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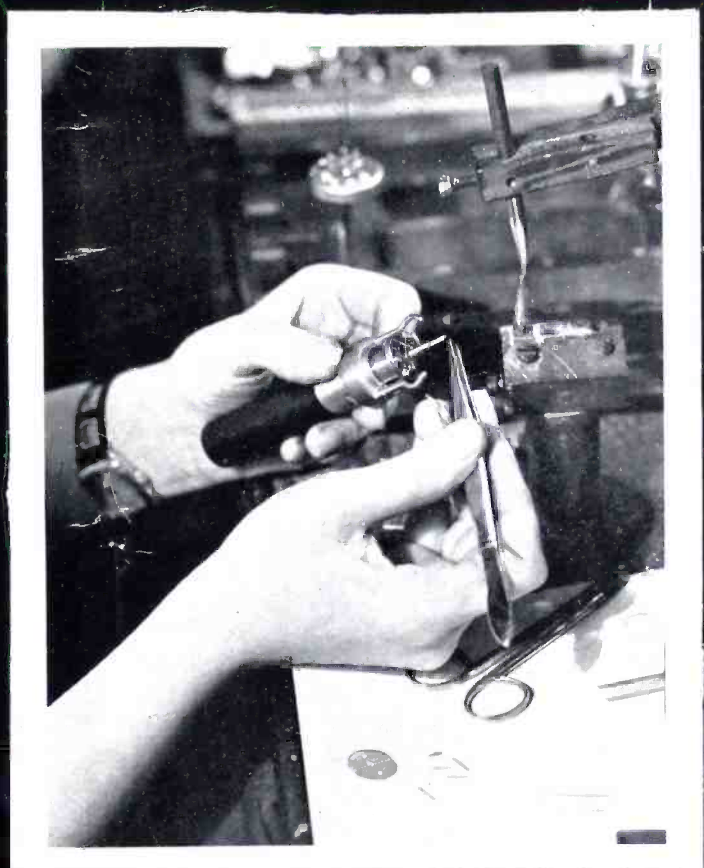
Radio Engineering

VOL. XV NO. 12



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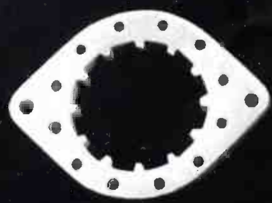
The Journal of the Radio and Allied Industries



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OPERATOR, WITH JIG, INSERTING A HEATER IN THE CATHODE OF AN ALL-METAL TUBE. (Photo courtesy RCA Manufacturing Co., Inc.)

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EDITORIAL

ALL-METAL TUBES

THE ALL-METAL TUBE has finally emerged as a practical, fool-proof device. The difficulties, of the type encountered in the manufacture of any new product, have been nicely surmounted. Production shrinkage has been brought down to a figure comparable to that generally anticipated in the production of the glass-type tube. The various bugs, such as high grid losses, noise, leakage, etc., have been eliminated in most cases. Shrinkage in shipment is practically licked right now.

Considering the fact that it took years to bring the glass-type tube up to its present standard of excellence, it is remarkable indeed that tube engineers have been able to conquer, practically overnight, the numerous mechanical problems that were evident at the start.

The fundamental design of the metal tube has been proven to be sound. The basic conception holds possibilities not open to the glass-type tube. It is therefore a certainty that the metal tube is here to stay, and there is no question that it will contribute immeasurably to the advancement of radio in many ways.

What the design engineer has already done with the metal tube is nothing compared to what he will do—but there is no reason why a set manufacturer should wait until better things are done before using the metal tube, any more than there is reason for the ultimate purchaser to hold off buying until something better turns up.

• • •

STANDARDIZATION

THERE IS NOTHING that will pay larger dividends to manufacturers in the radio and allied industries than standardization. The savings that can be gained are almost beyond computation.

Excellent work along these lines has been accomplished by the Radio Manufacturers Association, and a great deal more will be accomplished in the near future. Every manufacturer related to the industry should assist in this beneficial work.

General standardization can be gained only through whole-hearted cooperation. Once the entire industry is in accord on the matter, each and every manufacturer will benefit by the standards set for all.

VOLUME EXPANSION

ANY ONE WHO has witnessed a demonstration of the electrical phonograph equipped with a volume-expanding device, cannot help but marvel at the all-around improvement in the musical reproduction. The addition of the volume expander not only increases the volume range of the reproduction from the record, but practically eliminates surface noise.

No manufacturer of phonographs or radio-phonograph combinations can afford to overlook this device. The common type of electrical phonograph hasn't a prayer alongside the unit with volume expansion.

• • •

NOISE ELIMINATION

THE GREATEST PLAGUE to the radio industry is noise. Noise raises the very devil in the short-wave bands; it rears its ugly head in the majority of receivers equipped with automatic volume control; in the form of natural static, it ruins many a good program in the standard broadcast band; it is a potential barrier to the progress of television.

All the king's horses and all the king's men in the radio, electrical, auto and other noise-making industries, can't even make a dent in this national background of interference. All man's electrical noise couldn't be vanquished in ten years. Nature's own brand of racket can't even be touched in certain wavebands.

Snubbing half the nation's noise would take at least five years of intensive effort and possibly longer. But a half-way job won't satisfy the problem.

What is required is not coordinated effort on the part of noise-producing industries, but rather coördinated effort on the part of engineers or large radio organizations with a view to tackling the subject from the technical angle.

We need to know more about the characteristics of noise and its relation to radio waves. The problem calls for a tremendous amount of tedious research work, but that is the only manner in which the problem will eventually be solved.

Fortunately, Major Armstrong has presented a new angle to the subject. In his frequency-modulation system may lie the complete answer to the noise problem. It may require a new broadcasting set-up, but if it does the trick, the changeover will be cheap in the long run.

RADIO ENGINEERING

FOR DECEMBER, 1935

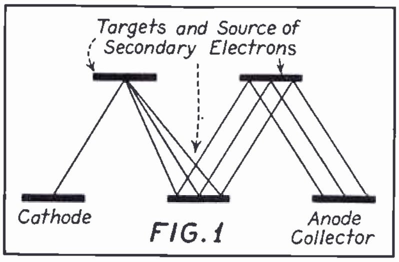
I.R.E. CONVENTION REPORT

THE GIST OF TECHNICAL PAPERS • STANDARDIZATION DISCUSSIONS

The attendance at the Rochester convention of the I.R.E. held on November 18-20 last set an all-time record. It was outstanding as well in the large number of localities represented and the enthusiasm displayed on every hand. In addition to the technical sessions, the talks at the banquet dealt with the probable effects of the new trade agreement between the United States and Canada, the outlook of the radio industry in view of recent political developments, as well as a comparison of the European radio industry with that in this country. It was evident that the industry as a whole is far from discouraged, and determined to adapt itself to best meet conditions as they exist, rather than attempt to mold conditions to better fit the industry. It is gratifying indeed to behold an industry at once so flexible and so determined that discouragement is met by stock-taking and progressive change.

OSCILLATOR TRACKING

The advent of all-wave receivers placed in the foreground the problems of oscillator tracking and oscillator stability. Methods of meeting these problems and the degree of performance attained were discussed by W. A. Harris. Another problem which has only recently come to the fore; namely, the losses in tubes and dielectrics at high frequencies, were discussed by C. J. Franks. R. M. Wise discussed some of the problems encountered in the manufacture of metal tubes and the technique developed to meet them.

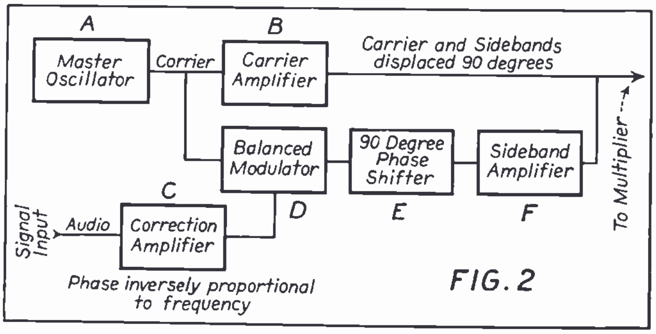


Illustrating the functioning of the electron multiplier tube.

ELECTRON MULTIPLIER TUBE

Dr. V. K. Zworykin discussed at some length the multi-stage electron multiplier tubes which were previously discussed at the October meeting of the New York Section of the I.R.E. These tubes, which function on the principle of secondary emission caused by impinging primary electrons, have the advantage of unusually high gain per tube, as well as a much lower noise level than conventional amplifier tubes. Heretofore secondary emission has been considered a serious handicap, which it still is in conventional tubes. Dr. Zworykin has, however, turned this handicap into a device which promises to be of considerable importance, particularly in high-gain low-frequency amplifiers. As shown in Fig. 1, this tube consists essentially of a cathode which emits an electron stream. This stream is attracted to a secondary electron emitter by virtue of its higher (positive) potential. The electrons impinging on this target release a larger quantity of secondary electrons which are in turn attracted to another target from which a still greater quantity of secondary electrons are emitted. This process is continued for the desired number of stages and the electron stream is finally collected on an anode.

The secondary emission surfaces of the targets are made of oxidized silver or beryllium with a calcium surface layer. This surface is very similar to that employed in modern photoelectric cells. The number of secondary electrons released by each impinging electron depends upon the velocity of the latter. This ratio may be as much as ten to one in some tubes recently developed. Focusing the electrons on successive targets is accomplished with an electrostatic field. Tubes with as many as 10 stages, and gains of about 200 db, have been constructed.



Block schematic of the essentials for attaining frequency modulation.

STANDARDIZATION

The pros and cons of standardization in the radio and allied fields were presented by L. C. F. Horle and P. G. Agnew. Some of the points raised indicated the absurd tolerances and almost but not quite identical requirements placed on component parts. Some of the tragic examples were the use of 1400 different field coils by one manufacturer of loudspeakers, the use of 392 types of shaft length by the manufacturer of variable volume controls, and the necessity in another instance of furnishing three identical paper condensers with different code numbers to one manufacturer of radio receivers. It was effectively pointed out that a considerable saving would accrue if engineers would show some inclination to use more standard components. It was pointed out that the Gas Industry had adopted the first fittings standards of the S.A.E. some years ago to effect a considerable economy for both industries. The necessary machinery for close cooperation on standards is now set up by the A.S.A. for coordination of the standards of the various industries.

STANDARDIZATION DIFFICULTIES

During the extended discussion it was brought out that some of the difficulties in the way of standardization in the radio field were:

1. Rivalry between manufacturers.
2. The complicated patent situation.
3. Rapid development in the radio field.
4. Frequent changes in practice.
5. Rapid changes in materials utilized.
6. Rugged individuality displayed in this field which is still in its pioneering stage.
7. The large number of companies involved.
8. Rapid changes in personnel.
9. Two standardization bodies: I.R.E. which is scientific, RMA which is industrial in nature.
10. Unbalance due to seasonal nature of the product.
11. Commercial necessity of gadgets.
12. Secrecy because the industry feels the need of immediate rather than ultimate profits.

In spite of these difficulties, a good case was made for closer cooperation and more standardization. It was clear that the feeling of those participating in the discussions was that there was a distinct need for honesty in the rating of products and that general standardization was not only desirable but possible.

FREQUENCY MODULATION

Major E. H. Armstrong's discussion of frequency modulation supplemented his earlier paper before the New York Section. He gave credit to such early workers in the field as Poulsen, Carson and others, and pointed out the reasons for dropping frequency modulation in 1925 when Carson showed mathematically that at least as great a band was required for frequency modulation as for amplitude modulation. Another hurdle was the difficulty of holding the no-signal carrier frequency fixed in the spectrum.

Fig. 2 shows in block schematic form the essential circuits for attaining frequency modulation in the transmitter. The essential elements consist of a master oscillator (A) followed by a carrier amplifier (B) feeding the frequency multipliers. Carrier and audio signal are supplied to a balanced modulator (D) through a phase correction amplifier (C). The balanced modulator suppresses the carrier and transmits the two sidebands only. The two sidebands are shifted 90 degrees in phase so that no demodulation can occur with the original carrier. These sidebands are then combined with the carrier and fed to the frequency multipliers. A total frequency multiplication of 3000 was employed in the experimental setup at the Empire State Building transmitters.

It is obvious from Fig. 2 that the carrier is initially phase modulated and this wave is converted to frequency modulation by subsequent multiplication. The details of the correction amplifier are shown in simplified form in Fig. 3. In this circuit the phase of the signal is changed inversely as the frequency. Fig. 4 shows in simplified form the arrangement used in the receiver for converting frequency modulation to amplitude modulation.

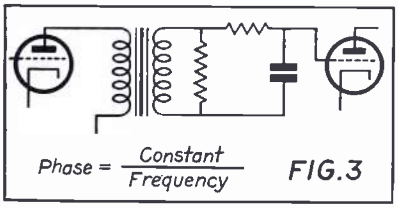


FIG.3

Circuit of the correction amplifier used in the frequency modulation system.

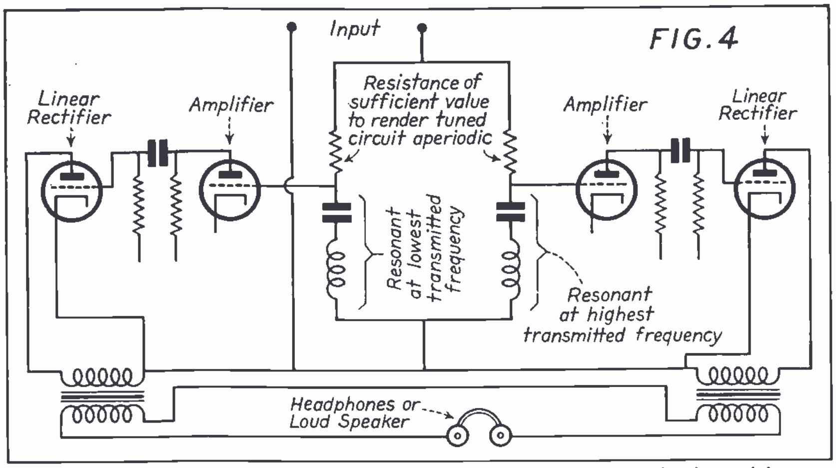


FIG.4

Circuit used in the receiver for converting frequency modulation to amplitude modulation.

SIGNAL-NOISE RATIO

According to Major Armstrong, the chief advantage of his system lies in the improvement in signal-to-noise ratio. He pointed out that received noise is proportional to the received bandwidth only where the amplitude of the noise is greater than the carrier amplitude. He has shown both analytically and experimentally that whereas in an amplitude-modulated wave an interfering voltage which is one percent of the carrier amplitude will spoil the program, while an interfering voltage which is 50 percent of the carrier will be negligible in his frequency-modulated system.

It appears that in the ultra-high-frequency band in which Major Armstrong proposes to use his system of modulation, ignition interference presents the only real interference problem. Measurements of a 2-kw frequency-modulated transmitter located at the Empire State Building in New York City made near Camden, N. J. showed about 30 db improvement in signal-to-noise ratio over the signal of WEAF.

FREQUENCY ASSIGNMENTS

Dr. Jolliffe discussed in considerable detail the frequency assignments since 1927. He pointed out that the spectrum below 30 mc is likely to remain as it is for some years, but that definite assignments can be expected shortly at frequencies above 30 mc.

Mr. Otto Schade described and demonstrated an oscillograph which will reproduce a family of curves, such as the characteristics of a vacuum tube, on a cathode-ray tube screen. This apparatus is capable of continuous calibration and can be put to a wide variety of uses.

RANDOM NOISE

The influence of tube and circuit properties on random electron noise was discussed at some length by W. A. Barden. He showed that the ratio of signal to thermal agitation noise does not increase as fast as signal step-up with increase in the Q of the first tuned circuit. He submitted the following values for noise voltage generated by tubes for a bandwidth of 6.6 kc and under ordinary operating conditions of bias, etc.:

Noise Voltage	*Tube*
.07 mv	6J7
1.0 mv	6K7
0.9 mv	6C6
1.1 mv	6D6
1.1 mv	77
1.1 mv	78

If the control-grid bias voltage is varied, the noise increases rapidly as cut-off is approached. Variation of screen potential makes little difference in noise for most tubes. Plate voltage variations have little effect on generated noise until the plate voltage approaches the screen voltage at which point the generated noise rises rapidly. In tubes of the 6L7 type, most of the noise is that generated at i-f, and the r-f noise heterodyned down to i-f is of negligible importance. Tube noise due to thermal agitation may be calculated from:

$$N = 2\sqrt{RTRF}$$

where T is the absolute temperature, say 800 degrees Kelvin, K the Boltzman gas constant, R the plate resistance, and F the frequency bandwith. This noise, however, only accounts for 5 per-cent of the total noise output of multi-grid tubes.

ALL-WAVE ANTENNA SYSTEM

H. A. Wheeler described a new all-wave antenna system with several novel features. In general automobile ignition noise and other man-made static generated near the ground appear to radiate more energy in the vertical polarized than in the horizontal field. For this reason doublet antennas have come into general favor for all-wave reception. Doublet antennas less than one wavelength long favor the signal arriving normal to the axis of the antenna. Ordinary twisted pair used as a properly terminated transmission line has a loss of about 2 db per wavelength which is independent of frequency. This may increase to 5 db per wavelength or more when the line is wet.

The antenna used in the arrangement described by Mr. Wheeler is of the double V variety. This doublet resonates at 8,500 kc at which point it has an impedance of 80 ohms. Below resonance the impedance is largely capacity reactance and above resonance it is inductive. The maximum impedance at any point in its useful range is about 2,000 ohms. Thus at 4,000 kc the impedance is 800 ohms and at 18,000 kc, it is 2,000 ohms. Below resonance this type antenna has about half the impedance and three times the power factor of the usual single-wire doublet.

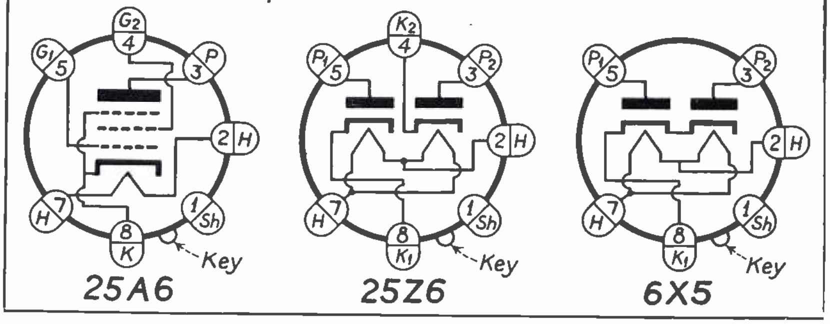
The coupling filters used in this system have extremely low loss over the useful operating range. The 500-ohm damping resistors used in conjunction with the antenna filter are intended to damp the ground leads which may approach quarter-wave resonance at some frequencies. It is, of course, essential that a quiet ground be used and the two ground wires should not be combined. In some of the commercial embodiments of this system, the ground wires are omitted and ground obtained through the transmission line. In general such an arrangement is more susceptible to interference.

NEW RAYTHEON TUBES

Three new type metal tubes have been announced by the Raytheon Production Corp., of Newton, Mass.

These new types include two tubes of special interest to those working with a-c, d-c combinations. The new 25A6 corresponds in characteristics to the type 43. The new 25Z6 has characteristics like those of the 25Z5.

Top Views of Sockets



The third new metal tube is the type 6X5, a narrow space, high-vacuum rectifier designed primarily for automobile receiver use.

Each of these three tubes is manufactured in the same type steel shell used for the types 6F6 and 5Z4.

The detailed characteristics of the new tubes are given in the accompanying tables.

TYPE 6X5 FULL-WAVE RECTIFIER

Heater	
Voltage	6.3 volts
Current	0.6 ampere
Maximum Over-all Length	3¼"
Maximum Over-all Diam.	1-5/16"
Base	Small Octal 6-Pin
A-C Voltage per Plate	350 volts max.
Peak Inverse Voltage	1,250 volts max.
D-C Load Current	75 ma max.
Peak Plate Current	375 ma max.

TYPE 25Z6 RECTIFIER-DOUBLER

Heater	
Voltage	25.0 volts
Current	0.3 ampere
Maximum Over-all Length	3¼"
Maximum Diameter	1-5/16"
Base	Small Octal 7-Pin
A-C Voltage per Plate	125 v max.
D-C Load Current as Voltage Doubler	85 ma max.
D-C Load Current as Rectifier	85 ma max.
Peak Plate Current	500 ma per plate

TYPE 25A6 POWER PENTODE

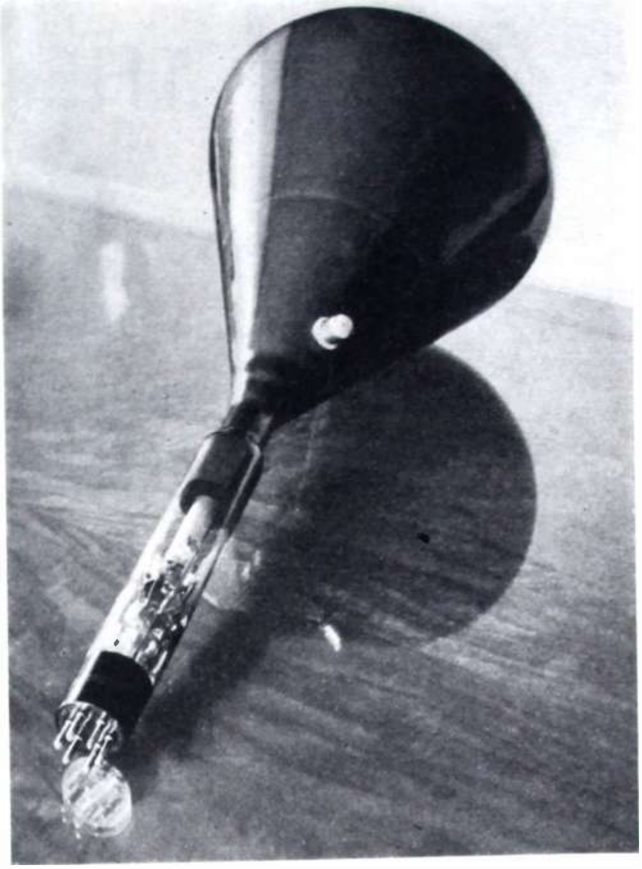
Heater	
Voltage	25.0 volts
Current	0.3 ampere
Maximum Over-all Length	3¼"
Maximum Diameter	1-5/16"
Base	Small Octal 7-Pin

Class A Amplifier Operating Conditions and Characteristics

Heater	25.0	25,0	25.0	volts
Plate	95	135	180	max. volts
Screen	95	135	135	"
Grid	—15	—20	—20	volts
Amplification Factor	90	99	96	
Plate Resis.	45,000	42,000	40,000	ohms
Mutual Cond.	2,000	2,350	2,400	umhos.
Plate Current	20	39	40	ma
Screen Current	4	8.5	8.0	ma
Load Res.	4,500	4,000	5,000	ohms
Power Output	0.9	2.0	2.75	watts
Distortion	11	9	10%	

CATHODE-RAY TECHNIQUE ABROAD

By BERNARD H. PORTER



Colloidal graphite deposits serve as a focusing anode in the 903 cathode-ray tube, a high-vacuum electromagnetic type.
(Courtesy RCA Manufacturing Co., Inc.)

Coincident with the increasing demands for kinescopes or cathode-ray tubes abroad, new production methods and techniques have been developed. Foreign experimenters, having observed that silver or similar metals impair the brilliancy of the images by reflecting light from the operating tube elements, now favor the use of opaque films formed with colloidal graphite dispersions in water. Such a material is also extensively used for similar purposes in this country.* (Fig. 1.)

EQUIPMENT IN ENGLAND

The equipment employed in England for coating cathode-ray tubes comprises three separate units, each of which will be duplicated to meet demands. The first device (Fig. 2) is designed for holding the glass envelopes in an upright position on a rotating table. The neck of the tube is then inserted over the proper apertures through which a solution of colloidal graphite in water of the required dilution is forced from a convenient reservoir by a pressure of three to four pounds. The treated tubes are then passed to the second unit or air-drying oven, mounted on small asbestos trucks, and so dried by the heat from gas jets. A rotary kiln, the final unit, some fifteen feet in diameter, is divided into ten segments at the outer edge of which the operators sit assembling the parts, exhausting the tubes, and sealing the same.

It is reported that the Ediswan Engineers in England have at present developed production lines, somewhat as described above, and which are capable of producing one hundred tubes a week. In view of the increasing demands made by radio and television-set manufacturers for greater quantities of cathode-ray tubes, the present production will soon be increased.

BINDING AGENTS

The technique surrounding the application of the fluorescent powders in

(*Continued on page* 15)

*Graphite Films. RADIO ENGINEERING, April, 1935.

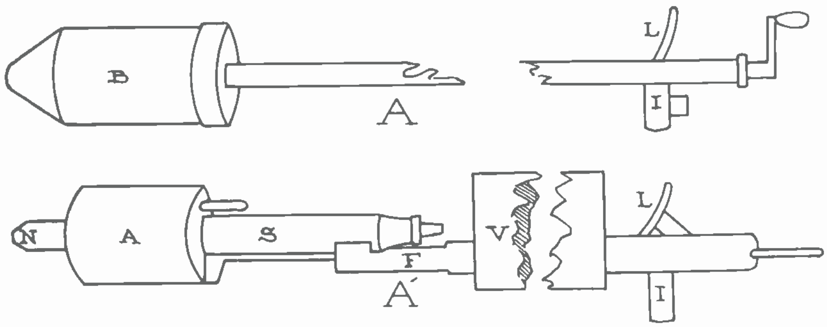


Fig. 3. (A') By pulling the lever L the intake I and the nozzle N open, as the section S moves back and forth on F. The chamber A contains the binder material, while V is a vacuum space. (A) By opening the valve by means of L and rotating the crank slowly, the fluorescent powders in B are forced out by the pressure of ½ to ¾ atmospheres. Overall length of guns, 12 inches. *(Courtesy of Pfaltz & Bauer.)*

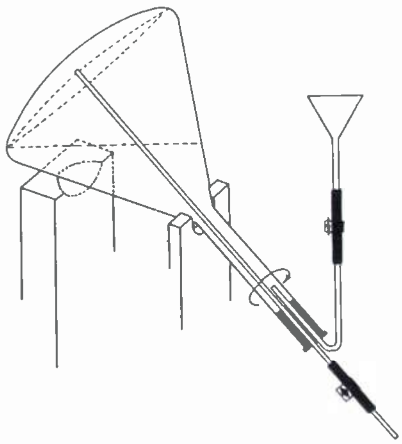
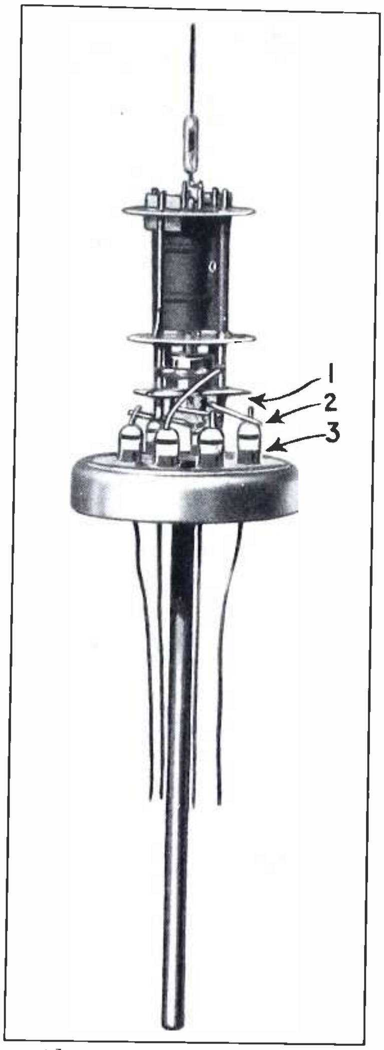


Fig. 1. Funnel method, as employed in this country on both an experimental and small-production scale, for coating the interior walls of cathode-ray tubes.

THE ALL-METAL VACUUM TUBE

A DISCUSSION OF METAL, METAL-GLASS AND GLASS TUBES IN RELATION TO THEIR CHARACTERSTICS AND APPLICATIONS



(Courtesy Raytheon Production Corp.)
Structure of the 6Q7. The mica spacer (1) which supports the diodes, is sprayed with liquid ceramic for the purpose of improving insulation. The beads (2) are also sprayed with a liquid ceramic. Small rings of copper (3) are brazed onto the Fernico eyelets to prevent leakage.

Engineering activity in the design of the 1936 series automobile receivers gives the old argument of metal versus glass an entirely new start.

FOR AUTO RECEIVERS

Now one of the advantages claimed for the metal tubes is small size. This advantage, while not obvious in the home receiver, is a real one for the auto set designer. Convention may be a sacred word in the home set, but it is thrown out completely in any consideration of auto set construction. Parts are dovetailed together to the point where they sometimes require that the set be dismantled if a part is replaced. Tubes can be mounted right side up in the assembly but often they hang upside down when the set is installed in a car.

With serious consideration given to the use of metal tubes throughout the automotive radio field, and with old arguments still unsettled, a review of the subject of radio tubes may be worth while.

METAL-TO-GLASS

Metal tubes, as originally developed, brought to the commercial field a scientific achievement wherein steel or a steel alloy was sealed to glass. For a long time the tube manufacturers had spoken of the possibility of some day manufacturing tubes in some kind of a metallic container. The glass bulb and support stem of glass, used in the manufacture of glass tubes, were handed down from the lamp industry. While a transparent envelope is an essential for an illumination device, there is no law that requires its use on a relay or amplifying device such as a radio tube. The difficulties of tube manufacture in glass go far beyond those connected with lamp manufacture. For example, the lead-in or seal wires passing through a lamp stem number two as against an average of six to seven in the radio tube.

THE "CATKIN"

The English "Catkin" or adaptation of copper-glass construction, used in large transmitting tubes in this country, to small receiving types is well enough known to engineers to warrant little attention here. The vacuum envelope in the "Catkin" is the plate, and each type required an external shield to limit the r-f field about the plate and to protect the user from shock. In addition, the "Catkin" construction called for a glass stem structure not unlike those used in glass tubes. This copper-glass tube was expensive to manufacture and offered no particular advantage other than anode cooling—important in the large transmitting tubes but of no advantage in most receiving types.

The development of the present series of metal tubes was announced in April. The mechanical advantages listed at that time were small size, rigid support of the elements with their center of gravity near the base of the tube and a new eight-prong base with a guide key to insure correct placement in the receiver socket. These mechanical advantages are mentioned because they play a part in what followed during the early summer.

THE "G" AND "M-G" TUBES

Several tube manufacturers installed the necesary welding equipment to produce metal tubes of the types first announced. Others, probably feeling that a shortage of the metal tubes would exist for some time, adapted to glass tubes the octal type base developed for the metal tubes. Thus, the "G" tube came into being. Metal tubes with characteristics equivalent to glass types were the 6A8, 6K7, 6J7, 6F6, 5Z4, and to a certain extent the 6C5. The 6D5 was announced, but this type did not materialize. The 6H6 and 6L7 were quickly reproduced in glass to complete the "G" octal base series, which could be manufactured without the expensive welding equipment necessary to metal-tube manufacture. At this same time, still another type—the "M-G," or metal-glass series was introduced. These were similar in certain respects to the "G" type tubes, but instead of using the conventional glove type shields these M-G tubes were manufactured in T or straight side glass bulbs and fitted with a tubular shield of metal crimped over the regular size metal tube bakelite base.

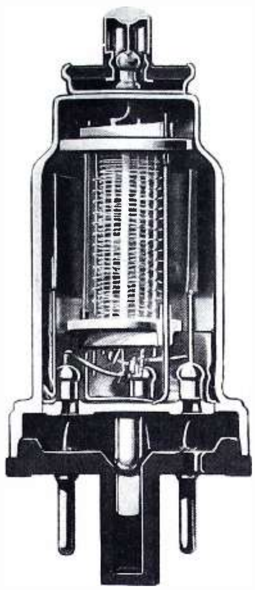
The variety of octal-based tubes introduced during the summer of 1935 did serve to relieve an actual shortage of metal tubes. The economy offered by substitutes for straight metal tubes is a subject of controversial nature with few points of interest to the design engineer. It is generally agreed that the octal base is an improvement whether it be employed on the true all-metal tube or on a glass or metal-glass counterpart.

INTERCHANGEABILITY

Considered together, metal-glass, "G" type and metal tubes are of principal interest to the engineer in connection with interchangeability. Capacity differences are substantial as might be expected, and interchangeability is not accomplished in the average receiver without realignment of the tuned circuits connected to the socket where the change is made. The loss of sensitivity is greatest, assuming that there is no realignment, when glass tubes equipped with glove shields are substituted for metal tubes in a set aligned perfectly for the metal tubes. The reverse condition is the same, of course. Metal-glass tubes fall about half-way between the "G" or octal base glass and the true metal tubes in sensitivity change without realignment.

CAPACITY DIFFERENCE

The reasons for capacity difference are obvious—the tube shield accounting for a large part of the difference and differences in lead length accounting



(Courtesy Raytheon Production Corp.)
Interior structure of representative metal tube, cut away to show the positions of the elements.

for the balance. The "G" series tubes equipped with glove shields do not differ from the straight glass types in capacities. The metal-glass tubes, which are made in straight side bulbs with a tight fitting tubular shield, differ slightly from glass tubes because the shield is closer to the elements. Lead length in the metal-glass tubes is about the same as in the glass tubes since this type uses the conventional stem and glass bulb. The true metal types show the greatest difference from glass because the metal envelope—acting as the shield—is very close to the elements and because the lead wires are extremely short. In general, inter-electrode capacities are lower for metal tubes than the corresponding capacities in glass or metal-glass and both input and output capacities are somewhat higher for the metal types. With any of the three types, sensitivity is the same with the receiver aligned for the tubes used.

Variations in sensitivity with change from one type of construction to another are minimized by the use of lowest permissible L/C ratios in the i-f amplifier tuned circuits.

Further discussion of glass and metal tubes can be limited to cover straight glass and the all-metal types only. The metal-glass type tube is to be considered as a glass tube from the manufacturing viewpoint.

METAL-TUBE ADVANTAGES

Electrically, the advantages claimed for the metal tubes cover better performance at high frequencies, less noise because of the bulb and internal structure, better shielding than has been available with glass tubes heretofore, and extremely short leads. In addition, the inter-electrode capacities are considerably lower in the metal tubes than in the glass types which they replace.

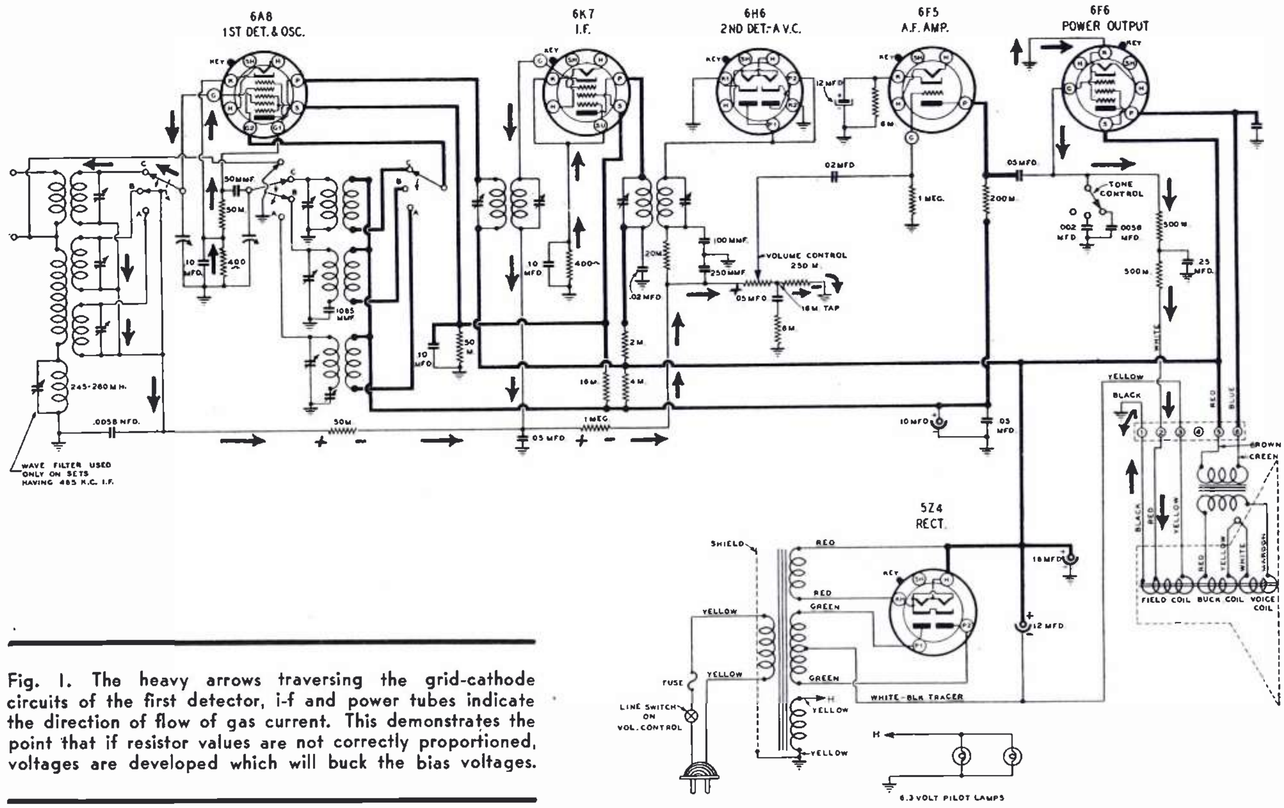
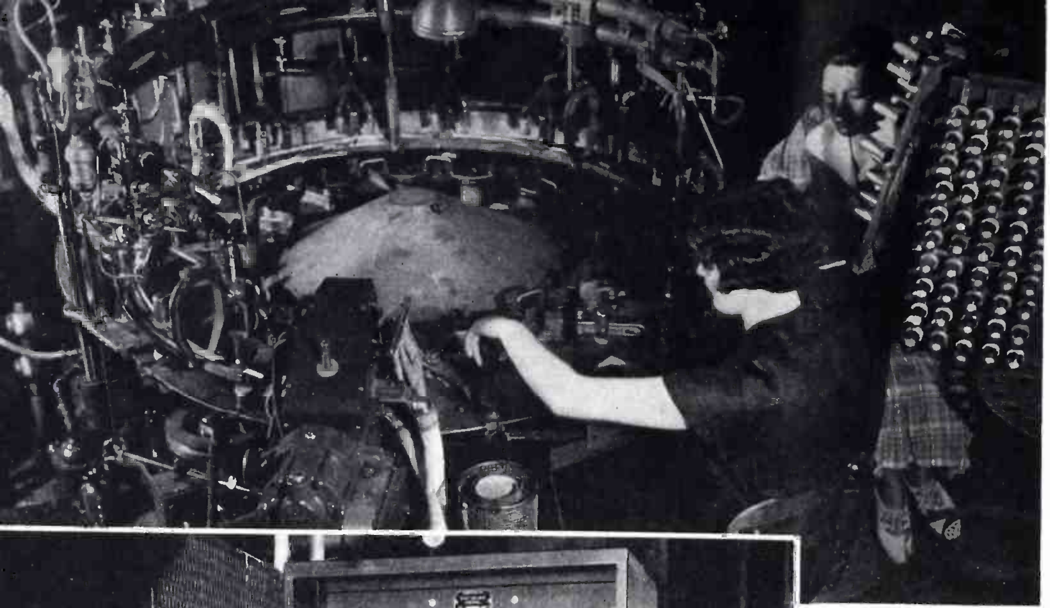


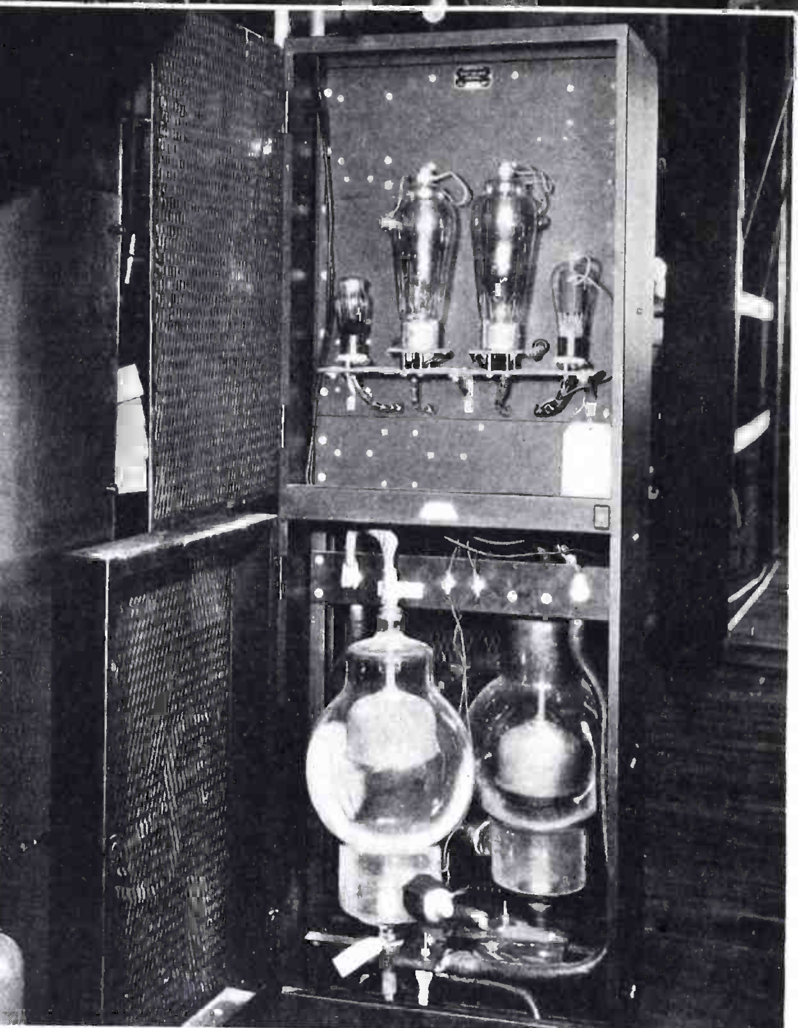
Fig. 1. The heavy arrows traversing the grid-cathode circuits of the first detector, i-f and power tubes indicate the direction of flow of gas current. This demonstrates the point that if resistor values are not correctly proportioned, voltages are developed which will buck the bias voltages.



The introduction of new types such as the 6H6 and the 6L7 brought out advantages which could be achieved through new circuit design. Also the 6L7 made possible almost complete elimination of capacity effect between the oscillator injection circuit and the signal circuit in mixer complications.

Glass tubes with octal bases have been developed in types corresponding to the 6H6 and 6L7 so that these circuit advantages are available with glass tubes as well as the metal types.

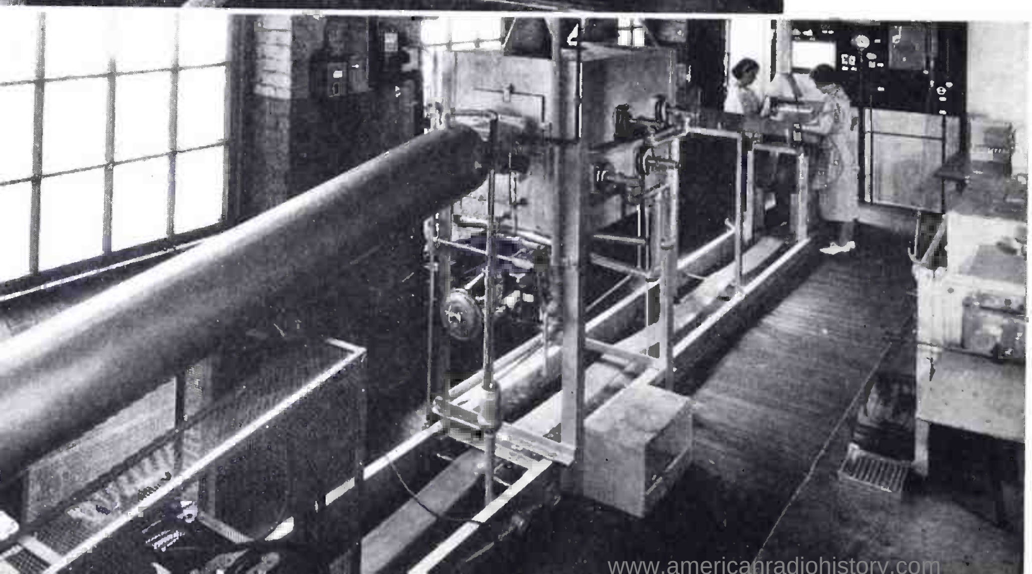
In analyzing the advantages claimed for the metal tubes, it is logical to assume that noise caused by stray electrons producing charge effects on the



Exhausting air from all-metal tubes. High-efficiency pumps draw off the air from the tubes as they rotate through gas fires which heat them and drive out gases occluded in the metal. All air is pumped out in the first fifteen seconds.
(Photo courtesy RCA Manufacturing Co., Inc.)

To insure precision control of welding operations in the assembly of all-metal tubes, Thyratron tubes are used. The parts to be welded are brought together between heavy copper electrodes, a starting impulse is given to the control system and automatically the Thyratron control tubes pass the heavy welding current through the metal tubes for a fraction of a second.
(Photo courtesy Raytheon Production Corp.)

A continuous-feed hydrogen furnace used for cleaning up metal tubes. Two operators are shown loading the chain conveyor belt and just beyond them is shown the elaborate equipment which maintains a temperature of approximately 950° C. and a smooth flow of hydrogen gas over the parts in the furnace. On the left, the water-jacketed cooling chamber is shown. The treated parts travel through this jacket cooling in an atmosphere of hydrogen. Hydrogen not only cleans the metal tube parts of all hydrocarbons, but in addition the hydrogen gas displaces any other gases which may be in the metal.
(Photo courtesy Raytheon Production Corp.)



bulb wall would be eliminated completely in a tube with a metal bulb. For several years glass tubes used in radio-frequency circuits have been coated on the inside wall of the bulb with carbon to carry away charges produced by the collection of stray electrons. Lower inter-electrode capacities in metal tubes are a definite advantage and probably will permit the development of higher signal gain through the use of better coils than could be used with glass tubes without oscillation trouble. This applies particularly to tuned radio-frequency circuits. It is difficult to mea-

WELDING EXHAUST TUBULATION TO HEADER. A POWERFUL THYRATRON-CONTROLLED WELDER FUSES THE OPEN LENGTH OF METAL TUBING TO THE HEADER.

(Courtesy RCA Manufacturing Company, Inc.)

sure any appreciable increase in signal response for metal tubes over glass due to the short lead wires in the metal tubes, except at ultra-high frequencies not yet in use for broadcast transmission.

R-F LOSSES

Radio-frequency losses in metal tubes as compared with glass might be said to have been higher for the metal tubes over the first few months of production, due to the type of insulation used for the support of the control grid cap at the top of the tube structure. The development of new types of phenolic insulation (XM-262) has brought the grid-loss factor down to a figure comparable with glass.

In a final analysis the performance of metal tubes as compared with glass in sets in the field depends almost altogether on the manufacture of the metal tubes. The manufacturing processes used on glass type tubes have developed over the course of several years and have reached a point where performance is taken for granted. The manufacture of metal tubes practically duplicates the steps used in the construction of glass tubes except for exhaust and seasoning.

EXHAUST AND SEASONING

Glass tubes are exhausted by passing them through a cycle lasting about six minutes during which the tube is being constantly evacuated. The heater is lighted at voltages varying from approximately the normal value to twice the normal value.

The plate and grids or screens are heated, to temperatures approaching 1000° C, inductively with radio-frequency power at approximately 400 kc. The entire heating process can be watched and controlled to a uniformity which is entirely satisfactory. The getter is flashed by inductive heating and the position of the getter in the glass tube is not difficult to control.

The exhaust of metal tubes follows the same procedure used on glass types except for the heating of the elements and the flashing of the getter. Inductive heating cannot be employed, so the outer shell or bulb of the metal tubes is heated with gas flames to a temperature sufficient to drive gas out of the bulb itself and to heat the plate and grids to a satisfactory temperature by direct radiation. The getter is flashed by applying a point flame to a position on the bulb wall where the getter pellet has been welded or fastened mechanically. The greatest difference in finished tubes at the end of the exhaust process is due entirely to the difference in element heating technique.

The problem of how much heat to apply to drive the gas out of the tube elements has been a difficult one to solve. Results over the last few months indicate that this new method of tube heating is fully as satisfactory as the inductive heating used on glass types. Trouble encountered in early metal tubes due primarily to high gas content are traceable to this new exhaust technique.

GAS EFFECTS

Early reports from the field indicated that some receivers have been found to be insensitive due to the presence of a very small amount of gas in the radio-frequency amplifiers. The design of most receivers using the new metal tubes was based on circuit constants found to be satisfactory with glass tubes. Grid and automatic volume control isolation resistors had the same values which proved to be satisfactory with glass tubes in which there is practically no gas current. Therefore, a gas current of only one or two microamperes for each radio-frequency amplifier tube would provide a total high enough to wipe out the no-signal bias due to the drop produced by gas current through the grid isolation resistors and the avc isolation resistor which was one megohm in most designs (See Fig. 1). During the last few months reports indicate that trouble of this kind is no longer encountered due both to improvement in the exhaust of the metal tubes and to correction in the design of the receivers.

SHRINKAGE

At present manufacturers report that metal tubes are made with shrinkage approaching shrinkage losses in glass tubes. Under these conditions glass and the new metal tubes can be considered on a par for trouble-free performance and the advantage in shielding and size in the new metal tubes can be fully realized.

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DETERMINATION OF MAGNETIC HYSTERESIS

THE FAHY simplex permeameter is in quite general use for determining the magnetic properties of ordinary magnetic materials. In its original form, values of magnetizing force corresponding to points on a hysteresis loop cannot be obtained as precisely as can be done for points on the normal induction curve. An attachment has been devised at the Bureau of Standards by which the hysteresis values can be obtained with a precision comparable with that attained in the determinination of normal induction data. This device is described in RP845 in the November number of the Journal of Research.

The 6F6 as a Triode-connected Class AB Amplifier

The requirements for obtaining optimum power output from a Class AB amplifier are usually based on the assumption that the power-supply source has nearly zero resistance and, consequently, furnishes nearly constant voltage as the power output varies from zero to a maximum. Because this assumption is seldom true in practice, it is desirable to know the requirements for obtaining optimum power output when the power-supply unit has some resistance. It is the purpose of this article to furnish detailed operating characteristics for two type 6F6 tubes when they are connected as triodes and operated as a Class AB amplifier. The data outlined is the result of research in the laboratories of the RCA Radiotron Division of RCA Manufacturing Co., Inc.

DESCRIPTION OF TESTS

The screen of each type 6F6 tube was connected to its plate and each control grid, in turn, was driven positive during a portion of the input-voltage cycle in order to obtain high power output; the power required by these grids was furnished by a suitable self-biased driver tube through an input transformer. In every case, the driver tube was biased to operate as a Class A amplifier.

Preliminary tests were conducted in order to determine the optimum input-transformer ratio and optimum plate-to-plate load for both fixed- and self-bias conditions and for several practical power-supply regulations. These tests show that the optimum plate-to-plate load is substantially independent of power-supply regulation. The value of this optimum load depends upon the power output desired, the permissible distortion, and whether or not the bias on the output tubes is obtained from a self-biasing resistor. The optimum input-transformer ratio was found to be a function of power-supply regulation only when the bias on the output tubes was fixed; when the output tubes were self-biased, the optimum transformer ratio was found to be substantially independent of power-supply regulation. The optimum plate-to-plate load and optimum input-transformer ratio for each test are given on the curves and in the summary table on the opposite page.

THE DRIVER TUBE

In order that a tube be suitable for use as a driver, it should have a reasonably high power sensitivity and should be capable of supplying the losses of both the input transformer and the grids of the output tubes. The results of a number of tests indicated that either a single 6F6 connected as a triode or a single 6C5 is a suitable driver. The 6F6 has reasonable power sensitivity and can satisfy the power requirements; the 6C5 has a high power sensitivity, although it cannot furnish all of the requisite power. The plate impedance of each type is low enough so that the inductance of the primary of the input transformer can easily be made sufficiently high to obtain good low-frequency response. In all tests, the 6F6 driver was self-biased to —20 volts and the 6C5 to —8 volts with no signal input; the zero-signal plate-to-cathode voltage was 250 volts for either type of driver. A comparison of the merits of the 6F6 and the 6C5 as drivers can be made from the accompanying curves or the summary table.

EFFECT OF PLATE-SUPPLY REGULATION

The total series resistance in the plate circuit of the 6F6 output tubes consists of: (1) r_p, the plate resistance of the tubes; (2) R_p, the load resistance; (3) R_c, the series resistance common to grid and plate circuits; and (4) R_b, the equivalent series resistance of the power supply. It will be noted that R_c in self-biased circuits is equivalent to the grid-bias resistor.

When R_c and R_b are zero, best plate-voltage regulation and maximum power output are obtained. Therefore, it is advantageous to use fixed bias instead of self bias and to have R_b as small as possible. If a plate-voltage source of approximately zero resistance is used in place of the regular power supply, and if resistance is then introduced in series with this source until it has the same voltage regulation as the regular power supply, the resistance added to the circuit is the equivalent internal resistance (R_b) of the power supply. In practice, R_b is determined by plotting the voltage-regulation curve of the power-supply system. This curve may be obtained conveniently by measuring the slope of the line joining the voltage outputs at the zero-signal and maximum-signal operating conditions. These correspond to minimum and maximum current drain. The slope of this line represents R_b, the equivalent d-c resistance of the power supply.

(A) OPERATION USING 6F6 DRIVER AND FIXED BIAS

Fig. 1 shows curves of d-c plate current, distortion, and d-c grid current vs. power output for power-supply regulations corresponding to 0, 500, and 1,000 ohms. As mentioned previously, a different optimum input-transformer ratio is required for each power-supply regulation when the bias is fixed; these optimum ratios are shown in the insert of Fig. 1 and in the summary table. The input-transformer ratio (primary: ½ secondary) decreases as R_b increases.

As the power output increases, distortion and plate current increase. Outputs of 18.8, 16.4, and 14.4 watts are obtained, corresponding, respectively, to power-supply regulations of 0, 500, and 1,000 ohms. (All curves shown in this and in subsequent figures terminate at the start of driver grid current.) The distortion at maximum output for each power-supply regulation is approximately 7 percent. If the input-transformer ratio is adjusted to optimum for zero power-supply regulation, the power outputs shown will not be obtained for any other power-supply regulation unless accompanied by increased distortion.

(B) OPERATION USING 6F6 DRIVER AND SELF BIAS

The change from fixed- to self-bias operation requires the use of a different plate-to-plate load and input-transformer ratio for optimum results. The transformer ratio and load were kept the same throughout this test. The results, shown in Fig. 2, indicate that less power output is obtained when self, rather than fixed, bias is used and that both plate current and distortion are independent of power-supply regulation. Driver grid current started to flow at the same value of input signal for all three regulations. The power outputs corresponding to regulations of 0, 500, and 1,000 ohms are 14.6, 14, and 13.5 watts; the distortions are 7.4, 6.2, and 5.4 percent, respectively. It is seen that the effect of 1,000 ohms in the power supply is to reduce the maximum power output from 14.6 to 13.5 watts, a decrease of 7.5 percent; the corresponding decrease in test A with fixed bias was 23.4 percent.

(C) OPERATION USING 6C5 DRIVER AND FIXED BIAS

Fig. 3 shows curves of d-c plate current, distortion, and d-c grid current vs. power output when a 6C5 is used as the driver and fixed bias is applied to the output tubes. In this test, as well as in test A, it was found that the optimum plate-to-plate load was 6,000 ohms

(*Continued on page 23*)

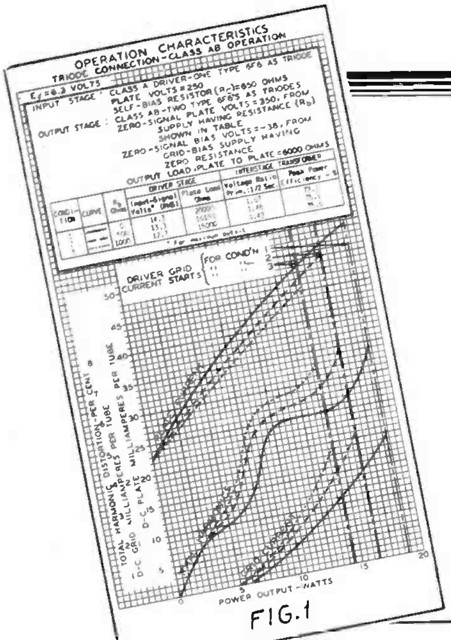


FIG.1

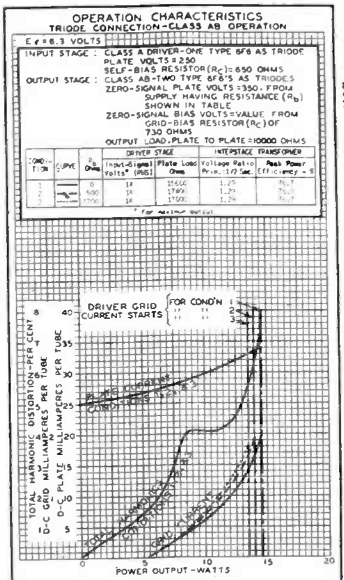


FIG.2

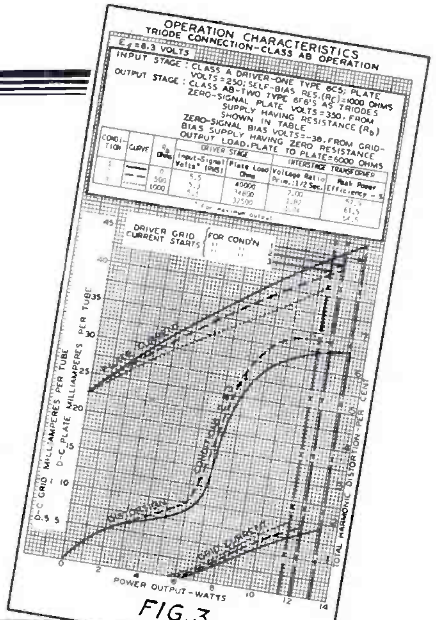


FIG.3

SUMMARY TABLE

CLASS AB OPERATION OF TYPE 6F6 TUBES (TRIODE CONNECTED)

INDEX	DRIVER STAGE[1]						INTERSTAGE TRANSFORMER[2]		OUTPUT STAGE[3]										
	Tube Type	Input-Signal Volts (RMS)	Grid-Supply Resistance (R_c) Ohms	Zero-Signal Plate Current Milliamperes	Plate Load Ohms	Max. Power Output Milliwatts	Primary / 1/2 Secondary	Peak Power Efficiency Per cent	Plate-Supply Resistance (R_b) Ohms	Grid-Supply Resistance (R_c) Ohms	Grid-Input Peak Power Milliwatts	Grid-Input Peak Volts (per tube)	D-C Grid Current Milliamperes (per tube)	Zero-Signal D-C Plate Current Milliamperes (per tube)	Max.-Signal D-C Plate Current Milliamperes (per tube)	Plate-to-Plate Load Ohms	Power Output Watts (two tubes)	Total Harmonic Distortion Per Cent
Fig.1	6F6[4]	14.3	650	31	20000	690	1.67:1.0	73.2	0	0[6]	505	63.8	2	22.5	54.5	6000	18.8	6.8
Fig.1	6F6	13.3	650	31	16150	685	1.48:1.0	75.8	500	0[6]	520	63.4	2.2	22.5	50	6000	16.4	7.0
Fig.1	6F6	12.7	650	31	15000	690	1.43:1.0	75.6	1000	0[6]	525	63	2	22.5	45.5	6000	14.4	6.8
Fig.2	6F6	14	650	31	15600	765	1.29:1.0	76.7	0	730	585	76.2	2	25	34	10000	14.6	7.4
Fig.2	6F6	14	650	31	17400	592	1.29:1.0	76	500	730	450	71.6	2	25	33.5	10000	14	6.2
Fig.2	6F6	14	650	31	17000	605	1.29:1.0	76.7	1000	730	465	71.4	1.8	25	33	10000	13.5	5.4
Fig.3	6C5[5]	5.5	1000	8	40000	330	2.00:1.0	57.9	0	0[6]	190	54.5	0.93	22.5	47.5	6000	13.1	6.6
Fig.3	6C5	5.3	1000	8	34800	330	1.82:1.0	61.5	500	0[6]	200	55.1	0.95	22.5	44	6000	12.1	6.8
Fig.3	6C5	5.1	1000	8	32500	310	1.74:1.0	64.5	1000	0[6]	200	54.5	0.95	22.5	41	6000	11.5	6.8
Fig.4	6C5	5.5	1000	8	35700	347	1.67:1.0	61.6	0	730	215	63.2	0.92	25	31.5	10000	11.4	6.2
Fig.4	6C5	5.5	1000	8	38500	304	1.67:1.0	59.6	500	730	180	62	0.9	25	30.5	10000	10.5	6.2
Fig.4	6C5	5.5	1000	8	37700	315	1.67:1.0	60.2	1000	730	190	62.4	0.9	25	30	10000	9.8	6.2

[1] Zero-signal plate volts equals 250.
[2] Primary resistance, 1000 ohms; secondary resistance, 400 ohms; equivalent core loss, 100000 ohms.
[3] Zero-signal plate voltage equals 350 volts.
[4] Plate resistance of 6F6 under indicated conditions equals 2600 ohms.
[5] Plate resistance of 6C5 under indicated conditions equals 10000 ohms.
[6] Fixed bias.

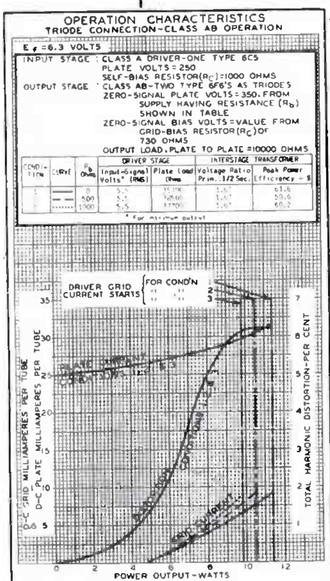
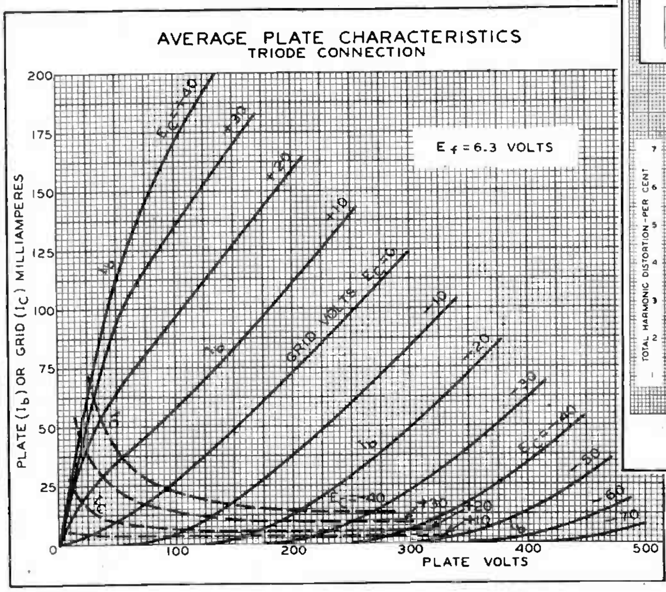


FIG.4



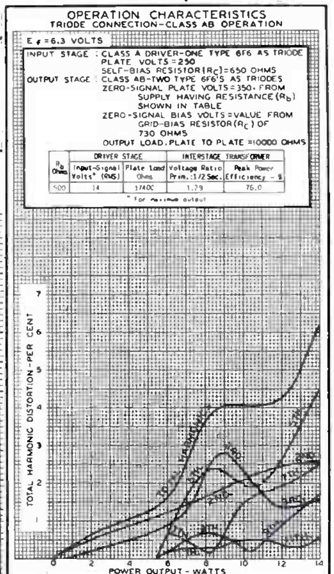
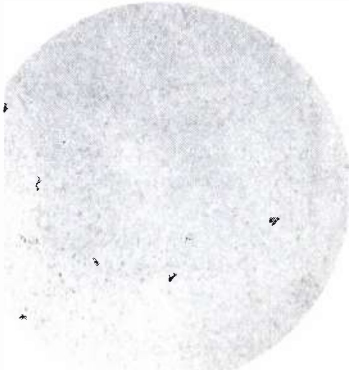


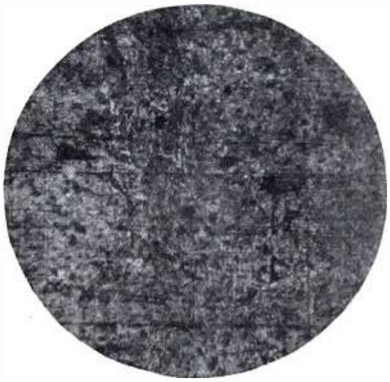
FIG.5

METAL

IN RADIO TUBES



Flat strip of Svea metal for radio: Surface with no polishing or etching (100X unretouched). Note uniformity with freedom from slag, impurities and gas bubbles.



Flat strip of nickel for radio: Surface with no polishing or etching (100X unretouched). Note relative porosity and non-uniformity of surface.

Special strip of purest domestic iron for radio: Surface with no polishing or etching (100X unretouched). Note impurities and elongated gas bubble under surface at right. Slag and carbon hard spots make uniformity impossible.

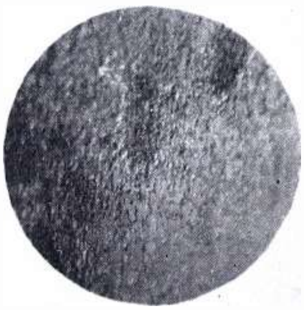
CHARACTERISTICS OF QUALITY IRONS AND COLD ROLLED STEEL

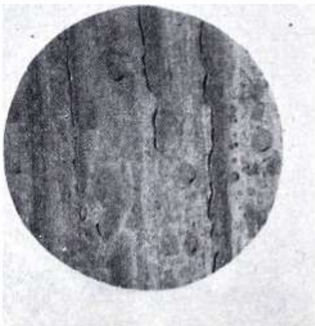
Right: Illustrating the effect of sharp bend on cold rolled steel. Metal structure will suffer under such treatment if impurities are present.

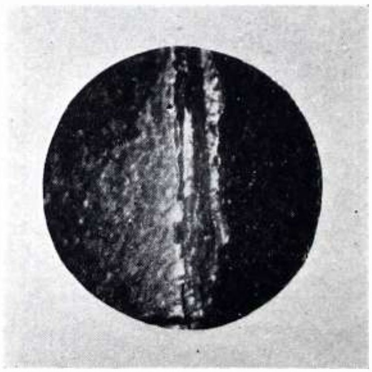
Below: Showing physical surface defects of cold rolled steel which are quite evident under the microscope which magnifies minute defects (30X).

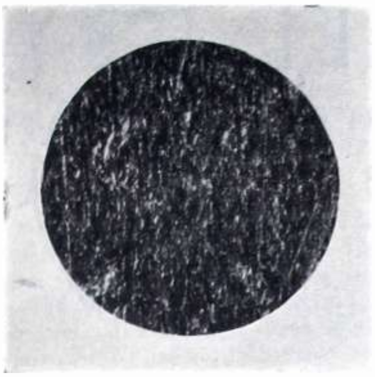
Lower Center: Specially prepared best quality domestic iron showing chemical action on the streaks of impurities—usually pockets of gas under the surface of the metal.

Below: Same quality of iron shows gas pockets under the surface which open with a single sharp bend. Such material will not stand fabrication and if used in tubes causes short life due to liberated gas.

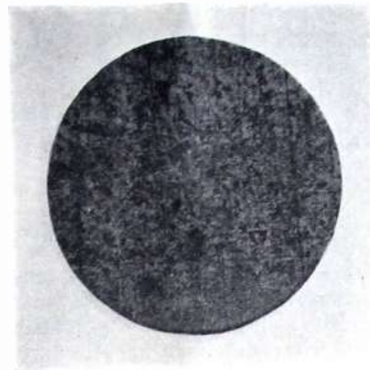




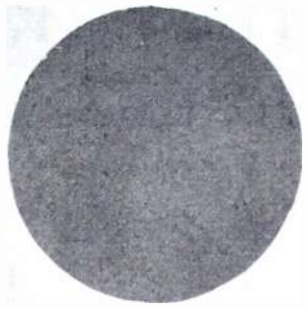




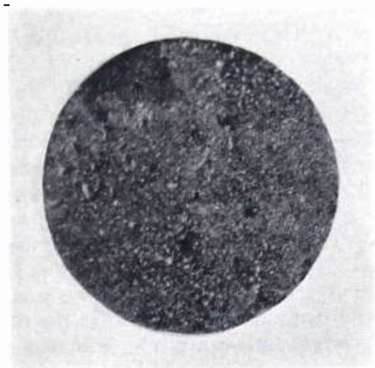
Copper, washed only. Not etched (60X).



Nickel, washed only. Not etched (60X).



Svea metal, washed only. Not etched (60X).



Copper, after 150-hour bath in mercury at room temperature (60X).

Nickel, after 150-hour bath in mercury at room temperature (60X).

Svea metal, after 150-hour bath in mercury at room temperature (60X).

ENGLISH RADIO MARKET

THE TOTAL TURNOVER of the British radio industry in the year inaugurated by the Olympia show will be nearly £30,000,000. This estimate was given by J. H. Williams, Chairman of the Radio Manufacturers' Association.

He anticipates that in the 12 months, 1,750,000 receivers will be sold, compared with 1,500,000 in the previous "radio year," when (from show to show) the total turnover was approximately £25,000,000.

He thought that the London exhibition indicated a steady expansion of trade. It was another sign that the 8,000,000 peak in receiving licenses would be reached.

Inquiries among tube manufacturers revealed the expectation that 10,000,000 tubes would be sold in the year—about 7,000,000 in new sets and the remainder in replacements.

Satisfactory expansion of overseas trade was reported by many firms. There are growing markets, particularly for all-wave sets, in India, Africa and the Empire generally. British sets, despite export difficulties and foreign competition, are finding their way into many countries. Among the chief foreign buyers are Norway, Sweden and Belgium, though business has been done with a score of others. *(Clerk Alfred Nutting, Consulate General, London).*

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CATHODE-RAY TECHNIQUE

(Continued from page 7)

such devices has also recently been improved, particularly since a thorough investigation has revealed many inadequacies in binding agents like silicate of potassium and sodium. Either such chemicals possess characteristics that are inherently fluorescent or produce the desired homogeneous, non-coloring and light-retaining surfaces only after extreme care has been exercised in their application. A new binding material, of unknown chemical constituents, has been compounded in Germany to overcome these difficulties. Likewise, a long-nozzled spray-gun (Fig. 3A') having an aperture of 0.4 mm has been designed to most effectively produce a uniform binding screen, once the envelopes have been cleansed with hydrofluoric acid. Using a pressure of about three atmospheres, one obtains a matted-appearing film from the fine spray in about thirty seconds time. After the binder has dried to a consistency comparable to that of a fly-paper, the fluorescent powders are carefully filtered on to the surfaces, or applied as in Fig. 3A, and the tube is finally dried in a weak vacuum at a temperature of 200° C.

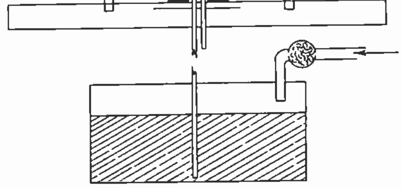


Fig. 2. A trap containing sodium hydroxide in the pressure-line to the reservoir absorbs gaseous acid-anhydrides, thus preventing the formation of electrolytes in the graphite solution.

THE GRID BIAS CELL

FROM DATA PREPARED BY THE ENGINEERING DEPARTMENT, P. R. MALLORY AND CO., INC.

THE GRID BIAS cell is a small acorn-shaped, self-contained device ⅝″ wide and 11/32″ deep. The case itself is the negative electrode, and the disc the positive. The no-current potential of the cell is 1.0 volt plus or minus 10 percent. This potential is constant within wide limits of temperature, humidity and superimposed alternating current. Its life is practically indefinite—cells studied on shelf life and under operating conditions over the full 2½ years development period showing no change in characteristics.

APPLICATION

The principal use of the Grid Bias Cell is to furnish bias for the type 75, 2A6, or similar tubes used as the first audio stage in modern high-gain audio, avc receivers. The use of these tubes has become increasingly popular during the last year, since no other tubes at present available permit the nicety of commercial balance between cost, commercial and technical requirements. These tubes we understand, however, have intrinsic disadvantages peculiar to extremely high-mu triodes which makes satisfactory *current* design either critical or expensive. As far as bias systems are concerned, there are two fundamental systems in common use. Of these, there are many modifications of detail only. The accompanying circuits are intended only as being illustrative of usual practice.

Fig. 1 represents a common circuit of this type in which the bias is obtained by a common cathode series resistor. It has been called to our attention that one major difficulty with this circuit lies in the necessity of providing a large capacity by-pass C, usually a low-voltage electrolytic, this condenser being made necessary by the fact that the cathode is above ground. This circuit is susceptible to the usual degenerative effects of self-biased audio circuits, and overloads easily with constant distortion.

Fig. 2 represents another bias circuit in common use, preferred by many manufacturers. In this case the cathode is grounded which is a distinct advantage over the system shown in Fig. 1. The bias return is usually brought to a point in the negative power supply return. We understand that though somewhat more stable and less sensitive to the disadvantages of the system of Fig. 1, this circuit usually requires the filter R-C, involving a resistor and a condenser. It is still susceptible to early overload and variations of potential of the bias return, which happens in economical design as the result of tube age, line voltage, variations, etc.

The circuit using the Grid Bias Cell is shown in Fig. 3. This circuit furnishes a definite normal bias of 1.0 volt on the grid; this bias remaining independent of tube characteristics, due to tube variations, and the variations encountered in one tube throughout its life. This circuit avoids degenerative effects and is not so greatly susceptible to overload distortions. The cell replaces the R-C filter of Fig. 2, as well as simplifying the negative power return circuit; and replaces the cathode resistor R and cathode by-pass C of Fig. 1, with the cell and grid resistor of Fig. 3.

"CONTACT POTENTIAL"

It has been stated that one of the greatest disadvantages of the use of the high-mu triode lies in the fact that the so-called "contact potential" (grid voltage at which the grid draws current) at least in the early life of the tube, is close to the operating bias, this resulting in positive overshooting by relatively weak signals, with consequent grid current distortion. Furthermore, this "contact potential" is not constant from tube to tube, nor does it remain constant throughout the life of the tube. Oxide-coated cathodes are reported to have as a general property relatively high negative contact potential when new. This potential gradually approaches zero, going positive, then through a minimum, and finally slowly increasing again in the negative direction. As far as grid-current distortion is concerned, this amounts to a continually changing operating bias throughout the tube life, the condition being most severe early and very late in the tube's life. In order to overcome this apparently inherent difficulty, we understand many designers overbias the tube, a practice, so we are told, which is not fully satisfactory due to loss in gain and grid cut-off distortion (rectification) as the contact potential recedes from its original negative value.

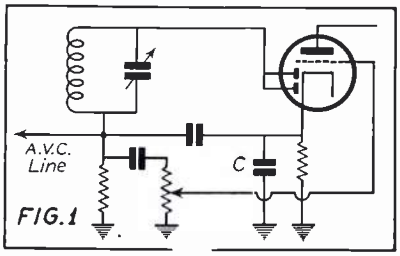


FIG. 1

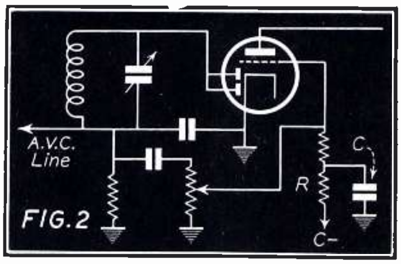


FIG. 2

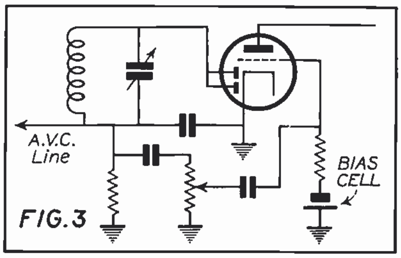


FIG. 3

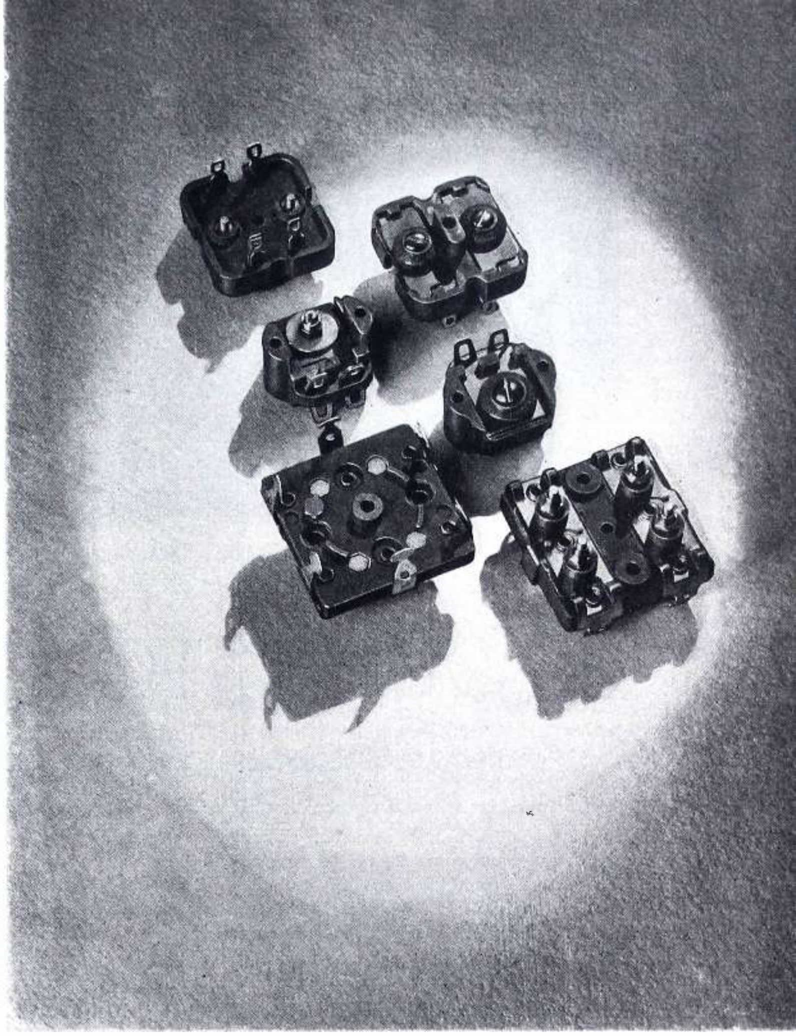
The Grid Bias Cell has an inherent property which enables it to accommodate the bias value to a considerable extent to variations in contact potential, due to the fact that grid current in the grid-to-cathode direction will charge the cell more negatively, and its potential will increase under continued charging to a value of approximately 2.0 volts. This voltage will, after operation has ceased, gradually decrease to the original design voltage of the cell, the time it takes to return being a function of the total quantity of electricity passed through it during charging. In some cases, after prolonged charging, the cell might take as long as 48 hours to return to its original voltage.

SELF-REGULATING FEATURE

A specific example will illustrate this action. Assume a contact potential of 0.9 volts,—a not unusual condition in a new tube. With the bias set at 1.0 volts by the Bias Cell, the tube will draw grid current when the signal peaks exceed 0.1 volt. The Bias Cell, however, will quickly become more negative as the peaks exceed the 0.1 volt, and increase

(*Continued on page* 20)

XM-262

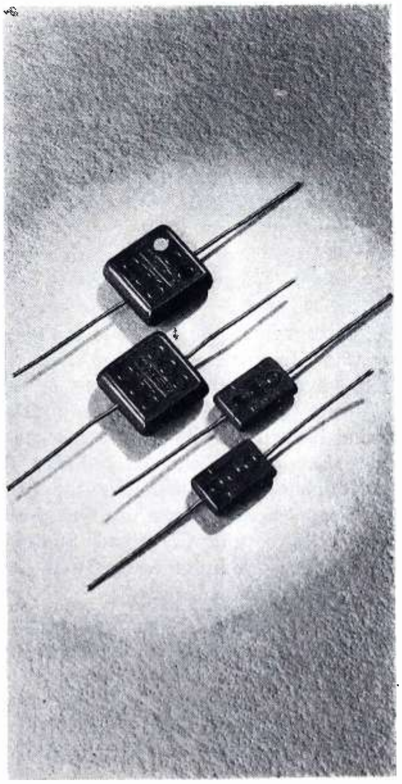


A New Mineral-Filled Molding Material Designed Particularly For Electrical Insulation Requiring Low Dielectric Losses

The Bakelite Laboratories have developed a new type phenolic insulation material, known as XM-262, which has low loss at high radio frequencies, high surface resistivity, low moisture absorption, has the desirable mechanical properties of other types of bakelite, is free from brittleness and breakage, and is adaptable to intricate and accurate forming. Its uses as bases for padding condensers, and as cases for molded mica condensers, are shown in the accompanying illustrations. The same material is also being used for grid-cap insulators in all-metal tubes.

Since the introduction of XM-262, a number of improvements have been made in certain of its characteristics. For instance, the moldability and the adaptability to preforming have been greatly improved. Whereas the original material required a six-minute molding cycle, it is now possible to mold the same material in three minutes with no sacrifice in electrical properties.

ABOVE: XM-262 BASES FOR MICAMOLD PADDING CONDENSERS.
BELOW: MICAMOLD FIXED CONDENSERS CASED IN XM-262.
(Photos courtesy Bakelite Corporation)



PHYSICAL AND ELECTRICAL PROPERTIES

The specific gravity of the material is 1.9. Its weight per cubic inch is 1.1 ounces. The energy required to break the material (Izod test) is 0.20 foot-pounds; per inch of notch, 0.40 foot pounds; per inch square, 2.50 foot-pounds. Its modulus of elasticity (flexure) is 4.5 to 5×10^6 lbs per sq. inch; flexural strength—9300 lbs. per sq. inch; tensile strength—6100 lbs. per sq. inch. The dielectric strength is 640 volts per mil. instantaneous and 400 volts per mil. step.

The power factor of XM-262 at 1000 cycles is .9 to 1.2 percent. At 1,000,000 cycles it is 0.75 percent. The specific inductive capacity is 5.0 to 5.5, and the resistance surface, based on the Western Electric Test (after 96 hours at 90% relative humidity at 95° F.) is 2000 megohms. The volume restivity is over 10^8 megohms centimeters.

The material has very low moisture absorption—only 0.002 percent at the end of 24 hours; 0.007 percent at the end of 48 hours; and at the end of 144 hours, only 0.025 percent.

MOLDING CHARACTERISTICS

The bulk factor of XM-262 is 2.5; the shrinkage is .0025" per inch. The cure, in 1/4" thickness, is five minutes hot and five minutes chill.

In all the tests on this molding material, steam-heated platens at 320° F. are used with 2000 pounds pressure per square inch on the piece. The molds are hand molds. The material has to be cooled to prevent blistering, espcially on large and thick pieces.

The Cleveland Stadium on the Closing Day of the National Eucharistic Congress. Estimated crowd, 160,000.

SOUND TO 160,000 PEOPLE

DETAILS OF EQUIPMENT USED FOR THE 1935 NATIONAL EUCHARISTIC CONGRESS

By K. J. BANFER

General Manager

SOUND SYSTEMS, INC.

To saturate with high-fidelity sound an oval double-deck stadium seating 80,000 people and an additional 80,000 people standing in a "human monstrance" in the center of the stadium—a line of procession ¾ of a mile long with sound for both those in the procession and spectators, a crowd of over 100,000—was the order given to Sound Systems, Inc., by the National Eucharistic Congress held in Cleveland, September 23 to 26th, 1935. This was to be accomplished in the face of a difficult program pick-up.

PROBLEMS INVOLVED

The program in the stadium consisted of groups of voices, massed bands, individual speakers and radio pick-up. Perhaps the most difficult was the program given on the last day, including the final procession, Benediction Services and the Pope's greeting from Rome.

To pick up and amplify the various forms of Mass during the three-day Congress with microphones at scattered points was a matter made difficult by being in the open air. To do justice to such a program requires special studios and various types of microphones, but similar results were required in amplifying the program at the Eucharistic Congress outdoors.

SERVICES HANDLED

On the final day the stadium was completely filled at one o'clock. The procession started at a point about one mile distant and the program started with sermons and chanting with a musical background. The procession and program were started simultaneously and those in the line of march were able to participate in the services held at the stadium during the three hours necessary for the entire procession to enter the stadium. It was very clearly specified that there should be no sound lag at any point, reproduction to be clear and undistorted and at a volume to override all street and crowd noises, and to be perfectly synchronized. At a time between 4:00 and 5:00 P. M. regardless of the program in the stadium the Pope's greeting from Rome, broadcast by short-wave to America, was to be rebroadcast over the entire system. The normal hazards of short-wave reception would have to be encountered, but to avoid unnecessary difficulties the program was carried direct by line from New York to the Cleveland Stadium and broadcast simultaneously with the national chain broadcast.

Inquiries received about the various methods used, indicate that a brief description of the installation might prove beneficial to those in the public-address business.

MIKE AND SPEAKER EQUIPMENT

Microphone equipment consisted of six crystal microphones selected for their high-fidelity of reproduction, sturdiness of construction and their imperviousness to adverse weather conditions. Two three-position mixers were employed with the necessary amplifications, explained in the block diagram.

Loudspeaker equipment was extremely important. In order to deliver sound of equal volume without lag or echo to all points in the Stadium, it was absolutely essential that the loudspeakers be grouped somewhere near the center and near the origin of sound. Permission for this location was given much against the desires of those conducting the Congress. It is doubtful if a major installation has ever been made anywhere in which so much consideration has been given in favor of good sound reproduction. Ordinarily, loudspeakers are specified at points already provided for before sound is considered, but the unconditional guarantee given in this installation made it necessary to make sound one of the original considerations. This is a fact which must be considered more and more in the future, if better sound reproduction and distribution is to be obtained.

SPEAKER DISTRIBUTION

Due to the oval arrangement of the audience and the long "throw" and high volume needed, it was necessary to use: (A)—two clusters of trumpets laid out with the actual dispersion beam of each one slightly overlapping. Eighteen trumpets with giant units were necessary to cover the area. This did not include the single-deck section at the rear of the Stadium, as it was inadvisable to project sound to the rear over the microphone positions because of feedback difficulties. The single rear section was covered with slightly shorter projectors and electro-dynamic units. These were (B) square baffles with bells 27" x 27" x 24" deep chosen for the dispersion and depth of coverage needed. On the outside at the rear of the Stadium it was known that the procession would be retarded and grouped at the entrance gates and complete short range was necessary. A wide-dispersion angle projector (C) with a bell 41" x 41" x 15" deep was used at these two points.

To cover the line of march required high power and a somewhat narrower beam, but wider than the beam of a standard trumpet. A baffle with a rectangular opening (D) 27" x 41" x 36" deep was used at the points shown along the line of march in the diagram. Fourteen of these units were necessary each covering from 250 to 300 feet.

TRANSMISSION LINES

In order to have even distribution of sound it was necessary to install transmission lines to carry the signal at comparatively low level (20 db, 0.6 watts) over the entire circuit. The transmission lines were divided into three circuits each having its own gain control, making it possible to equalize output signal depending upon the area covered. In order to check the volume on the street and various points of the Stadium, a telephone system was necessary to converse with the operator who controlled the entire system from the center of the Stadium near the microphone.

THE MIXERS

The two three-position mixers, shown in the block diagram, were primarily composed of three individual two-stage pre-amplifiers. The microphones were fed into the two grids of the input tube and an electronic mixer, composed of a tapped dual volume control with approximately 3 db attenuations per step, was used between the plates of the input tube and the grid of the second stage. The two stages of low-level amplification were, of course, push-pull and all the microphones used utilized the push-pull principle. The outputs of the mixers were provided with either a high impedance to feed directly into push-pull grids or through an electronic coupling device, the impedance to change to either 200 or 500 ohms as the requirements might be. The over-all gain per stage in the electronic mixer is approximately 56 db.

The outputs of the two mixers were paralleled into a three-stage triple push-pull voltage amplifier and master control. The over-all gain of this voltage amplifier is 84 db, with a power output of 30 db. Output impedances were arranged by means of a tapped secondary to give accurate matching for from one to six 500-ohm lines.

EQUALIZING PANEL

Following the voltage amplifier a line matching and equalizing panel was installed. This panel was arranged for 500-ohm input and two 500-ohm and one 125-ohm output lines with special high power attenuators in each circuit. The two 500-ohm output lines were used to drive two 20-watt output stages and the 125-ohm line was used to drive four 20-watt output stages all connected in parallel. All of these output stages were provided with 500-ohm input, and an output line for accurate matching to accommodate from one to six 500-ohm power lines.

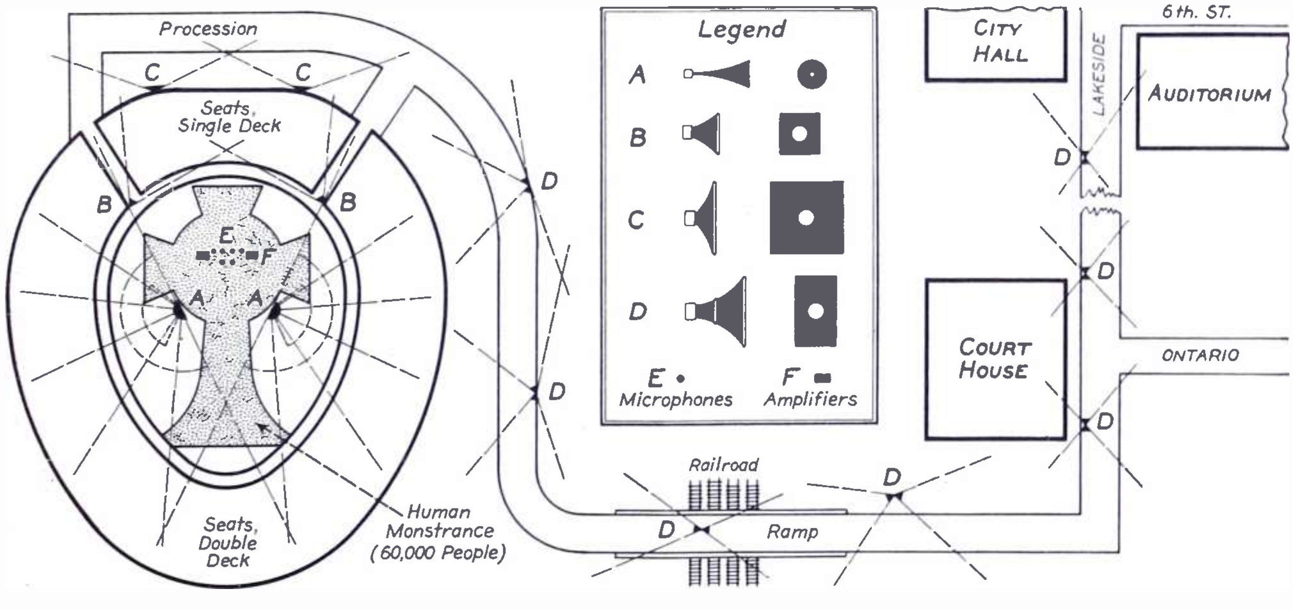
THE POWER SPEAKERS

The power speakers which are indicated as B, C, and D in the block diagram each consist of a high-fidelity, 12-inch cone type speaker having an over-all frequency response from 30 to 7,200 cycles. These speakers have a Class B audio stage built into the speaker chassis giving a maximum undistorted output of 10 watts, each with a maximum input signal of 0.6 watt. Field excitation is obtained from the power supply, also built into each speaker chassis. These power speakers were installed in exponential projectors with a dispersion angle of approximately 75 degrees.

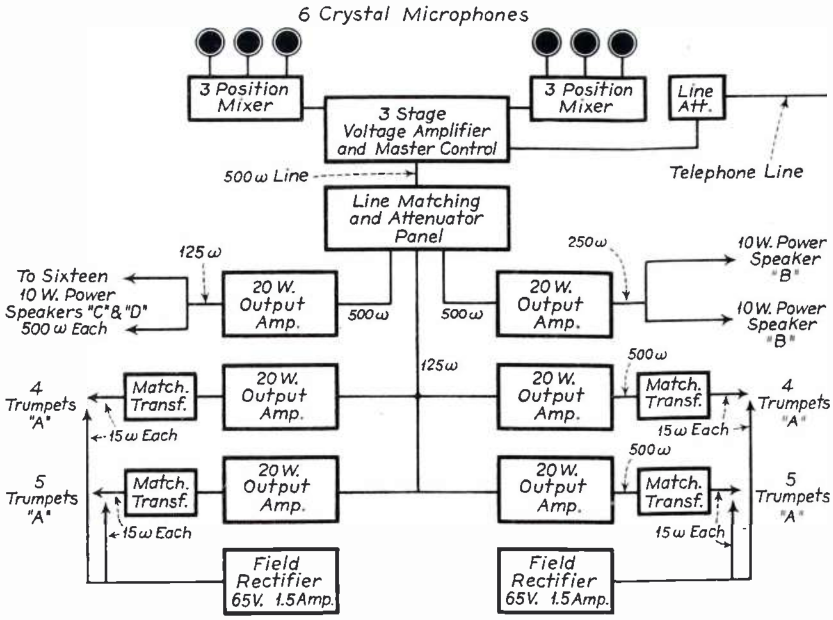
To supply field current for the 18 trumpets and giant units (A), two field rectifiers were used with all of the fields in series, supplying 65 volts at 1.5 amperes.

RESULTS

While the installation may be regarded as a standard type of public-address system, it was installed to serve two purposes. Inside the Stadium it was largely for the benefit of the audi-



Showing area covered by loudspeakers. Program amplified throughout the entire stadium and over the line of march nearly one mile in length. For three hours music and chanting were synchronized between the Stadium and line of march by the thousands participating.



Block diagram of the amplifiers showing the grouping of light-weight portable amplifiers to develop the volume of power needed. It was necessary to use the four types of speakers and baffles to properly cover the area designated.

ence, but the entire outside installation was for the purpose of synchronizing the program in which thousands were participating over an unusually large area. Failure of the system to do the work specified would have meant the cancellation of a large part of the mammoth program being attempted for the first time by a national organization of Catholic people.

Results met every wish of the organization, although it was planned with considerable doubt in the minds of the Congress as to the possibilities of the use of sound as compared to some other type of signal system.

A limited length of time was given for the installation due to other events in the Stadium, and last-minute changes were made continually during the four days, due to the unexpected overflow crowds. Small space was allowed for the amplifying equipment so as not to interfere with the special Altars and other arrangements.

The method of using small portable equipment to build up a total of over 300 watts of audio amplification needed for the work is not ordinarily used, but results were excellent. One cabinet 18" x 24" x 30" housed all of the amplifying equipment. From the diagram it will be seen that microphones were fed into mixers and pre-amplifiers. These fed into one small 7-watt amplifier which acted as a driver for six 20-watt output stages which in turn drove 10-watt stages built into the power speakers, the latter being used at remote points. This simplified the power problem at the main amplifiers and solved difficulties presented by long transmission lines and the necessity of uniform level over the whole system.

The public-address man will undoubtedly find suggestions here to help in the solution of similar problems which will become more complicated as new and greater uses are made of sound equipment.

THE GRID-BIAS CELL

(Continued from page 16)

in potential under continued operation until it has assumed such a voltage value that charging ceases. It will then automatically hold this voltage as long as the signal is strong, but will slowly return to normal as the signal is removed. As the tube ages, and the contact potential becomes less negative the tube will handle more and more signal without the necessity of charging the cell. These changes in bias, due to grid-current charging are so rapid that the effect of overshooting is practically unnoticeable aurally during the short time when the grid is overloading. This self-regulating feature thus becomes a most valuable and important asset of the Bias Cell, and allows non-critical design of the bias circuit with a degree of satisfactory and reliable operation heretofore unattainable.

OTHER USES

The Grid Bias Cell may also be effectively used to furnish the initial bias to the r-f, i-f, and converter tubes on the avc line. In this application, it is, of course, necessary to use several cells in series. Here again, this use allows the cathode to remain grounded, and experience has shown that regenerative effects and tendency to oscillate are considerably diminished by this bias method.

LIMITATIONS

The Grid Bias Cell is not adapted for power or output tube bias. No economy would result from piling up a sufficient number of bias cells to obtain the proper voltage for this service. Neither is the present cell so designed to satisfactorily handle the cathode-to-grid currents usually encountered in this type of service. The cell is a *potential device solely,* a discharge current of 0.5 microampere, drawn continuously over a period of several weeks, decreasing its voltage about one-third, the voltage returning gradually to normal after the discharge current has been discontinued.

CHARACTERISTICS

A-C: The characteristics of the cell are unaffected by super-imposed a-c as high as 360 microamperes of any frequency.

Impedance: The cell is non-reactive at audio frequencies, and the d-c resistance ranges between 11,000 and 50,000 ohms on standard production cells.

Temperature: The cell is unaffected and of uniform characteristics when operated in ambient temperatures in the range from minus 40-deg. F. to plus 120-deg. F.

Humidity: There is no change in cell characteristics when exposed indefinitely to a relative humidity of 90 percent at 120-deg. F.

Noise: The cell does not cause the development of any noise effects.

FIELD EXPERIENCE

For a period of nearly two years, a large number of cells have been in normal operation in various household and automobile receivers. In all cases the service in these sets has been highly satisfactory. Since October, 1934, many thousands of these cells are giving eminently satisfactory service in commercial receivers, without a single failure.

MOUNTING METHOD

In mounting the Grid Bias Cell in a receiver, it is necessary to have the exposed surface of the black electrode lie either in a vertical plane or in a horizontal plane at the bottom of the cell. It must never lie in a horizontal plane at the top of the cell.

CORES—

Design, Production

By Engineering Department
ALLEGHENY STEEL CO.

SELECTION OF MAGNETIC CORE MATERIALS FOR RADIO RECEIVER CONSTRUCTION—PART 2.

In the previous article, reference was made to impedance and reactance determinations which indicate inductance values. There follows data on the relations between such values.

CIRCUIT AND VECTOR RELATIONS

A non-inductive resistance "R" is placed in series with an iron cored reactance and a source of 60-cycle alternating current, as shown in Fig. 1. The voltages developed in this circuit are vectorally related in the manner shown in Fig. 2.

(I) Special case.

Assuming that $r + M = 0$, then $X = Z = 2\pi f L_a$.

Then $\frac{E_R}{R} = I$ the alternating current in amperes, which is flowing in the circuit.

$$X = \frac{E_X}{I} = \frac{E_X}{E_R} \times R$$

and for an applied terminal voltage of 1 volt rms across "X".

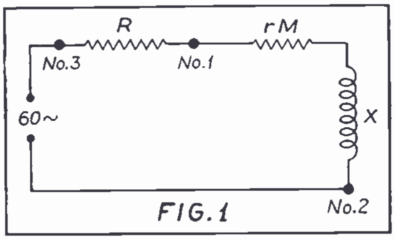
$$X = \frac{R}{E_R}.$$

(II) In the most general cases, the power factor of the inductance is cos θ

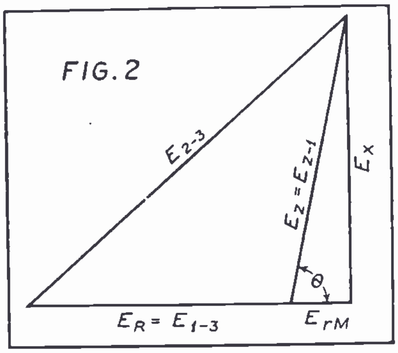
$$\text{and } \cos\theta = \frac{E_{2\text{-}3}^2 - E_Z^2 - E_R^2}{2\ E_Z\ E_R}.$$

From this relation the total losses in the core and winding may be determined.

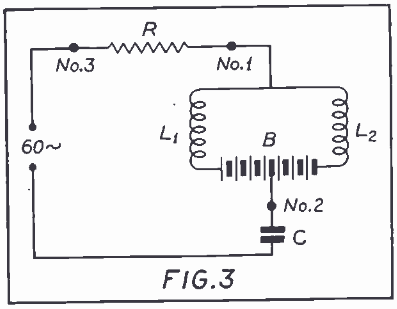
If a small battery be introduced into the circuit of Fig. 1, the proper amount of direct current can be sent through



Representative testing circuit.



Vectoral relations of voltages developed in circuit of Fig. 1.



Circuit for measurement of inductance of chokes.

the winding during measurement. A vacuum tube voltmeter may be used to measure the various voltages to advantage, inasmuch as it draws no appreciable current from the high-impedance circuit during the measurement. Care must be taken, however, that the proper type of vacuum-tube voltmeter is employed, so that only the a-c voltages will be measured, and the readings not be affected by the direct-current drop of potential resulting from the passage of the direct current through the circuit during the measurement.

MEASUREMENT OF INDUCTANCE OF FILTER REACTORS

The measurement of inductance of filter reactors carrying fairly heavy direct current through the winding during measurement, is accomplished by a slight modification to the circuit of Fig. 1. The modified circuit is shown in Fig. 3.

L_1 and L_2 should be identical in construction, in which case the combined inductance "L" of the two units is one-half of the inductance of either unit. Variation of the battery voltage will provide the necessary adjustment to send the proper amount of direct current through the two chokes, but this direct current will not flow through the remainder of the a-c circuit.

If only one inductance L_1 is available, another inductance L_2 should be very large with respect to L_1 so that the shunting action of L_2 may be neglected, or if the value of the inductance of L_2 be known at various values of direct current, proper allowance can be made for the shunting action of L_2 and the value of L_1 determined at various values of direct current.

L = parallel inductance value of L_1 and L_2.

From the relation $\frac{1}{L} = \frac{1}{L_1} + \frac{1}{L_2}$

the inductance desired is $L_1 = \frac{L L_2}{L_2 - L}$

The circuit for impedance measurements as outlined in the foregoing pages may be conveniently assembled from the apparatus indicated in the diagram of Fig. 4.

SELECTION OF PROPER TESTING SAMPLE

Any core having a rectangular cross section in the middle leg (if shell type construction is employed) may be used. Preferably stack the laminations alternately to give the lowest possible air-gap. If a butt-joint is used, the lowest practical reluctance that may be consistently maintained is the equivalent of a gap of .003″. This introduces a variable of considerable magnitude in the permeability determinations.

STANDARD UNITS

Having determined the permeability of the core material from the determination of the impedance, reactance and inductance of a given design, it is desirable for future reference and purposes of comparison to express the various magnetizing forces and flux densities in standard units.

The a-c flux density may be expressed in Gausses, as the maximum value or amplitude of a sinusoidal flux wave, equal in rms value to the rms value of the actual alternating flux density. On that basis,

STANDARD (TYPE L-7) LAMINATION FOR MAGNETIC TESTS

Magnetic Constants For Stack One-Half Inch Thick

A = 1.61 square centimeters.
l = 15.25 centimeters
V = 24.57 cubic centimeters
Wt. of full core high silicon steel = 184.3 grams
Wt. of full core Allegheny Electric Metal = 204 grams

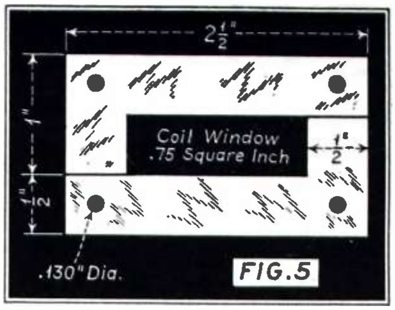


FIG.5

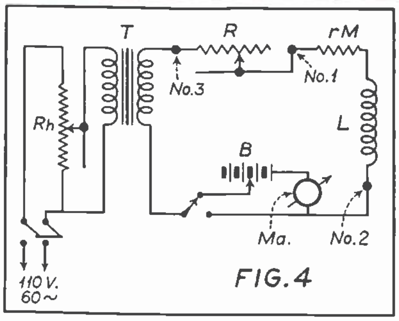


FIG.4

Symbol	Apparatus Characteristics
Rh	3200-ohm potentiometer type rheostat to carry .3 ampere.
Tr.	10-watt step-down transformer 110/10, 60 cycles
R	5-dial precision decade box from 1 to 100,000 ohms (non-inductive resistance spools)
Ma	0-10 ma milliammeter
L	Inductance to be measured
Ba	0-$67\frac{1}{2}$ volts "B" battery, variable in $1\frac{1}{2}$-volt steps

$$B_{max} = \frac{E_{effec} \times 10^8}{4.44\, f\, NAK_1} \text{ Gausses}$$

where E_{effec} is the rms alternating voltage across the coil
f is the frequency in cycles per second
N is the number of turns in the winding
A is the cross section of the magnetic core in square centimeters.

The polarizing magneto-motive force resulting from the direct current in the winding, expressed in Gilberts per centimeter, is given by the following expression:

$$H_o = \frac{1.256\ NI}{l} \text{ Gilberts per centimeter}$$

where N is the number of turns in the winding
I is the direct current in amperes
l is the length of the magnetic circuit in centimeters.

To express the magneto-motive force in ampere-turns per inch, multiply the Gilberts per centimeter by 2.032.

DESIGN RANGES

The tabulation in Table I gives the normal maximum values that are likely to be encountered in various audio transformers and smoothing reactors (chokes).

STANDARD LAMINATION FOR TESTING MAGNETIC CORE MATERIALS

On a purely theoretical basis, the standard ring sample test is unquestionably the most accurate. However, accuracy with the ring sample requires that the diameter of the ring be fairly large, necessitating a considerable loss of material. Furthermore, the coil must be wound upon the sample, making impossible the use of a previously prepared standard coil on a large number of similar size samples.

Usually, in the ring sample, there is no air-gap or break in the magnetic circuit, so as to have the entire mag-

TABLE I

Equipment	B_{max} Gausses	H_o Polarizing M.M.F. Gilberts per centimeter
Detector stage audio transformer	.5 to 10	.6 to 1.2
Second stage interstage audio transformer	250	1.5
Push-pull output transformer with two primaries	7,000	0
Polarized output transformer	4,200	6.7
Heavy duty filter reactor 80 ma.	300	27

TABLE II

COIL SPECIFICATIONS FOR STANDARD LAMINATIONS

Coil Type	Turns	Gauge	Approximate Resistance (ohms)	(B_{max}) Flux Density Gausses per volt 60 cy.	(H_o) Polarizing Force Gilb./Cm./milliampere
10	23,300	No. 40	4,000	10	1.9
100	2,330	No. 31	40	100	.19
1,000	233	No. 21	.4	1,000	.019
10,120	23	......	......	10,120	.00188
19,400	12	......	......	19,400	.000989

netic circuit included in the material under test. This does not reproduce the usual magnetic conditions in the core of audio transformers. In some such designs there is one air-gap, but more often there are two breaks in the magnetic circuit. Their effect is somewhat reduced by interleaving the laminations, which is the usual practice. In heavily polarized transformers and chokes, either a butt-joint or definitely controlled air-gap is necessary for satisfactory performance.

For the reasons noted above a standard lamination, covering the usual range of magnetic performance through the use of a series of standard coils is desirable. Such a lamination is shown in Fig. 5. The "L" lamination shown is economical to produce, and may be cut from Epstein watt-loss sample strips, when comparative study is made. If produced by a continuous dieing machine, these "L" laminations involve a scrap loss of between 15% and 20% of the sheet from which they are punched. When produced by a corner die, the punching loss is practically negligible.

Interleaving these laminations in a standard stack, in the usual manner, produces little strain upon the pieces. For service requiring either a butt-joint or definite air-gap, the "L" laminations place the two portions of the air-gap symmetrically in the magnetic circuit.

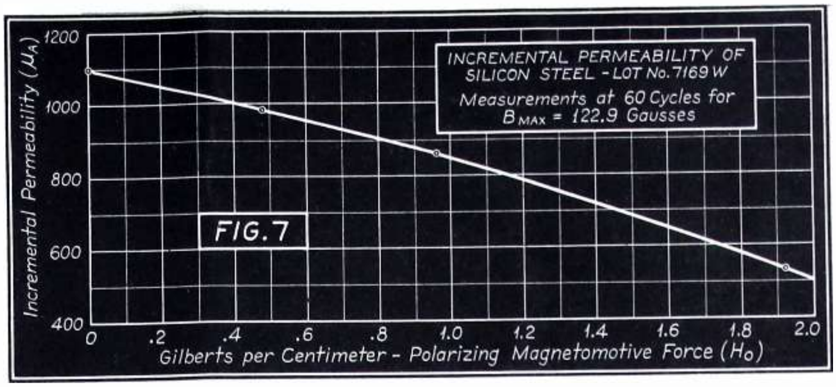


FIG. 7

COILS FOR STANDARD LAMINATION

In Table II is data on a series of five coils, which with the standard "L" laminations cover the entire working range of magnetic core materials, worked under a combination of alternating and direct flux densities. The resistance of each of these coils is sufficiently low to be practically negligible in comparison with the impedance obtained from the usual magnetic materials.

In Figs. 6 and 7 are given typical sets of observations and computations, illustrating the application of the foregoing suggested standard tests.

TEST FOR INCREMENTAL PERMEABILITY

Specimen: Silicon Steel Lot No. 7169 W		Pieces: 56 Gauge: .0143"		Wt. 150.5 gr. K_1 .813		Coil No. 100 B_{MAX}/Volt. (60 cy.) = 122.9		H_o/MA. = .192 μ_A/Henry = 170
E_z	E_r	R	Z	L	μ_A	MA.	H_o	B_{MAX}
1	1.222	3000	2455	6.52	1103	0	0	122.9
1	.917	2000	2180	5.78	984	2½	.48	122.9
1	1.204	2000	1924	5.10	867	5	.96	122.9
1	.844	1000	1183	3.14	535	10	1.92	122.9

FIG. 6

CLASS AB 6F6'S

(Continued from page 12)

and that the optimum input transformer ratio was dependent upon power-supply regulation. Power outputs of 13.1, 12.1, and 11.5 watts were obtained, corresponding to power-supply regulations of 0, 500, and 1,000 ohms. The distortion at maximum output for each power-supply regulation was approximately 7 percent.

Comparing these curves with those in Fig. 1 which shows corresponding results for the 6F6 driver, it is seen that the maximum power outputs are much less, although the power sensitivity of the driver and output stages combined is higher with the 6C5 than with the 6F6 driver. The two distortion curves corresponding to regulations of 500 and 1,000 ohms were found to be close enough to be represented by a single curve, as shown.

(D) OPERATION USING 6C5 DRIVER AND SELF BIAS

Curves of d-c plate current, distortion, and d-c grid current vs. power output for this test are shown in Fig. 4. Power outputs of 11.4, 10.5, and 9.8 watts, corresponding to regulations of 0, 500, and 1,000 ohms, were obtained. The distortion is approximately 6 percent for all three cases. The plate-current and distortion curves are independent of power-supply regulation.

HARMONIC DISTORTION

A harmonic analysis of the output using the set-up of test B was made in order to ascertain the nature of the distortion present under average operation conditions. The optimum plate-to-plate load was 10,000 ohms, the input transformer ratio was 1.29, the tubes were self-biased, and the power-supply regulation was 500 ohms. The results are shown in Fig. 5. Only second and third harmonics are present at low signal levels; at higher levels, the fifth, seventh, ninth, and eleventh harmonics appear. At high signal levels, the high-order odd harmonics form an appreciable part of the total distortion. The lack of high-order even harmonics is due, of course, to the cancellation of these harmonics in the plate circuit of the push-pull stage; the second harmonic shown is introduced by the driver stage.

Two 6F6's when connected as triodes in a push-pull circuit and operated to draw grid current, can provide power outputs up to approximately 18 watts at 7 percent distortion; the actual output depends on the regulation of the power supply, the method of obtaining bias, and the type of driver tube. The variation in maximum power output and distortion with power-supply regulation is small when self bias is used. This characteristic is desirable when power-supply costs must be kept low, although it is obtained at a sacrifice of power output. In all tests, the driver tube was driven to its grid-current point and was operated as a Class A amplifier.

The efficiency of the input transformer used in these tests was average; the actual efficiency for each test is listed in the summary table. It must be remembered, however, that the leakage inductance of this transformer should be small at all times, regardless of the efficiency of the transformer as a power-transferring device. The ratio of the input transformer was optimum in each test; any deviation from the optimum values will result in either less power output or increased distortion. It is suggested, therefore, that those contemplating the use of this audio system first determine the regulation of the power supply to be used and then estimate the transformer ratio from the values given in this article; power-supply regulations in excess of 1,000 ohms are not recommended.

THE 6L7 AS A VOLUME EXPANDER FOR PHONOGRAPHS

A DEVELOPMENT OF THE RADIOTRON ENGINEERING DEPARTMENT, RCA MANUFACTURING COMPANY, INC.

The ratio of maximum to minimum amplitudes that is feasible to record phonographically is not sufficient to take care of very large volume changes, such as may be produced by a symphony orchestra. For this reason, very large ranges in sound intensity are reduced in some way before the record is made. Such reduction, known as "compression," is usually accomplished manually by careful monitoring.

Most home phonographs have no provision for expanding the signal in order to compensate for the compression introduced at the time of recording. Hence, passages are distorted in the sense that they are not reproduced with full volume range. If full compensation for compression is desired, it is necessary to provide the phonograph with some means for increasing the amplification of loud passages in the same proportion that they were compressed at the recorder. However, if the volume control on the phonograph is set for reasonably loud volume on expanded passages, the residual noise level in the room may impair reception of soft passages when full expansion is used. Therefore, full compensation may not be desirable.

SIMPLE VOLUME EXPANDER CIRCUIT

The characteristics of the type 6L7 tube permit its use in a comparatively simple volume-expander circuit. This tube has a heater, a cathode, five grids, and a plate. Two of the five grids are control grids: the first (G_1) has a remote cut-off characteristic and the second (G_3) has a sharp cut-off characteristic. Of the three remaining grids, two are screens and one is a suppressor.

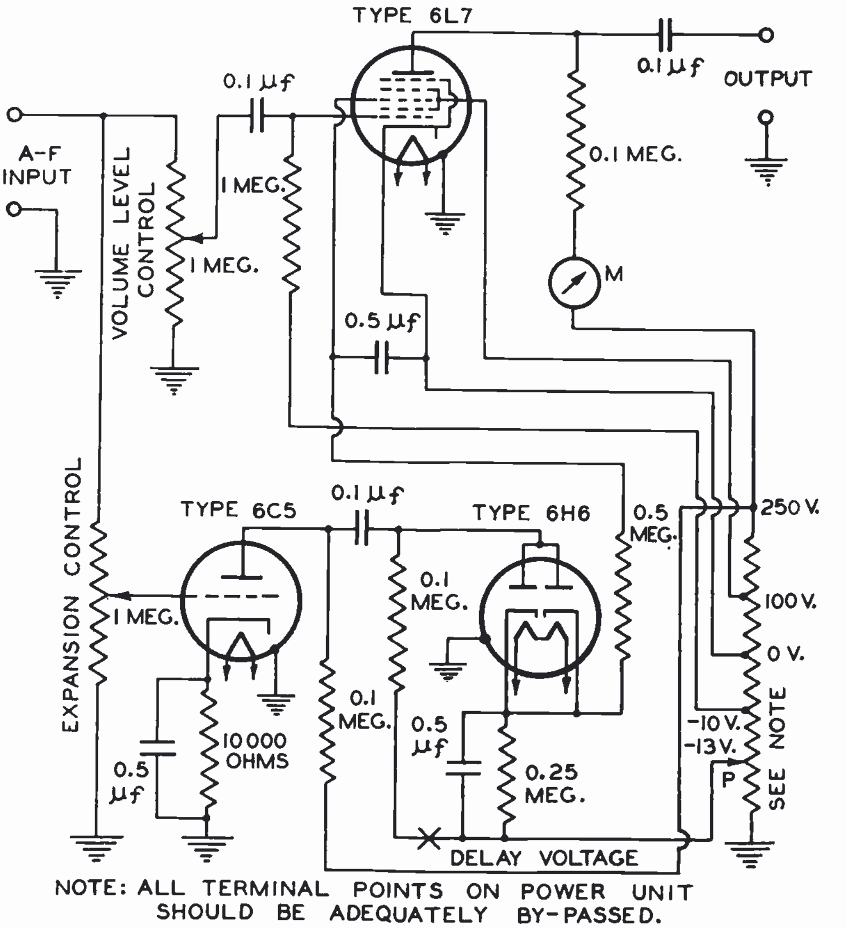


Fig. 1. Volume-expander circuit using a 6L7 tube.

The schematic diagram of a volume expander is shown in Fig. 1. The signal to be expanded is fed to the remote cut-off grid (G_1) of a 6L7 and also to the input of a 6C5, as shown. The output of the 6C5 is rectified by a 6H6; the positive terminal of the rectified output connects to the sharp cut-off grid (G_3) of the 6L7. The no-signal bias of this grid is such that the G_1-plate transconductance of the 6L7 is low (under 50 micromhos). When a signal is applied, the rectified voltage fed to G_3 increases the transconductance, and hence the gain, of the 6L7. This increase in gain is approximately proportional to the rectified diode voltage and, hence, to the signal amplitude.

TIME CONSTANT

It is essential that the time constant of the circuit generating the control voltage be so adjusted that changes in this voltage occur only for comparatively slow changes in signal amplitude. If the time constant is too short, speech will sound particularly unnatural; if the time constant is too long, there will be an objectionable lag. A time constant of 0.25 to 0.5 second is generally regarded as a satisfactory choice.

Distortion of the signal due to the characteristic of the remote cut-off grid (G_1) is appreciable for large signals. Therefore, the maximum signal input to G_1 should be 1 volt peak, which is of the same order as that obtainable from the usual magnetic phonograph pickup.

The plate-current value of the 6L7 serves as a good measure of the degree of expansion. It is suggested, therefore, that the initial bias on G_3 be adjusted for a no-signal plate current of approximately 0.15 milliampere by means of potentiometer P. This potentiometer requires no further adjustment if the same 6L7 is always used. The plate of the 6H6 may be biased negatively in order to delay expansion until a predetermined signal amplitude is reached. This delay voltage may be inserted at point X.

Although this system can operate from a radio receiver to provide expansion, it is suggested that, at the present time, volume expansion be used for phonograph reproduction only. Since large unanticipated changes in sound level during a broadcast may not be adequately monitored, the expander will act to exaggerate these changes. It is not probable that such accidental changes will be present in a phonograph record.

RMA NEWS

CLOSING a record-breaking year for the radio industry, the RMA Board of Directors met Wednesday, December 11, at the Commodore Hotel in New York City to canvass the results and make plans for 1936.

Sales of receiving sets during 1935 will total, for the first time in the history of the industry, over 5,000,000. The nearest approach to this record was the sale of 4,400,000 sets in 1929. Industry sales of radio tubes, parts and accessories have shown similar increases in the year now closing. With the business upturn and assured broadcasting features, especially with the coming presidential election, the prospects for 1936 are viewed with optimism by industry leaders.

RECORD INCREASE IN OCTOBER TAXES

A record-breaking increase of 129 percent in radio excise tax collections during October 1935 is tangible evidence of the prosperous radio season. During October, according to the latest official report of the U. S. Internal Revenue Bureau of collections of the 5 percent excise tax on radio and phonograph apparatus, radio manufacturers paid $643,440.02 as compared with $280,699.11 during October 1934. This did not include excise taxes on automobile radio which are not separately reported and are included among automobile accessories taxable at 2 percent. For the ten months' period ending October 1935 the total excise taxes collected on radio and phonograph apparatus were $3,134,941.04, compared with $2,490,099.01 during the same ten months of 1934, an increase of 25.9 percent.

Excise taxes collected on mechanical refrigerators during October 1935 were $258,797.91 against $308,406.37 in October 1934.

RADIO EMPLOYMENT INDICES FOR SEPTEMBER

Further data on the excellent business in radio is given in the latest report, for September 1935, of the Bureau of Labor Statistics, U. S. Labor Department, on radio factory employment. This increased 19.2 percent over August employment and, although seasonal, it evidenced the large annual increase in radio employment, payrolls and production. The federal report, however, omitted the number of radio companies contributing reports and the detailed number of employees.

The increase of 19,2 percent in radio factory employment over August 1935 also is comparable with an increase of only 15.9 percent over radio employment during September 1934. During September there was an increase of 154.9 in employment over the official three-year average of 1923-25.

Radio factory payrolls during September 1935 increased 24.2 over the preceding month, and were 30.9 over September 1934. They were also 66.3 over the three-year average of 1923-25.

Per capita weekly earnings in radio factories reported in September 1935 were $20.45, slightly less than the average per capita weekly earnings in all manufacturing industries, which were $21.14. In radio factories the increase per capita weekly earnings were 4.2 percent above August 1935, and 13.2 percent above September 1934.

Average hours worked per week during September 1935 were 39.5, placing the radio industry practically on a 40-hour weekly basis, and were an increase of 6.5 percent above August 1935 and 21.4 percent above September 1934.

Average hourly earnings of radio factory employees during September 1935 were 51.9 cents, a decrease of 2.1 percent from August 1935, and 6.9 percent less than September 1934.

ST. LOUIS ORDINANCE TO PROHIBIT AUTOMOBILE-RADIO IS FACING DEFEAT

Over one hundred representatives of automotive and radio interests, including broadcasters, united in opposition at St. Louis on November 25 against the proposed local ordinance to prohibit automobile-radio. No one advocated the ordinance at the hearing of the St. Louis Public Safety Committee. Opponents are confident that the proposed ordinance is defeated. The committee of the St. Louis Board of Aldermen took it under advisement and will not make a decision before the City Council's next meeting, December 6. Death of the proposed ordinance in committee or by adverse action later appears probable.

St. Louis local and also national organizations participated in the committee hearing against the bill. Spokesmen for the St. Louis Electrical Board of Trade, radio and automotive jobbers and dealers, the Greater St. Louis Automobile Club, and other organizations vigorously opposed the proposed ordinance. The St. Louis Safety Council said there was no evidence that auto-radio causes accidents and asked that no action be taken on the ordinance. In conclusion, for the Radio Manufacturers Association, Bond Geddes of Washington, executive vice president-general manager, presented a detailed statement and brief against the ordinance, including telegrams from officials of forty-four states attesting to the safety of auto-radio and that no highway accidents anywhere had been attributed to it.

Valuable cooperation in opposition to the ordinance was given by the St. Louis broadcast stations. For four days prior to the Aldermen's hearing the St. Louis stations made broadcasts against the ordinance and also urged motorists to file objections. J. L. Van Volkenburg of station KMOX and Raymond C. Schroeder of station WIL spoke at the hearing against the ordinance. The attack at the hearing was led by Carl H. Christino, manager of the St. Louis Board of Trade, and George M. Berry spoke for the Greater St. Louis Automobile Association.

The RMA was represented at the St. Louis hearing by John W. Van Allen of Buffalo, general counsel of the Association, and Director Paul V. Galvin of Chicago, in addition to Mr. Geddes, while many representatives of RMA companies, whose cooperation had been enlisted, also were present. In addition, the RMA had secured the active support of the Motor and Equipment Manufacturers Association, the Motor and Equipment Wholesalers Association, the Automobile Manufacturers Association, the National Standard Parts Association, and other national and local trade bodies.

St. Louis and Missouri newspapers gave prominence to the discussion of the ordinance and it was opposed editorially by the St. Louis *Post-Dispatch*.

The detailed RMA statement of facts and law regarding automobile-radio has been sent to automobile manufacturers and motor vehicle and state officials to develop the conclusion, which has been unanimous thus far, that automobile radio promotes highway safety, reducing speed and keeping drivers alert, and without a single accident anywhere attributed to auto-radio.

CANADIAN TREATY LOWERS RATES ON RADIO PRODUCTS

Results to the American radio industry from the new reciprocal trade treaty with Canada are not important, according to opinions received from both American and Canadian manufacturers by Bond Geddes, executive vice president-general manager of the RMA. American parts and accessory manufacturers and, to some extent, tube manufacturers promise to be the principal beneficiaries of the new Canadian treaty, according to the information available to Mr. Geddes. Control of radio patents in Canada prevents any substantial increase in receiving set sales by American manufacturers in Canada. American radio tubes may be sold in somewhat larger quantities although the tube patent situation in Canada also is a factor.

"Radio tariffs in the new treaty will be reduced about one-sixth," said Mr. Geddes. "and additional reduction will be effected by the promised modification by Canada of the arbitrary valuation plan heretofore in effect. However, neither American nor Canadian manufacturers regard the new treaty as a material benefit to American manufacturers.

"The treaty provides a reduction in Canadian import rates from 30 percent to 25 percent ad valorem, or about one-sixth. on 'electric wireless or radio apparatus and parts.' Various and similar reductions on all electrical products are made and the tariff on electric refrigerators was reduced from 40 percent to 30 percent.

"The new tariffs are effective January 1. 1936. Further legislation is required, however, by the Canadian Parliament to modify the present Canadian system of arbitrary valuation. In the past Canada has not accepted the face value of American invoices but made an arbitrary assessment compared with the market values of simi-

(*Continued on page 27*)

NEW PRODUCTS

RAYTHEON DEVELOPS NEW IMPROVED CONTROL GRID INSULATION FOR ALL-METAL R-F TUBES

Raytheon engineers, working with one of the large manufacturers of phenolic insulating materials, have developed a new wafer insulator for the control-grid terminal of the new metal tubes. Tubes, the performance of which will be improved by this new material, are the 6A8, 6L7 and 6K7.

Tests on r-f coil efficiency have shown that the Q of a really good coil is reduced by an undesirable amount when connected across the control grid and shield of the metal amplifier or mixer tubes if certain types of phenolic insulation are used.

To reduce these losses, the engineers in the Raytheon laboratory at Newton, Massachusetts tested all available types of insulation material including ceramics. The material finally selected was developed during the tests. It has the mechanical strength of the strongest material previously used but is near the best ceramic in low losses at the high frequencies.

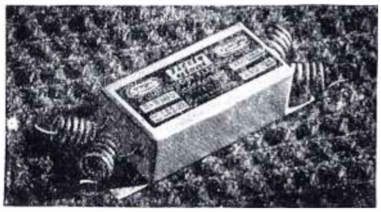
This improvement in grid circuit insulation will permit engineers to obtain the full advantages of low internal capacitance and short leads in metal tubes on short-wave reception.

•

CONDENSERS FOR CATHODE-RAY

The popularization of the cathode-ray oscillograph for radio servicing and experimenting, since more rugged and economical tubes for the purpose have become available, has led to the increased use of high-voltage condensers.

Normally, since the current drain by the cathode-ray tube is very small, a 1-mfd condenser is sufficient for filtration. Dykanol oil filled and impregnated Type TD condensers are suggested where space is at a premium, according to Cornell-Dubilier Corporation, 4377 Bronx Boulevard, New York. The physical size of these capaci-



tors is about one sixth that of paper-wax units.

The different cathode-ray tubes require different B voltages, to enable the tubes to be worked up to their safe operating characteristics. The most popular type tube, No. 906, takes 1,200 volts maximum, but is commonly worked at 1,000 volts. Therefore ordinary condensers can not be used in filtering the maximum B feed, since the condensers' working voltage is too low. The d-c working voltage rating is given by the manufacturer, and the actual d-c voltage present should never exceed specifications.

This type of condenser is fully described in the Cornell-Dubilier catalog No. 128.

DU MONT ELECTRONIC SWITCH

The Type 150 Electronic Switch is a new development recently announced by the Allen B. DuMont Laboratories of Upper Montclair, New Jersey, which greatly increases the value of the cathode-ray oscillograph by permitting simultaneous observation of any two voltage or current phenomena. Thus this device can be used to inspect and compare the waveform and phase of two voltages or currents from different parts of the same circuit, or compare the waveform of a standard wave and any other wave. For example, it is possible to see the input and output waveform and phase displacement of an amplifier. In a perfect amplifier the input and output waves cover one another, while even a slight distortion or phase shift will noticeably display the two oscillograms. Another useful application is to apply a timing wave in conjunction with the wave under observation. For example in testing switches or relays it is possible to inspect the length of time it takes to complete the switching if both the switched potential and a timing wave originating from an a-c source of known frequency are present on the oscillograph screen.

The number of different applications of this device are too numerous to mention. All measurements and tests are comparisions and there is no better way to compare two oscillograms than by placing them right on top of each other.

The device has no mechanically moving or vibrating parts. It consists of a switching tube and two amplifiers, one amplifier for each phenomena applied. The switching tube operates to cut in one amplifier, then the other at such a rate that the phenomena appear at the same time. In addition to switching the device also amplifies.

Controls are provided on the unit for adjusting the gain of the amplifiers for varying the speed of switching.

The unit is completely self-contained and sold with tubes so that it is only necessary to apply 110-120 volts 60 cycle a-c to it to start operation.

•

UNIVERSAL RECORDER IMPROVED

The No. 12 recorder engineered by the Universal Microphone Co., Inglewood, Cal., to secure maximum results up to 12 inches in diameter on aluminum discs, has been greatly improved to meet an increasing demand for fine quality.

The equipment has been developed for maximum results at a minimum cost both in machine and records. In the new model of the No. 12 recorder the recording head from the professional recorder is now a part of the assembly.

It is of four-pole, double coil, center pivot type and operates on the push-pull principle. The energy is furnished by a cobalt steel permanent magnet and eliminates the necessity of using battery energy as in the previous model.

This cutter is extremely small in external dimensions, being a half-inch thick, an inch wide and two inches long—about half the size of a package of cigarettes.

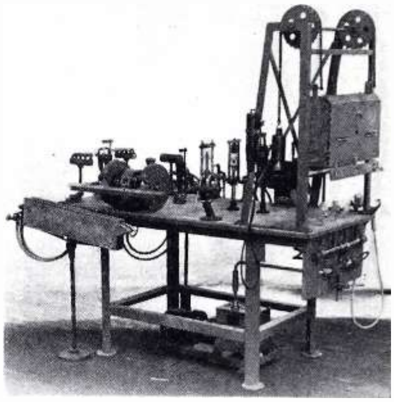
The reciprocating part is of extremely lightweight material, thereby preserving the frequencies. The turntables are heat treated and lathe-turned and the guide arm for the lead screw is now hinged overhead to assure perfect grooving and ease of handling. Tension screws are also provided to permit the adjustment of weight on stylus.

•

EISLER COMBINATION WELDER AND TRIMMER FOR FLEXIBLE SHAFTS, WIRE AND CABLE

Flexible shafts, stranded wire and cables composed of a multiplicity of small wires, either twisted together or helically coiled, have a tendency upon being cut, to unravel at the ends, sometimes ruining a considerable length and making it difficult to join it to other pieces of cable or mechanical parts.

In coping with this condition, the Eisler Engineering Co. of 747 So. 13th St., Newark, N. J., have developed a com-



bination cutting, welding and trimming machine upon which flexible cable may be cut apart or two pieces joined and trimmed without unraveling and at the same time maintain practically the same flexibility as it had before.

This combination welder and trimmer is designed to operate on either 110 or 220 volt alternating current and can be mounted on a bench or furnished with a movable pedestal permitting it to be readily moved from one position to another.

The machine is equipped with a special annealing device for annealing the welded stranded wire, a slide adjustment for closely regulating welding current, push-button control of upset and current, foot-operated clamping jaws for holding the work, a lamp with reflector for adequate light upon the work and an especially designed grinder or trimmer for trimming the work.

A flexible shaft or cable to be cut apart is clamped in the welding jaws. Application of current welds the strands together and finally severs the cable. The ends of the cable are then placed in the trimmer which is equipped with a Carborundum wheel driven by one-twentieth horsepower motor, and finished off.

In welding two ends of cable together the ends are first prepared as above and

(Continued on page 27)

NEWS OF THE INDUSTRY

DICTIONARY OF LETTER SYMBOLS

A new dictionary of letter symbols and abbreviations, the "language" of engineers and scientists, will be undertaken by a committee of the American Standards Association, it has just been announced.

Rapid coinage of new words and terms, and the adoption of many foreign words and phrases in the various fields of engineering and the sciences, demands a new compilation of standard usage, according to the committee.

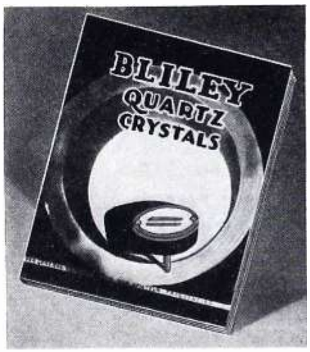
In spite of its great ramification, engineering and science is becoming more and more integrated and those working in one field find that lack of abbreviations, or confusion in their use, restricts and hampers their work.

The Committee on Symbols and Abbreviations of the ASA has been reorganized and will begin at once the intricate task of coordinating existing abbreviations and symbols, and rewriting the present standards into a comprehensive manual of letter symbols and abbreviations.

In line with American Standards Association procedure, the committee is anxious to see that every group which has a problem in respect to abbreviations and symbols in its own field, be represented on the committee. Any group which has published its own standard for symbols is urged to submit a copy for consideration by the committee.

NEW BLILEY CATALOG

The Bliley Electric Company has recently issued a 16-page catalog describing its complete line of quartz crystals, holders and ovens for transmitters, single-signal filters and standard frequency bars. Both general communication and amateur



frequency crystals are included. In addition several pages are devoted to technical information on crystals and crystal circuits. Copies of this bulletin may be secured by writing to the Bliley Electric Company, 202 Union Station Bldg., Erie, Pa.

NEW FIRST-AID KIT

A new first-aid kit, designed to meet the specifications of leading industrial medical directors, has been adopted as standard by the Standard Oil Company of New Jersey and other large American industrial companies.

The special feature of this new kit, which is known as the "Brac-Kit" and was developed by the Davis Emergency Equipment Company, New York, is that it can be permanently installed in a given place, but its contents are instantly available in emergencies and are protected from contamination and damage when treatment is being applied.

The kit consists of two baked enamel steel cases, an outer case which can be permanently attached to a wall by means of screws, and an inner case which is normally kept inside the outer, where it is held in place by a simple lock. When needed, the inner case can be unlocked by a twist of the handle and carried, with all necessary first-aid supplies, to the scene of the accident.

The Brac-Kit contains ten D-carton first-aid units, each of which holds enough material to serve for several treatments. The exact assortment depends upon the industry in which the kit is to be used, but a widely accepted assortment is comprised of adhesive plaster, gauze compresses, individual swabs of Isodine (the new iodine antiseptic), individual tubes of Tannoid (tannic acid treatment for burns in a water-soluble jelly), ammonia inhalants (for fainting), eye dressings, and a tourniquet.

RMA NEWS

(*Continued from page* 25)

lar Canadian manufacturers. It is this arbitrary valuation which is to be modified under the terms of the treaty by future legislation in Canada. Such legislation, however, will provide against 'dumping' and the new Canadian legislation 'will not include an advance for selling cost or profit greater than that which in the ordinary course of business under normal conditions of trade is added in the case of goods by manufacturers or producers of goods of the same class or kind in the country of export.' Another provision of the new Canadian legislation will provide that the new rates will not increase the value of the American imports beyond the price at which such or similar goods are freely offered for sale to producers at the time and place of shipment in the country of export in the usual quantities and in the ordinary course of trade.

"The one-sixth reduction in the Canadian tariff on radio sets is not expected to materially increase American set sales in Canada. The Canadian set manufacturers are well protected by their radio patent license organization. Licenses of American manufacturers do not provide for sales in Canada, where set manufacturers must secure separate Canadian licenses. Several American manufacturers have virtually Canadian branch factories and these, together with Canadian set manufacturers, will be benefited by their ability, under the new treaty, to secure cheaper American parts and accessories. The reduced tariff on American radio parts and accessories, therefore, promises to be the principal result of the new treaty so far as the American industry is concerned."

MANY RMA MEETINGS DURING IRE CONVENTION

A peak in radio engineering activity was reached during the annual fall meeting at Rochester of the Institute of Radio Engineers, November 18-20. As usual, the Rochester meeting drew large and representative attendance, with many exhibits by parts and accessory manufacturers. The program included discussion of many engineering developments of utmost future importance to the radio industry.

There were many meetings of RMA committees during the IRE convention, and the Association was represented officially by President Leslie F. Muter of Chicago; Bond Geddes, executive vice president-general manager, of Washington; Judge John W. Van Allen of Buffalo, general counsel, and Virgil M. Graham, chairman of the RMA Standards Section. A number of officers and directors of the Canadian RMA also were guests of the IRE at Rochester.

Plans for standardization of radio parts and accessories was a feature of the Rochester meeting. L. C. F. Horle is in charge of the component parts standardization work. A meeting was held of the RMA General Standards Committee of which Mr. Virgil M. Graham is chairman. Also there were meetings of the Broadcast Receivers Committee of which E. T. Dickey of Camden is chairman; the Sound Equipment Committee of which Hugh S. Knowles of Chicago is chairman; the Vacuum Tube Committee of which Roger M. Wise of Emporium, Pa., is chairman; the Television Committee of which Mr. A. F. Murray of Philadelphia is acting chairman, and of the Facsimile Committee of which E. W. Engstrom of Camden, N. J., is chairman.

NEW PRODUCTS

(*Continued from page* 26)

then welded together after which it is placed in the annealer.

After proper annealing the cable is inserted in an automatic centering device of the trimmer and the burrs of the joint ground off.

The machine will handle either square or round solid rods, wire and bars as well as flexible shafts and cables of steel, nickel, brass, copper and other metals up to .250" in diameter.

LINE VOLTAGE DROPPING RESISTOR TUBE

Resistance elements for use in series with tubes and pilot lamps operated on 110-volt circuits, are offered in a convenient unit developed by Clarostat Mfg. Co., Inc., 285 N. 8th St., Brooklyn, N. Y. The unit has a perforated metal housing similiar to the 5Z4 metal tube, and fits in the new octal socket.

Particular advantages are: (1) Lowest resistor operating temperatures; (2) High leakage resistance (greatest insulation) between resistance element and ground; (3) Provides means of mounting resistor above chassis while keeping "hot" or "live" leads under chassis; (4) Satisfies rigid requirements of underwriters.

Units available in different resistance values, providing voltage drops for taking care of one to seventeen 6.3-volt 0.3 ampere tubes on 117.5-volt lines. Units can be provided with sections taking care of 6-8-volt 0.25-ampere pilot lights. Other combinations and ratings on special order.

RADIO ENGINEERING BUYER's GUIDE

A continuous, indexed recording of the reliable sources of supply of

Materials—Component Parts

ALLOYS, RESISTANCE
AMERICAN ELECTRO METAL CORP., Lewiston, Maine
CALLITE PRODUCTS CO., 542 39th St., Union City, N. J.
Cleveland Wire Cloth & Mfg. Co.
Consolidated Wire Corp.
Driver Company, Wilbur B.
Driver-Harris Company
Fansteel Metallurgical Labs.
Hoskins Mfg. Co.
Jelliffe Company, C. O.
Prentiss & Company, Geo. W.

ARRESTORS, LIGHTNING
Birnbach Radio Corp.
Knox Porcelain Co.
Johnson, E. F., Co.

BASES, VACUUM TUBE
AMERICAN LAVA CORP., Chattanooga, Tenn.
American Phenolic Corp.
American Record Corp.
ISOLANTITE, INC., 233 Broadway, N. Y. C.
Kurz-Kasch Co.
RCA MFG. COMPANY, INC., Camden, N. J.
Westinghouse Lamp Co.

BINDING POSTS
BANKS INTER-AIR PRODS., Woodside, N. Y.
Eby, H. H., & Co.

BRASS—COPPER
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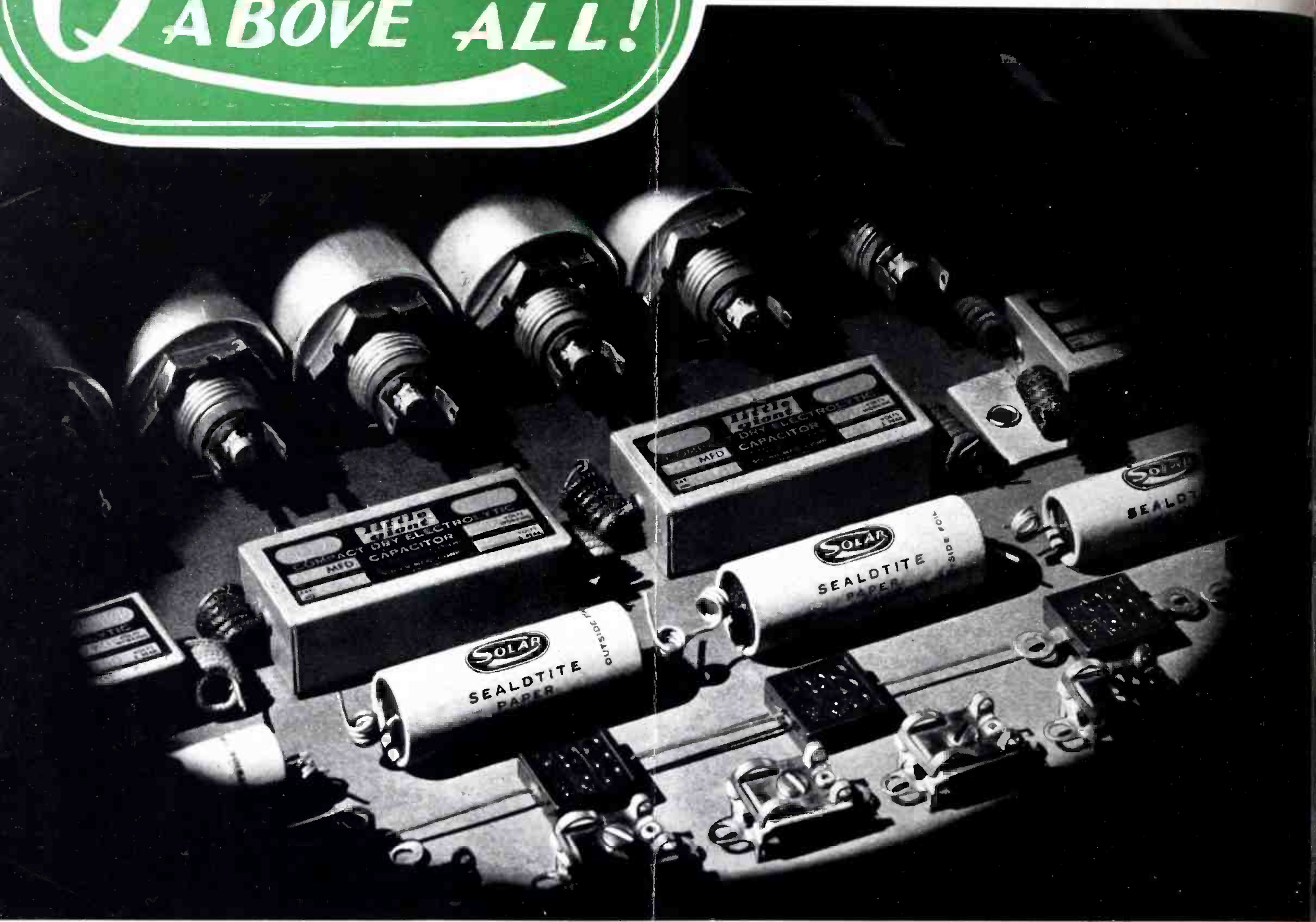

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