electronics

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

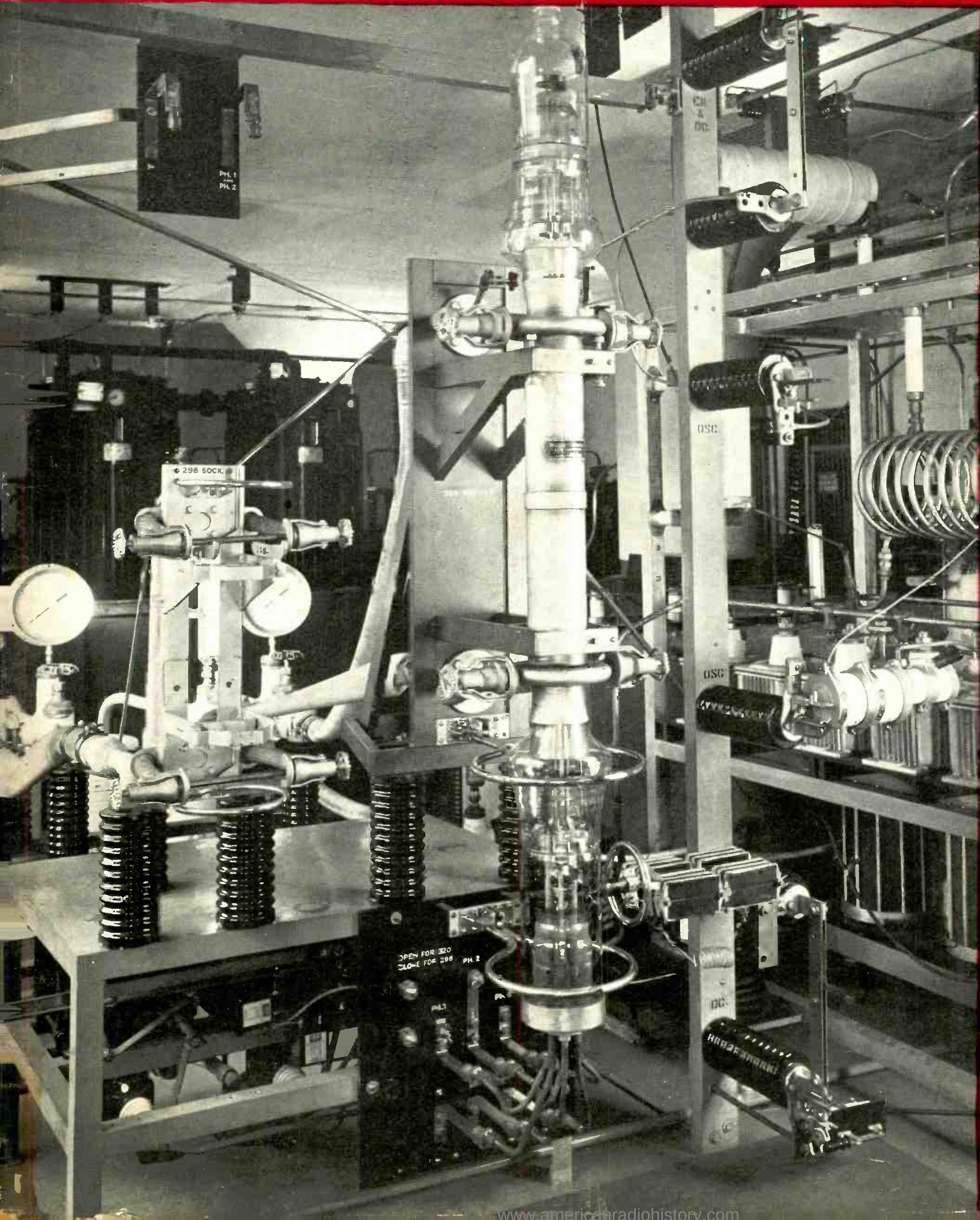


PLATE DISSIPATION: 250,000 WATTS
Type 320A on test

JULY 1940

Price
50 Cents

McGRAW-HILL PUBLISHING COMPANY, INC.

When Better Transformers Are Made

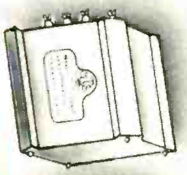
WILL MAKE THEM...

• It is interesting to note the great number of <u>sensational</u>, <u>new</u> developments advertised by contemporary transformer manufacturers • Close scrutiny will generally show the new development as an imitation of designs and features originally initiated by UTC.

Examination of the major improvements in transformers over the past few years will readily substantiate this:

1933 HIGH PERMEABILITY CAST SHIELD

(TOP AND BOTTOM MOUNT)

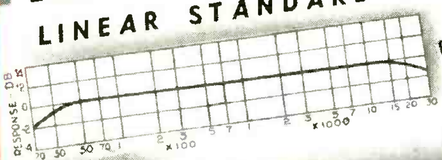


Used by UTC since 1933, the HIGH PERMEABILITY CAST SHIELD has been copied extensively by other manufacturers since that time.

1933 HUM BALANCED COIL STRUCTURE

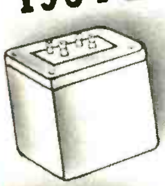
Used by UTC in practically all High Fidelity designs, hum bucking and hum balanced transformers are now accepted as standard practice in the transformer field.

1934 LINEAR STANDARD AUDIO UNITS



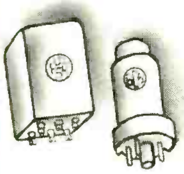
Flat from 30 to 20,000 cycles . . . a goal for others to shoot at.

1934 PORTABLE UNITS



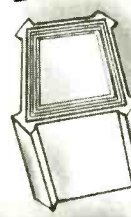
The UTC HIPERM ALLOY group of transformers were brought out to take care of portable high fidelity requirements. Have you seen copies since?

1935 ULTRA COMPACT AUDIO UNITS



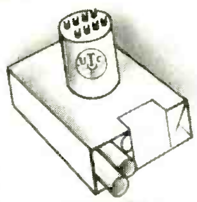
Developed originally for Aircraft and Hearing Aid Devices. In 1936, an entire series of these units were released for Broadcast Station applications. <u>ULTRA COMPACT AUDIOS</u> are <u>HUM BALANCED</u>, weigh from 4½ to 5½ oz. and are guaranteed ± 2DB from 30 to 20,000 cycles.

1936 TRI-ALLOY SHIELDING



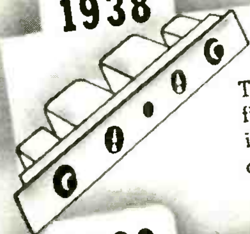
The combination of Linear Standard frequency response and internal TRI-ALLOY magnetic shielding is a difficult one to approach. That is why these units are used by G.E., R.C.A., Philco, Western Electric, Westinghouse, M.G.M., Walt Disney studios, and other discriminating organizations.

1937 OUNCER AUDIO UNITS



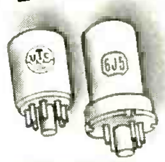
Extremely compact AUDIO UNITS for portable applications were a problem until the development of the UTC OUNCER UNITS. Fifteen types take care of practically all applications. Units not carrying DC are flat from 40 to 15,000 cycles. Imitations of this line are close ;— even the name has almost been copied.

1938 UNIVERSAL EQUALIZERS



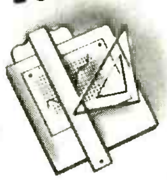
The UTC UNIVERSAL EQUALIZERS, ATTENUATORS, and SOUND EFFECTS FILTERS fill a specific need of the broadcast and recording field. Almost any type of audio equipment can be equalized to high fidelity standards.

1939 PLUG-IN AUDIO UNITS



The manufacture of UTC PLUG-IN components was commenced in 1937. In 1939, a simple octal base structure was developed. Fifteen stock items are now available in this housing similar to our OUNCER UNITS.

1940 NEW ITEMS



The UTC research laboratory will develop new items and improve standard designs in 1940. While some of these developments are described in our advertisements, many are applied to customer's problems. May we cooperate with you on your problem?

Imitation is the sincerest form of flattery

UNITED TRANSFORMER CORP.

150 VARICK STREET ★ NEW YORK, N. Y.

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electronics

A McGRAW-HILL PUBLICATION

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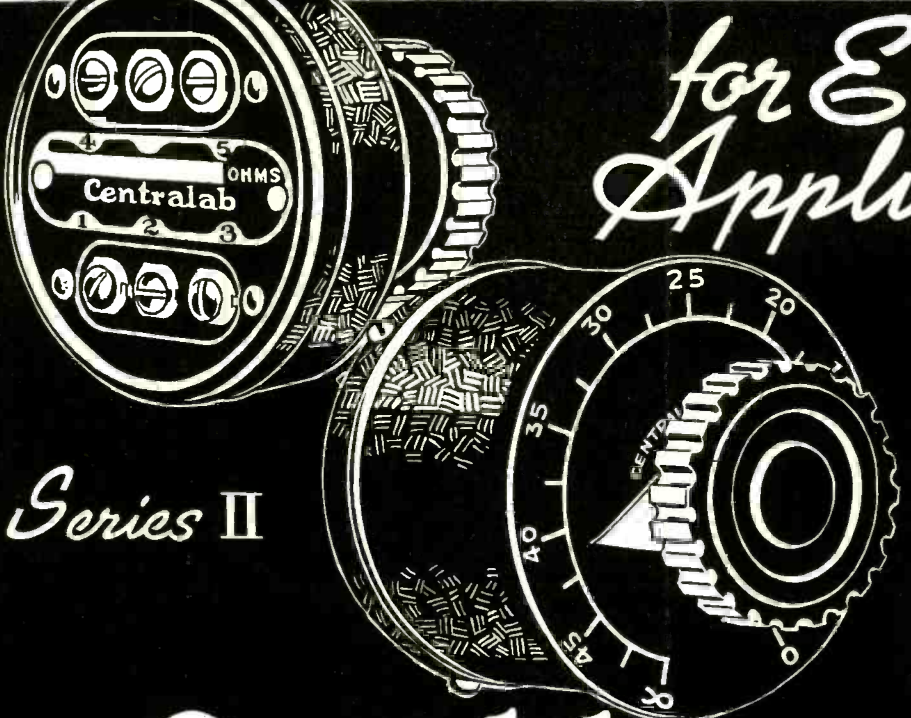
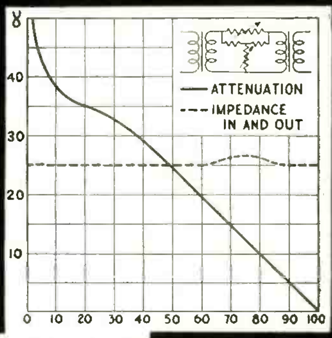
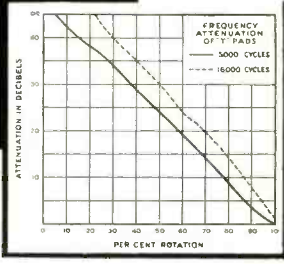


Series II

Centralab
SOUND PROJECTION CONTROLS





CENTRALAB SERIES II

Controls are the finest for input circuits in broadcast stations, public address systems, and recording apparatus of new or old design. Will prove faultless in the most critical service.

The curve chart above shows the change in impedance and attenuation plotted against clockwise rotation for a "T" pad attenuator. The impedance characteristic (dotted line) is substantially the same at any setting. The attenuation curve (solid line) varies from infinity at zero rotation to zero Db. at full rotation. No insertion loss.

Electrostatic and electromagnetic shielding provided by a black finished steel case. Bakelite screw type terminal strip on back of case. All resistance elements insulated from shaft and bushing. Single hole mounting. Mounting bushing ¾" long with 2 locknuts and lockwashers. Case diameter 2¾". Depth back of panel "T" Pad — 2⅜"; Gain Control — 1⅜". Maximum load dissipation 1 watt.

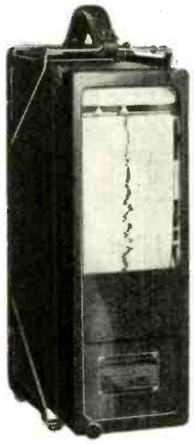
For detailed information, write for technical booklet.

CENTRALAB: Division of Globe-Union Inc.
MILWAUKEE, WISCONSIN

ECONOMY P/A CONTROLS

These controls are intermediate to the series II line and the older series I types. As their name implies, they are economy controls designed primarily for inexpensive sound equipment, where original cost is a limiting factor. They are designed for all types of fading and mixing systems. All units have soft aluminum shaft 2¼" from end of ⅜" brass bushing. Small diameter bakelite case same dimension as Standard Radiohm. Non-rubbing contact for smooth, quiet operation. Limited to input applications. Maximum power rating for all units one watt.

Difficult Measurements Are Easy
With These G-E Instruments



Photoelectric Recorders

Typical Characteristics (Recording Galvanometer)
Range—0 to 1 microampere
Resistance—approx. 2280 ohms
Response Time—approx. 1 sec.
Dimensions—5½ by 16 by 9¼ in.
Scale Length—3¾ in.

TO RECORD ONE MICROAMPERE

These sensitive instruments can be used to record any quantity indicated by the movement of a tiny mirror. They are the most sensitive recorders known which do not employ electrical amplification of the quantity being measured.

They are very useful for recording values such as grid currents of vacuum tubes, small photo-tube currents, and small thermocouple voltages for low-temperature records. Measurements can also be telemetered.

Both portable and switchboard types are available.

Direct-acting Recorders — Type CD

Typical Characteristics (Milliammeter)
Range—0 to 2 milliampere
Resistance—approx. 1800 ohms
Response Time—approx. 2 sec.
Dimensions—5½ by 12 by 9 7/16 in.
Scale Length—4 in.

TO RECORD ONE MILLIAMPERE

A new direct-current instrument in the Type CD line offers a convenient means for recording plate current and other small current values in lower ranges than were previously possible.

The chart is driven by a Telechron motor, thus assuring dependable operation. The instrument is lightweight, easy to use, and can be obtained in both portable and switchboard types.

This Type CD instrument is one of a complete line for recording current, voltage, watts, power-factor, and frequency.

TO INDICATE ONE-TENTH MICROAMPERE

These sensitive, portable, reflecting galvanometers find a wide variety of applications in electronics work. Typical uses are for indicating zero current and for measuring the low current values of photoelectric and photovoltaic cells.

They are lightweight, sturdy, and are easily connected into the circuit for making measurements.

Seventy-five ranges are available for immediate shipment.

Portable Reflecting Galvanometer

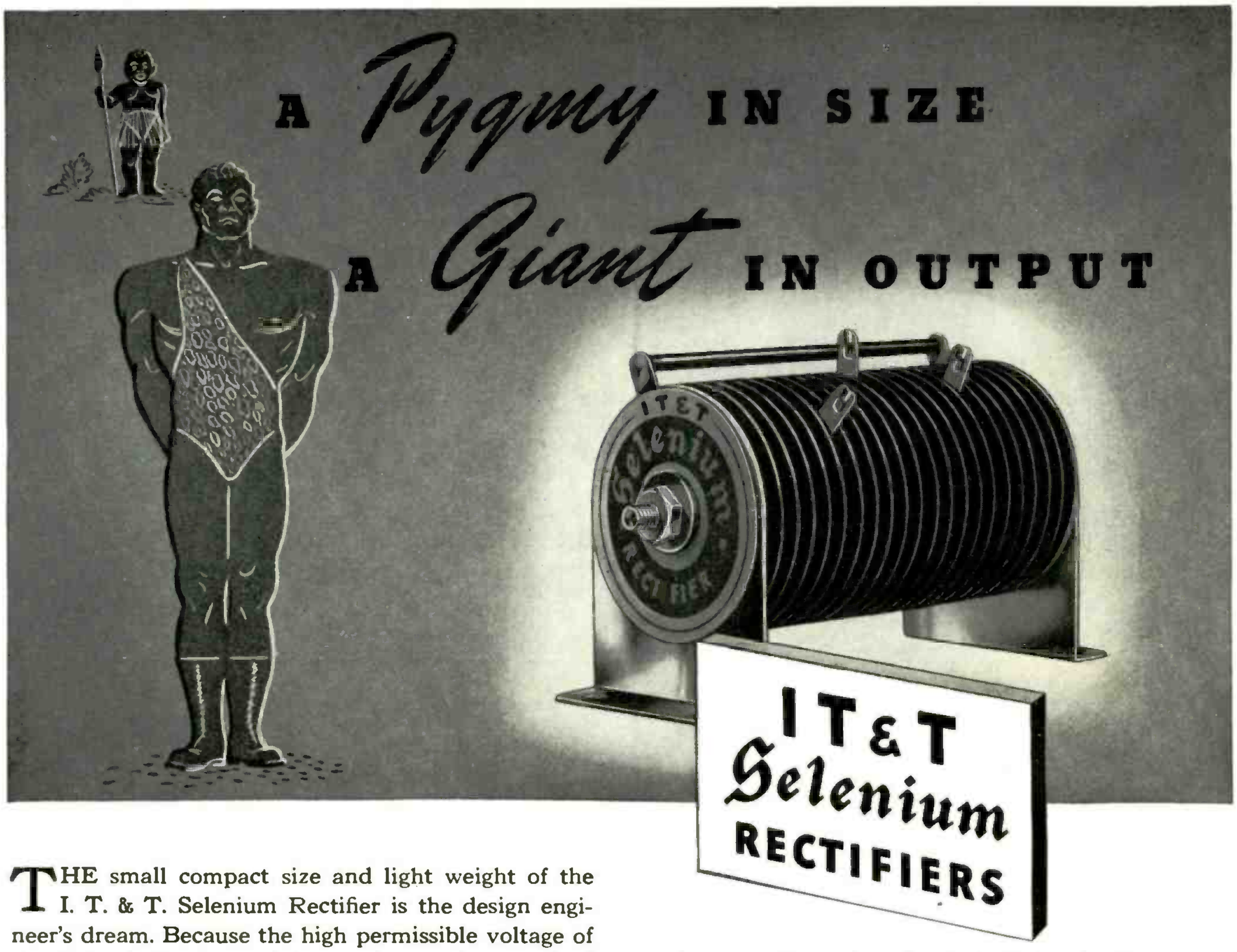
Typical Characteristics
Resistance—approx. 2280 ohms
Period—approx. 4.0 seconds
Dimensions—7 by 6⅜ by 15⅝ in.
Scale Length—10 cm.
Microamperes—approx. 0.04-0-0.04

For further information about these or other instruments in the complete G-E line, call the nearest G-E office, or write General Electric Company, Schenectady, New York.

HEADQUARTERS FOR ELECTRICAL MEASUREMENT

GENERAL ELECTRIC

602-9



THE small compact size and light weight of the I. T. & T. Selenium Rectifier is the design engineer's dream. Because the high permissible voltage of the plates holds to a minimum the number required . . . the high current density permits the use of small plates . . . and the one-piece plate minimizes the number of parts, the Selenium Rectifier is inherently a small unit for its high power-handling capacity.

The use of small hardware, including lighter mounting brackets, is made possible by light assembly pressure. The compactness permits reduction in the size and gauge of housings—thus adding to flexibility of design and reduction in costs.

Other Outstanding Features of I. T. & T. Selenium Rectifiers

The I. T. & T. Selenium Rectifier finds wide, general-purpose application in a variety of forms for the rectification of high or low currents at high or low voltages. It also has many other uses, such as: a spark quencher, polarizer, tone generator, etc.

Efficiency: In addition to low first cost, the high efficiency of the Selenium Rectifier over a wide load range assures economical operation and, furthermore, it requires no maintenance.

Wide Temperature Range: It operates instantly in ambient temperatures of from —40°C. to +75°C. for continuous service — higher for intermittent.

Overload Capacity: It will withstand short overloads of ten or more times the normal rated current without damage.

Ruggedness: It is entirely metallic, rugged in design and construction—unaffected by shock or vibration. Not critical to assembly pressure.

Regulation: Stable output and good regulation during years of wide use.

Electrical Stability: It has no moving parts, it requires no adjustments, or replacements, there is nothing to get out of order. It has practically unlimited life.

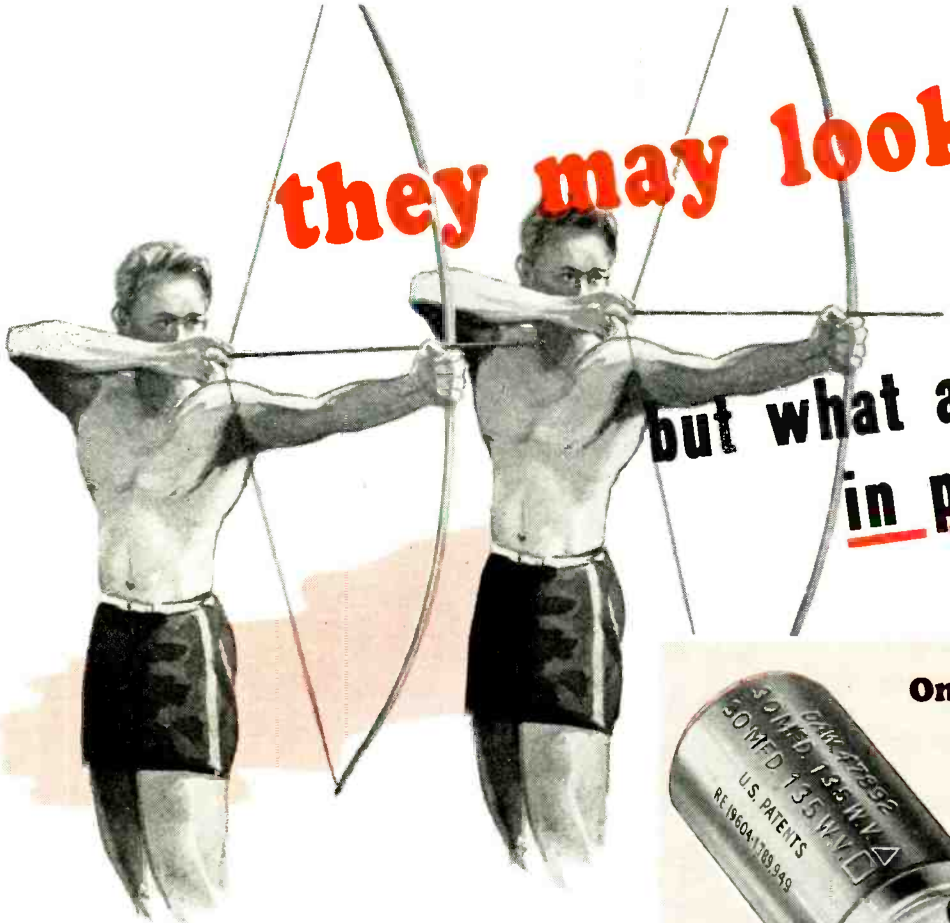
Low Back Leak: It has negligible back leak for battery charging. No protective devices required to guard against interruptions in A.C. supply.

Consulting engineering services available for your specific requirements.
Address Rectifier Division for descriptive bulletin.

INTERNATIONAL TELEPHONE DEVELOPMENT CO., INC.
137 Varick Street, New York, N. Y.

they may look alike

but what a difference in performance!



Archers or capacitors . . .

IN outfits the same, and with bows drawn, archers do look alike. But what a difference there is apt to be in performance. Hidden qualities coordinating eye and hand and brain—mark the champion. It is what's *inside* that counts.

As with archers, capacitors, too, look alike. Yet one is known the world over for its amazing long life . . . dependable performance . . . surviving economy, while the next—just another capacitor—falls wide of the mark.

Thirty years of specialized experience enable Cornell-Dubilier engineers to build into C-D's, features found in no other capacitor. It is this unique combination of *hidden ingredients* — that accounts for this capacitor's superior performance and more for the money value. Accounts, too, for the fact that there are more Cornell-Dubilier capacitors in use today than any other make. Investigate for your company the very real advantages C-D's give you.

CORNELL-DUBILIER ELECTRIC CORPORATION
1006 HAMILTON BOULEVARD
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Only Cornell-Dubilier Electrolytics offer all these *REAL* features

Type UP*

These Features:

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

Result in:

- Minimum capacity change over wide temperature range.
- Great reduction in physical size—up to 40% for some types.
- Increased useful life.
- Reduced direct current leakage.
- Reduced equivalent series resistance.
- Higher breakdown voltage.
- Improved audio and radio frequency impedance characteristics.

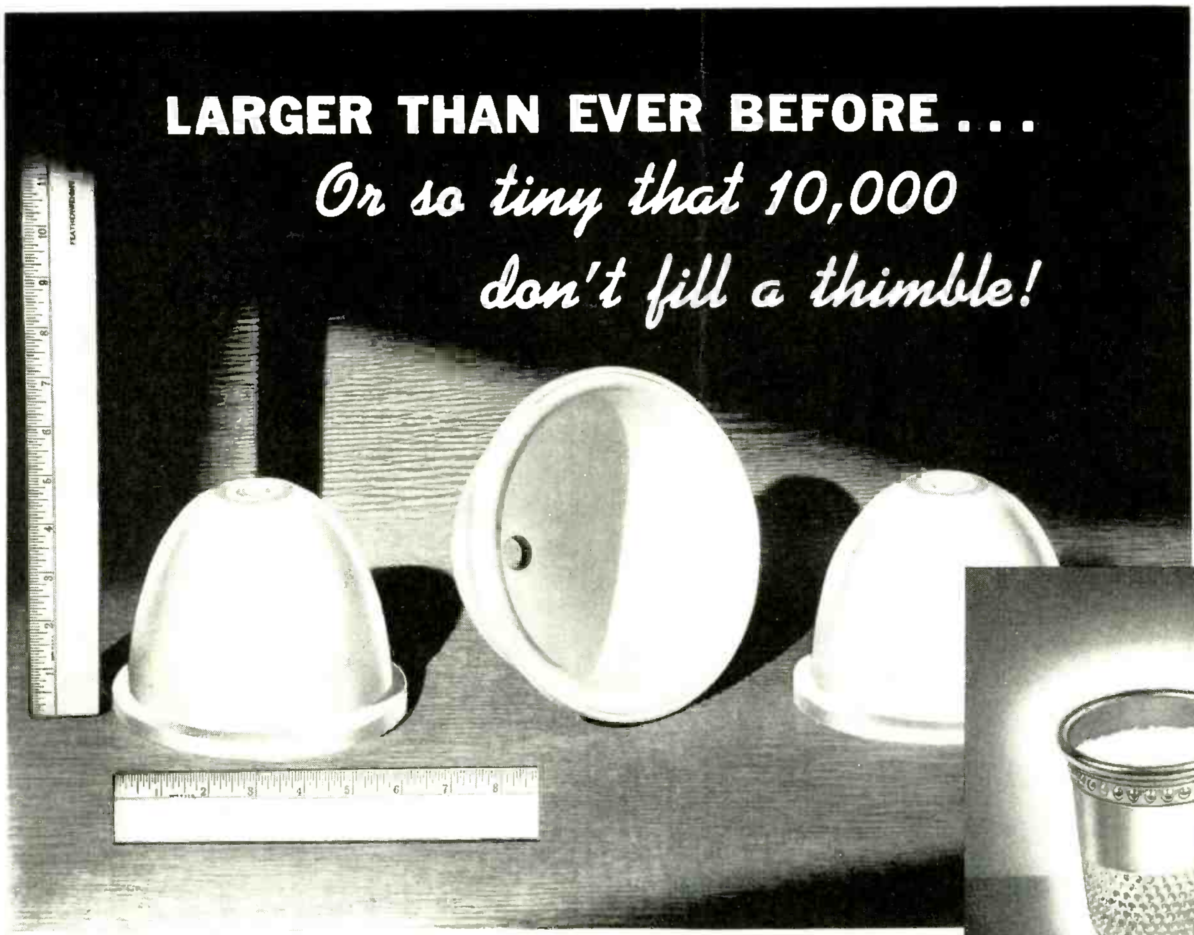
The Type UP is the smallest can type capacitor available, and can be supplied in single, dual, triple and quadruple capacity combinations. Complete physical and dimensional data on request.

Remember! All C-D capacitors are union made and competitively priced.

*ETCHED FOIL—NOT FABRICATED PLATE

specify CORNELL-DUBILIER!

THE WORLD'S LARGEST MANUFACTURER OF CAPACITORS...



NEW manufacturing facilities now make it possible to produce much larger pieces in AlSiMag Steatite Ceramics.

The excellent mechanical strength and remarkable dielectric properties of AlSiMag have proved so satisfactory in countless applications that constantly increasing sizes have been demanded. Therefore, a new method of production was worked out by American Lava Engineers.

By the new process, the material is cast in a cream-like consistency. If necessary, certain details can be machined before firing at high temperatures. Cast pieces are free from strains, uniformly dense, vitrified. They can be supplied glazed or unglazed. Initial pattern and mold cost is reasonable.

For many years AlSiMag has been supplied in sizes ranging from parts so tiny that 10,000 do not fill a thimble to the largest-in-the-industry, by pressing or extruding. Thirty-eight years of specialized experience in Steatite Ceramic Insulation is at your disposal, whether you seek microscopic sizes or sizes larger than have previously been considered practical. Your inquiry will have prompt attention.

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World's Largest Radio Coil Manufacturers

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In our new location we have laid out a plant that is a model of streamlined efficiency with the most modern facilities. We have made this move to raise still higher the standards of quality and service which have won world-wide respect for Sickles Products.

To our many friends whose continued confidence has made this expansion possible we take this opportunity to extend our thanks. We invite your inquiries on your particular radio equipment problems either direct or through our district sales offices.

The **F. W. SICKLES COMPANY**

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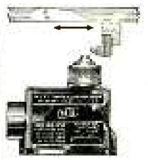
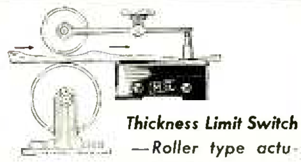
MANUFACTURERS OF *Radio Electrical Apparatus* CHICOPEE · MASS.

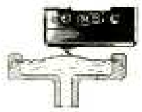


Hinged dog on slide *actuates sealed metal clad Micro Switch only on one direction of dog.*

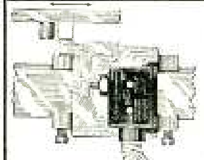
Straight Cam Control—*Cam on rod or bar actuates roller arm which operates the Micro Switch. Equipped with Type "J" Actuator. Used on machine tools and packaging machinery.*



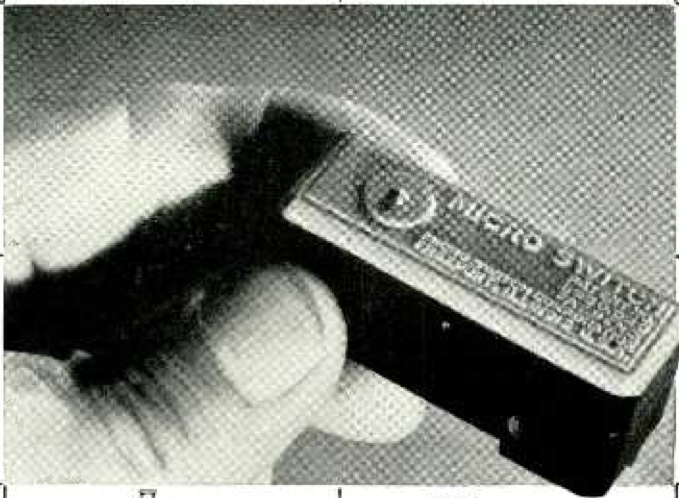
Thickness Limit Switch—*Roller type actuator rides material and operates the switch if thickness limit is exceeded.*

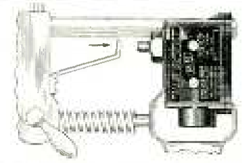


Diaphragm Pressure Actuated—*The pressure of a liquid or gas against the diaphragm actuates the Micro Switch at desired limits of pressure.*



Dog on slide *actuates pivoted arm which operates metal clad Micro Switch. Adjustable mounting plate and flexible coupling permit easy change of limit and stop positions.*



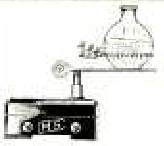


Lathe Carriage Stop—*Lathe carriage actuates the Die Cast Micro Switch at end of travel.*

Bellows Thermostat—*Fluctuations in temperature change the length of the bellows to operate the Micro Switch.*

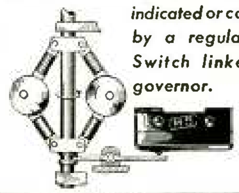
Disc and Cam Operated—*A sequence of operations is controlled by means of a roller-leaf actuator following the strips on a driven drum.*

Solenoid Control—*Plunger of solenoid actuates Micro Switch to control other circuits.*



Control of Weight—*Weight acts on a simple lever which in turn actuates the Micro Switch. Used to prevent complete evaporation of liquids in a container.*

Coin Actuated—*In a coin machine, the weight of a falling coin, through a proper lever, operates a regular sensitive Micro Switch.*



Speed Governor Control—*Speed indicated or controlled by a regular Micro Switch linked to a governor.*

IF YOU WANT TO . . .

locate a star . . . stop and reverse a tap in 1/10th of a revolution . . . get precise operation under the sledge-hammer blows of a heavy cam . . .

specify MICRO SWITCH

This little switch does a big job no matter where you put it—wherever time, temperature, pressure, weight, relays or solenoids are the control factor. It is no larger than your thumb yet it stands up under terrific pounding. It limits the movement of 5500 ton presses.

It is so light in weight—only one ounce—that airplane manufacturers are specifying it for important functions where size, lightweight, vibration resistance, absolute dependability and long life are all-important.

The Micro Switch, operated by thermostatic or other means, assures highly accurate operation because of the precise repetition of switch action on each cycle.

Wherever precision switching presents a problem you will find it to your advantage to investigate the Micro Switch. Its energy requirements are small, ranging from .004 to .0004 ounce inches, depending on the type of switch desired.

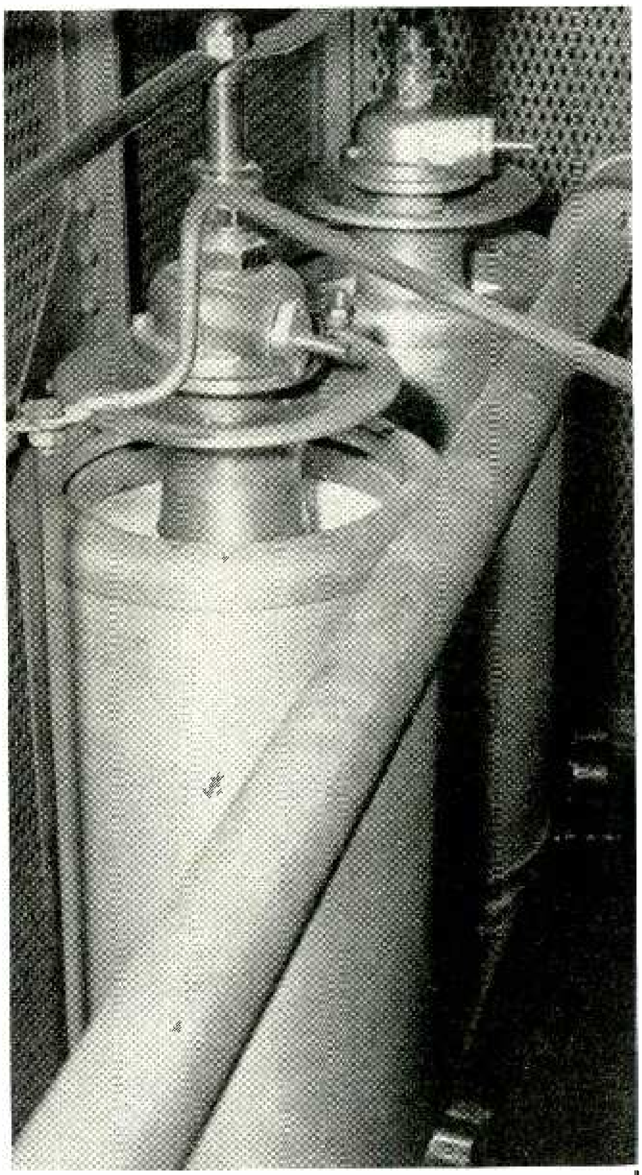
It is dependable, providing a sharp, clean snap action on slow actuation as well as at speeds up to 300 times per minute for as many as ten million operations.

The Micro Switch resists vibration, is rugged, has low electric resistance and high dielectric resistance. It is listed by the Underwriters' Laboratories at a rating of 1200 watts up to 600 volts.

Micro Switch engineers are specialists in precision switch application. Their knowledge can be of value to you in solving a problem.

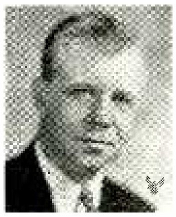
MICRO [TRADE MS MARK] SWITCH

Manufactured in FREEPORT, Illinois, by Micro Switch Corporation. Sales Offices: New York, Chicago, Boston



"HAD TO RE-ADJUST FINAL AMPLIFIER COUPLING CIRCUITS BECAUSE OF LAPP CONDENSER'S LOW LOSS"

writes L. W. STINSON, KVOO



L. W. STINSON

"The two continuously variable 1000 mmf Lapp gas-filled condensers were originally ordered as part of a plan to change over our 50 kilowatt transmitter to a modern high-efficiency type of circuit. Plans did not call for an immediate changeover, so they were installed in the regular circuit to replace the solid dielectric condensers in use. For this temporary installation the variable capacitance feature was used only to adjust the unit to a fixed value with a radio frequency bridge; minor changes were made in the neutralizing circuits and the Lapp units inserted in the same postion as the old bank of twelve mica capacitors.

"We had not anticipated that the increase of efficiency due to the gas-filled units would necessitate re-adjustment of the final amplifier coupling circuits but such was the case, as the increased impedance presented to the tube anodes raised the efficiency above optimum linear amplifier operating conditions. This of course, is a testimonial to the Lapp claim of 'low loss' features, and permitted us to transfer just that much more power to the antenna and to discard the air blower which had been found necessary to hold the temperature rise of the mica units to a safe value. As best we can determine, the gas-filled units operate at the ambient temperature.

"Our condensers, received in February, 1939, were filled to 200 pounds nitrogen shortly after arrival. Since then they have required absolutely no service of any kind."

Descriptive literature and list of 54 models in three voltage ratings available on request.

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CROSS TALK

► FM . . . Our readers are already aware of the green signal given FM. It is expected, now, that FM will really get under way and that the superior service possible under wide-band u-h-f FM will not be too long in becoming available to many people.

A demonstration by Radio Engineering Laboratories at Riverhead, Long Island, June 10 was convincing in showing the freedom from static, from inter-station heterodyning and in showing the efficacy of even medium power at the transmitter. It is only fair to state that ignition noise was not entirely absent. In our own case, however, moving the receiver from a front room near the street to a rear room and up one flight of stairs has completely eliminated all sign of ignition noise as well as solving the antenna problem. Completely adequate signals are received in Garden City, L. I., from Alpine and from Empire State with only a pitiful wire hanging to the receiver binding posts and running off in several different directions. No outdoor dipole, no science, no engineering —just nice clean signals.

► EX EUROPE . . . The following letter from F. H. Gulliksen is self-explanatory. Mr. Gulliksen with E. H. Vedder wrote "Industrial Electronics" published by John Wiley & Sons a couple of years ago.

Mr. Gulliksen writing from Oslo, Norway (his letter was carefully "geöffnet" somewhere between his address and New York City) has the following to say:

"I have read Mr. Goldsborough's excellent article on Patents in the February issue of *Electronics* and should like to take exception to the statement regarding the final claim in patents which are to be filed abroad. In most European countries except Great Brittain and France, a claim reading 'The invention substantially as described in connection with the accompanying drawing', is unstatutory and the examiner in the Patent Office will require its cancellation in the same manner as required in the United States.

"Being connected with the Norwegian Patent Office I have had occasion to see a number of American applications for Norwegian patents, and I have noted that most of these applications contain the above mentioned final claim. It is therefore apparent that most American patent attorneys specializing in the foreign field seem to believe that the said final claim will be allowed, and I should therefore be thankful if you should find space in *Electronics* to print this correction."

American newspapers, speculating on the ease with which German military units keep in touch with each other and with headquarters, have given some of the credit for this feat to Hans Roder who took to Germany all he had learned about American practice, especially the virtues of FM. It is supposed that u-h-f technique, probably including FM because of its ability to get around noise, has been worked to the fullest extent between mobile units on the battlefield. Mr. Roder contributed to the literature on FM while in this country.

► CROSSROAD . . . Television in America is at the crossroads. Sniped at by those who should have the greatest interest in it—the members of the radio industry—television stands almost prostrate, discouraged, losing men, trying hard not to give up. The issue seems clear-cut. Industry must get together and decide upon standards.

Television is bigger than any inter-company squabble; it is bigger than those who feel that television will harm sales of common radio sets and therefore ought to be knifed. It is bigger than anyone's investment to date, and certainly bigger than those who, having no investment, still knife for their own picayune reasons.

Either the radio industry must clean its own linen, get under one banner and indicate that it wants television to go ahead—or else. At present the industry merely invites agencies other than industry to step in and take control.

► STANDARDS . . . Speaking of the subject of television standards, industry should be interested in Administrative Order No. 4 of the Reich Trustee for Communication Devices which *forbids* the manufacture of 88 types of radio tubes in Germany in the interest of coordination and standardization.

► INDEX . . . Engineering Index 55th Annual Volume, a book of some 1,400 pages with 27,000 references in 2,000 periodicals was issued late in May. Engineering Index, Inc., is a non-profit organization carrying on work which engineers and research men in many walks of life find useful since it enables them to keep abreast of the tremendous annual output of techincal literature throughout the world.

Facts About Atomic Power

The isolation of U-235, the isotope of uranium which has potentialties as a true atomic fuel, has taken the scientific world by storm. Here is a factual review of the situation, including the "if's" which make the realization of atomic power still a matter for the future

THE practical man in engineering is usually somewhat skeptical of the endeavors of his brothers in the pure sciences. To him the problem of designing and maintaining a modern communication system, for example, is far more vital than the knowledge that mass and energy are different aspects of the same thing. But the practical engineer who has read the history of technology knows that the theoretical postulates of science may turn out to be of the greatest practical importance. Knowledge pursued for its own sake has time and again declared a big dividend.

An excellent example of such corporate finance in the scientific world is now before the public eye, so much so in fact that the story appeared on the front page of the *New York Times*—at a time when the ordinary affairs of men have been consistently relegated to the inside pages. The story is the isolation of the isótope of uranium whose atomic weight is 235 and whose symbol is U^{235}.

U^{235} appears to be the first true atomic fuel discovered, and although its practical importance in the affairs of men at present is precisely nil, its potentialities are sufficient to fire the imagination of anyone whose background permits them to understand the facts in the case. The readers of *Electronics* fall in this class, hence your editors have sought out the factual references in the matter, and have attempted to separate the actualities from the guesswork and the wishful thinking.

What Is an Atomic Fuel?

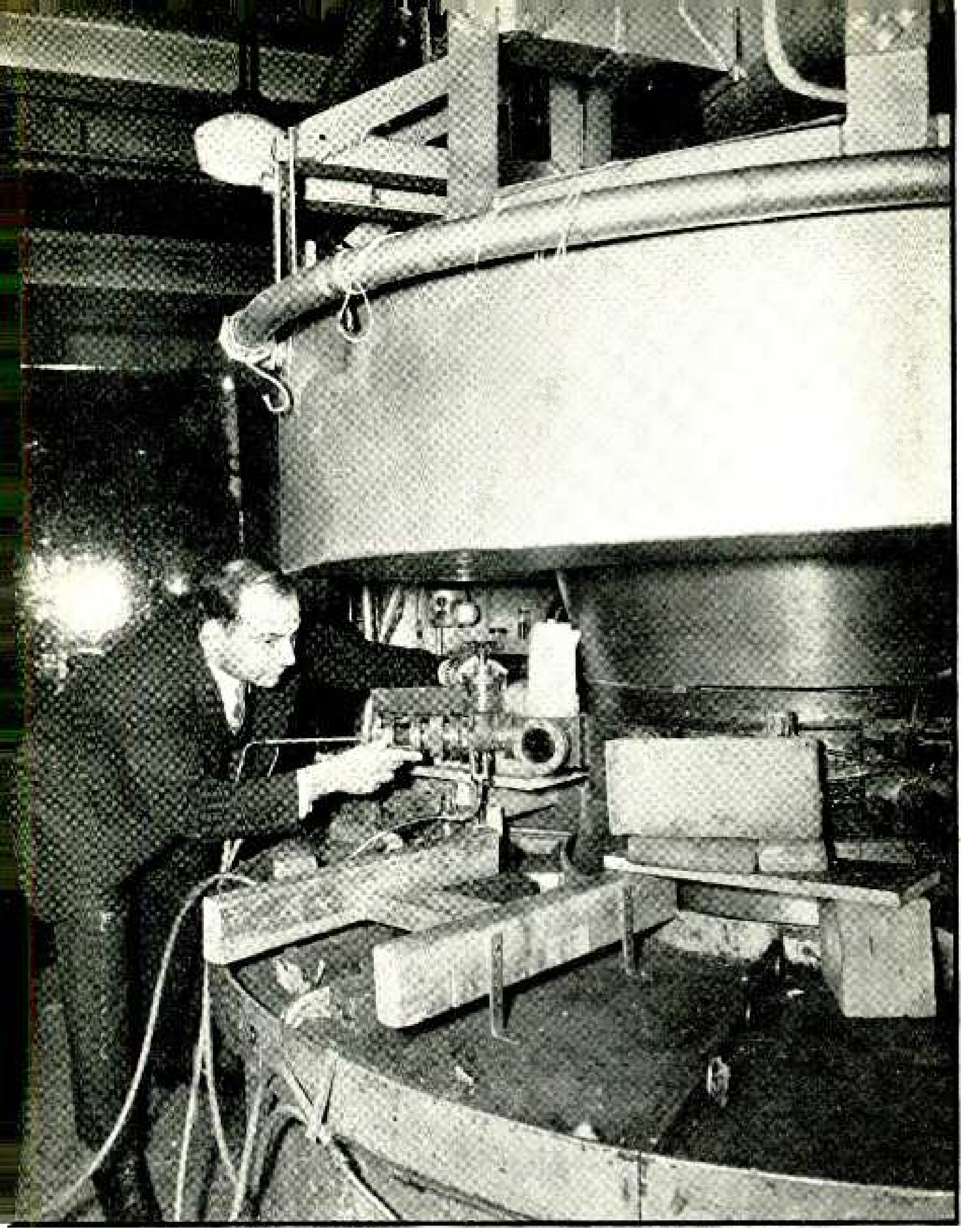
It need hardly be said that modern technology depends upon sources of power, and that sources of power depend on fuel, either directly or indirectly. The fuels thus far available to industry have been in the *chemical* class. Coal and oil, for example, are useful to us because they are unstable chemical substances which can be ignited and which thereafter will continue to furnish heat until they are consumed, provided they are kept in a suitable burner or furnace. The burning process in ordinary fuel is essentially a release of chemical energy which accompanies the reorganization of the molecules in the fuel. Thus the hydrocarbon molecules of coal, when burned, become separated into water, free carbon, carbon dioxide, ash and other combustion products. The energy freed in the process results from the reshuffling of the atoms and the outer electrons of the atoms concerned. The nucleus of each atom, however, remains unchanged.

For some time the physicists have known that an entirely different kind of fuel lies within the range of scientific discovery. That fuel is the *atomic* fuel, in which great amounts of energy can be liberated from within the nucleus of an atom. The nucleus, or central core of each atom, is composed of positive protons and neutral neutrons (possibly electrons also). The several positive charges are bound together in the nucleus very compactly, in direct contradiction to the electric law which states that charges of like sign repel each other. This anomaly has been explained on theoretical grounds, but its practical significance is that *if the law of electrical repulsion could be made to take effect within the nucleus*, the nucleus would fly apart with tremendous speed, and the associated energy could be transformed to heat in a manner very similar to that which makes the plate of a power tube glow red when bombarded by the electrons in the space current.

Such an atomic fuel, to be useful, must be capable of "supporting its own combustion," that is, once "ignited" it must continue to "burn" of itself until consumed. Moreover, it should be comparatively inert until ignited, and not too expensive in relation to the useful energy it can produce.

What is needed in an atomic fuel, then, is a nucleus which is normally stable, but which can be excited by some external means so that it becomes unstable. The heavier the atom, the more complicated its nucleus, the greater the number of positive charges it contains, and the greater its tendency toward instability. It is not surprising therefore that uranium, the heaviest element and having the highest positive charge on its nucleus, should prove suitable for the purpose.

Uranium exists in several forms, called isotopes, which have identical chemical properties but different atomic weights. The most prevalent isotope, of atomic weight 238, symbol U^{238}, is normally stable, but can be excited into instability if bombarded with neutrons of very high energy (energy such as would be imparted to a unit charge by passage through an electric potential of several million volts). Another isotopic form, the one of atomic weight 235, U^{235}, is very easily excited to instability by the action of neutrons of very low energy, corresponding to an electric potential of roughly 1/40 of a volt. Moreover, when the U^{235} nucleus flies apart, from to 2 to 3 neutrons are generated in the process. These neutrons may go off in turn to "set off" and cause the disruption of other nearby U^{235} nuclei. Thus the conditions for a "chain reaction" are available, and the atomic combustion may be made self-supporting. But the chain reaction cannot occur if the atoms of U^{235} are diluted by stable atoms of uranium such as U^{238}, any more than pulverised coal can be made to burn if it is mixed with a high percentage of sand or some other non-combustible material. Hence the need to obtain U^{235} in pure, or nearly pure, form.



The "match" for atomic fuel. Neutrons generated in this huge cyclotron at Columbia University were used to irradiate the sample of U^{235} isolated at the University of Minnesota. The neutrons, slowed down by passage through paraffin, induce instability in the uranium atoms, causing them to explode with tremendous energy. Thereafter the uranium isotope, if available in sufficiently pure form, will maintain its own "combustion"

In natural uranium, the two principal constituents are U^{238} and U^{235}, which occur in the ratio to 139 U^{238} atoms to every U^{235} atom. Thus the active component U^{235} is so heavily diluted by the inactive component that the atomic combustion cannot be self-supporting until the U^{235} is separated from the combination. U^{238} and U^{235} are identical chemically, hence cannot be separated by chemical methods. The only difference on which separation can be accomplished, so far as is now known, is the difference in their masses, and this difference is only 3 parts in 235, or less than two percent. Here, then, is the rub. Can a simple and economical means be found to separate U^{235} from U^{238}? If so, a new fuel is available which has the virtue of being highly concentrated, and which *may* compete with coal or oil on a price basis, *provided* the several economic and technical questions are satisfactorily answered.

A very interesting analysis of the problem has been worked out by Roberts and Kuper.[1] They point out that U^{235} supplies about 200 million electron volts of energy per atom, whereas coal supplies 4 electron volts of energy per atom. The ratio of energy is then 50,000,000-to-1 on an atom basis. By a weight basis, if we compare coal with uranium oxide as raw materials, this ratio must be divided by the relative concentration of U^{235}, 1 in 139, and by 20 to account for the difference in the molecular weights. This gives U^{235} an advantage over coal of about 17,000-to-1, on a weight basis, considering the raw materials. What about cost? Uranium oxide costs about $2 per pound or $4000 per ton, whereas coal costs but a few dollars per ton. Thus the cost of energy from coal turns out to be about 8 or 9 times as great as the cost of an equivalent amount of energy from U^{235}, provided that the cost of extracting the U^{235} from the uranium oxide is completely disregarded. No account is taken moreover, of the available supplies of uranium compared with coal, and the trend of the costs of uranium ore which will go up as the supply dwindles, or go down if the supply lasts and the mining methods improve.

The crux of the matter seems to be the cost of extracting U^{235} from U^{238}. If a method can be found which costs less than 1/8th or 1/9th the cost of coal for an equivalent energy production, then U^{235} is in direct competition with coal. Thus far, however, any such extraction method is only a dream. The grim reality is that U^{235} costs much more to extract than it is worth as an energy source. No one knows when an economical process may be found. The whole world is looking for it, but it may never come to light. If so, U^{235} is just a flash in the scientific pan, so far as atomic power is concerned.

There remains however one definite utility in the study of U^{235} which may be realized much more immediately. This possibility lies in the "ash" which remains when U^{235} has been "burned." When the U^{235} nucleus splits apart it forms two new nuclei of comparable weight (roughly 100 and 140 units of atomic weight each). The position of these nuclei in the atomic table approximates that of barium and the nearby elements. Actually, some 20 different types of atoms have been identified as the "combustion products" of U^{235}, and more will no doubt be found. These atoms, moreover, are artificially radioactive. Thus a whole new series of radioactive elements may be produced in quantity and very cheaply. The prospect of almost unlimited amounts of cheap radioactive materials of various characteristics, is so attractive to the fields of biology, medicine, chemistry, and physics that it justifies an intense study of U^{235} even if there were no larger implications involved from the power standpoint.

(*Continued on page 50*)

The INVERTED AMPLIFIER

By applying the input excitation in series with the cathode of a power amplifier, with the grid grounded, important advantages for high-frequency operation are gained since the grid acts as a shield and the output capacitance is reduced

By
C. E. STRONG
Radio Systems Manager, Standard Telephones and Cables, Ltd., London

THE term "inverted amplifier" is applied to vacuum tube amplifiers in which the grids are grounded and the driving excitation is applied to the cathodes. The basic form of the arrangement and its equivalent circuit are shown in Fig. 1.

It is evident from first principles that if the grid is maintained at zero potential and the cathode is driven in the positive direction, then the anode becomes more positive with respect to the cathode and, therefore, still more so with respect to zero. Therefore, the anode circuit emf is developed in series and in phase with the driving voltage and the driver and amplifier operate in series to feed power to the load resistance. It follows that the power delivered to the load is the sum of the powers delivered by the driver and by the amplifier less any power from the driver which might be absorbed in the amplifier grid circuit. It follows also that the power delivered by the driver into the output load is equal to the power delivered by the amplifier multiplied by the ratio between the alternating cathode-to-grid and the anode-to-cathode voltages.

Since the amplifier is effectively in series with the driver, the output current passes through the resistance of the driver, causing a voltage drop in that resistance in the sense to subtract from the original driving voltage. This means that reverse feed-back is inherent in the system if the driver has appreciable resistance.

When the amplifier is used at high frequencies the cathode-to-grid and grid-to-anode capacitances must be considered and the circuit becomes as shown in Fig. 2A. From this it appears that the grid acts as a screen between the input and output circuits and hence, for the simplified case shown, reaction due to the interelectrode capacitances is avoided.

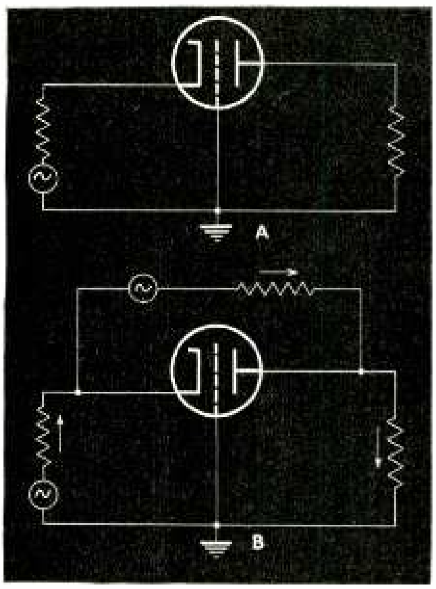


Fig. 1—Actual and equivalent circuits of the inverted amplifier. The input and output effectively operate in series, as shown in (B)

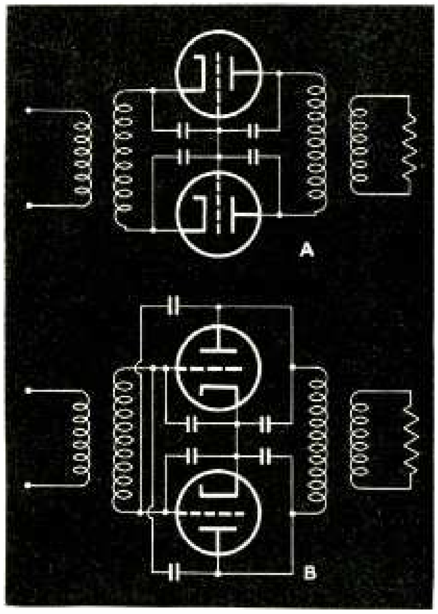


Fig. 2—Simplified inverted amplifier (A) and conventional neutralized balanced amplifier (B). In the inverted amplifier the output capacitance is halved

A conventional high frequency amplifier neutralized by the classical capacitance bridge method is shown for comparison in Fig. 2B. It will be observed that the minimum output circuit capacitance in this case is twice that for the equivalent inverted amplifier shown in Fig. 2A, consequently for equivalent operating conditions the minimum output circulating current for the case of the inverted amplifier is only half the value for the conventional amplifier and the maximum permissible output circuit inductance is twice that for the conventional amplifier.

Summarizing the foregoing, the principal features of the inverted amplifier may be stated as follows: First, the driver feeds power in series with the main amplifier into the output load. Consequently, a driver of higher power is required than would be necessary in the case of a normal amplifier. Secondly, reverse feed-back is inherent if there is any impedance in the driver. Thirdly, the grid forms a screen wholly or in part between the input and output circuits and, finally, the minimum output circuit capacitance is considerably less than in an equivalent normal balanced amplifier.

Of these features the two latter, namely, the screening effect of the grids and the reduction of output circuit capacitance, are of considerable value in relation to the design of high frequency amplifiers, particularly amplifiers involving high-power tubes operating, for example, at frequencies of the order of twenty megacycles as utilized in high-power short wave broadcasting transmitters or amplifiers working on still higher frequencies as required for television and other purposes.

The advantages of the system as

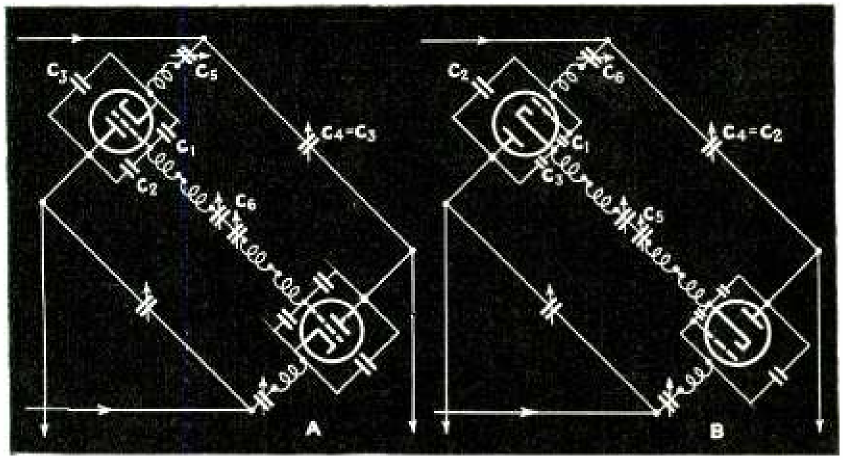


Fig. 3—Neutralization of inverted amplifier (A) and conventional amplifier (B). Similar methods are used, but the inverted amplifier requires smaller balancing capacitances

applied to high power short wave equipment appear when the difficulties arising in the design of conventional balanced amplifiers involving large tubes are considered. First, there are difficulties in the design of the neutralizing (balancing) condensers which, while they may not be physically large, must withstand a high voltage and must be located in restricted positions with respect to the tubes. Secondly, there is increasing tendency to instability because as the size of tubes is increased with resulting increase of interelectrode capacity, the resonant frequency of balancing condenser circuits becomes nearer and nearer to the frequency of operation with the result that selective damping becomes less and less practicable. Thirdly, with increasing anode-to-grid capacity and balancing capacitance, the output circuit capacitance increases to the point when efficiency is impaired and when the resulting reduction of output circuit inductance leads to design limitations.

These difficulties are reduced by use of the inverted arrangement. High voltage balancing capacitances are reduced if not eliminated, and the difficulties of balancing condenser circuit resonances are practically avoided. Also, larger tubes may be used before final limitation due to reduced output circuit inductance is reached. In the case of television amplifiers the reduction of output circuit capacitance simplifies the problem of passing the necessary wide spectrum of side-band frequencies.

In practice, particularly with large tubes, the inverted amplifier is more complicated than that shown in Fig. 2B. In the first place, owing to the dimensions of the tubes and the spacing required between tubes in push-pull there is no possibility of avoiding inductance in the connections between the grids and ground. This means that there would be reactance common to the input and output circuits and there would be feed-back on that account unless measures were taken to counteract the effect. Secondly, there is in general leakage capacitance within the tubes from anode to cathode and finally, there is inductance in the cathode leads within the tubes.

The effect of grid lead inductance can be cancelled by inserting condensers in the grid leads to series tune the inductances and so effectively connect the grids to ground through zero impedance. The condensers must, of course, be variable in an amplifier required to work on several frequencies. The adjustment is sharp, but is easy to control.

The stray anode-to-cathode capacitance can be neutralized either by shunt inductance, or in the case of a push-pull circuit, by crossed balancing condensers. The former method consists in the insertion of an inductive reactance from anode to cathode of such value as will transmit back to the input circuit a current equal to that transmitted back through the capacitance, but in opposing phase. The second method is the well known capacitance-bridge method generally used in conventional amplifiers to balance the anode to grid capacitances. The shunt inductance method is useful in single-ended amplifiers, and it has the advantage of not giving rise to any increase of output capacitance, but it has the disadvantage of requiring adjustment of the inductance for each working frequency. The balanced capacitance-bridge method is more convenient, at least in the case of push-pull amplifiers. As the values of the capacitances involved are comparatively small, the effect of the inductance of leads in the bridge is not very important and, consequently, sufficient balance can be obtained with fixed balancing condensers over a wide band of frequencies. Furthermore, for the same reasons the bridge has little tendency to give rise to spurious oscillations contrasting favourably in that respect with the higher capacitance bridge in a normal amplifier. The circuit of an inverted amplifier including the provision for neutralizing the grid lead inductance and the cathode to anode capacitance is shown in Fig. 3A. There are also shown in the circuit

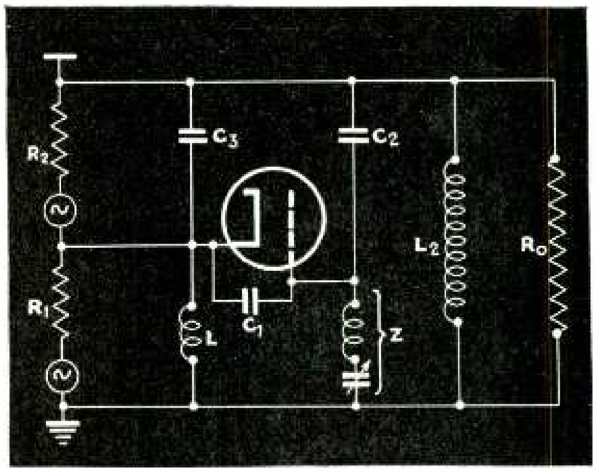
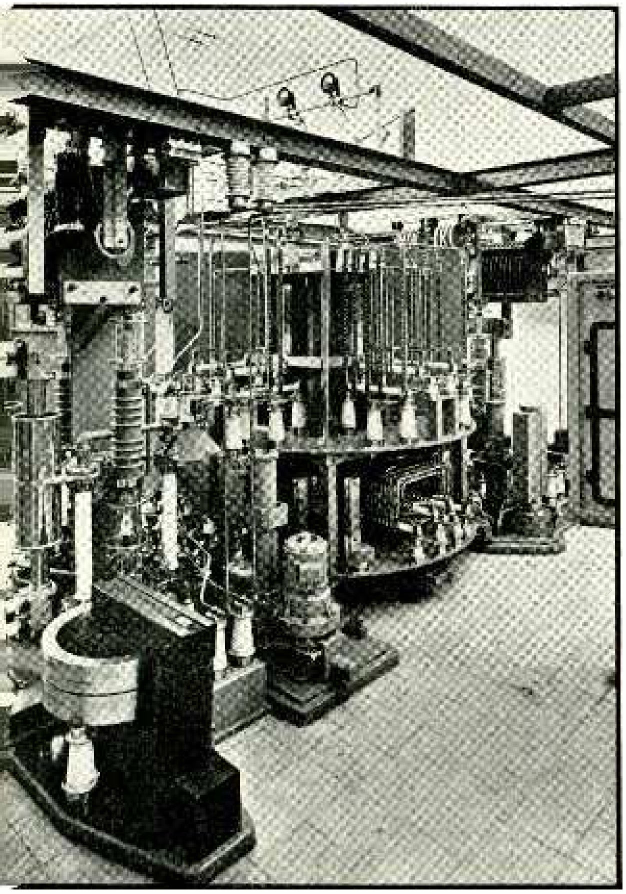


Fig. 4—Effect of grid-to-ground impedance, which may give rise to positive or inverse feedback according to whether the impedance is inductive or capacitive

capacitances to tune out the cathode lead inductances.

The effect of cathode lead inductance, if not tuned out, would be to give rise to feed-back even if the bridge were perfectly balanced for the condition that current in the output circuit should give no voltage across the corners of the bridge to which the input circuit is connected. The output circulating current traversing the bridge would set up voltages across the cathode lead inductances which would represent excitation of the cathodes. The requirement is, not only that the bridge should be balanced, but also that the cathodes should be at the electrical potential of the corners to which the input circuit is connected, hence it is necessary for perfect neutralization to tune out the cathode lead inductances.

It has appeared from the foregoing that there are three separate measures required to eliminate feed-back due to unavoidable reactances, namely, series tuning of the grid leads, neutralization of the anode-to-cathode capacitances and series tuning of the cathode leads. These are exactly equivalent measures to those required for the neutralization of a normal balanced amplifier as will be seen by reference to Fig. 3B, but there is the difference that in the inverted amplifier the capacitance bridge has to deal only with the relatively small anode-to-cathode capacitances as compared in the other case.



Two inverted amplifiers, operated in parallel and capable of delivering 100 kw carrier power

It is important to note that an amplifier is not necessarily neutralized if there is no transmission from the input to the output circuits through the system as a passive network. That result would be obtained in the case of a normal amplifier as long as the bridge circuit was balanced, but as we have seen, neutralization imposes additional requirements. Similarly, in the case of the inverted amplifier there is a certain value of the grid-to-ground impedance for which there would be no transmission as a passive network even without provision for balancing the anode to cathode capacitance. This arises for conditions expressed by the following formula in which Z_1, Z_2 and Z_3 are the impedences of the cathode-to-grid, grid-to-anode and anode-to-cathode capacitances respectively and Z_4 is the impedance of the grid-to-ground branch:

$$Z_4 = \frac{-Z_1 Z_2}{Z_1 + Z_2 + Z_3}$$

This condition does not represent neutralization as there is no assurance that current in the output circuit would not give rise to voltage across Z_1, that is, between cathode and grid.

It is an important requirement in the case of an amplifier to be modulated in amplitude for telephony that there should be avoidance of spurious phase modulation. It is evident that an amplifier with constant drive and having modulation applied to the anodes would be subject to this defect if there were feed-back in any phase resulting in a component in quadrature with the driving voltage. The magnitude of the component in quadrature would vary with modulation and, consequently, the resultant driving voltage would be modulated in phase. It is, therefore, of interest to consider the effects arising in an inverted amplifier through imperfect adjustment either of the grid-to-ground condenser or of the neutralization of the anode-to-cathode capacitance.

The effect of grid-to-ground impedance will be considered with reference to Fig. 4. Assume in the first instance that C_1 and L_1 are absent. Then if Z is a capacitive reactance at the working frequency, the current through the capacitance leg C_2 and Z in series leads the terminal voltage of the generators by 90°, and the voltage across Z lags that current by 90° and hence is in phase with the plate-to-ground and cathode-to-ground voltages. Consequently, when the cathode is positive with respect to ground the grid will also go positive with respect to ground due to the drop across Z and therefore, the cathode-to-grid voltage is reduced due to the flow of circulating current in the output circuit. This means that the capacitive reactance between grid and ground gives rise to reverse feed-back.

If, on the other hand, the grid-to-ground impedance is an inductive reactance and if it is of lower value than the reactance of C_2 as would be normal in practice, then the current in the C_2Z branch is 90° in advance of the plate-to-ground and cathode-to-ground voltages, and the voltage across Z is 90° in advance of that current and so 180° in advance of the generator voltage and therefore, when the cathode is positive the grid goes negative. The cathode-to-grid voltage is thus increased by the flow of output circulating current and hence there is positive feed-back. So far there is no feed-back in quadrature under the conditions considered. The result, however, is different when account is taken of C_1, the grid-to-cathode capacitance. Then the voltage set up across Z by the output circulating current aids or opposes the voltage of the driver in its effect on the capacitive branch of the input circuit so that there is more or less capacitance current. Thus the power factor of the input circuit is dependent on the value of the output circuit current and anode modulation of the amplifier would give rise to spurious phase modulation.

As regards the effect of unbalanced anode-to-cathode capacitance, the current through the small plate-to-cathode capacitance C_3 (Fig. 4) would be 90° in advance of the anode voltage and the resulting voltage set up across the driver resistance R_1 would therefore be 90° in advance of the driving voltage. There would therefore be feed-back in quadrature if R_1 were not negligibly small. This feed-back would give dynamic phase modulation if the amplifier were anode modulated and if the driving stage were not also modulated to an equal degree. As the effects in this case are different from those of reaction arising from impedance between grid and ground, it would evidently not be advisable as a rule to attempt to compensate for anode-to-cathode capacitance by

(Continued on page 55)

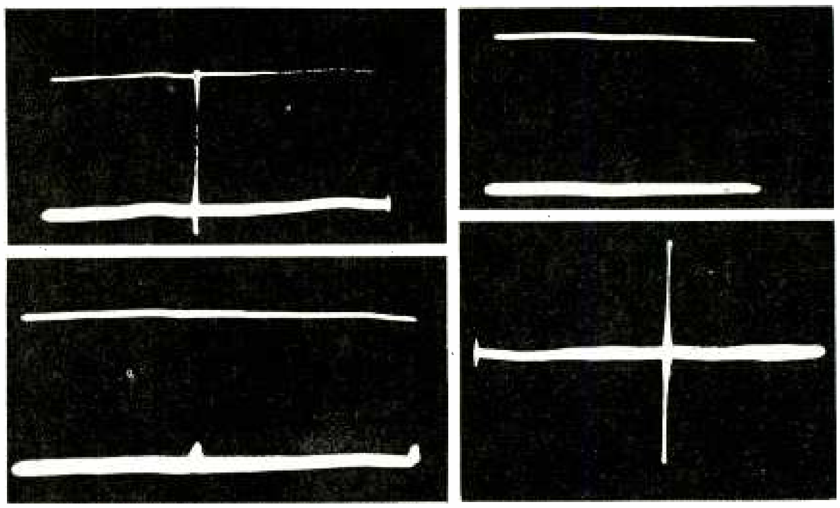
I. R. E. AT BOSTON

Large and well-organized program of papers covering frequency modulation, television, power tubes, microwaves and aircraft radio heard by 1000 engineers at Hotel Statler. Paxton F-M station visited by large group

ONE of the most interesting and elaborate programs ever to be presented at an I. R. E. meeting was offered at the 15th Annual Convention in Boston, June 27, 28, and 29. The technical papers were numerous, well arranged, and on timely subjects. The committee also had arranged numerous trips to laboratories and schools in and near Boston which were well patronized by an attendance of more than 1,000 members of the radio industry's technical fraternity.

The technical program was one of the largest in I. R. E. Convention history—46 papers arranged by subject matter and presented in seven sessions in the three-day period. By dint of considerable scurrying, one or more of your editors found it possible to hear each paper, but space limitations prevent any complete report of the whole proceedings. What follows is rather an attempt to hit the high spots.

But the technical sessions and trips were not the only points of interest. Among the highlights was the annual banquet, at which time Lloyd Espenschied was awarded the Institute's Medal of Honor for his long years of engineering and development work in the furthering of radio telephony, while Harold A. Wheeler was awarded the Morris Liebmann Prize for meritorious work in the analysis of wide-band, high-frequency amplifiers particularly suitable for television.



Oscillograms of the new DuMont television sync pulse: top, composite sync signal (left) vertical pulse removed (right); bottom, partial elimination of vertical pulse (left) and vertical pulse free of horizontal pulses

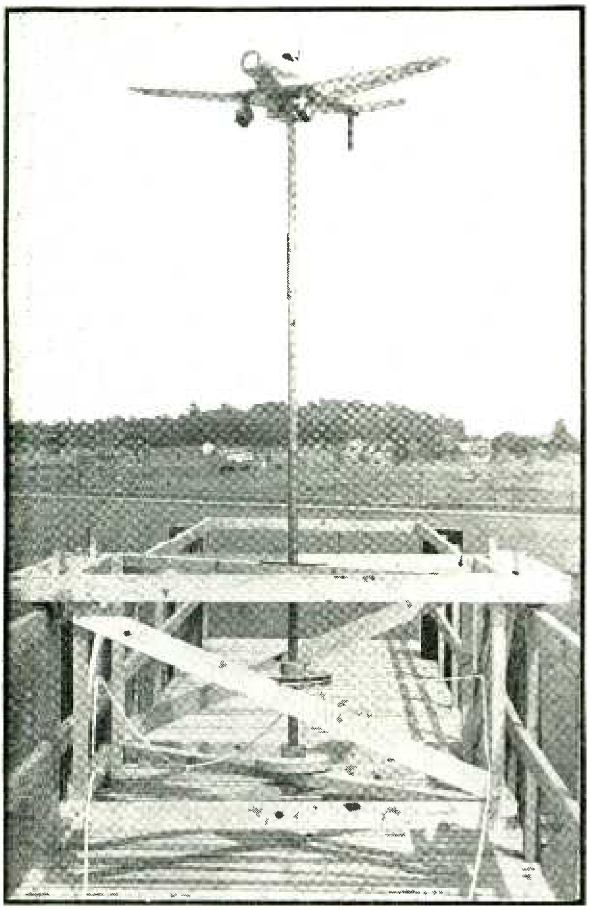
Opening the technical session on Thursday morning was an address of welcome by President L. C. F. Horle. Four technical papers, all of them descriptive in nature, were delivered. These were: "Marine Radiotelephone Design" by H. B. Martin, "50-Kilowatt Air-Cooled Broadcast Transmitter" by R. N. Harmon, "RCA-NBC Orthoacoustic Recording" by R. A. Lynn and B. F. Fredenhall, and "Instrument Production" by E. H. Locke.

Mr. Martin discussed the design of low power radiophone equipment for coastal and harbor communication with small boats, yachts, tugs and the like. He also described types of service available, and discussed the factors which influence the choice of suitable equipment and installations for a given service.

Advance features of 50-kw transmitters developed by Westinghouse were discussed by Mr. Harmon who also briefly outlined the history of KDKA where many of the recent improvements were first tried in regular operation.

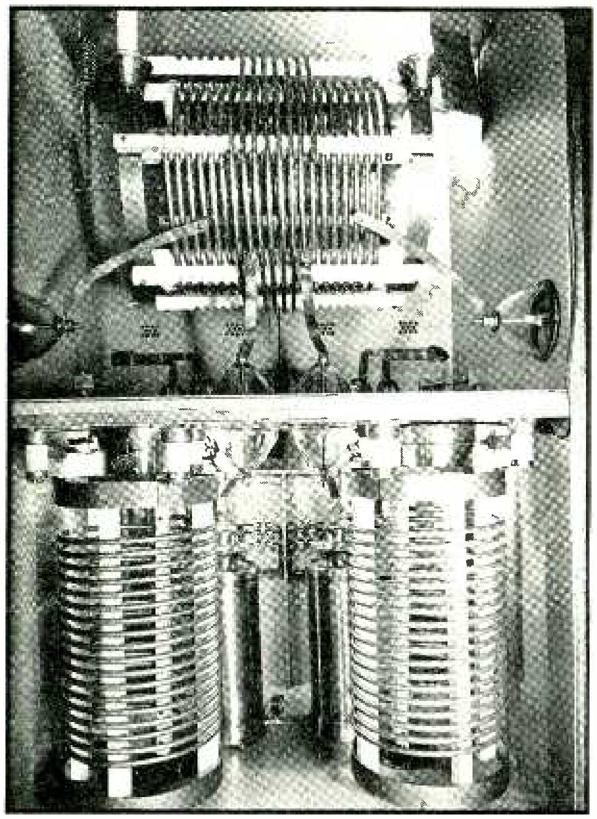
Discussion of various factors resulting in improved lateral recording were presented by Messrs. Lynn and Fredenhall of the National Broadcasting Co.

As a sequel to C. T. Burke's paper on the engineering aspects, E. H. Locke of the General Radio Company discussed the production problems facing a manufacturer of precision radio measuring equipment, and the methods which GR has used to overcome them.



Model plane mounted high on a wooden platform used to test directional properties of antennas at Wright Field (G. L. Haller)

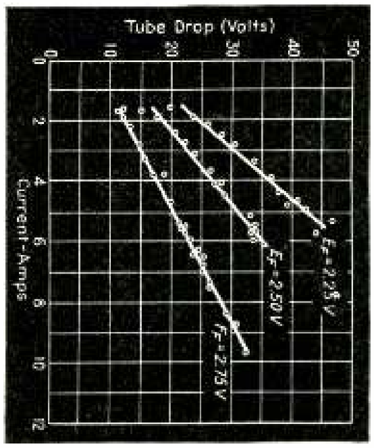
Tank circuit construction of the 50-kw air-cooled transmitter described by R. N. Harmon of Westinghouse



"Microwaves — Present and Future" was the title of an elaborate lecture-demonstration prepared by members of the Department of Electrical Engineering of Massachusetts Institute of Technology and presented by Prof. W. L. Barrow. In many ways this demonstration was the high point of the convention, for it revealed phenomena which most engineers had not previously been able to witness, but which are of basic importance in the future of radio engineering. Some 20 demonstrations were run off without a hitch, requiring the coordinated assistance of ten members of the Department.

Using a magnetron generator at a wavelength of 8.3 cm, Dr. Barrow first demonstrated the "optical" characteristics of microwaves, showing that they can be reflected and diffracted readily by metallic barriers, and that the direction of polarization must be taken into account. A reflector made up of parallel wires was shown to reflect the waves if the wires were parallel to the direction of polarization, but not if at right angles to that direction. For detection, small silicon crystal detectors were used, mounted on the end of rods and connected to an audio amplifier, loudspeaker and output meter. The wavelength of the waves was directly demonstrated by the standing waves set up by a reflector. Another demonstration of similar nature was performed with 1.5 cm waves (20,000 Mc) likewise generated in a magnetron. It was shown that a glass lens was capable of bringing these waves into focus, and that a spherical mirror could be used for the same purpose.

The guidance of microwaves along pipes was demonstrated, and the effect of filling the pipe with paraffin (thus increasing its effective electrical diameter) was shown. It was shown that waves propagated along pipes of rectangular cross-section could be blocked by adding another length of similar pipe whose cross-sectional dimensions were turned at right angles to those of the first. The action of a "valve", closely resembling a water valve, in shutting off the flow through pipes was also shown. An unusual effect was shown using a twisted pipe of rectangular cross-section which was shown to be capable of twisting the plane of polarization of the 8.3-cm waves.

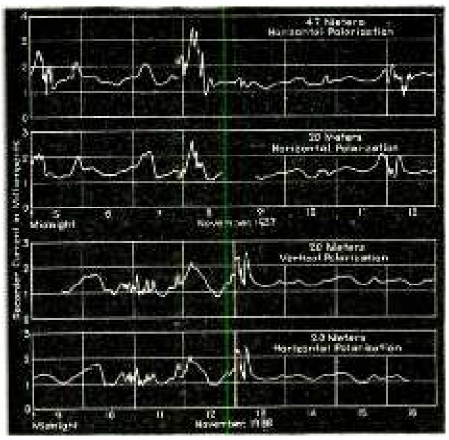


Effect of filament temperature on the voltage-current characteristic of the type KU-627 mercury-vapor thyratron (J. W. McNall)

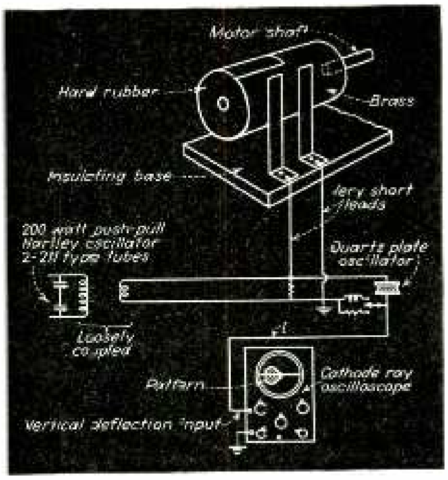
That a 2-by-4 beam of wood was capable of directing the waves was also shown. Using the 1.5-cm waves, transmission of the waves was demonstrated through the empty sheath of standard BX cable, which was turned directly back on itself.

There followed demonstrations showing the use of horns as radiators of microwaves. It was shown that the greatest increase in directivitity of the radiation was obtained in a plane at right angles to the widest dimensions of the horn cross-section, and that very directive beams could be obtained from horns having a wide flare. Using a triode oscillator operating at 10 cms, music from a phonograph was transmitted along such a beam and reproduced over the crystal-detector, amplifier and loudspeaker system.

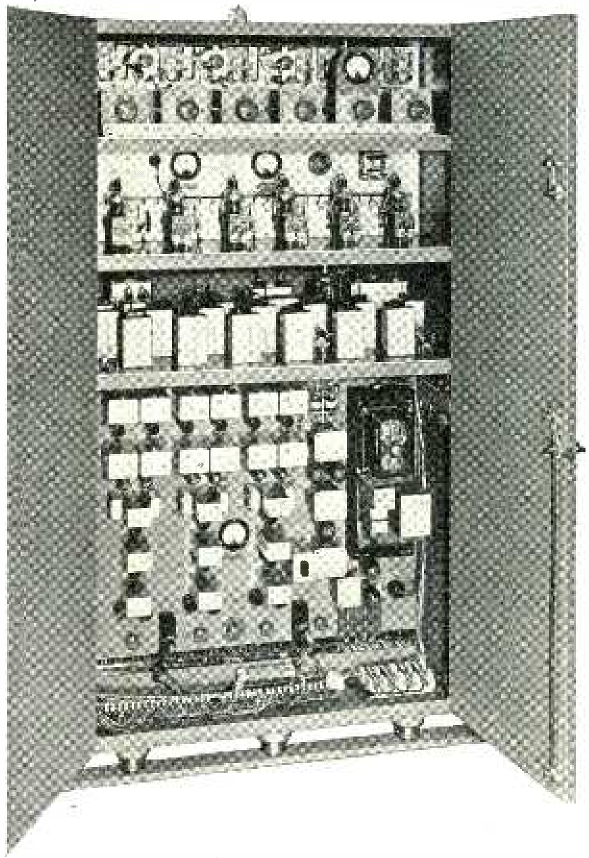
The practical applications of the microwaves were illustrated in a miniature aircraft guidance system which showed two overlapping beams, modulated at different rates on the left and right of the desired path. The generator in this case was a "sealed-off" klystron operated at 10 cms, with about 5 watts output. Reflection of microwaves from gas discharges was revealed by holding a neon stroboscope lamp in the path of the waves and detecting the reflected signal. The final demonstration employed a high-powered klystron operating at 42 cms, producing an output between 200 and 300 watts. The ability of this source to light filament and gas lamps at a distance from the antenna was demonstrated, and a standing arc about 1 inch high was drawn from the one end of the transmission line. The



Fading measurements on 2 and 5 meters (Englund, Crawford, and Mumford) showing similarity on different frequencies and directions of polarization



Method of observing the build-up of damped oscillations in quartz crystals, described by H. A. Brown of the University of Illinois



Radiotelephone transmitter designed for ship-to-shore service in the Great Lakes region, containing duplicate equipment for six channels (H. B. Martin)

output of this generator was then connected to a large horn radiator and small flashlight lamps, fitted with dipole antennas, were passed out to the audience. The radiated energy was detected as far away as 50 feet from the horn, and as many as 20 or 30 of the lamps were seen to glow simultaneously scattered throughout the audience in front of the horn.

Studies in U-h-f Propagation

Messrs. C. R. Englund, A. B. Crawford and W. W. Mumford of Bell Laboratories reported on the results of experiments in the transmission of waves of the order of 2 and 4 Mc over an optical path of 39.2 miles. Records were shown of the variations in field strength at the receiver over short and long periods. Correlation was shown between the variations and physical changes in the characteristics of the earth and atmosphere over the signal path, such as the dielectric constant of the earth and the atmosphere near the earth and the velocity of the wind.

Newly developed equipment for the generation and detection of waves in the frequency range of 3,000 to 4,000 Mc was described in a paper by E. G. Linder and R. A. Braden of R.C.A. A magnetron generator was used to produce the signals. Shielding presented quite a problem because the case containing the generator formed a resonant chamber at the frequencies used and permitted energy to leak out through the cracks around doors and other openings. Steel wool was found to be a good absorber of the high frequencies and reduced the leakage considerably when placed at the cracks. Comparative data on the sensitivity, resistance and bandwidth of diode, magnetron, crystal, and velocity-modulation detectors was presented.

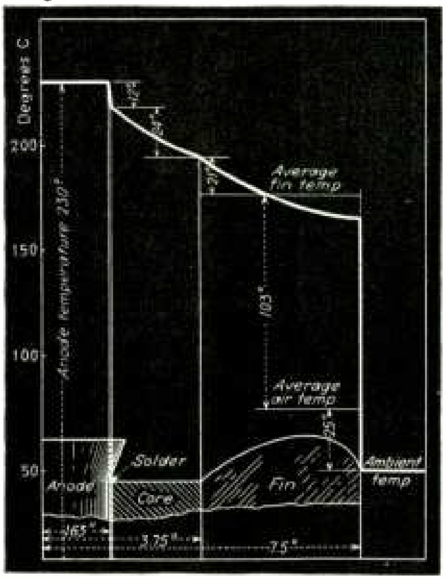
A beam tube of novel design for use in transmitters in the range of 100 Mc was described by A. K. Wing and J. E. Young of R.C.A. Two of these tubes (type 827R) operating with plate modulation will deliver 1 kw at 108 Mc. A metal header is used to provide a low-impedance connection to the screen grid. The tube is of the air-cooled type. High mutual conductance tubes currently available were reviewed by E. W. Schafer and E. R. Jervis of National Union. They discussed the development of such tubes and the factors involved in particular applications.

An instrument providing a direct reading of high-frequency (diathermy) power input to a patient was described in a paper by J. D. Kraus and R. W. Teed. The method used is that of "equivalent patient resistance". After the spacing of the electrodes is determined by fitting them on the patient, the instrument is calibrated by means of a calorimeter substituted for the patient. J. W. McNall of Westinghouse (Bloomfield) discussed the mechanics of sparking of oxide coated cathodes in mercury vapor tubes. The tube voltage drop cathode-current characteristic is linear and has an appreciable slope. The slope of this curve is a definite indication of the quality of the cathode.

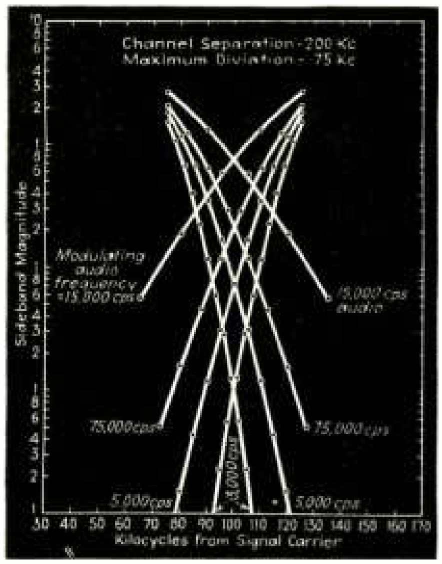
New Developments in Instruments

Among the improvements in oscilloscope design noted by P. S. Christaldi of DuMont Laboratories were the use of an intensifier ring for imparting acceleration to the beam, which permits about 32% additional deflection sensitivity for a given accelerating voltage, and the use of direct-coupled phase-inverter circuits for performing signal amplification and providing positioning voltages simultaneously. H. A. Brown of the University of Illinois described a method of measuring damped oscillations in a quartz crystal, using an oscillator, commutator and oscilloscope for observing the r-f output of the crystal. Methods of computing the Q of the crystal from such measurements were reported. H. W. Lamson of General Radio described a magnetic yoke for obtaining permeability and losses of iron core samples as functions of magnetization. A degenerative amplifier and a rectifier bridge are used as a null-indicator, allowing measurements to be carried out at extremely small values of magnetization.

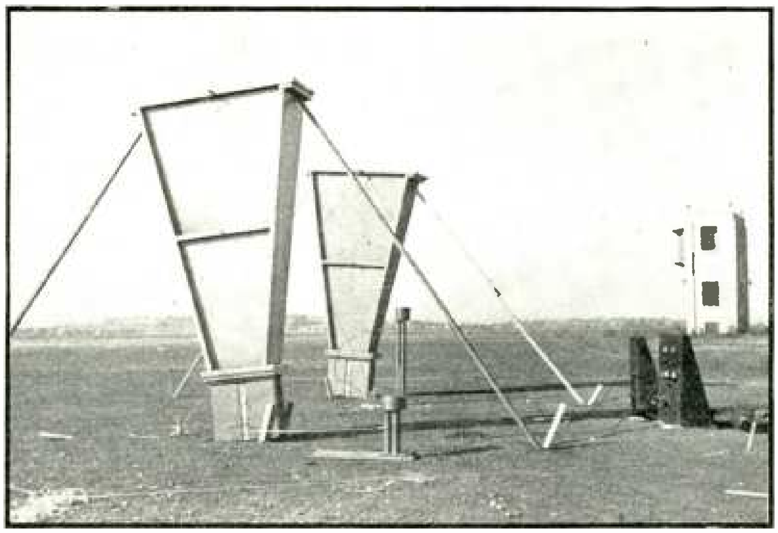
D. B. Sinclair, also of General Radio, described a bridge especially designed for low impedance measurements in the range from 400 kc to 30 Mc (up to 45 Mc with readily computed error at low resistance values). The bridge, which reads resistance and reactance values directly in ohms, is a modification of the Schering bridge using capacitance variations exclusively to obtain balance. Triple shielding of the reactance-balance capacitor is necessary, and a special design was required for the shielded input transformer. A method of measuring the reactances of coils at frequencies around 100 Mc was reported by Hamburger and Miller of Johns Hopkins. The coils are connected to the end of a transmission line, and the resulting change in wavelength measured with a dipole antenna and rectifier. The results showed that computed values of inductance closely followed the experimental values for small wire sizes, but that for wire sizes as large as number 18, the actual inductance might only be half the value computed by Palmero's equation.



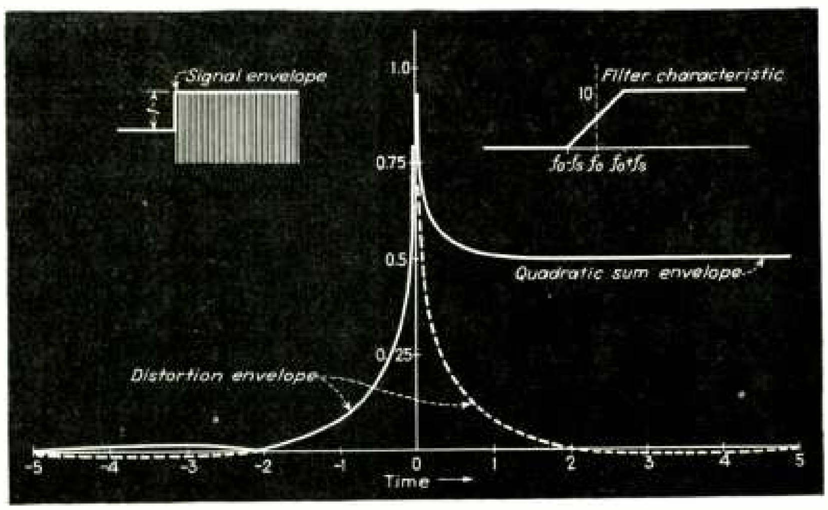
Temperature distribution in the cooler structure of the 891 air-cooled transmitting tube, described by I. E. Mouromtseff



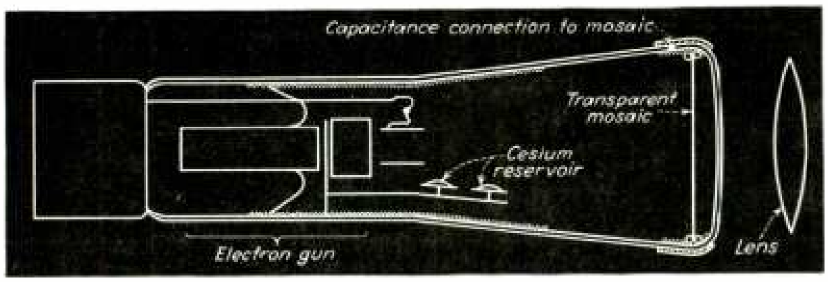
Magnitudes of sidebands generated outside the deviation limits of a frequency-modulated transmitter, calculated by Stanford Goldman



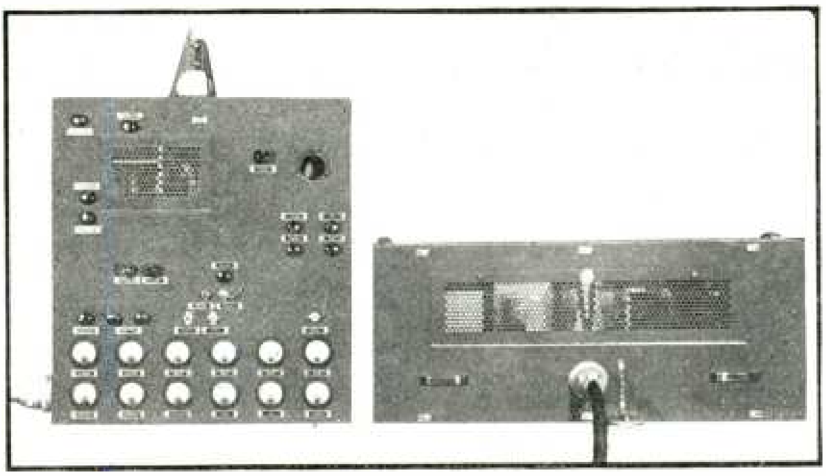
Microwave horns used by W. L. Barrow of M. I. T. for aircraft marker beacon experiments on wavelengths shorter than 50 centimeters



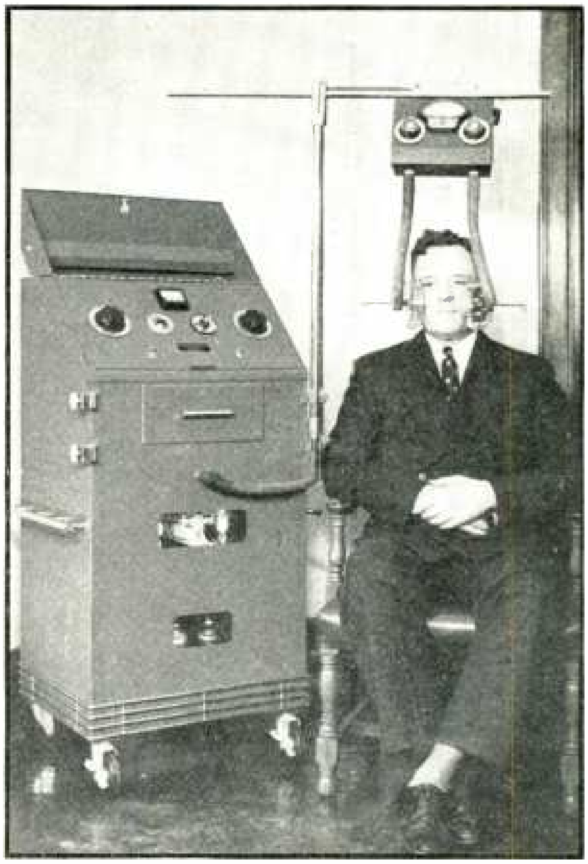
Response of an r-f amplifier to a sudden increase in carrier envelope in a single-sideband television system (Wilson and Wheeler)



Structure of the new 2-inch iconoscope tube recently developed for amateur experiments (priced about $25). (W. H. Hickok)



Portable television transmitter designed for relaying outside pick-ups to a main transmitter, developed by R. C. A. at Camden and described by C. D. Kentner



Apparatus for measuring diathermy dosage rate described by Kraus and Teed

Two papers on the electron microscope developed by R.C.A. at Camden concluded the session on instruments. Dr. Marton discussed the instrument itself, which has already been briefly described in *Electronics* (May, 1940, page 38). One slide of a specimen viewed in the microscope showed a detail only 100 Angstrom units (10^{-6} cm) across, which exceeds the result obtained by the best light microscopes by perhaps 100 or 200 diameters. A. W. Vance described the regulated power supplies required to keep the accelerating voltages and the focusing coil currents constant during the exposures, which range up to 30 seconds duration. A stability of 1 part in 15,000 for the voltage, up to 100 kilovolts, was obtained by using a three stage direct-coupled feedback amplifier consisting of a 1N5G, a 6L6 and two 203A's in push-pull, the latter being connected through a power transformer in series with the input to the high voltage rectifier. Current regulation to the extent of 1 part in 25,000 was obtained by passing the current through four 6L6's in parallel, controlled by a 6SJ7 voltage amplifier connected to their grids. The discussion of these two papers showed the wide range of interest in this new device, despite the fact that it is not in the radio category.

Aircraft Radio Systems Discussed

A description of the investigations of aircraft antennas carried out by the Army was presented in the aircraft radio session by G. L. Haller of Wright Field. Resistance and reactance measurements, as well as directional properties of fixed antennas, wing antennas and trailing wires were reported. A 50-foot tower on which directional patterns were obtained, using model planes, was shown in the slides. A new theory of the production of rain and snow static was advanced by Howard K. Morgan of T.W.A. The older theory that the plane "scoops up" a charge as it passes through a cloud of charged particles was discarded in favor of the view that a charge is built up by the rapid passage of the plane across vertical equipotential contours formed between the negative and positive regions on opposite sides of a charged cloud. The methods of alleviating the trouble by using a shielded loop and a trailing discharge wire were discussed by Mr. Morgan.

J. G. Flynn of American Airlines recited the reasons for the increased importance of u-h-f equipment in aircraft communication. He reported that equipment in the medium high frequencies was in the main highly satisfactory, but that the need for more ether space had forced consideration of the u-h-f region. Advantages of the u-h-f equipment are light weight, low power required, smaller and more efficient antenna structures, freedom from thunderstorm static and alleviation of precipitation static. However, the fact that u-h-f transmissions are limited to about 100 miles makes it impractical for long range aircraft, since the traffic control points on the transcontinental routes are separated by greater distances. American Airlines installation of u-h-f communication equipment at Boston, Providence, Hartford and New York is going forward, however, since over short distances the equipment may displace the medium high frequency systems. Mr. Flynn reported that

(Continued on page 75)

DISTORTION in COMPENSATED AMPLIFIERS

An approach to the frequency and time-delay discrimination problem in wideband amplifiers which not only gives a general solution of a given circuit but permits amplifiers to be designed to perform within given tolerances of phase and gain distortion

By

J. D. TRIMMER and Y. J. LIU

Department of Aeronautical Engineering
Massachusetts Institute of Technology

THE present article is the result of the writers' experiences in attempting to treat the problem of applying one method of compensation to the resistance coupled amplifier. The two aims of this study were, first, to obtain convenient generalized expressions for the gain and phase characteristics of various combinations of circuit elements; and second, to obtain convenient methods of designing amplifiers to meet specified distortion tolerances. The first aim was fully attained. Some of the results have been published,[1] and others make up part of the present article. In pursuing the second objective, however, certain difficulties were encountered—difficulties centering about the needs for a quantitative terminology relating to distortion and for a quantitative interpretation of distortion in terms of reproduced waveforms.

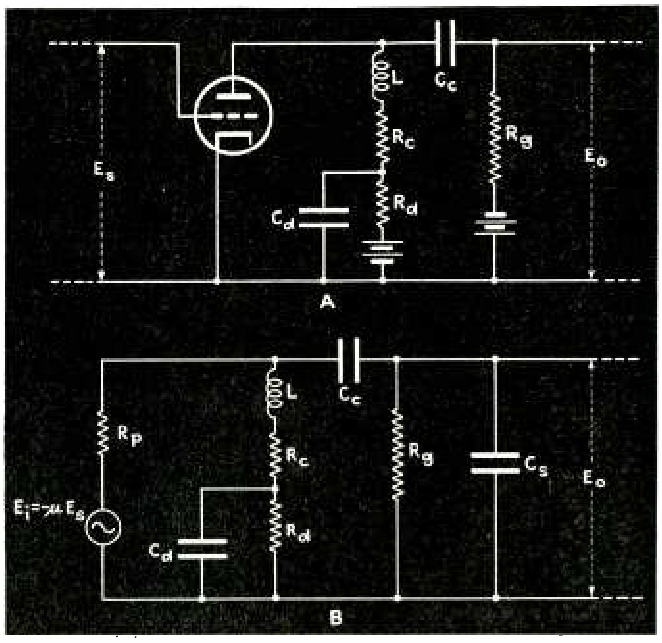


Fig. 1—Actual (A) and equivalent (B) circuits of the shunt-peaked compensated amplifier on which this analysis is based

Suggestions as to Terminology

It is understood here that distortion is a measure of the difference in waveform (that is, time dependence) between the output voltage E_o and some standard of comparison E_r. In many instances E_r is the input voltage E_i. A quantitative definition of distortion would have to be based on a mathematical or physical way of evaluating the quantity $(E_o - E_r)$, averaged in some manner over a chosen period of time. In preference to this, it has become customary to measure distortion in terms of its causes, the properties of the network.

For purposes of classification, the first distinction to be noted is between linear and nonlinear distortion. In nonlinear networks, the ratio between input and output voltages varies with the amplitude of the input voltage. The resultant change of waveform (due to presence in the output of frequency components not in the input) represents nonlinear distortion. In linear networks, the ratio of output to input voltage, though independent of the amplitude, still varies with the frequency of the input voltage. The effects of this variation may be called linear distortion. Of these effects, those due to frequency dependence of relative phase may be called *phase distortion;* and those due to frequency dependence of relative amplitude may be called *gain distortion* (the more directly suggested term, *amplitude distortion,* is not suitable because it has, unfortunately, become associated with nonlinear distortion).

This paper is confined to linear distortion, though many of the statements to be made would apply directly or analogously, to nonlinear distortion as well. In the actual circuit of the compensated amplifier, Fig. 1A, it is the vacuum tube which is the only seat of appreciable nonlinear distortion. Hence, considering only linear distortion, it is possible to use as basis for discussion the equivalent circuit of Fig. 1B, in which the vacuum tube is replaced by

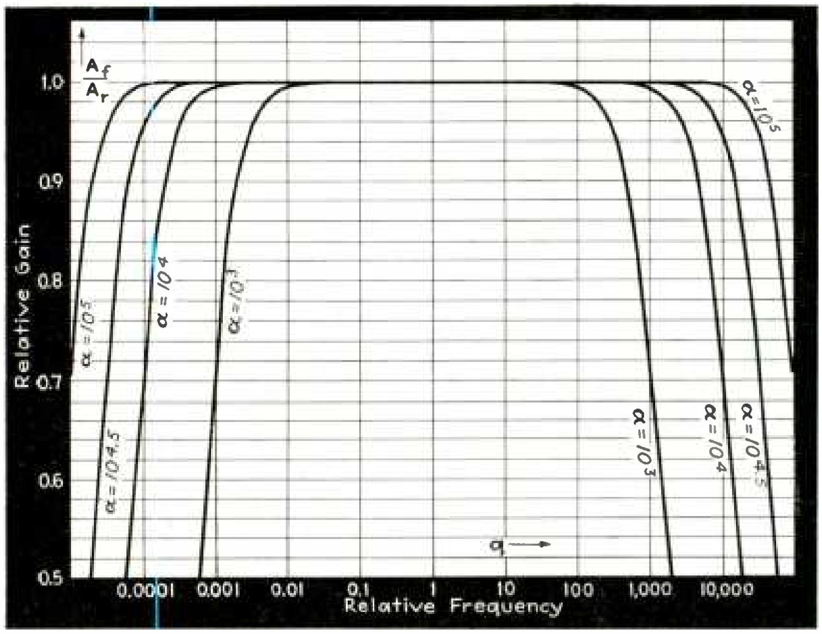


Fig. 2—Gain-vs-frequency response characteristic of an uncompensated amplifier plotted in terms of quantities defined in the text

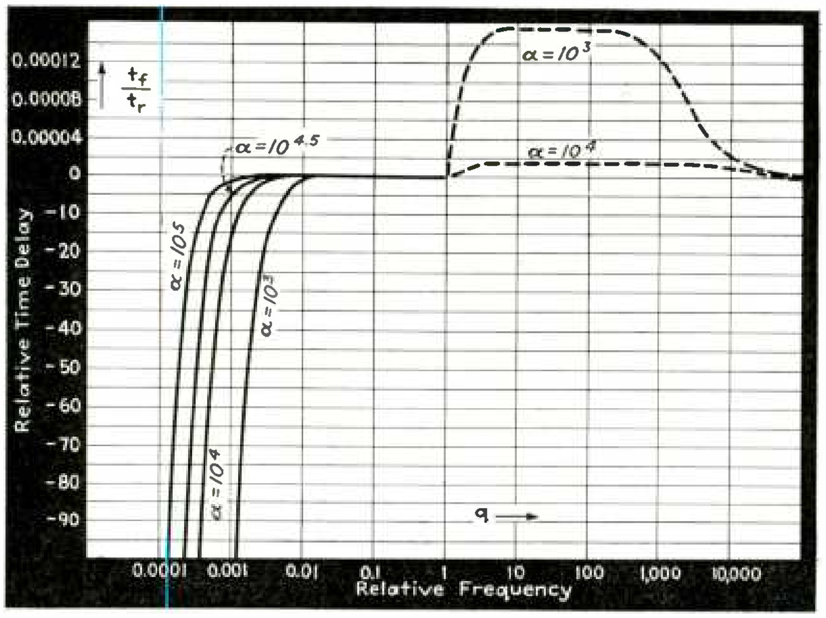


Fig. 3—Phase shift characteristic of the uncompensated amplifier, plotted in terms of relative time delay

a linear source of voltage $-\mu E_g$ and internal resistance R_p. The internal capacitances of the tube are included with wiring capacitances in C_s.

The properties of a network which cause linear distortion may be referred to as variations, with gain variation as a measure of the departure of the gain from a specified frequency dependence and phase variation as a measure of the departure of the phase shift from a specified frequency dependence.

The problem of compensating the resistance coupled amplifier may be formulated and discussed in terms of these definitions. Although the interest of practicing designers has shifted somewhat to compensating devices other than the one particularly emphasized here, this does not invalidate conclusions reached as to the general principles involved in the problem of compensation.

Compensation of the Resistance-Coupled Amplifiers

The equivalent circuit diagram for one stage of the uncompensated amplifier would be Fig. 1B, with C_d, R_d and L deleted. The gain and time-delay characteristics are plotted, respectively, in Figs. 2 and 3. For computation of these characteristics, the complex ratio of output to input voltage is reduced to the form[2]

$$E_o/E_i = (A_f/A_r)\,\epsilon^{-j\theta_f} = 1/(1+jQ), \quad (1)$$

where Q is a function of the frequency ratio $q = f/f_r$ and the non-dimensional flatness parameter α. The quantities are defined as follows:

$$\theta_f = \tan^{-1} Q$$

$$A_r = R_H/R_p$$

$$Q = \frac{q - (1/q)}{\alpha}$$

where $$q = \frac{f}{f_r} = 2\pi f\sqrt{C_sC_cR_HR_L}$$

$$\alpha = \sqrt{\frac{C_cR_L}{C_sR_H}}$$

$$R_H = \frac{R_gR_pR_c}{R_g + R_p + R_c}$$

$$R_L = R_g + \frac{R_pR_c}{R_p + R_c}$$

Since $Q = 0$ when $q = 1$, the ordinate of Fig. 2 is the gain at any frequency f divided by the gain at the reference frequency f_r. In Fig. 3, the ordinate is the phase shift (time delay) at any frequency f (given as the time $t_f = \theta_f/2\pi f$) divided by a reference time $t_r = 1/f_r$. In this figure, the negative ordinate scale applies to values of q less than one, the magnified positive scale to values of q greater than one.

It is seen that the time delay curve (Fig. 3) passes through a maximum positive value at some value of q greater than one. At this same value of q (call it q_m), the graph of the phase *angle*, θ_f, has its tangent pass directly through the origin. For the large values of α occurring in practice, q_m is given very closely by $q_m = 1.315\,\alpha^{1/2}$. So in contrast to the gain characteristics of Fig. 2, which are flat over a frequency range centering about $q = 1$, the phase characteristics of Fig. 3 are flat over a range centering about $q = q_m$, with q_m generally much larger than one.

Turning now to the more complicated case of the amplifier with compensating elements added as in Fig. 1, the ratio of output to input voltage can be written in the form:

$$E_o/E_i = (A_f/A_r)\,\epsilon^{-j\theta_f} = 1/(X+jY) \quad (2)$$

But the quantities X and Y are such

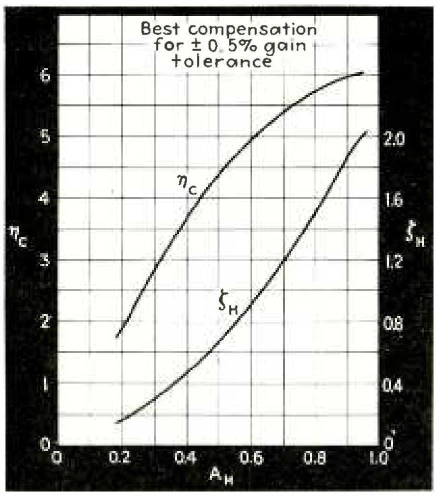


Fig. 4—Curves for obtaining the best compensation possible in the high frequency range

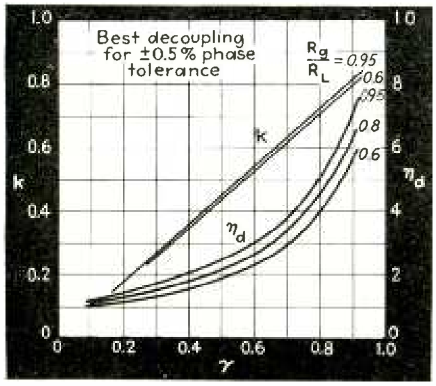


Fig. 5—Curves for obtaining the best compensation possible in the low frequency range

involved functions of frequency and the circuit elements that it seems feasible to study them only in the simplified forms they assume for the extreme ranges of high and low frequencies.

A suggestion for dealing with the problem of designing compensation to keep the variations within specified limits is embodied in Figs. 4 and 5. These graphs represent a useful and convenient way of summarizing the results of a survey of a large number of gain and phase characteristic curves, drawn for various combinations of parameter values.

In Fig. 4 one ordinate is the compensating advantage, η_c, which is defined as the ratio of the frequency at which the gain characteristic of the compensated amplifier shows a specified variation ($\frac{1}{2}$ per cent for Fig. 4) to the frequency at which the uncompensated amplifier shows the same variation. The plotted values of η_c are maximum values, which can be realized only by using optimum amounts of inductance to affect high frequency performance. This optimum relation is given by the ζ_H-curve, where ζ_H is inversely proportional to the inductance L. The parameter A_H is independent of the compensating elements.

Similarly, in Fig. 5, the ordinate η_d is the low frequency compensating, or decoupling, advantage, defined as the ratio of the frequency at which the uncompensated amplifier's time-delay characteristic shows a specified variation ($\frac{1}{2}$ per cent for Fig. 5) to the frequency at which the compensated amplifier shows the same variation. Of the two parameters γ and k, γ involves R_d while k involves both R_d and C_d. The ratio R_g/R_L does not involve the compensating elements. The optimum relations between k and γ are given by the k-curves, and the corresponding maximum values of η_d are plotted for the η_d-curves.

In Fig. 5 the 0.5 per cent tolerance of phase time variation is based on the ordinate t/t_L, where

$$t_L = C_cR_L.$$

The parameters ζ_H, γ and k of Figs. 4 and 5 are defined:

$$\zeta_H = \frac{C_cR_H^2}{L}$$

$$\gamma = \frac{R_pR_d}{(R_c+R_p)\,(R_c+R_d)}$$

$$k = \frac{C_d}{C_cR_g}\;\frac{R_cR_d}{R_c+R_d}$$

There remains the second problem, which may now be described as relating the variations of the network to the distortions of the waveforms which the network is supposed to handle.

Attention is to be given here primarily to phase distortion. The suggestions proposed concern themselves principally with two questions. First, there is the question of the best way of presenting the phase characteristic so that its variations are obvious and so that it is conveniently useful in predicting phase distortion. The second question is the finding of a method for estimating, from known variations of a given network, the distortion of particular waveforms.

An example which answers both questions to some extent is given in Fig. 6. It is assumed that a perfect saw-tooth input voltage E_i is applied to one stage of an uncompensated resistance coupled amplifier. If the fundamental frequency of the input is low enough compared to the middle reference frequency f_r of the amplifier, the output voltage E_o will show decided phase distortion. Figs. 6A and 6B are drawn, respectively, for fundamental frequencies $f_r/2000$ and $f_r/1000$. The amplifier is assumed to have a flatness parameter $\alpha = 10^4$.

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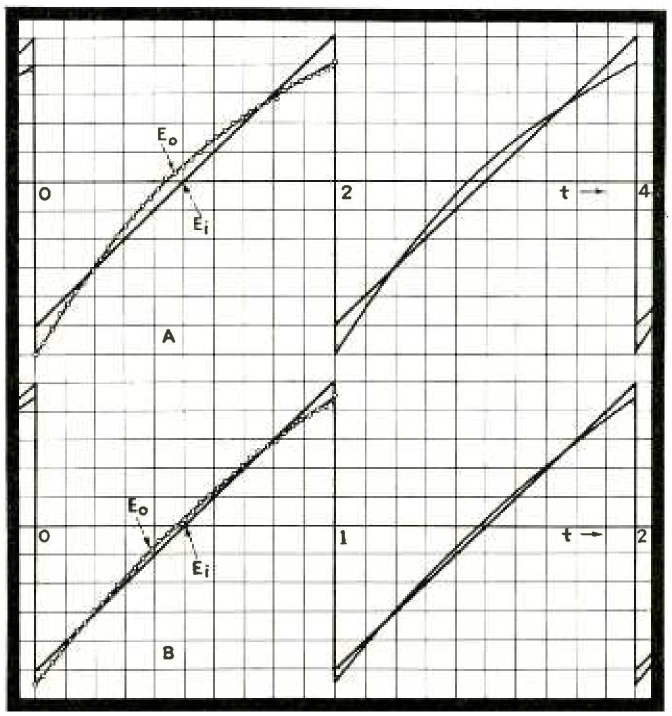
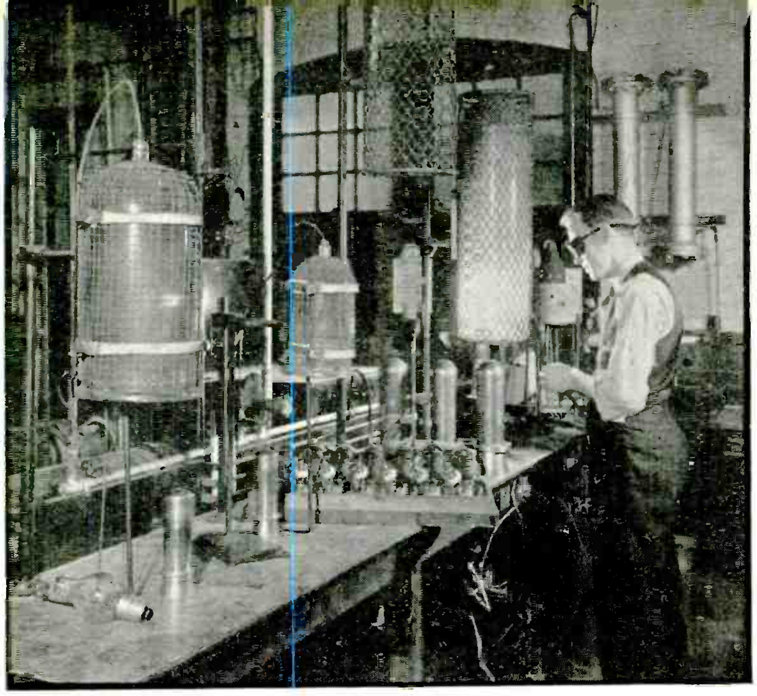
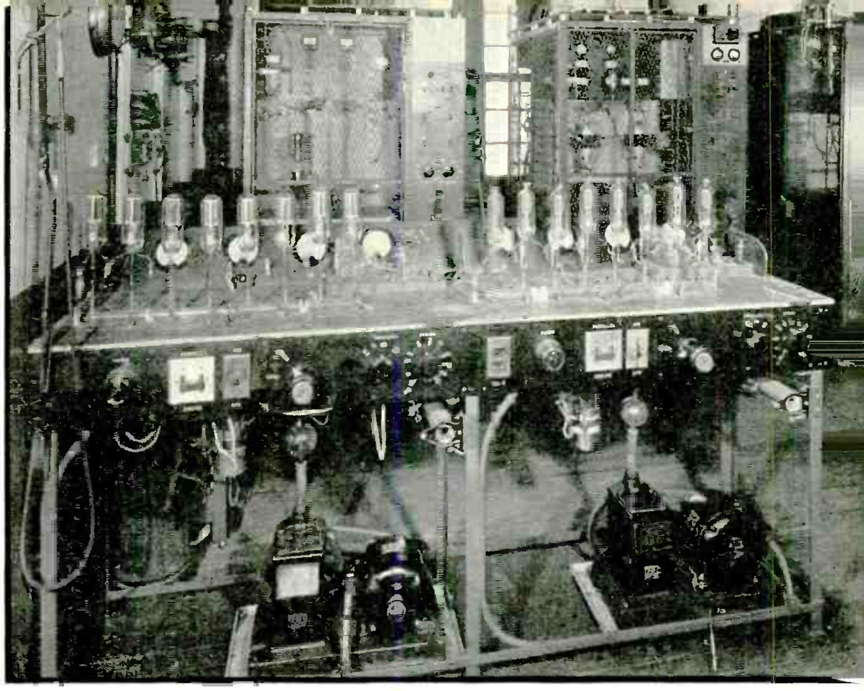


Fig. 6—Phase distortion of a sawtooth wave, computed by Fourier analysis



Because of the relatively large size of the lead wires, electric arc welding must be performed in an atmosphere of hydrogen to reduce oxides as they are formed. The hydrogen is contained in the bell and the parts to be welded and the welding electrode are extended up into it

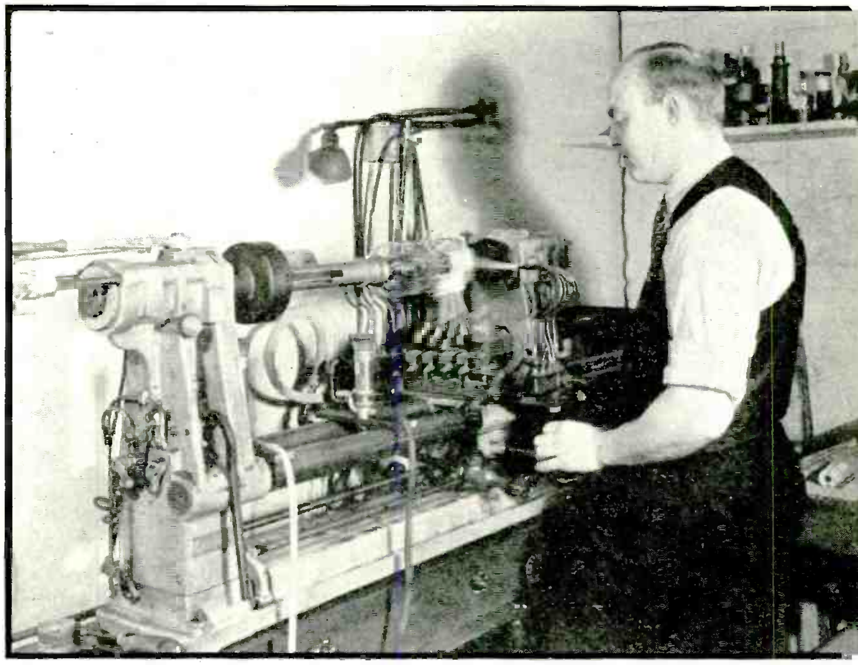


The thoriated tungsten filaments are subjected to a "carburizing" process. A small amount of acetylene gas is admitted and combines with the tungsten to form a very thin layer of tungsten carbide on the surface of the filament. This is to stabilize the evaporation of the thorium during the life of the tube

BUILDING THE BIG ONES . . .

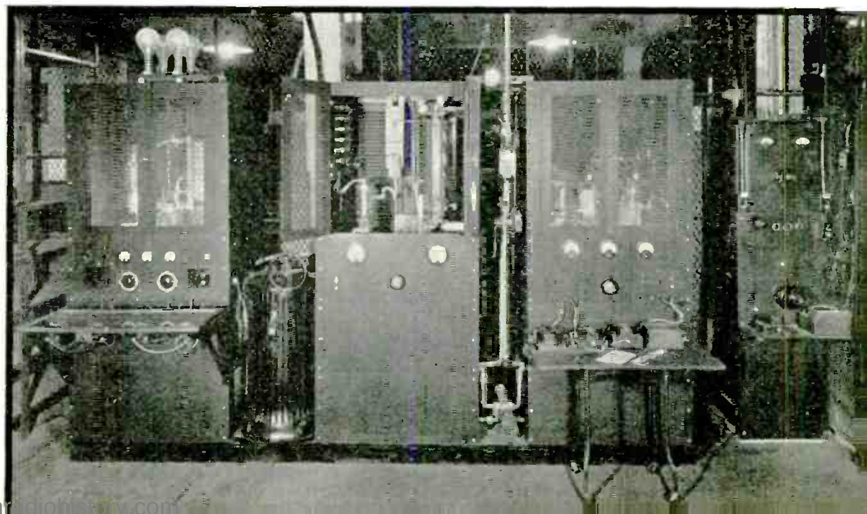
Several of the specialized processes used in transmitting tube manufacture are well illustrated in these pictures taken in the Amperex Electronic Products plant in Brooklyn, N. Y.

The pyrex glass envelope is sealed to the copper anode of a water-cooled tube. The surface of the copper must be clean and smooth. A very thin layer of oxide is formed on the surface so that the glass will adhere to it. An oxygen-hydrogen flame is used in this operation



Assembling the mounts of medium sized tubes (350 watts). The parts are stored in closed cabinets to avoid dust settling on them. Graphite anodes are used extensively to increase the heat dissipation and to prevent warping during processing and subsequent operation

The larger tubes are tested at frequencies up to 100 megacycles in these oscillator units. If the quality of the tube is not up to standard, or if it is to be subjected to rough handling, an X-ray picture is made to check the alignment of the parts



Embossing at Constant Groove Speed —a New Recording Technique . . . .

By E. E. GRIFFIN
Recordall Manufacturing Company

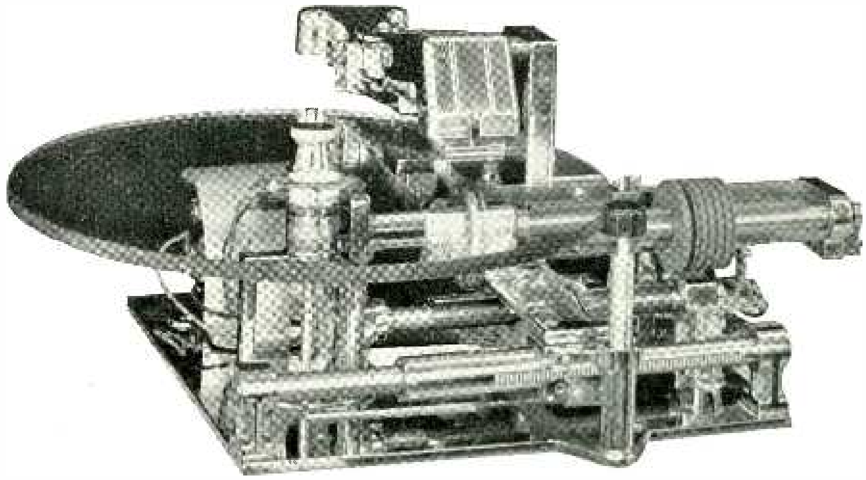


Fig. 1—The constant groove speed turntable. The drive wheel and stylus maintain fixed position while the turntable moves past them

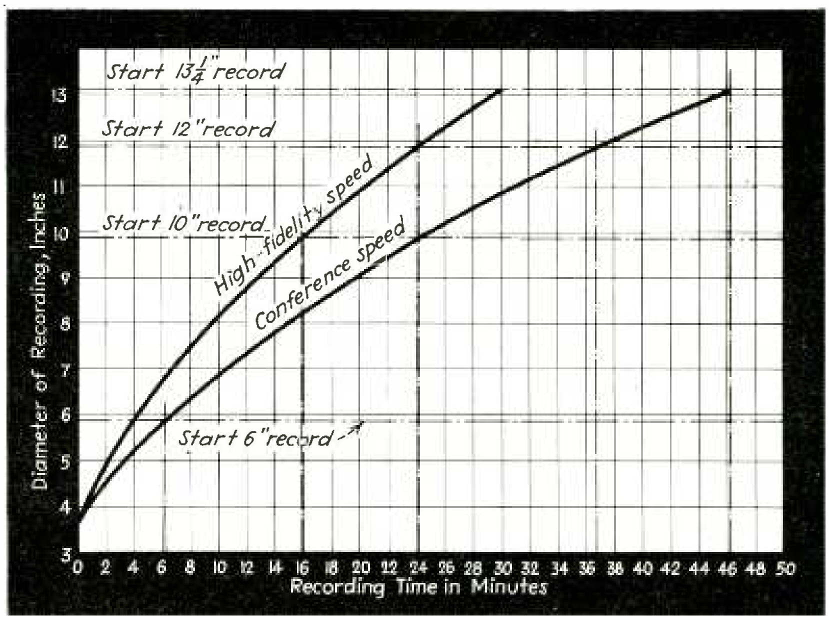


Fig. 2—Playing time of discs recorded at constant groove speed. Upper curve 10 inches per second, lower 7½ inches per second

OF the many compromises which restrict the performance of conventional disc recordings, one of the most important is the variation of the speed with which the groove moves past the stylus at different portions of the record. The high groove speed when the engraving stylus or reproducing needle is at the outer edge of the record, and the corresponding low speed at the inner edge give rise to a continuous variation of the recording conditions. Equalization of frequency response which is correct for one position is not correct for the other, so a compromise is usually adopted to fit between the two limiting conditions. This compromise has in itself restricted the use of several improved methods of producing the record. It has been recognized for some time, for example, that if the groove is formed by an embossing tool rather than by a cutting or engraving tool, the inherent noise formed by roughness in the groove is much reduced and other advantages are obtained. However a considerable degree of equalization is required when embossing is used, and the degree of equalization required varies with the groove speed. Hence it would seem highly desirable to develop a method of driving the record at constant groove speed, which would permit the use of a constant degree of equalization. Such a development was undertaken by the author and his associates, with the results outlined in this article.

Constant groove speed, as the words imply, means that the linear speed of the recording track in inches per second is fixed, independently of the diameter of the groove. In the conventional phonograph a fixed angular velocity of 78 or 33⅓ rpm is used, and this results in an excessive groove speed at the outside and a too slow groove speed at the inside of the record. With a 12-inch diameter disc, the groove speed at 78 rpm will change continuously from 48 to 12 inches per second as the stylus moves from the largest to the smallest diameter. The same size disc will give a variation of groove speeds approximately from 21 to 5 inches per second at 33⅓ rpm. It is at once obvious that it is not possible to have the same quality of recording for all of these different speeds without continuously variable compensation and equalization, in addition to correction for varying amount of distortion. The excessive linear velocity near the outside of the disc reaches a point where the heat created through friction puts excessive wear

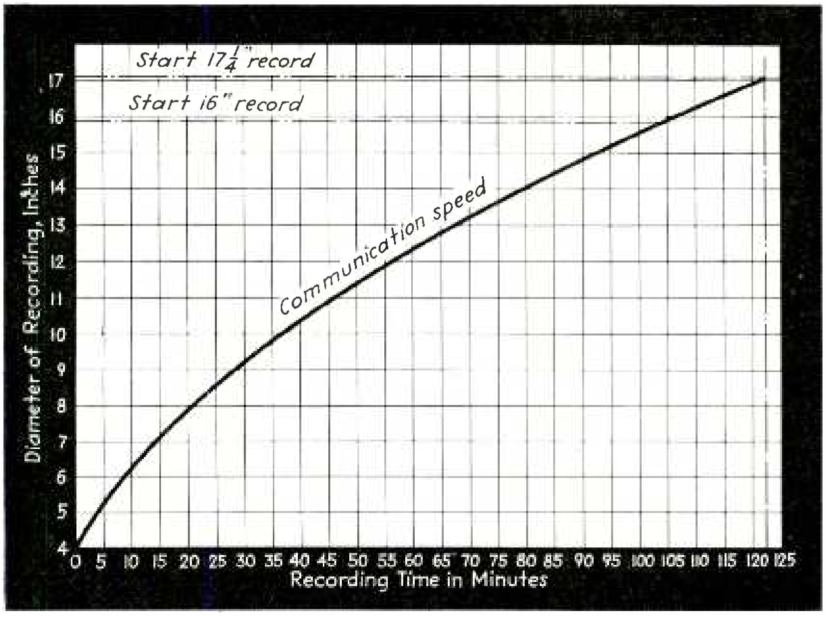


Fig. 3—Playing time at 5 inches per second, used for recording when intelligibility only is required

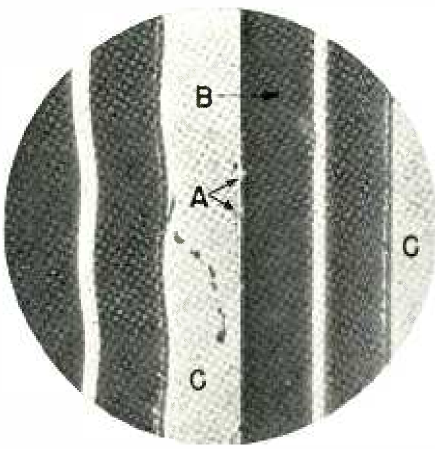
on the recording stylus and playback needle.

At constant grove speed an optimum linear velocity can be selected for the required frequency response in each case, and this linear velocity being constant, all equalization can be predetermined and permanently built into the amplifier. No variable equalization or compensation is required. The quality, volume level and distortion percentage remain fixed in quantity, regardless of the momentary diameter of the record at any recording position.

This feature of the constant groove speed makes the use of the embossing process practical, since excessive high frequency attenuation caused by the damping effect of the record material's resistance to burnishing, can be equalized by proper emphasis of the amplifier's high frequency response curve. The building up of high frequency response, on the other hand, is made possible by qualities inherent in the embossing process (outlined subsequently) without bringing surface noise to an objectionable level. Also, since the embossing process causes practically no wear on the polished round point of the embossing stylus, its life is practically limitless, a decidedly economical advantage over sharp-edged styli as used in the cutting method.

Figure 1 illustrates how constant groove speed is accomplished in the equipment in its present commercial form. The relative positions of cutting head, recording stylus and the drive wheel are fixed, as is visible through the plate glass turntable. This drive-wheel and shaft are integrally mounted with the head carriage mechanism, so that the relative position of the recording stylus and drive wheel remains the same, regardless of the momentary position of the head on the record. The drive wheel is rotated by a synchronous motor, thus producing constant groove speed. A drive shaft speed of 90 rpm has been arbitrarily chosen for high fidelity recording and is used on models intended for high fidelity recording of the wide range of the audible spectrum of voice and music. Slower drive shaft speeds are used on the business and conference models, where their use requires the intelligibility and recognizability of the speaker only, while still slower speeds are used on the communication models where intelligibility only is required. Figures 2 and 3 show the time available on different size discs for recording on the various models.

Embossing or burnishing was used almost exclusively in recording on aluminum blanks, the first and comparatively recent, yet already outmoded, form of "instantaneous" recording. The crystalline structure of aluminum alloys made this imperative, since cutting exposed such granularity in the material that the increased surface noise created an entirely unsatisfactory signal-to-noise ratio. The embossing process on aluminum, on the other hand, required very much greater power, since the cutting head had to be weighted and the cutting armature



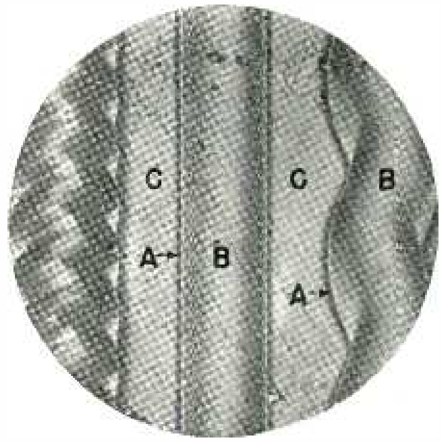


Fig. 4—(Left) Photomicrograph of a groove cut in acetate by conventional engraving

Fig. 5—(Right) Photomicrograph of groove cut by embossing method, comparable with Fig. 4

damped, "stiffened", to overcome the resilience of the metal and its high resistance to burnishing. These requirements created all kinds of frequency distortion. Moreover, the resultant distortion being a function of the momentary linear groove speed, equalization was extremely difficult. A well-trained experienced recording engineer could produce satisfactory results on carefully designed equipment, but even the best records were comparatively short-lived, deteriorated with age and had to be played with special equipment and non-metallic needles to maintain their quality, even during this short life. Thus embossing on aluminum has gradually gone into the discard and with it, apparently, its outstand-

(Continued on page 62)

A Picture Signal Generator—IV

After describing the waveform oscilloscopes and picture monitor circuits, the authors discuss the reasons for using a short picture tube of the magnetically-focused variety. Circuits for full deflection of the short tube at a second anode voltage of 7000 volts are described

By J. A. BRUSTMAN
and M. P. WILDER

American Television Corp.

THE two most useful instruments to the video control engineer are the monitor picture tube and the cathode ray oscilloscope. No picture signal generator is complete without them. In our unit we found it convenient to use two type 906 cathode-ray oscilloscope tubes. One is used to monitor the video signal and to observe the signal waveform either of one line or of one field. The other tube can be used to study or monitor the synchronizing pulses. A switch on the oscilloscope unit connects either of two time bases (sweep circuits), 60 cps ac or a continuously variable linear time axis from 20 cps to 25,000 cps. The switching arrangement is such that either time base may be used on either oscilloscope tube, but it was not found necessary to have both tubes use the same time base at the same time.

The oscilloscope contains its own power supplies, low voltage as well as high voltage. The sweep amplifier uses a double triode, one half being the amplifier and the other a cathode follower, which affords a convenient means of amplitude control without distorting the saw tooth wave form.

Another amplifier is designed to clip the top off the incoming wave form so that it can be distorted into a pulse to insure rigid synchronization. This amplifier is designed so that a 180° phase shift can be obtained at will. Thus it is always possible to secure the positive polarity of the synchronizing pulses.

The right-hand oscilloscope is designed for studying wave forms applied directly to its plates and does not have an amplifier. The input to the vertical deflecting plates is gain controlled by a simple potentiometer as this oscilloscope is not intended for wide range use.

The chief function of the right-hand unit is to monitor the vertical synchronizing pulse as to its phase relationship with the 60 cps power line frequency, and to check the width of the vertical blanking pulse. It is also possible by means of suitable jacks on the timer unit to observe the wave forms of the four different multivibrators and to compare them to 60 cps to be sure they hold the 7:7:3:3 relationships.

The left-hand oscilloscope contains a three-stage high-gain video amplifier good to 3 megacycles. The input attenuator is a switch set for low, medium, and high inputs to the grid of a cathode follower stage. A variable resistor across the cathode of this tube permits continuously variable control of gain in the video amplifier without damage to the waveform. The length of the lead from this input tube back to the video amplifier in the right rear position of the unit has no loading effect on the input to the video amplifier because of the low impedance of the cathode follower stage. The voltage developed across the output resistor in the final video stage is sufficient for ample deflection of the beam in the vertical direction. A voltmeter is used to monitor the line voltage and also to measure the amplitude of a calibrating voltage which is useful in measuring the actual peak values of the waveforms.

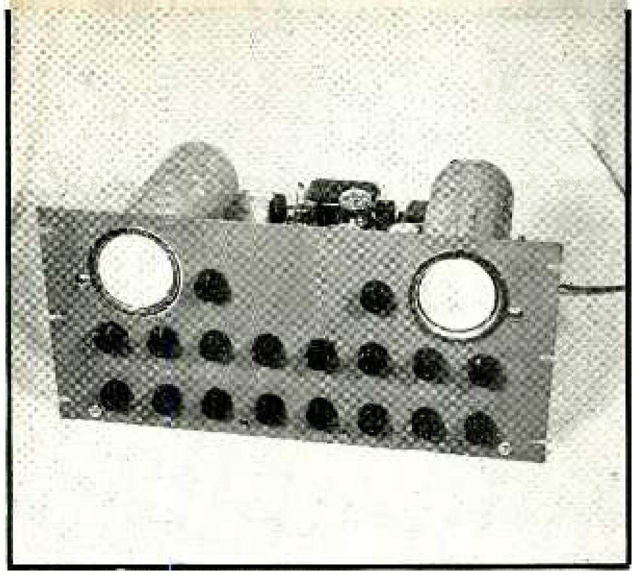
Controls of a semi-fixed variety are provided for intensity, focus, and position of each tube independent of the others. Others for coarse and fine speed, vertical and horizontal gain, and synchronous pulse amplitude are also available. Two input jacks are provided, the left-hand one for the wide range oscilloscope and the right-hand one for the general purpose (or phase monitoring) oscilloscope. This is particularly useful when calibrating the timer against an audio oscillator to be sure the master frequency is 13,230 cps. The complete oscilloscope circuit is given in Fig. 3.

The Picture Monitor

The video amplifier for the monitor was described in detail in the previous installment. The picture tube used in the monitor is of the "short" variety employing magnetic deflection and magnetic focus. The circuit for magnetic deflection of short tubes presented somewhat of a problem as it was desired to use the full 7000 volts of the second anode power supply, so that the unit could be operated in a fully lighted room.

The difficulties of obtaining ample deflection were found to revolve about the scanning yoke and considerable time was spent in developing a yoke suitable for the purpose. This yoke was found also to be entirely suitable for the iconoscope and was used in the camera unit described in Part I of this series. Complete data and specifications for the manufacture of this yoke were given as well as the type and numbers of the transformers to be used with it. The deflection circuit is somewhat different from that used with the iconoscope, however. Ordinary receiving tubes are used within their ratings. The complete circuit is given in Figs. 4 and 5.

Controls have been brought out for all conventional functions such as position, focus, amplitude, and brightness. The linearity adjustment is semi-fixed but can be ad-



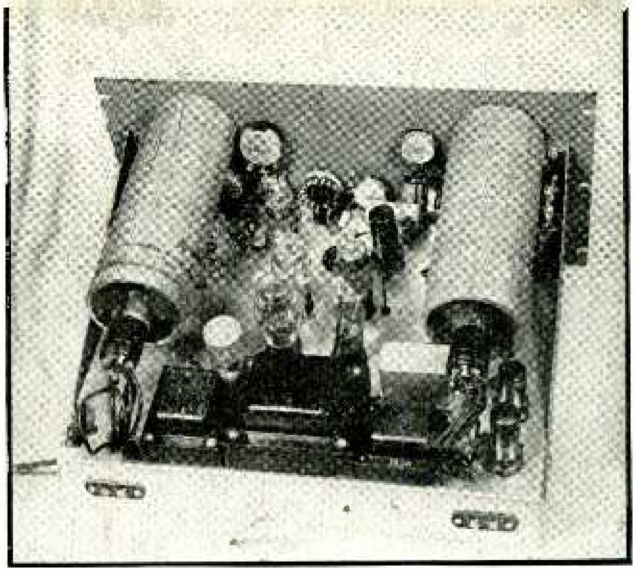
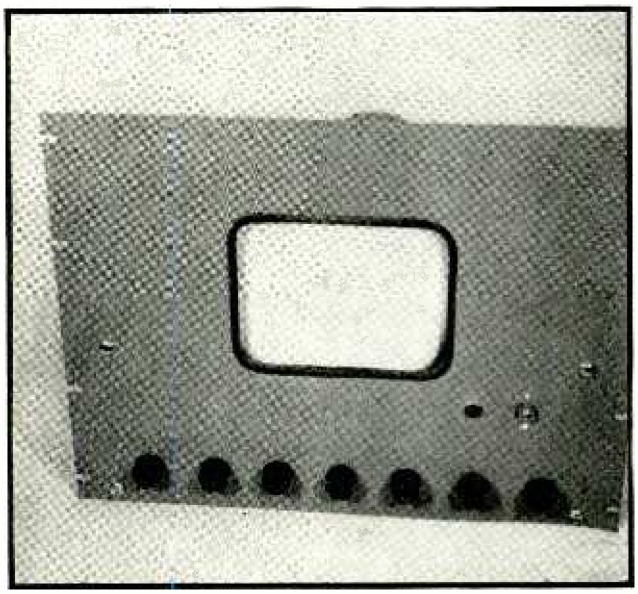


Fig. 1—Front and rear views of the waveform oscilloscopes. The unit at the left is used for observing phase relations in the sync pulses, that at the right for viewing the video signal waveform



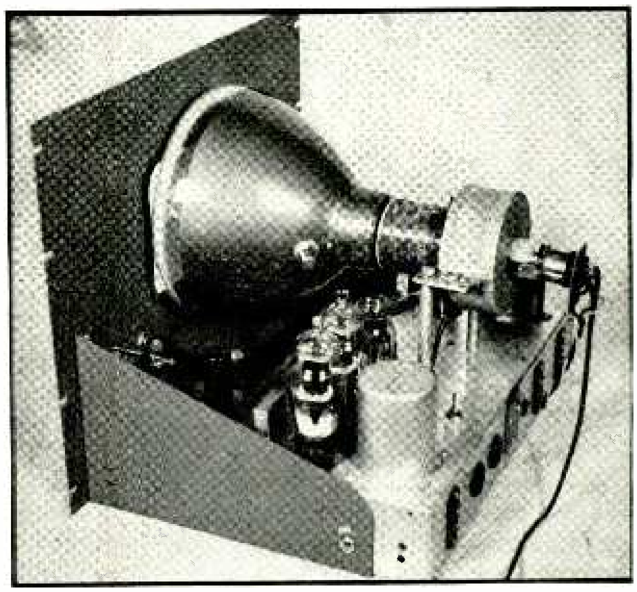


Fig. 2—Front and rear views of the picture tube monitor, which employs a short 9-inch tube using magnetic focus. The yoke and focusing coil are visible in the right-hand view

justed when necessary from the rear with a screw driver. The power supplies are conventional.

Magnetically Focused Tubes

In the American literature little has been written about the merits and demerits of magnetically focused picture tubes. This method of focusing was almost universally used in European television receivers before the current war. In this country, however, the cost of the focusing coil, its support and the current it used were viewed as sufficient reason for not carrying out further development of this means of focus. At present, however, the magnetic focus tube is beginning to reappear in a new and favorable light. It is our conclusion that magnetically focused picture tubes are better from a focus viewpoint, cheaper to build and to operate and have a longer life than electrostatically-focused tubes whether electrostatically deflected or magnetically deflected.

Perhaps the outstanding advantage of magnetically-focused picture tubes is the reduction in ion blemish. With this method of focusing the ions are out of focus when the electrons are in focus. Although picture tubes employing electrostatic focus have been made which are almost free from ion blemish for as much as 100 hours, when magnetic focusing is used this same blemish is spread over a large area and the presence of an ion blemish becomes purely academic. In practice it has been difficult to find traces of ion blemish on magnetically focused tubes which have been in service for several years. Tubes made to the authors' specifications have been in service for a year and have shown no evidence of ion spot detectable by the eye during everyday operation. This is only true however at high anode potentials. While other ways to remove completely even the remaining ions have been suggested and put to practice in "ion trap" tubes, the authors have come to the conclusion that straight magnetic focus of a well exhausted tube is the best solution to the ion spot problem.

Magnetic focus tubes are of two general types: tubes in which all focusing occurs after the beam is brought up to full final anode potential and those in which prefocusing takes place electrostatically. The authors prefer the former or simple triode type. This has many advantages over the others, specifically as regards "blooming," simplicity of construction, shortness of gun, fewer parts to be outgassed, and the development of such ion blemishes as

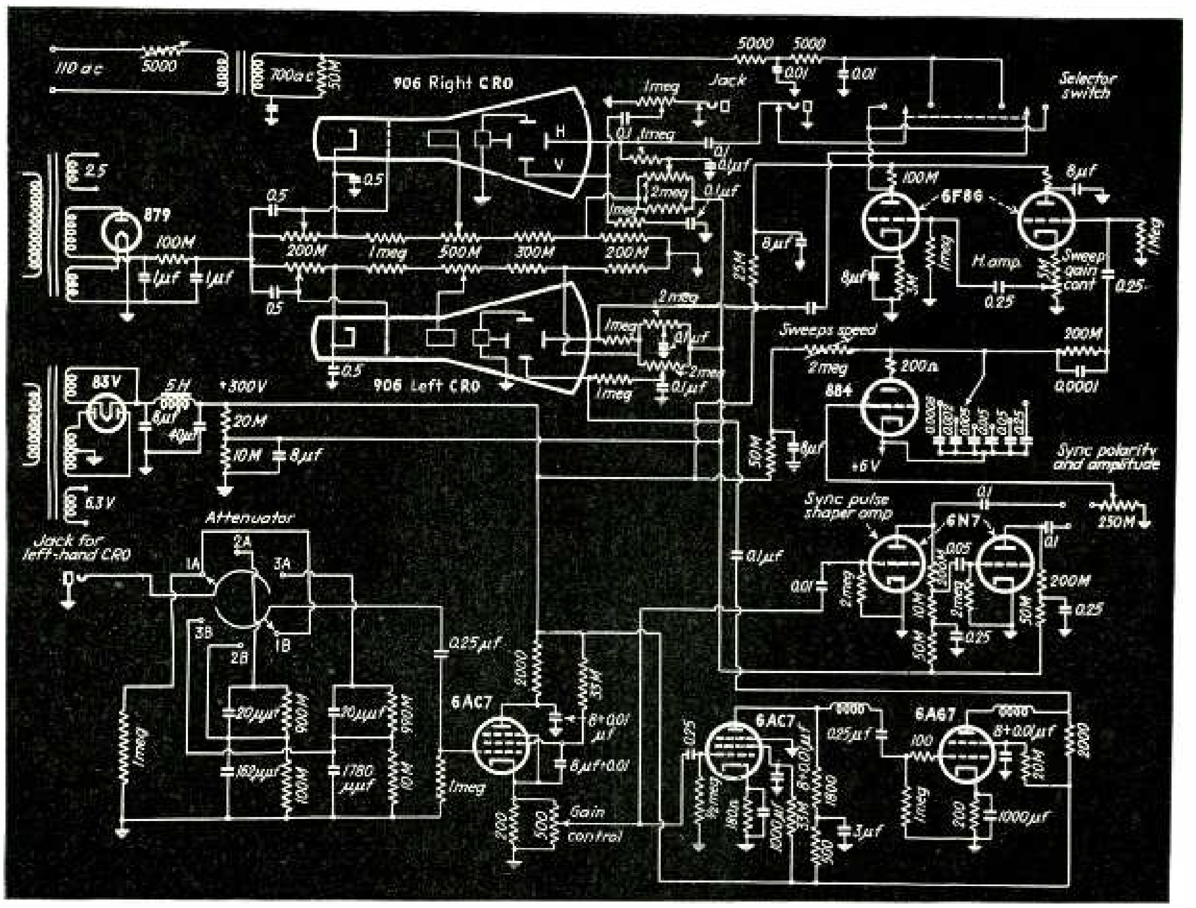


Fig. 3—Complete circuit diagram of the cathode-ray oscilloscope and its associated power supply

may ultimately appear being spread over the largest possible area hence causing a minimum of discoloration. This tube consists of a cathode capped by a cylinder with a small aperture used as a grid containing a .030-inch hole.

The final anode adjacent is the aquadag coating on the inside lip of a glass nozzle pointing toward the grid and several millimeters away. This anode draws all possible electrons from the grid while at the same time fanning the ions out to a circle of maximum diameter. The use of this glass nozzle lengthens the leakage path back to the getter thus reducing the loss of gas molecules with a negative sign from the getter, by electrostatic attraction, a fact which experimental evidence indicates contributes much to the low density of the ion blemish.

This particular design is due to Ediswan in England and had been very completely tested by them prior to England's entry into the war. This design is marked by high efficiency as all the beam current gets to the screen without the possibility of loss to any electrode en route. Also the chance of ions being dislodged from the lip of the electrodes is reduced to a minimum. This, by the way, is a very potent source of negative ions.

"Blooming" or defocusing at high brilliance in this simple triode structure also is noticeably less than in more complicated structures. The control-grid sensitivity is fairly good, twenty volts peak-to-peak being sufficient for good modulation. Other designs similar to a tetrode have higher sensitivity, but none that we have tried show an improvement of greater than two to one. In fact, all that did show better grid sensitivity also showed marked increase in blooming.

The use of European phosphors of zinc and cadmium sulphide activated with silver and air settled against a sodium silicate binder resulted in screens of a markedly improved contrast range. This wider range of contrast plus the low blooming of the magnetic focus tube allows more beam current to be used without compression of the blacks. The life of this material has been found equivalent to the sulphide silicate mixture type. Screen color is easier to hold constant and the screens discolor less under ion bombardment.

The overall brightness of these tubes can be raised without loss of contrast. Comparative tests of light output of these phosphors in comparison with the more common American phosphors show approximately equivalent light output in lumens per watt with no modulation. With modulation, however, they appear several times brighter.

The most important advantage of the short tube is the fact that comparatively large pictures can be obtained in a small shallow cabinet. This type receiver has considerably more sales appeal than a large deep receiver with a picture too small for the cabinet. This purely mechanical advantage can be much offset by viewing the tube in a mirror if the cost of the mirror can be disregarded. Another point to be considered is that mirror viewing is not as satisfactory as direct viewing from the angle of vision, picture-size and picture-brightness points of view. Cabinets with hinged tops are costly and are required when mirrors are used. They also prohibit the use of the set as a table top upon which to place books, flowers, etc.

Another important advantage of the short tube is the fact that less magnification takes place of the virtual cathode (sometimes called the cross over) in view of the fact that the image distance is less. A logical

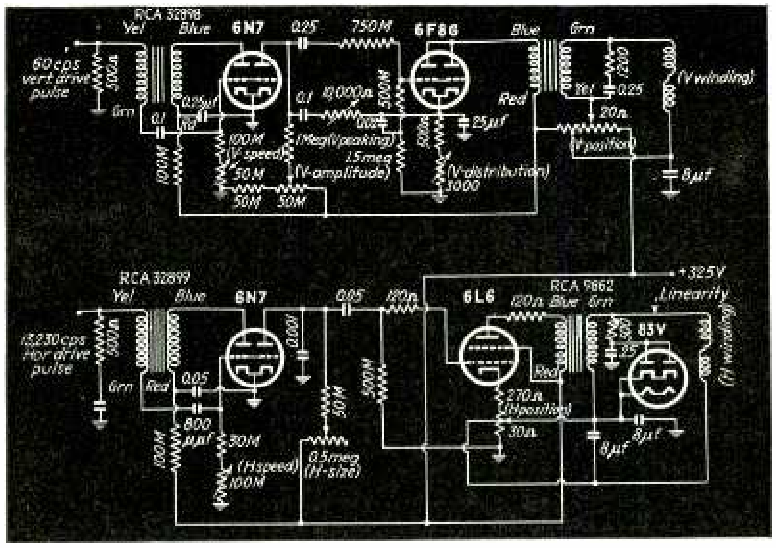


Fig. 4—Sweep circuits for the monitor picture tube, using blocking oscillators and output amplifiers. The scanning yoke was described in the first installment of the series

conclusion which can be drawn is that the beam will be smaller at any point along its length for a given terminal spot size in a short tube than in a long one. The cross over or virtual cathode can therefore be larger with a consequent increase in current density in the beam cross-section, which results in achieving a brighter image. Experience and conclusions from the above indicate we can expect short tubes to be actually brighter than long tubes when both have the same spot size on the screen. The authors have found this to be true. The chief disadvantage of the short tube is the difficulty of obtaining sufficient scanning deflection. The defocusing at the corners due to the greater angle of scanning is important but this latter is to a considerable extent offset by the improved focus which is realized by virtue of the low magnification and large object distance.

In the picture generator here described, the problem of scanning has been solved for potentials on the final anode as high as 7000 volts using conventional receiving tubes, within their ratings, in the sweep output circuits.

There are certain circuit and operating advantages and disadvantages regarding magnetic focus and electrostatic focus that must be considered. Magnetic focus requires a magnetic lens exterior to the tube. It may be either an electromagnet or a permanent magnet. The unit itself is actually not very expensive and consists of a simple solenoid approximately an inch thick wound in any fashion desired. The required magnetomotive force of 500 ampere turns can be obtained with a 10,000-turn coil when the total B supply current (50 ma) is passing through it, thus taking very little extra power.

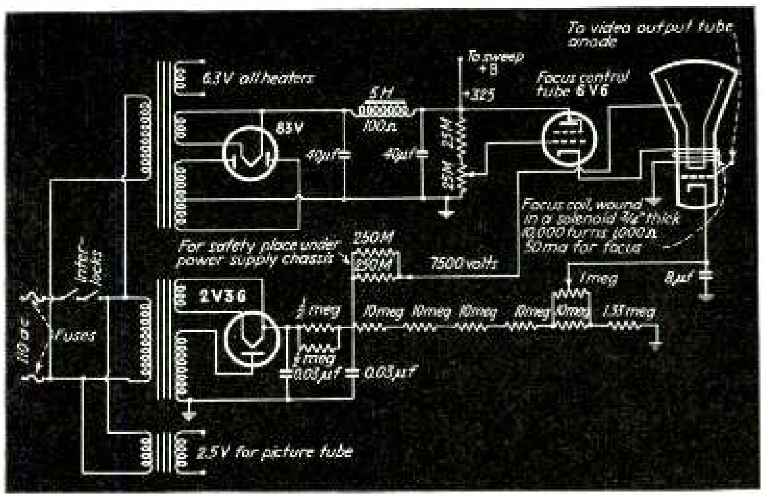
This brings up an advantage of the electrostatic tube over the electromagnetic. Power line changes will cause little or no defocusing in electrostatic focus tubes as they are dependent for focus upon the ratio of the voltages on the first and second anode remaining constant. This will theoretically remain constant if the resistors in the voltage divider remain constant and if the regulation is good. Unfortunately regulation cannot be good unless the voltage divider is of low overall resistance and the filter condensers are fairly large. Poor regulation makes for poor focus stability and makes the change in power line voltage effect on focus about equal in magnetic and electrostatic focus. However, there is a limit to how poor the regulation of an electrostatic focus tube can be if serious defocusing with brightness change is not to occur. On the other hand electromagnetic focus tubes of the triode type take no more power from the high voltage source than is actually being used in the beam, hence good regulation is easy to obtain. It is this fundamental advantage which allows an economic saving in the high voltage source and filter, which goes far toward overcoming the cost of the focusing coil.

Another difficulty of electromagnetic focus is the twisting of the pattern as the beam passes through the lens. This is minimized by making the lens as thin as possible. An optimum condition is one in which the lens is approximately one-half to three-quarters of an inch thick capped by iron end plates whose magnetic circuit has been completed near the maximum diameter of the iron end plates. The central ring or core should be made of fiber bakelite or some non-magnetic metal. With this lens good focus can be achieved and pattern twist on either side of true focus has no approximate distorting effect on the picture.

Another important advantage of magnetic focus is the ability to shift or center the pattern by tilting the magnetic lens. The limits within which the beam can be bent by tipping the lens and still not effect focus are wide enough to center the pattern easily. This saves some cost in pattern shifting components such as potentiometers, by-pass condensers, resistors, etc.

The next article will describe the television tuner used in this unit to pick up outside television stations for transmission to the kinets or for study on the monitor.

Fig. 5—Power supplies, focusing coil circuit and picture tube connections of the monitor. The control grid of the picture tube is connected to the video amplifier described in Part III



A V-T Voltmeter for Coaxial Line Measurements

By G. L. USSELMAN *R.C.A. Laboratories*

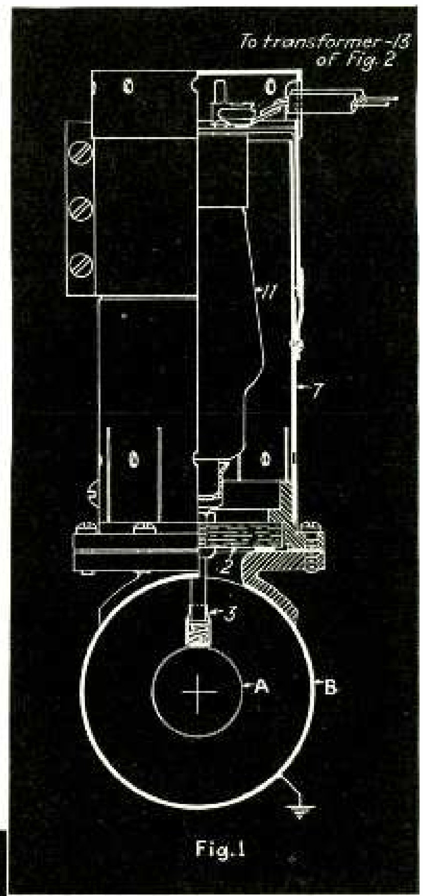


Fig. 1—Vacuum tube voltmeter tube unit, showing the rectifier tube and shield mounted on the coaxial transmission line A-B (end view)

VACUUM tube voltmeters are not new to the radio art, but when coaxial transmission lines began to be used for the transmission of high frequency electrical power, various new adaptations of these measuring devices began to appear in the laboratories. When gas-filled coaxial transmission lines were first used for the transmission of large amounts of high frequency power, as for example from a television transmitter to its antenna, it became desirable to have a means of measuring the power passing through these lines and to have some means of indicating the electrical condition of the transmission lines and the antennas during the time of operation. A special design of vacuum tube voltmeter seemed to be the best suited measuring means for this purpose. In the design of this equipment, due to the requirements for operation at relatively high frequency, high voltages and the maintenance of high accuracy, care must be exercised in selecting the component parts.

Because of the high frequency and the high transmission-line voltage on which the vacuum tube voltmeter is required to operate, a high-vacuum type of diode rectifier tube must necessarily be used. A rectifier tube should be chosen having a minimum spacing or distance between the cathode and the anode, but nevertheless able to withstand the maximum peak inverse voltage. This inverse voltage is substantially two times measured peak voltage. Close spacing of the tube elements is desirable in order to cut down the error in measurements due to the time required for electron travel between the cathode and anode. With very high frequencies, above 50,000,000 cycles per second, this error can be five per cent or more.

Small tube interelectrode capacities are desirable in order to keep down the reflection in the transmission lines on which the measurements are being made. Lump capacity, inductance or low resistance shunted across the line usually cause objectionable reflections of current and voltage. Other important features of design are the connections of the rectifier tube to the high frequency circuits to be measured. These connections should be as short as practical if true peak voltage indications are expected. Since the rectifier tube operates on high radio frequency voltages it must be adequately shielded to prevent objectionable stray radiations and to prevent injury to persons working around the apparatus.

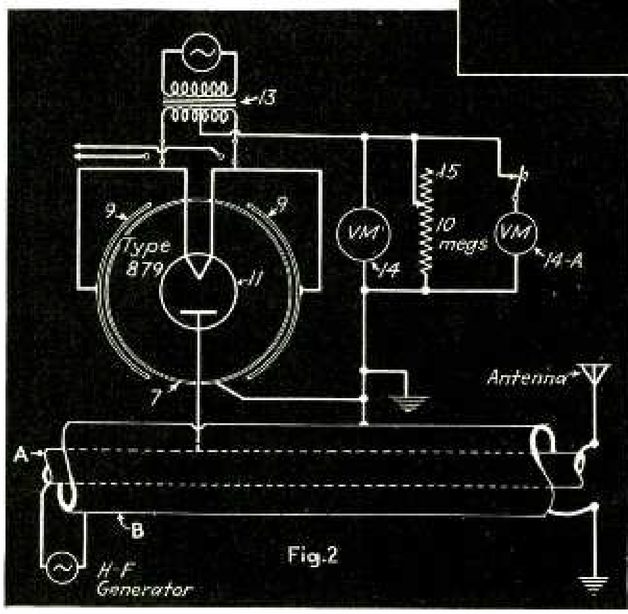


Fig. 2 — Schematic circuit diagram of the electronic tube voltmeter. Numbers 14 and 14-A indicate the electrostatic meters

Another important item is the indicating meter or voltmeter. It is desirable that this instrument be accurate and use very small current. If a meter is used which requires appreciable current, the meter will not indicate true peak voltage since the rectifier tube is of the high vacuum type having comparatively high resistance. The meter will, rather, indicate a voltage below the true peak value, the error being greater in proportion to the amount of current required by the meter and the attached load. Electrostatic types of voltmeters are particularly well adapted for this service.

The insulation of the rectifier tube filament transformer secondary

(*Continued on page* 79)

Increasing Radiator at Low Frequencies

By comparing a base loaded antenna with a transmission line, a method of increasing its radiating efficiency has been developed. The antenna current is increased by inserting a reactance at the top which is in effect the same as placing a reactance across a transmission line

By MILLETT G. MORGAN *Stanford University*

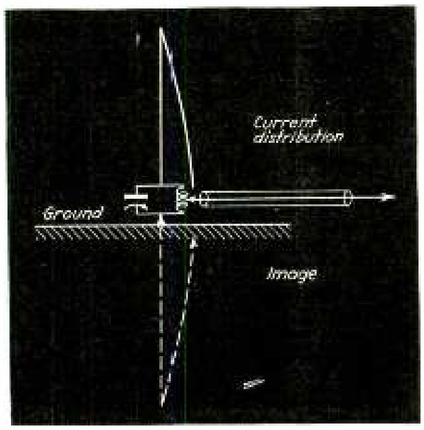


Fig. 1—Base - loaded antenna which is compared with a transmission line

ALTHOUGH the ultrahigh frequencies are highly desirable for mobile installations because of the low power required and the ease with which the radiator may be mounted on the mobile unit, their use is often precluded by the nature of the terrain in the desired coverage area. The development described herein was a project of the United States National Park Service and arose as part of the problem of equipping ranger patrol cars for two way radio operation on the National Park Service frequencies of 2496 kc to 3415 kc in areas where the terrain is predominately mountainous. The research on the problem was carried out jointly by the author and the National Park Service Radio Engineer, W. C. Hilgedick.

Recourse to the lower frequencies in order to secure sufficient diffraction into valleys and canyons makes even the longest radiator which it is practical to mount on a mobile unit electrically very short. This greatly reduces the radiation efficiency. Numerous approaches to this problem have been made. All, however, have been either mechanical or electrical compromises. The ideal system should be: (1) vertically polarized, (2) without pronounced directional characteristics in the horizontal plane, (3) capable of operation under motion without undue restrictions, and (4) efficient as a radiator. Vertical polarization is necessary in order that maximum radiation be along the horizontal and that attenuation be kept at a minimum. The nondirectional characteristic eliminates any form of vertical loop. Since requirement (1) eliminates any form of horizontal loop, we know that the radiator must be a symmetrical, vertical structure. Also the height is restricted to eight or nine feet. The only antennas of this type in use at present consist of an eight foot fish pole with sufficient reactance inserted at the base to resonate the system. The electrical configuration of such a system is shown in Figure 1. This antenna, though

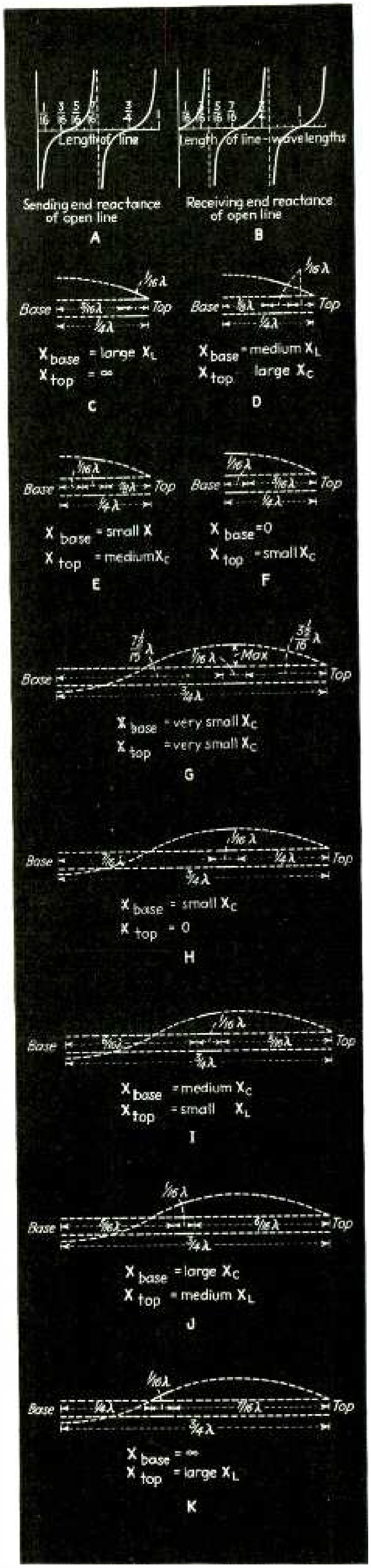
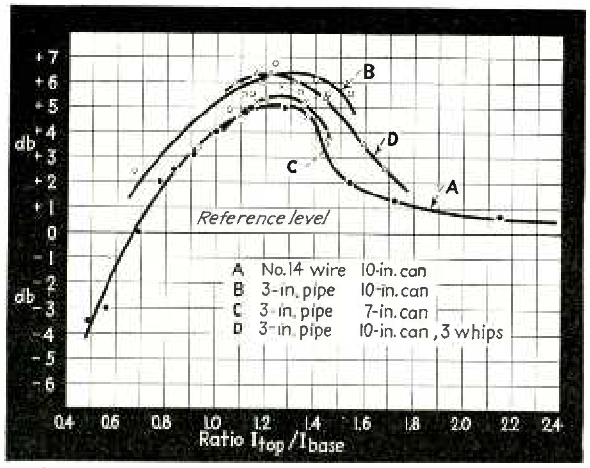


Fig. 2—By the use of the proper values of reactance at the top and bottom of a short antenna (one-sixteenth wavelength long or other short lengths), the current distribution may be varied at will



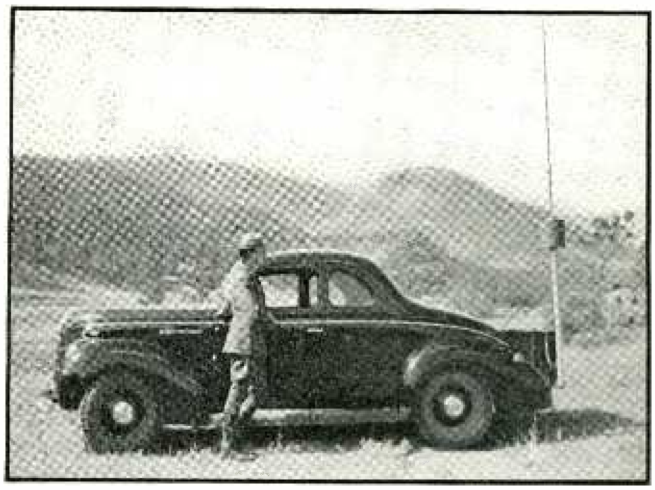
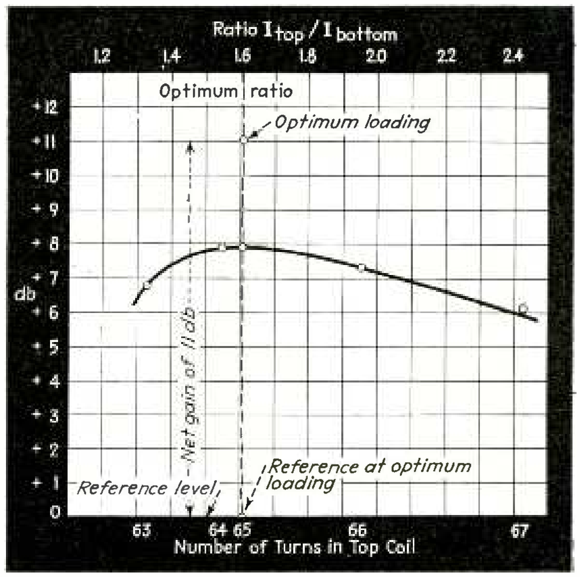


Fig. 3 above left—Comparison of several types of construction of the antenna. The ratio of current at the top to the current at the bottom indicates the current distribution

Fig. 4 above right—The antenna installed on a Yellowstone Park patrol car. The main radiating section is the three-inch duralumin pipe. The whip increases the capacitance to ground and also carries current

Fig. 5 right—Radiation of the new antenna, shown in Fig. 4, compared with that of a base-loaded antenna



meeting the first three requirements, is a highly inefficient radiator because at no point along the radiating portion does the current even approach its maximum loop value. Hence the problem is reduced to that of increasing the efficiency of the radiator shown in Fig. 1.

In general, an antenna may be likened to a transmission line. Hence, it may be analyzed by similar methods. The antenna shown in Figure 1, together with its image, constitutes an open wire line where the point of feed corresponds to the sending end of the line, and the top of the antenna and the bottom of the image correspond to the receiving end of the line. Figure 2 shows how any desired current distribution may be obtained on a section of line one-sixteenth wavelength long. The analysis is, of course, equally valid for shorter lengths, a sixteenth wavelength merely giving sufficient change in progressing from one diagram to the next to illustrate the procedure. By use of fictitious auxiliary lines, making the overall length resonant in each case, it is possible to see at a glance what kind of lumped reactance, and how much, is required at the receiving end of the line to obtain any desired current distribution. These diagrams are for lossless lines and are therefore somewhat idealized. However, they do illustrate the general trend and proved to be an immense aid in reaching rough approximations in the field.

Since the radiation from an element of current is proportional to the magnitude of the current, it is desirable to increase the current in the radiator as much as possible. Consequently, on first thought, one would expect Figure 2G to give the best field strength. On the other hand, as pointed out by Nickle, Dome and Brown[1, 2], in their discussion of vertical radiators in the neighborhood of a quarter wavelength long, the effect of losses at a given point in the circuit may be minimized by adjusting the current distribution so that a current node falls at the particular point of concentrated resistance. However, it should be pointed out that reduction of losses in this manner may lead to their increase in the ground at some distance from the antenna. Hence, in general we may expect the optimum current distribution to differ somewhat from that of Figure 2G. Since this deviation is a result of a complicated distribution of losses, it will be practically unpredictable analytically.

The question arises of how to place these various reactances across the receiving end of the antenna since one terminal is at the bottom of the image and a wire to the ground from the top of the antenna would carry current which would cancel the useful radiation. This was ingeniously answered by Nickle, Dome, and Brown by placing a large metal area at the top of the real antenna to form a capacitance between that point and ground, or across the receiving end of the line. An inductance placed in series with this capacitance can be varied to produce a net series combination reactance varying from that of the capacitance alone, through zero to large inductive values. Larger capacitive values can be obtained by decreasing the capacitance.

Lumped resistance will occur at the ground connection, in the base tuning coil and in the top coil. In order to reduce the losses at these points various expedients can be used. The ground connection should be as low a resistance as possible and the *Q* of the coils should be as high as possible. Furthermore, for a given value of net series reactance at the

(*Continued on page* 67)

New Books

Television — The Electronics of Image Transmission

By V. K. Zworykin and G. A. Morton, *RCA Manufacturing Company. Published by John Wiley and Sons, New York, N. Y. 1940, 646 pages, 494 illustrations. Price, $6.00.*

This is an authoritative and timely work by two of the foremost research engineers in the electronics field. As would be expected from the title, the greatest emphasis is upon the electronic aspects of the art, although the scientific foundations of the complete television process are thoroughly developed. The book is suitable for advanced students, and is especially recommended to workers in the field who have felt the need for a single reference text that would largely supplant the numerous important television articles that have appeared in the technical journals in recent years. A reasonable knowledge of the fundamentals of calculus, electron physics and radio engineering are pre-requisite to a complete understanding of certain chapters, although the book is by no means limited to theorectical aspects. A large amount of detailed information of a very practical nature is given, for example, on such diverse matters as the techniques employed in the construction of Iconoscopes and Kinescopes, vacuum plumbing, and television receiver design—information which should be of considerable help to experimental workers.

The first part deals with electron emission, electron optics, fluorescent materials and vacuum practice. Part II includes thorough analysis of the scanning process and picture resolution and deals with high-definition picture transmission, including video pickup devices and picture reproducing systems. In Part III the Kinescope and Iconoscope are dealt with in considerable detail, and video amplifiers, scanning and synchronizing circuits, television transmitters and receivers are all treated fully. Part IV describes the television program broadcasting facilities installed by R.C.A. and N.B.C. in New York City to field-test their all-electronic system prior to the start of the regular public service in 1939. This serves as a useful illustration of the application of principles and apparatus described in the preceding parts of the book, although the treatment here is not quite as complete nor as up-to-the minute as in the other parts. There is an interesting concluding chapter in which the present and future problems and prospects of the new art are dealt with.

The weight of the book is a minor annoyance to comfort when holding it unsupported for extended periods of reading, although it is recognized that the number of pages could not be reduced without sacrificing useful material. The style, printing, diagrams and general make-up are above reproach. In the opinion of the reviewer, this book will quickly find its way into the libraries of most serious workers in the fields of television and electronics.—R. E. Shelby.

National Broadcasting Company

Electronic Structure and Chemical Binding

By Oscar Knefler Rice, *Associate Professor of Chemistry, University of North Carolina. Published by McGraw-Hill Book Co., New York, N. Y. 1940. 511 pages, 91 figures, 5 appendices. Price $5.00.*

This extremely interesting and well composed book, although written primarily for physical chemists of the graduate grade, will find many receptive minds among engineers. The combining fields of electronics, physics and chemistry, so well typified by recent scientific developments, are well grouped in this work by Professor Rice.

The first third of the book leads from the simple electronic and nuclear structure conceptions through the nature of light to quantum and spectral relationships and elementary wave mechanics. The treatment of the "electron in a box" is unusually well done and is recommended to the many who have difficulty in reconciling the seemingly abstract substance of wave mechanics (de Broglie and Schrödinger) and the principle of indeterminancy (Heisenberg) with positive conceptions of physical entity and reality. After brief mention of quantum states and quantization, the structure of the helium atom and hydrogen atom and molecule is discussed in considerable detail. The electronic structure of the elements in relation to the periodic table is considered, and this leads in turn to a general study of forces and energy levels in atoms and molecules of less simple form. Valence and its relationship to bonding between atoms is discussed and compared with polar, ionic, and Van der Waal's forces.

Following these views on the individual molecules, the remainder of the book treats chiefly of the solid state as built up of ionic crystals, atomic, molecular and complex crystals, and metallic crystals. Inter-molecular and interatomic distances and forces are shown to determine many physical and chemical properties. Stability of compounds is discussed in terms of the Born-Haber cycle, showing the energy relationships in the various processes of combination and disassociation.

Many types of compounds are discussed to illustrate various physical relationships of the atoms comprising the molecule. Polar and magnetic moments as a result of such orientations are noted. Of particular interest to radio engineers is the formula given (page 198) for dielectric constant in terms of polarizability α, permanent electric moment μ, and temperature T.

The last few chapters contain so many brief excursions into rather unrelated physical and chemical characteristics as to be difficult to review, but still of great interest and with much informative material. Intermetallic compounds, properties of aqueous ions, solubility, oxidation and reduction reactions are typical subjects. Five appendices cover some principles of classical mechanics, equilibrium, electrical forces, geometry of crystals and a list of a number of reference works.

The volume is copiously annotated, and even where the admitted knowledge is not too quantitatively correct, the reader has a feeling of standing on solid ground. In general, the subject matter will be of interest only to those who realize that the commercial technical developments of the next twenty-five years will be based on such thorough groundwork as Professor Rice's book exemplifies.—K. W. Jarvis.

Radio Service Trade Kinks

By Lewis S. Simon, *Manager, Recall Radio Stores, Brooklyn, N. Y., McGraw-Hill Book Co., New York, 1939, 254 pages. Price, $3.00.*

The book is just what its title says it is. It is a compilation of a large number of kinks and tricks of servicing a wide variety of radio receivers, old and new. It gives the service man a quick reference to common radio ailments and practical methods of correcting them. It is stated in the preface that the information presented is the result of practical servicing of receivers since 1921 and has been checked and rechecked by the author and his assistants to ensure dependability. The sets are arranged alphabetically throughout the book and an adequate index is provided.—C.W.

TUBES AT WORK

Circuits for a recording and announcer's broadcast station console, an oscillator which will oscillate only within a given narrow band of frequencies, methods of feeding an antenna from two transmitters

A Console For The Small Station Transmitter House

By Earl Travis

Most broadcast stations with the transmitter separate from the studio have some provision at the transmitter for putting on a recorded program in case of trouble at the studio or in the program line. But the question is, how convenient are they to operate? The staff at KVEC, not wanting to put out the money for a commercial console, as they use the equipment at the transmitter very rarely, built the equipment here described.

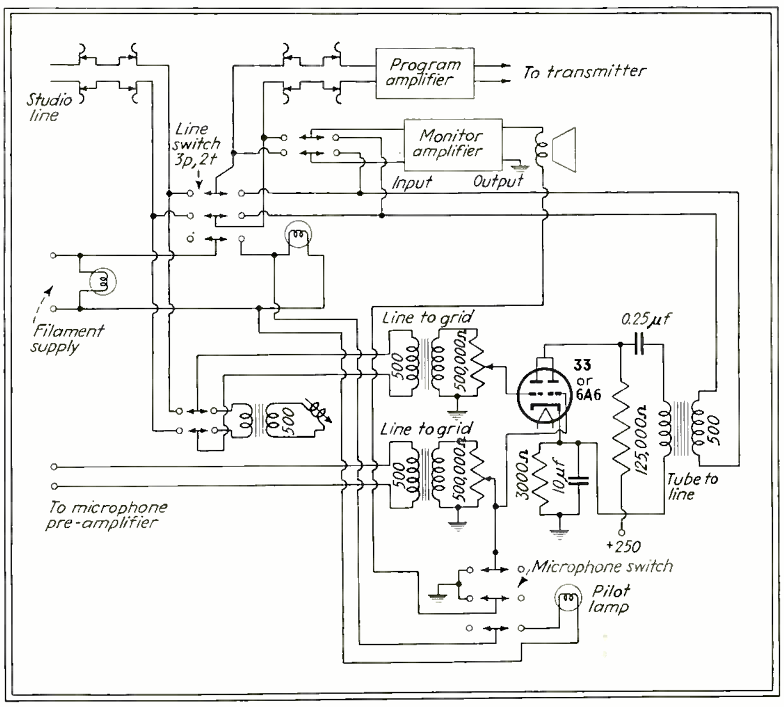
The console is intended for the following functions: to play transcriptions, announce, mix the announcement with the transcription, use it as an isolation amplifier to permit announcing on top of programs which the studio is feeding the network and transmitter, monitor programs on the line before they reach the program amplifier, and to reproduce audition transcriptions.

The principal cost of this console lies in the transformers. For our use, a medium-priced line of transformers was allowable. If at some time we want to put on regular programs from the transmitter, we can install some flat frequency transformers with very little trouble.

The diagram indicates the connections leading to the monitor amplifier and the microphone preamplifier. The plate voltage for the mixing tube as well as the filament current for it and the pilot lights is supplied by the monitoring amplifier. The unit has a maximum gain of 30 db and is flat within 1 db from 60 to 4500 cps, down 2 db at cps 6000 and above that the response drops off rapidly. When used at normal levels the wave form is practically free of distortion.

The switching and pilot lights are interlocked to the extent that it is impossible to use the microphone without disconnecting the monitor speaker, and the microphone pilot light will not light without first throwing the line switch.

To use the equipment as an isolation amplifier, the transcription channel is switched to the line at the same instant the line switch is thrown. This puts the program from the studio through the console mixer tube. It is then possible to mix the local announcement with the studio program, without affecting the studio program as it is fed to the network. This last use of course is only useful where one bridges the network across the program line, making it impossible to announce at the studio without it going out over the network. This is perhaps not the best way to feed a network, but it is done in many small stations.



For use in small broadcast station where occasional announcements must be made from the transmitter house, the circuits of the announcer's console shown above may be readily assembled by the station staff

A Band-Operative Oscillator

By Alan Bloch

Of the two main types of oscillator, crystal-controlled and self-excited, the second type is usually considered poor where reliable frequency-control is desired. Nevertheless the self-excited oscillator has a wide usefulness. The oscillator herein described is designed to give absolute frequency control over any desired band, and hence offers definite assurance against out-of-band operation. The circuit can be constructed also so as to *not* operate over a band and to operate on each side of the band, something like a band-stop filter.

If an oscillator is considered as a triode amplifier which supplies its own input, and if the case of mutual inductance (as opposed to self-inductance) is ruled out, then the simplest circuit for an oscillator is that of Fig. 1. The frequency of oscillation is then very close to the resonant frequency of the loop $Z_1 + Z_2 + Z_3$. In addition it can be shown that if Z_1 is inductive, then Z_2 and Z_3 must be capacitative and vice versa. These are the conditions for oscillation. The oscillator then takes one of the two forms shown in Fig. 2 and 3 (d-c voltages, biases, and all resistances except the plate resistance of the tube have been neglected). Figure 2 can be recognized as a Colpitts oscillator, and if the mutual inductance between the halves of the coil be neglected, the Hartley oscillator is a case of the circuit of Fig. 3. Figure 3 also represents a tuned-plate-tuned-grid oscillator provided there is no inductive coupling between the two tank circuits. The resonant frequency of Fig. 2 is approximately $\frac{1}{2\pi}\sqrt{\frac{1}{L}\left(\frac{C+C'}{CC'}\right)}$ and that of Fig. 3 is approximately $\frac{1}{2\pi}\sqrt{\frac{1}{C}\left(\frac{1}{L+L'}\right)}$.

In the case of a tuned-plate-tuned-grid circuit, L and L' are not the actual inductances but the equivalent inductances of the plate and grid tanks. That the frequency of oscillation depends on the loop $C + L + L'$ rather than on the resonant frequency of either the plate or the grid tank may easily be verified. If a tuned-plate-tuned-grid oscillator be constructed and the plate and grid tanks tuned to different frequencies, the frequency of

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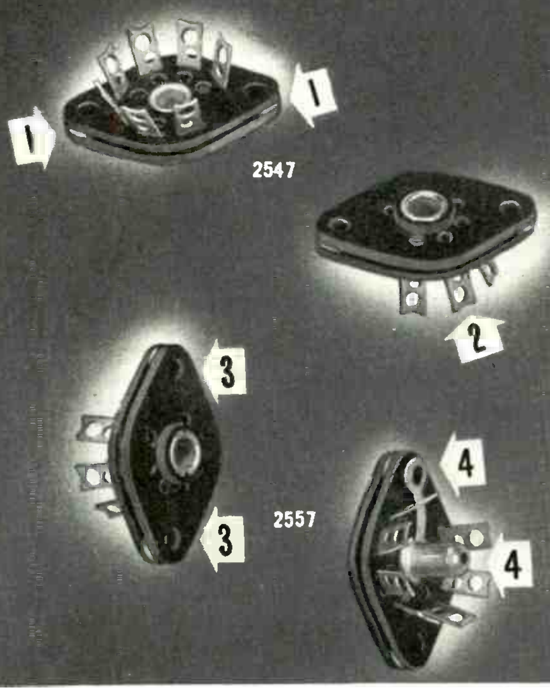

FEATURING:

1 Center spacing plate providing "floating" contacts.

2 Two ample size holes in soldering tails of each contact, aid in connecting any number of wires—hole sizes: $\frac{1}{16}$" and $\frac{3}{32}$" diameter.

3 Sockets have just $\frac{7}{8}$" mounting centers.

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These "CINCH" *mighty midget* sockets, the industry's new and improved miniature type are thoroughly tested by time and use, and come to you recommended and used by the nation's leading set manufacturers. For years satisfied customers have relied on "CINCH" to be ready for the rapid improvements within the industry.

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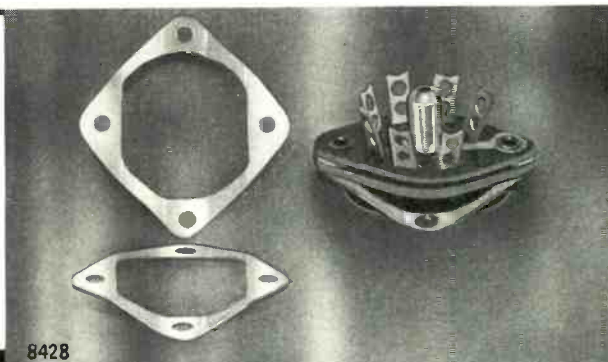

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oscillation will remain substantially constant when the two tanks are interchanged. Such shift as occurs is due to changes of resistances and to shift of the operating point of the tube due to change in the excitation.

The circuit of Fig. 3 has interesting possibilities when it is considered in this light. A series resonant coil and condenser combination is resistive at its resonant frequency, inductive above it, and capacitative below it. A parallel resonant circuit, on the contrary, is capacitative above its resonant frequency and inductive below it. This offers an electrical method of band limiting. If either L or L' be replaced by a parallel resonant circuit, the conditions for oscillation will be met only at frequencies lower than the resonant frequency of the combination. Similarly, if the other inductance be replaced by a series resonant circuit, oscillation is

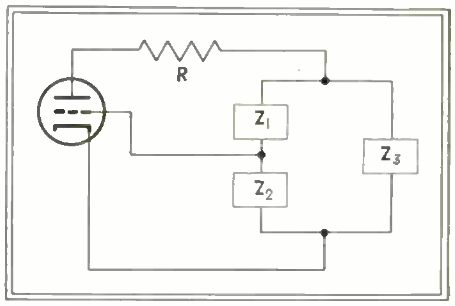

Fig. 1—Basic oscillator circuit with generalized impedances

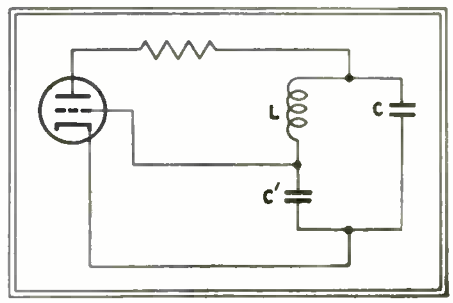

Fig. 2 — Double-capacitor version of oscillator

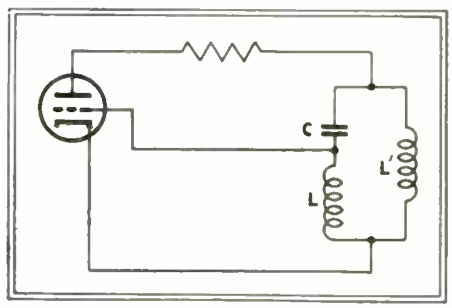

Fig. 3—Double-inductor form, the Hartley circuit

possible only above the resonant frequency of this circuit. If this is done, the circuit of Fig. 3 becomes either that of Fig. 4 or that of Fig. 5. In both cases oscillation is possible only over a predetermined band. The upper limit is set by the coil and condenser U, the

(*Continued on page 42*)

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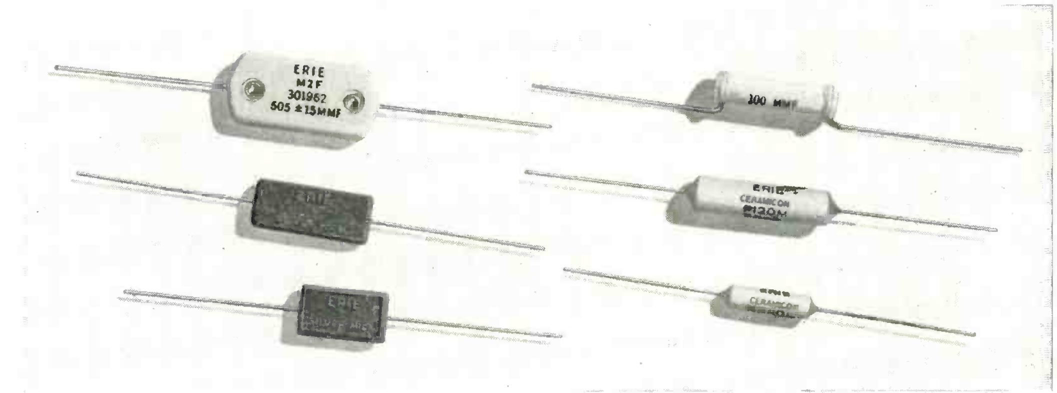
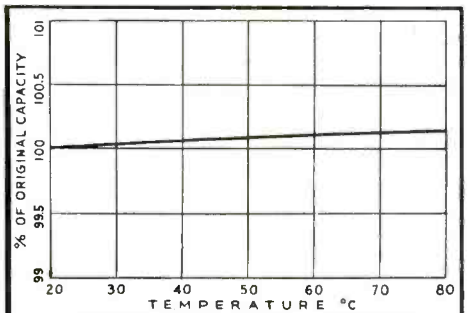


1 Eliminate condenser drift with ERIE SILVER MICAS



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A reliable way to eliminate frequency variations in tuned oscillator circuits produced by unstable foil condensers is to use Erie Silver Mica Condensers. With a practically zero temperature coefficient (+.000040 per °C, or less) and with only .2% or less permanent change in capacity after 5 cycles of from —40°F to +175°F, these units will provide an unusually high degree of tuning stability. Available in three types up to 2,500 mmf.

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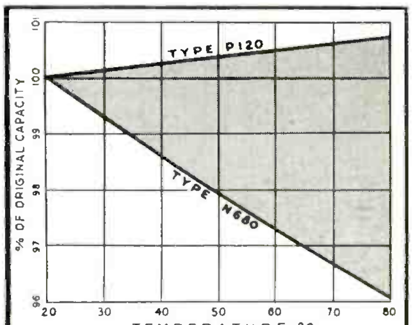

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Because these ceramic dielectric condensers can be supplied with a stable and reproducable temperature coefficient of any desired value between —.00068 per °C and +.00012 per °C, they can be used effectively to compensate for any known reactance drift that is introduced by other circuit elements. Erie Ceramicons are made in six non-insulated and insulated types in capacities up to 1,100 mmf. For capacities above this limit they can be combined with Erie Silver Mica Condensers.

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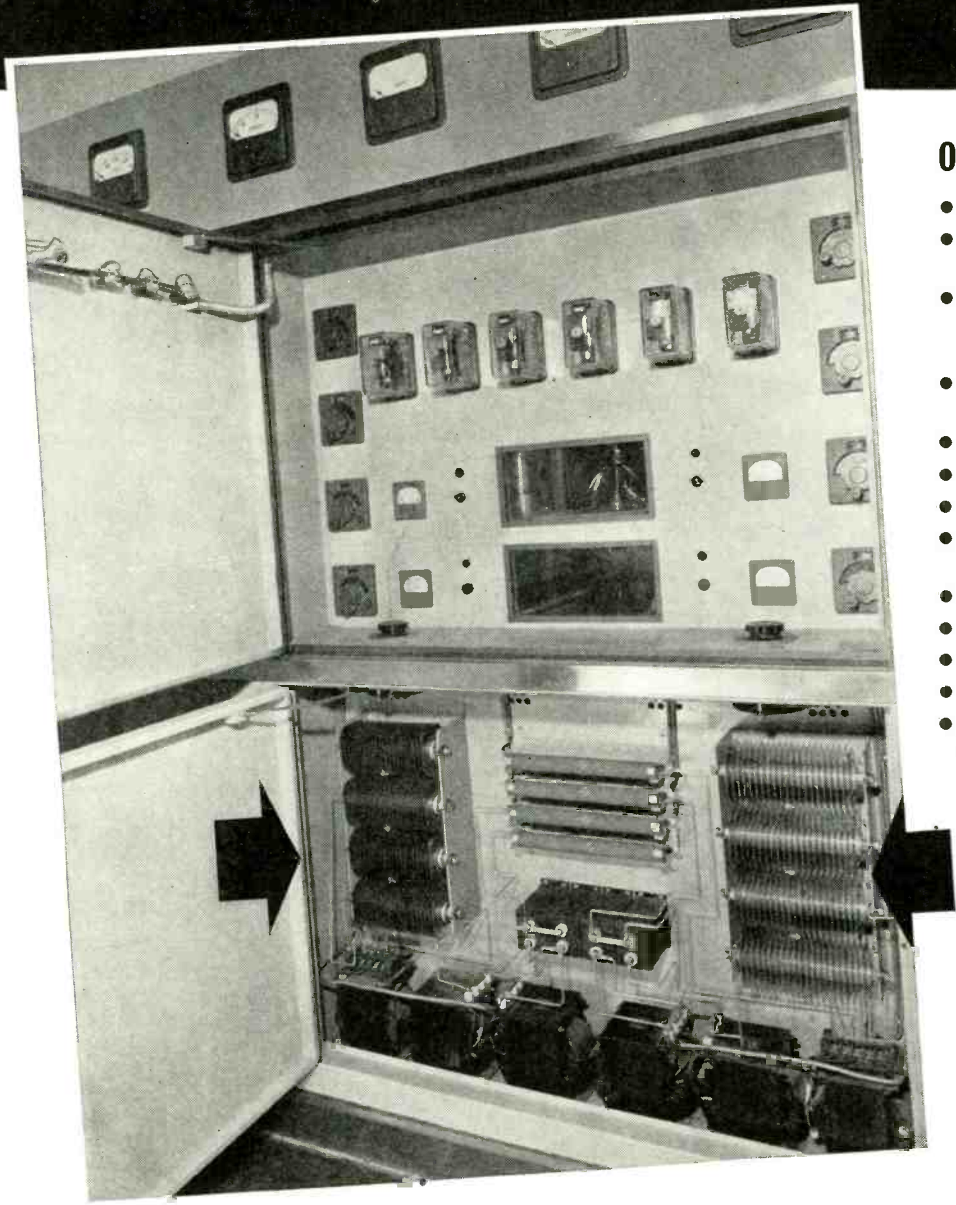

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- Extremely low operating costs.
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Front view of power amplifier center cubicle showing bias rectifier and transformer unit at bottom.

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The development of the new air-cooled WL 893R Transmitting Tube which made possible the construction of 50 KW air-cooled transmitters such as KDKA and the new WBZ, is typical of the many Westinghouse contributions to the radio industry.

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Broadcast Equipment

lower limit by the pair *L*, and the oscillator is tuned in the band by varying condenser *T*.

Such an oscillator was built using a 201-A tube with 120 volts on the plate. It functioned as expected. It was assumed that the series resonant frequency of *L* was identical with the parallel resonant frequency. The resonant points were then determined by using the pairs *U* and *L* separately as wave traps between an audio-modulated r-f oscillator and a t-r-f receiver. The results are summarized below:

Limits of Oscillation	Resonant Frequencies of *L*	and *U*
750–850 kc	690 kc	1155 kc
700–800 kc	645 kc	1080 kc
700–850 kc	655 kc	1150 kc

The discrepancies between the band limits and the resonant frequencies may easily be explained. The presence of resistance as well as the finite gain of the tube require that in each case the inductance be above a certain minimum value. This has the effect of

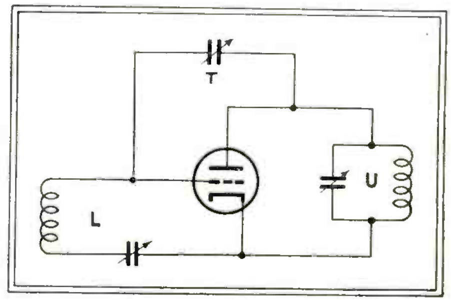

Fig. 4—Series-tuned-grid form of band-operative circuit

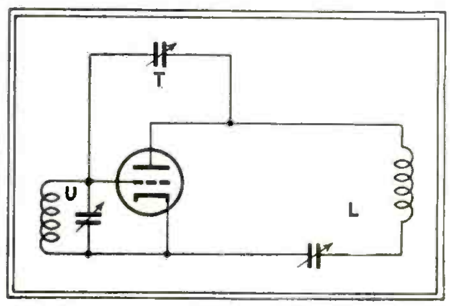

Fig. 5—Series-tuned-anode form of circuit

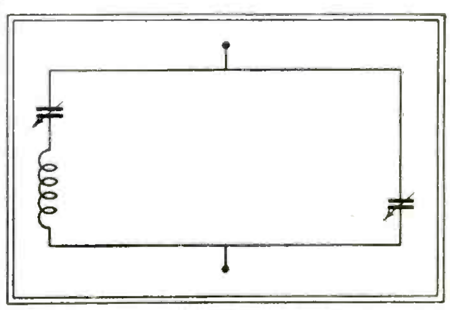

Fig. 6—Combination of elements useful in extra-band operation

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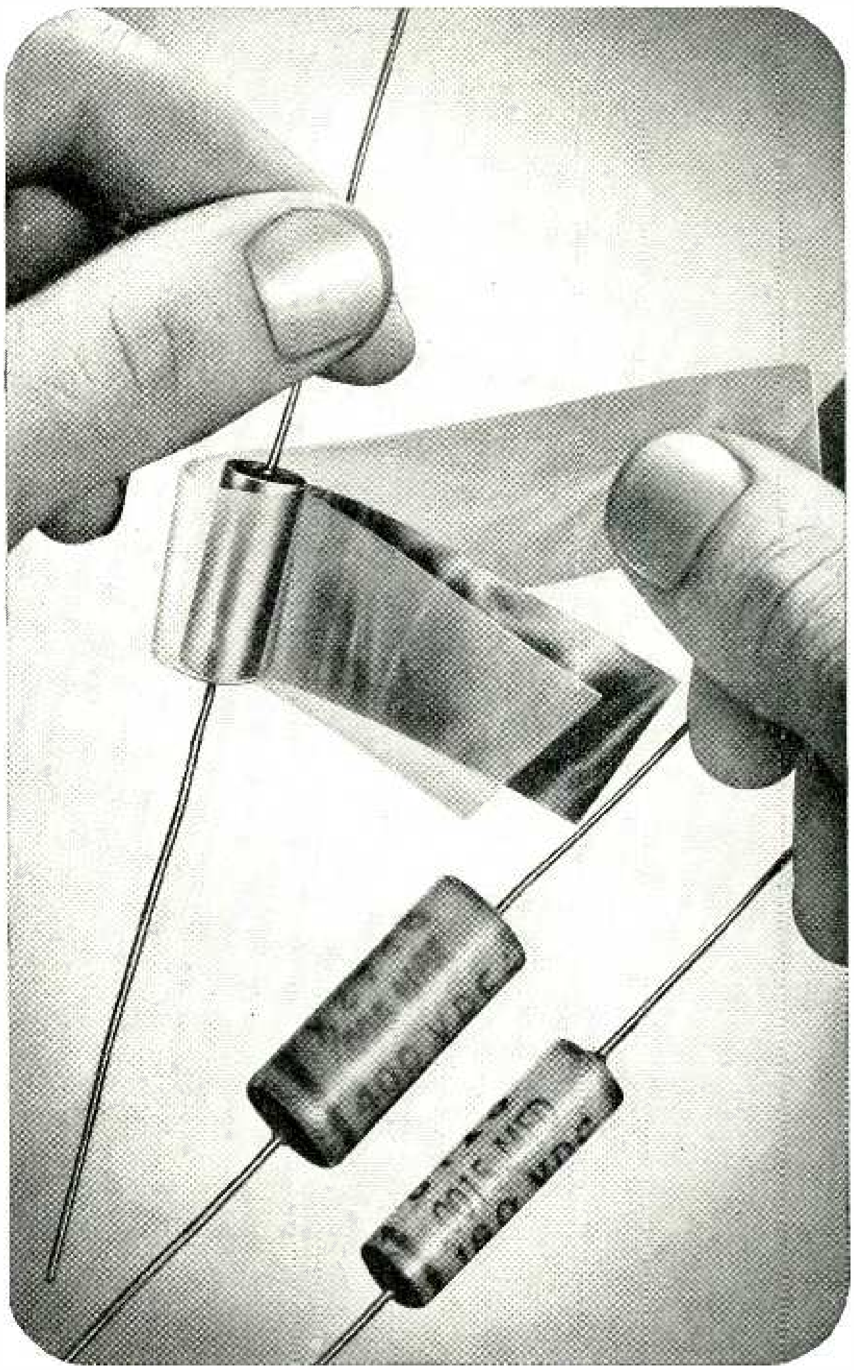

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Dielectric Strength (*60 cycles*)
500 to 525 volt/mil

Volume Resistivity
Over 10^9 megohm cms.

Arc Resistance (*proposed A. S. T. M. method*)
120 to 140 secs.

moving the band limits slightly inside the theoretical limits. In addition, the existence of certain capacities (inter-electrode, bypass, and distributed) require that both L and U have sufficient inductance that the net reactance between cathode and grid and between plate and cathode be inductive. The use of too small a bypass condenser in the plate power supply accounts for the inordinately large discrepancy at the upper end of the band since U was in the plate side of the circuit.

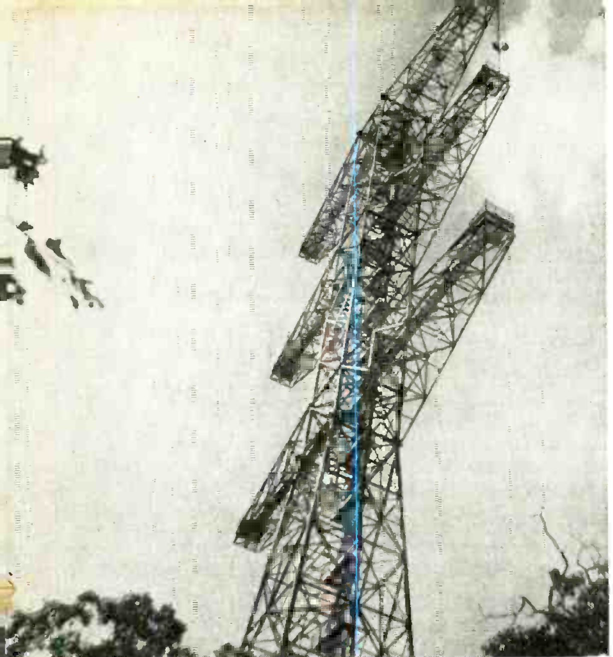
The limits of the band may be made to coincide with the edges of, say, an amateur band. This method insures against out-of-band operation and is not dependent for its accuracy on constant voltages. In other words, the oscillator operates in the band or not at all. Alternatively, the limits of the band may be made close together to provide narrower range of operations. Such an oscillator will drift more than a crystal oscillator, but it will drift out of oscillation instead of off frequency. Besides it has much greater flexibility than a crystal-controlled oscillator since it can be set within any desired frequency limits.

The combination of Fig. 6 may also be substituted for one of the condensers in Fig. 2. The circuit is then tuned by varying the other condenser. The combination of Fig. 6 then sets a finite band in which oscillation is impossible. This may be desirable when an oscillator is to operate on both sides of a prohibited band. It should be noted that parallel networks like that of Fig. 6 must be loaded with sufficient resistance to discourage parasitic oscillations.

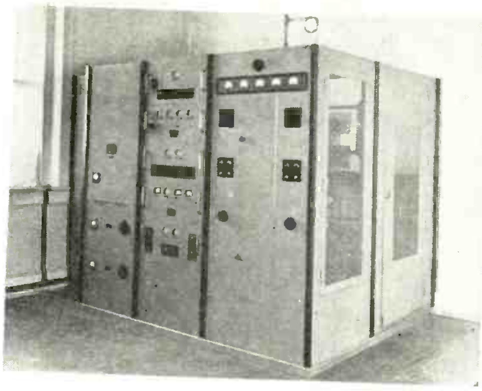
• • •

F.C.C. CHECKS TABOOED BROADCASTS

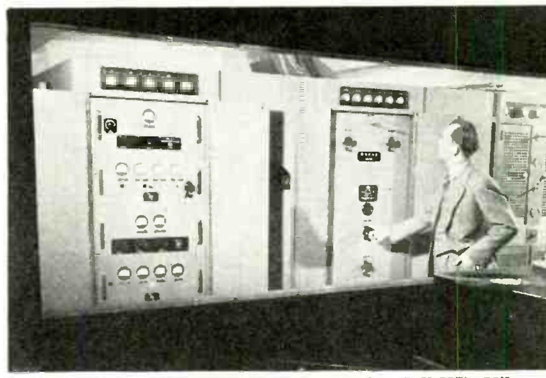
W. I. Abbott, inspector for the F.C.C. tunes an ultra-sensitive radio receiver as he monitors the ether in search for any violations of prohibited transmissions. A special check is being made on the amateur bands since the F.C.C.'s recent order prohibiting amateurs in the United States from communicating with other radio amateurs outside of areas under U. S. jurisdiction. The amateurs themselves provide an effective policing of their own channels to aid the government



W2XMN—Alpine, N. J.—Major E. H. Armstrong's original 40 kw FM transmitter tower—equipment by R E L—in service since April 1938.

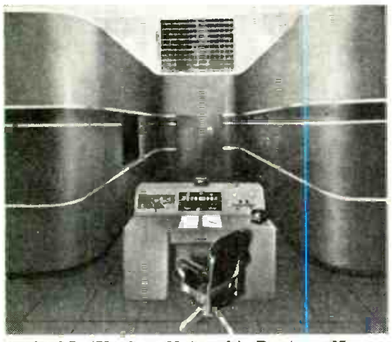


R E L FM equipment at W3XO—Washington, D. C.—Jansky and Bailey—in operation since August 1939.



R E L 3 kw FM transmitter at W9XAO (WTMJ) Milwaukee, Wisc.—The Journal Company—on the air since January 1940.

FM by REL

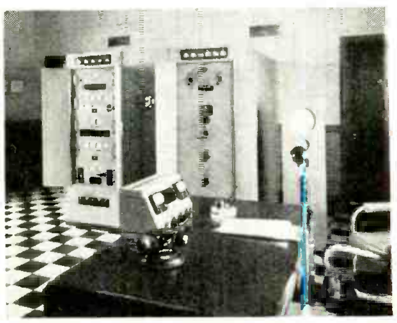


W1XOJ (Yankee Network) Paxton, Mass.—showing new 50 kw power amplifier room—on the air since May 1939 with 2 kw—since February 1940 with 50 kw—R E L equipped.

In collaboration with Major E. H. Armstrong, R E L built the first FM transmitters. As the pioneer manufacturer of FM equipment (since 1935)—R E L has built 95% of the FM stations now on the air.

All R E L FM transmitters employ the Armstrong phaseshift method of modulation with crystal control of the frequency—resulting in stability twice as great as required by regulations.

To assure yourself of the best in FM high fidelity and performance—we urge you to thoroughly investigate R E L—the pioneer manufacturer of a complete range of FM transmission units from 1 kw to 50 kw.



W8XAD (WHEC) Rochester, N. Y.—on the air since February 1940—equipped with R E L FM transmitter.

W8XVB (WHAM) Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.—on the air since November 1939—with R E L FM transmitter.

R E L is ready—complete manufacturing facilities—plus long engineering experience—enables us to immediately accept additional orders for FM transmitters—assuring prompt delivery—for fast installation and early operation.

All REL FM transmitters are guaranteed to conform with the latest FCC rules governing high frequency broadcast stations.

FM for other Services

REL FM equipment is also available for police, aviation and other important communication uses. Inquiries invited.

REL

RADIO ENGINEERING LABORATORIES, INC

35-54 36th STREET

Phone RAvenswood 8-2340
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LONG ISLAND CITY, N. Y.

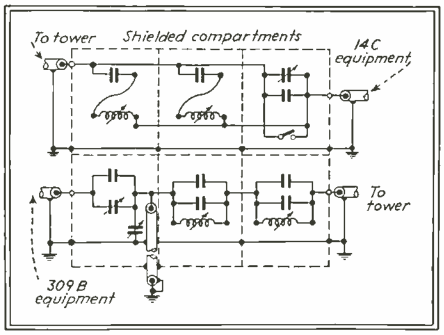
Double-Fed Antenna in Police Service

By JOHN BEALL

A UNIQUE FEATURE of the Kansas City, Mo., police radio installation is the simultaneous operation of a 1000-watt Western Electric WE-309-B transmitter, using voice transmission on 2422 kc, and a Western Electric WE-14-C ten channel radio telegraph transmitter, from a single 134-foot vertical radiator, located atop the roof. The simultaneous broadcasting of the dispatcher's voice and the radio telegraph code signals is accomplished without the slightest backing up, as evidenced on the interference meter of the WE-309-B transmitter. All transmitters feed their outputs through especially designed filters and concentric lines to the radiator.

Transmitting equipment of the Kansas City Police Dept.

Because of the emergency element involved in police work an auxiliary R.C.A. 500-watt voice transmitter was installed, guaranteeing uninterrupted service in the event of a failure of the main transmitter. The department is equipped with an auxiliary generator with a capacity of 25 kva, 240 volt alternator with a 3-phase direct connected exciters. This unit is powered with a Ford V8 gasoline engine.



Filter for feeding a single radiator from two transmitters

• • •

Phototube Installation Pays for Itself in Single Day

A SUCCESS STORY REPORTED by General Electric engineers concerns the performance of six phototube relays in-

stalled originally seven years ago in the plant of a manufacturer of automobile parts. The relays were installed to avoid damaging dies in a six-operation sequence press. The pieces fed to this press would occasionally jam and the feeding mechanism would place another piece on top of the first. When the ram came down on the two pieces, damage to the die would result. An obvious solution to this difficulty was the installation of a phototube relay to watch the operation, so placed that the light beam would be interrupted if more than one piece were placed under the ram before the operation was completed. Six relays with their outputs connected in series, and six sources of light, also connected in series, were arranged so that failure of the light or interruption of the light entering any phototube would throw the clutch on the machine and bring it to rest.

Since the die is an expensive piece of equipment, damage to it can equal or exceed the cost of the protective phototube equipment. In fact, on the first day of operation of this particular installation, the relay stopped the press and prevented damage to the die. The cost of this particular die would have been approximately twice that of the cost of the entire protective equipment. It is estimated that this particular installation has saved the manufacturer a total of $21,000 in the seven years it has been in operation.

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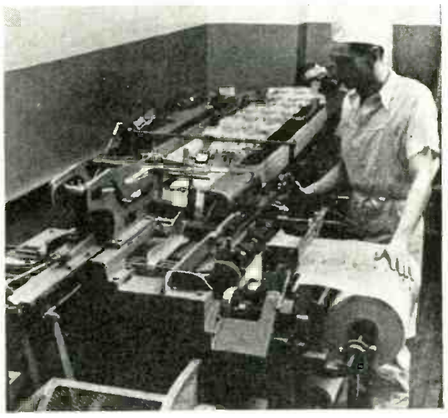
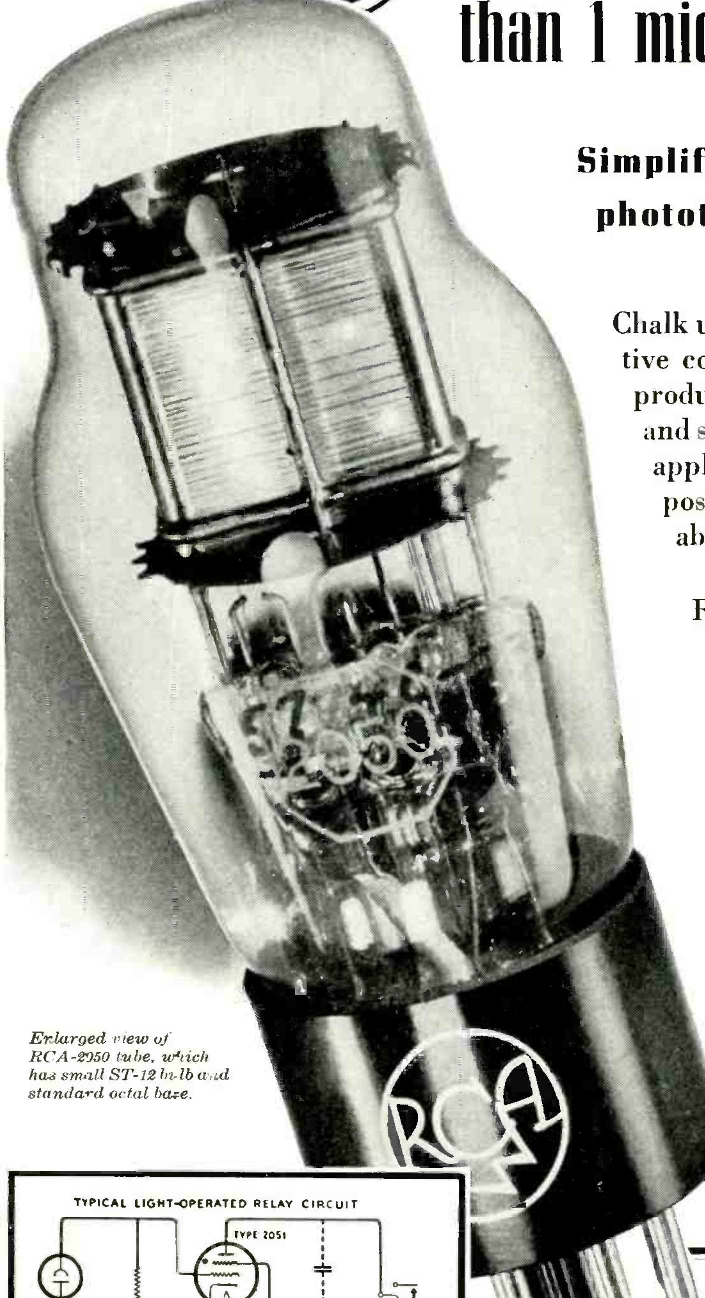
BREAD WRAPPED WITH AID OF PHOTOTUBES



More neatly wrapped bread is obtained from the Hayssen bread wrapping machines by using a simple Westinghouse electronic control which cuts the wrappers at just the right spot. A phototube scans the printed design and operates the cutter so that individual wrappers are of equal length and the printed design is always in the same location. The photoelectric control unit is to the right of the roll of wrapping paper, under the operator's right hand

New RCA Relay Tubes require less than 1 microwatt of control power



Enlarged view of RCA-2050 tube, which has small ST-12 bulb and standard octal base.

Simplify design and construction of phototube and relay circuits

Chalk up another for RCA! What designers of sensitive control circuits long have needed, RCA now produces... a gas-filled tetrode of high sensitivity and stability. In grid-controlled rectifier and relay applications, the new RCA-2050 and 2051 make possible simplified circuit design and dependable operation.

Another important feature of these new RCA tubes... internal parts are made of Pure Nickel or nickel alloy.

Why did RCA select Nickel? An excellent metal to fabricate, it is tough, rust proof, retains its strength at high temperature, is readily degassed, and stands up in the severest kind of service.

For economical production and uniform, dependable operation of radio, television and other electronic tubes, use Nickel. Write for the booklet, "Nickel in the Radio Industry."

THE INTERNATIONAL NICKEL COMPANY, INC.
67 Wall Street New York, N. Y.

NICKEL

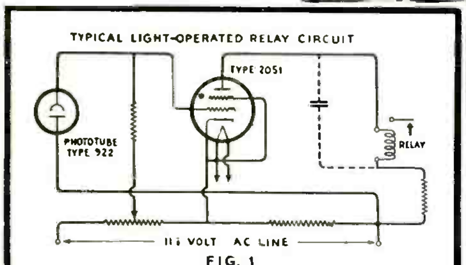


FIG. 1

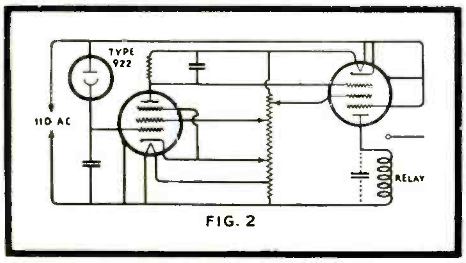


FIG. 2

CIRCUITS *made* SIMPLER *by use of* RCA 2050 *and* 2051

For operations such as those listed, the new RCA-2050 and 2051 make possible important savings. Their negligible grid current—permitting the use of high grid resistors with resultant high sensitivity—makes practical their direct operation from a phototube (Fig. 1). This feature eliminates one or more of the amplifier tubes required in conventional circuits (Fig. 2).

ANALYZING	ENLARGING	LIGHTING	PROTECTING	SYNCHRONIZING
COMPARING	GRADING	MATCHING	RECORDING	TELEMETERING
CONTROLLING	HEATING	MEASURING	REGULATING	TESTING
COUNTING	INDICATING	MONITORING	SELECTING	TIMING
DETECTING	INSPECTING	OPERATING	SIGHTING	WEIGHING
DIAGNOSING	LEVELING	PRINTING	SORTING	

FACTS ABOUT ATOMIC POWER

(Continued from page 13)

Two Germans, Hahn and Strassman started the ball rolling when they found, something over a year ago that ordinary uranium, consisting of a combination of isotopes, could be bombarded by neutrons and would supply atoms of barium as a result. Similar transformations from one type of atom to another had been known for years, but the distinguishing feature of this discovery was the fact that the original atom and the resultant atoms were very far apart in atomic weight. This meant that a very great amount of energy was given off in the process of disrupting the uranium atoms. No clue was given as to the actual seat of the disruption, that is, whether it resided in U^{238}, U^{234}, ^{235} or some other isotope. Measurements soon showed that the energy released was indeed enormous, some 200 million equivalent electron volts in each nuclear explosion. The clue to the atomic fuel had been found and the rush was on to identify and to abstract it in as pure a form as possible.

No one knows how many workers in physical laboratories addressed themselves to these problems in the ensuing months, but it must have been many hundreds. Much of the work is veiled in political secrecy, hence no one knows where the credit will eventually go, but certainly it will belong to dozens of men rather than to any single individual. Be that as it may, Professor Alfred O. Nier of the University of Minnesota was the first to announce the separation of U^{235} from U^{238} in a sufficient amount to permit further investigation. He did so by electronic means. A piece of solid uranium bromide was heated in a small box in vacuum, and the UBr_4 vapor thereby produced was bombarded by an electron beam of about 0.1 ma. Positive ions formed by collision of the electrons with the UBr_4 atoms were drawn through a slit, accelerated to about 1000 volts energy, then caused to move between the poles of a large electromagnet through a semi-circular tube. This apparatus, a mass

spectrograph, is used to separate atoms on the basis of weight, since the radius of the circular path pursued in the magnetic field by a charged particle depends on its mass. After passing through the semicircular tube, therefore, the heaviest atoms (U^{238}) were deflected least and the lightest (U^{234}) most. Nichrome plates were used to collect the separated streams of ions, which deposited as uranium atoms. In one run of 10 hours duration, 1.7 x 10^{-7} grams of U^{238} were deposited on one plate, and 1/139th as much of U^{235} (with small contamination of U^{234} also present) on the other. On another run 2.9 x 10^{-7} grams of U^{238} were deposited. These are truly infinitesimal amounts, and although the yield has since been increased by several hundred times, the isotope can only be said to be isolated, not made available in a practical sense.

The samples of U^{235} and U^{238} were then taken to Columbia University and bombarded with neutrons generated in the cyclotron in the Physics Laboratory by Booth, Dunning, and Grosse. The neutrons used were slowed down by passage through paraffin, since they are generated at too high a velocity by the cyclotron itself. In one run, only one fission (atomic disruption) in 100 minutes was noted with U^{238} and one every 2 minutes was noted with U^{235}. In a second run no fissions were noted within the experimental error with U^{238} and nearly one fission per minute was noted with U^{235}. This was the

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VEST POCKET RADIOS

Miniature radio transmitter and receiver, each using two of the recently announced miniature tubes, measure three inches by four inches by one inch and literally fit into the vest pocket

To solve those *delicate* problems

Western Electric 313C double gap, gas filled Cold Cathode Tube for use as a relay, rectifier or voltage regulator in special circuits. The illustration is an actual size, cut-away view.

Western Electric 346A three element, gas filled Cold Cathode Tube for use as a relay or rectifier in special circuits. Flexible leads are omitted. This tube employs special base for soldered connections and a resistor mounted in the control lead inside the base.

Western Electric 333A three element, gas filled Cold Cathode Tube for use as a relay or rectifier in special circuits. This tube is supplied with flexible colored leads with spade terminals.

Try
Western Electric
Cold Cathode Tubes

Now, using special circuits, you can really handle low current relay and rectifier problems. *And keep them well handled too.*

Hundreds of thousands of tubes from this Western Electric Cold Cathode Tube family are in use today as polarity detectors in Bell Telephones on party lines.

RATINGS AND CHARACTERISTICS	313C	346A	333A
Maximum peak cathode current	30 ma	30 ma.	30 ma.
Maximum average cathode current (average over 1 second)	10 ma.	10 ma.	10 ma.
Control gap breakdown voltage	70 volts	70 volts	70 volts
Control gap sustaining voltage	60 "	60 "	60 "
Main gap minimum breakdown voltage	150 "	225 "	150 "
Main gap sustaining voltage	75 "	80 "	75 "
Deionization time—in milliseconds	10	10	10

These Cold Cathode Tubes are faster and more sensitive than any electro-magnetic relay. They are ideal for stand-by service since they require no cathode power or starting time delay as does the thyratron.

Send for full details today. Write your nearest distributor. *In U. S. A.:* Graybar Electric Co., Graybar Bldg., New York, N. Y. *In Canada and Newfoundland:* Northern Electric Co., Ltd *In other countries:* International Standard Electric Corp.

Western Electric
ELECTRONIC EQUIPMENT

Distributed by Graybar

first experimental evidence reported[2] that U^{235} was in reality the seat of the atomic disruptions. The conclusion was reached that experiments with the possibility of a chain reaction should be confined to U^{235}. This report, in a letter in the *Physical Review*, was the signal for the newspaper reports which brought the matter to the attention of the public.

Physicists at the General Electric Company, K. H. Kingdon and H. C. Pollock, have separated U^{235} from the other isotopes using a mass spectrograph. Uranium tetrachloride was heated, the vapor bombarded by electrons to form the uranium ions and the ions separated by a magnetic field. An illustration showing these men and their apparatus appeared in the June issue of *Electronics*, page 74.

The Attack on the Separation Problem

The means of separating U^{235} from U^{238} on a large scale have been under active consideration during the last year. Chapman as long ago as 1917 suggested that separation of isotopes by weight might be accomplished by means of "thermal diffusion", an effect which takes place when convection currents are induced in a gas composed of particles of different weight. Clusius and Dickel built an apparatus for the purpose, consisting of a heated wire running on the axis of a vertical tube containing the gas. Brewer and Bramley[3] used two concentric vertical tubes the inner one heated, the outer cooled, and passed gas through the space between the walls of the tubes. Furry, Jones and Onsager[4] of Harvard and Yale worked out the theory of the concentric tube device, but did not consider its use in the uranium problem. Recently Krasny-Ergen[5] of the Wenner-Grens Institute in Stockholm applied this theory to the uranium problem. He considered two concentric vertical tubes 10 meters (33 feet) long, the inner tube 4 cms in diameter, with 1.34 mm distance between the walls of the tube. The inner tube is heated uniformly to 393° C, the outer kept cool at 60° C. The space between the concentric tubes is filled with uranium fluoride, UF_6, at one atmosphere pressure. In such an apparatus the lighter U^{235} tends to collect at the top, where it is caught in a chamber. The calculations indicate that if the upper chamber were allowed to come to equilibrium and the gas drawn off (discontinous operation), the concentration of U^{235} would increase 6.7 times in 80 days. In other words, the percentage of U^{235} would be 4.8 per cent the amount of the U^{238}. Furthermore 42.8 milligrams of the gas mixture, 4.8 per cent of which would contain U^{235}, could be drawn off per day. If the gas were drawn off continuously only 28.3 milligrams having the same percentage of U^{235} or about 1 milligram of U^{235} per day would be obtained.

The cost of heating a 4 cm tube 33 feet long to 393° C and of keeping the other tube near it at 60° C was not estimated in this analysis, but it would appear to be considerable. Since a milligram of U^{235} has the power potential of 5,000 grams (11 pounds) of coal, the apparatus must be capable of being operated with considerably less than 11 pounds of coal for each milligram of U^{235} produced. Whether such a ratio would exist must remain a question to be settled by experiment. Krasny-Ergen and his colleague Grabe began construction of the tube just described, but the work had to be discontinued "because of the political situation".

The matter stands at present waiting for a conclusive demonstration that the chain reaction of U^{235} is indeed a reality, and this must await the separation of much more of the isotope than has been reported up to the present. When this event takes place, the important questions of the rate at which the energy is released, and the methods of controlling this rate (by dilution of the U^{235} with inert atoms, for example) will be determined. All these are scientific, not engineering, questions. The practical utilization of atomic power must wait the answer to such questions, and it must certainly await the development of economical methods of producing the new fuel before it can possible enter into the industrial economy. In the meantime U^{235} is an isotope to watch. It may be going places.—D.G.F.

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1. R. B. Roberts and J. B. H. Kuper, Uranium and Atomic Power, *Jour. Applied. Phys.*, September 1939, p. 612.
2. A. O. Nier, E. T. Booth, J. R. Dunning, A. V. Grosse, Letters to the Editor, *Physical Review*, March 15, 1940 (Vol. 57, p. 546).
3. Brewer and Bramley, *Physical Review*, 55, 509A (1939).
4. Furry, Jones and Onsager, *Physical Review*, June 1, 1939 (Vol. 55, p. 1083).
5. W. Krasny-Ergen, Letter to the Editor, *Nature*, May 11, 1940.

See also an article in *Electrical Engineering*, February 1940, by Enrico Fermi.

The Inverted Amplifier

(*Continued from page 16*)

adjustment of grid to ground impedance. The feed-back in both modes should be dealt with independently.

Having compensated all feed-back due to the tube reactances we are left with the reverse feed-back inherent to the inverted amplifier due to the passage of the load current through the resistance of the driver. In the case of a linear amplifier it is to be anticipated this effect could be applied for the reduction of distortion. In the case of a fully-excited anode-modulated amplifier the effect is hardly appreciable. The driver is then usually an amplifier driven fully to plate voltage limitation under which circumstances the internal resistance is very low at the operating frequency and the degree of feed-back is therefore small. In this connection, however, it is well to observe that complications are introduced if the driver is connected to the amplifier through a transmission line. It is not very easy to ensure correct termination of the line, and if that is not done the regulation of the driver is impaired and the degree of feed-back is uncertain. It is better to couple the driver to the inverted amplifier through circuits of high kva to kw ratio.

It has been pointed out that it is a characteristic of the inverted amplifier that the driver delivers power into the main load in series with the amplifier. Consequently, if it is required to apply anode modulation for telephony it is necessary, in order to obtain full modulation satisfactorily, to modulate the driver as well as the final amplifier. This, as has been seen, must tend also to reduce the risk of phase modulation.

In the inverted amplifier the filament heating current has to be fed to filaments which are at comparatively high radio frequency voltage. One method is to feed the filaments through shielded transformers having small capacitance between primary and secondary. This is very easily done, but experiment has shown that heating the filaments of a high power short wave amplifier by alternating current can give rise to serious phase modulation at the fundamental and harmonics of the mains frequency even if the amplitude noise level is sufficiently low. The result is that noise is apparent under conditions of multi-path transmission. It is therefore more satisfactory to adopt d-c heating for the filaments.

The direct current can be fed to the filaments through insulated cables. These can be of a length such that their inductive reactance remains high compared to the capacitive reactance in the amplifier input circuit over a wide band of frequencies. Experience shows, for example, that one fixed length of cable is satisfactory for the whole band of frequencies normally utilized for shortwave broadcast transmission.

It is, in some cases, a disadvantage of the inverted amplifier that the driver must be able to deliver considerably more power than would be demanded in an equivalent normal amplifier system, but it is not always disadvantageous as the extra power is usefully transferred to the load giving a higher output power than would otherwise be obtainable with given tubes in the final stage.

The efficiency of the combination of a driver and inverted power amplifier can be somewhat higher than for an equivalent combination utilising a normal amplifier owing to improved efficiency in the output circuit resulting from the lesser output capacitance and also in practice there is a further small improvement due to the fact that there is no necessity to provide a load resistance to ensure stability of the driver, since the latter is loaded by the output resistance.

Examples of Performance

The following figures exemplify the performance of certain 50 kw Class B modulated inverted amplifiers at present in service in a number of shortwave broadcasting transmitters:

Number of tubes in final amplifier	2
Filament emission per tube	40 amps
Amplification factor	36
D-c anode voltage	11,000
D-c grid voltage	—1,000
Anode input	70 kw
Tube efficiency	70%

Power delivered by final stage
to output circuit..........49 kw
Peak grid swing per tube.2,500 volts
Peak anode swing per
tube ....9,500 volts
Power delivered to output circuit by driver............13 kw
Approximate power absorbed
by final amplifier grids.....4 kw
Total output from driver....17 kw
Efficiency of driver...........66%
Input to driver ....26 kw
Total input to driver and final
amplifier ....= 96 kw
Total power in output circuit ....= 62 kw
Approximate efficiency of
output circuit 95%
Total useful output power...59 kw
Overall conversion efficiency...62%

It will be noted particularly from the above that of the total carrier power of 59 kw delivered, 13 kw is furnished by the driving stage.

In addition to its application at high power, the inverted amplifier system promises to be of value for low power work at very high frequencies, for example, at frequencies exceeding 300 megacycles. For such applications it has been found effective to utilise special double triode valves constructed so as to have a very low impedance connection between the grids of the two sections, thus eliminating the necessity of providing means to tune out the grid to grid inductance.

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BRITISH DIRECTION FINDERS

A group of direction finding loop antennas and accessory equipment used in instructing members of the Royal Air Force

TUBES

Tubes registered with the R.M.A. Data Bureau during the month of May, 1940 and during 1937

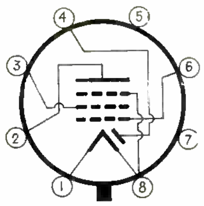
Tube Registry

Tube Types Registered by R.M.A. Data Bureau During May 1940

Type 1LD5 (GL)

DIODE-PENTODE; sharp cutoff; filament type; (T-9) integral glass envelope-base; seated height 2¼ inches (max), 8-pin loktal base.

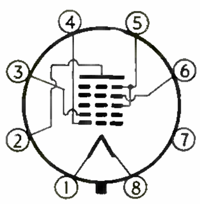
E_f = 1.4 v
I_f = 0.05 amp
E_b = 90 v
E_{c2} = 45 v
E_{c1} = 0 v
I_b = 0.6 ma
I_{c2} = 0.1 ma
g_m = 600 μmhos
r_p = 0.95 megohm
C_{in} = 3.2 μμf
C_{out} = 6.0 μμf
C_{gp} = 0.2 μμf
Basing 6-AX-L-O



Type 1LC6 (GL)

HEPTODE-CONVERTER, remote cutoff; filament type; (T-9) integral glass envelope base; seated height 2¼ inches (max), 8-pin loktal base.

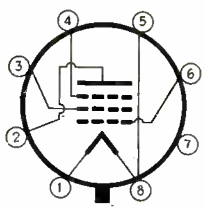
E_f = 1.4 v
I_f = 0.05 amp
FORTY-FIVE VOLT RATINGS
E_b = 45 v
$E_{c5,3}$ = 35 v
E_{c4} = 0 v
E_{c2} = 45 v
E_{c1} = 0.2 + 10^6 ohms × 35 + 10^{-6} amps = 7 v
I_b = 0.7 ma
$I_{c5,3}$ = 0.75 ma
I_{c2} = 1.4 ma
I_{c1} = 35 μamps
g_c = 250 μmhos
r_p = 0.3 megohms
$C_{rf\ in}$ = 9.0 μμf
$C_{if\ out}$ = 5.5 μμf
Basing 7-AK-L-O



Type 1LC5 (GL)

R-F pentode, sharp cutoff; filament type; (T-9) integral glass envelope-base; seated height 2¼ inches (max), 8-pin loktal base.

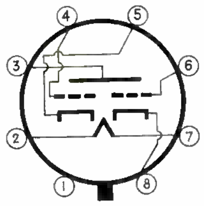
E_f = 1.4 v
I_f = 0.5 amp
E_b = 90 v
E_{c3} = 0 v
E_{c2} = 45 v
E_{c1} = 0 v
I_b = 1.15 ma
I_{c2} = 0.20 ma
g_m = 775 μmhos
r_p = 1.5 megohms
C_{in} = 3.2 μμf
C_{out} = 7.0 μμf
C_{gp} = 0.007 μμf (max)
Basing 7-AO-L-8



Type 6AE7GT

DOUBLE driver triode (common plate); heater type; (T-9) glass envelope; seated height 2⅝ inches (max); 8-pin medium shell bakelite base.

E_h = 6.3 v
I_h = 0.5 amp
E_b = 250 v
E_c = −13.5 v
Each Triode
I_b = 5 ma
g_m = 1500 μmhos
r_p = 9300 ohms
μ = 14
Basing 7-AX-0-0

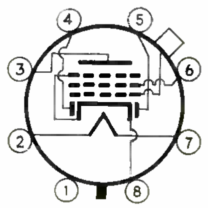


Type 6B8GT

Prototype 6B8 (M)

DOUBLE diode pentode, remote cutoff; heater type; (T-9) glass envelope; seated height 2⅝ inches; 8 pin octal metal shell base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
E_{c2} = 125 v (max)
E_{c1} = −3 v
I_b = 10.0 ma
I_{c2} = 2.3 ma
g_m = 1325 μmhos
r_p = 0.6 megohms (approx)
μ = 800 (approx)
E_{c1} for cut-off = −21 v
C_{in} = 4.5 μμf
C_{out} = 10 μμf
C_{gp} = 0.005 μμf (max)
Basing 8-E-1-8

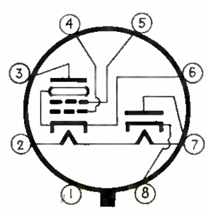


Type 117N7GT

Prototype 117M7 (GT)

RECTIFIER beam deflection power amplifier; heater type (T-9) glass envelope; seated height 2⅝ inches (max), 8-pin octal intermediate bakelite base.

E_h = 117 v
I_h = 0.09 amp
RECTIFIER
(with condenser-input filter)
E_p = 117 v (max)
I_b = 75 ma (max)
E_b = 20 v (drop) @ 150 ma
E_{inv} = 350 v (max)
I_{peak} = 450 ma (max)
POWER AMPLIFIER
E_b = E_{c2} = 100 v
E_{c1} = −6.0 v
I_{bo} = 51 ma
I_{c2} = 5 ma
g_m = 7000 μmhos
r_p = 16,000 ohms
R_l = 3000 ohms
P_o = 1.2 watts (6%)
Basing 8-AV-0-0

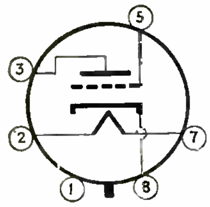


Tube Types Registered by R.M.A. Data Bureau During 1937

Type 6J5

DETECTOR amplifier triode, heater type, metal envelope, seated height (max) 2 1/16 inches, 6-pin octal base.

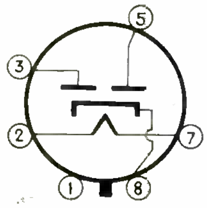
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_c = − 8 v
I_b = 9.0 ma
μ = 20
r_p = 7700 ohms
g_m = 2600 μmhos
Basing 6-Q



Type 6ZY5 (G)

FULL wave, high-vacuum rectifier, heater type, (ST-12) glass envelope, seated height (max) 3 9/16 inches, 6-pin octal base.

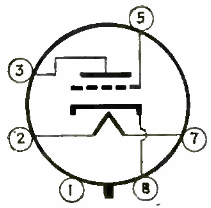
E_h = 6.3 v
I_h = 0.3 amp
CONDENSER INPUT TO FILTER
$E_{p\ ac}$ (rms per plate) = 325 v (max)
I_{dc} (per plate) = 40 ma (max)
CHOKE INPUT TO FILTER
$E_{p\ ac}$ (rms per plate) = 450 v (max)
I_{dc} (per plate) = 40 ma (max)
E_{drop} (I_{dc} = 40 ma per plate) = 18 v
Basing 6-S



Type 6P5 (G)

TRIODE amplifier detector, heater type, (ST-12) glass envelope; seated height, 3 9/16 inches; 6-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v (max)
E_c = − 13.5 v
I_b = 5.0 ma
μ = 13.8
r_p = 9500 ohms
g_m = 9500 μmhos
Basing 6-Q

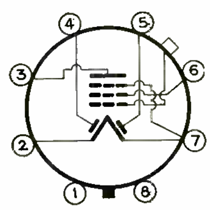


Type 1F7 (GH)

Prototype 1F6

DUPLEX-DIODE pentode, filament type, one diode is mounted on positive leg of filament and the other diode is mounted on the negative leg, (ST-12) glass envelope; seated height (max) 3 ⅞ inches; 8-pin octal base.

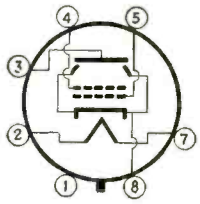
E_f = 2.0 v
I_f = 0.06 amp
E_b = 180 v (max)
E_{c^2} = 67.5 v (max)
E_c = −1.5 v
I_b = 2.2 ma
I_{c2} = 0.7 ma
r_p = 1 megohm
g_m = 650 μmhos
Basing 7-AD



Type 6V6

BEAM power amplifier, heater type, metal envelope, 7-pin octal base.

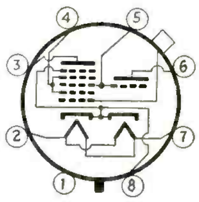
E_h = 6.3 v
I_h = 0.45 amp
E_b = 250 v
E_{c2} = 250 v
E_c = − 12.5 v
I_b(*zero signal*) = 45 ma
I_{c2}(*zero signal*) = 4.5 ma
R_l = 5000 ohms
P_o = 4.5 watts (8%)
R_p = 52000 ohms
Basing 7-AC



Type 6J8 (G)

TRIODE-HEPTODE converter, heater type, (ST-12) glass envelope, seated height (max) 3⅞ inches, 8-pin octal base.

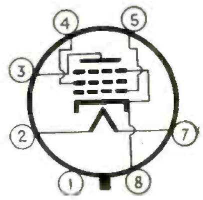
E_h = 6.3 v
I_h = 0.3 amp
E_b(*hex*) = 250 v (max)
$E_{c2,4}$ = 100 v (max)
E_{c1} (hex) = − 3.0 v
E_b(*osc*) = 250 v (max) through 20,000 ohms
I_b(*heptode*) = 1.3 ma
$I_{c2,4}$ = 5.0 ma
I_c(*osc*) = 0.4 ma
g_c = 290 μmhos
Basing 8-H



Type 6G6 (G)

POWER amplifier pentode, heater type, (ST-12) glass envelope, seated height (max) 3 9/16 inches, 7-pin octal base.

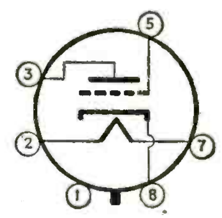
E_h = 6.3 v
I_h = 0.15 amp
E_b = 180 v
E_{c2} = 180 v
E_c = − 9.0 v
I_b = 15.0 ma
I_{c2} = 2.5 ma
R_l = 10,000 ohms
P_o = 1.1 watts (10%)
Basing 7-S



Type 6AC5 (G)

POWER AMPLIFIER, heater type, (ST-12) glass envelope, seated height (max) 3 9/16 inches, 6-pin octal base.

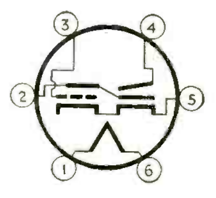
E_h = 6.3 v
I_h = 0.4 amp
E_b = 250 v
E_c = + 13 v
I_b = 32 ma
I_c = 5.0 ma
r_p = 36,700 ohms
R_l = 7,000 ohms
P_o = 3.7 watts (10%)
Basing 6-Q



Type 6AB5
Prototype 6N5

TUNING indicator, heater type, (T-9) glass envelope, seated height, (max) 3 9/16 inches, 6-pin base.

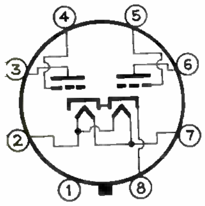
E_h = 6.3 v
I_h = 0.15 amp
E_b = 135 v
E_{target} = 135 v
I_b = 0.5 ma
I_{target} = 4.5 ma
Basing 6-R



Type 6Z7 (G)

Twin triode power amplifier, heater type, (ST-12) glass envelope, seated height (max) 3 9/16 inches, 8-pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_b = 180 v
E_c = 0 v
I_b(*zero signal*) = 4.2 ma
R_l(*plate to plate*) = 20,000 ohms
P_o = 2.2 watts (P_{input} = 80 *milliwatts grid to grid*)
Basing 8-B



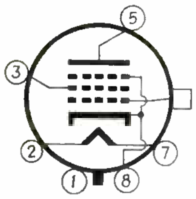
Erratum

The incorrect basing for tube type 6R6 (G) was given in the April issue. The correct basing appears below.

Type 6R6 (G)

R-f pentode remote cutoff, heater type, glass envelope, 8 pin octal base.

E_h = 6.3 v
I_h = 0.3 amp
E_p = 250 v
E_{c2} = 100 v
E_c = −3.0 v
I_p = 7.0 ma
I_{c2} = 1.7 ma
r_p = 0.8 megohm
g_m = 1450 μmhos
Basing 6AW



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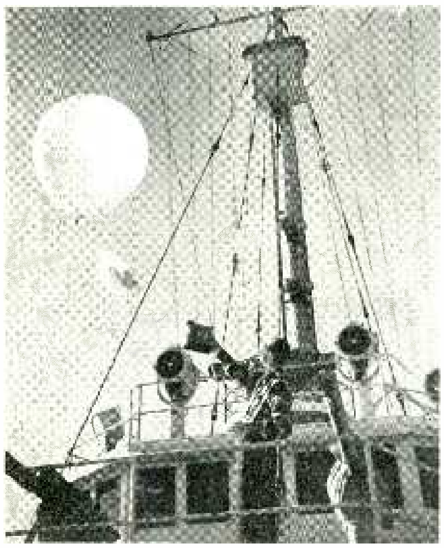
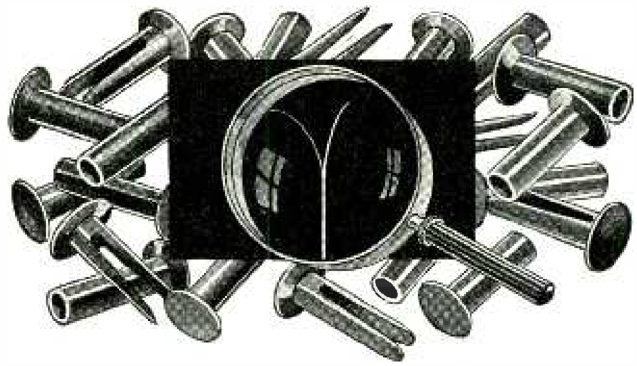
WEATHER BY RADIO



Coast Guard cutters stationed in blind spots in the Atlantic Ocean, one-third and two-thirds of the distance between Bermuda and the Azores, send up radiosonde ballons to determine the weather conditions at high altitudes

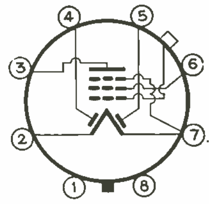


Type 1F7 (GV)

Prototype 1F6

DUPLEX-DIODE pentode, filament type, identical with type IF7 (GH) except that both diodes are mounted on the negative leg of the filament, (ST-12) glass envelope; seated height (max) 3⅞ inches, 8-pin octal base.

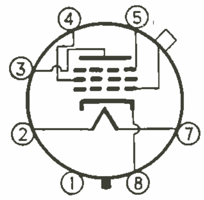
E_f = 2.0 v
I_f = 0.06 amp
E_b = 180 v (max)
E_{c2} = 67.5 v (max)
E_c = — 1.5 v
I_b = 2.2 ma
I_{c2} = 0.7 ma
r_p = 1 megohm
g_m = 650 µmhos
Basing 7-AD



Type 6S7

SUPER control pentode amplifier, remote cutoff, heater type, metal envelope, seated height (max), 2 9/16 inches, 7-pin octal base.

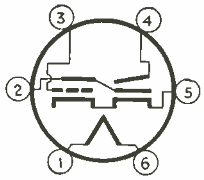
E_h = 6.3 v
I_h = 0.15 amp
E_b = 250 v
E_{c2} = 100 v
E_c = — 3.0 v
I_b = 8.5 ma
I_{c2} = 2.0 ma
μ = 1750
r_p = 0.1 megohm
g_m = 1750 µmhos
Basing 7-R



Type 6T5

TUNING indicator, heater type, (T-9) glass envelope, seated height (max) 3½ inches, 6-pin base.

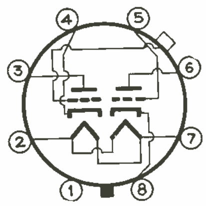
E_h = 6.3 v
I_h = 0.3 amp
E_b = 250 v
E_{target} = 250 v
I_b = 0.24 ma (max)
I_{target} = 3.0 ma
Basing 6-R



Type 6F8 (G)

TWIN triode amplifier, each triode identical with that of type 6J5, heater type, (ST-12) glass envelope, seated height (max) 3⅞ inches, 8-pin octal base.

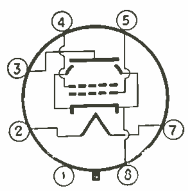
E_h = 6.3 v
I_h = 0.6 amp
Each Triode
E_b = 250 v
E_c = − 8 v
I_b = 9.0 ma
μ = 20
r_p = 7700 ohms
g_m = 2600 µmhos
Basing 8-G



Type 6Y6 (G)

BEAM power amplifier, heater type, (ST-14) glass envelope, 7-pin octal base.

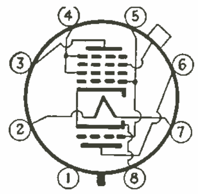
E_h = 6.3 v
I_h = 1.25 amp
E_b = 200 v
E_{c2} = 135 v
E_c = − 14 v
I_b = 61 ma
I_{c2} = 2.2 ma
R_l = 2600 ohms
P_o = 6.0 watts (10%)
Basing 7-AC



Type 6K8

TRIODE-HEXODE converter, heater type, metal shell, seated height (max) 2 9/16 inches, 8-pin octal base.

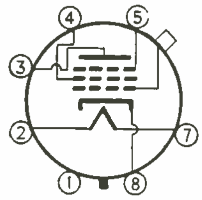
E_h = 6.3 v
I_h = 0.3 amp
E_b (hex) = 250 v
E_{c2} = 100 v
E_c(hex) = — 3 v
E_b(osc) = 100 v
Osc grid resistor = 50,000 ohms
I_b(hex) = 2.5 ma
I_{c2} = 6.0 ma
I_b(osc) = 3.8 ma
I_c(hex & osc) = 0.15 ma
g_c = 350 µmhos
Basing 8-K



Type 6W7 (G)

PENTODE amplifier, sharp cutoff, heater type, (ST-12) glass envelope, seated height (max) 3⅞ inches, 7-pin octal base.

E_h = 6.3 v
I_h = 0.15 amp
E_b = 250 v (max)
E_{c2} = 100 v (max)
E_c = — 3.0 v
I_b = 2.0 ma
I_{c2} = 0.5 ma
r_p = 1.5 megohm
g_m = 1225 µmhos
Basing 7-R



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COASTAL PATROL USES RADIO

A Coast Guard Grumman JRF twin-engined amphibian flying over New York harbor on the way to sea for offshore patrol. The aerial activities of the Coast Guard have been greatly increased during the last year or two as a result of the necessity for greater safety to shipping and to the United States. Ships such as the two shown here may require Coast Guard assistance and the plane shown is useful in radioing necessary instructions to its base headquarters

DISTORTION IN COMPENSATED AMPLIFIERS

(*Continued from page 24*)

The work summarized in Fig. 6 and in Figs. 2 and 3 may be regarded as a complete solution to the problem of specifying phase distortion tolerances for the uncompensated amplifier. For one has only to look at Fig. 6 and decide whether the amount of distortion shown in A or in B (or in another similar graph) is the most that can be tolerated, and the numerical factors of the design are at once determined.

The E_o-curves of Fig. 6 were obtained by replotting the first six harmonic components of E_i shifted along the time scale according to the phase characteristic given in Fig. 3, and plotting the higher frequency components as though they had no phase shift at all. The error involved in this approximation is indicated by the slight "ripple" which can be detected in the strings of points. Reference to the appropriate low-frequency points of the gain characteristic for $\alpha = 10^4$ in Fig. 2 shows that gain variation is quite negligible (less than 2 per cent). One might expect that the gain variation at high frequencies would cause a rounding of the corners as indicated in Fig. 6. How small this effect actually is can be inferred from the fact that for the same tolerance of 2 per cent, $q = 2000$, and the amplitude of the component at this frequency is one-four-millionths of the fundamental amplitude.

This example, therefore, suggests the following general procedure for estimating distortion of periodic waves. The input wave is analyzed into its Fourier components; each component is changed in amplitude according to the relative gain at its frequency, and shifted along the time axis an amount equal to the phase shift at that frequency; the changed components are then added together to make up the output wave; and finally, the output wave is compared to the input wave for changes in shape. In general, this would appear to be a very tedious effort. But the above example suggests that, as far as the wave is concerned, usually only a limited number of components are of important amplitude; and, as far as the network is concerned, usually the variations are appreciable only in a limited range of frequency.

The Phase Tangent

In concluding this discussion, it may be well to refer to the statement, widely disseminated in the literature, that the phase time shift (usually called time delay) at a given frequency is equal to the slope of the phase angle characteristic at that frequency. This is an approximate truth which may be quite useful in many cases, but which may cause serious errors if used injudiciously. The criterion is simple to appreciate and is as follows. The phase time shift is exactly equal to the slope of the phase angle characteristic for a characteristic which consists solely of lines drawn from zero or multiples of 2π on the ordinate axis. Hence if a phase characteristic can be closely approximated by tangents drawn from these points, the actual phase distortion will be closely approximated by taking phase time shift equal to the slope of the phase angle curve. But for cases in which the tangents give a poor approximation (e.g., one stage of a resistance coupled amplifier), phase time shift at a given frequency may be far from equal to the slope at that frequency.

Acknowledgments

The writers took up the theory of compensating the resistance coupled amplifier at the suggestion of Professor C. S. Draper, who had reduced the circuit to non-dimensional terms in his design studies for a pair of wide-band, high-gain amplifiers to be used in observing detonation in internal combustion engines.[3]

Sincere appreciation is expressed to Professor E. A. Guillemin, of the Department of Electrical Engineering for several interesting discussions on the subject of phase distortion.

1. Y. J. Liu and J. D. Trimmer, *Electronics*, September, 1939.
2. D. G. C. Luck, "A Simplified Method for Resistance-Capacity Coupled Amplifier Design." *Proc. I.R.E.*, 20, 1401 (1932).
3. C. S. Draper, *Journal of Aeronautical Sciences*, 5, 219 (1938).

CONSTANT SPEED RECORDING

(Continued from page 27)

ing one good feature, either overlooked or purposely disregarded by recording engineers, but retained by the present method of embossing on thermoplastics.

The introduction of 'acetate" coating on aluminum recording discs caused the return to cutting instead of embossing, since cutting was at the time a much better developed art and without any doubt had quite a few advantages. It didn't require excessive weight on the cutting head or too much equalization at average speeds and could be played back with almost any kind of pick-up and almost any kind of needle. The fine-grained structure of most nitrates used to make these "acetate discs" reduced surface noise to a satisfactory minimum and with a little training even the uninitiated laymen could learn to produce records comparable in many respects to commercial pressings. These facts account for the increasing popularity of instantaneous recorders. The facts that acetate records are much more stable to temperature changes than wax, in combination with simplified mechanical construction and the instantaneous playback feature, make their use in professional recording advantageous.

Constant groove speed, as mentioned above, made the return to embossing possible, whereas several features of this process in combination with acetates and other plastics make it desirable. The atomic structure of these materials shows a combination of hydro-carbons and crystalline substances, and the "floating" process used in the manufacture of records, brings the finest grain to the surface. The coating and hardening of the substance creates a surface tension. The combined result is a shiny "skin", the thickness of which is a function of the chemical structure, the thickness of the entire coating and the speed employed in the drying process. Considering the fact that total thickness of coating seldom exceeds 0.0065 of an inch (for cutting), it is easy to see that the skin can be measured in microns only.

Cutting disturbs the continuity of the skin, unbalancing the surface-tension. The micro-photograph in Fig. 4 (reproduced through the courtesy of the Gordon Laboratories) clearly shows at A the resulting "tear", ragged edges on the unmodulated grooves. At the same time comparatively larger grains are exposed, as is plainly visible if the dull structure of the sidewalls (B) is compared with the shiny undisturbed land (C) between grooves. Obviously, faithful reproduction of this groove will result in surface noise.

The micro-photograph of an embossed section of the same record is shown in Fig 5. The photographs were taken under identical conditions with the same magnification and are unretouched. The cut was recorded on a standard professional recorder with a new sapphire stylus by a competent recording engineer and the embossing on a standard Recordall machine. It is obvious, that the "skin" was not disturbed on the embossed record. The edges (A) of the unmodulated groove show no tear or raggedness, and the structure of the sidewalls and the bottom of the grooves (B) is just as smooth and shiny as the undisturbed land (C) between grooves. An enlargement of approximately 200 diameters does not show any source of surface noise.

Analyzing the embossing process it was found that the triple action of burnishing results in the best groove obtainable if used in combination with constant groove speed. A blunt stylus under great pressure (between 75,000 and 125,000 pounds per square inch) compresses the recording substance, the heat created by friction followed by rapid cooling, uniform at constant groove speed, hardens the groove by "heat-treatment" while the blunt smooth nose of the stylus polishes the recorded surface by burnishing. The result is a hardened, durable and smooth groove with an excellent signal-to-noise ratio.

Examining the frequency-distortion characteristics of the two kinds of recording, the cutting process has an undisputed superiority in recording. A sharper stylus under less weight, with less damping can more faithfully follow high frequency modulation. But the necessity of using a differently shaped playback needle-point and equalization necessitated by the inherent surface noise features of the cut groove, practically eliminate these advantages. The fundamental defect existing in all disc recording systems where a sharp-edged chisel-shaped cutting tool is used to form the groove, and a round-nosed needle is used in playback is the fact that these two shapes are entirely different. This condition is overcome in the method here described since the recording stylus is used in playback exactly the same as it is in recording, thus resulting in the best possible coupling and minimum distortion.

The damping effect of the plastic on the embossing stylus attentuates the high frequencies, as pointed out above. The constant groove speed on the other hand makes permanent predetermined equalization for this diminished high frequency response possible and the absence of inherent noise in the embossed groove makes this equalization practical with very little effect on the signal-to-noise ratio. Boosting the high frequencies as much as 30 db at 7000 cps was found to be quite permissible, the noise level of the resultant record when played back without equalization being still lower than that of any typical cut records.

Another glance at the micro-photographs (Figs. 4 and 5) will show also that the groove-width remains constant in the modulated track on the embossed record, but undergoes substantial variations in the cut record. This is caused by the chisel-point shape of the cutting stylus in combination with the pivoting of the armature as usually employed, causing a vertical shift of the momentary periphery of the point doing the actual cutting. The blunt nose of the play-back needle will have a noticeable up and down motion as it is squeezed out of the groove where it contracts, adding to the distortion and increasing the danger of jumping grooves. This necessitates a deeper groove in the cut than in embossing. Thus more lines per inch can be used with the embossing system without endangering the tracking of the play-back needle in the groove while the reduced depth also reduces the required thickness of the recording substance.

THE ELECTRON ART

This month's review of the technical literature includes studies in corrosion of wires, chamber resonators (klystrons), high-frequency propagation, and a description of a sensitive phototube exposure meter

Corrosion in Fine Copper Wires

ALL RADIO ENGINEERS will be interested in an article appearing in the June, 1940 issue of *Electrical Engineering*. It is "Causes of Corrosion of Fine Copper Wires Carrying a Potential" by H. N. Stephens and G. B. Gehrenbeck. Corrosion of copper in fine wire coils is a very serious problem in radio apparatus which makes use of coils of small diameter copper wire. The usual type of copper corrosion involves the formation of a green material on the surface of the wire which is obviously due to chemical reaction of the copper with materials in contact with it. As this process progresses at a given point, the cross section of the wire gradually diminishes until it finally breaks, opening the circuit and rendering the coil useless. The authors concern themselves primarily with the causes of corrosion by adhesive tapes used in the fabrication of coils, but the results have implications of much broader significance.

Adhesive tape may be considered as a combination of two functional parts—the adhesive and the backing. Glue, no matter how highly purified, was found to be highly corrosive. A rubber resin type of adhesive, on the other hand, which is widely used at the present time, is not a cause of corrosion provided reasonable care is used in its manufacture. It was discovered during the tests described that all cellulosic materials (paper, cloth, etc.) caused corrosion. The elimination of paper and all fabrics made from natural fibers led to a search for a material which would be free from corrosive nature. It was found that there are a number of materials satisfactory from a chemical viewpoint. The one which is the most economical to use and with the best mechanical properties is cellulose acetate. Tests show that there is every indication that a fine copper wire in contact with cellulose acetate will last as long as one suspended freely in air.

The article discusses the various causes of corrosion in copper and the mechanism of copper corrosion. The conclusion is made that the most satisfactory and practical construction for a corrosion-free electrical tape is cellulose acetate coated with a good quality rubber resin adhesive.

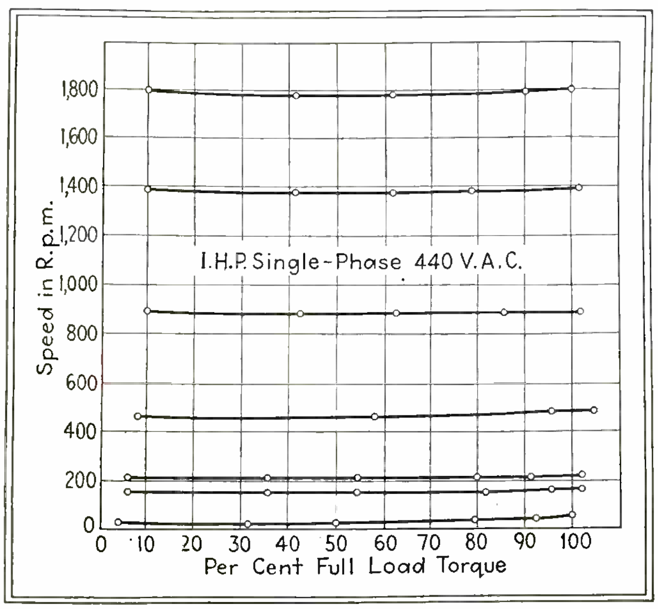
Klystron Theory

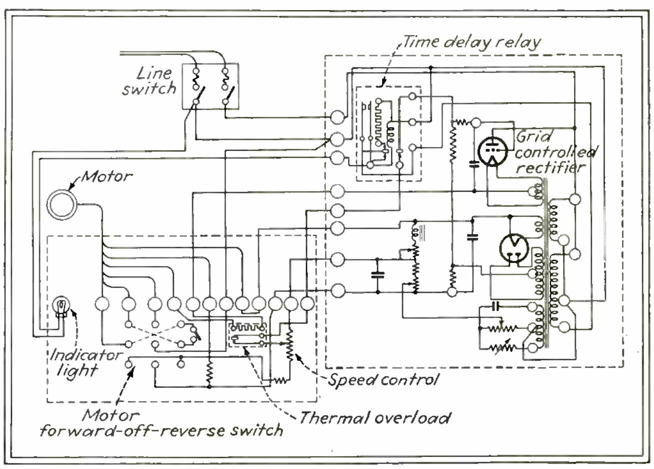
THERE APPEARS in the December, 1939 issue of the *Journal of Applied Physics* an article by David L. Webster entitled "The Theory of Klystron Oscillations." The author states that the principles governing the oscillations in a klystron may be divided into four groups: (1) those of space resonance within each rhumbatron, (2) the equations of coupled circuits with modifications appropriate to space-resonant systems, (3) the kinematics and dynamics of cathode-ray bunching and (4) the constraint on phase relations between the rhumbatrons introduced by the cathode-ray bunches. It is shown that the fourth group makes the oscillations assume very different forms from those familiar in free oscillations. The general equations of these forms are given and applied to three specific problems: Obtaining the maximum power output from an oscillator, minimizing the power input and determining the frequency stability which changes the cathode potential.

Electronic Speed Control

A VERY INTERESTING APPLICATION of electronics to an engine lathe is described in the June, 1940 issue of *Product Engineering*, in an article entitled "Variable Speed Through Electronic Control." A conventional grid-controlled rectifier system controls a commutator-type single-phase motor which drives the lathe. In addition to maintaining rigid speed regulation and flat speed-torque characteristics, the speed is automatically maintained at any pre-set figure.

The acccompanying diagram shows how the speed is maintained constant over the range from no load to full load and from approximately 25 rpm to 1,800 rpm. An interesting aspect of this device is that it has been in operation since 1933 without the replacement of any parts being necessary.



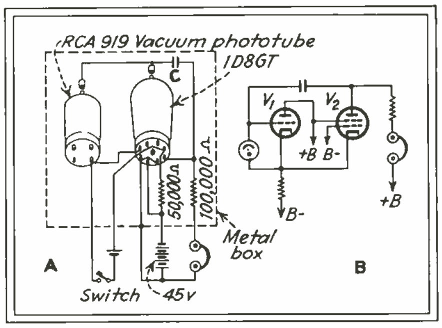


Above, circuit diagram of electronic speed control which maintains rigid speed regulation at any speed

Speed regulation curves of electronic speed control

Exposure Meter for Photographic Enlarging

"A Simplified High Sensitivity Photometer or Exposure Meter for Photographic Enlarging" is the title of an article by Walter van B. Roberts, which appeared in the May, 1940 issue of the *Review of Scientific Instruments*. In the instrument described, the telephone receiver is substituted for a meter so that an extremely simple system of few parts will equal the sensitivity of an instrument with an amplifier. The circuit diagram is shown at *A* in the accompanying figure. It is essentially a relaxation oscillator which causes a series of clicks to be heard in the high impedance telephone or loudspeaker. The frequency of these clicks is proportional to the intensity of the light falling on the phototube and inversely



Circuit diagrams of simple exposure meters for photographic or other purposes. Diagram A is for battery operation and B is for alternating current

proportional to the capacity of condenser *C*. Measurements may be made by noting the value of *C* required to produce a standard number of clicks in a standard time, by counting the number of clicks in a standard time, by adjusting the amount of light falling on the phototube by varying an iris diaphragm through which the light is admitted until a standard click frequency is obtained or by any combination of these methods.

The sensitivity of the instrument is limited only by the leakages across condenser *C* and from the cap connections on the tubes. The tubes should be carefully cleaned with alcohol and to further reduce leakage due to atmospheric humidity, the upper portions may be dipped in melted ceresin wax. If these precautions are taken with a condenser of 25 microfarads in the circuit there should not be more than about two clicks per minute in total darkness, while a candle 30 feet away will give about 45 clicks per minute.

For photographic enlargement work it is convenient to inclose all the parts except the batteries and receiver in a small flat metal box which is grounded to the circuit. In this arrangement the phototube should be shielded from the light of the filament of the other tube. It is essential to turn off all safelights during photographic measurements because of the high sensitivity of the phototube to red light.

The values of the resistors are not critical and those shown are illustrative. The instrument can be adapted to use for alternating current by the use of the circuit shown at *B* in the diagram and provided that tube V_1 has its grid connection at the top of the bulb.

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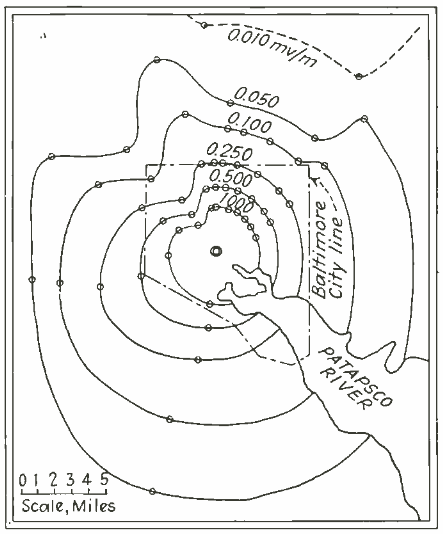
High-Frequency Propagation

Messrs. F. Hamburger, C. V. Larrick and Martin Jones report the results of an urban field-strength survey performed by them at a frequency of 35.6 Mc, in an article entitled "High-Frequency Propagation Characteristics" in the April, 1940 issue of the *Proceedings of the I. R. E.* The survey was performed in the urban and suburban area of Baltimore, Md. The transmitter radiated amplitude modulated signals and was located near the center of Baltimore in an area surrounded largely by dwelling houses. The antenna was a half-wave vertical radiator connected to one side of a quarter-wave matching section fed through a coaxial transmission line from the transmitter located near the base of the 165-foot tower on top of which the antenna was located. Another antenna system covering the same configuration was located at a point only 35 feet above the ground and was overshadowed by buildings on at least two sides. The transmitter had a power output of about 150 watts.

The accompanying diagram shows the field-intensity contours in the vicinity of Baltimore in millivolts per meter using the high antenna. The following conclusions were drawn from the experimental results: 1. The Beverage inverse square or propagation formula (*RCA Review*, January, 1937) predicts in a satisfactory manner the field strengths obtained from an antenna of moderate height situated in



Field intensity contours at 35.6 Mc in the vicinity of Baltimore, Md., measured by Hamburger, Larrick and Jones

an urban area and radiating over hilly terrain. 2. The signal strength varies inversely as the square of the distance for points between the transmitter and the horizon and inversely as the 3.6 power of the distance beyond the horizon. 3. The slope of the terrain in the immediate vicinity of the transmitting antenna has a marked effect on performance. If the ground slopes downward from the transmitter for a mile or more in some direction, the performance in that direction will be relatively good. If the ground slopes upward in some direction, the performance in that direction will be relatively poor. The Beverage formula predicts the performance in the more favorable directions. 4. A spread in the observed field strengths of from one third to three times the mean or predicted value is to be expected. It is the opinion of the authors that a careful study of contour maps is well repaid in a survey of this type.

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Frequency Stability

THE INHERENT STABILITY of oscillators has been the subject of considerable interest in recent months due to increased activity in the higher frequencies. An article discussing this subject is "The Limits of Inherent Frequency Stability," by Walter Van B. Roberts in the April, 1940 issue of the *RCA Review.* The causes of frequency variations may be separated into three groups: First, charges in the constants of the frequency determining circuit itself; second, changes introduced by the loading on the circuit, and third, changes in the effective input and output impedances of the oscillator tube which are reflected into the circuit by the necessary coupling of the tube to the circuit. The discussion in the article is confined to the third group.

After considerable discussion including a description of practical circuits the author reaches the following conclusions: (1) The fundamental frequency should be as low as possible; (2) the "Q" of the coil should be as large as possible at the fundamental frequency. This means that the coil should be as large physically as there is room for it within the shield can, subject to reasonable clearance; (3) the loosest coupling between the tuned circuit and the tube that will give the required output and a small enough bias resistor so that the effective transconductance in the oscillating condition is not seriously reduced should be used; (4) the oscillator tube should be one which has a high ratio of transconductance to capacitance fluctuations when operating at the required level; the oscillation strength should be kept constant as the ratio between the grid and plate coupling vary. The author also recommends that any or all the tricks known to the trade be added.

IMPROVING RADIATOR EFFICIENCY

(*Continued from page 34*)

top of the antenna, the size of the coil will be reduced as the capacitance is increased (capacitive reactance decreased). Hence, by this means losses in this coil may be considerably reduced by using the largest capacitance consistent with unrestricted mobility.

In addition to these methods, the current in a line may be increased by lowering the surge impedance of the line. When considering an antenna such as shown in Figure 1 as an open wire line, the spacing of the line varies linearly along the line. Since this variation is not logarithmic this gives rise to some reflection loss. However, the magnitude of this effect with short antennas is slight. On the other hand, the surge impedance is also controlled by the conductor diameter and by increasing this, it is possible to lower the surge impedance and increase the current.

The data plotted in Figure 3 show the experimental verification of these facts and point out their relative magnitudes. The curves show relative field strength in decibels vs the ratio of current at the top of the main radiating section to that at the bottom. This ratio serves to indicate the actual current distribution. Power input was maintained constant and the zero reference level indicated is the field strength of a typical base loaded fish pole of the same over-all height and with the same input power. These data at once show that worth while gains are to be had from such an approach. It should be noted that, as predicted, the optimum distribution is not that of Figure 2G, but something slightly different. Furthermore, it has been found that variation of the magnitude or distribution of the losses will alter this optimum distribution considerably. The optimum ratio per cent in different installations has been found to vary by as much as 30 per cent. Hence, unless an installation is identical to a previously tuned one, it must be tuned by adjusting the top coil and reading relative field strengths after the system has been brought into resonance each time by the base tuning. The number of turns in the top coil for a particular case is shown in Figure 5 and it is clearly evident from the steepness of the curve that the coil must be adjusted turn by turn. It is recommended that a complete run be taken and then the coil be rewound to the correct number of turns. Figure 2 will be found helpful in providing the correct reactance at the base to produce resonance each time.

The original tests shown in Figure 3 were made on 2496 kc with dimensions similar to those of the unit shown on the automobile in the accompanying photograph. The main radiating section is, of course, considerably less than the over-all height including whip in order not to restrict mobility beyond that of the fish pole type. The use of a three inch duralumin pipe for the main radiating section represented an increase in diameter of 47 times over a No. 12 wire and an increase in field strength of 1.3 db as shown by Fig. 3. The pipe also adds mechanical strength for support of the can and coil at the top. The whip is used to increase the capacitance and to carry some current to greater heights.

The original antenna has been demonstrated to a number of highway and marine services with excellent results. Satisfactory phone coverage for highway patrol use has been obtained on 2496 kc up to 40 miles using 15 watts input to the antenna. In several cases complete coverage has been obtained in areas which contained many dead spots with existing equipment of the same or greater power. A marine installation on Lake Meade at Boulder Dam has given 100 per cent coverage in an area which contained many dead spots with a base loaded antenna seven feet higher.

A complete discussion of this work, including detailed photographs and diagrams, is available in "A Report On Mobile Antennas For The Intermediate Frequencies" by W. C. Hilgedick, Radio Engineer, National Park Service, 601 Sheldon Building, San Francisco, California. A detailed discussion was also presented by the writer as a thesis to Leland Stanford, Jr. University, Stanford University, California, for the degree of Engineer.

[1] C. A. Nickle, R. B. Dome, W. W. Brown, "Control Of Radiating Properties Of Antennas". *Proc. I.R.E.*, Vol. 22, No. 12.

[2] R. B. Dome, "Increased Radiating Efficiency For Short Antennas". *QST*, Vol. 18, No. 9.

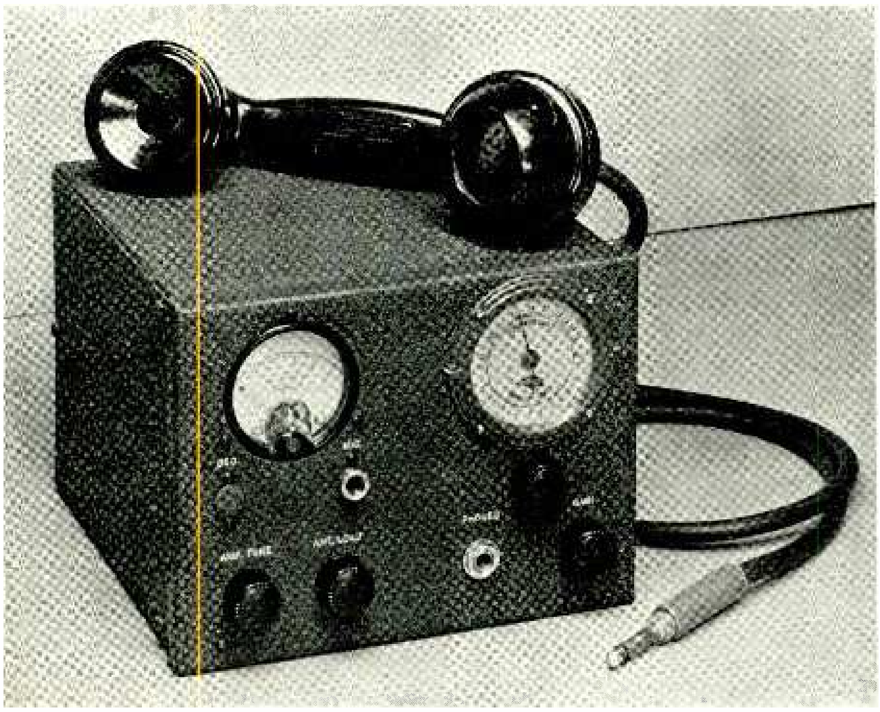
THE INDUSTRY IN REVIEW

News

✦ The immediate opening of a new west coast office to handle increased sales and service activities has been announced by Sperry Gyroscope Co. . . . Danziger Radio Labs., 119 West 57th St., New York City, announce a custom radio service. High fidelity radios, phonographs and special apparatus will be designed and custom built to individual requirements . . . Jas. R. Fouch, President of Universal Microphone Co. has been granted patent number 2,198,080 as an additional patent on Universal's cutting head for recording machines . . . Associated Research, Inc., have moved to new quarters at 431 S. Dearborn St., Chicago . . . RCA and the *New York Post* are publishing an experimental radio facsimile newspaper in the RCA Exhibit Bldg. at the New York World's Fair . . . The C. S. Brainin Div. of I. Stern & Co., manufacturers of electrical contacts, have moved to new and larger quarters at 233 Spring St., New York City . . . Howard J. Tyzzer, former Chief Engineer of the household radio division of Crosley Corp. has been made Superintendent in charge of Finch Telecommunications Inc., facsimile plant in Passaic, N. J. . . . Jefferson-Travis Radio Mfg. Corp. have moved from Baldwin to 136 West 52nd St., New York City . . . Mr. Lenox Lohr, has resigned his position as President of NBC to become President of the Chicago Museum of Science and Industry . . . Lester S. Lappin, formerly with Federal Telegraph, has joined the engineering staff of Harvey-Wells Communications, Inc. . . . A. C. Callen, Dean of Lehigh University announced the appointment of Loyal V. Bewley to head the Department of Electrical Engineering . . . Construction of a new factory has been started by G-M Labs., Inc., of Chicago, to provide larger manufacturing and research facilities for its widely diversified line of products.

Literature

Sound Equipment. Catalog F-40 contains information on the various types of speakers, microphone stands, connectors, etc., available from Atlas Sound Corp., 1443–51 39th St., Brooklyn, N. Y.



Designed particularly for private plane operation, this new development of Harvey Radio Laboratories contains an extremely sensitive 5 tube receiver, including one multi-purpose tube, which give it the effectiveness of a 7-tube receiver. The receiver is for use on 3105 kc. It is an exceptionally small and compact battery-operated combination transmitter-receiver

MALLORY ISSUES INDUSTRIAL ELECTRONICS CATALOG

A new 1940 catalog of "Approved Precision Products" especially designed to interest buyers in the industrial electronics field has recently been issued by P. R. Mallory and Company, Inc. of Indianapolis, Ind. The catalog, besides describing the standard Mallory lines of resistance controls, switches, plugs, jacks, connectors, wire wound resistors, paper, transmitting and electrolytic capacitors, vibrators, etc., gives full details on the alloys, bi-metals and electrical contacts available from the Mallory Metallurgical Division. Promotional plans in the Mallory distributors set-up are underway to stimulate interest in sales to non-radio users of electronic circuit parts and components.

Reactance Chart. A reactance chart is contained in a 32-page catalog (No. 160-T) on radio transmitter capacitors available from Cornell-Dubilier Corp., South Plainfield, N.J. This book gives rather complete information on capacitors and includes diagrams.

Engineering Handbook. This loose-leaf type handbook which contains 73 pages, gives full sized detailed drawings of all Bernard pliers and plier action tools. The price of the book is 25¢. Wm. Schollhorn Co., Engineering Dept., New Haven, Conn.

Receiving Tube Handbook. This book published by Ken-Rad Tube & Lamp Corp., Owensboro, Kentucky is of particular interest to radio set manufacturers, radio engineers, and set designers. The Handbook shows the ratings, characteristics and curves of recommended types of receiving tubes sufficient in number and circuit function to meet design requirements of most radio receivers.

Two-way Speaker. Model 816, Iconic System, two-way speaker is illustrated and described in bulletin 4-B available from Lansing Mfg. Co., 6900 McKinley Ave., Los Angeles, Cal.

Ferris Instruments. Several bulletins describe such instruments as Model 22A Signal Generator, Standard Signal Generator Models 16C and 14C, Microvolter Models 20A and 18B, Radio Frequency Calibrator Model 33, and Radio Noise and Field Strength Meter Model 32. Ferris Instrument Corp., Boonton, N. J.

General Catalog. Bulletin No. 240 (which supersedes No. 225) illustrates and describes components for receivers, transmitters, television, sound equipment, and experimental work. Crowe Name Plate & Mfg. Co., 3701 Ravenswood Ave., Chicago.

Cathode-ray Tube and Equipment Data. Available cathode-ray tubes and laboratory equipment such as 3, 5 and 9 inch oscillographs and the electronic switch, together with commercial television equipment including cameras, synchronizing signal generators, monitors and transmitters, are described in the DuMont General Catalog B just issued. Allen B. DuMont Labs., 2 Main Ave., Passaic, N. J.

Converter. Bulletin 106 contains data on a new 5-10 meter converter for use with both mobile and home receivers recently announced by Browning Labs., Inc., Winchester, Mass.

Cathode-ray Oscillograph. The 8 pages of this two-color bulletin deal with cathode-ray oscillograph functions generally, and the features of the Type 208 in particular. Available from Allen B. DuMont Labs., Passaic, N. J.

Engineering Data Sheet. Beryllium Corp. of Pennsylvania have just issued Vol. 1, No. 1, of the "Engineering Data Sheet" which covers the subject of the beryllium alloys, giving physical properties, heat treating data and other information of interest to the design and engineering field.

World Time Conversion Chart. A chart that enables radio listeners to compute the time of day at any point on the globe has been made available by General Electric Co., Schenectady, N. Y. To meet the demand from listeners in South America and Europe, the chart has been printed in Spanish, Portuguese and French as well as English.

Vinylite Resins. Detailed recommendations on how to machine and fabricate vinylite resins by common woodworking and metalworking methods are given in a new booklet "Fabricating Processes for Vinylite Resins" available from Carbide and Carbon Chemicals Corp., 30 East 42nd St., New York City.

Service Instruments. "Condenser Quick-Check" (Bulletin QC) describes instruments available from Solar Mfg. Corp., Bayonne, N. J. Another bulletin (Form RC-10) is devoted to a description of "Red-Caps" dry electrolytic condensers.

Measuring Instruments. Instruments for measuring speed, frequency and rates of vibration are described in Bulletin 1650 available from Jas. G. Biddle Co., 1211 Arch St., Philadelphia, Pa.

Communication Products. Three bulletins are available from Communication Products Co., 245 Custer Ave., Jersey City, N. J. Bulletin 122 describes co-axial half-wave antennas for receiving and transmitting; Bulletin 123 tells about "Magicseal" solderless sealing elements for coaxial transmission lines; and Bulletin 124 deals with solderless fittings for ⅞ inch transmission lines.

Voltage Multiplier. A voltage multiplier for use with the vacuum-tube voltmeter at radio frequencies is described in Vol. XIV, No. 12, of the "Experimenter" available from General Radio, 30 State St., Cambridge A, Mass.

Sound Systems. Catalog No. 150, 1940–41, contains data and illustrations of Clarion products available from Transformer Corp., of America, 69 Wooster St., New York City.

Temperature Measuring Instruments. Anyone interested in indicating, in recording or in controlling temperatures automatically will find of value N-33 bulletin just issued by Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia, Pa.

New House Organ. Vol. 1, No. 1, entitled "D-H Alloy Craftsman" is a new house organ to be issued by Driver-Harris Co., Harrison, N. J. This first issue contains an article on "The Cathode-ray Tube."

High-voltage Capacitors. Cornell-Dubilier Electric Corp., South Plainfield, N. J. have just published a special catalog (No. 180X) describing high-voltage capacitors for heavy-duty X-ray and impulse or surge-generator applications.

Sound Projector. A 10 page booklet presents the new RCA 16-mm motion picture sound projector, and illustrates many of its outstanding features. RCA Mfg. Co., Camden, N. J.

Receiving Tube List. The data contained in this "Receiving Tube List" was prepared for the dual purpose of supplying information indicating interchangeability of one type with another and the identification of newer types as to functon and purpose. Ken-Rad Tube & Lamp Corp., Owensboro, Kentucky.

Wire Wound Resistors. Instrument Resistors, Inc. (Little Falls, N. J.), who specialize in wire wound resistors have issued a nicely bound catalog which contains information about their various products. A table of continuous working currents and voltages is also included in this catalog.

Amphenol Products. Vol. 1, Nos. 4 and 5 of "The Amphenol News" are available from American Phenolic Corp., 1250 W. Van Buren St., Chicago. In No. 4 issue is included an article on "The Engineering Design of Coaxial Cables" while No. 5 tells about Amphenol's new "AN" series electrical connectors for aircraft, marine, electrical and electronic, use.

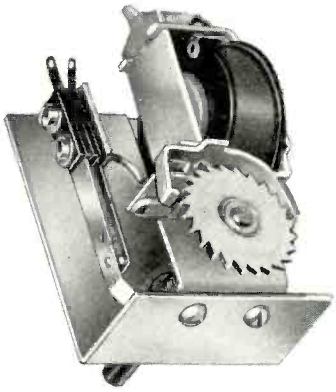
General Products. Burton-Rogers Co., 857 Boylston St., Boston, Mass., have available a catalog which describes ammeters, voltmeters, milliammeters, switchboard instruments, as well as portable instruments.

Transformers. A 12 page catalog is devoted to data about constant voltage transformers available from Sola Electric Co., 2525 Clybourn Ave., Chicago.

New Products

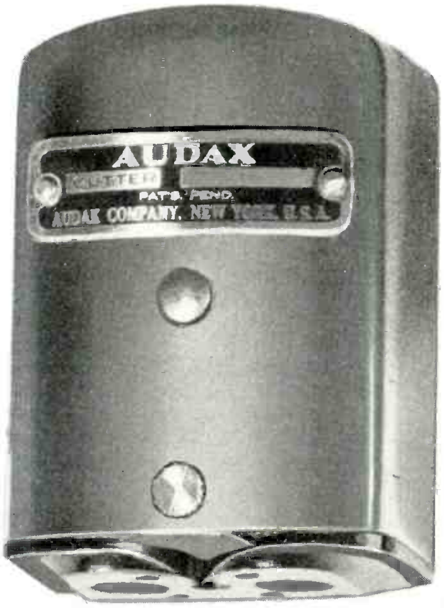
A-C D-C Counting Unit

A NEW DEVELOPMENT for use in the field of wired music is a sensitive a-c coin counter, a product of the Advance Electric Co., 1260 W. 2nd St., Los Angeles, Cal. Designed and constructed to be as compact as possible without loss of efficiency, these units are available for operation over a wide range of a-c and d-c voltages.



Cutter

Audak Company, 500 Fifth Ave., New York City announces a new high fidelity cutter which overcomes the great retarding factor in instantaneous recording,—distortion. This new audax cutter has a flat response to over 9000 cps and has a negligible distortion factor. The manufacturer feels that it fills an important gap in instantaneous recording technique. In engineering, materials, finish etc., this new cutter is up to the usual standards set by the Audak Comapny.



Small Motor

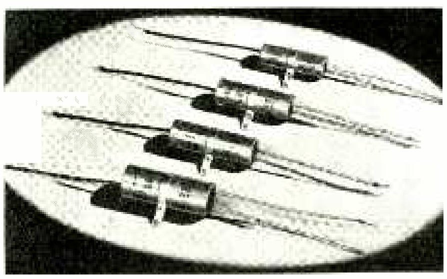
This new small motor available from Eicor Inc., (515 S. Laflin St., Chicago) was designed to give smooth, trouble-free performance in exacting aircraft service, or for bandswitching, antenna reels, or any type of remote control. It delivers 1/13 hp at 8500 rpm. The dimensions are 2 5/16x2 3/4 inches, and it weighs 1 1/2 lbs.

Cutting Stylus

For recording direct on all coated aluminum or paper base discs, H. W. Acton Co., Inc., 370 7th Ave., New York City, have a cutting stylus individually lapped for quiet, high quality cutting.

Capacitors

A new Type BRH capacitor is available from Cornell-Dubilier Electric Corp., S. Plainfield, N. J. Capacities range up to 500 μf at 25 volts, 1000 μf at 15 volts, and 2000 μf at 6 volts. In circuits where it has heretofore been necessary to parallel two or more conventional high-capacity units to obtain the required high values for certain cathode by-pass and resistance-capacity filter applications it is now possible to obtain the same effectiveness with less bulk and at lower cost. Dimensions vary from 5/8x1 1/16 inches for smaller sizes, to 1x2 1/2 inches for high capacities. A choice of either pigtail or lug terminals is provided.



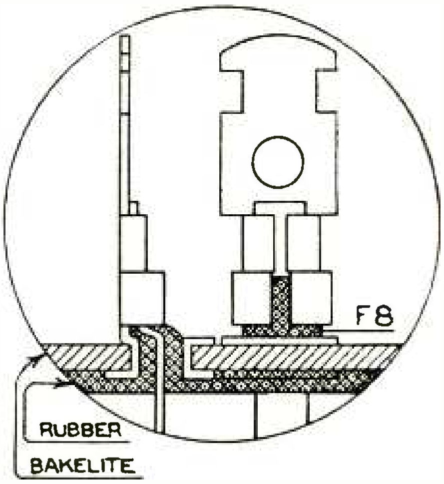
Dynamic Cutter

A dynamic cutter with a frequency range of 9000 cps and an impedance of 6 ohms can be connected to any loud speaker (low impedance) outlet, and since the impedance does not vary with frequency, no matching problems exist. This cutter, for lateral recording, is available from Sound Apparatus Co., 150 West 46th St., New York City. Its driving power is 1 watt, it weighs 7 ounces, and measures 1x1 1/2x2 inches. Damping is obtained entirely by air.

Electrolytics

Aerovox Corp., (New Bedford, Mass.) announce their PRS Dual Dandees condensers; the PRS 450 8-8 and the PRS 250 16-16 measure 1x2 1/2 inches, while the PRS 150 20-20 measure 1x1 1/2 inches. The units have two entirely independent sections and four leads, permitting the use of either section and either common positive or common negative connections.

Several improvements have been made on Aerovox's Series AF units which supersede the former F series. Improvements include positive sealing of base and prongs, reduction of possible corrosion to an absolute minimum, and better mechanical construction obviating the shearing of tabs and the loosening of internal connections.



Break-In Relay

The Staco break-in relays, commonly known as push-to-talk relays, come in two types BBA and BMA depending upon the insulation used, triple-X or mycalex. The BB series is insulated for operation up to 15 Mc and the BM series for 60 Mc. Obtainable from Standard Electrical Products Co., St. Paul, Minn.

New Meter Line

THE DEJUR-AMSCO CORP., Shelton, Conn., announces its entrance into the meter manufacturing field and is now in production on a complete line of ammeters, milliammeters, microammeters and voltmeters in 2, 3 and 4 inch sizes, round and square cases. This line is primarily intended for manufacturers of radio, recorder, transmitter, service and miscellaneous electrical equipment.

Spot Welder

THE EISLER ENGINEERING CO., OF NEWARK, N. J., has introduced a 5 kva high speed production spot welder. This welder is an air operated, vertical press type machine supplied with a suitable automatic timer and contactor. There are two operators for this welder, one to load the welding fixture and the other to operate the foot switch and slide the fixture along after each weld. A speed of 150 spots per minute can be attained.

Communication Receiver

RCA Mfg. Co., Camden, N. J., present the AVR-20 aircraft communication receiver which is similar in appearance to the AVR-15 radio range receiver and was built to operate in connection with it. It is tunable through a frequency range of 2300 to 6700 kc and provides for crystal controlled reception on any two frequencies within these limits. A beat frequency oscillator is provided for CW reception. An RCA-991 voltage regulator tube is used to maintain stability of voltage on r-f oscillator. The light weight of the receiver permits installation in almost any convenient location on even the smallest aircraft.

Speech Input Equipment

The newest portable speech input equipment, Type 22D, announced by Western Electric Co., 195 Broadway, New York City, features durable lightweight duralumin construction and complete studio channel amplifier and control facilities in an extremely small space. The new apparatus operates from microphones of 30 ohms impedance into wire lines. Facilities for a degree of equalization is also provided when used with cable loops. The frequency response of the equipment is flat within one db from 30 to 10,000 cps. Maximum flexibility of operation is gained through the use of four parallel mixers and a master gain control. A catalog is available which describes the unit in detail

Thermo Regulator

Thermostatic accuracy of 1/10 of 1 deg. is possible with the new low-priced "Thermolett", a product of Standard Controls of New York. This device utilizes a vacuum tube, is set at the factory, sealed in glass and connected at the point of control with ordinary electric wiring. The Thermolett is wired to a control box, which may be placed at any desired distance from the point of control without loss of accuracy and without additional expense. Because of the two-unit construction of this new temperature control, it is possible at small additional cost to check several points independently.

Electronic Photometer

Accurate and rapid determination of Vitamins A and B_1 is possible by the Bills and Wallenmeyer electronic photometer. The basic principle is the photoelectric measurement of ultra violet light absorbed by vitamin A solution. The light source is an argon lamp which exhibits bands within the vitamin A absorption band. These lines are isolated by means of filters which absorb all other light to which the phototube is sensitive. The instrument is accurate, speedy and portable. It is made by the Schoene Equipment Co., 1411 Lodge Ave., Evansville, Ind.

Tube Tester

Radiotechnic Laboratory, Evanston, Ill., announce Model 120 designed to accommodate any possible combination of heater and control elements of all existing sockets. In the event of new sockets appearing on the market, space is provided, and wiring would only be made to an adjacent socket. Three d-c voltage ranges, 0-10, 0-100 and 0-1000, are available for the testing of batteries and d-c power supplies.

Autotone Transmitters

High frequency transmitters with power outputs ranging from 500 to 3000 watts embodying the Autotone frequency changing device are available from Collins Radio Co., Cedar Rapids, Iowa. Until recently these transmitters were made on a custom or contract manufacturing basis but are now available as standard equipment. Model 231C is for all high frequency services even where only one or two frequencies are actually employed. An elaborate bulletin which describes Model 231C autotone transmitter is available from Collins.

Midget Relay

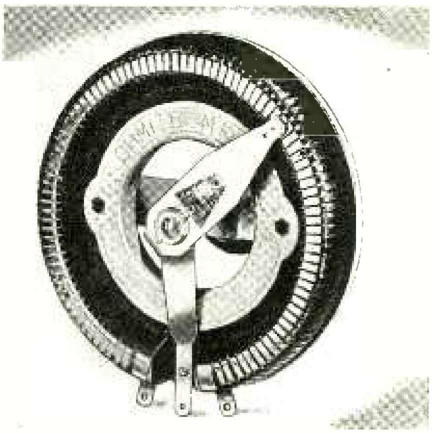
Bulletin 105 describes a midget relay marketed by Ward Leonard Electric Co., Mount Vernon, N. Y. Designed for use on either ac or dc, the relay is available with contacts arranged for single pole, normally open, normally closed or double throw. It is rated to handle 1 hp, and is furnished with coils for operation on standard voltages, either ac or dc up to 110/115 volts at standard frequencies. On 220/230 volts, coils can be supplied for not less than 50 cycles.

Electric Connectors

American Phenolic Corp., 1250 Van Buren St., Chicago, announce a new AN series of electrical connectors for aircraft,. radio broadcasting, marine, telephone, and industrial controls designed in accordance with U. S. Army-Navy Procurement Specification AN-9534. These connectors are completely described in the May 1940 issue of "*Amphenol News*."

Rheostats

Model T (750 watt vitreous enameled rheostats) is a new unit filling in between the 500 and 1000 watt rheostats available from Ohmite Mfg. Co., 4835 Flournoy St., Chicago. This model is 10 inches in diameter, with a ⅜-inch shaft, and can be regularly supplied to mount on panels up to 1¼ inches. The construction of Model T is similar to other Ohmite rheostats. Ohmite vitreous enamel rheostats are now available in 25, 50, 75, 100, 150, 225, 300, 500, 750 and 1000 watt models in a wide range of resistance values, and in straight or tapered windings.



Loud Speakers

Jensen Radio Mfg. Co., 6601 S. Laramie Ave., Chicago announce two new improved loudspeakers, Model SPH-8 and Type "S" Peri-Dynamic. SPH-8 is an all-purpose projector which employs an especially designed permanent magnet loudspeaker sealed into an enclosure. The air stiffness within the enclosure is exactly suited to the radiator. The result is a sharp improvement in the middle frequency response and an assured quality of crispness and intelligibility. In addition, the entire lack of radiation from the back of the projector is of great advantage in eliminating feedback trouble. It is weatherproof, easily handles 25 watts, and electrical access is gained by a strong bayonet type separate plug and socket assembly. Type "S" Peri-Dynamic projector employs a heavy duty permanent magnet speaker capable of handling 15 to 25 watts of power input. It is similar in characteristics to SPH-6.

Rotary Converters

Pioneer Gen-E-Motor Corporation, 466 West Superior Street, Chicago, Illinois announce a new line of Pincor rotary converters. The line comprises units of every size, type and capacity for operating radio receivers and transmitters, power amplifiers, PA systems, electrical musical instruments, gaseous signs, and other equipment requiring alternating current. These converters are available less filter or with filter (the latter for the operation of radios or sensitive sound apparatus) for converting 6, 12, 24, 32, 48, 110, 220 or any special d-c voltages to 110 or 220 volts ac. Capacities are 40 to 5,000 watts.

Television and Radio Receiver

Allen B. DuMont Labs., Inc., Passaic, N. J., offer a new Model 195X television and radio combination receiver. A 20-inch diameter teletron provides an image measuring 11¼x15 inches. It is a console type and has a 12 inch dynamic speaker, and a push-pull 10 watt audio amplifier. The television controls are simple to operate, and provide a choice of five television bands. Broadcast programs are tuned in by dial or pushbutton.

Break-In Switch

Microphone modernization is offered by the new Atlas Sound Corp., (1447 39th St., Brooklyn, N. Y.) in their break-in switch which offers on-off or press-to-talk operation. It is completely wired and can be attached to any microphone.

50 Watt Amplifier Unit

RCA Mfg. Co., Camden, N. J., announce a low priced 50 watt amplifier complete in one unit and designed for general PA applications where high power and low cost are the principal considerations. Frequency response is essentially flat between 50 and 10,000 cps, within 3 db. A terminal board is provided with output impedances of 4, 7½, 15, 60 and 250 ohms. By making certain indicated connections, additional impedances from 0.05 to 192 ohms may be provided.

Terminal Amplifier

A new 8 to 10 watt amplifier designed to meet modern PA requirements has been announced by the Terminal Radio Corporation 68 West 45th St., New York City. The frequency response permits this new model T-8 to be used in homes with good record players and frequency modulation tuners. Its audio power capabilities provides amplification for audiences up to 500 persons indoors or outdoors coverage of up to 3000 square feet. It has two high impedance input channels for microphone and record player, with complete mixing and fading features of good quality.

I.R.E. AT BOSTON

(*Continued from page 21*)

preliminary work had shown no great advantage in using f-m as against a-m for aircraft communication work.

W. L. Barrow and F. D. Lewis of M.I.T. then discussed two phases of the M.I.T.-C.A.A. microwave blind-landing project, which has been described in some detail in *Electronics* (November, 1939, page 12). The utility of horn structures as radiators for glide path, localizer (left-right indication) and marker beacon transmissions were reviewed by Dr. Barrow and a practical receiver for 700 Mc reception was described by Mr. Lewis.

Marcel Wallace described and demonstrated his panoramic reception system which was reviewed last month in *Electronics* (June, 1940, page 14). Three separate 125 Mc oscillators were set up and an oscilloscope trace of their signals formed on the panoramic receiver to show how the position of the receiver with respect to the transmitters (which might be beacons on an air route) might be continuously determined.

The final paper in the aircraft radio session, delivered by D. G. C. Luck, described in detail the omni-directional beacon system which has been under development in the R.C.A. Laboratories at Camden. Five vertical radiators operating on 125 Mc are used to form a combination of two reversing figure-eight radiation patterns and two circular patterns which are so changed in phase to produce an overall cardioid pattern which rotates continuously about the axis of the system. The radiation is keyed out as the maximum lobe of the pattern passes the northerly direction. The receiver in the plane uses a cathode-ray indicator on whose face a circular trace appears. On the circumference of this circle a short v-shaped notch appears which marks on a compass scale the direction of the transmitting station with respect to the position of the plane (but independently of the direction in which the plane is flying). A deviation indicator is also available to show the pilot just how much correction to apply to compensate for drift in flying a given course.

Session on Large Vacuum Tubes

Prof. E. L. Chaffee opened this session by delivering a talk on "Optimum Conditions for the Operation of a Class C Amplifier." Through the use of a series of graphical plots and three dimensional models representing the static characteristics of the amplifier tube, it was shown that the operation of a Class C amplifier at specified plate voltage is a function of three independent variables: (1) the direct grid voltage or bias, (2) the alternating grid or driving voltage, and (3) the alternating component of the plate voltage. While the graphical method required to determine these optimum conditions is rather lengthy, the method has considerable educational and academic merit in outlining the mode of operation of Class C amplifiers.

The second paper in this group, entitled "Power Tube Performance as Influenced by Harmonic Voltage" by R. I. Sarbacher showed that the efficiency of a power amplifier could be increased by introducing, in proper phase, a second or third harmonic voltage into the grid or plate circuit. Harmonics of higher order were, in general, undesirable. Maximum improvement resulted when the power tube was operated as a Class C amplifier; when the tube is operated as a linear amplifier or as a grid or plate modulated amplifier, the benefits derived are less pronounced and may even be detrimental.

A method has been developed for calculating the performance of a plate modulated power amplifier with resistance bias. The results of this method explain, theoretically, the improvements in performance resulting from the injection of the harmonic voltage. The harmonic voltage must be introduced by an external generator, and cannot be produced by tank circuits tuned to the harmonic. A typical case was cited in which the injected power at the third harmonic was 10 per cent of the power output delivered by the amplifier.

J. E. Shepherd delivered a talk on "High Frequency Doublers" and showed that the efficiency and power output of a frequency doubler could be materially increased by the introduction of small amounts of power of higher frequencies in the grid and plate circuits of the doubler stage. An analytical discussion of the reasons for this improved operation was given, and circuits showing various methods of injecting the higher frequency voltages were shown.

E. L. Chaffee delivered another paper on "Space Charge Relations in Triodes and the Characteristics Surface of Large Vacuum Tubes", the purpose of which was to show a simplified method of determining static characteristics from a relatively few measurements at low voltages. The new graphical plot is based on the fact that the grid, plate, and total currents vary as the 3/2 power of the plate voltage in the absence of secondary emission and when proper allowance is made for contact potentials.

A particularly instructive paper, entitled "Equivalent Electrostatic Circuits for Vacuum Tubes" was delivered by Prof. W. G. Dow. Although inherently little new material was presented, the presentation was unusually lucid and is important to the electrical engineer since it permits him to gain an understanding of tube operation based only on well established electrostatic circuits without the introduction of vacuum tube theory. The method is based on the fact that the electrostatic capacitances of a triode may be represented by three capacitances connected in a star arrangement, the magnitudes of the star capacitances being directly related to the geometry of the tubes.

I. E. Mouromtseff spoke on the design of air-cooling radiators for large power tubes based on the general laws of heat transfer from the hot anode to cooling medium of water or forced air. Calculated data was compared with experimental observations and the conditions for optimum cooling by forced air were given.

A comparison between forced air and water cooling of the anodes of large power tubes was given by W. G. Moran. An air-cooler for tubes having plate dissipation up to 30 kw was discussed.

Upon conclusion of these papers, an informal discussion of the problems in the design, rating, and use of power tubes was conducted by

Prof. Chaffee. Grid dissipation, secondary emission effects, and permissible overload under certain conditions were discussed by Messrs. Chaffee, Mouromtseff, Mendenhall, and Nottingham.

Television Developments

Seven papers presented in the session devoted to television reviewed several significant developments of the past year. C. D. Kentner of R.C.A. in Camden described the 25-watt, 300-Mc portable television transmitter designed for outside pick-up relaying. This transmitter employs an 807 crystal oscillator, an 829 tripler, two 1628 triplers and a 1628 push-pull final amplifier. The total frequency multiplication is 18 times. The video modulator is flat from 30 cps to 6 Mc, and is capable of fully modulating the output with 2 volts peak-to-peak input. The equipment is built so as to be readily portable and may be carried conveniently in a taxicab. W. H. Hickok of R.C.A. in Harrison described two new iconoscopes. One, intended for experimental use by amateurs, is mounted in the envelope of a standard 2-inch oscilloscope tube, contains a mosaic at right angles to the scanning beam, and delivers the signal to the external circuit by capacitive coupling through the glass envelope. The simple construction makes possible a correspondingly low price. The other iconoscope is a small version of the standard iconoscope, resembles it in appearance, has equal output voltage (despite the smaller size) due to increased collection efficiency and has its color sensitivity adjusted for outside pick-ups. It was found in developing this latter tube that a considerable portion of the spurious dark spot signal in iconoscopes arises from a defocusing effect in the scanning beam which may be corrected by modulating the focus potential with the scanning waveform.

The DuMont proposals for a type of synchronizing system which will allow ready adjustment of the number of lines and frames in the picture were reviewed by S. W. Stanton. The waveform of this system has already been described in *Electronics* (February, 1940, page 22). The paper discussed the differences between the triggered oscillator (blocking type) which is merely controlled by the sync pulses and the direct coupled type of scanning generator which uses the scanning impulses directly to form the scanning waveforms.

A new development in the technique of reproducing television images was brought forward by Donal and Langmuir of R.C.A. in Harrison. The device is a light valve extending over an area which is scanned by a cathode ray beam. The valve itself consists of a suspension of conducting particles in an insulating liquid (such as graphite in castor oil), placed between two mica plates. The potential applied to the mica faces causes the particles to line up along the lines of electric force and hence to allow light to pass through the liquid. The potential difference is developed, point by point, by the action of a scanning beam which passes over one of the mica faces, while the potential of the beam is varied in accordance with the video signal. Light from an external source is collimated, passed through the suspension, and the image formed by the passage of the light through the suspension is focused on a projection screen. The device has been used successfully to reproduce television images, although the quality does not approach, as yet, that available by other means.

A description of the television relay system installed by R.C.A. Communications on Long Island was delivered by J. E. Smith. Operating with a few watts of power on 500 Mc, this equipment is designed to pass video signals of high quality over distances of some 15 miles, using highly directional antenna systems. Frequency modulation is used, with a deviation factor of about 0.6, and signal-to-noise ratio of 31 db is achieved.

J. C. Wilson delivered the Wilson-Wheeler paper showing the effect on distortion of the filter characteristics of a single-sideband television system. The mathematical analysis showed that for minimum distortion, the filter characteristic should have zero slope at the carrier frequency rather than the finite slope as is commonly used at present. If distortion is to be minimized, 6 db attenuation of the low frequency video components should be introduced after the second detector, rather than in the i-f circuits.

Self-excited oscillators of extraordinary frequency stability developed by Anderson and Seeley of the R.C.A. License Laboratory were described and demonstrated by Mr. Seeley. Experiments showed that most of the frequency in stability was caused by temperature variations, although changes in humidity and interelectrode capacitance might also be important. By using coils so designed that temperature changes produced inappreciable variations in inductance, and by using temperature compensated condensers, high quality components and suitable circuit design, it was demonstrated that a change in frequency of only 100 cps in 10 Mc resulted when the temperature was changed 30° C. The coil in this case was made of copper-plated nilvar on a ceramic form, and the stability of this oscillator compares favorably with crystal controlled generators.

Frequency Modulation

The various aspects of frequency modulation were discussed in a series of five papers. Dale Pollack presented a mathematical discussion of interference between frequency-phase-modulation transmitters as well as the noise reducing properties of this system of modulation. Mr. Pollack compared the results with measurements of interference and noise on frequency-modulation and frequency-phase-modulation systems. Stanford Goldman of General Electric analyzed mathematically the interference between two frequency modulated signals and derived formulas pertaining to such interference.

J. F. Morrison of Bell Labs described a new f-m transmitter which has a frequency stability of 0.0025 per cent, equal to that of a crystal controlled transmitter, but without the use of temperature-controlled crystals or apparatus. Use is made of a new circuit in which the frequency stability is independent of the modulation characteristics. The characteristics of four deviation systems of frequency modulation were discussed by M. L. Levy of Stromberg-Carlson. A complete receiver was built for each deviation frequency. Measurements were presented for the various characteristics of each receiver. Recommendations were made concerning the necessary channel assignments for equal interference on all four frequency deviations.

The results of the field test of frequency modulation during 1939 and 1940 by the National Broadcasting Co. were described by R. F. Guy and R. M. Morris. A special transmitter capable of radiating either frequency-modulated or amplitude modulated signals and four special receivers were used. The signals were radiated from the video signal antenna of the N.B.C. television station atop the Empire State Building. Measurements were made over a large area for both amplitude- and frequency-modulation, and for various frequency swings of frequency modulation. A demonstration was made by means of recordings of the interference between two f-m stations on the same channel, but of different signal strengths.

The session on frequency modulation concluded with a demonstration of reception of programs from WIXOJ, the 50-kw f-m station located at Paxton, Mass., 46 miles from Boston. Immediately after the session closed, nearly 400 members were transported by means of bus and private automobile, to Paxton where they inspected the transmitter and grounds of WIXOJ.

COAXIAL V-T VOLTMETER

(Continued from page 32)

winding and its attached wiring should be sufficient to withstand highest voltages to which it will be subjected and at the same time have very small leakage current to ground. Otherwise the accuracy of the vacuum tube voltmeter is reduced.

A special form of vacuum tube voltmeter was devised in the R.C.A. laboratories for measuring peak potentials in the coaxial transmission lines carrying high frequency power from the television transmitters to the antennas at the Empire State Building. The potentials measured here were usually in the order of one to three thousand volts, peak value. Figure 1 shows the method of mounting the diode rectifier tube on the coaxial transmission line and Fig. 2 shows the schematic circuit diagram of the vacuum tube voltmeter. Figure 1 illustrates a cross section of the coaxial transmission line *AB* carrying high frequency electrical energy, the peak voltage of which is to be measured. Mounted on the outer conductor *B* of this coaxial line and supported by it is a shielded high vacuum diode rectifier tube 11, whose anode is electrically connected to the inner conductor *A* by means of a short probe 3 as shown. A shield 7 surrounds the diode tube. This shield has incorporated in the upper end a filament socket for the rectifier tube which at the same time forms a cathode to ground bypass condenser. The disk insulator 2, which carries the probe, is clamped and sealed to the outer conductor of the transmission line to prevent gas leakage. These same clamps also serve to secure the tube shield 7 in position on the line. It may be noted that this arrangement serves as a tube socket, filament by-pass condenser, tube support, tube guard and radio frequency shield. Consequently the tube is completely shielded to prevent personal injury and undesired radiation of high frequency energy at this point.

It may be seen by reference to Fig. 2 that the operation of this

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vacuum tube voltmeter is in general similar to that of all vacuum tube voltmeters, that is, they usually indicate peak voltages. The diode tube 11 constitutes a half-wave rectifier so that a small pulse of current is rectified from every other half cycle of the radio frequency energy in the line *AB*. This requires that there be a low resistance direct current path or circuit between the inner and the outer conductors of the coaxial transmission lines in order to complete the vacuum tube voltmeter circuit. Usually at the transmitter or at the antenna the two conductors of the line are connected together for other purposes and incidentally form a direct current path. By this means the diode filament bypass condensers (numbered "9") are charged. The voltmeter 14 is, in this case, of the electrostatic type. supplied by Ferranti Electric, Inc. The resistance 15 is about 10,000,000 ohms and the filament transformer and other circuit insulation current leakage is very small. Since the voltmeter 14 requires no current to operate the voltmeter indicates substantially true peak voltages.

In most installations it may be desirable to employ one electrostatic voltmeter and one filament transformer for several vacuum tube rectifier units. For this purpose a two-pole switch having several positions may be connected between the rectifier tube 11 and the filament transformer 13. This selector switch should have small insulation current leakage and sufficiently high voltage rating. In this particular installation there is employed a selector switch having as many as six positions for switching a single filament transformer with the voltmeters into use with any one of five remotely located rectifier units. For installations where large ranges of voltages are to be measured more than one electrostatic voltmeter may be employed. In this installation a large voltmeter is connected permanently in the circuit to indicate the larger voltage readings and then smaller voltmeters are connected momentarily in the circuit by means of push buttons to obtain accuracy at the lower voltages. The electrostatic voltmeters, filament transformer and selector switch are, in this case, installed in a centrally located control unit and leads are extended to the rectifier units.

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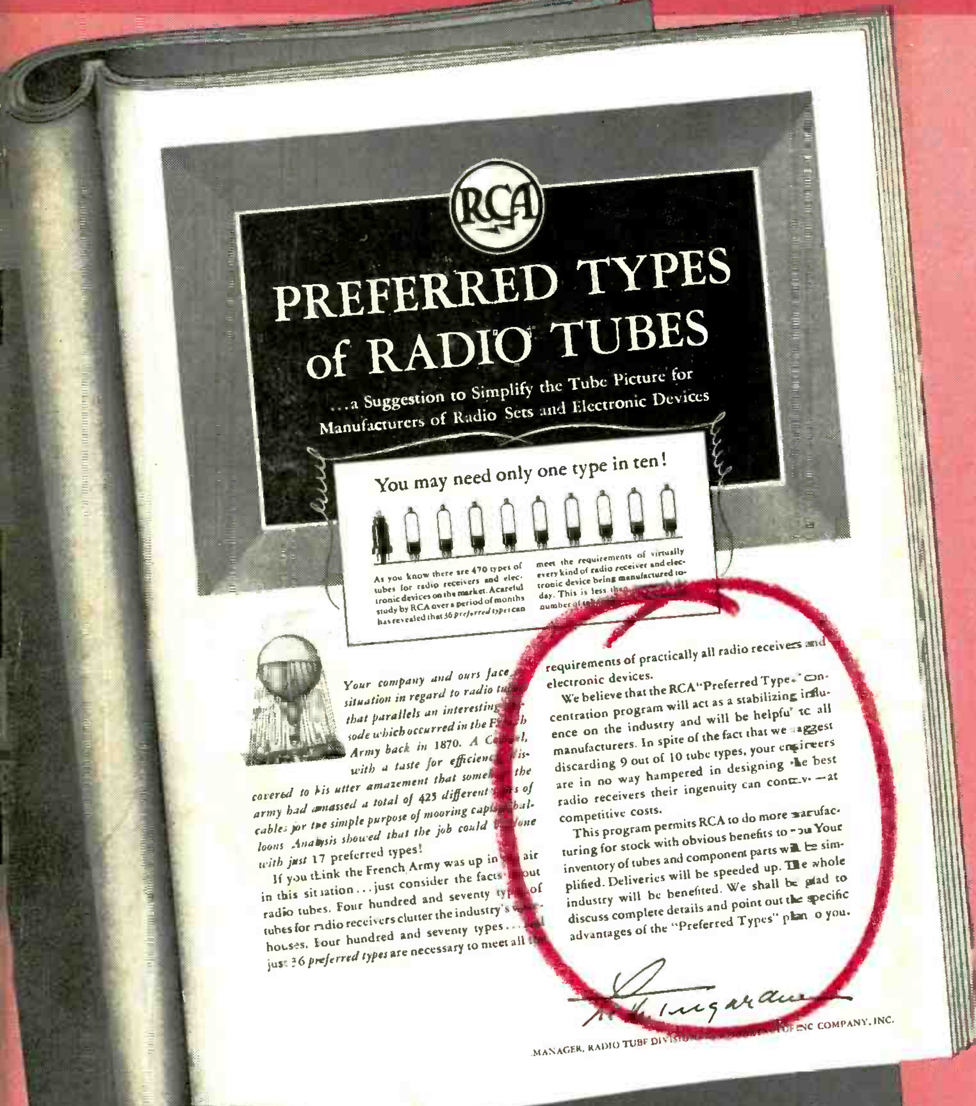

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