistance which would supply an equal and opposite current through the meter. This was done, but the instrument, though much more linear, did not have the convenience and flexibility of the Miller circuit[2].

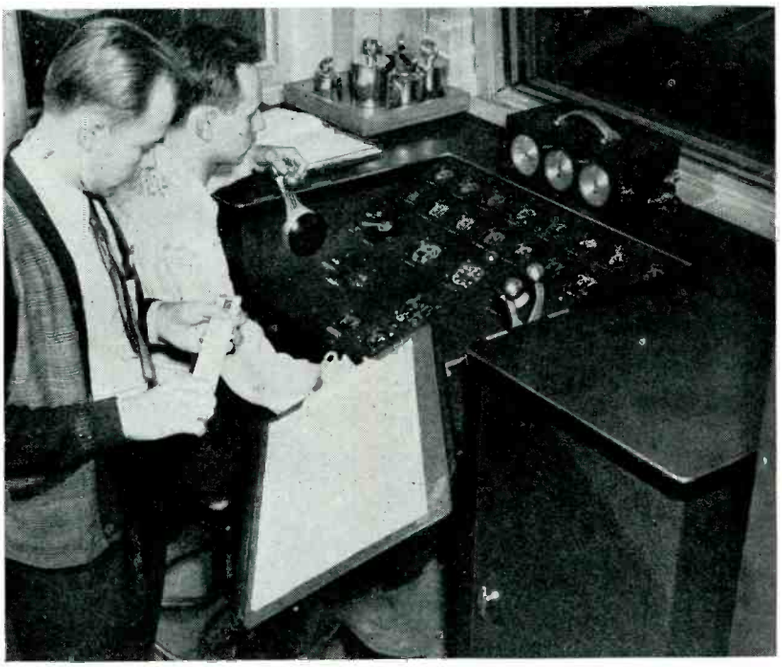
The principal advantage of the Miller circuit lies in using two tubes as arms of a Wheatstone bridge, with an ammeter connected from plate to plate of these tubes. This meter is shunted by a variable resistance which permits adjustment of the meter to read full scale for any density desired. A resistance in the fourth arm of the bridge can be varied to produce zero current for zero density and linear indication.

The Densitometer Circuit

The circuit developed by the author is illustrated. The phototube is illuminated by the light of a 32-candlepower 6-8 volt auto headlight bulb through an aperture 0.125 inch in diameter. (RCA 868 and CE 1 tubes have been used by the author merely because they were available. RCA 917 is probably preferable.) A resistance of 2 megohms is in series with the anode and is connected to the plate of the 77 tube, which is connected to the grid of the amplifier tube 6C6, A. The three grids of the 77 are connected to a potential of 10 to 45 volts, the exact voltage depending on the peculiarities of the particular 77 used. As shown in Fig. 3 A, B, and C linearity depends on the adjustment of this potential. The cathode of the 77 is connected to a potentiometer P_1 (50,000 ohms) which is used to adjust the bias of the 6C6, A. This potentiometer is set so that operation is on the linear part of the characteristic of this tube. After this is once adjusted it need not be changed again. Potentiometer P_2 (also 50,000 ohms) serves as a rough adjustment to equalize the currents I_A and I_B. P_4 can be used as a fine adjustment, but must always be approximately equal to R_2. The tube 6C6, B serves the function of balancing the current of the 6C6, A.

To adjust the instrument, insert an ammeter in series with the plate of the 6C6, A. Adjust P_1 so that full light pro-

AVIATION ENGINES CHECKED



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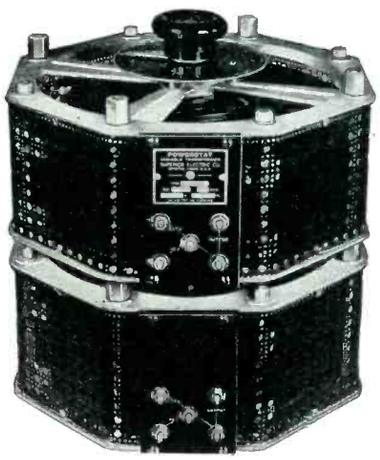

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duces a plate current so high that it is almost at the top of the characteristic curve of the 6C6, A. (This operation is facilitated by removing the 77, and inserting a wire shorting plate to cathode.) Replace the 77, and adjust the bias for the selected value of plate current. The voltage drop across the 77 is between 1 and 3 volts.

The resistance R_2 should be about 10,000 ohms, and the potentiometer P_4 should have the same maximum value. When operating the instrument P_4 should first be made equal to R_2. Adjust P_2 to give approximately zero current (with P_3 set to give maximum sensitivity). Readjust P_2 and P_4 until the meter is exactly zero. Decrease the light (as explained below) until the light falling on the cell is the same as it would be if it passed through an area whose density is the greatest you desire to measure. Adjust the shunt P_3 until the meter reads full scale for this light value.

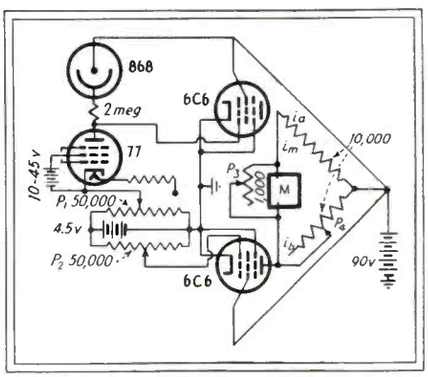


Fig. 1 — Circuit diagram of the bridged amplifier used with the phototube. The upper 6C6 tube is "A", the lower "B"

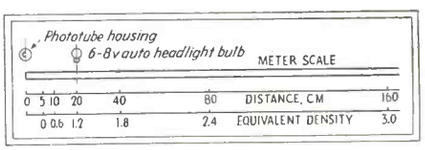
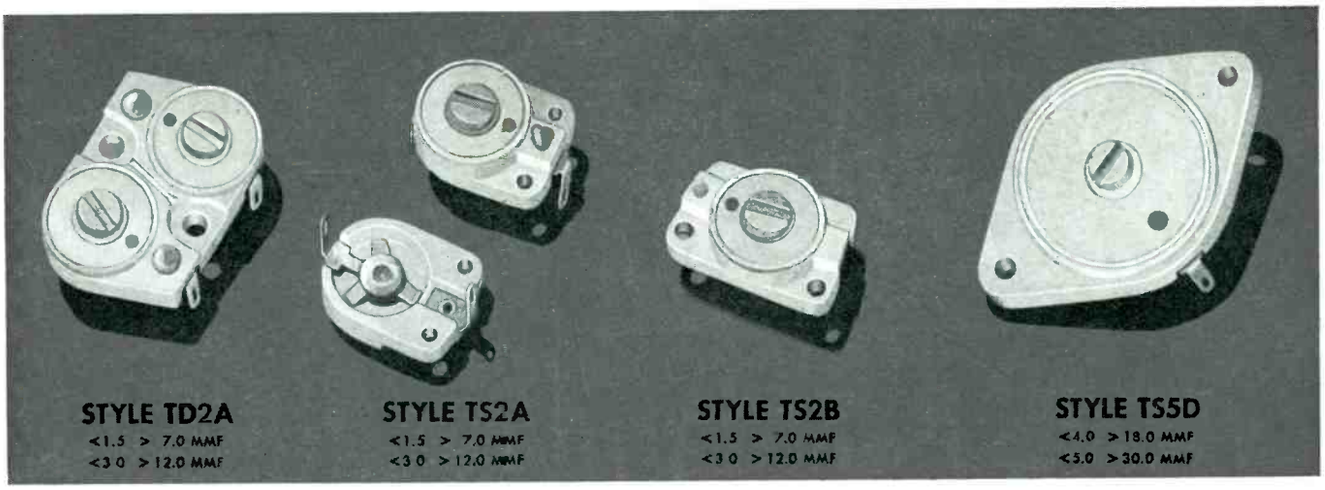


Fig. 2—Method of calibrating the densitometer on an optical bench

The method of calibrating the instrument is shown in Fig. 2. The aperture of the photocell is placed over the zero mark of an optical bench (or a meter stick). The filament of the headlight bulb is placed 5 cm from it. If it is desired to have the instrument read full scale for a density of 3, the bulb must be moved to 158.2 cm. (The ratio $5^2 : 158.2^2 = 1 : 1000$.) To facilitate adjustment of the grid potential of the 77, the lamp can be placed in turn at 9.9, 19.8, 39.6, and 79.1 cms, which correspond to densities of 0.6, 1.2, 1.8, and 2.4. When a potential is found which gives a linear response for the tube used, a calibration curve can be made using closer spacings. A multiplying factor of 1.26, for example, gives positions equivalent to density increases of 0.1.



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4. Once the rotor has been adjusted, it will not be altered by vibration, as in addition to being statically balanced, a constant-pressure berylium spring holds it firmly in place. Ceramicon Trimmer specifications call for a rotor torque averaging 1 inch pound.

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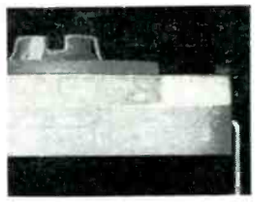
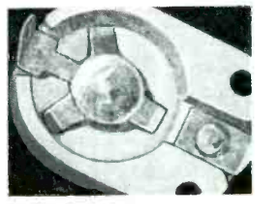


2 ***Soldered internal connections***



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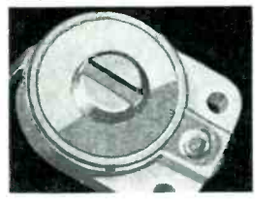


4 ***Vibration-proof adjustment***

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

If a film strip having a number of density steps is made and measured while the calibration is still fresh, the optical bench can be eliminated if at some future time one of the tubes is replaced. The method described by Wm. G. Houskeeper[4] for making density strips is simple and adequate. However, since typewriter spacing is usually 0.1 inch, it would be best to use either double spaces or make the measuring aperture less than 0.1 inch. This densitometer could be used with such an aperture. The author happened to have a phototube mounted with an eighth inch aperture and used it. Compensation can be made by operating the lamp at more than 6 volts.

After the calibration has been established on the optical bench, changes in plate voltage have little effect on the shape of the curve, since mere differences in plate current are indicated on the ammeter.

Calibration Technique

Although the inverse square law is valid only for a point source, calculation indicates that the error will be less than 1 per cent if the distance from filament to aperture is at least ten times the largest dimension of the source. Since the filament of the bulb is about 3 mm long, and the smallest distance used is 5 cm, or 50 mm, this error is negligible.

Errors of serious magnitude may be introduced if the orientation of the light source relative to the aperture is not maintained. The candlepower in the plane of the filament is less than half the candlepower in a plane perpendicular to the filament plane.

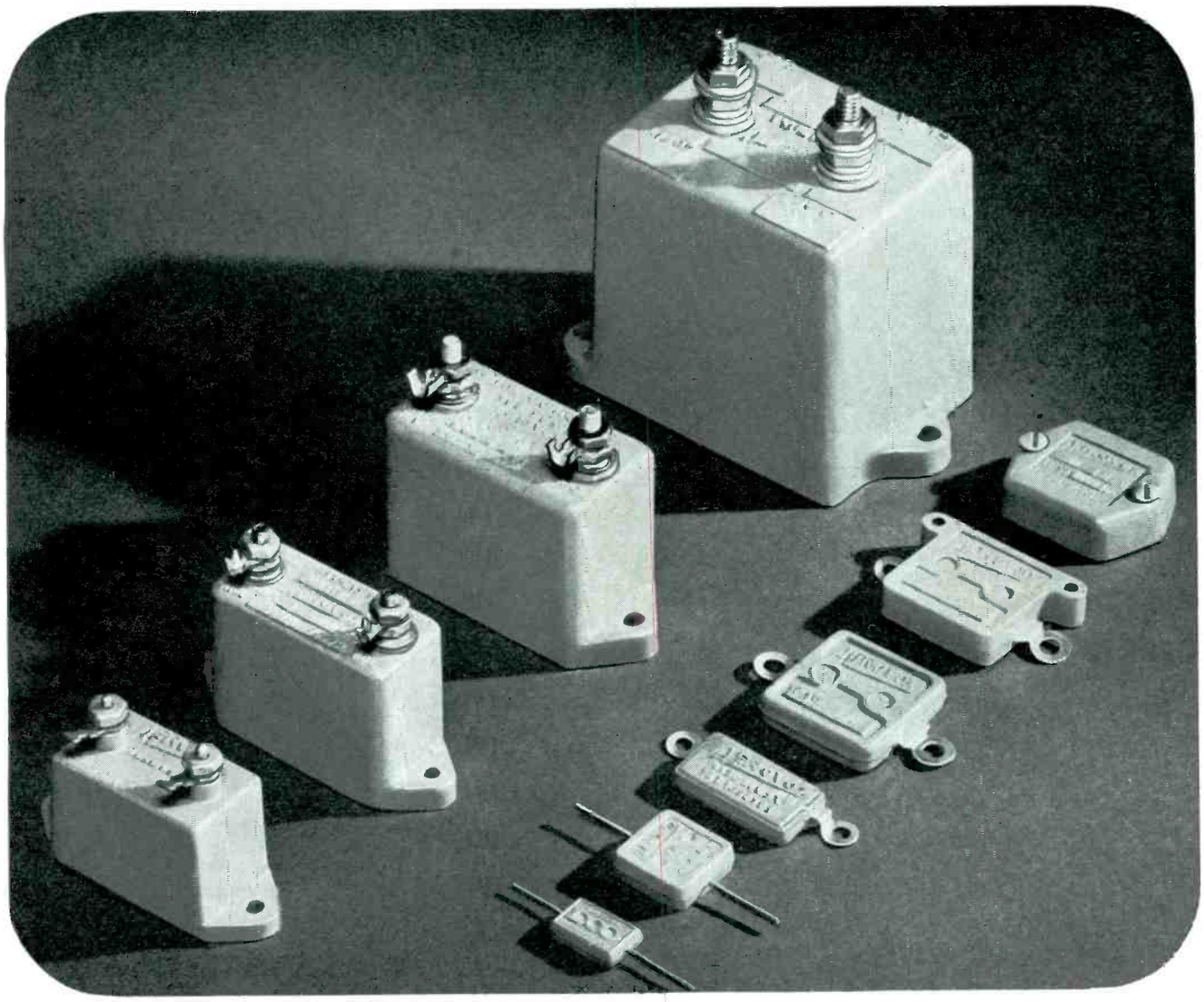
The photocell is mounted as close to the measuring aperture as possible. Table I is calculated for an assumed distance of 1 inch between the aperture and cathode surface. It demonstrates that the relative area illuminated varies from 225 per cent to 104 per cent for the calibration distances used. In spite of this wide variation, no difficulty has been experienced.

TABLE I

Position of Light Source cms	*Comparison of Diameters, Illuminated Area and Aperture* Per cent	*Comparison of Areas Ill. Area and Aperture* Per cent
5	150	225
10	125	157
20	113	127
160	102	102

The principal source of error lies in the difficulty of measuring the initial 5 cm distance. A 1-mm error introduces a 2 per cent error in the measurement of low densities, though a negligible error for high densities.

An optical bench is ideal for calibration, since measurement is simplified, and the orientation of filament is easily maintained. If one is not available, wooden guides could be tacked to a bench and the source mounted on a board to slip between them. The room



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PLASTICS HEADQUARTERS

should be darkened during calibration.

The arrangement used by the author gives diffuse density, since the size of the phototube cathode assures the collection of all light penetrating a film placed immediately in front of the aperture. The arrangement could be modified to give specular density.

Practical Considerations

A densitometer should be a complete instrument, always ready for use, with its own galvanometer, batteries, and other accessories. It should be designed so that it is ready to operate as soon as the tubes are heated. The instrument built by the author has about fifteen minutes warm-up period, which is probably the time necessary for the grid battery to settle down to a steady voltage. On several occasions the instrument has been operated for eight hours, with no perceptible change in response over this period.

Care must be taken to light the filament of the 77 tube before the grids of this tube are connected to a potential source. Failure to do this may result in erratic action.

One of the greatest sources of error is the fluctuation of the voltage on the lamp. A series resistance and a voltmeter are used to keep the lamp voltage constant while operating.

In use, it is usually necessary to mark the areas to be measured with ink, as it is impossible to see when an area is centered in front of the measuring aperture by reflected light. Since this takes a great deal of time, the instrument can be arranged so that the measuring aperture can be examined by transmitted light. The phototube may be mounted in a light-tight compartment on a platform which can be swung away from the measuring aperture by an external lever. A second aperture is placed in the rear wall of the compartment in a line with the filament and measuring aperture. When the cell is in position for taking read-

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A close-up view of the mechanics of the radio controlled power boat built by Lt. Henry W. Wickes. The motor and driving battery are at the left; the receiver at the right. The metal rod near the rail is the antenna. The small boat has a cruising radius of about eleven miles

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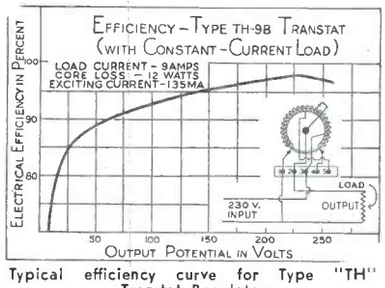
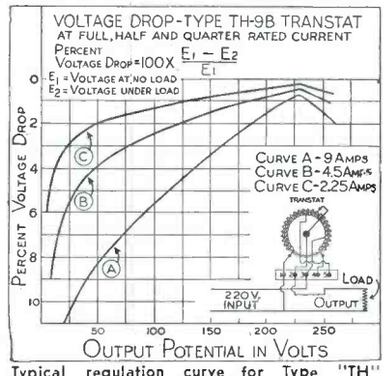


Typical efficiency curve for Type "TH" Transtat Regulator



Typical regulation curve for Type "TH" Transtat Regulator.

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For single-phase or poly-phase service.

For frequencies of 25, 50 or 60 cycles.

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ings an extension of the photocell mounting covers the second aperture so no light can enter. While it is difficult to see with reflected light whether an area of density greater than about one is properly over the aperture, the dividing line between densities 3.0 and 3.1 can easily be seen in transmitted light.

The light source and photocell are purposely mounted on one edge of the box containing the batteries and tubes so that the circuit can be readily adapted to the measurement of reflection densities. In Fig. 4, G is a board parallel to the plane of the aperture.

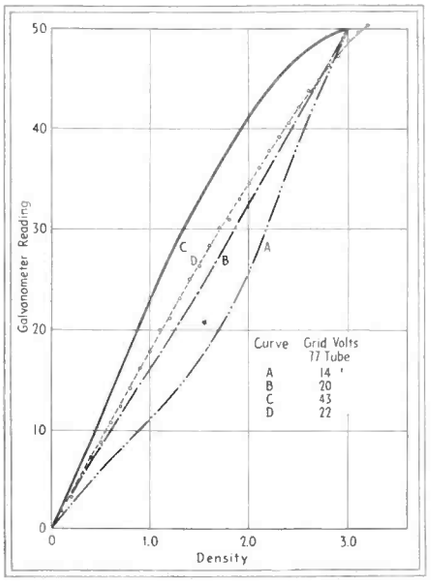


Fig. 3—Calibration curves obtained at different grid voltages

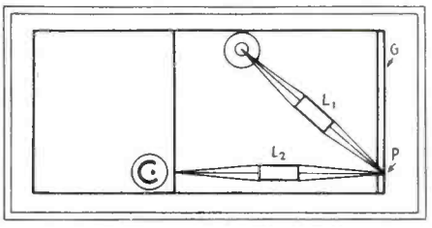
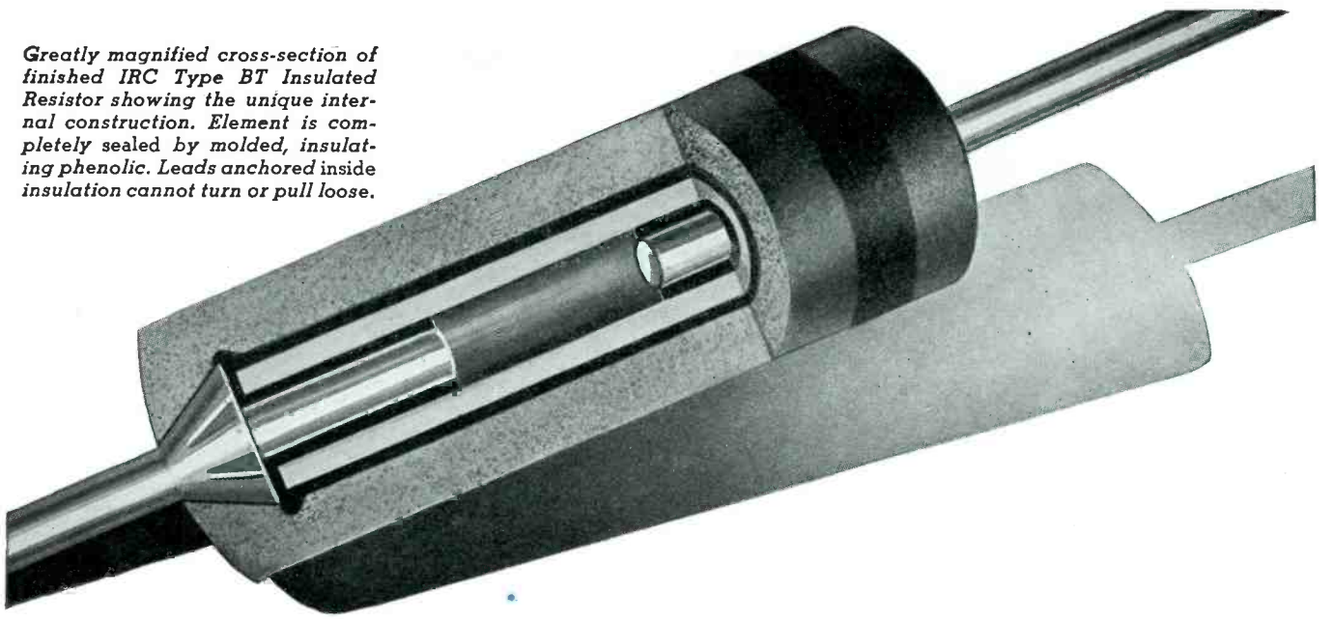


Fig. 4—Arrangement of the optical elements of the densitometer

It can be equipped with grooves in which a standard size strip of paper to be tested can be slipped. The point P is the foot of a perpendicular from the aperture. The light source and lens are arranged to form an image of the filament at P. The lens may be a projection lens from an 8- or 16-mm movie projector. A second lens focusses an image of the first image in the plane of the aperture. When white paper is at the point P, the densitometer can be adjusted to read zero. When the paper is slipped along in the guides so that the image falls on denser silver deposits the instrument will read the higher density of the deposit relative to the assumed zero. This is satisfac-



Greatly magnified cross-section of finished IRC Type BT Insulated Resistor showing the unique internal construction. Element is completely sealed by molded, insulating phenolic. Leads anchored inside insulation cannot turn or pull loose.

INSULATION (AS SUCH) is Only Part of the Story

Following the far-reaching success scored by IRC Insulated Resistors, it was inevitable that many other insulated resistors should appear. It was also inevitable that all insulated resistors should look so much alike as to be confusing to the user who does not examine the construction. Beneath the insulation, however, resistor similarity ends with amazing abruptness.

The IRC Insulated Resistor was designed from the ground up for what it is—an integral, scientifically constructed unit offering a new and distinctly different approach to resistance engineering problems.

IRC resistor insulation did not come in the nature of an afterthought. It did not come as something added to an old and possibly outmoded type of resistor construction.

IRC insulation is far more than an insulator. It assures humidity characteristics hitherto unobtained. It facilitates rapid, low cost resistor manufacture. It anchors the leads. It seals the unit from end to end. Above all, it simplifies and modernizes the use of an exclusive resistance principle that has proved its superiority since the early days of Radio—the famous filament type of resistance element.

Insulation is highly important in itself, to be sure. But it is only part of the story. Not this protection *but what it protects* is the final determining factor of quality—and here IRC Insulated Resistor construction reigns supreme.

1. A glass tube continuously drawn with utmost precision to the size of a small pencil lead, is the beginning of an IRC Type BT Insulated Resistor.

2. The tube is coated with a Metallized filament type resistance material permanently bonded to its outer surface and stabilized by a baking process.

3. Special leads have enclosed, positive contact to element which cannot open. Leads inserted *inside* element tube draw heat rapidly out of the resistor.

INSULATED *Type BT* RESISTORS

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tory for most purposes, but must be used with caution when comparing tinted paper stocks and toned images, since the response of the cell differs greatly from that of the eye. Measurements of the densities of any one strip, or of similar strips are reliable, but comparisons between strips of different tint and tone are not.

The meter used is a 0–50 microampere instrument, having a resistance of 100 ohms. If it is desired to build an instrument reading up to density 3, a scale of 0–3 would make a calibration curve unnecessary except for extreme precision. A 1-milliampere instrument might be used, but a 300-microampere meter would be ideal.

REFERENCES

[1] *Photo Technique*, p. 52, December 1939.
[2] A Linear Photoelectric Densitometer, Carl W. Miller, *Review of Scientific Instruments*, p. 125, April 1935.
[3] A Vacuum Tube Circuit to Measure the Logarithm of a Direct Current, *Review of Scientific Instruments*, November 1939. Vol. 10, p. 336.
[4] *Photo Technique*, p. 36, January 1940.

• • •

Thermal Delay Relays In Tube Circuits

By WALTER BACON
Conventry, England.

WHEN USING RECTIFIERS of the mercury-vapor type it is essential that the high voltage shall not be applied to the anodes until the filaments have been given ample time to warm up, as otherwise dangerous stresses will be caused. A common method of insuring this is to close the high-voltage circuit by a thermostat, the heating element of which is connected to the same supply as the filaments. This gives full protection when switching on initially but, in its simple form, suffers from the defect that it is left on all the time. Thus, should the power supply fail, or be switched off momentarily, and come on again after only a short interval, the thermostat may not have sufficient time to cool down. High voltage will then be applied to the filaments before they have warmed up and it may cause serious damage.

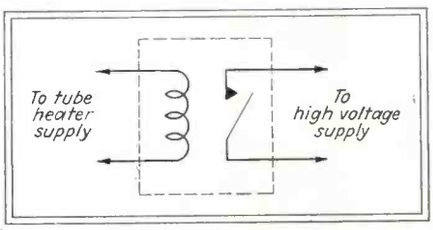

Fig. 1—Basic relay circuit

A more recent circuit which greatly lessens this risk is shown in Fig. 2. The high-voltage circuit is made by means of a relay, the coil of which is in series with the thermostat contacts. When the thermostat has warmed up, the relay operates, locks itself in by means of the contacts 3 and 4, and cuts off the current to the thermostat coil by means of the contacts 5 and 6.

The thermostat cools down, and momentary failure of the power supply will cause the relay to fall out and the full delay to be applied before the high voltage comes on.

Though this is a great improvement, it cannot yet be described as 100 per cent perfect. The reason will be seen if the details of operation are considered. To begin with, suppose that the thermostat is completely cold. Voltage is applied to the coil, which warms up. After the normal delay time the thermostat contacts close, the relay is operated and the thermostat begins to cool down again. Consider what will happen should the supply voltage fail during this period. When the voltage fails, the relay will fall out and the delay circuit will be in its normal unoperated condition with the important difference that the coil of the thermostat is still warm. So if the supply is restored within a short period voltage may be applied to a partially warm thermostat coil. The thermostat will thus operate sooner than usual and high voltage will be applied to the rectifier anodes before they have been given the normal time to warm up.

The effects of this reduced delay will however be mitigated by the fact that tube heaters have only been given a limited time to cool down. Thus it is very probable that the tube heaters will reach a safe temperature in a much less time than usual. If, for a given cooling time, the time taken by the tube heaters to reach a safe temperature is less than that taken by the thermostat to operate, we may consider that the thermostat gives complete protection to the tubes under all conditions.

To determine whether this is so or

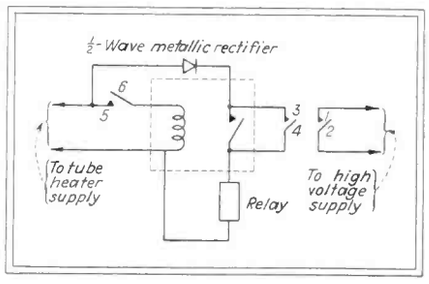

Fig. 2—Lock-out type of self-protecting relay

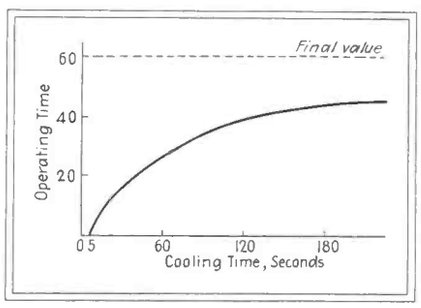

Fig. 3—Relationship between cooling time and operating time

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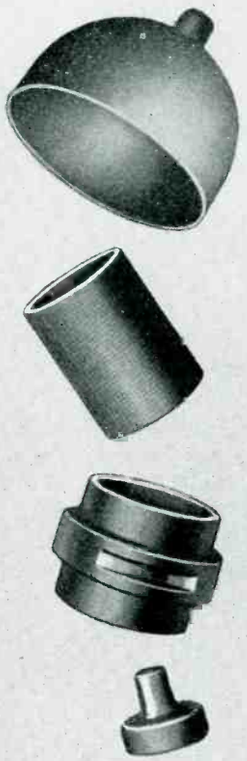

With SPEER Graphite Anodes, transmission and power tubes have longer service life because the anodes cannot be damaged by overloading. They will not warp, fuse, soften or blow.

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not we need the following information: (1) The time taken by the thermostat to operate after cooling for a given period. (2) The temperature reached by the tube heaters when heated for a given time after being allowed to cool for a given period.

The first part of this information is easily obtained. Normal voltage was applied to the heater of a thermostat wired up in the circuit of Fig. 2. The element duly closed and began to cool off again. It was allowed to cool for a given number of seconds. Voltage was then again switched on and the time in seconds taken by the thermostat to operate was noted. This was repeated with values of cooling time from five seconds upwards and a curve of operating time against cooling time plotted. This is shown in Fig. 3.

It will be observed that with less than five seconds cooling time the thermostat takes no time at all to operate, in other words it takes five seconds for the thermostat to come out of contact. As the cooling time increases above five seconds the curve rises sharply, bends over and rises less sharply for some time, and finally becomes practically flat for cooling times of greater than 180 seconds. The delay is then in the neighborhood of 42 seconds and only increases very slowly with increase of cooling time. It is not, however, until after a considerable time has elapsed that the thermostat attains its final value of delay time, which was found to be some sixty seconds.

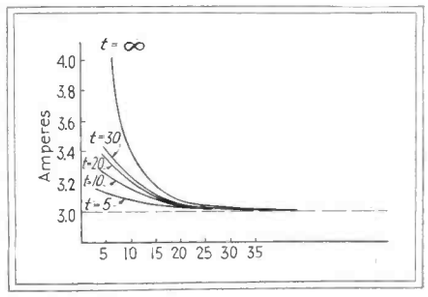


Fig. 4—Current vs. time in seconds for values of cooling time

To determine the actual temperature of the tube heaters would be a matter of great difficulty. But the temperature of the heaters fixes their resistance; and their resistance fixes the current through them. Thus we may take the shape of the current time curve as an indication of the way temperature will vary with time. Where the current curve is falling rapidly the temperature will be low and rising rapidly; and where the current curve is flat and almost horizontal the valve heater will have practically attained its final temperature.

A series of curves were taken for the two rectifiers controlled by the thermostat mentioned above. The heaters were switched on and allowed to attain their normal operating temperature. They were then switched off and allowed to cool for a given period, after which they were again

switched on and the current through them noted from the instant of switching at intervals of five seconds. This was repeated with values of cooling time up to forty seconds and a series of curves of current against time for various values of cooling time plotted. These curves are shown in Fig. 4.

The curves follow the shape to be expected, i.e. they come down rapidly at first and then flatten out to the normal current of three amps. Initial current is less as the delay is less.

The curves of Figs. 3 and 4 taken together give us the information we require. A value of cooling time was taken. From the curve of Fig. 3 the value of thermostat operating time corresponding to this was found. Selecting from Fig. 4 the tube current—time curve with the same cooling time, the value of current was found for the operating time obtained above. This current is the current the tube heaters will pass at the instant the thermostat operates, after it and they have been allowed to cool for the given time. It hence represents the temperature of the heaters when they are switched on.

By taking different values of cooling time in this manner a curve of heater current against cooling time was plotted and is shown in Fig. 5. It will be seen that for cooling time greater than 40 seconds the tube current is very nearly equal to the normal value, i.e. the tube has very nearly attained its normal temperature. Between this and 10 seconds the current goes up rapidly, but below 10 seconds the curve appears to flatten out again and approach a limiting value of 3.14 amps.

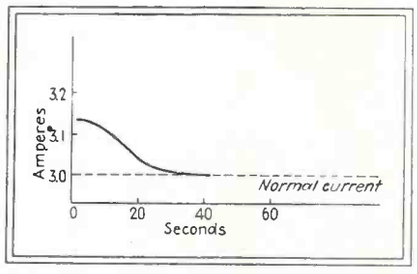


Fig. 5—Heater current vs cooling time, from Figs. 3 and 4

Consulting the current time curves we see that this value of current is well on towards the flat portion on any of them: that is to say that in the worst condition the tube will have substantially reached its final temperature so the protection afforded by the thermostat is quite adequate.

The thermostat was of the ordinary type consuming 4 volts, 1 amp. The tubes were two 1500-volt mercury vapor rectifiers with a filament voltage of 5 and a filament current of 3 amps. each. The curves obtained will, of course, differ from thermostat to thermostat and from tube to tube; but it is hoped that this article will have indicated the general character of the results to be expected and an experimental technique for obtaining them.

Receivers for the Tropics

(Continued from page 28)

cities, a considerable number of receivers bound for Latin America can be expected to be subjected to salt water mist in some degree.

Aside from the usual failures that befall a receiver, the following faults occur with monotonous regularity, even in quite new equipment.

Fine wires corrode rapidly and break, especially if the wires carry high potentials and are held in place by adhesive tape, glue, or cardboard and fibre forms. This makes a high mortality rate in loudspeaker field coils, output transformers, power transformers, and i-f and r-f coils.

Investigation shows that the breaks always occur where the wires are touching some fiber or adhesive material; or near the terminals where soldering flux or the oil from human hands may have played a corrosive role. It occurs frequently in coils that have been painted with insulating compound. However, if the coil has been both hot and cold dipped in a wax or other impregnating material, it seldom gives trouble. The recent article by Stephens and Gehrenbeck[1] no doubt points the way to a correction of these difficulties. Switch contacts and the wiping contacts of tuning condensers give frequent trouble due to corrosion, but can usually be cleaned.

Moisture, and the accompanying growth of green mold on the wiring, increases the leakage paths in the receivers. The Q of coils is frequently changed so much by this that both the sensitivity and alignment of a receiver are thrown completely off. The a-v-c action is sometimes nullified because the leakage resistance of the wiring is less than the value of the filter resistors in the circuit.

A rusty chassis usually does not affect the operation of an otherwise well-built receiver, but if large patches of rust appear before it can leave the dealer's shelf its sales appeal is definitely affected, even in countries where rust is an all too common sight.

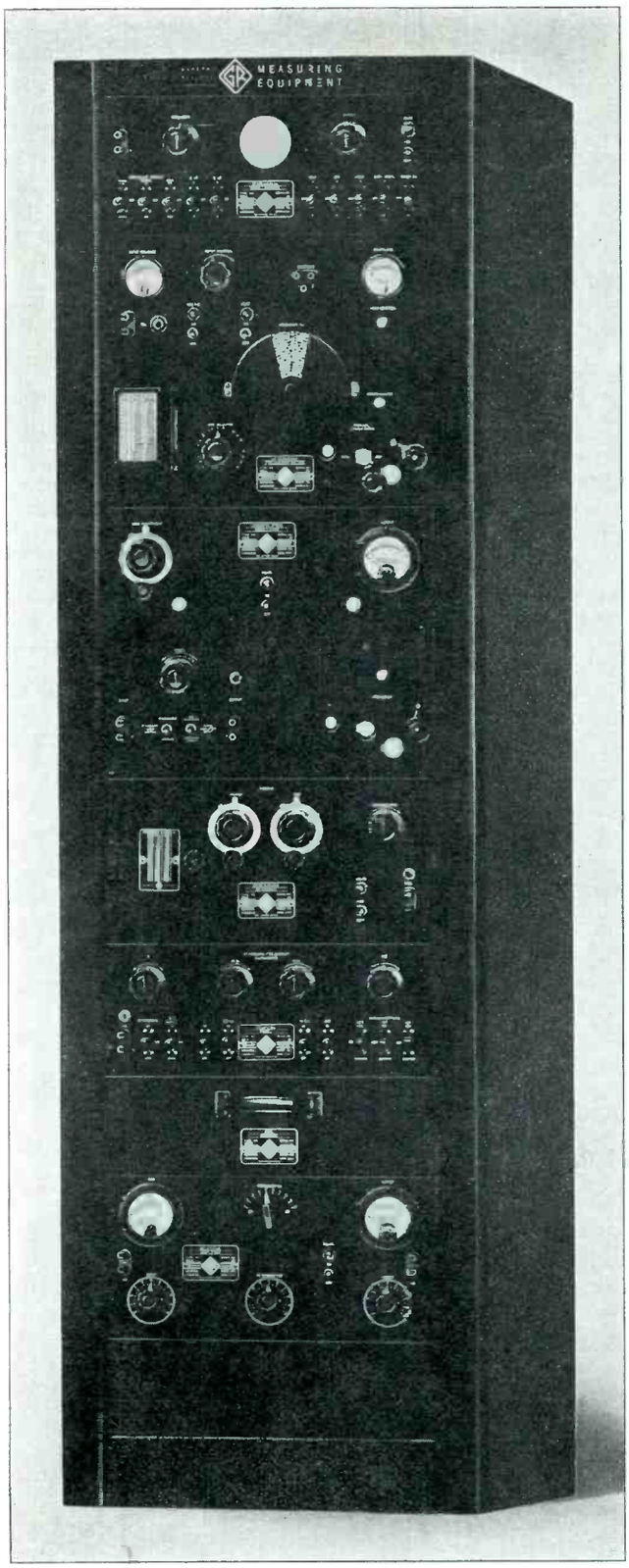
United States furniture dealers ordinarily withdraw the guarantee on their product if it is shipped to a tropical climate. Radio cabinets seem to withstand the climate comparatively well, however. There are instances where the glue has failed and the finish dulled, but the extremes of the temperate climates probably test a radio cabinet more than tropical humidity. Cabinets of plastic materials eliminate the problems which might be encountered along this line.

The climate plays another important role in radio reception in the tropics. The static level is so high throughout the standard broadcast band that only local reception is possible most of the time. Most Latin American stations broadcast simultaneously on both standard and short wavebands. Thus, all the programs are available on the short waves. However, the customer must buy an all-wave receiver to obtain short-wave reception. In most cases, the purchase will consist, by necessity, of a receiver with well engineered broadcast-band reception, and with indifferent short-wave reception added for sales appeal.

The customer may have to buy a larger set than he wishes to obtain the short wave reception. He may have a 50- or 75-watt heater installed inside the cabinet to keep it drier and to prevent humidity failures. Since electricity is expensive in Latin America, both these items add greatly to the cost of operation and maintenance. None of these factors make contented users.

Except in the Canal Zone, where United States standards of living prevail, the average income in the tropical Americas is comparatively low. The economic systems have a much broader base of low wage earners. It would seem that, if the radio dealer is to reach deeply into this market, he must have a low priced short-wave receiver (not necessarily all-wave) which is efficient and is properly protected against high humidity.

[1] "Causes of Corrosion of Fine Copper Wires Carrying a Potential" H. N. Stephens and G. B. Gehrenbeck, *Electrical Engineering*, June 1940. Reviewed in ELECTRONICS July, 1940.



Precise Measurements of Frequency with G-R Measuring Equipment

FROM THE G-R PRIMARY STANDARD OF FREQUENCY, fundamental frequencies of 50, 11, 10, 9, 1 and 0.1 kilocycles are obtained. By means of harmonic frequency multipliers in the primary standard, a large number of harmonics of each of these frequencies are available, also, at the output terminals of the standard.

For the precise measurement of frequencies in terms of these standard frequencies, suitable auxiliary and interpolation equipment is needed. The G-R Frequency Measuring Equipment assembly, with the Primary Standard of Frequency, makes possible the accurate, direct, precision measurement of *any* frequency from a few cycles up to 25 megacycles, or higher if external receivers are used.

The units comprising the measurement equipment are as follows:

Heterodyne Frequency Meter covering the range of 100 kc to 5,000 kc in sixteen steps. Sufficient harmonic output is obtained to produce beats in a high-frequency receiver operating at 30 Mc or more. For many measurements, sufficient accuracy is obtained through use of direct-reading finder and interpolation dials on the heterodyne frequency meter.

Interpolation Oscillator which is a direct-reading, linear-scale audio-frequency oscillator covering frequencies between 0 and 5,000 kc. It is used to measure the audio-frequency differences between the unknown frequency (or a submultiple thereof) and a standard 10-kc harmonic. When the difference is very small, use is made of the 9-11 kc standard harmonics to avoid measurements with very low audio frequencies.

Heterodyne Detector with plug-in coils covering the range from 25 kc to 25 Mc. This detector is used to obtain beats between the standard and the unknown radio frequencies.

Regenerative Selective Amplifier which is used to select any multiple of 1 kc between 1 and 10. This amplifier is particularly useful when the cathode-ray Comparison Oscilloscope is used in calibrations in the upper audio-frequency and lower radio-frequency ranges.

Comparison Oscilloscope with 100-cycle and 1,000-cycle smoothing filters, networks for obtaining circular sweeps at these frequencies, and switches for connecting units of the frequency standard and measuring equipment to the oscilloscope.

The assembly is housed in a steel cabinet and includes a built-in loud-speaker. Permanent shielded connecting cables between the measuring equipment and the Primary Standard and for all interconnections between units of the measuring assembly are furnished. All connections for actual measurements are made by suitable switching on the centralized coupling panel, through which the standard and unknown sources and the various measuring instruments are connected. Suitable power supplies for a-c operation from 115/230 volt and 50-60 cycle mains are individually built in each instrument.

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

THE ELECTRON ART

The review of the literature this month uncovers modulation interference studies, a method of locating airplanes acoustically, characteristics of negative glow lamps, and the use of radio in coal mines

Interference in Modulated Systems

AN INTERESTING mathematical article on "Interference in Relation to Amplitude, Phase and Frequency Modulated Systems," by O. E. Keall appears in the January 1941 issue of *The Wireless Engineer*, from which the author's summary which follows is taken. Some characteristics of the three systems of modulation are first described, the more important are:

(a) In amplitude modulated systems the amplitude change of the carrier is directly proportional to the percentage of modulation and the signal may be resolved into a carrier of fixed amplitude together with a pair of sidebands whose (equal) amplitudes are proportional to the percentage of modulation. The intelligence spectrum is twice the modulation frequency. The maximum radiated power associated with the intelligence (i.e. the sidebands) is 50 per cent of the (constant) carrier power.

(b) In phase modulated systems the phase displacement of the carrier is directly proportional to the percentage of modulation and the signal may be resolved into a carrier whose amplitude decreases on the application of modulation and a multiplicity of sidebands whose number and amplitudes vary as the percentage of modulation. The intelligence spectrum varies as the percentage of modulation and the modulation frequency, and for full modulation approaches 2.6 times the phase displacement times the modulation frequency (or 2.6 times the frequency deviation, or displacement, equivalent to the phase displacement). The maximum radiated power associated with the intelligence is very nearly 100 percent of the power of the transmitted.

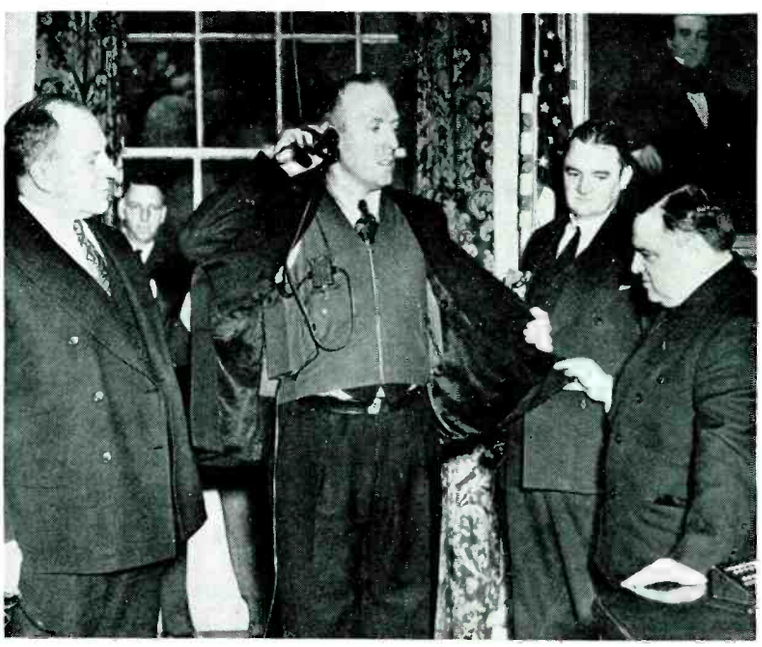
(c) In frequency modulated systems the frequency deviation, or displacement, of the carrier is directly proportional to the percentage of modulation and the signal may be resolved into a carrier whose amplitude decreases on the application of modulation together with a multiplicity of pairs of sidebands whose number and amplitude vary as the percentage of modulation. The intelligence spectrum varies as the percentage of modulation but is independent of modulation frequency. The maximum radiated power associated with the intelligence is very nearly 100 per cent of the power of the transmitter.

(d) When two or more modulation frequencies exist simultaneously, in amplitude modulated systems the sidebands in the complex signal are the sum of those that would be produced were each frequency to modulate the carrier independently, but in phase or frequency modulated systems the sidebands in the complex signal are both as to number and amplitude derived from the product of the sidebands that would be produced were each frequency to modulate the carrier independently.

The effect of an interfering carrier is then considered assuming the wanted signal to be unmodulated. It is shown that the two carriers may be combined in such a way that they may be completely represented by a single carrier (of frequency of that of the wanted signal) carrying an equivalent modulation, this equivalent modulation being dependent upon the ratio x of the amplitude of the interfering signal to that of the wanted signal $\left(x = \frac{\text{Interfering amplitude}}{\text{Wanted amplitude}}\right)$. It is a necessary condition for the validity of the expansions employed that x shall be less than unity. When the interfering signal is greater than the wanted, the roles of the two signals are, as far as this analysis is concerned, reversed, the interfering signal taking charge and the wanted appearing as an interference thereon. Under these conditions increasing the receiver selectivity has in general little effect and directional reception methods must be resorted to.

It is shown that the interference is much less for phase or frequency modulated systems than for amplitude modulated systems while in general a frequency modulated system is to be preferred to one phase modulated. Next, the carriers are considered as being modulated by each of the three systems in turn, the reduced interference when frequency modulation is employed being maintained. In both phase and frequency modulated cases the interference decreases as the depth of modulation of either carrier is increased. It is shown that by means of a graphical representation of the spectrum, the labor of computing the equivalent modulation in phase or frequency modulated systems may be very materially reduced. Several examples are given from which the advantages to be gained by frequency modulation are made apparent. A final note stresses the conditions for which the analysis is valid.

TWO-WAY VEST RADIO FOR NEW YORK POLICE

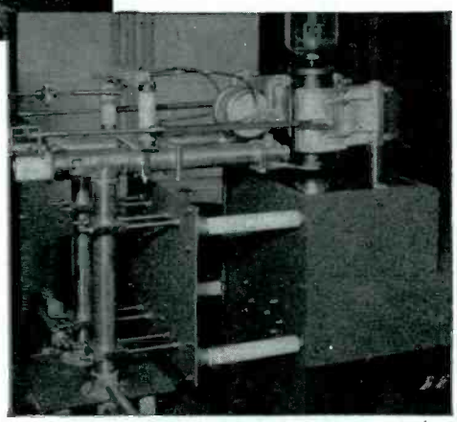


Mayor LaGuardia looks over a two-way communication system weighing 11 pounds and having a range of one-fifth of a mile. At the left is Police Commissioner Lewis Valentine, while Patrolman William Proctor demonstrates the equipment developed by Gerald S. Morris

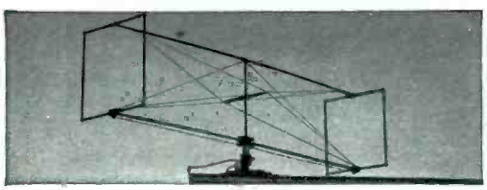
INSULATION HIGHLIGHTS

(*Above*) PROGRESS IN FM BROADCASTING offers an expanding field for Isolantite*—the logical insulation choice for this and other types of radio work. Photo shows the 50KW FM transmitter built by Radio Engineering Laboratories, Inc., for The Evening News Association, Detroit—the third unit of this type to go on the air. Plate lines and other units are supported by Isolantite insulators. Photo at right shows close-up of power amplifier unit.

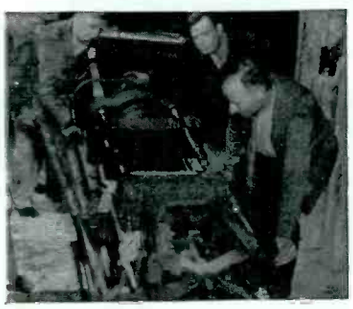
(*Below*) LOCATING PLANES IN FLIGHT is made possible by newly developed radio compass. Signals from plane are picked up at two or more points, employing this metallic frame antenna, which is rotated by motor until signal is strongest. Position of plane is triangulated from directions of the various antennas.

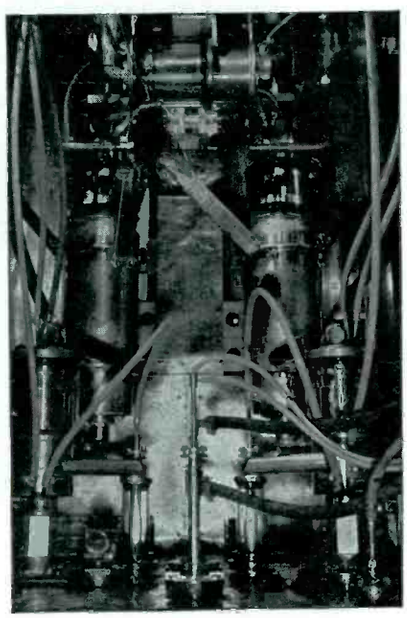


(*Below*) INSULATOR TROUBLES WERE ELIMINATED in this experimental 1,000,000-volt radio frequency X-ray equipment in use at a leading university research laboratory in N. Y. C. by the use of the *new style* Isolantite stand-off insulators. The original insulators, employing cemented castings, seriously overheated within 15 to 20 minutes at full voltage. The new Isolantite insulators, employing spun-on aluminum shields, have been tested at full voltage for practically 16 uninterrupted *hours*—without signs of heating. Insulators used in this equipment are generally subjected to 25,000 volts at 6 megacycles.

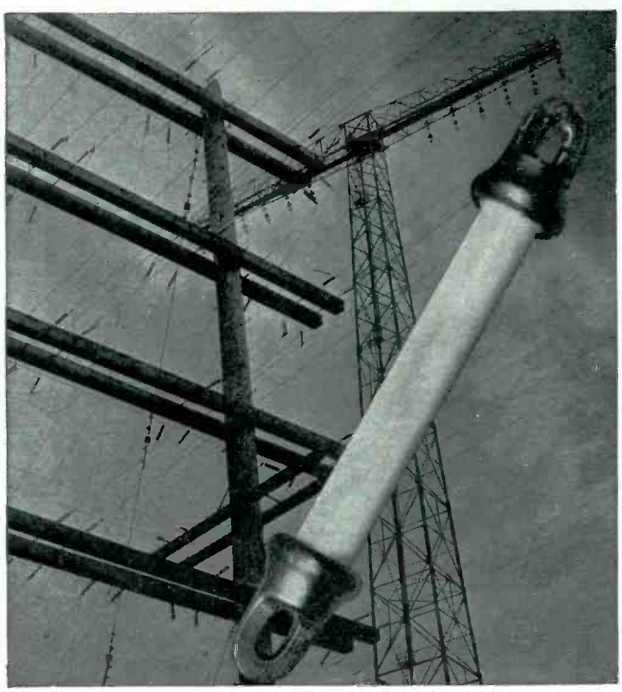


(*Right*) PRODUCTION FACILITIES are being expanded at the Belleville, N. J., plant of Isolantite, Inc., to meet the demand for Isolantite insulators. Photo shows small 20-ton hydraulic press—part of the new equipment—being moved into the plant.





(*Left*) ISOLANTITE STRAIN INSULATORS are especially popular because of their high mechanical strength and low electrical loss, and are economical in custom-made designs. Shown in the background are some short wave open wire transmission lines and part of a long wave antenna at RCA's Rocky Point Station.



*Registered trade-name for the products of Isolantite, Inc.

ISOLANTITE

CERAMIC INSULATORS

ISOLANTITE, INC. FACTORY: BELLEVILLE, NEW JERSEY

SALES OFFICES: 233 BROADWAY, NEW YORK, N. Y.

Coal Mine Uses Radio for Communication

THE RADIO COMMUNICATION system in use by the Maureen Coal Co., of Spelter, W. Va., is described in an article in the January 1941 issue of *Coal Age*, by Ivan A. Given. In this system good communication between the operating point in a mine and the outside is obtained at a fraction of the cost of a standard telephone system. The radio units are of the transceiver type and utilize the 250-volt trolley system for carrying the high-frequency waves. Power for operation of the unit in the mine is also obtained from this trolley system.

Mine radio telephone equipment, built to take abuse

The installation was made in March 1939, with one set permanently located in the shop at the mine portal and the other a portable unit kept in the mine foreman's shanty two miles underground. Each of these sets was purchased at a cost of $95.

Communication between cars, miners and shaft is possible at low cost

When the units were received one was installed on the haulage locomotive to determine the effective distance over which the system would operate and to locate any bad spots in the trolley system. A reasonably good trolley system is necessary for most efficient operation of the set, as heavy grounds to hangers, bad splices and the like result in considerable interference. Because of this characteristic, the radio set performs an incidental service which is of considerable value in that it provides instant evidence of bad circuit conditions of a trolley line.

Although in this case only two units are required, it is possible to operate a number of units without interference between each other by the use of several frequencies. The management of this mine is of the opinion that one of the biggest fields for equipment of this type is in service on locomotives, not only those hauling coal but also locomotives for other transportation equipment used by electricians, supplymen, inspectors or others who customarily move around underground and sometimes must be located quickly. As this system is inexpensive and can be connected up ready for operation in a very short time, it is felt that it lends itself very well to such portable operation.

• • •

Airplane Location by Electro-Acoustic Method

AN ELECTRO-ACOUSTIC device for the location of aircraft, is described in the December 1940 issue of *Electronics and Television and Shortwave World.* Although complete efficiency is not claimed for the system, it is now installed in the large public buildings in the London area, and its value at times when visibility is bad, has been definitely established. The equipment is described under the title, "Aeroplane Spotting by Electro-Acoustical Method".

Essentially the device consists of a parabolic reflector mounted on a tripod in such a manner as to be capable of being swung about in any horizontal or vertical direction. At the focal point of the parabolic reflector is a piezoelectric crystal microphone. The output from the microphone is taken through a screened table to a four-stage high gain a-c operated amplifier. The output of the final amplifier may be fed into an aural or visual indicator as required. In practice an approximate location is obtained by the aural method and a more precise spotting is accomplished by use of a meter in the output circuit of the final amplifier.

It is not claimed that great accuracy is obtained with this device, as many variables enter into the final results. Reflection of sound gives rise to erroneous readings and it is difficult to check a mass flight of aircraft due to the large area of engine sounds. However, for a single plane its usefulness has been thoroughly proven.

Characteristics of Gas Lamps

AN EXCELLENT SURVEY of the characteristics of commercially available gas lamps is contained in an article "Characteristics and Applications of Negative-Glow Lamps," by H. M. Ferree in the January 1941 issue of *Electrical Engineering*.

As given by the author, the popularity of the small lamp is largely attributed to the following factors: (1) low current consumption, (2) insignificant heat, (3) reliability, (4) long life, (5) wide voltage range and (6) ruggedness. Furthermore, the fact that these lamps do not fail suddenly in service, but become less efficient as a result of gradual decrease in loss in light output during a period of some 3,000 hours, accounts for their extensive use in signalling circuits, pilot lamp arrangements and similar applications. These lamps, of which the small size neon and argon lamps are familiar to most radio men have a negative characteristic and if these lamps are operated on circuits of sufficient voltage to cause the gap to break down, a current would immediately rise to such a value as to permanently damage the lamps. For this reason, the limiting resistor is used in series with the lamps and lamps are customarily sold with this limiting resistor permanently in place. For certain applications, lamps are obtainable without the external resistance.

In this article three tables showing the characteristics of standard glow lamps are given and each table summarizes the important electrical and illumination characteristics of the neon and argon lamps. The breakdown voltage varies from about 45 volts to 83 volts, although variation may be expected from lamp to lamp and the breakdown voltage is also influenced by the amount of light contingent on the lamp since these lamps show a definite photoelectric effect. Likewise, the breakdown voltage may be increased if the ambient temperatures become as high as 75 to 150 degrees C.

Some attention is given to the application and use of these lamps as test lamps, signal or pilot lamps, and as low frequency generators. As a pilot lamp the gas tube indicates polarity since only the negative electrode flows if direct current is used. The circuit of the lamp may also be used to indicate whether the circuit is alive (provided the voltage is greater than the breakdown voltage) and by indicating in general the frequency of the supply by the rate of flicker.

• • •

Radio Interference in Electrical Power Line Insulators

RADIO INTERFERENCE originating in electrical power lines and sub-station insulators is discussed in an article entitled "Some Insulator Designs Require Special Features to Insure Radio Quietness," by Charles J. Miller, Jr., in the February 1941 issue of *Electrical Engineering*. Fundamentally, the radio interference originating from insulators is caused by an electrically overstressed condition of the air adjacent to certain regions of the insulator. It is a fortunate condition that overstressed air makes its presence known by a visual phenomenon known as corona, or corona discharge. It was found that the principal regions of overstressed air were at the conductor and tie wire, and in the pin hole where thin layers of air are subjected to intense electric fields. The obvious solution to this problem is to eliminate the air from these critical regions or to alter the design of the insulator in such a way that the intense dielectric field of the insulator between the pin and the conductor and tie wire lie wholly within the dielectric medium of the insulator and not across these layers of air.

Simple methods of radio-proofing are discussed and are followed with the recommendations of the Joint Co-ordination Committee on Radio Reception of Edison Electric Institute, National Electric Manufacturers Association and Radio Manufacturers Association.

Standards have been set up determining the maximum radio noise generation permissible for various types of transmission lines. Based on these standards it is shown that the following conditions for radio-proofing exist:

1. For distribution voltages up to 4,400 or even 5,500 volts, the small one-piece pin-type insulators used require no radio-proofing, even on solidly grounded pins.

2. If there is 6 to 12 inches of wood crossarm in series with small one-piece pin-type insulators on low-voltage distribution lines up to 13 kv no radio-proofing is needed on the insulators.

3. Standard untreated pin-type insulators used on 17- to 69-kv distribution and transmission lines have radio noise-influence voltages in the order of several thousand microvolts at a test potential about 10 per cent above the usual line-to-ground voltages. Radio-proofed pin-type insulators, readily meeting reasonable requirements for freedom from radio interference, are available for use on lines in this voltage range.

4. Standard cemented pin-and-cap switch and bus insulators up to the 69-kv rating, with the exception of the 66-S-class, readily meet the suggested requirements for freedom from radio interference without any special "radio-proofing" treatment; they are inherently quiet.

5. Standard switch and bus insulators for the 66-S-class and the 115-kv and higher-voltage classes may require radio-proofing or other precautions to meet the suggested abnormally low requirements. These insulators with slight changes can be made to meet the requirements readily.

6. Regular cemented pin-and-cap suspension insulators of modern manufacture readily meet the suggested requirements for freedom from radio interference without any form of radio-proofing; they are inherently quiet.

Calculation of Cavity Resonators

"A NEW METHOD for the Calculation of Cavity Resonators," by W. C. Hahn is presented in the January 1941 issue of the *Journal of Applied Physics*. In the development of shortwave tubes one of the problems requiring considerable attention is that of radio frequency circuits. This is essentially true because the size of these circuits becomes large enough compared to the wavelength so that their calculation is really a field problem rather than a circuit problem. In the intermediate range from about a meter down to about 10 centimeters it has been possible to approximate the field effect, reducing everything to a circuit for certain practical configurations. At 10 centimeters and below these approximations rapidly become invalid for the desired sizes of resonators. Thus, an exact and rigorous method of calculation is almost a necessity, either for use directly in design, or if too cumbersome for this, for justifying new approximations which will allow reasonably simple design formulas. The author states that the method seems to meet these requirements in so far as application of it has been made.

The new method consists of dividing a cavity into two or more spaces, finding series solutions which fulfill the original boundary conditions in each space separately, and then matching the solutions at their common surface. Depending upon how the cavity is divided, different series may be obtained. The solution appears as equations containing the known geometric constants in a set of infinite series which converge very slowly. Other types of matching may produce more rapid convergence, but this does not appear likely at first glance. If, however, these slowly converging series are subtracted from standard series, the sums of which are known, the new series converge very rapidly so that if the sum of the standard series were tabulated, the process would be reasonably practical from a numerical standpoint.

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A Correction

Mr. L. Malter of the RCA Manufacturing Company was erroneously reported on page 25 in the February 1941 issue of ELECTRONICS as having stated in his paper before the I.R.E. Convention that amplication loss results from the finite time taken for electrons to "get started". Mr. Malter informs the editors that no such time lag was reported, and that he set an upper limit to the time taken for secondary emission to occur, which is of the order of the period of the highest frequency studied.

Integrating Circuit

(*Continued from page 35*)

Northrup potentiometer, that is, the voltage drop across the low impedance slide wire, is equal in magnitude to the voltage which has appeared across R_5 due to the clicks. We have, then, a voltage substitution or opposition method in which the voltage developed by the extremely small leakage current in R_5 is matched and hence recorded in a slide wire of low impedance, i.e. the slide wire of the Leeds & Northrup recorder.

Since this voltage is linearly proportional to the movement of the recorder, and, at equilibrium, the vacuum tube always operates at constant plate current and constant grid voltage, it is evident that the vacuum tube and recorder act as a vacuum tube substitution voltmeter which is independent of the form of the tube grid-voltage plate-current characteristics.

The overall characteristics of the system remain, therefore, the characteristics of the *R-C* network, i.e. pulse rate vs I_{R5} (except for secondary phenomena discussed in the next section). This in turn is nearly linear.

If we wish to consider adjustments leading to close approximations to overall linearity, it is appropriate to study the voltage and current relations of the system in greater detail, at least in the quasi-equilibrium state corresponding to a constant, sustained pulse rate.

For a given click rate and specified closure time, the solution for the time variation of the current in various elements of the resistive network, shown in Fig. 1, is susceptible of exact formulation by the methods of the operational calculus.[4]

However, the analysis thus obtained contains rather involved mathematical expressions which, without approximations, do not contribute materially to the physical visualization of the salient voltage and current relationship. Moreover,

leakage and secondary phenomena probably vitiate the fundamental network assumptions to a degree which hardly justifies the elaborate formulation corresponding to a rigorous solution.

A useful visualization of voltage relations in the steady state (which is a sufficient guide for the choice of most of the circuit constants) may be derived from certain current relationships which must be satisfied in the quasi-steady state by virtue of conservation of charge conditions, etc. Such a simplified analysis will be considered in this section.

Thus, referring to Fig. 1, and assuming that the system has attained quasi-equilibrium for a given click rate, it will be noted that the charge transferred from C_1 to C_2 over any interval of time (long compared to the click rate) must equal the charge leaving C_2 through resistances R_3, R_4 and R_5, that is:

$$(V_L - V_{C2})\ (C_1)\ (N) = I \qquad (1)$$

V_L = Constant charging voltage of C_1 (approximately 200 volts)
V_{C2} = Voltage across C_2
N = Clicks per second
I = Average discharge current of C through resistors, in amperes

This merely states that at quasi-equilibrium the rate at which the charge flows into C_2 must on the average equal the charge flowing out.

TELEVISION FOR ARMY RECRUITING

The first television recruiting for the United States Army got under way at the Don Lee studios of W6XAO when a regular Army captain and two recruiting sergeants selected eleven youths for service. More than 1500 televiewers watched the unusual spectacle by means of the 500 television receivers in the Los Angeles vicinity

The voltage across C_2 is evidently

$$V_{C2} = I(R_3 + R_4 + R_5) \qquad (2)$$

So, neglecting any abrupt changes in the voltage of C_2 due to the small individual charges transferred from C_1, we have:

$$(C_1) \quad (N) \quad V_L - I(R_3 + R_4 + R_5) = I \qquad (3)$$

Solving for I, we obtain the voltage V_{R5} across the grid bias control resistor, that is:

$$V_{R5} = IR_5 = \frac{V_L\ C_1\ N_{R5}}{1 + C_1 N\ (R_3 + R_4 + R_5)}$$

It will be noted that V_{R5} is nearly proportional to N provided $C_1\ N(R_3 + R_4 + R_5)$ is small compared to unity.

The graph of Fig. 3 shows V_5 as function of N for the values of V_L, C_1, C_3-R_3, R_4 and R_5 indicated in Fig. 1. The dotted lines indicate the limit of the usual working range of N with the Westinghouse setup as at present employed. The value of V_{C2} is 1.22 volts for the upper limit of N usually encountered (0.167 clicks/sec or 10 clicks/min).

The Leeds and Northrup records obtained by the click recorder as modified in its operation by the integrating circuit just described, give rather readily readable indications of ultraviolet intensity and its variations due to such phenomena as clouds. A comparison of the records is shown in Fig. 2.

It should be noted that the counting circuit described can readily be adapted to indicating the average number of impulses per second produced by any type of circuit, provided the clicks can be used to activate a relay such as that indicated by relay x. The major precaution to observe is to provide a relay x with a sufficiently high leakage resistance to make the current leaking to the front contact across the relay negligible compared to the charge transferred by the relay from C_1 to C_2.

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[1] "An Ultraviolet Light Meter," Rentschler Trans. A.I.E.E. 49, 576, 1930.

[2] For further details see: "Studies in Solar Radiation and Their Relationship to Biophysics and the General Problem of Climate and Health." Kenrick and Del Toro. P. R. *Journal of Public Health and Tropical Medicine*. June 1940.

[3] A modified form used by the U. S. Public Health integrates the clicks day by day with a Veeder Counter.

[4] Carson, John R., "Electrical Circuit Theory and the Operational Calculus," McGraw-Hill, 1926. The solution may also be carried out as a converging series of transient solutions by classical Heaviside Operational Methods.

TUBES

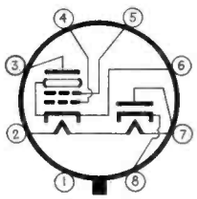
Two new 117-volt-heater rectifier beam-power tubes were registered with the R.M.A. Data Bureau during January, 1941. Older tubes, registered prior to 1936, are also listed for reference

Tube Types Registered with the R.M.A. Data Bureau During January, 1941

Type 117P7GT

RECTIFIER, beam tetrode, heater type, T-9 glass enevelope, seated height 2⅞ inches; 8-pin octal base.

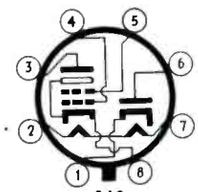
E_f = 117 v
I_f = 0.09 amp
$E_b = E_{C2}$ = 117 v
TETRODE SECTION
E_b = 105 v
I_{bo} = 43 ma
r_p = 17,000 ohms
r_l = 4000 ohms
E_{C2} = 105 v
E_{C2o} = 4 ma
E_{C1} = − 5.2 v
g_m = 5300 ohms
P_o = 0.85 watts (5%)
HALF WAVE RECTIFIER
E_p = 117 v ac (max)
E_{pin} = 350 v (max)
E_{drop} (150 ma) = 16 v
E_{hk} = 175 v dc (max)
I_{peak} = 450 ma (max)
E_p = 117 v
I_b = 75 ma
Minimum total effective plate supply impendance = 15 ohms
Basing 8AV-O-O



Type 117L7GT/117M7GT

RECTIFIER, beam tetrode, heater type, T-9 glass envelope, seated height 2⅞ inches, 8-pin octal base.

E_f = 117 v
I_f = 0.09 amps
$E_b = E_{C2}$ = 117 v (max)
TETRODE SECTION
E_b = 105 v
I_{bo} = 43 ma
r_p = 17,000 ohms
r_L = 4000 ohms
E_{C2} = 105 v
I_{C2o} = 4 ma
E_{C1} = − 5.2 v
g_m = 5300 μmhos
P_o = 0.85 watts (5%-
HALF WAVE RECTIFIER
E_p = 117 v r-m-s ac (max)
E_{pinv} = 350 v (max)
E_{drop} (E_p = 150 ma) = 16 v
E_{hk} = 175 v dc (max)
I_{peak} = 450 ma (max)
E_p = 117 volts
I_b = 75 ma
Minimum total effective plate supply imped ance = 15 ohms
Basing 8AO-O-O



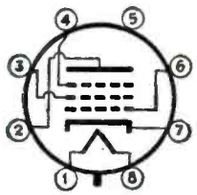
LISTENING CENTER AT PRINCETON

Monitoring a foreign short wave broadcast at the Princeton Listening Center at Princeton University are J. R. Snedeker, Jr. and Harold N. Graves. The purpose of the center is to check up and record, if necessary, programs from foreign countries

Type 7V7 (GL)

R-F PENTODE, sco, heater type, T-9 integral glass envelope-base, maximum seated height 2¼ inches, 8-pin lock-in base.

E_f = 7 v
E_f = 6.3 v
E_b = 300 v
E_{c1} = cathode bias resistance 160 ohms min
I_b = 9.6 ma
g_m = 5800 μmhos
I_f = 0.48 amp
E_{c2} = 150 v
I_{c2} = 3.9 ma
r_p = 0.3 megohm
C_{in} = 9.5 μμf C_{out} = 6.5 μμf $_gC_p$ = .004 μμf (max)
Basing 8V-L-5

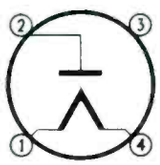


Tube Types Previously Registered with the R.M.A. Data Bureau

Type 81

HALF-WAVE high-vacuum rectifier, filament type, ST-16 glass envelope, maximum seated height 4¾ inches, 4-pin bayonet base.

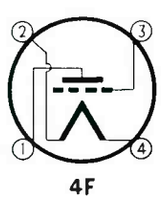
E_f = 7.5 v (ac)
E_f = 1.25 amps
E_p(max peak inverse) = 2000 v
E_{drop}(I_p 170 ma) = 91 v
Half Wave (1 tube)
E_p(rms) = 700 v
I_{dc} = 85 ma
Full Wave (2 tubes)
E_p(rms) = 700 v
I_p(two tubes) 170 ma
Basing 4B-O-O



Type WD-11

TRIODE detector amplifier, filament type, T-8 glass envelope, maximum seated height 3½ inches, 4-pin base.

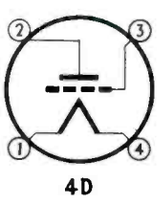
E_f = 1.1 v (dc)
I_f = 0.25 amp
E_b = 135 v
E_c = − 10.5 v
I_b = 3 ma
μ = 6.6
r_p = 15,000 ohms
g_m = 440 μmhos
Basing 4F-O-O



Type WX-12

TRIODE detector amplifier, filament type, T-10 glass envelope, maximum seated height 4 1/16 inches, 4-pin bayonet base.

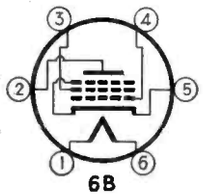
E_f = 1.1 v (dc)
I_f = 0.25 amp
E_b = 135 v
E_c = − 10.5
I_b = 3 ma
μ = 6.6
r_p = 15,000 ohms
g_m = 440 μmhos
Basing 4D-O-O



Type 2A5

POWER amplifier pentode, heater type, ST-14 glass envelope, maximum seated height $4\frac{1}{16}$ inches, 6-pin base.

E_h = 2.5 v
I_h = 1.75 amp
E_b = 285 v
E_{c2} = 285 v
E_c = − 20 v
I_b = 38 ma (zero signal)
I_{c2} = 7 ma (zero signal)
r_p = 78,000 ohms
g_m = 2550 umhos
R_l = 7000 ohms
P_o = 4.8 w (9 per cent)
Basing 6B

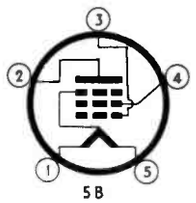


6B

Type 1D4

POWER amplifier pentode, coated filament type, ST-14 glass envelope, maximum overall length $4\frac{1}{16}$ inches, 5-pin base.

E_f = 2.0 v
I_f = 0.240 amp
E_b = 180 v
E_{c2} = 180 v
E_c = − 6 v
μ = 330
r_p = 137,000 ohms
I_b = 9.5 ma
I_c = 2.3 ma
R_l = 15,000 ohms
P_o = 750 milliwatts (10 per cent)
Basing 5B

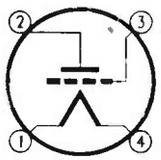


5B

Type 6A3

POWER amplifier triode, ST-16 glass envelope, maximum seated height $4\frac{3}{4}$ inches, 4-pin base.

E_f = 6.3 v
I_f = 1.0 amp
E_b = 250 v (max)
E_c = − 45 v
I_b = 60 ma
μ = 4.2
R_l = 2500 ohms
P_o = 3.5 watts
Basing 4D



4D

ANY SOUND ON TAP

Sound man extraordinary is T. J. Valentino who makes recordings of any sound called for. Here he is shown over Broadway capturing the sounds of the city for subsequent use in broadcast programs

Type V99

TRIODE detector amplifier, filament type, T-8 glass envelope, maximum overall length 3½ inches, 4-nub bayonet base.

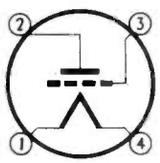
E_f = 3.3 v
I_f = 0.063 amp
E_b = 90 v
E_c = − 4.5 v
I_b = 2.5 ma
μ = 6.6
r_p = 15,500 ohms
g_m = 425 μmhos
Basing 4E-O-O

4E

Type X99

TRIODE detector amplifier, filament type, T-9 glass envelope, maximum seated height 3⅜ inches, 4-pin base.

E_f = 3.3 v
I_f = 0.63 amp
E_b = 90 v
E_c = − 4.5 v
I_b = 2.5 ma
μ = 6.6
r_p = 15,500 ohms
g_m = 425 μmhos
Basing 4D-O-O

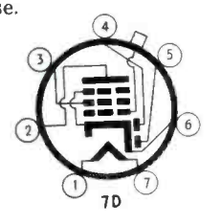


4D

Type 6B7

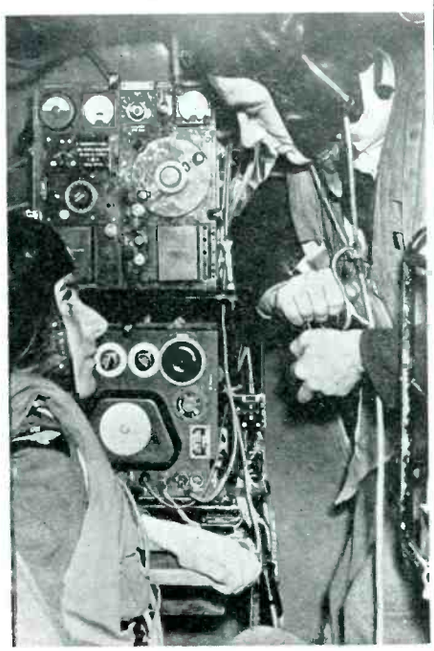
DUPLEX-DIODE pentode, heater type, ST-12 glass envelope, seated height 3 3/32 inches, 7-pin base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 125 v
E_c = − 3 v
I_b = 9 ma
I_{c2} = 2.3 ma
g_m = 1125 μmhos
r_p = 0.6 megohm
Basing 7D



7D

FLIGHT RADIO EQUIPMENT

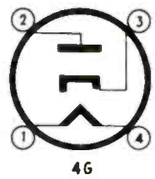


Operators at the radio controls in a British airplane. These R.A.F. members undergo intensive ground training before taking over in the air

Type 1V

HALF-WAVE high-vacuum rectifier, heater type, ST-12 glass envelope, seated height $3\frac{9}{16}$ inches, 4-pin base.

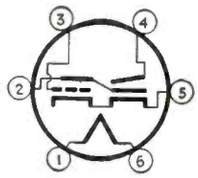
E_h = 6.3 v
I_h = 0.3 amp
CONDENSER INPUT TO FILTER
E_{ac}(rms) = 325 v (max)
I_{dc} = 45 ma (max)
$E_{drop}(I_{dc}$ = 90 ma) = 20 v
Peak inverse voltage = 1000 v (max)
Basing 4G



Type 2G5

ELECTRON ray tuning indicator, heater type, ST-12 glass envelope maximum overall length $4\frac{1}{4}$ inches, 6-pin base.

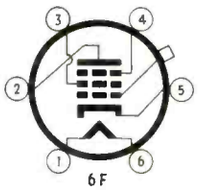
E_f = 2.5 v
I_f = 0.8 amp.
E_{target} = 250 v
E_b = 250 v (through 1.0 megohm)
E_c = − 22 v (for zero degree shadow angle)
Basing 6R



Type 6D6

TRIPLE-GRID super-control amplifier, heater type, ST-12 glass envelope, maximum seated height $4\frac{5}{16}$ inches, 6-pin base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{c2} = 100 v
E_c = − 3 v
I_b = 8.2 ma
r_p = 0.8 megohm
g_m = 1600 μmhos
Basing 6F



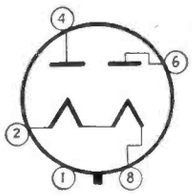
THE "WALKIE TALKIE"

This portable radio communication outfit used at Fort Ord, California, to keep commander and troops in communication, has been dubbed the "walkie talkie". Complete station is light enough for one soldier to carry and has a range of 5 miles

Type 5W4

FULL-WAVE high-vacuum rectifier metal envelope, seated height 2 1/16 inches, 5-pin octal base.

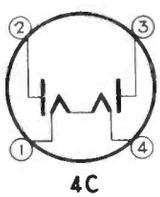
E_f = 5.0 v
I_f = 1.5 amps
CONDENSER INPUT TO FILTER
E_{ac} (rms per plate) = 350 v (max)
I_{dc} = 100 ma (max)
Total effective plate-supply impedance per plate = 25 ohms (min)
CHOKE INPUT TO FILTER
E_{ac} (rms per plate) = 500 v (max)
I_{dc} = 100 ma (max)
E_{drop} (I_{dc} = 110 ma per plate) = 45 v
Peak inverse voltage = 1400 v (max)
Basing 5T



Type 83

FULL-WAVE mercury-vapor rectifier, filament type, ST-16 glass envelope, maximum seated height 4¾ inches, 4-pin base.

E_f = 5.0 v (ac)
I_f = 3.0 amps
E_p(max inverse) = 1550 v
E_{drop} = 15 v (approx)
Condensed Mercury Temperature Operating Range 20°–60° C.
CONDENSER INPUT TO FILTER
E_p(rms per plate) = 450 v
CONDENSER INPUT TO FILTER
E_p(rms per plate) = 450 v
I_p = 225 ma (max)
Total Effective Plate Supply Impedance (per plate) = 50 ohms (min)

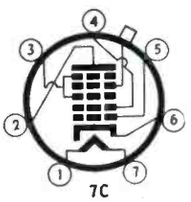


4C

Type 2A7

PENTAGRID converter, heater type, ST-12 glass envelope, maximum seated height 3 29/32 inches, 7-pin base.

E_h = 2.5 v
I_h = 0.8 amp
E_b = 250 v (max)
$E_{c3,5}$ = 100 v
E_{c2} = 250 v (supply)
$I_{cathode}$ = 10.6 ma
E_c = −3 v
g_c = 550 μmhos
$I_{c3,5}$ = 2.7 ma
I_{c2} = 4.0 ma
I_b = 3.5 ma
Basing 7C

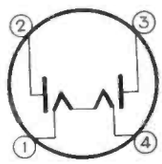


7C

Type 5Z3

FULL-WAVE high-vacuum rectifier, coated filament type, ST-16 glass envelope, maximum seated height, 4¾ inches, 4-pin base.

E_h = 5.0 v
I_h = 3.0 amp
E_{h-k} = 450 v (max)
E(inverse peak) = 1550 v (max)
E_{drop} = 58 v (at 225 ma per plate)
CONDENSER INPUT TO FILTER
E_p = 450 v. (max rms per plate)
I_{dc} = 225 ma (max)
CHOKE INPUT TO FILTER
E_p = 550 v (max rms per plate)
I_{dc} = 225 ma (max)
Basing 4C



Packaging Machinery

(*Continued from page 27*)

tube was increased by the introduction of the spot. This was an exceptional case but it does point to the importance of avoiding the use of red, or orange, or yellow spots as the indexing means on printed wrappers. A dark blue or black spot is much better, or if red-yellow end of the spectrum must be used, the printer must put on as much ink as possible to insure density of print.

If an opaque material such as a foil has to be used, then the spot must be illuminated on the same side as the phototube. In such a case it is most advisable to use an optical system to project the image of the spot on an aperture directly in front of the phototube. When this is done, the image of the spot travels across the aperture just as the spot on the actual paper travels across an aperture immediately below it. Due to the optical leverage there is a magnification of the distance traveled by the spot, which tends to increased accuracy of placement.

With the optical system the register mark or spot need be no larger than one-sixteenth inch wide by one-half inch long. Indeed a spot one thirty-second inch wide will generally be quite adequate.

In this brief article the writer has made no attempt to cover paper register control as applied to machines with very high web speeds but has purposely limited himself to applications which he feels must be generic to the majority of uses. The methods outlined have been most satisfactorily applied to over three hundred machines by Package Machinery Company, and as these machines have been shipped all over the world the reliability and soundness of phototube register control has been amply attested.

FM for Utilities

(*Continued from page 43*)

transmit either, but not both, fm or am on the same frequency, which was expected to create hash on the opposite type of mobile receiver. Actually, however, for various more or less obscure reasons, f-m transmissions, which in this service use 15 kc deviation, can be readily understood on a-m receivers at considerable distances. Similarly a-m transmissions can be identified on f-m receivers, and the expected confusion did not materialize. Secondly, a main station might not know whether to reply to a given mobile unit on fm or am. The trained operators controlling the main station soon became familiar with the situation and reported no particular trouble on this score.

FM-AM Changeover at Main Stations

The field changes required in the Link type 250-UPS equipments to convert them to fm-am operation were made in a few hours time and consist of the following:

(1) Substitute a standard f-m modulator-exciter chassis for the standard 250-UPS exciter chassis. These chassis are mechanically interchangeable and one pair of wires (audio circuit) was run to previously unused terminals. The new chassis is the middle one shown in the close-up view of Fig. 8.

(2) Add fm-am control relay. This relay is shown at the lower left of Fig. 9, and all added wires except the previously mentioned audio circuit are less than six inches long.

(3) Install f-m receiver in the spare receiver position and connect r-f input permanently in parallel with a-m receiver input.

(4) Make minor wiring change in dual receiver power supply so this unit supplies power to both receivers continuously rather than selectively.

(5) Make minor changes in the two-wire control unit including the addition of an fm-am control switch.

The above changeover was accom-

plished using standard assemblies and the parts left over consisted only of standard exciter chassis, which were returned to the factory for credit. The resulting transmitter is capable of operation on fm at 400 watts output.

The method used to accomplish operation of the transmitter on am or fm is electrically very simple. For f-m operation, the audio input is impressed on the f-m modulator-exciter chassis and the a-m modulator input circuit is disconnected and shorted. The output of the modulator-exciter then supplies frequency-modulated excitation to the power output tubes and the normal am modulators are disabled. For a-m operation the audio input is impressed on the a-m modulating system in the normal way and the f-m audio input circuit is disconnected and shorted, under which condition the f-m modulator-exciter chassis supplies only the required unmodulated excitation to the power output tubes.

Range of the Transmitter

While the question of fm or am was one requiring an immediate answer, in reality it formed only a part of the problem of obtaining adequate two-way coverage under many widely different conditions. In general, the desired range is as far as a given car or truck travels from its headquarters. Many cars operate normally entirely within their own division or district, while others may range over the entire territory of the company. Thus, providing direct emergency communication for all cars and trucks would mean a two-way range of 100 miles or more on the power systems under consideration. At present such a direct range is impractical and would eventually create greater interference problems between adjoining companies than at present anticipated, particularly on the three main station frequencies allocated to special emergency service in this band. Cars operating within their local territory require reliable ranges up to thirty miles or more, which is the immediate problem in the application of special emergency radio to our system, and cars ranging the entire system will continue for the present to communicate with the nearest main station where the message is relayed to their headquarters

by carrier telephone or over other existing telephone channels.

While a considerable amount of data was available covering u-h-f transmission over flat, or nearly flat, country we found very little data regarding transmission in mountainous country, and regarding penetration into river and creek bottoms, where roads are usually located. There was also considerable disagreement between equipment manufacturers as to the coverage obtainable in practice. Furthermore, reliable information regarding the amount of man-made static to be expected in a given territory could only be obtained by field tests. For the above reasons it was necessary to determine coverage by actual operating experience, some of the results of which are summarized briefly below.

Figure 10 indicates the coverage being obtained in the South Bend area where the main station antenna is of the J-type installed on a concrete smokestack 220 feet high, not far from the center of the city where man-made static is rather severe. While the territory is comparatively flat, surrounding hills, some of which are 10 or 15 miles distant, are 50 to 100 feet in height which makes coverage of the valleys beyond these hills more difficult. At Riverside Substation the coaxial antenna is 117 feet above ground and both topography and local interference conditions are more favorable. The two-way coverage being obtained with a 117-foot antenna at Riverside is somewhat better than that from South Bend with the higher antenna. Although maximum ranges of 30 to 40 miles are not unusual the dependable range using fm averages about 23 miles and using am it averages about 17 miles, a ratio of 9 to 5 in terms of area.

While car-to-car communication on our system has not been used frequently it may be of interest to note that car-to-car ranges using fm in urban territories have been in the order of 10 to 12 miles while a-m ranges in the same territory were 6 to 8 miles.

Separate Mobile Frequency

The use of a separate transmitting frequency for the mobile units may appear at first to be a disadvantage rather than an advantage, particularly in view of the very satisfactory

experience in power-line carrier telephony using a single frequency for a number of inter-communicating stations. Conditions and requirements applying to special emergency communication, however, differ in several fundamental ways from those applying to carrier communication: (*a*) The power and range of mobile equipment as well as its ability to cause interference, is definitely limited by battery drain, space requirements, and antenna height; (*b*) only three fixed station frequencies and 7 mobile frequencies have been allocated to special emergency use in the desirable 30 to 40 Mc band; and (*c*) communication between the fixed station and its associated mobile units should usually have preference over other communications since operating experience indicates that over 98 per cent of emergency contacts are of this type. Under these conditions a separate frequency for the mobile transmitters offers the following advantages:

(1) A nearby and possibly powerful fixed station on the same fixed station frequency cannot interfere with the reception of mobile transmissions. In the case of transmissions from the fixed station to a mobile unit, the mobile unit will usually be closer to its own headquarters and the interfering signal will then be blanked out.

(2) Considering long range interference, only other mobile units can cause such interference on the mobile frequency. Experience has shown that such interference is not serious and occurs at infrequent intervals.

(3) An appreciably greater number of simultaneous communications can take place without interference if a separate mobile frequency is used.

(4) There is the further consideration that any system experiencing interference from another system is in a disadvantageous position if every reasonable precaution, such as using a separate mobile frequency, has not been taken to avoid such interference.

When a separate mobile frequency is used, car-to-car communication does not follow automatically as it does on the single frequency system. It may be obtained however in a simple manner if the mobile frequency is close to the fixed station frequency, by adding a crystal for the main station frequency. Antenna and transmitter tuning will be sufficiently good to obtain 80 per cent or more of full output on 31,460 kc, for example, when the mobile frequency is 31,740 kc. The standard f-m mobile sets in use can be converted for car-to-car service by placing the crystal in the jack provided and connecting the dash control, which permits the operator to select car-to-car or car-to-headquarters transmission at will.

It often happens that the principal operating headquarters is not in a suitable receiving location, in which case the main station, or at least a supplementary receiving station must be remotely controlled. For a system which functions principally

OPERATIONS SUMMARY

	November 11	6 Months Average
Emergency situations (radio used)	57	3.2
Emergency contacts	95	5.9
Routine test contacts	12	18.8
Entries regarding frequency monitoring	None	.44
Incomplete calls—operator absent	10E/3T	2.5 (T+E)
Incomplete calls—out of range	2E/4T	.29 (T+E)
Incomplete calls—interference	None	.11 (T+E)
Incomplete calls—equipment failures	None	.17 (T+E)
Incomplete calls—reason unknown	None	1.6 (T+E)

E = Emergency T = Routine Test

Summarized data for November 11, 1940 and daily average during last half of 1940 for entire Indiana & Michigan Electric Company System. Of the 0.17 incompleted calls per day chargeable against equipment failures almost half were due to the telephone lines used for remote control and the remainder were due to miscellaneous causes such as tubes, broken mobile antennas, blown fuses, etc.

during storms this presents a serious problem. Open wire telephone lines will generally be less reliable than the power lines which the radio system is designed to protect and are therefore not very suitable for the purpose. The power lines which may be present between the two desired points may not have the reliability of the steel tower construction used on the main high voltage power lines, to which carrier is usually applied. Consequently power line carrier is not applicable in the majority of cases. The most promising solution in one such case appeared to be a u-h-f radio channel. Although more costly than other alternatives it is expected to provide the maximum reliability. This channel is under construction and will operate above 100 Mc. Control functions will include send-receive and transfer between am and fm.

Operating Experience

The wind storm of November 11th, 1940, which was general over the midwestern States, is one of the many times on record when the communications system played a vital part in reducing hazards and quickly restoring service. Wind velocities as high as 72 miles per hour were recorded at South Bend.

Although the 132-kv transmission system and its associated carrier telephone systems were not affected, local wire line communication at a number of strategic points and in several communities was completely interrupted. The extent to which space radio was used during this storm and its general performance is indicated in the table. Although radio contacts per emergency situation averaged less than two, these contacts were vital for quickly determining location of trouble, extent of damage, hazards to public, and for directing trouble crews to the most serious cases. Overall performance of the radio system during the six-months period included in the table indicates that only 2.4 per cent of all calls were incomplete due to interference, range limitations and equipment failures. A performance rating of 97.6 per cent, while it leaves room for improvement, indicates a thoroughly practical system.

[1] Sporn and Wolford. Experience with carrier-current communication on a high-tension interconnected transmission system. *A.I.E.E. Transactions*, Vol. 49. pp. 288-313.

THE INDUSTRY IN REVIEW

News

✦ The schedule of transmissions of frequency modulation programs over station W2XWG, New York, has been changed to include the broadcasting of programs on Saturdays and Sundays. Under the new schedule the regular N.B.C. programs will be on the air over W2XWG daily, except Monday and Tuesday, from 3:00 to 11:00 p.m. The former schedule was from Monday through Friday. The broadcasts also will be on a new frequency of 45.1 Mc. . . . Orders received by General Electric Company during the year 1940 amounted to $654,190,000 compared with $360,748,000 for 1939, an increase of 81 per cent. . . . Sigma Instruments, Inc., are now located in their new plant at 76-78 Freeport St., Boston, Mass. The new plant has improved facilities for the manufacture of sensitive relays, acoustic switches, and audio frequency relays. . . . Before the outbreak of war, short-wave radio in Australia was mainly for the benefit of listeners in the far country and in the islands around the coast of the Continent. Since the war, however, Australia's short-wave radio activities have grown until ten transmissions are now broadcast daily in English, French, Dutch and Spanish. . . .Neville Miller, president of the National Association of Broadcasters, announced recently that the association would hold its nineteenth annual convention May 12–15 at the New Jefferson Hotel, St. Louis, Mo. . . . At a special meeting recently, stockholders of Simplex Radio Company adopted a plan whereby they will receive one share of stock of Philco Corporation in exchange for each three shares of Simplex Radio Company stock, and the assets and business of Simplex Radio Company will be transferred to a successor company of substantially the same name, Simplex Radio Corporation which will continue to operate as a radio manufacturing organization in Sandusky, Ohio. In excess of 90% of the stock of Simplex Radio Company is owned by Philo Corporation, which will own 100% of the stock of the new Simplex Radio Corporation.

✦ Plans for the expenditure of approximately $400,000 for the expansion of the eastern facilities of the Plastics Department of the General Electric Company have been announced. The expansion will include new buildings and equipment in Pittsfield, Mass., and at Meriden, Conn., and additional equipment in the Lynn, Mass., plant. . . . G-M Laboratories recently completed a new building planned to serve the needs of precision products. The new building is at 4314–26 North Knox Ave., Chicago.

✦ Kenneth Foute has been appointed Sales Engineer for the Drake Mfg. Co., of Chicago . . . Scott Helt, Chief Engineer of station WIS, Columbia, S. C., has been appointed Chairman of the Engineering Committee of the Fourth District of the National Association of Broadcasters . . . Construction has been started on new studios for General Electric's television station, W2XB, to be located in Schenectady . . . Radio stations KZRH, Manila, and KZRC, Cebu, Philippines, have joined the NBC network.

✦ Carbide and Carbon Chemicals Corp., New York City, are supplying Vinylite plastic for phonograph records which are being made of articles in *Reader's Digest* for the benefit of the blind who cannot read Braille . . . The Amperite Co., has licensed the Radio Corporation of America on U. S. patent 2,196,342, owned by the Amperite Co. This patent covers the use of the acoustic compensator in connection with velocity microphones . . . Establishment of the Clear Channel Broadcasting Service with offices in Washington, D. C., was announced by Edwin W. Craig of Nashville, Tenn., chairman of a committee composed of independently-owned radio stations throughout the country. The service is intended to familiarize American radio listeners with the importance of preserving clear channel broadcasting not only as a domestic service, but also in line with the North American Regional Broadcasting Agreement.

✦ Goat Radio Tube Parts, Inc., of Brooklyn, N. Y., is now known as Goat Metal Stampings. The officers and personnel remain the same . . . To meet rising radio requirements for national defense, the radio division of Westinghouse Elec. & Mfg. Co., in Baltimore is expanding its manufacturing space to three times its original size . . . Because of the shortage of trained personnel in all branches of the aeronautical industry, Lear Avia, Inc., Dayton, Ohio, is inaugurating a free vocational training program for its employees . . . The War Department will send questionnaires to all licensed amateur radio operators in the United States in order to obtain certain information for national defense purposes. The data obtained will be used for statistical purposes, and will not obligate or register the amateur operator in any way. Further details will be given by Corps Area Signal Officers.

✦ Solar Mfg. Corp., Bayonne, N. J., manufacturers of capacitors, announces Ambos-Jones Co., 1085 The Arcade, Cleveland, Ohio, as their industrial sales engineers for the State of Ohio . . . United States' radio and radio equipment exports during 1940 were valued at $22,037,234 as compared with $22,180,561 in 1939, $23,099,047 in 1938 and $32,102,070 in 1937, according to the Electrical Division, Department of Commerce. Radio receiving sets shipped to foreign markets during 1940 were valued at $10,155,445, a decrease of 2.8, 3.8 and 37 %, respectively, from the 1939, 1938 and 1937 totals of $10,542,020, $10,551,547 and $16,129,321. Transmitting sets, tubes and parts therefor marketed abroad in 1940 reached the highest level since this classification has been recorded and were valued at $3,287,879, an increase of 22, 11.1 and 22.5% over the 1939, 1938 and 1937 totals of $2,695,790, $2,957,896 and $2,684,336, respectively. Exports of radio tubes in 1940 were smaller than for any year since 1932 and were valued at $2,451,920. This compares with foreign sales of radio receiving tubes in 1939, 1938 and 1937 valued at $3,000,701, $2,973,059 and $4,062,768, respectively.

Two General Electric Company ignitron tubes (old and new styles) for welding control. These water-cooled mercury-pool controlled-rectifier tubes are particularly adapted to welder control service because of their ability to carry very high peak currents for short periods

Literature

FM and Other Bulletins. The following literature is available from General Electric Co., Schenectady, N. Y.: Bulletin GEA-3480 entitled "FM Communication Equipment" contains information on receivers and 25-watt transmitters; Bulletin GEA-2511 contains data on a simplified FM circuit design; Bulletin 3327A describes Type GF1B 250-watt FM broadcast transmitter; VU volume-level indicator, type DO-61, a new standardized volume-level indicator for radio broadcasting, sound recording and communication systems is described in bulletin GEA-3145A; a square-wave generator for testing over-all performance of communication systems and networks is illustrated and described in bulletin GEA-3442.

Direct-Coupled Amplifiers. Diagrams of the outstanding features of new amplifiers available from Amplifier Co. of America, 17 West 20th Street, New York City are in Circular No. 4111 which also contains suggested optional features for standard applications as well as specifications.

Voice-Powered Telephone. An article on a voice-powered telephone developed by Bell Laboratories is contained in *Inco bulletin*, Vol. 17, No. 3. This bulletin is a quarterly magazine devoted to the uses of nickel and nickel alloys and is published by The International Nickel Co., Inc., 67 Wall St., New York City.

Auto Radio Antennas and Accessories. The Insuline Corp. of America, 30–30 Northern Blvd., Long Island City, N. Y., announces that a new eight page catalog is available which tells about their new line of auto radio antennas and accessories, and also new f-m, television and home antennas.

Engraver. Mico Instrument Co., (10 Arrow St., Cambridge, Mass.) manufacturers of precision apparatus have published a booklet "The Mico Engraver" which describes a pantograph machine adaptable to many lettering tasks associated with experimental work, as well as the routine production of panels, nameplates and small parts.

Molding Plastics. Bakelite Corp., 30 East 42nd St., New York City, have available a thirty page catalog entitled "Bakelite Molding Plastics" which contains the physical, mechanical and electrical properties and characteristics of Bakelite phenolics, ureas, polystyrenes and acetates. These are enumerated in editorial and table form so as to give the reader an understanding of how these materials can be employed.

Type "RM" Switches. Specification sheets are contained in a folder on the Yaxley type "RM" Switches available from P. R. Mallory & Co., Indianapolis, Ind.

Phase Inverter Circuits. This subject is covered in the November-December, 1940, issue of *Successful Servicing*. *Successful Servicing* is a house organ dedicated to the financial and technical advancement of the radio serviceman and is available from John F. Rider Publisher, Inc., 404 Fourth Ave., New York City.

Thermocouple Pyrometer Catalog. Catalog E-33A-503 available from Leeds & Northrup Co., 4907 Stenton Ave., Phila., Pa., describes apparatus for checking thermocouple pyrometers in plants and laboratories. Much of the apparatus it describes has been available for some time but the book is intended as an easy reference to aid in the problem of selecting the instruments and standards best suited to a given job of checking.

Relays. Advance Electric Co., 1260 W. Second St., Los Angeles, Cal., have available Catalog E which contains complete information and illustrations of relays available. Included in the catalog is a recently perfected a-c pole piece which was designed for higher efficiency, less temperature rise and quieter operation.

Aluminum Conduit Fitting Assemblies. A new bulletin, containing over fifty aluminum conduit fitting assembly illustrations, has been announced by American Phenolic Corp., 1250 Van Buren St., Chicago. Twelve U. S. Army-Navy Standard conduit fittings are included in this bulletin.

Handy Calculator. A new Handy Calculator, based on the 1940 National Electrical Code is available from Bull Dog Electric Products Co., 7610 Joseph Campau Ave., Detroit, Mich. This calculator gives information on new wire sizes and capacities and also data for wiring motor circuits.

Sound Systems. Sun Radio Co. 212 Fulton St., New York City, have published their 1941 general catalog on Sun sound systems.

Inerteen-filled Capacitors. A two-page data sheet (No. 49–225) on high-voltage Inerteen-filled capacitors, for d-c service, has been announced by Westinghouse Elec. & Mfg. Co., Dept. 7-N-20, E. Pittsburgh, Pa. Numerous applications are listed and use of capacitors in each explained. Electrical ratings and dimensions in a convenient table are also included.

Square Wave Analysis. The technique of square wave analysis is illustrated and described in a bulletin available from Instruments Corp., Boonton, N. J. Descriptive matter on Model 71 square wave generator, and Model 54 and 65 standard signals generators is also included in the bulletin.

Electrostatic Voltmeter. Bulletin GEA-3020A contains a complete description of an electrostatic voltmeter designed for a-c and d-c measurements of volt-

age on systems where one line is grounded. It can also be used where a high-impedance, high-voltage instrument is required. General Electric Co., Schenectady, N. Y.

Miniature Panel Instruments. A new twelve page illustrated catalog No. 43–350 covering the "35" line of miniature panel instruments of the three-inch classification is announced by Westinghouse Elec. & Mfg. Co., Dept. 8-N-48, E. Pittsburgh, Pa.

Insulating Varnish. Irvington Varnish & Insulator Co., 24 Argyle Terrace, Irvington, N. J., have available a folder which describes Harvel 612-C insulating varnish. This is a varnish recently developed and is an internal drying, synthetic resinous phenol-aldehyde type that offers substantial electrical, mechanical, and application advantages over oxidizing type varnishes.

Rheostats. Type F-500 watt rheostats are described in bulletin 1040 available from Hardwick-Hindle, Inc., Newark, N. J. These are for use in motor speed control, generator field control, lamp dimming, electronic tube control, etc.

Condensers and Resistors. Catalog 64 available from Girard-Hopkins, Oakland Cal. describes the several types of condensers (dry, wet, paper tubulars, paper filter, oil filled, oil transmitting) as well as carbon and insulated resistors available from them.

High Speed Power Level Recorder. This instrument was designed to make a permanent continuous record of the variation of intensity of any electrical signal, on either a linear or logarithmic scale, or to record rapid changes of intensities over a wide range. Several models are illustrated and described in an eight page bulletin available from Sound Apparatus Co., 150 West 46th St., New York City.

Tubes and Rectifiers. Characteristics, ratings and prices are included in a bulletin available from Amperex Electronic Products, 79 Washington St., Brooklyn, N. Y. on transmitting tubes and mercury vapor rectifiers.

Tube Characteristics. Complete information on the characteristics, classification, and socket connections of RCA receiving tubes is included in the new edition of the RCA Receiving Tube Characteristics Chart now available through RCA tube distributors.

Resistance Decades. Resistance decades available from Shallcross Mfg. Co., 10 Jackson Ave., Collingdale, Pa., are described in literature available from the manufacturers. Unmounted decade resistances, wire wound resistances, wire wound resistors, rotary instrument switches, binding posts, and decade potentiometers are also described in the bulletin.

New Products

Automatic Double Reset Timer

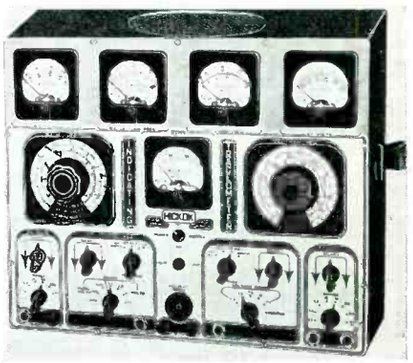
A NEW AUTOMATIC DOUBLE RESET TIMER has been designed by The R. W. Cramer Co., Inc., of Centerbrook, Conn., for industrial applications requiring an adjustable and rapidly repeating time cycle. The timer incorporates the latest improvements of Cramer's time delay relays and reset timers and is designed to provide accuracy and flexibility in repeat cycle operation. The unit consists of two reset timer mechanisms mounted upon a control panel. Micrometer adjustments and bandspread time scales are provided to facilitate accurate settings. A gray enameled die-cast housing provides both rugged and dust-proof protection and facilitates mounting and wiring. Either conduit or BX type wiring may be used. The housing may be locked as a protection against alteration of critical timing of industrial processes. These units are available for 110 and 220-volt and 50 or 60-cps operation. At the present time, the time ranges available for each of the individual timers are 15, 30, 60 and 120 seconds, maximum. Current carrying capacity of the switches is 10 amps at 110 volts, 60 cps. Housing dimensions are 7⅞x4¾x3¾ inches. Knockouts for ¾ and ½ inch conduit are provided.

Time Standard

BULLETIN 2089AC RECENTLY MADE AVAILABLE from American Instrument Co., 8010 Georgia Ave., Silver Spring, Md., describes a tuning fork controlled time standard. This instrument consists essentially of an electronically driven 500 cps tuning fork and an electrically isolated pickup and power amplifier as the source of the output power. The fork is free of all mechanical connections. The unit is complete with a self-contained stable fixed-frequency power oscillator. The instrument is for use in driving galvanometers for oscillographs, oscillograph cameras; driving synchro-chronographs; a time standard for adjusting watches, motors, generators; a source of modulating current for signal generators and radio beacons; a source of constant frequency sine-wave voltage for all types of a-c bridge circuits; geophysical and structural explorations; or for other uses where alternating current of constant and known frequency is desired. The output is 2½ watts maximum undistorted sine-wave power (continuously variable), controlled by a knob on the panel. The push-pull amplifiers are rated at 10 watts maximum output, and the final output transformer has a power rating of 20 watts. The tuning fork is rated at a frequency of 500 cps ± 0.2 per cent at 25° C. The temperature coefficient of frequency is minus 0.012 per cent per degree C.

Radio Testing Instrument

IT HAS BEEN ANNOUNCED by Hickok Electrical Instrument Co., (10307 Dupont Ave., Cleveland, Ohio) that their model 155 "Traceometer" has been improved by the addition of a self-contained speaker internally connected for monitoring either r-f, i-f or a-f channels Model 155 with its five meters gives continuous, accurate measurement of voltages and traces the signal in any five circuits at one time without interfering with the performance of



the set. The vacuum tube voltmeter circuits are so arranged that accidental overvoltage cannot damage the meters. These measurements are possible with this instrument: Signal measurement in microvolts at any point on the entire rf-if section; measurement of actual oscillator voltage throughout its entire range; measurement of all d-c voltage, avc, afc, power supply, etc.; measurement of a-f and a-c voltage in any circuit; measurement of actual wattage consumption of any a-c system to 300 watts.

Photoelectric Relay

A NEW PHOTOELECTRIC RELAY, housed in a cast alloy chassis with a compact molded cover, was recently announced by General Electric, Schenectady, N. Y. This new relay will operate at speeds up to 150 interruptions per minute and at a minimum of 40 foot-candles at the phototube with not more than 15 foot-candles of extraneous light present. Applications include counting, sorting, weighing, measuring, controlling, signalling, inspecting and regulating when conditions permit. The relay has a controlled contact rating of 10 amps at 115 volts ac, with two normally open and two normally closed contacts. The coil of the relay is energized when the light at the phototube is reduced below 30 foot-candles. There is provision for mounting the relay by any one of several methods.

Frequency Converters

TWO TYPES OF FREQUENCY CONVERTERS are available from Clark Laboratories, Palm Springs, Cal.

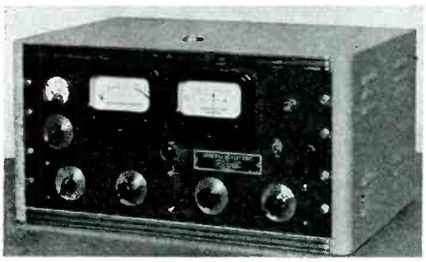
The first of these is a new 30 cps electron tube frequency converter for the operation of industrial vibrating screens, conveyors, coolers, feeders,

dryers, etc. This unit provides a 30 cps half wave supply with 1800 vibrations per minute, from a 60 cps line, and replaces a 15 cps motor-generator set. The instrument is simply constructed and requires no special training for installation or maintenance. Units are available up to 9 kva.

The second instrument is an h-f converter for surface hardening and melting. It is designed to simplify the static conversion of ac from one frequency to another, and especially in the h-f ratings. The unit operates on a three phase, 60 cps, and delivers single phase power of 1000, 2000, 3000 or more cps, or any intermediate frequency within its range. This instrument is available in sizes of 30 kva to 3000 kva.

FM Station Monitor

A NEW FM STATION MONITOR has been introduced by the General Electric Company, (Schenectady, N. Y.), as an addition to its line of frequency modulation equipment. The new unit performs the vital functions of a center-frequency monitor, modulation monitor, high-fidelity audio monitor, and modulation-limit indicator of the flasher type. Complete in one compact unit, the monitor reads center-frequency deviation directly regardless of whether or not the transmitter is being modulated. Easy-to-read illuminated instru-



ments indicate center-frequency deviation and percentage of modulation. Instant calibration of the center-frequency deviation instrument at the flip of a switch is also provided for by means of a crystal standard, mounted in the new high-precision G-E Type G-31 Thermocell. The high-fidelity audio monitor has sufficient output to feed an audio-monitor amplifier. Its frequency uniformity is better than ½ db from 30 to 15,000 cps. The modulation-limit flasher (with a range of from 50 to 120 per cent) is adjustable to show whenever modulation exceeds the value for which the panel control is set.

Radio Receiver and Direction Finder

A NEW JEFFERSON-TRAVIS, "TRI-ADD" marine radio receiver and direction finder consists of a compact, three band marine-type receiver designed to operate as such alone or as a direction finder by the addition of a plug-in loop antenna with a compass scale. A second unit is the direction finder

loop and compass scale assembly with ear phones, arranged so that they may be added to the receiver to form a complete marine direction finder. The receiver can be purchased initially and used alone, and, at the owner's option, the direction finder assembly can be purchased with it or it can be added later. The tuning range covers three bands which include the marine radio beacon range of 200 to 400 kc; the standard broadcast band of 550 to 1500 kc and the marine radiotelephone range of 2000 to 3000 kc. The manufacturers are located at 136 West 52nd Street, New York City.

Marine Radio Equipment

COMMUNICATIONS CO., (CORAL GABLES, FLA.), 25- and 50-watt marine radio equipment has the following features: Dual stand-by receiver, completely pretuned transmitter, complete press-to-talk operation. Cast construction is used throughout. The castings are of non-ferrous and non-magnetic material treated to withstand corrosion. The transmitter, receiver and modulator power units are separate, and therefore their location can be made as flexible as necessary in conforming to individual space requirements. The transmitter is pretuned and locked at the time of installation to assure maximum output. No tuning is necessary when shifting from ship-to-shore, ship-to-ship or Coast Guard. Two dynamotors (one for the receiver and one for the transmitter) require low battery drain. The transmitter dynamotor is used only while talking. This equipment can be supplied for 6, 12 and 32 volt battery systems. The converter is for use only on a 110 volt model.

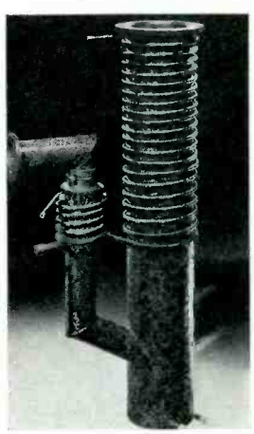
Interference Locator

THE SPRAGUE MODEL IL-2 INTERFERENCE Locator is a new device, designed in cooperation with public utility engineers and radio interference specialists to provide an inexpensive, highly sensitive and rugged portable device for the location and isolation of radio interference elimination. It is useful to radio servicemen who are interested in noise complaints arising from electrical devices attached to power lines, or to public utility engineers to eliminate radio noise sources from the power or distribution line itself. The instrument operates either from self-contained batteries for portable operation, or directly from 115 volt a-c or d-c lines. A directional loop antenna is mounted on top of the cabinet when in use, or carried within a cover recess en route. An extensible pole antenna with a special input circuit is provided as standard equipment.

Tuning ranges are 500 to 1700 kc; 1.7 to 5 Mc; and 15 to 32 Mc. An input signal of less than two microvolts will produce a deflection of 10 per cent on the output meter scale. The Locator is equipped with a loudspeaker unit, and a two range calibrated output meter, which provides a visual and an audible measure of interference intensity. A calibrated volume control may be used with the output meter to measure interference suppression devices. The loop antenna can be switched to audio input as a search coil for a-f interference pick up or for use as a pipe finder. A special coaxial cable, complete with connectors is also available at extra cost, for remote use of pole antenna as a probe.

All-Metal Fractionating Pump

A NEW ALL-METAL fractionating pump Type MC-275, has been announced by Distillation Products, Inc., Rochester, N. Y., as an addition to its line of high-vacuum equipment. The new pump, a vertical unit, has been developed specifically to meet the needs of industrial fields in which a more rugged pump than the glass-metal type is required. Its all-metal construction guards against accidental breakage, and the pump can easily be adapted to fit most



vacuum systems. Speeds of nearly 300 liters per second, are available in the Type MC-275 unit, in the range of 10^{-3} to 10^{-5} mm of Hg. This speed, coupled with the ultimate vacuum rating of 6×10^{-6} mm, makes the pump suited for use with cyclotrons, electron diffraction cameras and ultracentrifuges, and in mirror coating, metal sputtering and the recently developed art of lens coating.

Although not of the multistage type, the unit is a fractionating model due to its catchment lobe on the forepressure arm. Special rugged esters are used as pumping fluid.

Negative Temperature Coefficient Resistor

KEYSTONE CARBON CO., ST. MARY'S, PA., announce a negative temperature coefficient resistor which decreases in resistance when there is an increase in temperature. The temperature of the resistor may be raised either by the passage of current through the resistor itself or by means of some external heat source. The unit may be used to reduce or eliminate initial current

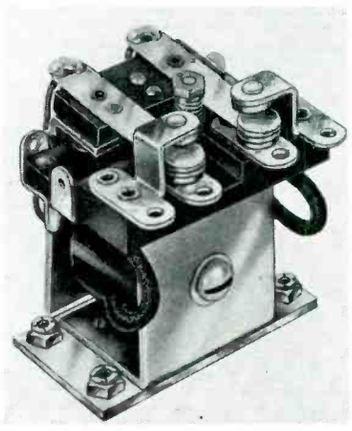
surges in various types of equipment, to provide various degrees of time delay action, or to compensate for resistance changes due to temperature variations in circuit components. The decreasing resistance of the resistor can be made practically linear over a wide range. All of the connections are molded to the body of the resistor to insure a permanent contact and to provide simple and rugged construction.

High Impact Phenolic Molding Compounds

A NEW DEVELOPMENT IN HIGH IMPACT phenolic molding compounds has recently been completed by Durez Plastics & Chemicals, Inc. of North Tonawanda, N. Y., to be known as Durez 1910. This is the third in their new series of 1900 materials. Durez 1910 contains graphite and was developed especially for applications where minimum frictional resistance is desirable. Durez 1910 has a particle size comparable to dry rice and may be preformed easily. It flows freely through standard feeders. Specific gravity is 1.45. Bulk factor is 3.6:1.

Aircraft Relays

ALLIED CONTROL CO., INC., 227 Fulton St., New York City, announces a special line of precision-built aircraft relays designed for minimum of size and weight and increased resistance to vibration. The units incorporate the dynamic balanced armature principle and have a stainless steel pin hinge to insure reliability. Contact and coil lugs are located on top of the relays for easy accessibility. Silver is used as the standard contact material although



special alloys are available for particular applications. A spring arrangement provides ample wipe. Wax-impregnated bakelite is used for insulation. Coil specifications are rated from 5 to 220 volts for ac, and from 1 to 125 volts for dc. These relays have been designed particularly for aircraft transmitters and receivers, flight instruments, control devices and remote control switching, but can also be used for all types of industrial and mobile requirements.

Pyrometer Controller

MODEL 486 ELECTRONIC PYROMETER controller was designed for automatically controlling temperatures up to 3300° F. in industrial furnaces, ovens, and kilns. It is available from The Bristol Co., Waterbury, Conn. Moving parts, such as motors, depressor bars, toggle switches, and contacts are completely eliminated from the control circuit, since the control is accomplished by a photoelectric cell. The pointer of the pyrometer unit is free to travel throughout its normal range without mechanical engagements, enabling accurate indications plus closer control of the quantity under measurement.

Microphone

UNIVERSAL MICROPHONE CO., LTD., Inglewood, Cal., has introduced model CU-1 microphones for aeroplane and yacht installations. Bakelite molded plastics of black phenolic type is used for the housing to achieve moisture resistance, durable finish and lightness of weight. Characteristics of the new unit include single button carbon, moisture proof cord which is 3½ inches long, motor noises damped out by anti-noise construction, press-to-talk switch which connects the microphone and the relay circuit at the same instant, and "push-in" mounting bracket.

Automatic Relay

AN AUTOMATIC RELAY available from Amperite Co., 561 Broadway, New York City, changes a battery set to a-c or d-c operation by plugging a cord into an a-c or d-c line and turning on the set switch. When the switch is turned on, the set operates immediately on the battery for approximately 25 seconds (the time it takes for the rectifier to heat up) and then switches off automatically to a-c or d-c operation. The relay consists of two single pole contacts which are placed in the —A and —B battery lead. As soon as ac or dc is passed through the set the relay automatically starts operation.

Tellurium Portable Cables

CABLES FOR USE IN INTERCONNECTION or control of portable equipment wherever extremely heavy duty is encountered are available from General Electric Co., Schenectady, N. Y. Several types are available for 600 volts and for 2500 volts and above. The over-all jacket is made of 60 per cent new rubber compounded with tellurium which assures a tough, long lived, water-resisting outer jacket. The cable is molded in a lead sheath. When the lead is stripped off, it leaves a smooth surface, and the cable can be dragged through stones, weeds, etc., without catching. The cable is flexible and is able to withstand the effects of being accidentally run over.

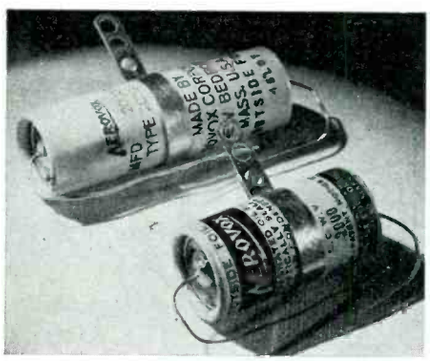
Directional Loop Antenna

A NEW DIRECTIONAL loop antenna for civilian planes which makes radio direction finding possible with a conventional aircraft receiver, has been announced by the Aviation Radio Section of the RCA Manufacturing Company, Inc. It can be used to direct the plane toward a radio beacon or a radio broadcasting station or, by simple navigation, can be used to plot a course in any direction with the aid of radio bearings. Light in weight, the loop is designed to give long service under severe conditions. The antenna, measuring 12 inches in outside diameter, is provided in both local and remote control models. It will operate as a direction finder on the beacon (195–420 kc) band, or on the beacon and broadcast (195–420, and 495–1400 kc) bands. A high quality, air transport size unit, it combines high electrical efficiency with the rugged construction necessary for passing Civil Aeronautic Authority requirements.

The antenna is designed for use with RCA aviation radio receivers Model AVR-7D, E, F, G and H, and two inexpensive conversion kits have been provided to make the installation. It can also be used with any other receiver having an adequate sensitivity, and whose input circuits can be trimmed to match the electrical characteristics of the versatile loop transformer. The two models are designated as AVA-56 and AVA-56A. The former has the loop tuning control at the end of a 10, or 30, inch shaft. The other model provides remote tuning control by means of a cable from the instrument board or from some other convenient location.

Midget Tubular Oil-Filled Condensers

AEROVOX CORP., NEW BEDFORD, MASS., announce as a standard item, a series of oil-impregnated oil-filled condensers in a handy tubular form, type 89. A cadmium-plated brass can is used for hermetic sealing. The can is covered



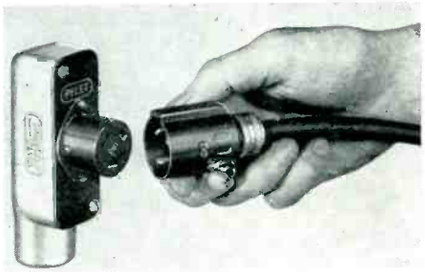
by a varnished-paper jacket with spun-over ends to prevent the shorting or grounding of sharply-bent leads. A center mounting strap is included with the unit. These condensers are available in 400, 600, 1000 and 2000 volt ratings, and 0.006 to 0.5 μf capacities.

Antenna Reel

LEAR AVIA, INC., DAYTON, Ohio, announce an automatic foulproof antenna reel. The reel is used to let out and draw in a trailing antenna for use in radio transmission from aircraft in flight. Fabric-base Synthane material, produced with Bakelite resin laminating varnish, and fabricated by Synthane Corporation, is used for the housing. The reel has the tensile strength to withstand strenuous vibrations and the drag of the weighted antenna of the plane in flight. It has the resistivity to withstand a 12,000 volt breakdown test.

Plugs and Receptacles

THE PYLE-NATIONAL CO., 1334 North Kostner Ave., Chicago, announces a new line of midget heavy duty plugs, receptacles and cord connectors for use with portable electrical equipment. Some of the characteristics of the plugs and receptacles are: interchangeable contact units; reversible contact units for safety protection; automatic locking features; plugs cannot be inserted incorrectly, nor can they be inserted in any receptacle having a different number of poles. Polarity is maintained by unequal spacing of the contacts and a keyway in the contact unit insulation; grounding is achieved by contacts which are provided with a spring clip which



contacts the plug or receptacle housing. Bulletin No. 1140-1 gives more detailed information on these products. They are available in 2, 3 and 4 pole types, rated at 10 amps, 250 volts or 15 amps, 125 volts.

SEARCHLIGHT SECTION

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10 cents a word, minimum charge $2.00.
(See ¶ on box Numbers.)

Positions Wanted (full or part-time salaried employment only), one-half the above rates.

Proposals, 50 cents a line an insertion.

INFORMATION:

Box Numbers in care of our New York, Chicago or San Francisco offices count 10 words additional in undisplayed ads.

Discount of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

DISPLAYED—RATE PER INCH:

The advertising rate is $6.00 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page. E.

NEW ADVERTISEMENTS received by 10 A. M. March 27th will appear in the April issue, subject to limitations of space available.

WANTED — TRANSMITTING TUBE ENGINEER

capable of designing and supervising production of hard glass tubes. Must be familiar with all small transmitting power tubes and their applications. Write stating experience and other pertinent details including salary desired. This opening is with an established manufacturer wishing to expand the scope of its operation and offers a permanent position in a progressive organization and a most unusual opportunity.
P-268, Electronics, 330 W. 42 St., New York City

POSITION VACANT
(See also "Selling Opportunity Offered")

LARGE MIDWESTERN radio receiver manufacturer has openings for experienced automotive and household radio receiver design engineers. Applicants should state education, experience and give references. Our own employees know of this ad. P-270, Electronics, 520 N. Michigan Ave., Chicago, Ill.

POSITIONS WANTED
(See also "Selling Opportunity Wanted")

FACTORY WORKER, (Master Electrician) all around experience, inspector on elect. and radio parts, tester, adjuster, assembler. Blueprints read; Ambitious, inventive and adaptable; hard worker. Basch, 108 West 76th St., N. Y. C. SUsquehanna 7-9719.

PHYSICIST, five years Government research-development experience, electronics expert, effective writer. Creative instrument and circuit designer. Desires stable technical or administrative position. Reply PW-269, Electronics 330 W. 42nd St., New York, N. Y.

12 YEARS ENGINEERING and production development in radio and electronics fields, including aircraft, broadcast receivers, industrial devices, short wave communications. Supervisory, executive experience. Age 34. PW-273, Electronics, 330 W. 42nd St., New York, N. Y.

PATENT APPLICATIONS
PREPARED AND FILED
THOMAS APPLEBY
(Lt. Commander, USNR, Ret.)
REGISTERED PATENT ATTORNEY
Munsey Building
WASHINGTON, D. C.
(Established 1920)

SELLING OPPORTUNITIES
OFFERED—WANTED
Selling Agencies—Sales Executives
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OPPORTUNITY OFFERED

AGGRESSIVE SALES MANAGER with a progressive and expanding manufacturer of industrial and electronic equipment wanted. Salary basis. SW-271, Electronics, 330 W. 42nd St., New York, N. Y.

OPPORTUNITY WANTED

ELECTRONIC-RADIO-SOUND Engineer desires to represent manufacturers of quality products in Chicago territory. Give full information. RA-272, Electronics, 520 N. Michigan Ave., Chicago, Ill.

FOR SALE
Several W. E. 400 Watt
Radio Telephone Transmitters
type 9A revised for quick shift to four frequencies. This is used equipment removed from service during 1940. **Price $350.00 each** less tubes, crystals and microphone.
Wire or Write for further information
TRANSCONTINENTAL & WESTERN AIR, INC.
Kansas City, Mo. U. S. A.

MEASURING EQUIPMENT
Four General Radio decade boxes.
2 General Radio variable inductors, Model 1070.
General Radio 219F decade condenser.
General Radio 377 audio oscillator.
Weston Model 322 200 microampere meter.
Weston Model 45 voltmeter.
Numerous Weston 301 voltmeters, milliammeters in student bases.
Also
Bound volumes IRE, 1916 to 1928.
Bound volumes Experimental Wireless, 1923 to 1928, unbound to 1940.
Wireless Age 1914—1925 unbound.
Radio Broadcast, bound 1922 to 1929.
Also many tubes of period 1923 to 1930.
Best offer takes all or part.
FS-274, Electronics
330 W. 42nd St., New York City

HIGH GRADE USED
ELECTRON TUBE MACHINERY
Huge Stock of Every Type and Variety
KAHLE ENGINEERING CORPORATION
Specialists in Equipment for the manufacture of Neon Tubes, Radio Tubes, Incandescent Lamps, Photo Cells, X-ray Tubes, etc.
900 DeMott St., North Bergen, N. J.

DEPENDABLE
Used
ELECTRONIC TUBE EQUIPMENT
Complete line of used equipment for the manufacture of Radio Tubes, Neon Tubes, Incandescent Lamps, etc. Write for Bulletin showing 25 to 75% savings.
CALLITE TUNGSTEN CORPORATION
formerly Eisler Electric Corp.
534 39th Street, Union City, N. J.

TO HELP YOU
Sell Equipment You No Longer Need
"Searchlight" Advertising

INDEX TO ADVERTISERS

Magnetic Recording Head

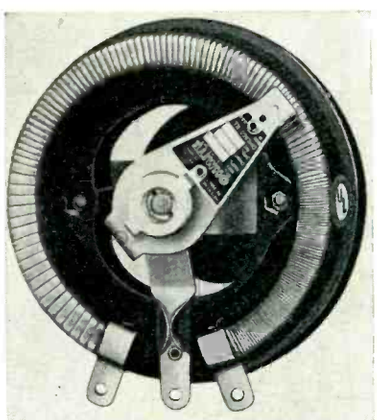
A MAGNETIC RECORDING HEAD (No. 44A) is available from Shure Brothers, (225 West Huron St., Chicago), for use with home recording equipment. The unit will operate directly from the voice-coil winding of an output transformer and was designed to give long service under all climatic conditions. Stiff moving parts permit recording on practically all recording materials. The records can be played back on any record player. The instrument has an impedance of 10 ohms at 400 cps and 4 ohms on dc, and is suitable for output circuits having an impedance of four to eight ohms.

Limit Bridge

SHALLCROSS MFG. CO., 10 Jackson Ave., Collingdale, Pa., announce No. 623 Limit Bridge which is a Wheatstone Bridge arranged for rapid production resistance testing. By means of a plug and socket arrangement, it provides a selection of percentages of either 1, 5, 10, 15 or 20 per cent. The instrument has a self contained variable standard and ratio arms. The rheostat, or working standard, consists of 3 decades totaling 11,100 ohms and the ratio has three multipliers, one, ten, and one-hundred. The range of resistance that may be tested is from 10 ohms to 1,100,000 ohms.

Generator Field Rheostats

OHMITE MFG. CO., CHICAGO, have available generator field control rheostats which were designed for smooth, close, gradual control of welding generators or for ship, aeroplane and automotive equipment. By providing practically continuous variation of resistance, including the smallest sizes, the units effect saving in control-panel space, and provide control for separately or self-excited generators. Available in a series of ten wattage sizes, from 25 to 1000 watts. By connecting the rheostats in tandem, this range can be extended. Catalog No. 40 contains a complete listing of the rheostats.



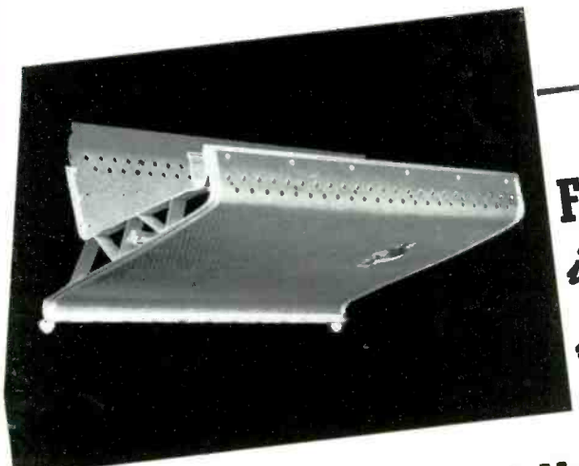
THIS APPLICATION OF **FYBR-TECH** WON

HONORABLE MENTION

IN THE FIFTH ANNUAL MODERN PLASTICS COMPETITION

QUESTION: *When is a Luggage Rack an Air-Conditioning Conduit?*

ANSWER: *It is in the* **600** *New Greyhound Coaches... Thanks to* **FYBR-TECH** *made with* **PEERLESS INSULATION** (National Vulcanized Fibre) *by* **TECHNICAL PLY-WOODS**



What FYBR-TECH *is and why it is the* Ideal Material for Luggage Racks and Many Other Uses

"Fybr-Tech," made by Technical Plywoods, 228 North La Salle Street, Chicago, Ill., consists of two sheets of "Peerless" Insulation (National Vulcanized Fibre), bonded with resin in a hot plate press by high heat and heavy pressure to a sheet of thin wood.

In making the luggage rack, shown above, the sheets are made in exact panel size. Then they are fabricated: the lamp holes stamped, the thousands of 1/8-inch holes for air conditioning punched, and the larger holes drilled. The panels then are bent to the proper forms. The bottom face of the upper panel and the upper face of the lower panel combine to make the air conditioning conduit. The resin bond provides 100% adhesion against moisture.

"Fybr-Tech" is ideal for this application due to the characteristics of "Peerless" Insulation (National Vulcanized Fibre) which are: Great Mechanical Strength, Light Weight, High Dielectric Strength, Excellent Flexibility (Bends of 1-inch radius are simple), Ease of Fabrication, Fine Painting Surface.

"PEERLESS" Insulation (a grade of National Vulcanized Fibre), because of its great mechanical strength and excellent electrical properties, is constantly demonstrating its worth as the practical material for countless new uses in industry. And National engineers are demonstrating also their ability to work with technical men in all lines of business in the development of better products through the use of National Vulcanized Fibre and Phenolite, laminated bakelite. We invite your inquiry.

FOUNDED 1873

NATIONAL VULCANIZED FIBRE CO.

Offices in Principal Cities

WILMINGTON DELAWARE

78- small RCAF photo R-1052
7- 200W xmtr bank on SS America

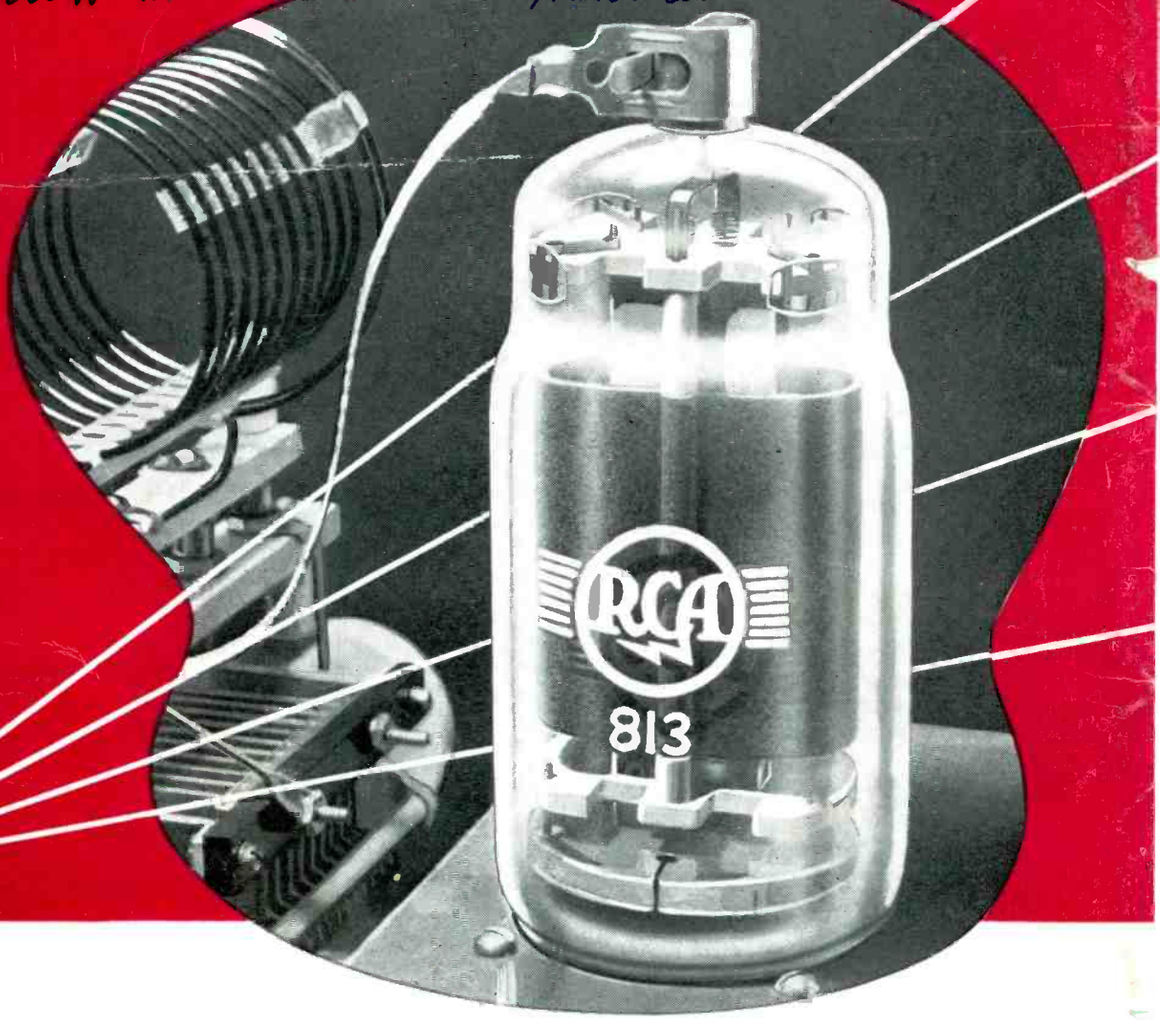
RCA-813

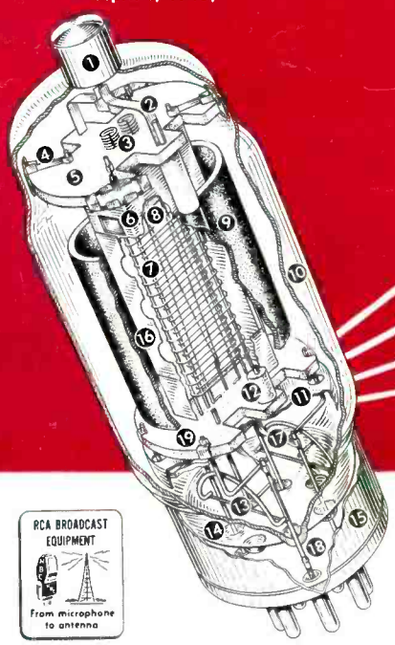
BEAM POWER AMPLIFIER

360 Watts Input With Less than 1 Watt Driving Power!

NET PRICE $22.00

(Reduced from $28.50, April 1, 1940)





RCA BROADCAST EQUIPMENT

From microphone to antenna

NOTE THESE FEATURES

1. Medium Metal Cap
2. Short Ribbon Plate Connector
3. Filament Support Springs
4. Mount Support
5. Top Ceramic Mount Support
6. Top Shield
7. Aligned-Turn Control and Screen Grid
8. Heavy-Duty Thoriated-Tungsten Filament
9. Large Sturdy Graphite Plate
10. Hard Glass Bulb with Mount-Aligning Dame
11. Bottom Shield Disc
12. Ceramic Plate-Support Spacer
13. Directive-Type Getter Container
14. Dish Type Stem
15. Ceramic-Insert Giant Base
16. Beam-Forming Plate
17. Filament Connector
18. Tungsten-to-Glass Seal
19. Bottom Ceramic Mount Support

BIG-TIME PERFORMER

OF THE BEAM TUBE LINE!

For transmitters requiring exceptional overall efficiency—for ultra-modern intermediate and final stages that need no neutralizing adjustments, units that can switch channels in a flash—for high-power transmitters with few tuning controls, requiring a minimum of driver equipment—use the RCA-813. It's the largest of the glass air-cooled "beams", big-brother of the famous RCA-807. It can handle a greater variety of big-time jobs than any other tube of its size or class.

As a straight amplifier in class C telegraph service RCA-813 takes 360 watts (CCS) with less than a watt of drive. As a final in plate-modulated service, it takes 240 watts with only 1.2 watts of drive. Moreover, it doubles, triples and quadruples with unusually high efficiency and high harmonic output. It can be operated at full ratings up to 30 Mc—at reduced ratings up to 60 Mc. Power sensitivity of the RCA-813 is extremely high. Grid-plate capacitance for the power-handling ability of the tube is low. Screen current requirements are very low. Internal leads are exceptionally short and provide low lead inductance

In brief, the RCA-813 gives you real circuit simplification—real economy—excellent performance in a variety of applications. And it makes possible efficient and flexible high-gain stages at a cost comparable with that of equipment using ordinary tube combinations.

Direct Interelectrode Capacitances:

Grid-Plate (with external shielding)	0.2 max	μμf
Input	16.3	μμf
Output	14	μμf

Typical Operation Class "C" Telegraphy (CCS)

Filament voltage, 10 volts; filament current, 5 a.; d-c plate volts, 2,000; d-c screen volts, 400; d-c grid volts, −90; d-c plate current, 180 ma.; d-c screen current, 15 ma.; driving power, 0.5 watt; power output, 260 watts.

RCA-826... A NEW THREE-ELECTRODE TRIODE FOR THE ULTRA-HIGHS

Operating at maximum ratings at frequencies as high as 250 Mc and at reduced ratings as high as 300 Mc, the RCA-826 fills a long felt need. It is specifically designed as an oscillator, r-f power amplifier, or frequency multiplier at the ultra-high frequencies. Internal lead inductance is reduced to a minimum. All terminals at one end of bulb make possible the use of short leads in neutralizing circuits.

Typical Operation as R-F Power Amplifier and Oscillator—Class C Telegraphy

D-C plate voltage, 1,000; d-c grid voltage, −70; d-c plate current, 125 ma.; d-c grid current, approx. 35 ma.; driving power, approx. 5.8 watts; power output, approx. 86 watts.

RCA-826 TRIODE—*Price* $19.00

RCA Transmitting Tubes

RCA MANUFACTURING CO., INC., CAMDEN, N. J. • A Service of The Radio Corporation of America

In Canada: RCA Victor Company, Limited, Montreal