EIGHTH YEAR OF SERVICE

RADIO ENGINEERING

Vol. VIII — OCTOBER 1928 — Number 10

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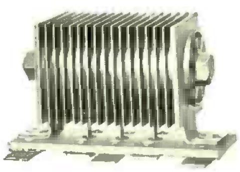

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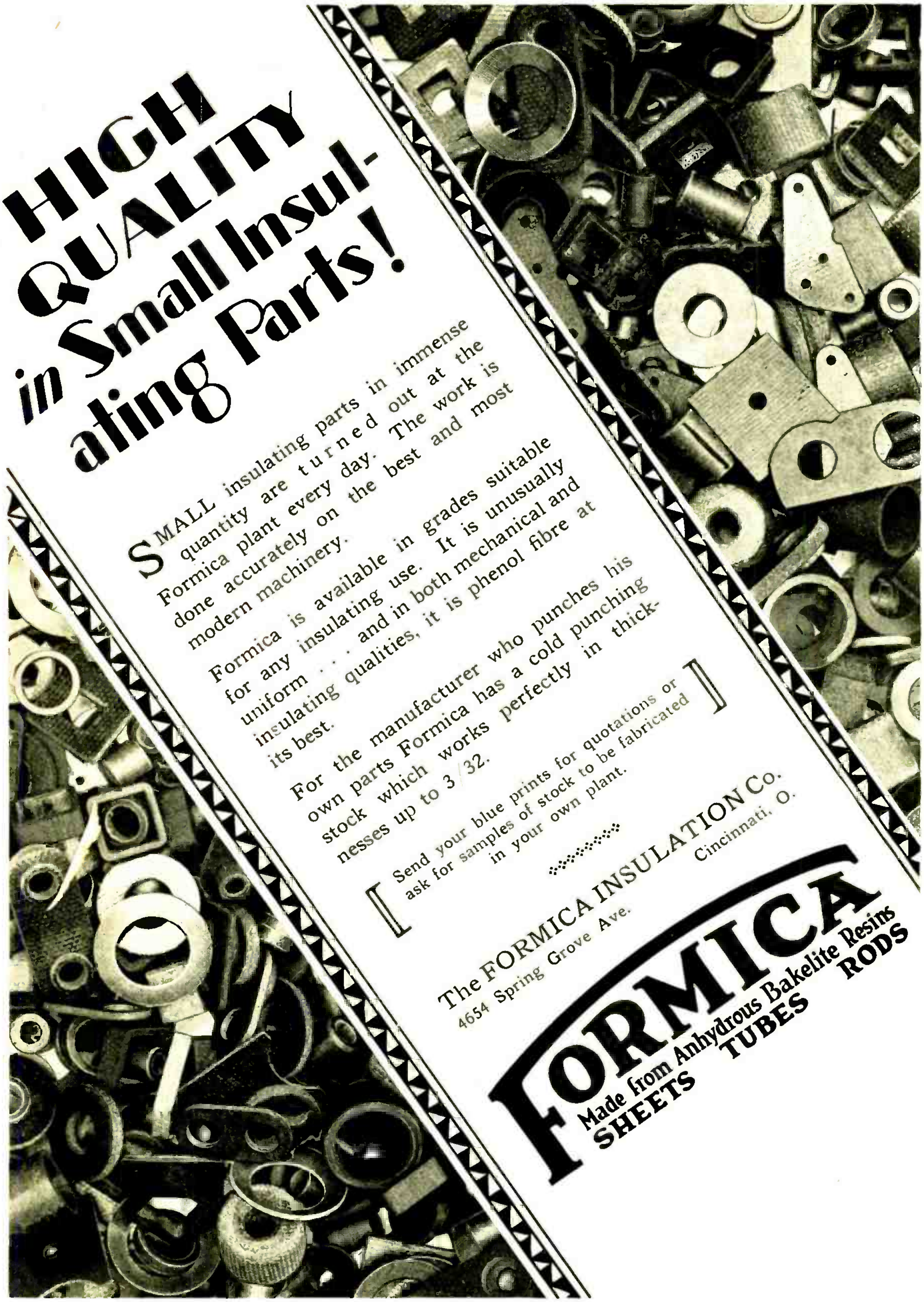
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RESEARCH IS ESSENTIAL

By DR. E. F. W. ALEXANDERSON
Consulting Engineer, General Electric Co.

WITHIN a comparatively few years Industry as a whole has found that research has become a necessity. Executives and stock holders no longer are aghast when someone proposes that they apportion a certain sum annually for the search of new things.

While it is true that "research methods differ," as was mentioned in RADIO ENGINEERING editorial in September 1928, yet it should be born in mind that the Scientist and the Inventor are the backbone of research. Just as in Biology it takes the cooperation of two to create a third, so in the evolution of the technical arts the Scientist and the Inventor must work together to give to the Engineer ideas which he can give the world in finished form. The average Engineer does not delve into the subvisible field of matter—this is the realm of the Scientist—and he is likewise seldom called upon to assume the Inventor's role. His job is the collecting and adapting of facts, and incorporating them into something of value for the world. Each of the three factors is necessary to the other.

New things of necessity must be developed if Industry is to progress continually. Companies must work a decade or so ahead in order to be prepared for the changes that are certain to occur. Isolated groups of Engineers or Scientists are apt to work along set lines whereas a close contact between engineering and research organizations inspires the ideas which will keep industry abreast of the times ten years hence.

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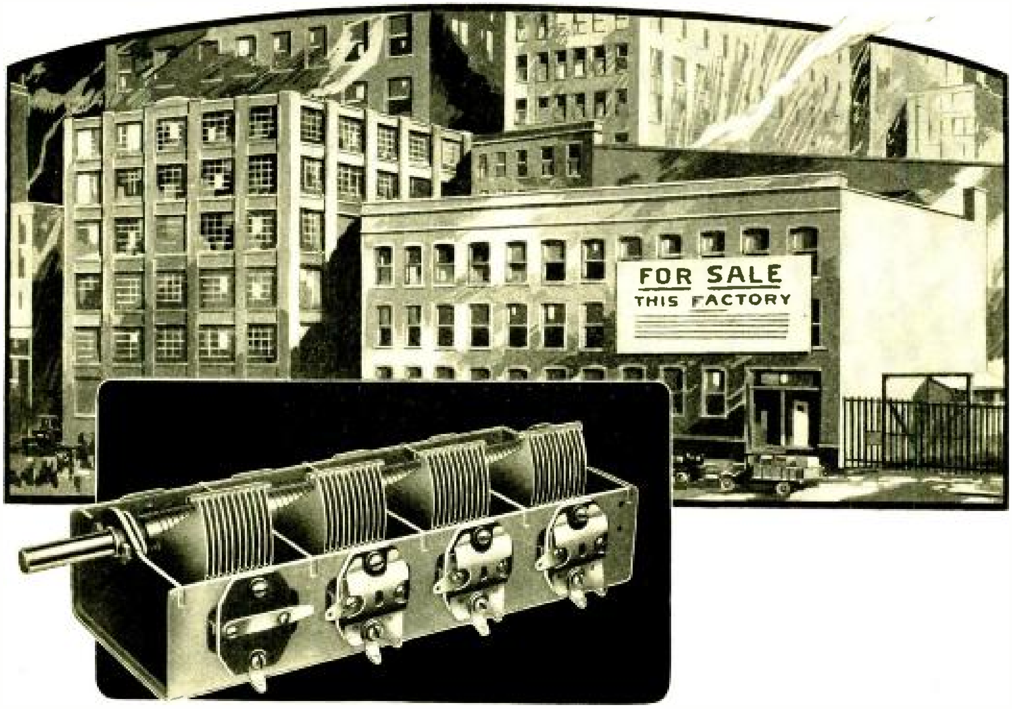
RADIO PRODUCTION CHANGES



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EDITORIAL

October 1928

RADIO-AERONAUTICS

RADIO and aviation are closely allied. The factor of prime importance in aviation is safety, and radio in its many forms is doing its part in increasing the safety factor of the airplane and widening its channels of usefulness.

The demand for airplane radio equipment is increasing with the expansion of the aviation industry. No doubt the day will come when every plane will be required by law to carry a transmitter and receiver.

There are only a few radio companies catering to the aviation field, but the number will increase when it becomes generally known that handsome returns may be expected.

Individual research is contributing a great deal to these combined arts. Through such efforts radio has extended its utility to aviation. Among the new developments we find—a radio altimeter, which indicates the altitude of the plane from the surface of the earth, not the sea level; improved radio beacons; radio guiding channels; advanced short-wave equipment; special speech amplifiers permitting communication with airports; "electric eyes," which indicate the presence of guiding beacons in fogs; radio compasses, and last but not least, improved radio-control for airplanes.

Of the above mentioned devices the radio-altimeter stands out as the most important development. The common form of altimeter indicates the altitude of a plane from the sea level. Since the radio-altimeter indicates the altitude of a plane from the level of the terrain over which it is flying, a pilot is warned should he approach a mountain range or any other form of obstruction. Thus does the radio-altimeter introduce a new factor of safety in night flying and in flying through fog banks.

The aviation industry has been looking for just such a device. It was developed in a radio engineering laboratory and fundamentally is nothing more than a short-wave transmitter. No new principles are involved. Other devices may spring from the same principle. A radio speed-indicating device suggests itself. Some contrivance more accurate than the present form of airplane speed indicator would be a welcome addition.

Without a doubt, many new radio devices adaptable to the aviation field will spring up in the very near future. Each stride forward will automatically create a new market for many radio products.

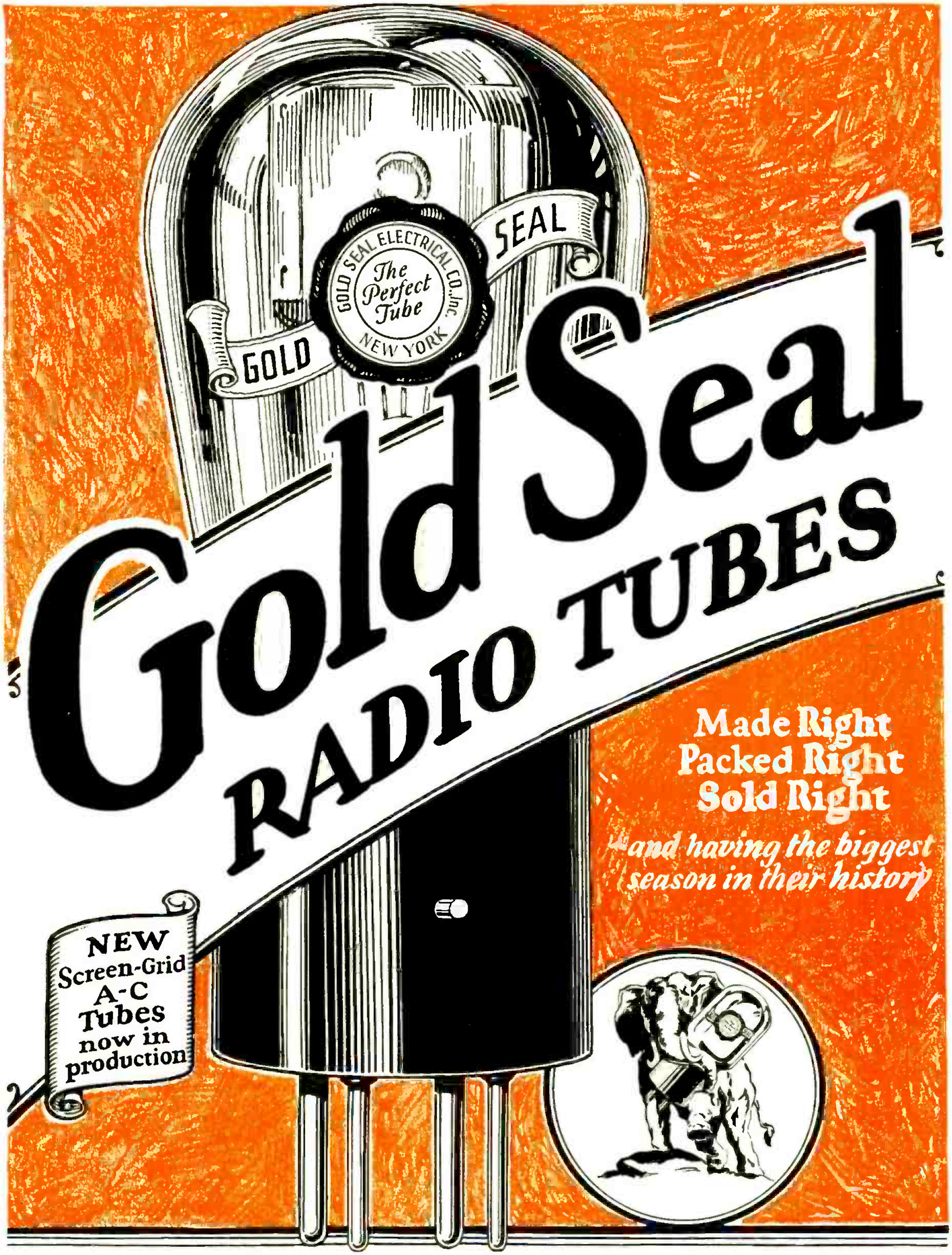
Estimated production of airplanes for the coming year is 10,000. If we think only in terms of radio transmitters and receivers, the figure does not suggest a correspondingly large radio business. But, transmitters and receivers represent only a part of the available business "in the air" and discounts nearly the entire "ground" business.

There are 2,000 well equipped airports in the United States and new ones are being planned every day. The whole country is becoming dotted with radio and light beacons and radio guiding channels. Replacement business alone runs into large figures.

The potential market for aviation radio equipment will have to be developed. Aside from the purely technical investigations there is a great deal to be done along the lines of industrial research. This necessitates a close contact with the aviation field in order that the radio manufacturer may become acquainted with its problems. It is only through an expert knowledge of aviation practice that radio can be successfully applied .

RADIO ENGINEERING is in a position to supply technical information through the medium of its companion publication, AVIATION ENGINEERING, and would be pleased to cooperate with radio manufacturers in any way possible. The technical staffs of both publications are at your disposal.

M. L. MUHLEMAN, *Editor.*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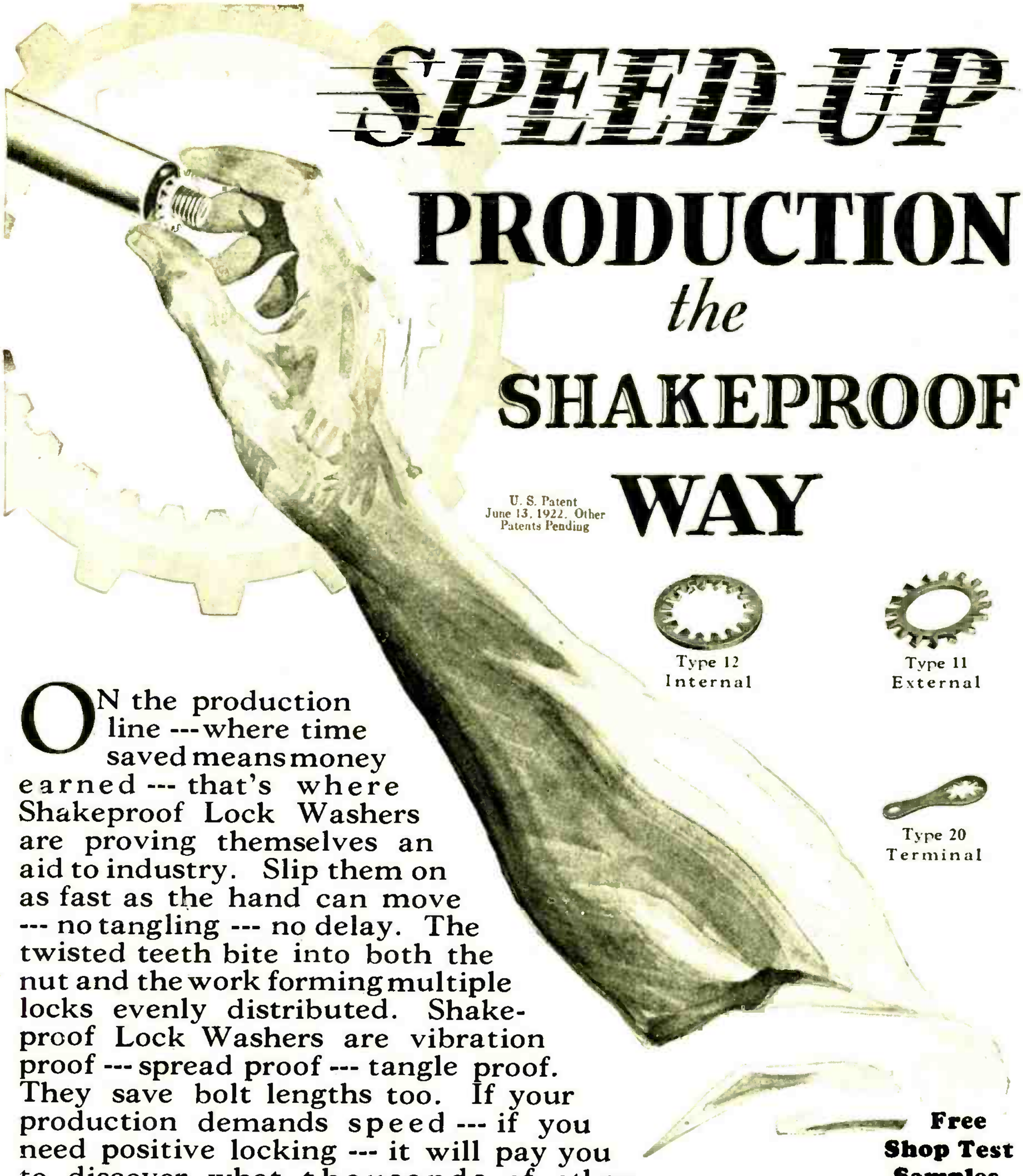

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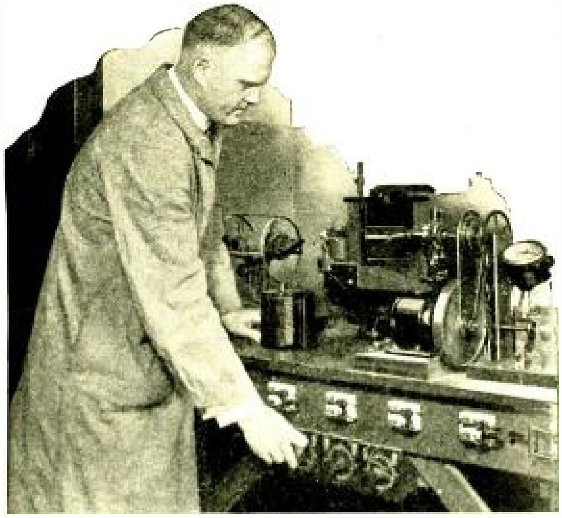

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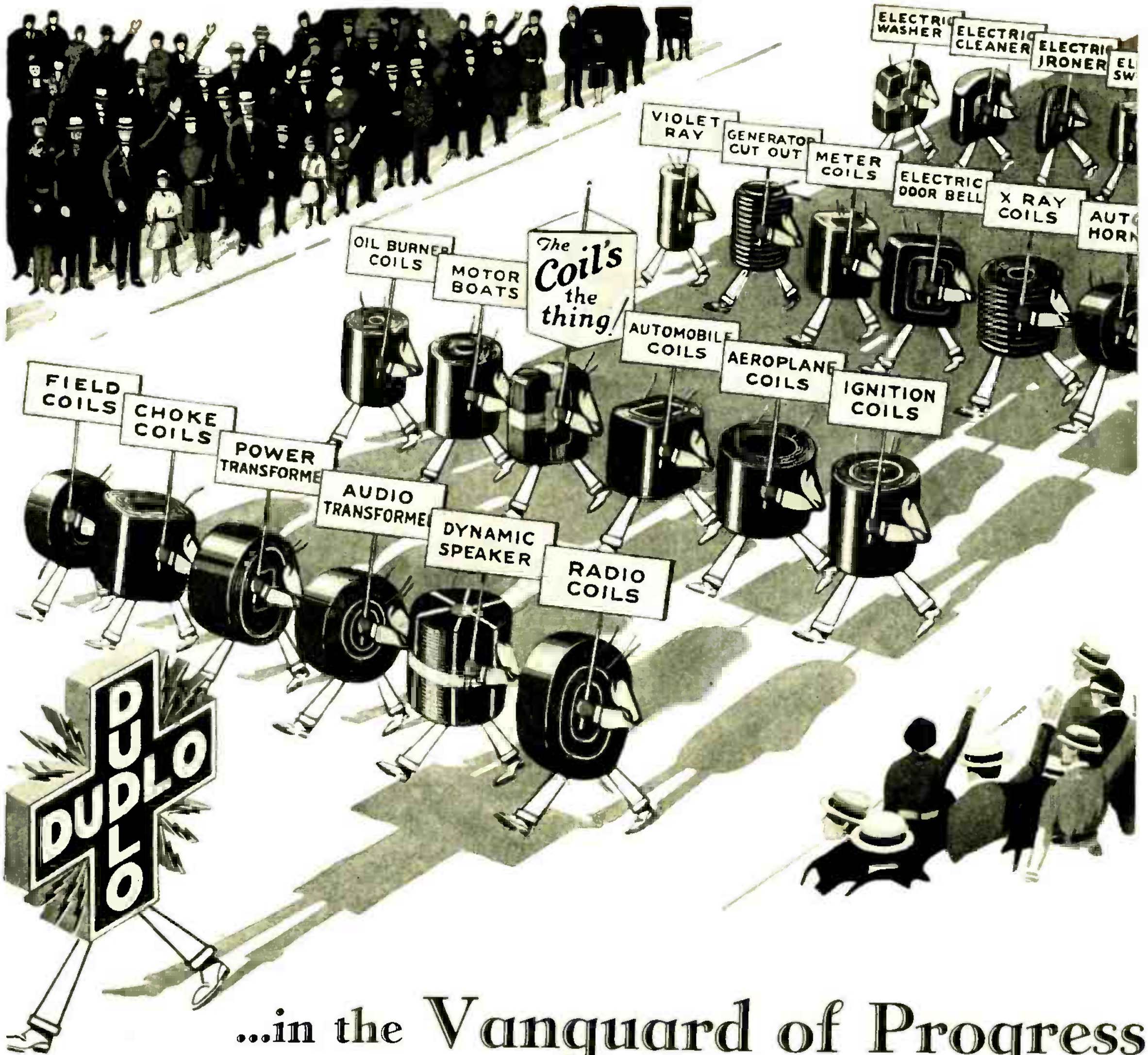
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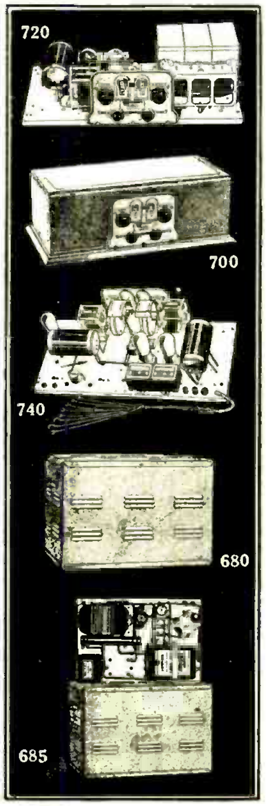


720 Screen Grid Six

The new S-M 720 embodies in the most perfect form the revolution that screen-grid tubes have brought about in long-distance reception. Three of these tubes in the R.F. stages, with shielded S-M coils, bring in distant stations on the next 10 kc. channel to powerful locals! The new S-M 255 and 256 transformers set a far higher standard of tone quality than ever known before. Custom-built complete in 700 cabinet, $102.00; complete *kit*, with pierced metal chassis and antique brass escutcheon but without cabinet, $72.50.

700 Shielding Cabinet

Beautiful two-tone brown moire finish, with walnut finish wood base, $9.25.

740 Coast-to-Coast Four

A time-tested and famous circuit—one R.F. stage, regenerative detector (non-radiating) and two A.F. stages—combined with immeasurably finer coils, the high efficiency of the screen-grid tube, all the gain of smooth-working regeneration, and new S-M Clough-system audios, make the 740 the greatest value in the fifty-dollar class. WIRED in 700 cabinet: 740 (for D.C. tubes) $75; 740AC (A.C. tubes) $78. Kit less cabinet: 740, $51; 740AC, $53.

680 Series Unipacs

Perfect reproduction and hum-free light-socket operation have made S-M Unipacs famous. There are four types: two single-stage, and two two-stage models, using 210 or 250 tubes singly and in push-pull. Each Unipac supplies 45, 90, and 135 volts B to receivers, and two-stage models supply in addition 1½ and 2¼ volts for A.C. tube filaments. Available as kit or wired. Prices from $81.50 to $117.

685 Public Address Unipac

For coverage of crowds of 1,000 to 10,000 people, indoors or outdoors, with one to twelve loud-speakers, the 685 Public Address Unipac furnishes unequalled tonal clearness. It uses one UY227, one UX226, one UX250, and two UX281 rectifiers in three stages for microphone, radio or record pick-up amplification. 685 WIRED Unipac is priced at $160.00; or 685 KIT, $125.00.

710 Sargent-Rayment Seven

Designed by two famous engineers to give the very extreme of results now possible in broadcast reception, irrespective of cost, the S-M 710 Sargent-Rayment Seven sets an entirely new standard. Exhausting the tremendous distance possibilities of 4-screen-grid R.F. stages—bringing in a station on every 10-kilocycle channel right around its single-control dial (with five auxiliary vernier knobs)—equipped with the unequalled S-M Clough system audio amplifier—yet the 710 is only $175 custom-built complete, or $130 for kit including aluminum cabinet.

730 Round-the-World Four

The famous "Thrill Band" set—for long-distance broadcast reception; has S-M Clough-audio-system tone quality—splendid also for code. One screen-grid R.F. stage, regenerative (non-radiating) detector. Coils in kit tune from 17.4 to 204 meters; S-M 131X Coil ($1.25) extends range to 350 meters, and 131Y coil ($1.50) to 650 meters. Aluminum shielding cabinet included with 730 KIT $51, or fully WIRED $66. Also with 731 Adapter (plugs into any receiver, converting it to short wave) KIT $36, WIRED $46. 732 Essential Kit, $16.50.

B and ABC Power Supplies

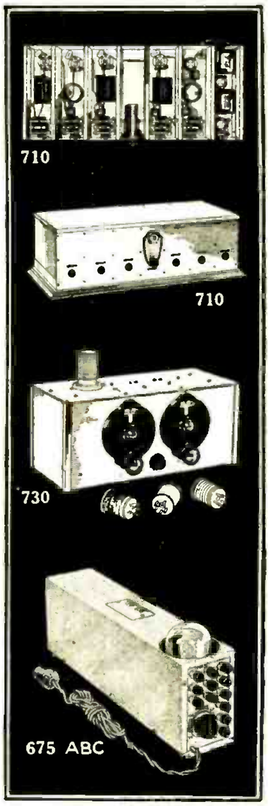
The 675ABC with an adapter allows a UX210 or UX250 power tube to be used in the last stage of any radio receiver—to which it supplies B power at 425, 135, 90, and 22 volts; also 22-90 variable. A and C power are supplied to the power tube, and 1½ and 2¼ volts for A.C. tubes if used. Uses one UX281 rectifier. Price $58 WIRED, or $54 in KIT form.

670ABC Power Supply has max. B voltage of 180; otherwise similar to the 675ABC. Price, WIRED, $46; KIT $43.

670B Power Supply for B power only, 180 volts max., and lower voltages as in 675ABC: WIRED $43.50; KIT $40.50.

676 Dynamic Speaker Amplifier

A single-stage power amplifier, using one 250 type power tube and one 281 type rectifier. Used with any receiver, as a third stage before a dynamic speaker, it will give wonderfully improved volume and tone quality, WIRED, $55; KIT $49.



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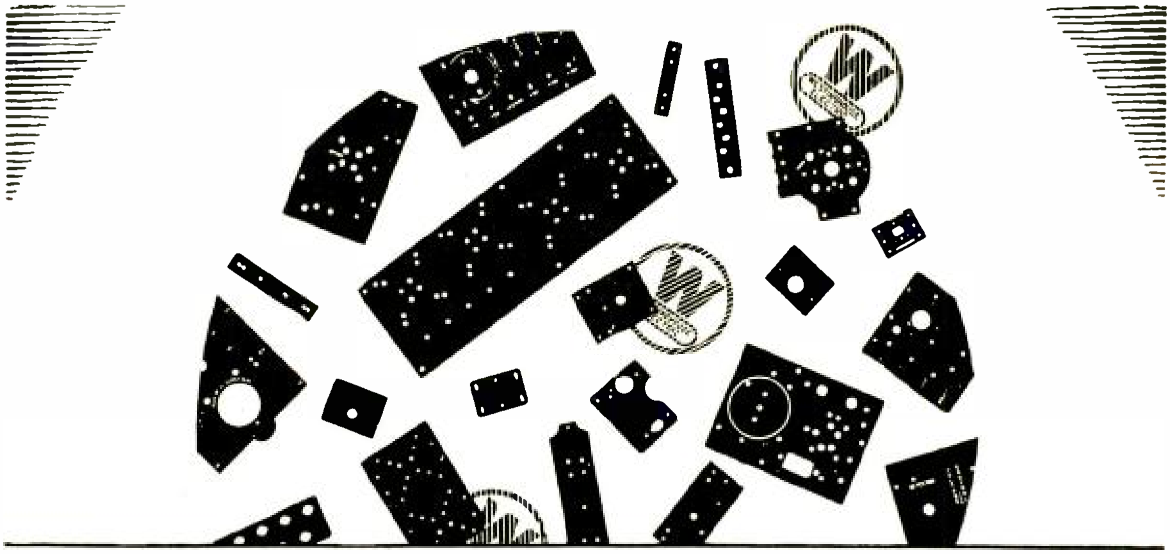

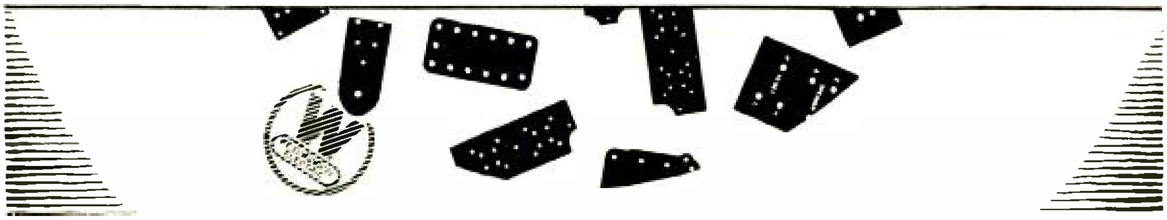

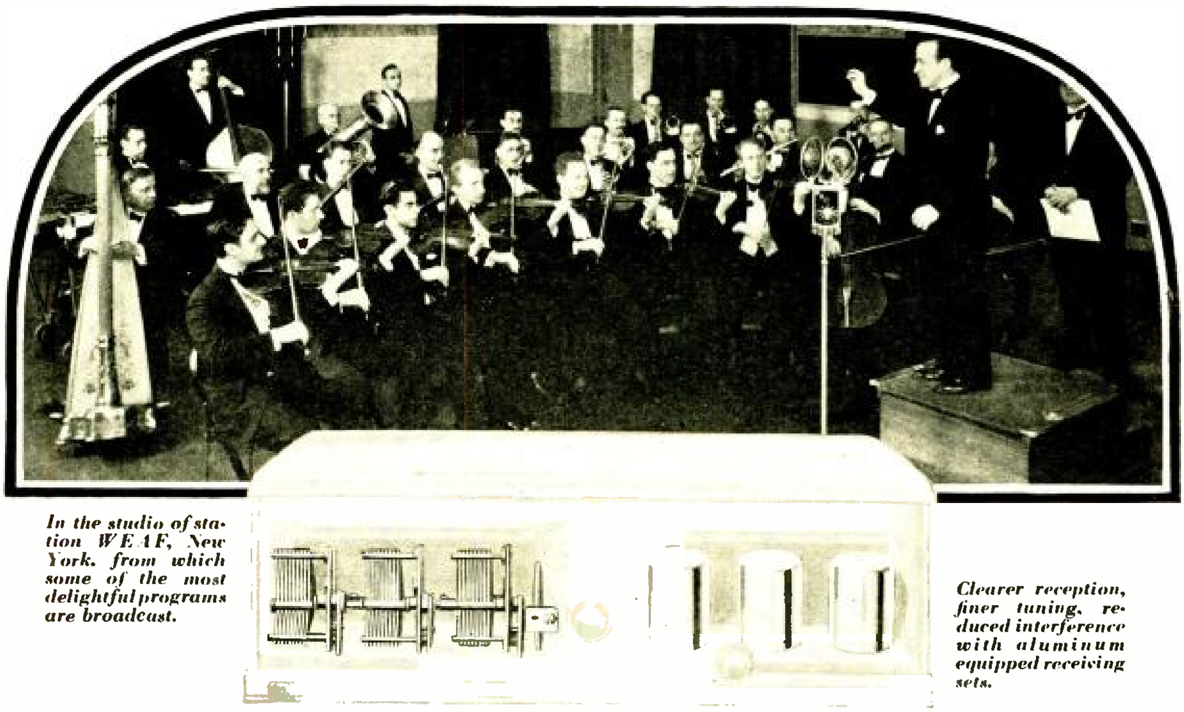

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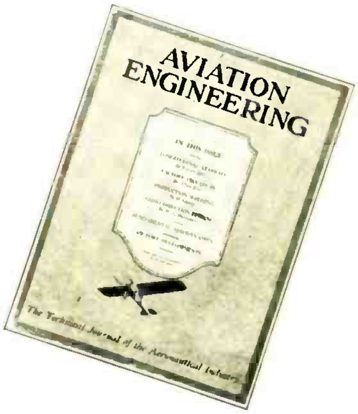

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AVIATION ENGINEERING

A companion publication to "Radio Engineering"

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The Editorial Policy of Aviation Engineering is to present non-biased technical, engineering and industrial material for the benefit of engineers, executives and technicians interested in the aviation industry.

Departments covering airports and airways, news of the industry, new developments, new aircraft, and radio communication is included in the text.

> *Editor*, AVIATION ENGINEERING:
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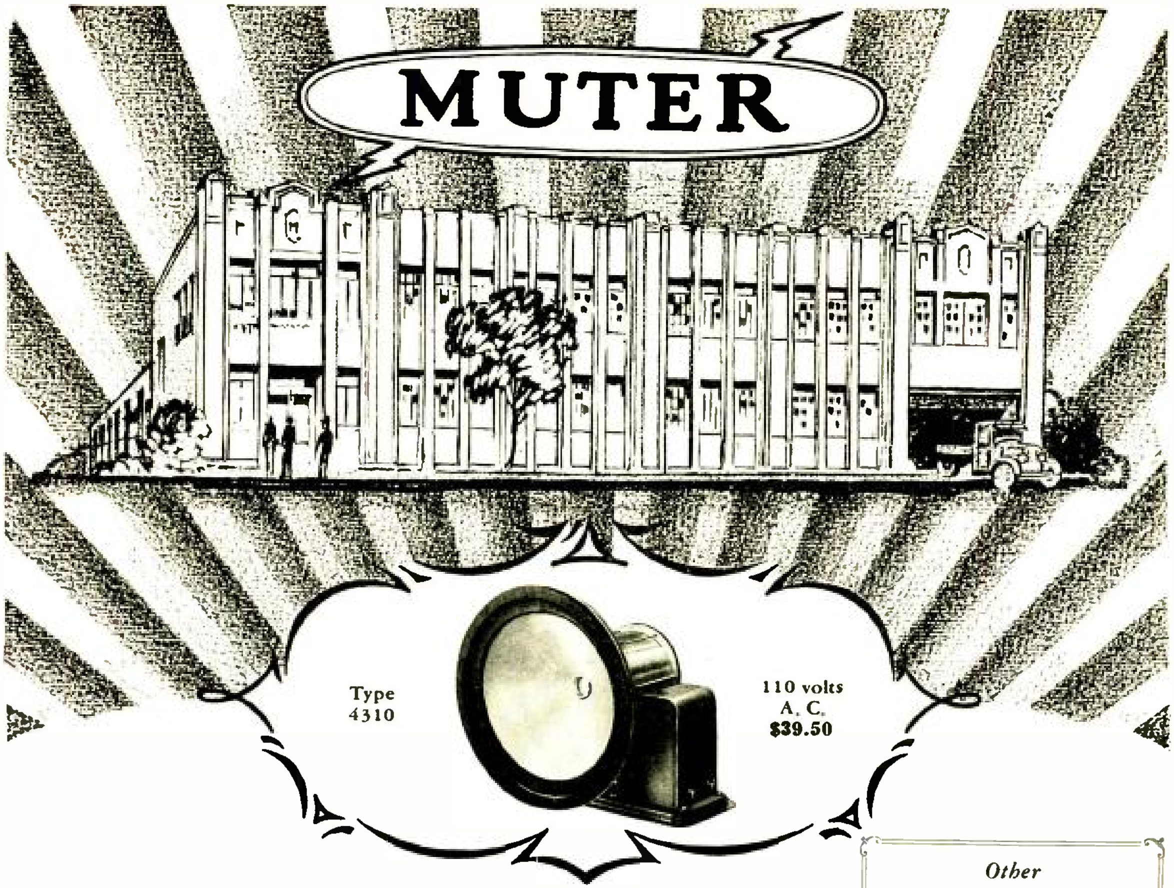

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THE Dynamic Speaker with its superlative performance is this season's outstanding radio sensation. It has changed the radio set from a mechanical reproducer of sounds to a musical instrument supreme. The distinctive tone of the various new manufactured receivers can be attributed almost entirely to the Dynamic Speaker, and this same improvement can be embodied in any set by the attachment of a Muter Dependable Dynamic.

Dependable Dynamic Speaker Unit

Power	Type	Price
6 volts D. C.	4306	$29.50
90 volts D. C.	4390	33.00
110 volts A. C.	4310	39.50

Table Model in Solid Walnut Cabinet

Power	Type	Price
6 volts D. C.	4406	$49.50
90 volts D. C.	4490	53.00
110 volts A. C.	4410	59.50

Spinet Console Model of Solid Walnut

Power	Type	Price
6 volts D. C.	4506	$64.50
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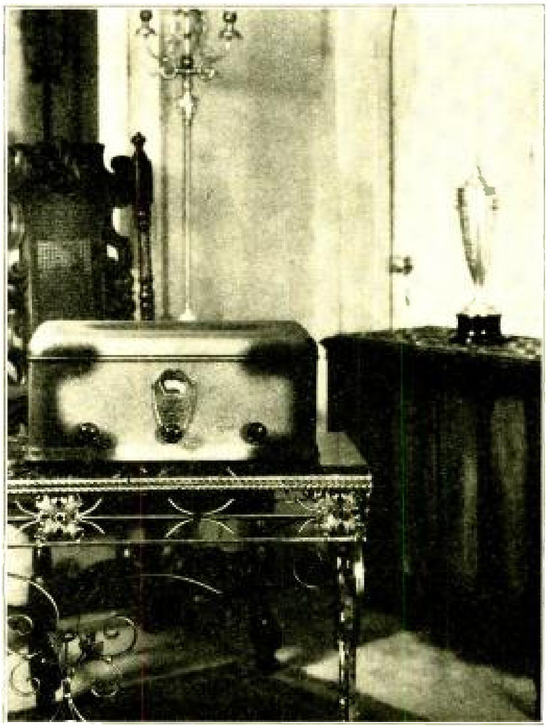

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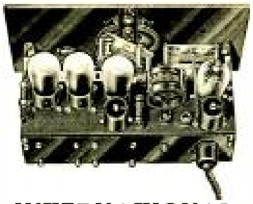

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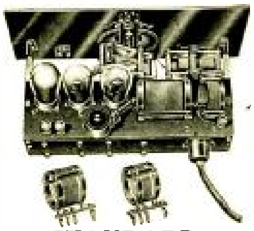

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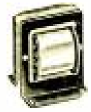

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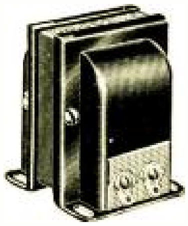

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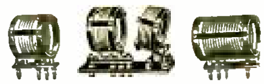

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Detection with the Screen-Grid Tube

Dealing With the Inherent Properties of the Screen-Grid Tube as They Apply to Detection, and the Circuit Requirements

By J. R. Nelson*

THE voltage amplification that may be realized with the screen-grid tube is greater than that obtainable with three element tubes. An amplification of 25 to 50 per stage may be realized in the broadcast range with the screen-grid tube and a tuned circuit of average good quality. This is greater than that obtained using a three element tube with which an amplification of about 10 is as high as it is practical to use because of selectivity requirements.

The screen-grid tube used as either a screen-grid tube, or space-charge tube with a high impedence will give an amplification of about 40 to 75 in the audio-frequency range. This high audio-frequency voltage amplification is not always desirable for two reasons. First, the coupling between stages due to common voltage supply circuits becomes serious and may lead to frequency distortion. Second, microphonic disturbances in the detector become more serious than usual.

Selectivity Requirements

With conventional tuned circuits in the radio-frequency amplifier three or four tuned circuits will be necessary because of selectivity requirements. It is not practical to reduce the number of stages in the radio-frequency amplifier and to use more audio-frequency amplification because of selectivity requirements and the objections to high audio-frequency amplification.

To take full advantage of the high radio-frequency amplification of the CX-322 it was considered desirable to investigate the detector action of the CX-322 with the elimination of the first audio-frequency amplifier stage in view. This would be an advantage as the audio amplifier introduces frequency distortion and the elimination of one stage would reduce this distortion considerably. This imposes the following requirements on the detector tube: First, it must be able to utilize efficiently radio-frequency input voltages of several volts without overloading. Second, it must be capable of supplying 20 to 30 volts peak to the grid of the power tube.

A consideration of grid leak detection was eliminated for two reasons; first, it could not fulfill the first requirement mentioned above, that is, efficiently utilize several volts radio-frequency input voltage without overloading and second, this method would add damping to the tuned circuit and reduce the selectivity and thus the voltage that could be built up across the tuned circuit.

Plate or grid bias rectification using the CX-322 was found to fulfill both of the requirements imposed on the detector provided that a suitable output circuit was used. Either impedance or resistance coupling could be used but the values of impedances required are larger than required for a three element tube because of the high internal resistance of the CX-322.

Grid Bias Detection

A brief analysis of grid bias detection will be presented in this article. The sensitivity of the CX-322 used for plate or grid bias rectification will be compared with the general purpose tube, the CX-301-A, and the A.C. detector tube, the C-327. The required gain in radio-frequency amplification using the CX-322 detector working into the power tube to produce the same voltage on the grid of the power tube, as is produced by the usual detector and first audio stage amplifier, may be found from the data presented.

The voltage impressed in the broadcast receiver when the carrier wave is modulated with only one audio frequency consists of three frequencies.

$$E = A \cos pt + \frac{AB}{2} \cos (p + q) t + \frac{AB}{2} \cos (p - q) t. \quad (1)$$

where:

A is the peak value of the unmodulated carrier or the average amplitude of the modulated radio-frequency emf.

p is 2π times the radio-frequency.

q is 2π times the audio-frequency.

B is the per cent modulation.

The part A cos pt is the carrier wave and the other two components of E are the side bands. The side bands beating with the carrier in the detector circuit causes a current of audio-frequency $q/2\pi$ to flow in the plate circuit of the detector. The reason that this audio-frequency current appears in the plate circuit of the detector may be explained as follows:

Distortion occurs whenever the relation between current and voltage is non-linear. Fig. 1 shows the plate current Ib of the 301-A plotted against the grid voltage Ec with the plate voltage Eb constant. The relation is non-linear, that is, equal changes of Ec do not produce equal changes of Ib. Assume that the D.C. voltage Ec has the value at O and A voltage A sin ωt is placed on the grid. The voltage A sin ωt is symmetrical about O. The change in current is shown by the wave BDC. The current is not symmetrical about the line OBC as the in-

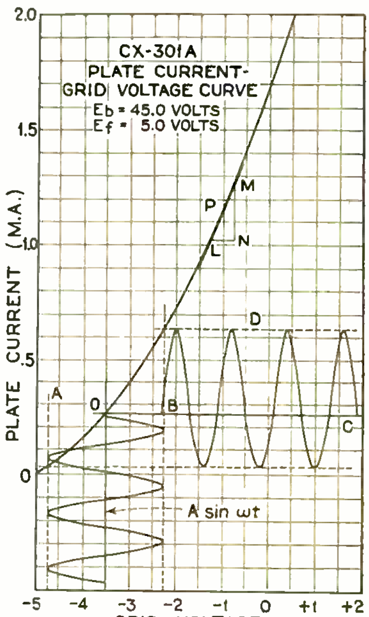


FIG. 1

The plate current-grid voltage characteristic curve of a CX-301A vacuum tube.

* Engineering Dept., E. T. Cunningham, Inc.

crease in plate current when the instantaneous value of the grid voltage is at B is greater than the decrease in plate current when the grid potential is at A. The plate current is distorted and this distortion is equivalent to modulation or detection as it implies the presence of new frequencies.

Mutual Conductance

The mutual conductance gm, of a tube may be found from the Ib-Ec curve with Eb constant. To find gm at any point P we take a small triangle LMN about the point P. The curve at P has the same slope or tangent as the line Lm. The tangent of LM is MN/LN or $\Delta ip/\Delta eg$. As the triangle LMN is taken very small $\Delta ip/\Delta eg$ becomes $\delta ip/\delta eg$ or gm. The value of $\Delta ip/\Delta eg$ depends upon the instantaneous value of grid bias. If the voltage E (eq1) is applied to the grid of the tube the output current will be distorted because gm varies over the cycle. One component of the output current will have the frequency $q/2\pi$ and is the frequency that we desire in the detector.

A mathematical analysis shows that the main term of the audio-frequency voltage (DetE)q introduced in the plate of a grid bias detector is

$$(DetE)q = \frac{rp}{4}\frac{\delta gm}{\delta eg} \times 2A^2B \quad (2)$$

where:

rp is the internal plate resistance of the detector tube. The value of $\delta gm/\delta eg$ may be found from the Ib-Ec curve. First the values of $\delta ip/\delta eg$ or gm are found for different grid biases as explained above and a curve is plotted using the values of gm as ordinates and the values of grid bias used in determining gm as abscissae. The value of $\Delta gm/\Delta eq$ or $\delta gm/\delta eg$ are then found from this curve in the same manner that the values of gm or $\delta ip/\delta eg$ were found from the Ib-Ec curve as explained above.

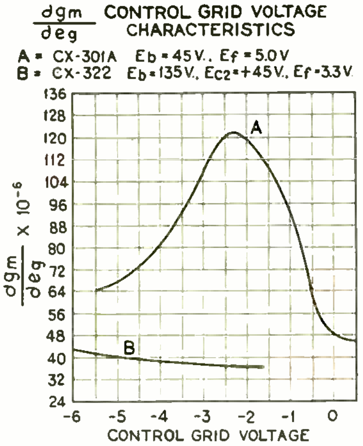


FIG. 2

Curve A shows $\frac{\delta gm}{\delta eg}$ plotted against the control grid voltage of a CX-301A. Curve B, the same coordinates plotted for a screen-grid tube.

TABLE I

Comparison of Detector Sensitivity of CX-301A, CX-322 and C-327 at 1000 Cycles

	Bias Detection				Grid Leak Detection			
	CX-301A		CX-322		CX-301A		C-327	
$Zp = \frac{Zp}{rp+Zp}$ (DetE)q								
Ohms resistance:								
50,000	.5	x $2A^2B$	.488	x $2A^2B$	4.8	x $2A^2B$	14.5	x $2A^2B$
100,000	.6	"	.95	"	5.44	"	15.6	"
250,000	.682	"	2.2	"	5.75	"	16.41	"
Ohms inductive reactance:								
50,000	.672	"	.5	"	5.9	"	16.9	"
100,000	.73	"	1.0	"	6.0	"	17.1	"
250,000	.75	"	2.5	"	6.0	"	17.1	"
Zp = rp	.35	"	14.14	"	4.24	"	12.1	"

Curves A and B of Fig. 2 show the values of $\delta gm/\delta eg$ plotted against Ec for the CX-301-A and the CX-322 tubes. The curve for the CX-301-A rises to a maximum value and the value of $\delta gm/\delta eg$ depends upon the grid bias. The curve for the CX-322 is practically flat for the range of grid voltages shown. This means that an input voltage of several volts could be applied to the grid of the detector and it would not overload, that is, the output would go up practically as the square of the input voltage. The range of input voltages that could be applied to the CX-301-A without overloading would be much less than for the CX-322.

From these curves it appears that if the voltages on the CX-301-A tube were adjusted properly that it would be a better detector than the CX-322. Actually this would not be the case as the internal impedances have to be taken into consideration, as shown below.

Comparison of Impedance Values

The value of the voltage introduced into the plate circuit of a detector by bias rectification is given by Eq 2. This voltage may be used as μeg is used in the usual amplifier equations. The voltage across an external plate impedance Zp is then

$$ep = \frac{Zp}{rp + Zp}(DetE)q. \quad (3)$$

Table I shows the voltage ep developed across different plate loads for the —22 as a bias detector, the CX-301-A both as a bias and grid leak detector and the —27 as grid leak detector. These voltages were calculated from formulae and data taken from an article by Chaffee and Browning,[1] an article on the screen-grid tube by the author[2] and additional data taken in the laboratory. The values of detection coefficients for the C-327 and the CX-301-A were those at the most sensitive operating points. The internal grid resistance was about the same for both the CX-301-A and the C-327. As used in practice the values would probably be somewhat less, as a detector is not usually operated at its most sensitive operating point. The voltage ep for the different tubes and loads is a measure of the tubes as detectors with the same input voltages. The values as given for the CX-301-A and the C-327 hold only for small values of the input voltage A not over .1 volt. The values as given for the CX-322 are practically independent of the value of A up to several volts.

Amplification Requirements

From the data given in Table I we can compute the additional R.F. amplification required to work a CX-322 detector into a power tube over that required with the ordinary detector and first audio stage. We will assume that the step-up ratio of each transformer is three and the mu of the tube in the first audio stage is eight. The amplification is then 3x8x3 = 72. The C-327 as it is the most sensitive detector from Table I will be chosen. As it is transformer coupled optimum amplification will occur when the plate impedance is equal to the external impedance. Under these conditions ep is $12.1 \times 2A^2B$. It is not practical to match the tube impedance of the CX-322 so a plate impedance of 250,000 ohms inductive reactance will be assumed. Under these conditions ep is $2.5 \times 2A^2B$. The C-327 for the same input voltage will then have 12.1/2.5 = 4.8 times as much voltage across the plate impedance. The voltage on the grid of the power tube using the C-327 will then be 4.8x72 = 345.6 as much as it would be using the screen-grid tube feeding into the power tube. As the voltage on the grid of the power tube for the CX-322 is proportional to the square of the input voltage the radio-frequency amplification will have to be $\sqrt{345.6}$ or 18.6 times as much.

As a matter of interest we will com-

(Continued on page 22)

[1] E. L. Chaffee and G. H. Browning. "A Theoretical and Experimental Investigation of Detection for Small Signals." *Proceedings of the Institute of Radio Engineers*, Vol. 15, page 113, Feb., 1927.

[2] J. R. Nelson. "Detection with the Four-Element Tube." *Proceedings of the Institute of Radio Engineers*, Vol. 16, page 822, June, 1928.

A Constant-Frequency Laboratory Oscillator

An Instrument Which Will Be Found Useful for Many Purposes in the Experimenter's and Engineer's Laboratory

By A. Binneweg, Jr.*

A LARGE percentage of all common radio-frequency measurements in the engineer's laboratory require the use of an oscillator of constant frequency. An oscillator of the type to be described may be used for numerous purposes and has many advantages over the ordinary types. A grid meter is used for a resonance-indicator, giving greater sensitivity; plug-in coils are used for all-wave use and a convenient rheostat-and-socket arrangement gives remarkable flexibility and choice of power output.

The oscillator is supplied with three paralleled sockets so that various power outputs up to two UX-210s in parallel may be conveniently obtained. The UX socket is used for the small tubes and the others are used for the larger tubes. The oscillator also serves very well as a portable transmitter.

As shown in the circuit diagram, a convenient rheostat arrangement is used so that various tubes may be employed. A carbon-pile rheostat is used for all usual tubes but a low resistance rheostat is used for the large tubes, the two being connected in series. By using a panel-switch either one or the other of the rheostats is shorted out so that for a known "A" voltage, the rheostats can each be calibrated and a filament-voltmeter is therefore not necessary.

Uses of Milliammeter

A grid meter for a resonance-indicator, usually, averages about three times the sensitivity obtainable with a plate meter, with certain adjustments, the plate-current change may be very small but the grid current change is always appreciable. A convenient shunting arrangement with the 1½-milliammeter is used. The two shunts give the instrument four ranges in all, this being necessary where different power outputs are required, and the binding posts shown, allow the meter to be used externally, although the oscillator may be in operation. Switch "A" is closed and the shorting connections to posts PQ and RS (normally shorted) are opened; the instrument when used externally thus has two ranges. The arrangement allows the use of the same instrument as a plate meter, if exceptionally small plate voltages should be used. In this case, the plate meter may be used for the indicator or a pair of phones may be inserted in the plate circuit. The shunts consist of a few inches of fine wire and the ranges which should be used are 1½, 7½ and 30 milliamperes. The grid currents given by different tubes will be quite different.

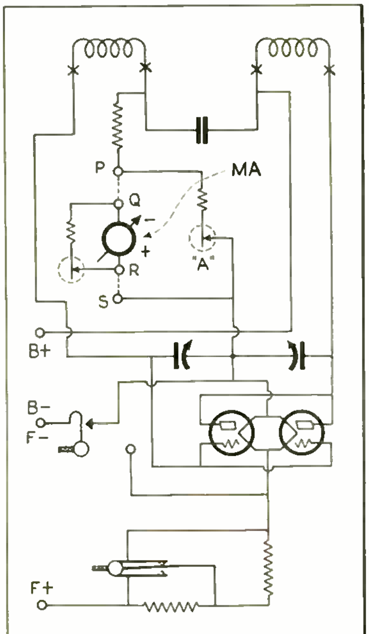


FIG.1

Schematic diagram of the laboratory oscillator for the generation of constant frequencies.

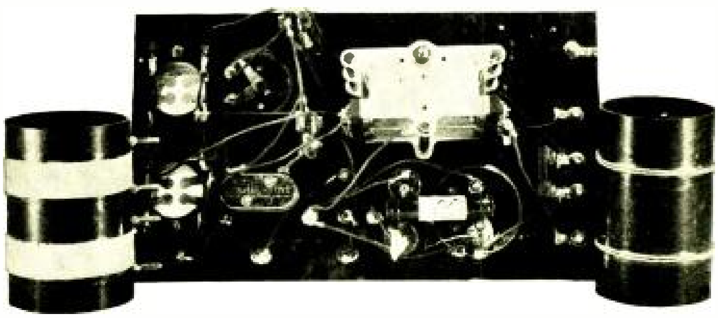
The coils are wound on 3 inch bakelite tubing, each coilform being 4½ in. long and provided with four plugs. The coupling-coil may have various numbers of turns depending upon the use of the set. A similar plug and jack will allow one to vary the coupling by rotating the coil in same.

Ample power is supplied by the oscillator so that loose-coupling can be used even with set-ups requiring considerable input. Direct current is usually better for plate supply when measurements are being made; well-filtered and rectified A. C. will often serve. If A. C. should be used, a large choke should be used in the plate circuit, this serving to smooth out possible low-frequency "drifting" of the galvanometer needle in the circuit under test. In the laboratory it is often convenient to use "B" batteries to supply the plate. In any case, the filaments can be operated from a small step-down transformer. A post is provided on the panel so that the filament voltage at the tube terminals can be read, should this be necessary.

Everything is mounted on the panel which measures 7 X 12 inches. A Radiola 111-A cabinet will serve very well for the case. If the coils are constructed as described, and a .00035 Mfd. double-unit condenser is used, the wavelength-ranges will be approximately as follows:

No. of turns	Each section	Wavelength range meters
2	No. 16 wire	11–30
5	No. 16 wire	26–65
13	No. 16 wire	53–150
33	No. 22 wire	135–375
74	Bank-wound No. 22	315–800

These sizes give ample overlap for the various wavelength-ranges so that points at the lower dial-settings may also be found at high settings with the next coil. Other ranges can be covered by using other inductance values.



The under side of the constant-frequency oscillator and two of the coils used for different frequency bands.

* 524 Fairbanks Ave., Oakland, Cal.

Precautions to be Observed

One is inclined to neglect effects in the design of an oscillator of this type, which may have serious consequences at the higher frequencies. For good results, somewhat higher plate voltages are necessary for the oscillator at the higher frequencies because of the losses introduced.

A simple test with a small parallel plate condenser showed that a wavelength of 12 meters, as much as 40 milliamperes of R. F. current would pass through a capacity as small as 1.5 mfd. with a single 310 as oscillator. It is obviously a simple matter to so design the oscillator that the distributed effects amount to much more than this. Short leads are desirable but the correct spacing of parts is of prime importance at these frequencies. The high voltage parts should be kept well away from all surrounding parts if one is to realize good efficiency, as shown by repeated tests.

In the oscillator illustrated, good results will be obtained even at wavelengths of the order of 12 meters. These effects are relatively unimportant at the lower frequencies (80 meters or so). One should design for the highest frequencies to be used.

The circuit used is such that no radio-frequency chokes need be used, these often being troublesome when a very wide frequency-range must be covered efficiently. The by-pass condenser in the oscillating circuit should be .006 Mfd.; a .0005 size will give poor oscillations above about 150 meters. Although a fairly large frequency range is covered by each coil, very close adjustment can be made with the vernier dial.

The power output can be varied by using the proper tubes and adjusting the battery voltages.

A calibrated condenser is a useful adjunct to the oscillator. A good short-wave condenser of about 11 plates is all right for general use. This should be mounted in a case, and should be shielded; the condenser terminals are provided with two posts and a jack each, mounted on the 6 X 8 panel.

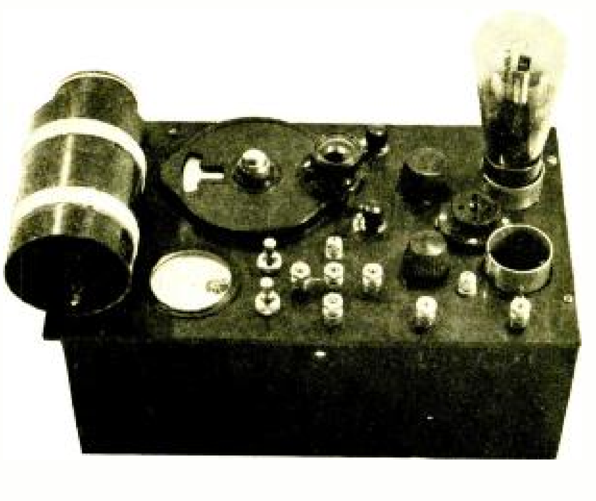
Some measurements may require a radio-frequency line for transmitting power into a circuit surrounded by other apparatus. Such a line consists of a few turns at each end and a twisted pair for the lead. One end of the line is coupled to the oscillator and the other to the required circuit. Resonance is always indicated by a dip of the grid meter.

Receiving tubes will furnish sufficient strength for ordinary work but for measurements of high-frequency resistance and the like, the larger tubes are used. From 45 to 150 volts are used on the smaller tubes, but voltages as high as 350 or more may be used with the larger ones.

Used as a Transmitter

When using the oscillator as a portable transmitter, the key is placed in the negative high-voltage lead. About 6 turns are wound round the secondary bakelite tubing to which the antenna is connected. For portable use, the simple single-wire antenna is used consisting of about 60 feet of wire at 40 meters. The secondary is connected in the center of the wire and a series condenser is used for tuning. One can change from one wave-band to the other by using the proper coil and retuning the antenna system to a harmonic or changing its length.

A general-purpose instrument of this type need not be calibrated with extreme accuracy since various types of tubes are to be used. When calibrating from standard transmissions, a simple low-loss tuned circuit is used and the known frequencies are transferred from the oscillator to the tuned circuit in one operation, which can be accurately done. For accurate frequency measurements, the oscillator is always compared with the tuned circuit calibration.



One of the special coils mounted in place on the constant - frequency oscillator, which is well adapted for accurate work in the laboratory. This instrument can also be used as a portable transmitter.

LIST OF PARTS FOR OSCILLATOR

1—1½ milliampere D. C. meter.
8—Binding posts.
1—5000 ohm resistor.
1—.006 mica fixed condenser.
22—½ in. 3 in. diameter bakelite tubing.
20—Coil plugs.
4—Jacks.
1—Double-unit condenser, 00035 mfd. each.
1—UX-type tube socket.
1—Double bakelite tube-socket unit.
2—Push-pull switches, panel-mounting.
1—Two-way panel switch.
1—Filament panel switch.
1—Filament rheostat.
1—2½ ohm power-tube filament resistance.
1—0-100-0 vernier dial.
No. 16 and 22 wire for osc. coils.
1—Pkg. hookup wire.

DETECTION WITH THE SCREEN-GRID TUBE

(*Continued from page 20*)

pare it with the CX-301-A used as a bias detector. When the plate impedance is equal to the internal impedance ep is .35x2A² B for the CX-301-A. The ratio of the CX-301-A to the CX-322 is .35/2.5 or .14. This is amplified 72 times so the voltage on the grid of the power tube is 72 x .14 or 10.08 times as much as for the CX-322. The radio-frequency amplification of the set using the CX-322 detector will have to be $\sqrt{10.08}$ or 3.17 times as much.

Thus we see that under the most favorable conditions the set using the CX-322 detector will have to have 3.17 times the radio-frequency amplification of the ordinary set and under the least favorable conditions 18.6 times. Taking the value of 18.6 if two stages are used each stage will require $\sqrt{18.6}$ or 4.32 times the amplification per stage of the ordinary set and if three stages are used $\sqrt[3]{18.6}$ or 2.65 times as much.

There is another factor that should be taken into account when comparing the CX-322 bias detector with a detector using grid leak detection. When bias detection is used the grid-to-filament resistance is very high. When grid-leak detection is used the grid-to-filament resistance drops down to values ranging from several meghoms to 10,000 ohms, depending on the type of tube used, grid return and size of grid leak. This low grid resistance is in parallel with the tuned circuit preceding the detector and reduces its amplification and selectivity factor. In the above example the factor of 18.6 would be reduced because of the effect of the finite grid-to-filament resistance. The amount that the factor 18.6 would be reduced would depend upon the tuned circuit and grid leak used and cannot be taken into account except for a specific case.

From the above calculations it can be seen that the use of a screen grid bias detector working into a power tube is practical provided that a good R.F. amplifier is used and a high impedance load is placed in the plate circuit of the detector. If only two stages of R.F. amplification with screen-grid tubes are used each stage should have about three or four times the usual stage amplification. If three stages are used each stage will only require about two times the usual stage amplification.

High-Voltage Chemical Condensers

A Description of the Characteristics of a Dry Chemical "B"-Pack Capacity

*By P. E. Edelman, E.E.**

THE rather complete discussions of filter circuit design in the columns of RADIO ENGINEERING have not exhausted the subject to date. Search for the most satisfactory and economical design has led to various modified improvements. In general, the art has moved from the extreme of preponderant brute force filters to arrangements using scanty capacities. While not neglecting consideration of series and shunt resistances, most discussions have overlooked the commercial possibilities of preponderant capacity.

The present paper brings to attention the economy of using large capacities of a commercial type developed by the author. Filtering results are superior and manufacturing costs much reduced, permitting satisfactory filteration with resistance substituted for one or both of the choke coils commonly used heretofore.

Electrochemical High Voltage Condensers

The "B" pack type condensers developed by the author are characterized by proven durability, permanence of capacity value, low energy loss, small bulk, and small cost. They are substantially free from surge breakdown troubles due to inherent self-healing properties and withstand high operating temperatures.

Difficulties due to instability of dielectric film and evaporation, common to "wet" type condensers, have been overcome.

As a result of elaborate experiments, the developed "B" pack condenser consists of a compact roll of prepared aluminum sheets separated by a thin layer of organic dielectric forming material. A 25 Mfd. condenser of this kind with standard filter circuit taps, uses less than eight cents worth of aluminum and occupies less space than the average 5 Mfd. paper condenser does. Absolutely nothing containing water is employed in the structure, so there is nothing to evaporate. The chemical ingredients are non-aqueous and prepared non-hygroscopically, so that all troubles formerly due to presence of water in structures of this class are avoided. Moreover the chemicals are stable at temperatures ranging more than twice the highest likely operating temperatures of the condenser.

The "B" type pack condensers act more like wax impregnated paper and foil condensers than any chemical types heretofore known or experimented with. The losses are exceedingly small and the condensers will retain a charge for an appreciable time, the same as a paper condenser. It is not necessary to resort to series connected condensers for high voltages due to the high dielectric value of the spacer chemicals. Probably condensers of this type can be made commercially to withstand 2,500 volts if desired.

Permanizing Dielectric Layer

One of the problems worked out contributing to the proven durability of this type condenser is in the preparation of the electrode sheets. It has been known for years that the film on a wet condenser electrode dissolved into the solution used so that "reforming" was required. Theoretical considerations verified by experiments resulted in a permanizing process whereby this dielectric coating on the electrode is permanized.

The process is analogous to the case of permanent magnets, an ingredient being used to temper the molecular lattice structures to preserve the orientation. The resulting dielectric coating is very smooth, exceedinly thin and permanently adherent to the base aluminum, and does not crack nor flake therefrom on bending. Nor does the molecular coating lose any of its dielectric value on exposure to the atmosphere or to various liquids. Prepared electrode sheets left standing for months, both dry and wet, prove this permanizing.

The Principle Utilized

Perhaps it is well to explain for radio technicians not familiar with physical chemistry, that the operating dielectric in this kind of condenser is of a thinness expressed in molecular dimensions rather than any small decimals of an inch, determinable by observing the action of light projected on the surface of the prepared electrode sheet. A true oriented molecular lattice structure acts substantially as an insulator, conduction occuring only on ionization or else on movement of electrons feebly held at the molecular boundary.

When aqueous chemicals are used or solutions, as in wet condensers, conditions are favorable for ionization and the dielectric properties of the film can be destroyed though the condenser stands idle. With the Edelman "B" type condenser this is not the case, because the molecular dielectric coating is permanized and stabilized, and also because the operating chemical employed is favorable for operation by electron transfer. The latter action resembles that occuring in dry disc type rectifiers.

Illustrating that the high capacity is due largely if not wholly to this principle, it may be remarked that two condensers prepared identically, except that a thicker layer of operating chemical is used on one sample, show no appreciable differences in measured capacity. The use of thin chemical layers is further advantageous in preventing rise of temperature in the condenser during use, as the relative thermal mass of the electrodes with respect to the thermal property of the operating chemical is greatly preponderant, causing internal heat to be dissipated as rapidly as it is set up. The main heating occurs in the first condenser section used in the first filter, as this is the only one which withstands a large current measurable with an A. C. milliammeter. Only very minute currents measurable on an A. C. milliammeter ever flow in the second and succeeding terminal sections

The dimensions of a 25-mf. high - voltage chemical condenser with the capacities indicated under the color of the leads. At the right is shown the principle of the construction of this type of condenser.

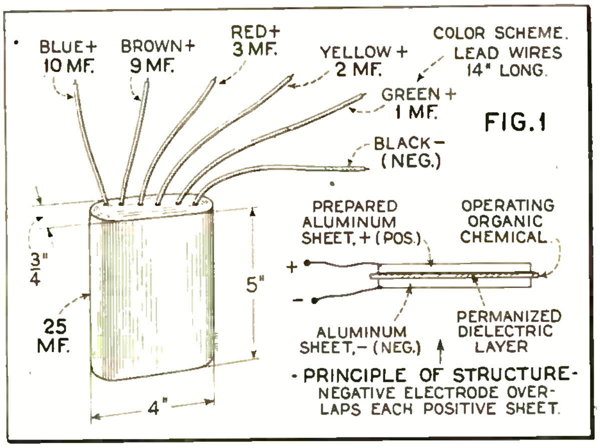
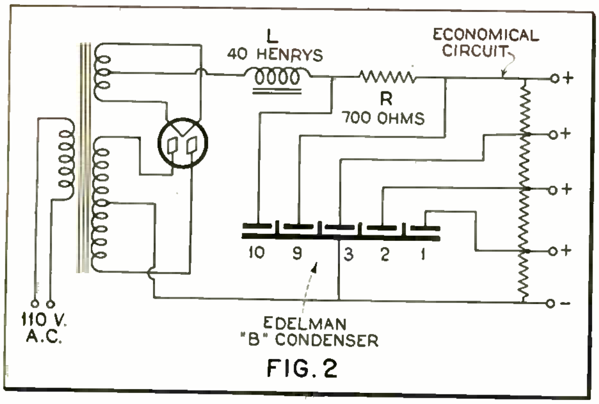


FIG. 1

· PRINCIPLE OF STRUCTURE · NEGATIVE ELECTRODE OVERLAPS EACH POSITIVE SHEET.

* Patentee, 7258 Yates Ave., Chicago, Ill.



Schematic diagram of a "B" eliminator circuit in which is incorporated the 25-mf. chemical condenser.

of the condenser. There is no measurable loss of capacity nor increase of leakage with time, proving the permanent nature of condensers of this type. Unlike wet type condensers the capacity values of the condenser are stabilized and do not vary up and down with different operating voltages.

Commercial Uses

Various uses other than in filter circuits are indicated and under investigation. A condenser of this kind shunted around the secondary of a regular pack transformer affords commerical regulating characteristics tending to compensate for normal variations in supply current. The question is often asked, how such condensers act on pure A.C. In general they are more suited to use in filter circuits where a direct flowing component is present, because polarized, but whatever increase in temperature occurs on A.C. operation, without direct current component simultaneously applied, is lagely due to the increased energy flow through the condenser. By selection of proportions of the chemical ingredients a true A.C. condenser can be built, because the polarization is so rapid that it is able to follow changes in the cycle of the applied alternating current. Such condensers have been operated on A.C. exclusively without heating.

Practical Features

The theoretical principles have been outlined but practical readers are likely to be more interested in practical measurements of performance.

A typical "B" pack condenser, with total of 25 Mfds. capacity divided into the usual filter sections in a single roll, has approximately the following characteristics:

1. Cost, a small fraction of price of equivalent paper condenser.
2. Cubage—¾" x 4" 5", for 25 Mfds. Mfds.
3. Weight ⅝ lb.
4. Leakage, measured at 250 volts, less than 1/10 milliampere per Mfd.
5. Capacity per sq. inch electrode sheet, ¼ Mfd.
6. Safe operating temperature rating, 300 degrees F. Normal operating temperature, room temperature plus rise due to conduction and radiation from other apparatus parts, rectifier heat energy, etc. Normal rise, 5 degrees F.
7. Operating life, indefinite and at least 10,000 hours.
8. Breakdown voltage rating 700 volts; condensers self heal on any surge breakdown.
9. Normal operating voltage, up to 300 volts.
10. Non-motorboating in filter circuits used with quality radio amplifiers.
11. Filter circuits recommended; filament tube or Raytheon or Elkon rectifier, ladder filter with one or two small chokes, or pure resistances of 700 ohms, or one choke section and one pure resistance section.
12. Behavior at radio frequencies; radio-frequency resistance increases rapidly with increase of frequency, but useful characteristics remain in the structure up to 1,000,000 cycles.
13. The condensers are more suited at present to low frequencies where energy losses are a negligible minimum.
14. When used in Raytheon type circuits, buffer condensers appear unnecessary due to properties of the "B" type condenser.
15. Increased life of rectifier; this condenser insures longer rectifier life proven by tests because surge short circuits are minimized, leaving rectifier output normal without short circuit loads of measurable time duration.
16. Transformer "burn-outs" similarly are insured against, due to prevention of rectifier short cicuit load caused by beakdown of ordinary type "B" condenser.
17. Licenses issued to responsible makers insure quality product available at fair prices in near future.

Fig. 1 shows present condenser dimensions and suggested pack circuit of low cost, high efficiency, capable of operating a quality radio receiver.

The novel features are protected by pending patent applications and issued patent claims.

BUREAU OF STANDARDS TO AID BROADCASTERS IN FREQUENCY REALLOCATIONS

The Federal Radio Commission recently announced its plans for cooperation with broadcasters in putting into effect the Commission's new schedule of radio allocation.

To assist broadcasters in their efforts to make mechanical adjustments necessary to permit operation on the new frequencies, the Commission announced, arrangements have been made with the Bureau of Standards and the Radio Division, Department of Commerce, for special cooperation by these two bureaus with the broadcasters.

The Commission's statement follows in full text:

Under the new allocation of broadcasting stations, effective November 11, 1928, most of the stations will operate on frequencies different from those in the past.

It is necessary that every station be equipped with a standard indicating accurately the frequency on which the station will operate, in order that there be no undue interference and in order to comply with General Order No. 7 (fixing one-half kilocycle as the extreme deviation from authorized frequency which will be permitted).

Prompt Adjustment Required

It is urged that each station proceed without delay to make the necessary arrangements to secure a standard adjusted to the new frequency, and to make alterations in the transmitting set where required. In order to aid in the adjustment to the new frequency, the Commission has secured the cooperation of the two branches of the Department of Commerce concerned.

The Bureau of Standards has agreed to make special arrangements to expediate the calibration of the broadcasting station frequency standards, and the Radio Supervisors of the Department's Division will cooperate in the adjustment of all stations to the new frequencies.

In all cases where a station is now using a piezo oscillator which has been calibrated by the Bureau of Standards, the Bureau will calibrate it for the new frequency without charge to the station.

Making of Alterations

The Bureau requires all standards submitted to it be in working order, and will not undertake manufacturing or repair work. The alteration of the piezo oscillator to operate on the newly assigned frequency will not be made by the Bureau; the station owner must in general, have that done by the manufacturer or a qualified radio instrument shop.

Information concerning the requirements for tests, fees charged, etc., by the Bureau of Standards can be obtained on application to the Bureau. Arrangements should in all cases be made with the Bureau by letter before any apparatus is sent for test.

Isolation and Resonance in Audio Frequency Circuits

Observations on a Unique Type of Audio Amplifier Employing an Improved Form of Parallel Feed and Resonant Circuits

By Kendall Clough*

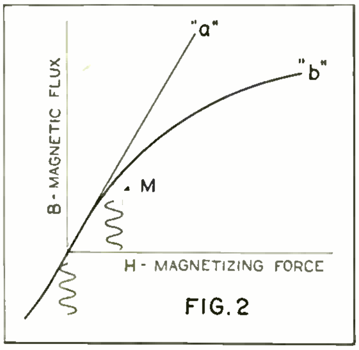
A GREAT deal has been said in the technical press during the year past about the isolation of radio frequency currents in the functions of a receiver. The whole principle of such isolation resides in the properties of inductors and capacities of passing currents of different frequencies with unequal facility. The usefulness of isolation is manifold as it permits a tube, with its associated circuit, to function entirely apart from the B-supply device, and this has become of tremendous importance when so many functions in a receiver are supplied from a common power source as demanded by modern practice. In addition, it permits the elimination of a certain type of distortion from the reproduction, a type that has until recently been practically overlooked in amplifier design.

The reader is familiar with the common practice in R.F. circuits of connecting a choke and a condenser in the B-supply circuit in such manner that the choke carries the direct current from the supply to the plate of the tube, while the condenser shunts the alternating currents from the primary of the transformer to the ground in such manner that they may not pass through the supply circuit. It has been general practice in many telephone circuits to insert reactances in audio circuits to perform such an isolation with perhaps as many advantages as are realized by the isolation of R.F. circuits.

Isolated or "Engineered" Circuit

The diagram in Fig. 1 shows the manner in which this connection is usually made. V is a tube operating as an audio amplifier in connection with the step-up transformer, T. This is shown as a transformer of the auto type (part of the winding common to both the secondary and primary circuits). In practice the choke and condenser would be made large electrically, with the effect that practically none of the signal current from the tube would be short-circuited by the choke and thus be lost to the transformer. In the same way, the large condenser presents practically no impedance to the signal current so that there is a practically complete transfer of the tube signal currents to the transformer. Now, several advantages accrue from the insertion of these items in the circuit.

In the first place, no direct current flows through the primary of the transformer, thus magnetizing the core and producing hysteretic distortion, a term



Curves "a" and "b" are two magnetizing curves of different types of steels. The magnetic properties of the transformer laminations are important.

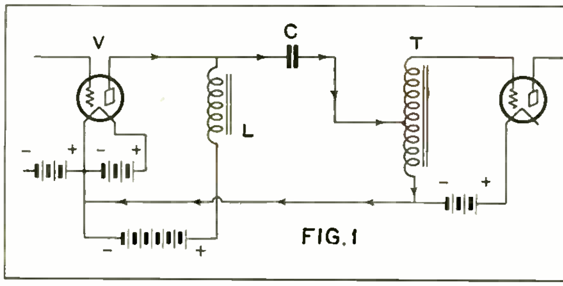
that will be explained later; second, the principal portion of the audio energy finds its way *directly* through the primary, performing the function of supplying grid voltage to the following tube, and thence finds its way back to ground rather than through the supply circuit (shown as a battery for simplicity). Both of these effects are of profound importance if the fidelity of the reproduction is to be as faithful as possible. We will discuss them in the order named.

Magnetizing Force

It is a well known fact that iron and transformer steels do not magnetize linearly. This means, simply, that equal amounts of magnetizing force do not produce proportional amounts of magnetism in the core material. This idea is illustrated graphically in Fig. 2. The curve "a" illustrates an ideal material that magnetizes linearly and curve "b" is similar to that of available materials showing that, beyond a certain point, the material does not magnetize with the same ease that an ideal material would. In a transformer the magnetizing force is proportional to the product of the primary turns and the current in the primary at any instant. A study of many of the products on the market has indicated that without any isolation of the plate current from the transformer primary, the iron is magnetized by the tube current to a point such as, M. It can be seen that, as the signal current varies about this point, the steel will not be magnetized to as great a degree by the right-hand half of the current wave as it will be demagnetized by the left-hand side of the wave. The voltage appearing across the secondary of the transformer is proportional at any instant to the change in magnetism in the core during that instant so it is apparent that the secondary voltage wave will be distorted by the non-linear characteristics of the iron. This distortion is called hysteretic as it originates in the hysteresis curve of the iron. The effect of this is far more important than this simple analysis would make it appear, and one should not allow himself to believe that simply because the curve on an audio amplifier is good, that there is no distortion of this type. The equipment that is ordinarily used for the preparation of curves employs instruments that indicate only the effective values of the voltages impressed on and appearing from the amplifier, and give no indication whatsoever of the shape of the output wave. In this way, a highly distorted wave of voltage appearing across the output will have sufficient effective value to secure a good indication in the output meter and in this way a good curve is produced, although the distortion may be considerable.

Symmetrical Magnetization

It was stated that by the use of such



Audio amplifier employing an autotransformer in an isolated circuit. Advantages of the system are outlined in the article.

* Director of the Laboratories, Silver-Marshall, Inc.

a circuit as Fig. 1 this type of distortion could be reduced. This is true because there is no direct current through the transformer primary to cause initial magnetization to the point, M, (Fig. 2) and hence the wave of current is impressed on the iron in a free state, as illustrated, and the magnetization is symmetrical for both halves of the wave. Thus the secondary wave of voltage will be symmetrical and undistorted.

It can be seen that, because the impedance of the choke, L, cannot be infinite, all of the alternating current cannot be excluded from passage through it. Also, a practical choke for this purpose cannot be constructed without the use of a steel core. For these reasons there will be some hysteretic distortion due to the action of the plate and signal currents on the steel core in the same manner that was described for the transformer core. This can be also eliminated in a practical system.

It has been customary in systems to provide a supply of sufficiently high voltage to operate a power tube and to reduce the voltage by means of a potential divider to one satisfactory for the operation of the lower voltage tubes. Power is wasted in the potential divider and, as long as it is to be wasted, it is perfectly feasible to employ the circuit of Fig. 3. Here the wastage of power takes place in a resistor, R, individual to the stage. The resistor has none of the non-linear characteristics of an iron core impedance and a further source of hysteretic distortion has been eliminated.

Obviously there is no point in going to such refinement of circuit design unless it is to be applied to all stages of the amplifier. This may raise some question in the reader's mind as to why this method is not, as a rule, applied to the design of output transformers in order to make each device of the amplifier of equal strength in this particular respect. The answer to this question is that the design of an output transformer is such that it does not ordinarily preclude the insertion of an air gap in the core structure of such size as to guarantee linear magnetization over the range of primary currents encountered in practice. This air gap cannot be used, as a general rule, in the design of the inter-stage transformers as the reduction in inductance due to it impairs the bass reproduction from a frequency amplification curve viewpoint.

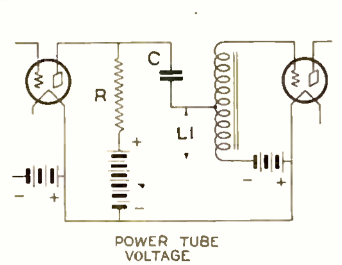


FIG.3

By the insertion of the resistor R the hysterisis distortion in the transformer is reduced.

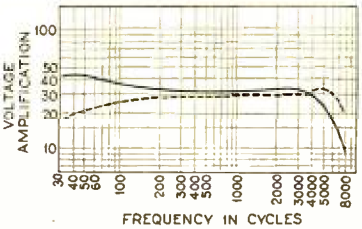


FIG.4

Frequency response curve of a transformer coupled amplifier (dotted lines) and of the amplifier described in this article.

That the method of isolation and reduction of hysteretic distortion shown in Fig. 3 is effective has been repeatedly demonstrated to the ear by means of switching devices arranged to eliminate the device and substitute an ordinary transformer of equivalent frequency curve. The difference in quality of tone is apparent in this test, even to the untrained ear.

There is a further advantage in arranging the isolation in this manner. When a signal is impressed on the amplifier and the tube starts drawing audio current from the eliminator, the supply is not instantaneous, due to the impedance of the filter chokes, unless the condenser across the terminals of the supply is large. As eliminators are ordinarily designed, the capacity across the high or power tube voltage terminals is large, while the by-pass condensers on the voltage divider are required to be small in the interest of economy. By the elimination of the voltage divider, in accordance with the circuit above, all stages are enabled to obtain the instantaneous supply necessary for an undistorted note from a large capacity across the supply terminals.

Obtaining Resonance Peaks

Throughout this discussion we have regarded the condenser C to be of such large size that its reactance, at the lowest frequency to be transmitted by the amplifier, would be negligible. This is the manner in which the circuit has ordinarily been employed in the past. While examining the equations of the stage of amplification shown, it became apparent to the writer that, provided the inductance, L1, (Fig 3) exceeded a certain critical value, determined by the lowest frequency to be reproduced by the amplifier, the condenser, C, could be chosen of such size as to have a reactance at the lowest reproduced frequency equal to the reactance of the primary. This is another way of saying that resonance would be obtained at that frequency. This made possible an improvement in the frequency characteristics of such devices so that, whereas all transformers of the past had produced less amplification of the bass frequencies than of the treble, it became possible to produce an equal or greater amount of amplification of the low notes. The ultimate outcome of this thought is better expressed by the curves of Fig. 4 than could be done with words. The dotted curve shows the best transformer that had been produced by ordinary methods up to the advent of the tuned type, while the solid curve indicates the performance of a tuned transformer of the same size but less weight than the other. The latter curve varies from the ideal straight horizontal curve by far less than is detectable to the ear, and yet we must impress the reader with the fact that practical tests have repeatedly indicated that this perfection, from a frequency standpoint, is of no avail without the elimination of hysteretic distortion by the isolation of that combination of currents so detrimental to the operation of the steel in the ordinary transformer or choke coupled amplifier. This has been effectively accomplished in commercial models of transformers from which the solid lined curve of Fig. 4 was obtained.

VISIT THE BUREAU OF STANDARDS

HOW many manufacturers ever have visited the Bureau of Standards? It is out Connecticut Avenue and comprises a large collection of buildings. A manufacturer who has not visited this bureau is overlooking something that may revolutionize his methods of manufacture by suggesting more economical or efficient processes. The building devoted to industrial production is the largest in the group. Testing machinery of every sort is being operated. Experiments involving the saving of millions of dollars are conducted.

Two men are at work in one room letting a weight fall on china plates and when the plates break they know how perishable they are. Some withstand a good many blows from a hammer of cumulative weight. Another machine in another department is testing tires. A ponderous machine with mammoth screws is pulling apart a member weighing several tons that has been sent in by a bridge company. Enamels for kitchen ware are being tested in the division of ceramics. One of the enamels upon which the engineers are working will overcome the blue tinge which is characteristic of all initial enamels. The enamel bends without cracking—most desirable as any maker of enamel ware will agree.

A person could spend hours in the building, learning something every minute.

Progressive manufacturers of course know all about the Bureau of Standards. Those to whom the bureau is only a name might find it immensely profitable to pay it a visit.

—*Manufacturers News.*

Sane Radio-Frequency Amplification

A Resumé of Laboratory Experiments Covering This Important Field Using a Screen-Grid Tube

By Bert E. Smith*

THE past few years have shown much of improvement in audio-frequency amplifiers and their component parts, and the art of loud speaker manufacture has advanced with tremendous strides. Quality of reproduction has been a watch-word, and deservedly, for certainly little has done so much to bring radio from a fad to an art as really truthful reproduction. During this period, however, the radio-frequency end of most receivers has been a perfect step-child. Nothing really new has appeared since the Hazeltime neutrodyne system several years ago, and even this was merely a re-hash of the much older Rice system in its basic theory.

In the meantime there have been occasional flashes of some new scheme whereby tremendous amplification was obtained or whereby radio-frequency amplifier tubes could be stabilized without losing any of their theoretically possible efficiency. But these have all proven either impractical or useless. Efficient radio-frequency amplification still appears to be one of the chimeras which will not become established facts for some time. In the main, there has been retrogression rather than advance, and a surprising number of sets are being built today which are stabilized by the oldest method known—potentiometer grid control. Others reduce the amplification of the tube by various means and many of them simply cut down the plate voltage applied to the radio-frequency amplifiers until the tube fails to function sufficiently well to amplify the feed-back signals to the point of oscillation.

In other words, after many wild schemes, much talk of "perfect shielding" and various other wonderful things purporting to introduce tremendous selectivity and amplification, we have an industry which has tacitly admitted itself unable to conquer the problem of perpetual motion without motion.

This situation has been of late even further complicated by the introduction of the shield grid tube. Announcements by tube manufacturers of a tremendous amplification constant and a tube which would not cause oscillation in a circuit, even when operating at full efficiency, led the public to expect great things and equally wild statements in many of the large publications, which have utterly failed to be borne out and results obtained, have led the average radio fan to decide that this shield grid business is all the bunk. Even the largest tube manufacturers and some of the best engineers in the country have allowed themselves to be responsible for such statements as that—"A voltage amplification of 200 per stage is obtainable but at broadcast frequencies the resonant impedance is lower, reducing the amplification 25% of this value."

Such statements are not deliberate lies. Amplification of such values can be obtained from the tube in laboratory oscillators built by experienced and carefully educated engineers under the most favorable conditions, but they are by no means to be expected from the normal broadcast receiver, and it has become somewhat doubtful as to whether the tube, when used for amplification at frequencies higher than five hundred kilocycles, can be expected to produce a great deal better all-around results than the 201-A tube, which has been standard for so long a time.

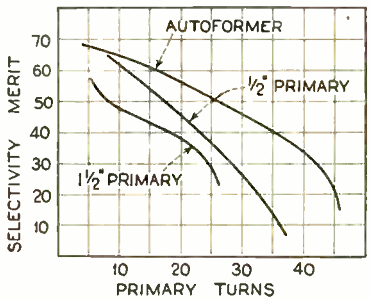


FIG. 1

Selectivity curves of various types of R. F. transformers.

A number of experiments were recently undertaken in the laboratory of a large manufacturer to determine under just what conditions the tube might be expected to give its optimum results, both as to selectivity and sensitivity. Inasmuch as the results lend themselves to application to the older types of tubes, it was thought that they might perhaps be interesting to the readers of this publication.

Apparatus Employed

Before setting up any apparatus at all, certain facts were necessary as a basis upon which to commence experimentation, both in the matter of circuits and transformer design. In the first place, standard apparatus must be utilized, as far as possible. By standard apparatus, it was not necessarily meant that, for example, special transformers could not be developed, but they must be applicable to standard method of construction. Shielding was not barred but at the same time, if anything like equivalent results were obtained without it, its presence was frowned upon as introducing superfluous expense and trouble.

The set-up shown in Fig. 7 was employed for testing originally. The output of a modulated oscillator variable over the broadcast range actuated the input grid of a vacuum tube and an input voltmeter. The vacuum tube was coupled by the coil under test to another voltmeter, thus simulating very closely the actual conditions obtaining in a receiver, with the exception of

Curves showing the "amplification merit" obtained with the autoformer and R. F. transformers with ½ inch and 1½ inch primary windings at broadcast wavelengths.

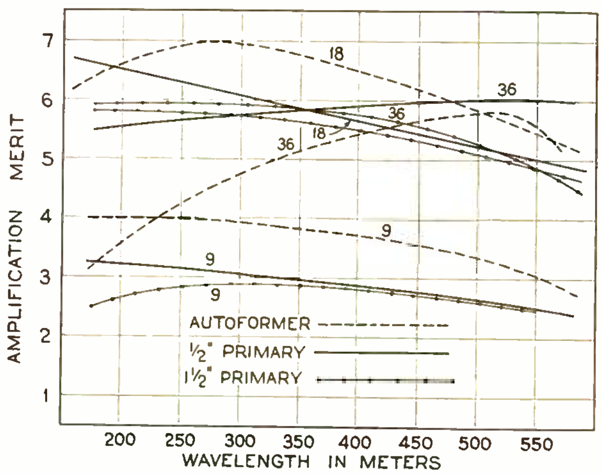


FIG. 2

* Aero Products, Inc.

course that the input signal was considerably stronger than would be found in the first stage of the average set.

Later on it was found advisable to add a second stage, using more or less standard types of coupling and then allow for the overall amplification of the additional stage in order to reproduce more closely the input conditions to the stage under test. In order that oscillation might take place as freely in the test unit as it would in the receiver, a radio-frequency transformer with an absolutely flat curve and with some actual loss of amplification per stage was taken as a standard, and the figure of amplification merit was based on the relation between the output characteristics of this and the test circuit. This amplification test was given to a large number of coils and circuits and the results of all of them are not shown here as they would take up several pages of rather minute diagrams. In the main the mechanical construction was kept the same. The transformer secondary invariably consisted of ninety-four turns of wire wound in the customary manner on a skeleton bakelite form, so that losses are at the lowest possible figure. This secondary winding is two inches in diameter and extends over a space two and one-fourth inches long. Among the types of primary used were:

One.—A primary space-wound to take up a length of one and one-half inches.

Two.—A primary wound to take up a space of one-half inch or less.

Three.—A primary wound with a length of not more than one-eighth inch.

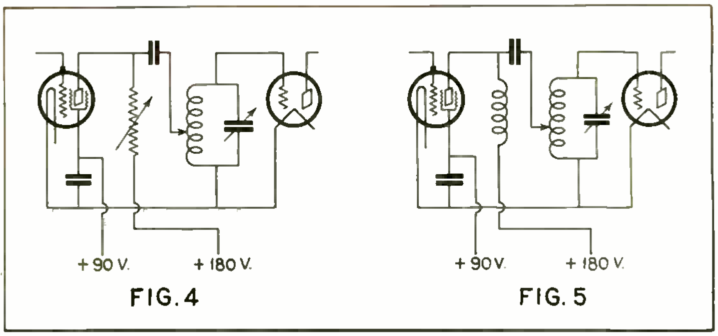


Fig. 4. A tuned radio-frequency circuit employing resistance-autoformer coupling. Fig. 5. The same form of circuit as that of Fig. 4 but using impedance-autoformer coupling.

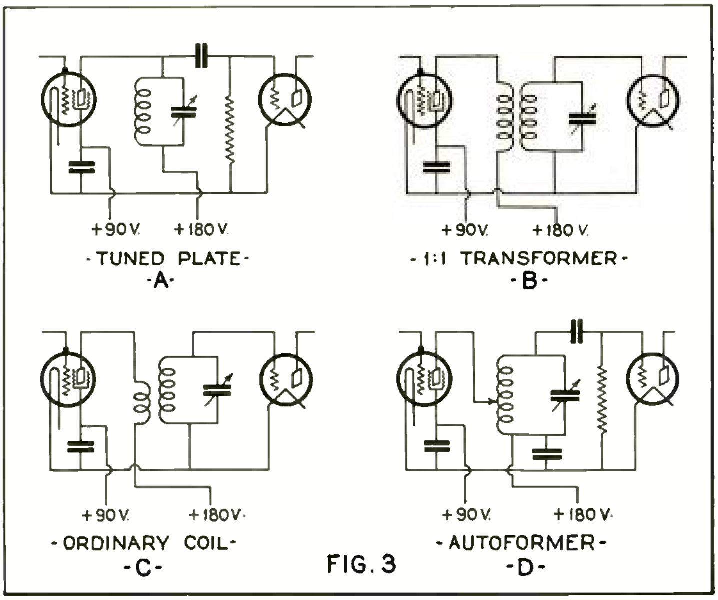
Four.—A slot wound primary.

Five.—A primary wound on the same diameter as, and at an adjustable distance from, the low potential end of the secondary.

Six.—A tuned primary with adjustable coupling to the secondary.

Seven.—A transformer in which the primary and secondary are coupled by a by-pass condenser at the low potential end and turned from plate to grid, as in the "R.B. Lab." and similar circuits.

Each of these was tested with a varying number of primary turns and where possible, with varying degrees of coupling. Examination and analysis of expected results led us to believe that where capacity coupling existed between the plate of the preceding tube and the grid of the following tube, this would be in quadrature with the voltage induced by the inductive coupling. This was borne out perfectly. Further analysis indicated that after a certain value of impedance was built up in the plate circuit of the preceding tube, no particular gain would be obtained by further increasing the number of primary turns and also that by balancing the inductive and capacity couplings carefully, this value might be obtained without losing selectivity.



Various forms of tube coupling. A, is a tuned impedance coupling; B, transformer coupling with large primary winding; C, the same but with small primary and D, autoformer coupling.

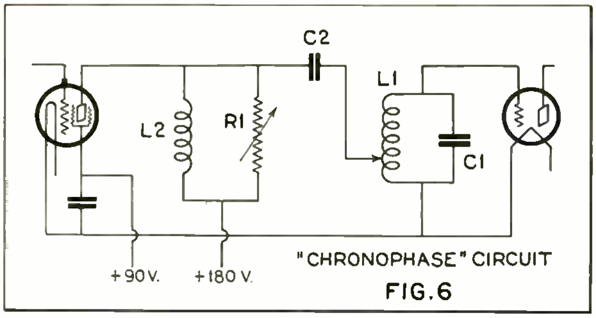
Findings of Tests

Some of these results are shown in Figs. 1 and 2. In order to simplify observation, curves have been shown on only three of the most commonly utilized types of coil and on the one which worked out to the best advantage. Fig. 3-A shows a tuned impedance such as has been recommended for use with the shield grid tube. Inasmuch as the selectivity merit of this particular arrangement was extremely poor and the energy transferable was no greater, as will later be shown, than by other methods, this was quickly abandoned.

Fig. 3-B illustrates the one to one coupling used in most circuits with shield grid tube when tuned impedance is not employed. From the curves of this type of transformer using a varying number of turns spaced to take up a long distance, it will be noticed that the amplification increases rapidly up to a certain point and then no greater gain is obtainable by a further increase, hence the one to one ratio is unnecessary.

Fig. 3-C illustrates the connections to a coil with a primary concentrated at the low potential end of the secondary in the usual manner for standard radio-frequency transformers.

The results indicate that at least as good results are obtainable with the same number of turns from this arrangement as with the wide spread primary. At this point, we confirmed the fact that varying the number of turns will vary the wavelength at which the maximum amplification is secured, and hence by adjusting the number of primary turns in the consecutive transformers of a cascade amplifier, comparatively uni-



A radio-frequency circuit, known as the "Chronophase," which is a combination of the arrangements shown in Figs. 4 and 5.

form amplification can be obtained over the whole band.

The third curve shown indicates the results obtained from the circuit shown in Fig. 3-D, where a varying portion of the secondary coil is used for primary, with the primary and secondary currents in this portion of the coil in quadrature. Once again this follows out the theoretical analysis perfectly—as the inductive coupling is much greater, there is a tendency towards greater energy transfer, but when a large number of turns are used for the primary the portion of the coil in which the currents are in quadrature becomes greater and the voltage built up on the following grid falls off seriously at the higher frequencies, although very large amplification is obtainable at the same frequencies when a smaller number of turns are used. This once again can be put to extremely good practical use, as in effect it is possible to vary the peaks of consecutive transformers and secure substantially uniform amplification over the entire broadcast band.

Now let us look at Fig. 2, which gives us some idea of the relative selectivity received from these various types. These curves were derived from the inverse ratio of overall amplification obtained with the secondary circuit tuned to frequencies fifty kilocycles distant from the oscillator frequency at three hundred meters. As would be expected, the wide primary was much the poorest and the autoformer much the best, since the resistance of the latter to radio-frequency currents is much lower in proportion to the impedance of the tuned circuit.

The circuit shown in Fig. 3-D necessitates that the tuning condenser be at a high D.C. potential and to avoid this, the circuit shown in Fig. 5 was employed, and equally good results were obtained.

Due to the high amplification obtained, however, oscillation in a cascade amplifier was present.

When a circuit consists of two or more branches in parallel, as in this case, the total alternating current cannot be obtained by calculating the branch currents and adding them because of the difference in phase of the various branch currents.

In Fig. 4, we have one branch consisting of resistance only and the other of capacity and inductance in series. In a branch having only a constant resistance R (or a conductance G equivalent to 1/R mhos) the voltage and the current i at any instant are related by the equation:

$$i = eG$$

The voltage and the current have the same wave form and are directly in phase.

When the voltage is changing across a branch having a constant capacitance C and a constant self-inductance L, the voltages at any instant are in relation to the following equations:

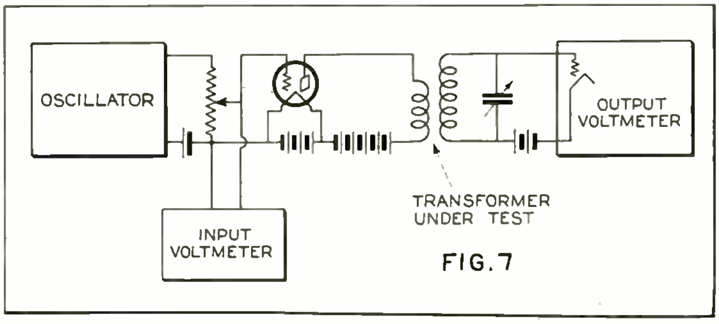
$$e = \frac{Z}{C\frac{de}{dt}}$$

$$e = L\frac{di}{dt}$$

Depending upon the proportions of inductance and capacity, the current will either lead or lag behind the voltage and irregularities in the wave form will be increased or smoothed out, in any case, resulting in distortion unless the circuit is carefully tuned to resonance. Inasmuch as this is impractical in the case in question, it becomes desirable to use a disproportionate amount of capacity in this branch of the circuit. By varying the resistance then, it is possible to change the angle by which the current leads the voltage in any one stage, and hence the tendency towards oscillation caused by the amplification of fed-back currents will be considerably reduced as the energy in various branches of the circuit. Unfortunately, however, when resistances of the proper value to give adequate control of the phase angle are employed, it will be found that any variation of the resistor varies the plate voltage applied to the tube and may seriously affect the amplification obtainable. In order to avoid this, the circuit shown in Fig. 6 was finally adopted. The inductance L-2 having a comparatively low D.C. resistance was shunted around the resistance, maintaining a maximum static value of plate voltage at the tube, while offering a very high impedance of radio—frequency currents. The resistance R-1 can now be varied without affecting the static value of the plate voltage and will be found to serve very nicely as an oscillation control and if provision is made so that it can be reduced to a low value so as to effectively short circuit C-2, it can also be employed as a volume control for the receiver.

In a circuit containing two stages of radio-frequency amplification, it will rarely be found necessary to employ more than one such resistance, as sufficient adjustment of the time relation can be obtained to avoid oscillation while still maintaining the satisfactory value of overall amplification. Maximum results regardless of the type of tube used can be obtained by varying the proportion of L-1, which is used in the plate circuit of the preceding tube. Little trouble was experienced from inductive coupling between coils, provided they were maintained at a distance of at least six inches between coil centers.

Shielding always introduces certain losses in the coil, due to linking a portion of the coil's field, and also complicates the mechanical construction of the receiver. It will be seen from the curve that the necessity of shielding is mitigated as far as inter-stage coupling effects go, while the diameter of the coil is so small that direct pickup from local stations is reduced to a minimum as has been demonstrated in practice.



Circuit arrangement of the test outfit employed for making measurements on various types of R. F. transformers.

The Engineering Rise in Radio

By Donald McNicol

Fellow A.I.E.E., Fellow I.R.E., Past-President, Institute of Radio Engineers

PART V

King's Transmitter

As an instance of the attempts which were made in the period 1901-1905, to devise a system of producing electromagnetic waves for signaling purposes, other than the induction coil, arc, and alternating current transformer methods, the plan of James Foster King, of New York, is worth reviewing.

King's transmitter scheme was based on the knowledge that a condenser may be charged from a direct-current source. The method of conversion depended upon the steep rise in the potential difference between the separated ends of a previously closed exciting circuit including an inductance of large value to charge the closed oscillator circuit, the latter being independently connected between the source of excitation and the transmitting antenna.

Briefly, the system comprised an oscillator circuit including a condenser and a spark-gap. One terminal of the spark-gap was connected to the negative pole of a direct-current machine generator. The positive pole of the generator had in series a large inductance unit, the wire from the other side of the inductance extending to the armature of a relay device. The armature extension was equipped with a metal contactor which, as the relay was operated by means of a transmitting key, moved between the terminals of the spark-gap.

In 1904, commercial sources of direct current were much more numerous than sources of alternating current, and the King system might have had extended use if about that time the Poulsen arc, the alternator, and step-up transformer systems of transmission had not been in an advanced stage of development. Also, from the service viewpoint there was a natural disposition to regard the introduction of mechanical devices, such as the movable armature of the King system, as introducing sources of interruption which it was desirable to avoid.

Rochefort's Transmitter

It may be supposed that while unending efforts were being put forth to devise ways and means of producing electric waves without employing induction coils, often fitted with inefficient vibrators to interrupt the primary circuit, that partisans of the Ruhmkorff instrument were industrious in seeking means of improving the operation of that device.

In France, in 1900, Dr. Oudin, invented a bi-polar resonator, primarily for electrotherapeutic purposes, the principle of which was availed three years later by Professor Rochefort in designing a transmission system for wireless telegraphy. The Oudin apparatus was quite similar to the air-core high-frequency coils of Tesla, but as utilized by Rochefort a single air-core coil was energized by an oscillating circuit consisting of bridged spark-gap, series condensers and connection to the secondary terminals of an induction coil. The induction coil retained the advantage of a low voltage, direct current source of e.m.f. to actuate the primary. The single, air-core resonator coil was, in fact an antenna tuning inductance, arranged so that taps might be made along its length to obtain various transmitting frequencies.

The noteworthy feature in the early Rochefort assembly was the improved form of the induction coil employed. Previously, most induction coils were built with the iron wire core in a horizontal position, one reason for this being that as long as the magnetism of the core was employed to attract the armature of the make-and-break device, which interrupted the primary circuit, the armature could be mounted in a vertical position, or in such position that it would vibrate in a horizontal or vertical plane. With the use of independent circuit-breakers, such as the electrolytic type invented by Dr. Wehnelt in 1899, there was no need to attach a vibrator to the induction coil proper. The interrupter could be mounted separately. The Rochefort coil was of the vertical type, and the potential developed at the terminals of the secondary was unipolar. To achieve this end the secondary was formed of a double winding of wire, returning and reuniting at the pole from which it started. By this method of double winding the potential at the terminals was disymmetrical, and while the tension at the center of the coil was negligible, it was greatly accentuated at the terminals.

With the introduction of the other types of transmitters previously described, induction coils had almost disappeared in commercial wireless service by the year 1906, but they were to remain for another decade and a half a source of unalloyed inspiration for a host of amateur experimenters in all parts of the world.

Theories of Electric Wave Propagation

In order to pave the way toward an understanding of the improvements which were made in oscillators and spark-gap devices from the time of Marconi's 1896 disclosures until the introduction of tube oscillators nearly twenty years later, it is of advantage here to review the trend of thought bearing on the nature and theory of electric wave propagation.

The chronicler seeking to identify the exact state of knowledge of an art at a given period must needs extend his inquiry into the colleges, laboratories and workshops of all countries as of that time. Attacking the subject from an eminence of time a quarter of a century away, there is no way but to glean through the literature of the science as published in treatise or discussion form. The task is, of course, simplified somewhat by virtue of personal recollection and by files of note- and scrap-books containing chronological series of references, classified and dated.

At the International Electrical Congress, held in Paris, France, in the year 1900, a paper was presented by André Blondel and Gustave Ferrié, both of whom were closely identified with electric wave signaling from the beginning. The paper contained an intelligent and thorough review of the science as it was understood and practiced at that time.

For many years after Hertz; indeed, for a number of years following Marconi's early demonstrations, the phenomena experimented with were far from being understood in terms acceptable to all thinkers. The fact that at the present time (1928) several points remain to be cleared up, suggests that in 1900, convincing explanations were out of the question.

An interpretation which persisted for a time was that there existed a mutual induction between the separated elevated conductors employed, one at each station. But, the gradual increase in the distance over which operation was accomplished removed support from this thought. Also, the knowledge that communication could be set up between two stations far enough apart to be screened from each other by the curvature of the earth left the "induction" advocates without an argument.

A number of writers claimed that the effect was of an electrostatic nature, but these were left with little to stand on when it was observed that in this case the effect should diminish in inverse proportion as the cube of the distance, and quickly disappear as energy capable of actuating any known detecting device.

Following the marked gains in distance achieved by Marconi by grounding one terminal of transmitter and receiver in 1897, physicists were impressed with the idea that possibly there was a conductive action through the earth. But, here again there was confusion when signaling tests were carried out between a ground station and wireless equipment carried in the basket of a balloon.

When no agreement could be had as to the exact nature of the phenomena, it was a passable statement for a physicist, in 1900, to say that wave propagation was a combination of several effects, one or the other predominating, according to the existing conditions.

In the paper by Blondel and Ferrié, appeared the following rather clear picture of the general understanding of the nature of electric wave propagation. "Electric oscillations are produced along the wire and in the neighboring ether in the space between the antenna and the earth. From the seat of this disturbance originate the waves, which are propagated into surrounding space. These waves are polarized and form surfaces of revolution around the antenna. The lines of electric force are in meridional planes and connect perpendicularly with the earth: the magnetic lines of force are in circles having the antenna for a common axis. But as a result of this polarization and of the effect of concentration, well known in the propagation of waves along wires or metallic surfaces, the electric density is much greater at the surface of the earth, directly connected with the oscillator, than in the atmosphere; and in large part the magnetic lines appear to slip along the earth. This concentration, moreover, is the greater the more perfect the conductivity of the surface over which the waves proceed, and the loss of energy in this transmission is thereby lessened.

"Yet this concentration does not prevent the diffusion of an important part of the energy into all space in the form of hemispherical waves, the effects of which are less intense than those near the earth but, nevertheless, noticeable.

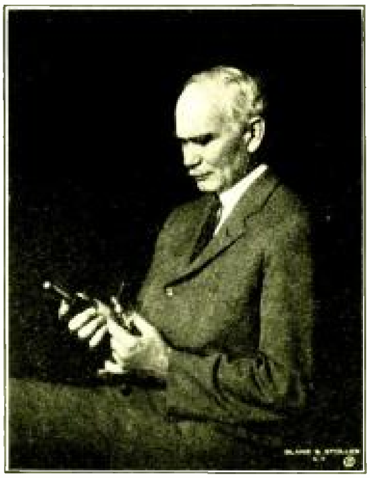
"The receiving wire cut at all points by the magnetic lines of force, is the seat of a resultant electromotive force proportional to the intensity of the field and to the rapidity of the oscillations.' The higher the antenna, the more lines of force are cut. With a given length fewer lines are cut as we ascend further from earth, but the range seems to be slightly extended, due to a conduction effect."

Further Progress in America; Lee deForest

In the year 1896, when the twenty-one-year-old Italian genius was demonstrating his first crude apparatus to the telegraph authorities in England, there was in America a twenty-three-year-old descendent of John Alden, who had a Ph. D. degree in view at Yale University. This young man, Lee deForest, was destined to play a very large part in the extension of radio signaling to utilitarian purposes. His most outstanding contribution to the art of electric communication was the invention of the three-electrode tube called the audion. The audion with all its wonder-working possibilities was born in 1905, and just how it was nursed into being shall be considered in another chapter. At this point there is opportunity to make reference to Dr. deForest's earlier contact with radio, beginning in 1899.

After graduation from Sheffield Scientific School, Yale, Dr. deForest was engaged in research work in the service of the Western Electric Company, but in 1900 entered into research, independently.

From what has been recorded herein relating to the introduction and growth of space telegraphy, it may be realized that in the year 1900, four years after the first faltering steps were taken, the art was in that formative stage which might properly be designated as its infancy. Dr. deForest, therefore, began his attack upon the problems involved at a time when few, if any, of these problems had been solved. Speculation, hypothesis, opinion, gesture and cut-and-try, were the agencies out of which fruition was to come.



DR. LEE DE FOREST

In his earliest work, in Chicago, Dr. deForest had associated with him Edwin H. Smythe, of the Western Electric Company, and Clarence E. Freeman, of the Armour Institute of Technology. What was perhaps the first description of the wireless telegraph instruments assembled by these experimenters appeared in the journal *Western Electrician*, Chicago, of July, 1901. This was less than two months after Marconi had taken out his first American patent.

The first noteworthy demonstration of the system outside of the laboratory was when signals were transmitted from a shore station, on Lake Michigan, to a station on a yacht five miles off shore.

In the summer of 1901, Dr. deForest came to New York and within a short time the deForest Wireless Telegraph Company, of New Jersey, was organized. As the purpose in this work is not to trace the financial fortunes of companies organized to promote wireless, but, what is more important, to trace the engineering rise of the science, reference is made to technical contributions which were the bricks and mortar with which was erected the great edifice, the radio of today.

CHAPTER 5

Antennas

RESUMING the narrative at a point where was discussed the difficulties incident to dependable transmission, it was natural that as the transmitting devices were studied with a view to increasing range and to bringing about selectivity, attention also should be given to antenna design and construction.

The gain in distance by employing an elevated vertical antenna, associated with an earth connection was so encouraging that from 1897, until 1899, this method of transmission prevailed. Thought then began to turn toward possible *directive*, if not *selective* advantages by employing antennas which were not vertical in all of their elements.

Attempts were made to set up directed waves by depending upon an anticipated interference of waves from two antennas located a half wavelength apart.[1]

In England, in 1899, J. Erskine Murray carried out some experiments with variations in antenna design, which perhaps would have anticipated results obtained by later workers had he been in a position to follow up the investigation. In 1900, Garcia noted a directive effect when the antenna was suspended in a horizontal, or an inclined position. Radiation took place through a small solid angle; direction of radiation being altered by changing the direction of the antenna.

In the year 1901, Dr. deForest proposed the use of an antenna system made up of a relatively short vertical arm, continuing in a horizontal section to a second vertical arm. In patents applied for by deForest on May 28, 1904, he described a method for determining direction of transmission. This contemplated the use of a grid of vertical wires, supported so that it might be rotated on its vertical axis. In a receiving installation the strongest signals were received when the plane of the grid of wires was at right angles to the direction from which the signals came.

deForest found that by employing a grid fifteen by six feet, as an antenna.

[1] S. G. Brown, British patent No. 14,449 (1899); John Stone Stone, U. S. Pat. 767,-970, Filed June (1901); J. S. Stone, U. S. Pat. 716,955, Filed January 23 (1901).

and rotating this until maximum strength of signal was observed it was possible, within certain limits, to determine the direction of transmission.

On this very important subject many bright minds were at work. Noteworthy proposals were made by A. Artom, in Italy; A. Blondel, in France; F. Braun, in Germany, G. W. Pickard and John Stone,[2] in America. To Artom, perhaps first, is due no little credit for stating the underlying principle of the direction-finder, widely used in marine work years later.

Early Work of Stone

John Stone Stone, in America, was in 1904 granted some forty patents, the specifications of which treated chiefly of resonant and co-resonant systems. The specifications did not disclose key inventions, but presented many combinations of open and closed circuit oscillators and resonators which brought within the realm of practicability much of the thought and experimentation of the previous four years bearing on directive signaling, selectivity and increase of distance.

At the International Electrical Congress, St Louis, Missouri, September, 1904, Mr. Stone presented an important paper on the subject, "The Theory of Wireless Telegraphy," which was one of the earliest American expositions of the science of radio signaling. In fact, this paper, with one presented a year later,[3] contained the most complete and intelligent mathematical treatment of the subject made available to American students and engineers.

As we are here dealing with the growth of ideas relating to wave transmission, reference should be made to Stone's proposal in 1904, to employ a radiating circuit extending from an earth connection through the secondary of an oscillation transformer, and by way of a short vertical lead, to a large metallic plate mounted parallel with the ground. It was pointed out that the metal plate should preferably be circular, and its diameter in measurement great compared with its distance from the ground.

The method was an elaboration of Lodge's proposal of seven years previously. It was, further, a refinement, because of the clearly worked out reasons for shape and dimensions of the metal plate, and distance above the earth at which it should be mounted. From the start, however, it was regarded as introducing mechanical troubles to employ elevated plates, and when it was learned that the same ends could be served by employing grids of wires, and to a much more satisfactory degree, the employment of elevated metal plates was not extensively availed of, nor long continued.

[2] U. S. patent No. 716,134 (1901).
[3] Read before the Electrical Section, *Canadian Society of Civil Engineers*, Montreal, Canada, March 9, 1905.

The Inverted "L" Antenna

In 1904, Dudell and Taylor, in England, made preliminary investigations into the properties of antennas designed to have relatively short vertical sections and long horizontal sections. This is the antenna commonly known as the inverted "L" type. From the published results of these tests it would appear that marked directive properties were not discovered.

A year later, Mr. Marconi, in a patent application, and in a Royal Society of Arts lecture, treated of the directional effects of the horizontal type antenna, both for transmitting and receiving purposes. At that time, and later, there was no end of controversy relative to the supposed directional properties of antennas of this type. T. L. Eckersley, in England, held

GREENLEAF W. PICKARD

to the view that the directive effect of an inverted "L" antenna "is of a very small amount", while J. A. Fleming stated that "any bent oscillator, however arranged, has no asymmetry of radiation for very large distances". Some years later, however, Professor Fleming related that such a directional antenna "is now generally employed in long distance, high power stations intended to communicate with corresponding distant stations," and that it radiates most strongly in its own plane and away from its open end.

In the 1895 specification Mr. Marconi stated that while antennas of this type are preferably grounded at one end only, "they may be attached to ground at their tail ends, or at other points and inductance and condensers may be inserted in these earth connections."

It is interesting here to note that the above paragraph was prophetic of the multiple-tuned antenna system of Alexanderson[4], in America, employed at large transoceanic stations of the Radio Corporation of America about fifteen years later.

With reference to this form of antenna, in later years Mr. C. S. Franklin[5], in England, stated that when "correctly adjusted as regards phase" such an antenna radiates most strongly in a direction at right angles to its length; which view differs from that originally held by Marconi and Fleming.

In his 1905 work, Marconi, as stated in his Royal Society lecture, referred to in the foregoing, had observed that the most advantageous length of the receiving horizontal wires, in order to obtain results at maximum distances, was about one-fifth of the length of the transmitted wave, if the wires were placed at a distance above the ground, but the receiving wires should be shorter if placed on the ground.

Mr. Marconi's reference to maximum effect when the horizontal antenna is one-fifth the length of the received waves is interesting in view of the work of H. H. Beverage, Chester W. Rice and E. W. Kellogg, in America, about sixteen years later, following which receiving antennas came into use for transoceanic, long wave (about 18,000 meters) service, which are nine miles long, of the order of a wavelength, the antenna line parallel to the direction of propagation of the signals to be received.

Following Marconi's original work, in 1905, on horizontal antennas, the subject was taken up in an analytical way in all countries.

Artom's Work

Continuing the subject along with a view to bringing to light improvements which contributed to advance in radio signaling or which set up a basis for subsequent investigations, it is important here to refer to the work of Artom.

From the inception of practical wireless telegraphy in 1895, Alessandro Artom, in Italy, devoted time to studies of the phenomena involved, his researches and experiments being carried out in the Royal Industrial Museum, at Turin.

His results were published in a paper communicated to the Royal Academy of Lincei, Italy, entitled "A New System of Wireless Telegraphy." This was in 1904.

It was Artom's notion that the principle of the rotating magnetic field which had sprung from optics might find a logical application in the corresponding phenomena produced by electric oscil-

[4] The multiple-tuned antenna is an arrangement for using a number of ground connections in parallel to secure a low ground resistance. In its general form it consists of a long flat top antenna having a number of downleads attached at approximately equal intervals along its length, each downlead being connected through a tuning inductance of suitable value for the wave length employed.
[5] Journal of the I. E. E., August, 1922.

tions such a class of circularly and elliptically-polarized rays of electric energy which (as previously suggested by Righi) must be present around a determinate direction as the properties of the electric and magnetic rotating fields.

Zehnder, in Germany,[6] ten years previously, had demonstrated certain characteristics of elliptically-polarized waves by employing two plane polarizing grids consisting of a number of parallel wires fastened to a frame, placing the grids parallel to each other a short distance apart, with their wires crossed.

When the two grids are mounted closely together they act as a wire gauze and will reflect polarized radiation, but when the crossing wires of the grid are an eighth of a wavelength apart and the plane of the incident radiation is at 45 degrees to the wires the reflected radiation will be circularly polarized. Further, a change in their positions will make it elliptical.

The production of circularly and elliptically-polarized waves by reflection from metallic grids, in 1894, was an interesting laboratory demonstration. That was six years after Hertz, but two years before Marconi.

When Artom revived the subject in 1903, he was provided with facilities by the Italian naval authorities for investigating the supposed properties of these waves, as to the disymmetry of the electromagnetic field produced. His method of producing circularly or elliptically-polarized waves considered in causing disruptive discharges between a plurality of discharge gaps arranged at the vertices of a triangle, the current supplied to the gap terminals differing in phase; the disruptive discharges differing also in direction due to the angular position of the gaps.

The advantage sought in this method was in sending out radiation from a transmitting station in a compact cone in, or about, a single direction, normal to the plane of the discharge terminals and to the plane of the antenna, both planes being parallel to each other.

Artom's tests of 1903, 1904, indicated that the system had definite advantages in the way of directive signaling.

Bellini and Tossi

Later, Artom's inventions were taken up by his compatriots Ettore Bellini and Alessandro Tossi, and carried forward to a stage of general practicability.

Bellini and Tossi developed an ingenious system of directive radio telegraphy which has had various special and useful applications. In the form patented in 1907[7], the antenna consisted of two equilateral triangles of wire, open a short distance at the top, and around a central vertical wire. At the middle point of the base of each triangle was connected in series the secondary winding of a transformer, the two secondaries mounted to form a rectangular cross. A single primary winding for both secondaries was mounted in a parallel plane, pivoted at its mid-point immediately below the crossed secondaries. In one arrangement the primary was in series with the spark-gap and the vertical wire of the antenna system, the other terminal of the spark-gap being earthed. There were variations of this, one of which is shown in Fig. 7.

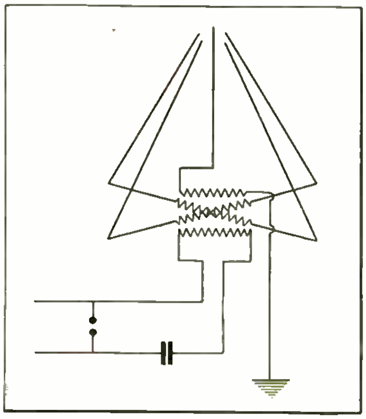


Fig. 7. One form of the Bellini-Tosi directive antenna.

To transmit in a desired direction the primary was rotated to point in that direction. The oscillations in the secondaries divided into components, according to the parallelogram law, the triangular elements of the antenna being excited accordingly and the maximum of radiation being in the direction in which the primary pointed.

For many years little was done in investigating Zehnder's and Artom's findings with reference to circularly and elliptically-polarized waves. Indeed it was not until the new and pressing problems of short-wave signaling were presented, or again presented, that Pickard and Alexanderson, in America, 1925, 1926, directed attention to the subject.

The Pickard "Cage"

Greenfield W. Pickard, as early as the year 1900, studied the vagaries of "static", and since that time has carried out many searching inquiries into the nature of the phenomena. In 1906, Pickard filed an application (U. S. patent 842,910) covering the invention of an aperiodic shield, or cage, to be erected around the operating antenna, and so designed as to permit the passage through it of signaling waves, but to shut out all or part of any static impulses arriving at the station. A similar arrangement was described in 1912, by M. Dieckmann, in Germany, and became known as the "Dieckmann cage."

Loop Antennas

It will be remembered that Hertz's original ring or loop antenna was employed in the earliest demonstrations of space signaling, the distances covered being very short. With the introduction of the earthed antenna in 1897, ungrounded loops were laid aside, not to be re-introduced in service until about 1916, when the needs of the Great War demanded direction indicating radio systems, and when there were available signal amplifying systems which made it possible to receive signals over distances of a few hundred miles without employing elaborate and extensive antenna structures.

In the attack on the problem of static elimination the possibilities of loop antennas occurred to the early workers soon after message service was attempted. Static effects in receiving telephones used by the telegraph operators resulted in false signals with consequent mutilation of the words transmitted. In 1905, Pickard worked out ideas covering the design of double-loop antennas, as covered by his patent application of September 3, 1907, No. 956,165. On June 10, 1907, he filed an application, No. 876,966, for a combination loop and open antenna, in principle the same as the Bellini-Tossi arrangement brought out a little later.

Various receiving antenna systems were in later years designed with a view to the elimination or mitigation of static disturbances.

The Counterpoise

A variation in station radiation systems which early engaged the thought of engineers working on these problems was that of substituting a counterpoise, or earth screen, for the ground contact introduced by Marconi in 1897. John Stone Stone, in America, Braun and Zenneck, in Germany, and others, developed the theory of the counterpoise.

The counterpoise consists of a large flat conducting surface placed horizontally immediately above the earth. It acts as the opposite of the antenna, and may consist of a system of suspended wires instead of a plate.

In 1903, 1904, the German school of thought, following the reasoning of Count Arco, was strongly inclined toward the employment of a suitable counterpoise instead of a positive earth connection. It is to be remembered that the elements which label the first wireless telegraph system as Marconian are the elevated antenna and the earth connection. One side of the oscillator gap was connected to an elevated antenna wire, while the opposite side of the gap was connected directly to earth. It was Count Arco's view[8] that it would be impossible to convert large amounts of energy into electric waves by directly earthing one side of the system. So far as the study had progressed at that time Arco pointed out that the capacity of the antenna was limited and an increase of energy could be had only by augmenting the charging current.

(To be continued)

[6] Berichte der Naturforschenden Gessellschaft, Freiburg, Sept. 2, June 21, 1894.
[7] U. S. Patents, 943,960 and 945,440.
[8] *Electrical World and Engineer*, New York, July 22, 1905, page 136.

The Mathematics of Radio

Relating to the Characteristics of Audio Amplifiers and Typical Characteristic Curves

By John F. Rider, Associate Editor

PART XI

IT is only natural after the conclusion of a discussion of audio-frequency systems and principles of audio-frequency amplification, to consider illustrating whatever results are being obtained with a system. As a matter of fact the illustration of the operating characteristics of an audio amplifier is very closely

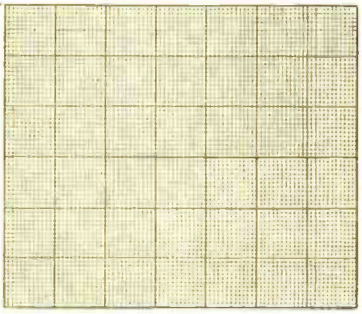


FIG. 61

Standard graph, with equal ordinate and abscissa scales.

allied with the voltage transfer between the tube and the load, as explained in the previous issue.

Every audio-frequency system is possessed of a certain operating characteristic, or response characteristic; falling or rising as we mentioned. A description of this response characteristic or curve is usually mentioned whenever an audio amplifier is discussed. This applies with equal facility to the transformer-coupled system, the tuned double-impedance system and the resistance-coupled system.

We observed during the discussion of the impedance relation between the tube and the load that the voltage transfer is not constant at all frequencies. We must arrange some means of expressing the response of the coupling unit at various frequencies, when it is used in an audio amplifier, by itself or with a tube feeding it. The expression of the operating characteristic of a single coupling unit, or a single stage or a complete amplifier, is the function of the response characteristic or curve.

Response characteristics of the audio system are usually of two types. One shows the variation in amplification with applied frequency, or the operating characteristic of the system with varying frequency, and the other shows the power transfer between the output tube and the load, whatever it may be, with varying frequency. At this time we will consider the former only.

Frequency and Voltage Amplification

It is evident that we have two quantities to consider, amplification and frequency. The amplification in an audio system is a regular arithmetical progression involving simple multiplication. For example, we have a two-stage transformer-coupled audio amplifier. For purpose of discussion we will assume perfect transformers, which will give us the full benefits of the turns ratio. If the input signal to the first audio tube, through the first audio-frequency transformer, is 3 volts and the turns ratio of the first audio-frequency transformer is three, and since the transformer is classed as perfect, the input to the transformer is apparently 1 volt. The tube has an amplification constant of 8, consequently the output voltage from the tube will be 8 x 3 or 24 volts. The turns ratio of the succeeding transformer is 2, hence the output voltage from the transformer will be 24 x 2 or 48 volts. If the amplification constant of the output tube is 8 (210 tube) the total voltage amplification available with the amplifier is 48 x 8 or 384. Several methods of expressing this voltage amplification are available, but we at this time will consider the simplest, i. e., the mention of voltage increase as relative amplification or the use of voltage figures.

A close study of the preceding paragraph will show that frequency was not considered when solving for the voltage amplifying power of the amplifier. Theoretically, the total

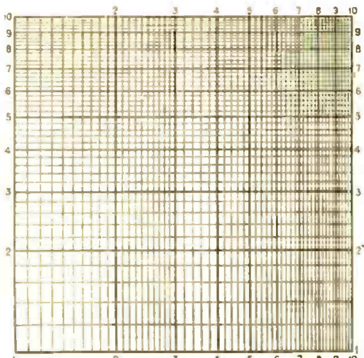


FIG. 62-A

Here the ordinate and abscissa are plotted along a logarithmic scale.

voltage increase from the input to the output is 384. In practice, however, this figure may be decreased or increased due to the variations of the coupling units and the voltage transfer between the tube and the load with applied frequency. We showed in the previous installment, that under certain conditions the voltage transfer between the tube and the

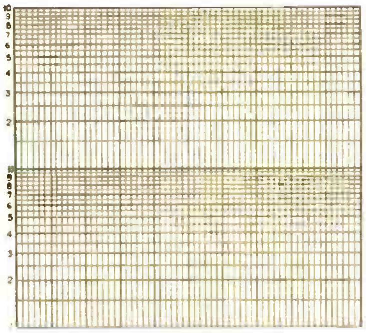


FIG. 62

Graph with squares plotted along a logarithmic scale.

load increased with frequency increase.

If the maximum voltage transfer is obtained at say 600 cycles and thereafter, the voltage transfer between the tube and the load at some or all frequencies less than 600 cycles will be some figure less than maximum. If the gain is less than maximum and the maximum is 8, the total gain of the amplifier at this frequency will be some value less than 384. Then we must consider the operating characteristic of the coupling unit when measured without the tube feed. It seldom passes all frequencies with equal facility. Perhaps it is resonant at some frequency, in which case transfer through the coupling unit at that frequency may be predominant. If it is a transformer, the gain in the unit will exceed the turns ratio. The same is true of the tuned double-impedance unit. If the coupling units functioned in a uniform manner on all frequencies and the impedance relation between the load (coupling units) and the tube were, such as to afford the full amplifying power of the tube, the theoretical amplification figure as determined for the entire amplifier or for one stage would be correct, and the response curve of the complete unit would be flat at the 384 volt level. We are also ignoring the effects of tube capacity, that is, the capacity between the grid and plate, and plate and filament. These capacities tend to by-pass some of the energy on the higher frequencies. It is difficult to figure their effects in a theoretical analysis, hence the response curve of an individual stage or the complete amplifier.

Characteristic Curves

When considering voltage amplification against frequency, the voltage amplification curve is plotted against the applied frequency. Here we find that the type of paper employed for the graph will materially effect the appearance of the curve, and will be deceptive to the eye. General engineering practice considers the ideal audio amplifier curve, as being a flat curve, a straight line from the lowest applied frequency to the highest applied frequency. It must be admitted, however, that in many instances the flat curve is not the best suited to fill a certain requirement. If the radio-frequency amplifier cuts or reduces the intensity of sidebands, particularly the higher audio frequencies, the audio amplifier should accentuate these frequencies. If the speaker is deficient on the lower audio register, as is the case with the majority of speakers, the audio amplifier should accentuate these frequencies. Under these circumstances, flat characteristic audio amplifiers are not the correct ones.

Improvements in radio-frequency amplifiers and loud speakers are being made daily, and the ideal audio-frequency amplifier may be considered

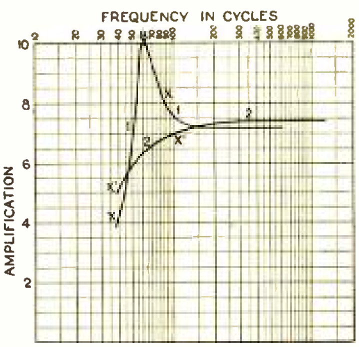
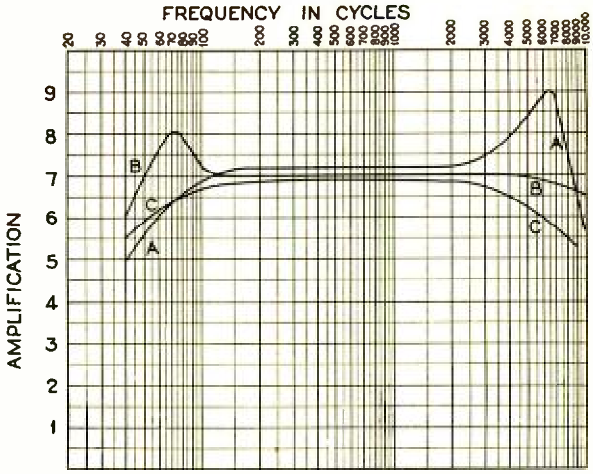


FIG. 64

Frequency response curves plotted on a combination square-logarithmic paper.

to be one with a flat characteristic. That this is correct is proved by the efforts of amplifier manufacturers to produce units with flat characteristics, that is, flat insofar as response is concerned and not as far as tone is concerned.

Now we reach the prime subject. The type of paper employed for the graph influences the appearance of the curve, although the voltage values are alike in all cases. The curve "appears" to be more flat when plotted in a certain manner, than when plotted in another. Three types of graph paper utilized for such curves are shown in Figs. 61, 62 and 62-A. Fig. 61 shows paper plotted with equal squares, that is the ordinate and the abscissa scales are equal squares. Fig. 62 shows paper plotted with squares and along a logarithmic scale. Fig. 62-A shows paper on which the ordinate and the abscissa are plotted on a logarithmic scale.



Frequency response curves of three types of audio amplifiers plotted on a combination square-logarithmic paper. The curves indicate the amplification at various audio frequencies.

FIG. 63

Logarithmic Scale

When plotting voltage amplification against frequency in audio-frequency work, and when the voltage amplification is expressed in volts and the frequency in cycles, only one type of paper is satisfactory. This is the one shown in Fig. 62. The voltage amplification designations being marked on the ordinate of the graph, on the uniform scale, and the frequency being marked on the abscissa of the graph, along the logarithmic scale. Plotting frequency on a logarithmic scale is based upon the fact that the musical scale or the keyboard is plotted on a logarithmic scale. If the frequency is plotted in octaves, a uniform scale may be used. This arrangement, however, is seldom followed and audio-frequency values are invariably shown on a logarithmic scale. In the event that the voltage amplification of a system is interpreted in "TUs" or transmission units, then a logarithmic scale is used for the ordinate as well as the abscissa, since the conversion of voltage amplification into TU values is along a logarithmic basis. Plotting voltage amplification in volts on a logarithmic scale gives a better appearance and might deceive the observer, unless he examined the voltage values quoted on the ordinate. The difference in appearance due to plotting on different scales will be discussed later.

Fig. 63 shows various response curves, (amplification against frequency) and illustrates the performance of audio frequency coupling units. Frequency is plotted on the abscissa of the graph and amplification on the ordinate line. Curve A is that of a transformer. Note how the response increases between 40 and 150 cycles, or if expressed in the reverse manner falls between 150 and 40 cycles. Note how it remains level from 150 to approximately 200 cycles and then rises to approximately 6,500 cycles, and the sharp drop thereafter. This curve is not given as an illustration of the performance of any one specific transformer, but merely as an illustration of coupling unit performance and audio-frequency response curve. The relative degree of voltage amplification is shown on the ordinate. This curve would be known as having a peak on the upper end of the scale.

Curve B illustrates a tuned double-impedance audio unit, with a peak on a low frequency, 75 cycles. It rises from 40 to 75 cycles, then falls at 110 cycles, remains level up to approximately 5,000 cycles and then falls gradually between 5,000 and 10,000 cycles. Curve C illustrates the performance of the average resistance coupled stage. It falls at both ends. The actual performance of these units when applied to receivers and when designed to fulfill a specific requirement will be different, being invariably improved.

With respect to the utility of the response curve of any audio coupling unit, it is essential and imperative that the curve show the performance of the unit in actual use, that is with its associated vacuum tubes and under operating conditions. A curve of a transformer, a tuned double-impedance unit, or a resistance coupling unit when used with the testing device only, and not in actual practice, with the correct vacuum tube or tubes and correct plate voltages, is useless. It means nothing, since the performance will change in actual practice. Regeneration in the system will influence its operation to a very marked degree. The plate resistance of the tube or the resistance simulating the associated tube output resistance will affect the operation of the coupling unit. If it is a transformer, the load applied will display an effect. Considering all of the above, response curves are without significance unless made actual operating conditions.

Plotting Curves

Now we arrive at the subject of plotting curves. The probability of deceptive appearance is most likely at the low end of the scale, since the variation in the curve is most pronounced. In Fig. 64 are shown two curves; the curves for frequencies between 40 and 100 cycles. Curve No. 1 is highly peaked at 60 cycles. Curve No. 2 has a gradual slope between 40 and 100 cycles. The curve No. 1 shows a value of 4 volts at 40 cycles and a value of 10 volts at 60 cycles, falling to a value of 7.5 volts at 100 cycles. Curve No. 2 shows a value of 5 volts at 40 cycles and 7 volts at 100 cycles. These curves are plotted on combination square-logarithmic paper, the voltage being designated on the uniform scale.

Now suppose we transpose the voltage designations from a uniform scale, as in Fig. 64, to a logarithmic scale as in Fig. 65. Here we see two sets of figures on the ordinate. The large figures show the apportionment on a uniform scale and the small figures show the same voltage values designated on a logarithmic scale. The curves shown are those illustrated in Fig. 64. Curves 4 and 3 in Fig. 65 are identical to curves 1 and 2 in Fig. 64. The difference in shape is due to a wider frequency scale. Now compare curves 1 and 4 and 2 and 3 in Fig. 65. The same curves are plotted differently insofar as the scale for the voltage designations is concerned. Curves 3 and 4 are plotted on a uniform scale, whereas curves 1 and 2 are plotted on a logarithmic scale. Bear in mind that the voltage designations are the same in both cases. The only difference is the scale. Note the apparent improvement of curve 1 over curve 4. Note how much steeper the latter *appears* to be. The same is true of curve 3 in comparison with curve 2, the erroneous impression cast when voltage, in terms of volts or voltage amplification expressed in relative amplification is plotted on a logarithmic scale, is very obvious.

There is no reason for plotting the voltage amplifying characteristics of an audio amplifier or a coupling unit, when expressed in volts, on a logarithmic scale. Doubling the voltage input into a vacuum tube voltage amplifier will not square the voltage output. The voltage output follows in proportion with the input. Hence the voltage curve of an amplifier should be plotted on a similar scale.

Voltage and Power Amplification

Power output, however, should be plotted on a logarithmic scale, since the power output of a vacuum tube is proportional to the square of the input voltage. In other words if, when a tube is used as a power amplifier (the output tube in every audio amplifier) and the tube is rated at 2 watts output with an input potential of 40 volts, and the input voltage is 20 volts, the output power is ½ of one watt. Since the output power is proportional to the square, it is plotted on a logarithmic scale. We have for example

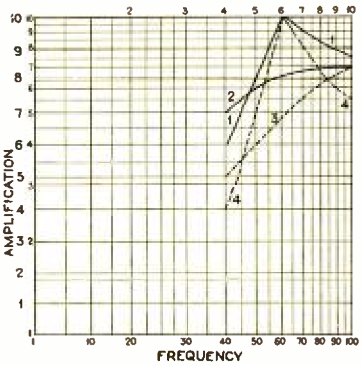


FIG. 65

Comparison of frequency response curves of Fig. 64 of actual equality plotted on square and logarithmic scales.

in Fig. 66 an audio amplifier, of which VT3 is the output tube. The plate voltage is fed through a choke and the speaker at LS is the load upon the tube. This load is usually represented as a resistance. In contrast to the requirements for voltage amplification, that is, the impedance relation requirements, maximum undistorted power is obtained when the load impedance is equal to twice the tube output impedance. Once again we find that the load impedance as represented by the speaker is not constant in value but rather varies with frequency, since the speaker unit utilizes an inductive winding. This is particularly true with the horn and cone type of speakers. The introduction of the dynamic type of speaker has altered the situation somewhat, by virtue of the design of the unit. Effort has been made to produce a speaker which will offer a constant load impedance at all frequencies.

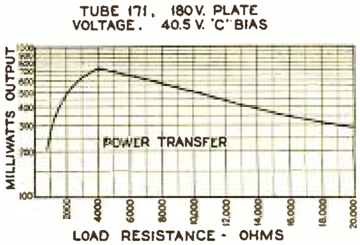


FIG. 67

A curve indicating the power output of a 171-type tube at various values of load resistance. Power output is plotted on a logarithmic scale.

Since the maximum undistorted power output is obtained when the load impedance is equal to twice the tube output impedance, any change in this impedance relation will cause a corresponding change in power transfer between the tube and the load. Fig. 67 shows the power output of a 171 tube, with 180 volts plate voltage and 40.5 volts "C" bias with various values of load impedance. Note how rapidly the power output falls when the impedance of the load is less than the requirement. Note how an increase above the required load impedance causes a gradual decrease in power output. And last, but not the least, note that the power output in milliwatts is plotted on a logarithmic scale. The approximate tube output impedance is 2200 ohms.

Input Voltage and Power Tube

Referring again to the operating properties of power amplifier and power tubes, we must stress the fact that the input voltage is of great importance. Many amplifiers are equipped with the 250 type of tube, purely on the basis of increased power output rating. But the anticipated power output is not obtained because the required input signal voltage is not available. Hence the selection of an output power tube should be based upon the possibility of obtaining sufficient input signal voltage to satisfactorily operate the tube.

With respect to the output power tube and the load impedance, and when considering the impedance characteristics of the average cone and horn type of speaker, we cannot help but recognize the effect upon tone: that is, the effect upon the power transfer on various frequencies. Since the speaker unit winding is inductive, its impedance decreases with frequency and increases with each increase in frequency. Assuming a certain tube and a certain load at a certain frequency, as represented by the speaker impedance at that frequency, we immediately see the need for a low output impedance power tube, and for a high load impedance at the lowest frequency.

(To be continued)

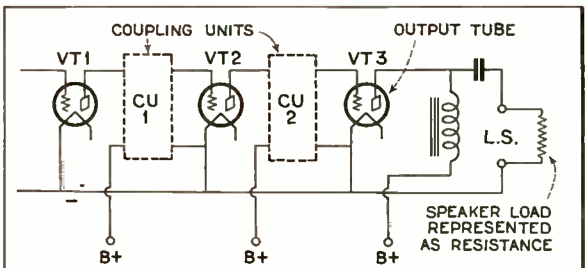


FIG. 66

A double impedance audio amplifier circuit with a power tube in the output working into a speaker load represented as a resistance.

A Low Power Airplane Transmitter

Design of a Dry Cell Operated Short-Wave Transmitter Particularly Adaptable for Use on Airplanes

By W. H. Hoffman, D. H. Mix and F. H. Schnell*

LOW power radio transmitters operated from dry cell batteries, at wavelengths below 100 meters, have been proven reliable for communication over distances of a few hundred miles either day or night.

The present low power transmitter was designed for short wave use where there is need for light and compact apparatus that will operate under severe conditions such as are found in airplanes, motor boats or automobiles, and where dry cell batteries are a most satisfactory form of power supply.

Two receiving type UX-201A or CX-301A tubes with associated apparatus are enclosed in a stiff aluminum case, which measures 8½ inches long, 6½ inches high and 4 inches deep. This case is arranged in a manner that allows the top and back to fold back when two suit case snap catches are released, one at each side. From the lower back corners, where the two sections of the case are hinged together, the case opens diagonally upward to the front top corners and across the top. When the case is open all apparatus is readily accessible from the top, the back or the upper halves of the sides. The weight of the unit including tubes, is 4 pounds and 12 ounces. A small eye bolt is provided in each corner of the case in order that the unit may be mounted by shock absorbing cord or springs.

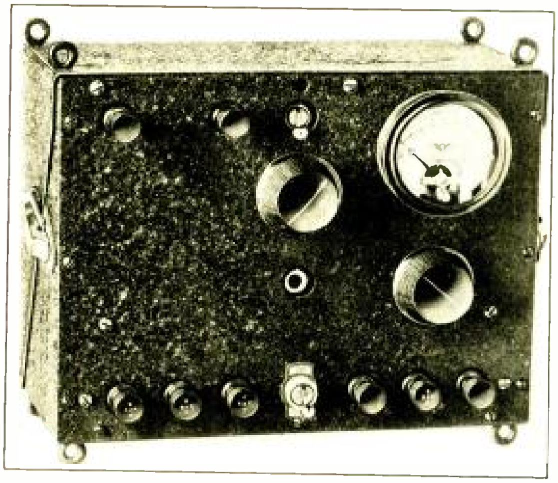
The Circuit

Although two tubes are used, only one tube delivers its energy into the transmitting antenna system. The output tube which works as a radio frequency amplifier is connected in a balanced bridge circuit and carefully adjusted so that there cannot be any appreciable coupling from the antenna circuit to the other tube which is arranged to work as an oscillator or radio frequency generator.

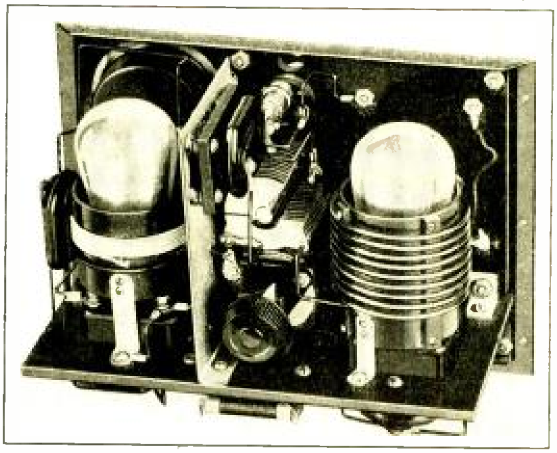
This transmitter arrangement, commonly known as a Master-Oscillator Power-Amplifier, has long been recognized as a superior form of stable transmitter. When the oscillator is supplied with power from a constant D. C. source, such as can be obtained from dry cell batteries, and the amplifier is properly balanced, an arrangement is obtained that has remarkable stability.

The unit is primarily a telegraph transmitter and delivers about 4 watts when 350 volts are connected to the amplifier tube, and 180 volts supplied to the oscillator. Voice transmission is also provided for in a manner making it effective over short distances.

In the top middle portion of the front panel there is a small peep hole behind which a 2.3 volt flashlight lamp is mounted and connected in the antenna circuit for indicating resonance. Under this hole there is mounted a toggleswitch for shorting the lamp out after tuning adjustments are made. Below this switch is a knob for adjusting the series antenna condenser. The two binding posts at the upper left hand side are for antenna and counterpoise connections. Filament voltmeter and a knob for filament rheostat adjustment are provided at the right side of the panel.



The complete high-frequency transmitter, showing the rings at each corner for spring suspension. By the use of springs practically all vibration of the transmitter is eliminated.



The oscillator tube is on the left and the amplifier on the right. The tubes are mounted within the inductances to conserve space. The single turn of black wire, (under the 6-turn coil) is for voice modulation.

* *In consultation, Burgess Battery Co.*

These are essential when receiving type tubes are operated with high values of potential in their plate circuits.

A jack, central in the panel, is arranged for plugging in a microphone when voice transmission is desired. Binding posts for battery and key connections together with a filament switch are arranged across the bottom.

Within the case, a sub-panel of hard rubber behind the front panel mounts the apparatus. The oscillator inductance and the amplifier plate to antenna transformer are mounted in vertical positions, over the tube sockets at either side of the unit in such a manner that the inductances surround the tubes when they are in place.

An aluminum sheet forming a shield is mounted between the coils of the two tube circuits.

The amplifier balancing condenser is mounted below the antenna tuning condenser and can only be adjusted by opening the case. Fixed tuning and by-pass condensers and grid leak resistances are mounted in positions best suited for convenience in connecting and for keeping connecting leads short.

By removing the 9 screws from the edges of the front panel, the entire apparatus may be removed from the case as a unit.

Details of connections are shown in the circuit diagram. The antenna circuit runs from the antenna terminal to the antenna coil, which also is the secondary of the amplifier plate transformer, then to the antenna series capacity, which is made up of a fixed and a variable condenser in parallel. From the condensers the circuit continues through the indicating lamp which is shunted by a switch, to the counterpoise or ground terminal.

The amplifier tube feeds its energy to the antenna circuit through the plate transformer which is untuned. Such a transformer will transfer efficiently over quite a band of wavelengths, if the secondary turns are made adjustable so that the impedances of the tube plate and the antenna circuits can be matched. A characteristic curve of such a transformer is shown in Fig. 1.

The oscillator tube is connected in a modified Colpitts circuit (Described in patent No. 1,585,244, of May 18, 1926, by W. H. Hoffman) and the value of the capacities and inductances making up the tuned circuit are fixed.

Energy from the grid side of the oscillator circuit is fed through a fixed condenser to the grid of the amplifier tube. A grid leak from the amplifier grid to the filament circuit furnishes the required negative bias.

A connection from the plate side of the oscillator circuit through a small variable condenser to the plate of the amplifier makes it possible to balance or neutralize the amplifier preventing self oscillation and reducing coupling between the oscillator and antenna circuits to a very small value.

A single turn of wire, in close inductive relation to the oscillator inductance, is connected to the terminals of a jack. By plugging an ordinary telephone type microphone into the jack, short range voice transmission is made possible.

For plate power supply for operation from an airplane, eight "B" batteries inclosed in a wooden case 13¾ x 9¼ x 7 inches have been used, furnishing a maximum of 360 volts. A 180 volt tap is brought out for the oscillator.

A similar case 11 x 7½ x 6 inches houses eight dry-cell "A" batteries for filament supply.

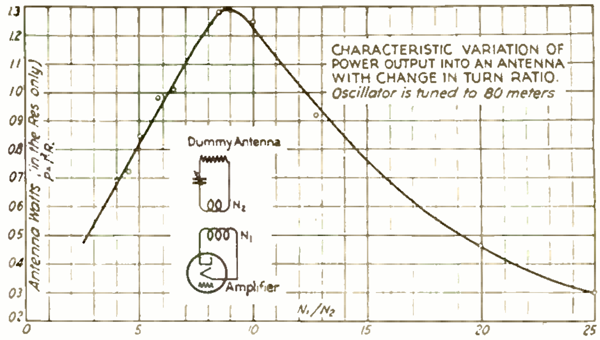
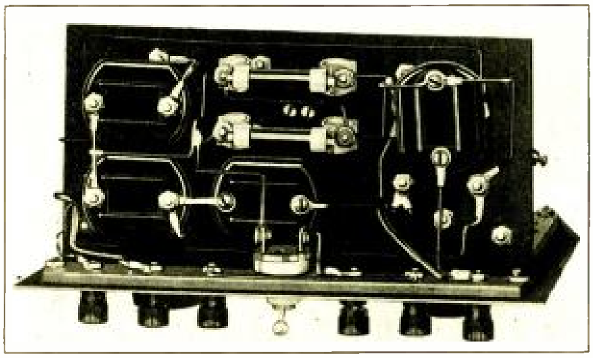
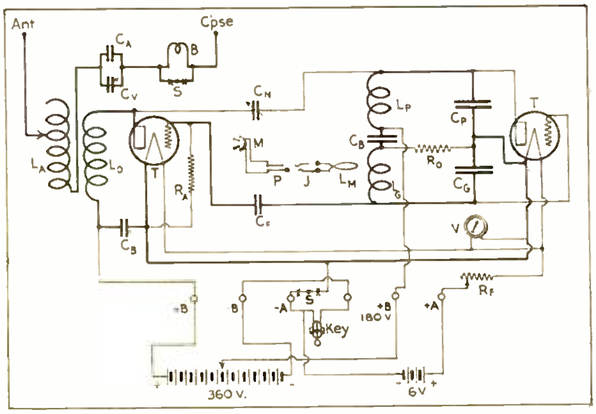


Fig. 1. The plate transformer N is untuned and will transfer efficiently over a wide wave band if the secondary turns are made adjustable so that the impedance of the tube plate and the antenna circuits can be matched.



On the right is the bottom view of the transmitter, showing how the condensers and resistors are arranged.



The schematic diagram of the transmitter, which can be used for either telegraphy or telephony. See legend at right for values of components.

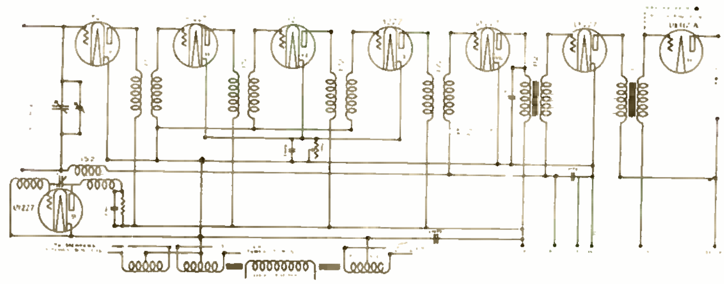
Legend

B........Flashlight lamp, 2.3 volt.
Ca & Cf..Fixed mica condenser, 0.0001 mfd.
Cb.......Fixed mica condenser, 0.005 mfd.
Cv.......Variable air condenser, 135 mmf.
Cn.......Variable air condenser, 15 mmf.
Cg & Cp..Fixed mica condensers.
For 80 meters—0.0005 mfd. each.
For 40 meters—0.00025 mfd. each.
J........Single circuit jack.
Lg & Lp..Oscillator inductance coils, No. 16 DCC wire wound on 2 inch tubing.
For 80 meters—5¼ turns each.
For 40 meters—3½ turns each.
Lo.......Amplifier plate coil, wound on 2-inch tubing.
For 80 meters—35 turns No. 22 DSC wire.
For 40 meters—15 turns No. 28 DSC wire.
La.......Antenna inductance, 9 turns No 12 bare copper wire, wound over Lo and spaced 1-16 inch from it. Turns spaced 3-16 inch.
Lm.......Voice modulation loop, 1 turn No. 28 DSC wire, wound ¼ inch from grid end of oscillator inductance.
M........Hand microphone.
P........Phone plug.
Ra.......Resistance unit, 10,000 ohms.
Ro.......Resistance unit, 20,000 ohms.
S........Toggle switch.
V........2-inch voltmeter, 0 to 8 volts.
T........CX 301A or UX-201A tubes.

The 1929 Victoreen "A. C." Receiver

By E. A. Bensen

THE Victoreen 1929 A. C. receiver has been designed only after exhaustive research into A. C. requirements for super heterodyne use. It renders a most natural reproduction with clear cut definition of both the spoken word and musical note. Compact in assembly and free from frills, this hookup has a most pleasing appearance and simplified panel layout, and contains no "bugs" prevalent to this type of receiver. It incorporates every feature for quality reception and reduces the number of panel controls to a minimum, consistent with practical operation. Its assembly is simplicity itself and the results meet the requirements of the most exacting radio critic.


Fundamental schematic diagram of the Victoreen "A.C." Receiver which uses heater type tubes throughout, with the exception of the second audio tube. Arrangements are provided for plugging a phonograph pickup into the grid circuit of the detector tube.

The following marked improvements have been made in 1929 Victoreen circuit:

(1.) An improved method of detection.

(2.) An unusual and smooth volume control.

(3.) A special oscillator eliminating objectionable repeat points.

(4.) A simplified circuit making assembly still easier.

(5.) A special fixed adjustment in the oscillator to simplify tuning.

(6.) A redesigned and new type R. F. transformer providing greater selectivity and sensitivity.

(7.) A sharpened loop circuit without using regeneration.

(8.) There is no hum, therefore, no hum adjustments.

(9.) Variable adjustments have been reduced in number.

The R. F. Transformers

The Victoreen 172 R. F. transformers are designed on the same principle as the old No. 170 type, which proved their worth over a period of years. Each unit contains a variable condenser, and is tuned and sealed at the factory to a standard frequency of 90 kilocycles; thus any four transformers may be used together without the necessity of matching in sets of four. A second adjustment is made at the factory, by means of which, the gain per stage is closely controlled, so that the tendency to oscillate is regulated to a point at which it acts to increase the selectivity, by virtue of the negative resistance thus obtained. It is not necessary to place these transformers at an angle, as the gain per stage is regulated so that maximum efficiency is obtained when the coils are aligned in a straight position.

The Oscillator

This unit is responsible for the elimination of many of the so-called harmonics usually found in superheterodyne circuits. This unit is radically new in design and contains an adjustment made at the factory, whereby each oscillator is tuned to cover a definite frequency range. This special feature makes the oscillator and antenna circuits tune together throughout the broadcast range, although the circuits naturally operate at different frequencies; thus practically no compensation is required. In order to overcome the troublesome harmonics, it is essential that a resistor be incorporated as shown, as the oscillator requires an extremely low plate voltage.

Plate Rectification

This system is used in the 1929 Victoreen A. C. receiver and, in a measure, is responsible for the unusual quality obtained from this circuit.

90 Volt Intermediates

The new Victoreen 172 R. F. transformers are designed to operate in this circuit with 90 volts plate potential and several advantages are thereby gained.

First, the use of 90 volts on the first *six* tubes permits the same grid voltage to be applied to the detectors as is applied to the first audio which operates from 180 volts; thus simplifying the circuit.

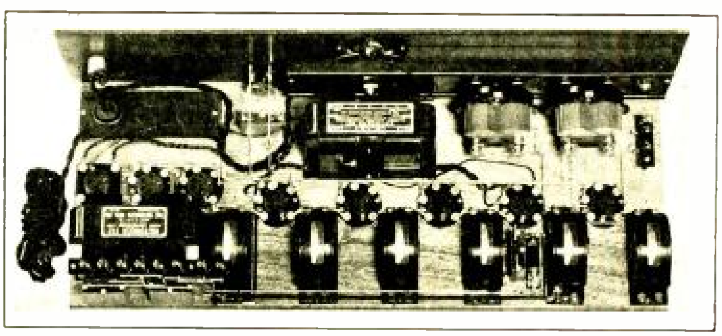
Second, it permits the use of a 90 volt, voltage regulator tube, which assures a constant potential and eliminates reaction from the audio circuits.

The balance of Victoreen parts are well known to radio fans. The 112 audio transformer unit is used in this circuit, as its performance has already made it outstanding for audio amplification. It combines the first and second stage transformers in one case to insure the proper location and combination of these transformers. It is designed to handle high plate potentials up to 500 volts.

The Victoreen 327 filament transformer is designed to supply the standard A. C. tubes slightly below their rated voltage. This transformer is standard for 50 to 60 cycle use only and is normally furnished for 108 to 112 volts. This unit contains two separate 2½ volt windings and one 5 volt winding, all of which are center tapped. This unit is designed to supply up to five UY-227 tubes from each 2½ volt secondary and two UX-112A or one UX 210 tube from the five volt secondary. A pair of leads are brought out from the 5 volt secondary for lighting the dial lamp. This unit is especially designed to furnish low voltage on the 2½ volt secondary winding as a precaution for the life of the UY-227 tube. This transformer comes equipped with leads all attached to facilitate ease in placement and wiring. The placement of the transformer in its particular location on the baseboard assures efficiency.

The old style 326 filament transformer may be used in place of the 327 transformer by connecting all of the UY-227 tube heaters in parallel, although the No. 326 unit is not recommended in the 1929 circuit.

The Victoreen 333 Switch and Plug Unit is of unusual design. It eliminates the necessity of any A. C. wiring connections, by providing three receptacles in which the power leads for the "A," "B" and "C" connections may be plugged. This unit


Interior view of the 1929 Victoreen "A.C." Receiver. The I.F. transformers and the audio coupler unit are mounted along the rear of the sub-base. The power transformer is mounted just to the rear of the panel.

comes equipped with a 110 volt switch permanently connected and with leads of proper length for correct placement. An extension is also furnished with 6 feet of cord permanently connected to the plug unit. This unit is placed in the set and permits all the A. C. devices to be operated by the panel switch.

Tube Requirements

The UY-227 tubes have been selected because of their greater stability in operation. Their use eliminates variation in volume with line voltage, while at the same time reducing the hum to an imperceptible value. A point of interest in this circuit is the placing of the cathode potential at zero, rather than at 45 volts, as is the usual practice; thus tending to give longer life to the tubes.

Volume Control

An unusual method of volume control is incorporated in the Victoreen 1929 A. C. circuit which employs a resistor in the common plate return of the intermediates. This variable resistor not only acts to decrease the plate potential but also places a high negative on the grids of the intermediate tubes, resulting in an extremely smooth and unusual volume control.

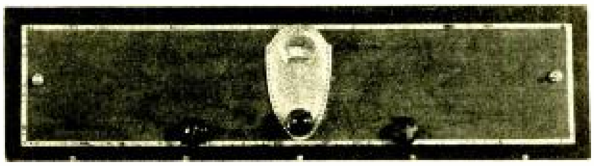
Whereas most volume controls are apt to change the tuning due to a change in voltage relations in the different circuits, the volume control in this circuit does not change the tuning at all. Therefore, it is unnecessary to readjust the dial when the volume is changed.

Voltage Requirements

In order to reduce the so-called harmonics it has been necessary to make some of the foregoing changes in the circuits, which in turn necessitates different "B" voltage requirements and it is essential that the following specifications be strictly followed.

The first audio must have 180 volts of "B" voltage and the detector 90 volts of "B" voltage, in order that the same "C" voltage be applied to both the first audio and the detectors. This is really an advantage as the "C" voltage may be found quite critical to within 1½ volts. Therefore, when the "C" voltage is once adjusted, the audio is sure to have the right value, which is automatically determined by the requirements of the detectors. Thus, there is but one "C" voltage on the set which needs to be questioned, and this voltage is easily determined; its value being approximately 10½ volts.

Front panel view of the single tuning control Victoreen "A.C." Receiver.



Phonograph Pickup

Phonograph pickups give excellent results when used with the audio channel of the 1929 circuits. It is important to note, however, that the pickup *cannot* be plugged into the detector socket, but must be placed in series with the grid return of the second detector. This method is shown in detail on the schematic diagram and may be added to the receiver by means of a jack switch, or plug and closed circuit jack conveniently located. The 6 volt battery may be a small "C" battery as no current is required therefrom.

Adjusting the Loop Circuit

The Victoreen No. 152 Oscillator is adjusted at the factory, so that there is but little difference in condenser settings for given stations. The small compensating condenser has been added to compensate for different types of loops, and the capacity of this small condenser has been chosen, of such value, that the rotor plates are not quite half into the stator plates when in operation under normal conditions. Therefore, the number of turns on the loop should be so adjusted that the condenser is in this position. If the small condenser plates give maximum signal strength with the condenser plates entirely open, one or two turns should be removed from the loop and vice versa. This may be accomplished by making a bare spot in each of the last two or three turns on the loop, using a clip to determine the proper number. Before attempting this, however, be sure that both variable condensers are operating in exactly the same position.

Tuning the Receiver

Tune in a local station in order that the approximate position of the compensator and volume control can be determined. The tuning is sufficiently critical so that quality will not be obtained unless both the dial and compensator are adjusted to the center of the maximum volume point. The volume may now be reduced to its desired value by means of the right hand knob on the panel.

When tuning for distant stations, tuning is accomplished in a somewhat different manner. The volume control is first increased until the usual rushing sound is heard, indicating that the receiver is increasing in sensitivity. Next, adjust the compensator to its maximum volume point. The tuning dial is then very slowly revolved until a station is heard. The compensator is then tested again and the volume increased by the volume control.

Loop and Aerial

Either loop or aerial may be used on this set. To use the antenna it is merely necessary to remove the loop leads and connect the antenna coupler secondary to the loop posts.

LIST OF PARTS REQUIRED

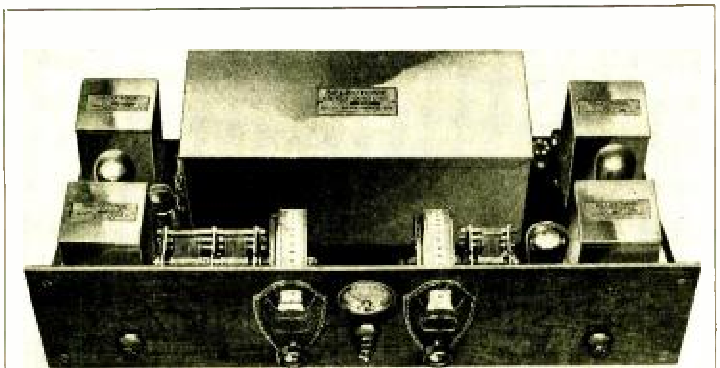
1—Cabinet for 7"x26" panel, 10" deep
1—Lignole front panel 7"x26"x$\frac{3}{16}$"
1—Binding post strip ⅝"x6½"x$\frac{3}{16}$"
1—Binding post strip ⅝x2¼"x$\frac{3}{16}$"
1—Wood baseboard 10"x25"x½"
4—Victoreen No. 172 R. F. transformers
1—Victoreen No. 152 Oscillator
1—Victoreen No. 162 Antenna coupler
1—Victoreen No. 112 audio transformer unit
1—Victoreen No. 327 filament transformer unit
1—Victoreen No. 333 Switch and Plug Unit
1—Victoreen 1929 single dial control
1—Electrad 25,000 ohm Royalty variable resistor
1—Lavite 25,000 ohm fixed resistor (not grid leak type) (3 watts)
7—Benjamin UY type tube sockets
1—Benjamin UX type tube socket
4—1 mfd. Tobe small by-pass condensers
1—.002 mfd. fixed condenser
1—Precise 100 mmf. Microdenser
10—Eby binding posts (marked as per diagram)
36 ft.—No. 14 square tinned bus bar
50—Solder lugs
Kester Rosin Core Solder. Quantity of necessary small round head brass wood screws.

The "Scott World's Record Shield Grid Nine"

By Harold Newmann

THE already well-known "Scott World's Record" receiver bids fair to increase substantially in popularity now that the fundamental circuit has been engineered to accommodate the screen-grid tube.

The advantages of the screen-grid tube have been fairly well broadcast by this time and the average experimenter is acquainted with its electrical characteristics. He has learned, for one thing, that the *inherent* amplification factor of the screen-grid tube is tremendous, when compared to the 201-A type tube, but that this high degree of amplification cannot be realized under practical conditions.



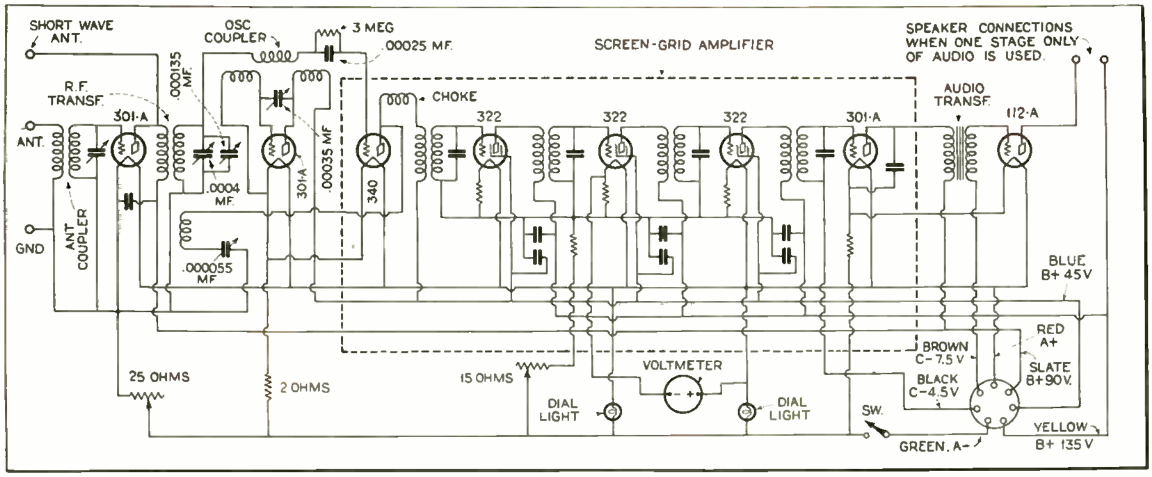
View of the "Scott World's Record Shield Grid Nine." The I.F. coupling units and the screen-grid tubes are enclosed in the large metal shield. The R.F. transformer and oscillator coil are also shielded.

Screen-Grid Circuits

The first "screen-grid circuits" developed were very inefficient in their handling of the potential mu of the screen-grid tube and futhermore, average selectivity was not available. Engineers have since learned a great deal about the tube and circuit design has consequently been handled more intelligently.

Experience with the screen-grid tube has brought out a number of salient points, some of which cast a new light on super heterodyne circuit design. With this tube it is possible to effect a greater gain per stage of intermediate-frequency amplification than can be had, under similar conditions, per stage of radio frequency amplification, tuned or otherwise. The practical limit of amplification, however, is governed by selectivity requirements which introduce difficulties, if the coupling mediums are poorly designed. The coupling medium that offers the greatest gain per stage is, unfortunately, inefficient from the standpoint of selectivity. We refer to the pure impedance load. Transformer coupling has provided for a greater degree of selectivity, but until very recent changes in design have not shown substantial efficiency in relation to voltage amplification.

It is at this point we arrive at the heart of the "Scott Shield Grid Nine": the intermediate frequency coupling units are engineered to the extent that a relatively high degree of gain per stage is obtained together with selectivity ample for all conditions *in a highly sensitive receiver.*



Schematic diagram of the "Scott World's Record Shield Grid Nine." Note that the first detector is preceded by a stage of tuned R.F. amplification. The first detector is regenerative. Plate rectification is employed in the second detector.

I. F. Coupling Units

The intermediate-frequency coupling units are so designed that a high load impedance is introduced into the plate circuits of the screen-grid tubes, the first requisite. The load impedance is coupled to another inductance which is a portion of a resonant circuit, being shunted by a capacity. By introducing the correct amount of coupling between the two inductances and by virtue of the capacity across the secondary inductance it is possible to obtain a high state of resonance, producing a curve sufficiently broad to prevent the cutting of sidebands and yet narrow enough to provide the necessary selectivity. Theoretically, both inductances have their individual resonance peaks, which under ordinary conditions are widely separated. They are made to merge, so as to form a resonance curve partially rectangular, by taking advantage of the mutual inductance effect common to the coupled coils.

The coupling units, which are to enter into one set, are matched together in an oscillatory circuit, which indicates the exact frequency band at which each unit peaks. The peaks can be moved one way or the other by an adjustment of the capacity shunting the secondary inductance.

General Description

Referring to the schematic diagram, it will be seen that there are eight tubes in the receiver proper. The first tube functions as a radio-frequency amplifier, in a tuned circuit. The second tube is the oscillator and the third the first detector. It will be noted that the first detector tube is of the 340 type (high mu) and is regenerative. Regeneration is controlled by a throttle condenser connected in series with the tickler coil, which is inductively coupled to the secondary of the R. F. transformer.

Three screen-grid tubes follow the first detector and these are the high-gain intermediate-frequency amplifiers of which we have spoken. The plate and screen-grid of each tube is by-passed to the filament circuit by fixed condensers. These condensers tend to isolate each intermediate stage and are instrumental in preventing feedback due to common coupling of the stages through the source of "B" supply.

The seventh tube is the second detector and it will be noted that plate rectification is employed, the grid of the tube carrying a negative bias from a 4½-volt "C" battery. The tremendous amount of amplification in the intermediate stages produces an extensive voltage swing on the grid of the second detector. This would overload the tube if grid-leak detection were employed. Plate rectification is less susceptable to overloading and consequently there is no appreciable distortion.

The eighth tube is in the first audio stage and is the 112-A type with a one-quarter ampere filament. Ample volume for a small room can be had from the output of this tube, but for real results a power amplifier should be used. The ninth tube of the "Scott World's Record Shield Grid Nine" is the power tube and is not included in the accompanying diagram. The power stage is built into the power-supply unit designed for this receiver. It will be described in the forthcoming issue of Radio Engineering.

Short Wave Reception

The "Shield Grid Nine" is also adaptable to the reception of short waves, as low as 30 meters. This is made possible by the use of plug-in coils, which are readily interchangeable. The complete shielding of the coupling units in the receiver makes the reception of short waves a practical matter.

A Universal "B" Eliminator

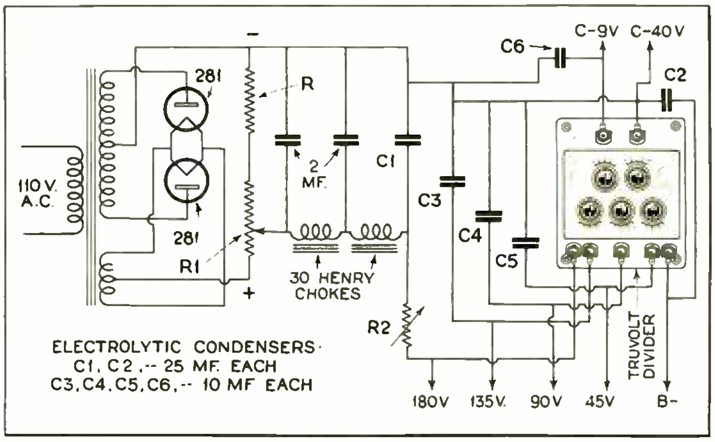
By F. Read

A "B" battery eliminator of special design incorporating several new features insofar as voltage control and regulation is concerned, is shown herewith.

The eliminator is of interest. First it utilizes electrolytic condensers which, when operated within certain limits, will not be irreparably injured. That is to say a puncture due to a sudden surge does not permanently ruin the condenser. Second, the system utilizes a voltage divider across the rectifying system output, whereby the voltage delivered to the filter system can be controlled and maintained within limits which will permit the use of lower rated filter condensers. Third, the "B" eliminator utilizes a final voltage divider system which does not require any calculation.

This Truvolt voltage divider consists of a series of resistances arranged with 5 variable taps affording two values of "C" bias between 0 and 40 volts and 3 variable values of "B" voltage from approximately 18 to 160 volts. A fixed 180 volt tap is also included. The "B" minus terminal for the network is to be found in the divider. The exact value available at the 180 volt tap is governed by the resistance R2, the function of which is to reduce the voltage being fed to the voltage divider so that the maximum is approximately 220 volts D. C. making available the 180 volt maximum "B" voltage and the required maximum of 40.5 volts for the "C" bias.

Referring to R and R1 in the eliminator wiring diagram, we see two resistances across the tube output. The voltage fed to the filter and the remainder of the eliminator is the voltage drop across this resistance network. Since a section of the R1 carries the load upon the eliminator, R1 is rated at 75 watts while R is rated at only



Schematic diagram of the Universal "B" Eliminator. It will supply ample current for most any receiver-amplifier and is satisfactory for use with the Television Amplifier described on page 44.

25 watts. The latter resistance carries only the network leakage current. The function of the slider on R1 is to limit the voltage fed into the filter to approximately 400 volts D. C. in order to permit the use of the electrolytic condensers, which units afford high values of capacity within a small area, but are definitely limited in operating voltage. The use of high values of by-pass capacity as herein employed are highly beneficial. The two 2 mfd. condensers are of the regular paper dielectric type. The one nearest the rectifying system is a 1,000 volt D. C. condenser. The filter midsection condenser is of 650 volts D. C. rating. The high voltage lead for the plates of the power tube is taken from the filter end of resistance R2. The function of this resistance is to reduce the voltage being fed to the voltage divider so that the maximum is 220 volts D. C. The electrolytic condenser designations are given in the illustration. The copper can is always negative.

LIST OF PARTS REQUIRED

1–Full-wave transformer for 281 tubes
2–Eby four prong sockets
1–Electrad type B 40,000 ohm. Truvolt resistance (R)
1–Electrad type D 4,000 ohm. Truvolt resistance with slider (R1)
2–30 henry chokes
1–Mershon D 25 electrolytic condenser (C1 and C2)
1–Mershon Q 10 electrolytic condenser (C3, C4, C5 and C6)
1–Electrad Truvolt Divider
1–Electrad type T 15,000 ohm. variable Truvolt (R2)

Compact A.C.-A-B Power Supply

By Perry S. Graffam

ELECTRICALLY and mechanically the better class of battery operated receivers sold during the last two years are as good as the new A.C. jobs. The fan who wants to be relieved of the care of batteries is faced with junking his set or selling it for a song in order to get A. C. operation.

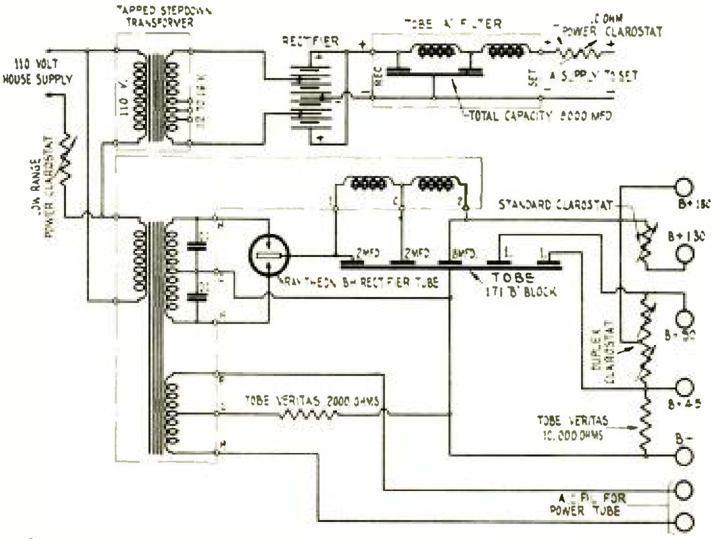
The "B" end of the battery question has long been solved with satisfactory eliminators. The "A" end has just been solved for this year sees a perfected "A"-eliminator comprising a first class condenser and choke filter system for "A" current. This unit combined with a good "B"-unit gives the owner of the battery operated set complete dry A.C. operation with all the advantages of his present set added to it.

The accompanying diagram shows the parts and wiring of this supply unit. The upper part is the "A" end of the job and the lower the "B". Taking the "A" end we have a transformer which steps the incoming 110 volts A.C. down to 12 to 16 volts. This in turn is fed into a metallic rectifier which converts it into direct current.

This current however, still has a bad ripple in it which would cause a loud hum in the set so it is filtered through a special condenser of 8000 microfarads capacity and two large chokes which will permit the passage of the heavy current drawn for "A" work. The actual voltage to the set is controlled by a 10 ohm power Clarostat. It is advisable to connect a voltmeter across this line in order to insure against putting too great a voltage into the receiver.

Two input transformers are required. One is to be associated with the "A" Filter and the other is a part of the 171 Power Compact.

Points F-C-H are the low voltage side of the power transformer and are for lighting the filaments of the power tube in your set. Although the "A" Filter will also supply this current a "C" battery would be necessary. With the arrangement as shown no "C" battery is required. If your set is not wired for this arrangement you can do this very easily. Disconnect the wires on the filament lugs of your power tube socket and place some sort of insulation around the wires so they will not come in contact with any others. Connect these two lugs on the socket now vacant to two additional binding posts for easy connections to the corresponding posts on the "A" and "B" supply. If your set is not wired for a "C" battery no other changes are required. If it is wired for a "C" battery connect the "C" minus binding post to the "A" minus post of your set.

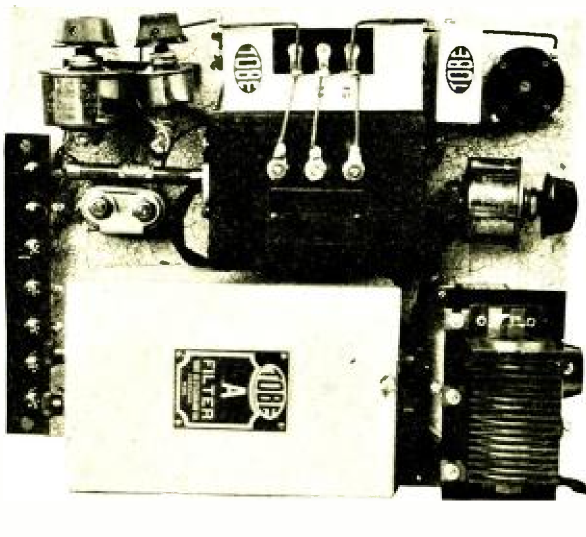


Schematic diagram of the Compact A.C.-A-B Power Supply. Filament current is obtained from a special "A" filter circuit

A Duplex Clarostat is used to divide and regulate the voltage for the "B" plus detector and "B" plus 90. Also a standard Clarostat is shown for those who require three "B" plus leads beside the "B" plus 180 volts. If this is not required in your set, you may omit this piece of apparatus and its associated wiring (two leads).

Two Power Clarostats are shown, one a low range, not more than 500 ohms being required, to regulate the 110 volts to the supply. A good voltmeter, A.C. type, should be used for this purpose. If, however, you have a D.C. voltmeter you may regulate the A.C. supply by connecting your voltmeter on the D.C. side of your "A" and "B" supply and make adjustments to suit. If you are measuring between "B" minus and "B" plus 180, you can adjust until you are obtaining this voltage.

The 10 ohm power Clarostat is connected in the "A" plus lead to your set, to regulate the "A" voltage to not more than 6 volts, depending upon the number of tubes in your set. Another point worth mentioning is that the total current of your tubes should not exceed 2 amperes.



Layout of the apparatus for the A.C.-A-B Power Supply. Clarostat voltage controls are employed. The dry rectifier is mounted to the right of the "A" filter.

LIST OF PARTS REQUIRED

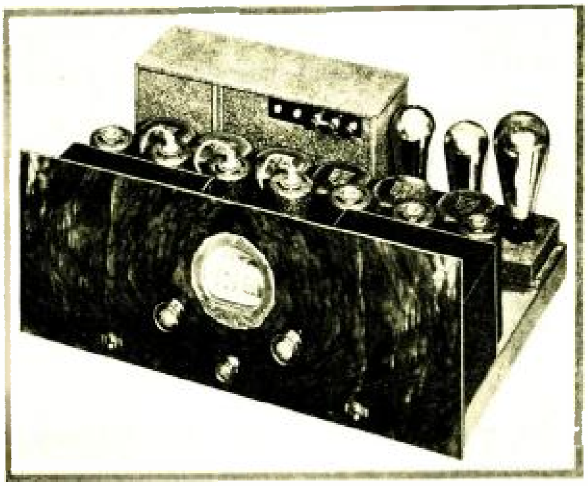
1—Tobe Tapped 50 watt Transformer
1—Tobe "A" Filter
1—Tobe 171 "B" Block
1—Tobe 411 Buffer Condenser
1—Tobe Veritas 10,000 ohm
1—Tobe Veritas 2,000 ohm
1—Thordarson R-171 Power Compact
1—Low range Power Clarostat
1—Power Clarostat 0 to 10 ohms
1—Standard Clarostat
1—Duplex Clarostat
1—Raytheon B-H tube
1—Elkon Dry rectifier or
1—Benwood Linze B 16 rectifier
7—Eby Binding Posts and Mounting Strip
50 ft. Cornish Hook-up Wire.

The Tyrman Imperial "80"

By W. P. Lear

THE Tyrman Imperial "80" is not just another receiver kit adapted to A. C. operation. The A. C. screen-grid and A. C. tubes together with the power supply on the chassis presented problems necessitating an entirely different technique in design. Tyrman Engineers were able to develop a circuit specially designed to successfully obtain efficient use of the tremendous amplification possibilities of A. C. screen-grid tubes.

Every part for the Tyrman "80" has been designed to co-ordinate and interlock with each other, creating in the final assembly an A. C. operated receiver unequalled for selectivity, sensitivity, stability, power and tone.



The Tyrman Imperial "80", a receiver of the superheterodyne variety, employing A.C. screen-grid tubes in the intermediate amplifier and a 350 power tube in the output. The power supply equipment is housed in the metal case at the rear of the chassis.

Foundation Assembly and Wiring

The chassis base or platform of the Imperial "80" is heavy gauge steel, cadmium plated, brushed to a silver-like finish. It is formed and punched to automatically accommodate the units to be mounted upon it. Attached underneath the steel chassis is a bakelite subpanel arranged in such a manner that contacts which are to be insulated from the chassis are held away from it and terminals to be grounded are allowed to touch it. This makes the wiring of the "80" extremely simple and practically fool-proof.

The Power Supply

The power supply is an integral part of the chassis. It is mounted on the steel platform with four screws, directly back of the other apparatus in such a position as to have no inductive or magnetic coupling with the audio units. It is capable of delivering one hundred milliamperes of direct current at a potential of more than four hundred volts. The power supply also supplies the filament current by operating the seven heater type filaments as used in the type 27 and type 22 A. C. tubes.

Two CX-381 tubes are used to rectify the heavy current supplied by the power pack. These tubes are operated at only one-half of their normal current load per tube which should give exceptionally long tube life.

One Spot Reception

The I. F. transformers in the "80" operate at a frequency of 475 K. C. assuring one spot reception on the oscillator dial.

The Tyrman "80" employs four I. F. Units each of which is designed especially for the particular position in the circuit where it is used.

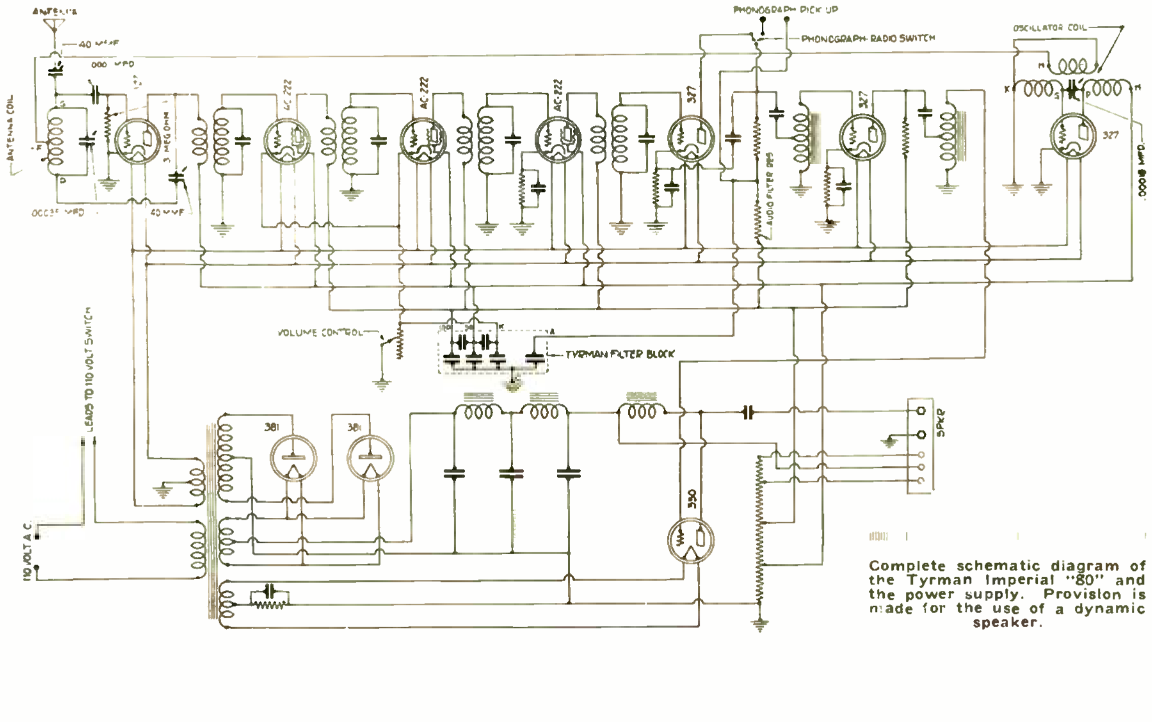
Transformer No. 9-14 is the input transformer from the first detector, which is of the grid detection type using a grid leak and condenser, has a small primary consisting of a few turns of wire. This is necessary because of using a first detector tube of low plate impedance and a maximum transfer of energy could be effected with an entirely different type of primary than was possible for the other type of primary used. The bakelite bracket upon which condensers are mounted allows the use of a regenerative circuit in the first detector and also the use of the Hartley series feed type of oscillator noted for its ability to produce sinusoidal wave form and to oscillate at a higher frequency or lower wave length more readily than other types of oscillator circuits. This insulated bracket also prevents body capacity effects.

Along side of each variable condenser, coil sockets are provided for various antenna and oscillator coils. The variable condensers have been designed expressly for the Tyrman "80" and will match each other at various settings on the dial much closer than the ordinary super-heterodyne. The antenna tuning condenser is of .0005 mfd. capacity and the oscillator condenser of .00015 mfd. capacity with a compensator. This compensator is used to increase the minimum capacity allowing the oscillator dial to just cover the broadcast wave band without extending beyond it at the lower end. Shields provided for the condensers are easily removed for changing coils.

Voltages delivered to the various tubes in the "80" are 50 and 150 volts respectively. 50 volts is applied to the screen grids, first detector and oscillator. 150 volts to the plates of the screen grid tubes and first audio amplifier, as well as to the second detector. Although the actual voltage on the plates of the detector and the first audio tubes will be considerably lower due to the drop in potential through the resistance units in the audio couplers and detector plate filter.

Grid detection is used in the first detector or mixer tube. Plate detection is obtained in the second detector by applying the drop in the potential obtained across the three thousand ohm resistor connected between the cathode of the tube and the ground.

The same scheme is used to obtain the grid potential for the amplifying stages with the exception that the first and second I. F. stages are returned to the variable



Complete schematic diagram of the Tyrman Imperial "80" and the power supply. Provision is made for the use of a dynamic speaker.

resistor of seventy-five thousand ohms maximum which changes the bias enough to give a very smooth and complete control over sensitivity and thereby regulating the volume or output.

Volume Control

The new Tyrman volume control effects only the bias of two of the intermediate frequency stages and does not change the peaking in the slightest degree, therefore making it unnecessary to readjust the oscillator or antenna dials for change in volume. It also gives a range of control from zero to maximum.

Shielding

It is a well-known fact where amplification is present that any tendency to feed back energy either by induction or capacity causes instability. Any one of the intermediate frequency amplifier tubes will couple by capacity of the whole tube to that of another tube resulting in objectionable feedbacks. Tyrman shielded sockets completely shield each tube from the other by forming a short circuit for this energy to ground. The shield is automatically grounded through a small phosphor bronze spring which presses against it at the base and which is connected to the filament or cathode lead of the socket.

The Antenna

The antenna used on the "80" can be of any length although it is recommended not to use an antenna of over forty feet due to the extreme sensitivity of the set. It is possible to get very good results without any antenna at all but of course quieter operation will be obtained by working the set at a less sensitive condition and feeding it with more energy. Regenerative control and antenna adjusting condensers are provided at the extreme left side of the chassis and easily adjusted to any length of antenna.

Audio Coupler

The Tyrman audio coupler system has been developed along the lines of tonal principles laid down by Professor Andrés at the meeting of the R. M. A. Standards Committee, the essential extract of which is that an audio amplifier will perform only when specially designed to the R. F. circuit and to its interpreter, the loud speaker. Abundant iron of high permeability is used for the core. High inductance windings in the secondary and resistance in the primary assures full amplification of the low bass notes and a faithful rendition of the wide range of all musical instruments and the human voice.

The climax of the Tyrman audio coupler system is expressed in the application of either the CX-310 or CX-350 power amplifier tube for the second audio stage. Either of these tubes is adapted as standard for the "80" being able to assure a distortionless output of the enormous amplifying signals. When a maximum of volume is desired with a slight increase of distortion a CX—310 is better than a 350 tube, but where maximum tone quality is desired at a slight sacrifice of volume a CX-350 tube is recommended.

Reproduction Phonograph

Provision is made in the Tyrman "80" to permanently connect a phonograph pick-up unit which enables changing from radio to phonograph record reproduction by simply turning a switch on the front panel.

Short Wave Reception

Screen-grid tubes have proved to have little or no advantage as a low wave or high frequency amplifier when used in ordinary circuits which of course is a great disappointment for the experimenter and low wave reception enthusiast. The Tyrman "80" overcomes this objection by enabling those interested is low wave reception to take advantage of the tremendous amplification of the screen-grid tube by heterodyning the high frequency to a much lower one and then amplifying. Two complete sets of short wave coils are furnished with the "80" which can be conveniently and easily plugged in.

Dynamic Speakers

An outstanding feature of the "80" is the fact that a standard 100 volt dynamic speaker can be energized directly from the Tyrman "80" power pack. Any other type speaker can be used. The voltages delivered to the various points remain the same whether a dynamic speaker is used or not.

An A. C. Audio Amplifier for Television

By J. R. Francis

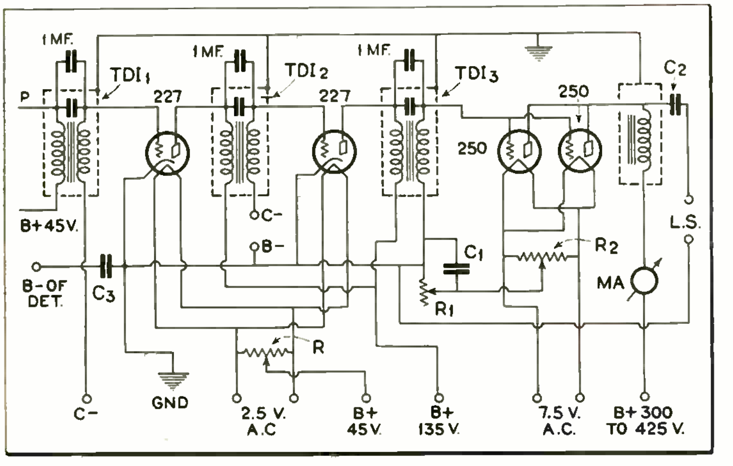
DR. E. F. W. ALEXANDERSON, in a recent talk, stressed the requirements of television in transmission and reception, and expressed himself to the effect that a substantially flat response characteristic between 50 and 20,000 cycles was one of the requirements of the average audio amplifier employed in television work. Furthermore, if the same characteristic could be extended to a lower value, that is, with a lower limit, better results would be obtainable.

The construction of this amplifier is based upon the above statements and since present day speakers and radio frequency amplifying systems have undergone tremendous improvements, such an audio amplifier would also be ideal for general broadcast reception. Power amplifiers, however, are not very convenient for operation at D. C. filament potentials; A. C. filament and "B" eliminator operation being imperative. The result is shown. Here is a three stage tuned double impedance amplifier utilizing two 227s and two 250 tubes, providing a total gain of approximately 46 TU's and an output power of approximately 6 watts, with a flat characteristic between approximately 20 and 16,000 cycles, as determined by means of oscillograph measurements. The curve has a small dip around 100 cycles, but it is so small that its presence is not noted in actual operation.

The complete amplifier has been used for television and regular broadcast work. Television reception from WRNY was very successful. The fact that A. C. filament operation is used is not detrimental, since the total hum from the complete unit is not audible one foot distant from the loud speaker. The selection of the tuned double impedance system of audio amplification is based upon the fact that the operating range of the system can be varied to suit each requirement. It furthermore affords the possibility of operating closer to the "Mu" of the tube; permits greater effective plate voltage since the D. C. drop in the unit is very small, and it has a flat response characteristic on the upper portion of the audio frequency spectrum. It furthermore permits a small amount of grid current in the event that momentary overloading occurs, without consequent change of the operating characteristic of the unit, since the grid winding is magnetically isolated from the plate winding of the same coupling unit.

The basis for the 250s, rather than 171 type output tubes, is founded upon several facts. First, the average "B" power unit supplying 171 type of tubes and designed for these tubes, is often incapable of supplying the additional 20 mils required for the neon lamp. Furthermore, the 170 or 180 volts available from the "B" power device, is often insufficient to cause the neon lamp to glow. The high plate voltage required for the 250s is ample for the neon tube.

The 227s provide excellent operation with A. C. potentials, because the ripple voltage is very small. Filament circuit balance is obtained with a potentiometer. The "C" bias for the two 227s is a battery, but the "C" bias for the 250s is obtained from a resistance in the plate-filament circuit. As is evident from the wiring diagram, a 1 mfd. condenser is connected across the plate-grid terminals of each tuned double impedance unit. The addition of this condenser tunes each unit to approximately 8 or 10 cycles, producing substantially flat response on all high frequencies. Each tuned double impedance case is grounded as is the "B" minus connection. This in addition to isolation of the twisted A. C. filament wires aids in the minimization of hum.



Schematic diagram of the audio amplifier especially designed for television reception. Note the two 250s in parallel in the output.

LIST OF PARTS REQUIRED

3—Tuned double impedance units (1st stage)
2—Eby five prong sockets
2—Eby four prong sockets
1—DeJur 20 ohm. potentiometers (R)
1—DeJur 85 millihenry choke (plate circuit of detector tube)
1—Electrad 50 ohm. center tapped resistance (R2)
1—Output choke
1—Weston D. C. milliameter 0 to 150 mils
1 Electrad type T20 (2,000 ohm.) Truvolt variable resistance (R1)
3—1 mfd. 300 volt condensers
1—4 mfd. 600 volt filter condenser (C2)
1—4 mfd. 200 volt condenser (C1)
1—1 mfd. by-pass condenser (C3)
12—Eby binding posts

AMERTRAN ALTERS SALES POLICY

Announcement that they are abandoning their previous sales policy was made by the American Transformer Company, of 172 Emmet Street, Newark, N. J., at the same time that they announced the appointment of Chambers & Halligan, of 549 West Washington Boulevard, Chicago, Ill., as their representatives for the Middle West.

American Transformer Company has for years been selling their line of high grade apparatus direct to dealers on a C. O. D. basis. Their change to the direct to jobber—open credit basis of selling, is regarded as a revolutionary move on the part of the Officials of American Transformer Company, and it is predicted will earn them a very great increase in sales volume. The new policy became effective October 1st.

Addition of the AmerTran line puts Chambers & Halligan among the foremost factory representatives in the Middle West. Other lines that they are selling include Potter Condensers, Air-Chrome Speakers and B. B. L. Units and Phonograph Pickups.

DE FOREST COMPANY DISMISSES SUIT AGAINST CROSLEY

The DeForest Company, which has been recently reorganized and appears to be rapidly forging to the front under its new management, has dismissed a suit which has been pending for about a year against Powel Crosley, Jr., of Cincinnati, Ohio. This suit was filed by Arthur D. Lord, former receiver of the DeForest Radio Company. It is stated that the new President, James W. Garside, has instructed the withdrawal of this suit, and that Mr. Crosley, President of the Crosley Radio Corporation, has been invited to become a member of the Board of Directors of the DeForest Radio Company, which invitation he has accepted.

PRICE CHANGE IN RADIOTRONS

The Radio Corporation of America announced that effective September 29th the suggested list price of Radiotron UX-112-A is reduced to $2.75, of UX-171-A to $2.75, of UX-226 to $2.25, of UY-227 to $4.00, of UX-280 to $4.25 and of UX-250 to $11.50.

ERLA AND GREENE-BROWN COMBINE

Another important consolidation in radio has been effected in the announcement of the merger of two more veterans and leaders in the radio industry, the Electrical Research Laboratories, Inc., and the Greene-Brown Manufacturing Company. The new company will be known as the Erla Corporation, with general offices at 2500 Cottage Grove Avenue, Chicago, where the spacious plant and offices of the Electrical Research Laboratories have been located for a number of years.

FRED S. ARMSTRONG REORGANIZES MELLOTRON

The Fray Manufacturing Company, 2021 South Michigan Avenue, Chicago, a new corporation organized by Fred S. Armstrong and Raymond W. Armstrong, has purchased the entire plant and good will of the Mellotron Tube Company. The new corporation, which has been operating since August 1, will manufacture a complete line of radio tubes under the brand name of "Mello-Tron."

Fred S. Armstrong is the president of the Fray Company. He is best known to the radio industry for his work in the organization of the Radio Protective Association, of which he is treasurer.

Raymond W. Armstrong has had twenty years of experience in lamp and tube making, seven years of which was spent in the lamp development laboratory of the National Lamp Works of the General Electric Company.

The new company has announced an improvement in the manufacture of heater type A.C. tubes, which greatly prolong the useful life of this type of tube. Patents have been applied for.

TWO PLANTS PRODUCING FRESHMAN RECEIVERS

Two plants are in full operation these days, producing the Freshman receivers. One plant is located in the Bronx, while the other is in the Bush Terminal section of Greater New York. There are over 500 employees in each plant, or well over a thousand employees on Freshman production, aside from the large business department at the main office in the Freshman Building on 40th Street, New York City.

FRESHMAN ANNOUNCES BRANCH OFFICES AND WAREHOUSES ON COAST

To provide the closest contact, together with the advantages of prompt delivery and servicing, for the trade west of the Rockies, the Chas. Freshman Co. has arranged for three branch offices and warehouses on the Coast.

Far West trade will be in charge of Walter J. Epstein. The Los Angeles office and warehouse has been retained. The main branch office and warehouse has been installed at San Francisco. A third branch office and warehouse will soon be installed at Seattle. Each of these branches will represent a complete, self-contained sales and servicing unit, ready to take care of the requirements of the trade in its respective territory.

R. S. REYNOLDS ANNOUNCES REORGANIZATION

The United States Foil Company having recently acquired the Robertshaw Thermostat Company of Youngwood, Pa., and the Beechnut Foil Company of Brooklyn, N. Y., has organized a new operating company known as Reynolds Metals Company which has been incorporated under the laws of the State of Delaware.

Reynolds Metals Company on August 1, 1928, took over the operation of the foil business formerly operated by the United States Foil Company and will also, through its wholly owned subsidiary the Robertshaw Thermostat Company, continue the business of that Company.

Reynolds Metals Company may in the near future acquire control of Fulton Sylphon Company of Knoxville, Tenn., Fulton directors having already recommended to their stockholders that the offer of Reynolds Metals Company be accepted, and said stockholders are expected to take definite action upon such offer within the next thirty days.

The fact that all three companies; namely, the United States Foil Company, Robertshaw Thermostat Company and the Fulton Sylphon Company, use many of their supplies in common; chiefly, lead, tin, zinc, copper and aluminum; an immediate prospect of operating economies is afforded.

RMA AND NAB OFFICES MOVED

Expansion of the Radio Manufacturers Association and its service has made necessary larger quarters in New York City for eastern RMA headquarters.

On October 1st new RMA offices in New York will be in the Salmon Tower, Room 1330, 11 West 42d Street.

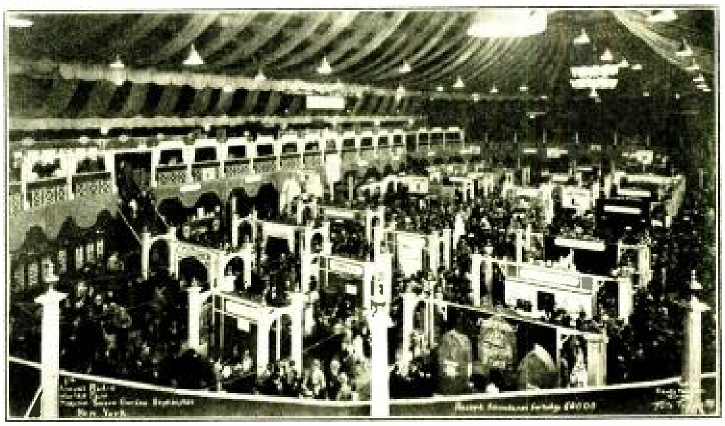
The National Association of Broadcasters have also taken new quarters in the Salmon Tower Bldg.

BELDEN APPOINTS NEW REPRESENTATIVES

The Belden Manufacturing Company announces the appointment of Mr. Charles Hofman, City Bank Building, Kansas City, Missouri, as the Southwest representative of the Belden line of automotive, electrical and radio products. Mr. Hofman covers Western Missouri, Kansas, Nebraska and Colorado.

E. V. Blake will travel Southern Ohio, Southern Indiana, Southern Illinois, St. Louis and Kentucky, in behalf of the Belden line of automotive, radio and electrical products. The entire line is merchandised through jobbers in that territory.

Mr. Wallace R. Lynn, with offices at 268 Market street, San Francisco, California, will represent the Belden Manu-



Madison Square Garden during the Fifth Annual Radio World's Fair sponsored by the Radio Manufacturers Association. Attendance was at the rate of 50,000 a day. As many if not more exhibits were in the basement of the Garden.

facturing Company on the Pacific Coast. He is devoting his time to merchandising Belden electrical, radio and automotive products through jobbers in that territory.

U. E. LAMP CO. APPOINT NEW REPRESENTATIVE

The Universal Electric Lamp Co., of Newark, N. J., announce the appointment of H. L. Dalis, 135 Liberty street, as their New York representative.

FRANK REICHMANN WITH JOY-KELSEY CORP.

Friends of Frank Reichmann, one of the pioneers of the radio industry, will be interested in learning that he has joined the Joy-Kelsey Corp., of Chicago, manufacturers of a complete line of speakers, dynamic cones, both A.C. and D.C. and radio chassis of seven and eight tubes, including screen grid tubes.

Mr. Reichmann originated and built the Thorola Speakers, also the Thorophone Dynamic and Thorla Receiving Sets.

KELLOGG ADDS NEW RADIO DISTRIBUTORS

The Kellogg Switchboard and Supply Company, of Chicago, announce the appointment of several new distributors for Kellogg radio merchandise.

Berrodin Auto Supply Company, Philadelphia, Pennsylvania, are distributors for the city of Philadelphia, southeastern Pennsylvania, and southern New Jersey.

Atlantic Radio Company, Boston, Massachusetts, is the distributor for New Hampshire, Rhode Island and eastern Massachusetts.

Henry J. Rowerdink, Rochester, New York, is the distributor for Western New York state.

Krauss Sales Corporation, St. Louis, Missouri, is the distributor for the entire state of Missouri except the extreme western part, also for north central and northeastern Arkansas, and for southern and central Illinois.

Kiefer Electrical Supply Company, Peoria, Illinois, will act as distributor for Peoria, Illinois, and several of the surrounding counties.

Magic Auto Supply Company, Hartford, Connecticut, is the distributor for eastern and central Connecticut.

Clemons Auto Supply Company, Eau Claire, Wisconsin, is the distributor for northwestern Wisconsin.

Haynes and Chalmers, Bangor, Maine, is the distributor for the state of Maine, except the southwestern section.

Collins Kelvinator Corporation, Los Angeles, California, is the distributor for southern California.

The Kellogg Company is to be congratulated for their line-up this fall with prominent distributors in the automobile supply, radio, electrical and refrigerator fields.

All of the concerns mentioned are well known in their respective fields and have a good following of dealers who are in a position to distribute Kellogg radio.

PAUL GODLEY JOINS FEDERAL SALES

Mr. Paul E. Godley has joined the sales staff of the Federal Radio Corporation and will represent Federal Ortho-sonic radio in the New York metropolitan territory.

SPLITDORF APPOINTS ADDITIONAL JOBBERS

Fifield Bros., of Augusta, Maine, have been appointed distributors for the Splitdorf line of radio sets. The Augusta jobbers are a well known firm, having started in business in 1895, specializing in automotive equipment. They cover the State of Maine with eight salesmen and have departmentized radio. B. B. Herrick, general manager of the company, and Mr. Hall, head of the radio department, are in charge.

Another Splitdorf appointment is that of Waite Auto Supply Co., 356 Westminster Street, Providence, R. I., to become jobbers for Rhode Island and the following Connecticut counties: Toland, Wyndham, and New London. This is an old line automotive house traveling 12 men. E. W. Waite is president of the company.

ACOUSTIC PRODUCTS SHARES

E. F. Gillespie & Co., Inc., offered 100,000 shares of common stock of the Acoustic Products Company priced at $15 per share. The company, better known to the public and trade as "Sonora," was organized in 1927 and owns approximately 93 per cent. of the total outstanding preferred shares and 96 per cent. of the outstanding common shares of the Sonora Phonograph Company, Inc. The company manufactures, either directly or indirectly, machines and devices which cover the entire field of sound reproduction, both recorded and broadcast. A new phase of the company's business, which is just now being developed into an important branch of the firm's activities, is the synchronization of sound with film for use in theaters, churches and auditoriums. All the company's products are manufactured and marketed under the trade name of "Sonora" and includes phonographs, electric phonographs, radios, loud speakers, records and tubes. The company operates through its subsidiary, the Sonora Phonograph Company, a plant in Saginaw, Mich., and an electrical apparatus factory in Stamford, Conn. The forecast for the current fiscal year, based on the management's estimate of gross sales volume of $8,000,000 indicates substantial net earnings.

UNITED REPRODUCERS CORP.

Thompson Ross & Co. and Lane, Roloson & Co., Inc., are offering 75,000 shares of preference and participating Class A stock without par value of United Reproducers Corporation at $33 a share. The stock will carry warrants which will be exchangeable for Class B stock of the company after September 1, 1929. The stock has been listed on the Chicago Stock Exchange. The company is being formed to acquire the business and assets of Newcobe-Hawley, Inc., and United Radio Corporation.

POLYMET STOCK SOLD

The Polymet Manufacturing Company, manufacturers of radio parts, has sold 10,000 shares of its no par common stock through an offering made by C. L. Schmidt & Co., Inc., at 21. Proceeds will be used to increase the company's facilities and for additional working capital. With the completion of this financing the company has outstanding a capitalization comprising 30,000 shares of no par common. It has no funded debt, bank debt or preferred stock.

Earnings for the 12 months ended March 31, 1928, amounted to $85,922, or approximately $3 a share.

It is the intention of directors to authorize the payment of dividends at the rate of $1.50 a share, starting January, 1929.

DE FOREST CO. ANNOUNCES DISTRICT MANAGERS

The names of the District Managers, together with the territories which they cover, have just been announced by H. C. Holmes, Director of Sales of the DeForest Radio Company of Jersey City, N. J.

The New England Territory is to be handled by William J. Barkley of the R. A. Chambers Company, 10 High Street, Boston, Mass. This territory includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut north of and including Hartford.

The New York or Metropolitan Territory is to be handled by H. H. Southgate, 50 Church Street, New York City, and includes Connecticut, south of but not including Hartford, New York excluding Buffalo, and New Jersey north of but not including Trenton.

The Philadelphia Territory will be handled by Charles N. Wiltbank, 609 Washington Square Building, Philadelphia, Pa., and will include Delaware, Maryland, District of Columbia, New Jersey south of and including Trenton, and Pennsylvania east of but not including Altoona.

The Pittsburgh Territory will be handled by H. B. Parke, 305 Seventh Ave., Pittsburgh, Pa., and includes West Virginia, Ohio excluding Toledo, Pennsylvania west of and including Altoona, and that corner of New York State including Buffalo.

The Detroit Territory will be handled by Phil M. Day, 517 E. Woodbridge St., Detroit, Mich., and includes Toledo only in Ohio, Michigan, and Indiana excluding southwestern corner that includes Evansville and Terre Haute.

The Chicago Territory will be handled by Tideman & Whetter, 600 W. Jackson Blvd., Chicago, and includes Iowa, the northern half of Illinois or north of Springfield and Decatur, and the southern half of Wisconsin or south of LaCrosse and Oshkosh.

The Denver Territory is to be handled by F. E. Staible, Inc., 2356 Blake St., Denver, and includes Colorado, Wyoming, Utah and New Mexico.

The West Coast Territory is to be handled by J. T. Hill, 823 San Fernando Bldg., Los Angeles, and includes Arizona, Montana, Idaho, Nevada, Washington, Oregon, California, and the corner of Texas including El Paso only.

The St. Louis territory is to be handled by Richard V. Hughes, 1120 Fullerton Bldg., St. Louis, and includes Kentucky, Memphis only in Tennessee, the eastern half of Missouri including Jefferson City, the southern half of Illinois south of Springfield and Decatur, and the southwestern corner of Indiana including Evansville and Terre Haute.

The Kansas City territory will be handled by C. H. Annis, 237 Railway Exchange Bldg., Kansas City, and includes Kansas, Nebraska, and the western half of Missouri not including Jefferson City.

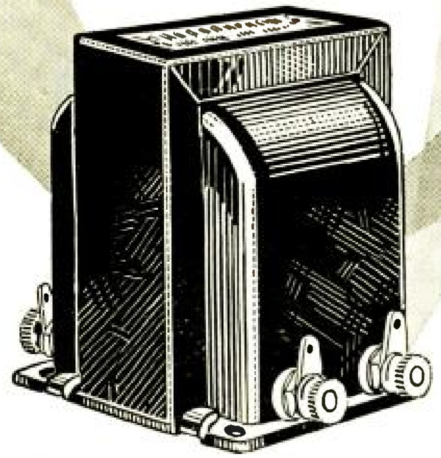
The Dallas territory will be handled by Jenkins & Gunther, Santa Fe Bldg., Unit Two, Dallas, and will include Oklahoma, Arkansas, Texas except El Paso, and the northwest corner of Louisiana including Shreveport.

RADIO AND ASSOCIATED STOCK QUOTATIONS

(October 3 closing prices)

Company	High	Low	Last	Company	High	Low	Last
Acoustic Products	19	19	19½	Kolster	74¾	73	74¾
All-Am. Mohawk	19½	18½	19½	Magnavox	4¼	4⅛	4⅛
American Bosch	33⅞	33⅝	33⅞	Polymet	35½	35½	35½
Bruns-Blake Collen (Com.)	57⅜	55¼	57⅜	Radio (Com.)	211⅜	208½	209½
Crosley "A"	59	57	59	Raytheon	51⅜	51⅜	51⅜
Davega	34	34	34	Sangamo	32½	32½	32½
De Forest	15	14⅝	14¾	Sonatron	115	113½	114¾
Dubilier	4⅞	4⅝	4¾	Sparks-Withington	146	142⅛	146
Erla	24	21¼	24	Stewart-Warner	105	103½	103¾
Fansteel	17¼	15⅞	16¾	Utah	62	61	61¾
Formica	25	25	25	Tower	3¾	3	3⅛
Freed-Eisemann	4⅞	4⅞	4⅞	Union Carbide (Com.)	188¾	187	188½
Freshman	11⅞	11⅝	11⅞	Vesta Bat.	14½	12½	12½
General Electric (Com.)	165⅜	163⅞	164¾	Victor (Com.)	109⅛	107¼	109⅛
Gold Seal	8¾	8¾	8¾	Westinghouse	105	103¾	104⅞
Grigsby-Grunow	312	312	312	Weston (Com.)	25½	25⅛	25½
Hazeltine	16	16	16	Weston "A"	33⅛	33⅛	33⅛
Kellogg	14½	14	14½	Zenith	110	110	110
Kodel "A"	27½	27	27				

A NEW NOTE IN AUDIO AMPLIFICATION



THORDARSON R-300 AUDIO TRANSFORMER

SUPREME in musical performance, the new Thordarson R-300 Audio Transformer brings a greater realism to radio reproduction. Introducing a new core material, "DX-Metal" (a product of the Thordarson Laboratory), the amplification range has been extended still further into the lower register, so that even the deepest tones now may be reproduced with amazing fidelity.

The amplification curve of this transformer is practically a straight line from 30 cycles to 8,000 cycles. A high frequency cut-off is provided at 8,000 cycles to confine the amplification to useful frequencies only, and to eliminate undesirable scratch that may reach the audio transformer.

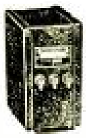
When you hear the R-300 you will appreciate the popularity of Thordarson transformers among the leading receiving set manufacturers. The R-300 retails for $8.00.

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer Specialists Since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Huron and Kingsbury Streets — Chicago, Ill. U.S.A.

Power Supply Transformers

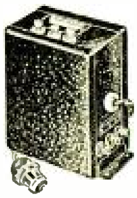
These transformers supply full wave rectifiers using two UX-281 tubes, for power amplifiers using either 210 or 250 types power amplifying tubes as follows: T-2098 for two 210 power tubes, $20.00; T-2900 for single 250 power tube, $20.00; T-2950 for two 250 tubes, $29.50.

Double Choke Units



Consist of two 30 henry chokes in one case. T-2099 for use with power supply transformer T-2098, $14; T-3099 for use with transformer T-2900, $16; T-3100 for use with transformer T-2950, $18.

Power Compacts

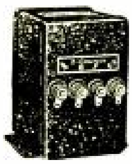


A very efficient and compact form of power supply unit. Power transformer and filter chokes all in one case. Type R-171 for Raytheon rectifier and 171 type power tube, $15.00; Type R-210 for UX-281 rectifier and 210 power tube, $20.00; Type R-280 for UX-280 rectifier and 171 power tube, $17.00.

Speaker Coupling Transformers

A complete line of transformers to couple either single or push-pull 171, 210 or 250 power tubes into either high impedance or dynamic speakers. Prices from $6.00 to $12.00.

Screen Grid Audio Coupler



The Thordarson Z-Coupler T-2909 is a special impedance unit designed to couple a screen grid tube in the audio amplifier into a power tube. Produces excellent base note reproduction and amplification vastly in excess of ordinary systems. Price, $12.00.

THORDARSON ELECTRIC MFG. CO.
500 W. Huron St., Chicago, Ill. 3583-K

Gentlemen: Please send me your constructional booklets on your power amplifiers. I am especially interested in amplifiers using .... tubes.

Name ....

Street and No. ....

Town .... State ....

The Atlanta territory, handled by Fulwiler & Chapman, 915 Atlanta Trust Co. Bldg., Atlanta, includes Georgia, Alabama, Louisiana except northwest corner, Tennessee except Memphis, Virginia, South Carolina, North Carolina, Florida and Mississippi.

One more territory, namely, Minneapolis, is being organized and the district manager will be announced shortly.

NEW LITERATURE

Catalogs

A. M. Flechtheim & Co., Inc., 136 Liberty St., New York City.

Descriptions of by-pass, filter, high-voltage and transmitting paper condensers, with prices.

Radio Corp. of America, 233 Broadway, New York City.

"Getting the Most Out of Radio." Descriptions of receivers, loud speakers, tubes and "B" eliminator, with prices.

Empire Steel Corp., Mansfield, Ohio.

Specifications of sheet sizes of all types of steels for many different uses with prices.

Aerovox Wireless Corp., 70 Washington St., Brooklyn, N. Y.

Descriptions of all types of fixed paper condensers and resistors, with prices.

Sangamo Electric Co., Springfield, Ill.

Two catalogs describing audio-frequency transformers and impedances with prices. Several circuits showing the uses of their products.

Carter Radio Co., 300 S. Racine Ave., Chicago., Ill.

Descriptions of tube adapters, different types of condensers, jacks, name and outlet plates, plugs, variable and fixed resistors, rheostats and potentiometers, switches, etc., with prices.

Dubilier Condenser Corp., 4377 Bronx Blvd., New York City.

Two catalogs, one describing socket power condensers and the other small fixed condensers, grid leaks, light-socket aerial, etc., with prices.

NOTE: *These catalogs sent free upon request.*

Ferranti, Inc., 130 W. 42nd St., New York City.

1928 Year Book. Descriptions of A. F. transformers, chokes, etc.; voltages to be used on various tubes in different positions in receivers; constructional details for several receivers, A.F. amplifiers, power amplifiers and eliminators, etc. Price 15c.

Bulletins

BULLETIN TS-10 deals with practical television reception and discusses the short-wave receiver the A.F. amplifier, the neon tube and the scanning device.

Raytheon Manufacturing Co., Kendall Sq. Bldg., Cambridge, Mass.

TECHNICAL BULLETIN Vol. 1, No. 3, covers useful facts about the Raytheon neon tube, such as luminosity obtained, brightness ratio, power required, etc.

Raytheon Manufacturing Co., Kendall Sq. Bldg., Cambridge, Mass.

THE BOSTON POST BOOK ON TELEVISION. By Henry M. Lane. Description of the reception and transmission of television signals written in a non-technical manner. Well illustrated.

The Radio Department of the Boston Post, Boston, Mass.

HOW TO BUILD AND OPERATE "THE WIRELESS WORLD" MOVING COIL LOUDSPEAKER. By F. H. Haynes. The constructional details of an electrodynamic loud speaker and the power amplifier and supply necessary. Price 1s 6d.

Iliffe & Sons, Ltd., Dorset House, Tudor St., London E.C. 4, England.

AN INVESTIGATION OF A ROTATING RADIO BEACON. By Dr. R. L. Smith-Rose and S. R. Chapman, Radio Report, Special Report No. 6. Descriptions of beacons and findings of extensive tests recently run. Price 2s 3d.

British Library of Information, 5 E. 45th St., N. Y. C.

HOW TO SERVICE RADIOS. Where trouble is liable to occur in the different parts of a receiver and tests for locating these troubles.

Supreme Instrument Corp., Greenwood, Miss.

House Organ

"The Aerovox Research Worker." Vol. 1 No. 8, Part I, of an article dealing with the principles of voltage divider design by Sidney Fishberg, Research Engineer of the Company. A description of the Taylor Pre-Selector Tuner, consisting of a modulator and oscillator to increase the selectivity of an existing receiver.

Aerovox Wireless Corp., 70 Washington St., Brooklyn, New York.

Pamphlets

"How to Pack It." A description of the different types of corrugated paper-board and its uses in the packing of a great number of different articles.

The Hinde & Dauch Paper Co., Sandusky, Ohio.

"The Amperite Blue Book." A description of this self-adjusting filament control and its application in amplifier and receiving circuits. Price 15c.

The Radiall Co., 50 Franklin St., New York City.

"Powerizing." A folder containing information on the conversion of any receiver to socket-power operation and super-power amplification.

The Radio Receptor Co., 106 Seventh Ave., New York City.

"Instructions for Radio Servicing with the No. 199 Radio Set Analyzer." Complete instructions for the testing of receivers, both A. C. and D. C. operated, all types of eliminators, etc.

Jewell Electrical Instrument Co., 1650 Walnut St., Chicago, Ill.

THE NATIONAL ELECTRICAL CODE. Its purpose and development, how the underwriters laboratories operate, their functions and the information necessary for anyone desiring the O. K. of the laboratories.

National Electrical Manufacturers Association, 420 Lexington Ave., New York City.

NEMA HANDBOOK OF RADIO STANDARDS, 4th edition. The Handbook contains 106 general standards, 97 transmitter standards, 121 receiver standards, 64 on power supply and 60 on vacuum tubes.

National Electrical Manufacturers Association, 420 Lexington Ave., New York City.

PRACTICAL TELEVISION. By E. T. Larner, Engineering Dept., General Post Office, London. 175 pages. Illustrated. 8¾ x 5½ inches. Stiff buckram cover. Published by D. Van Nostrand Co., Inc., 8 Warren St., New York City. Price $3.75.

In writing about a subject of this nature it is difficult to bring to the reader's attention the latest developments. Progress along these lines is being made so rapidly that by the time the page proofs of a book are in the author's hands some of the systems that he said were the best and latest have been discarded in favor of something new.

Mr. Larner has made his book as complete as possible bringing it up to the time that Mr. John L. Baird of London transmitted his image across the Atlantic Ocean to Hartsdale, N. Y. on 45 meters. Since then we have seen more remarkable developments, those of Dr. Alexanderson and of the Bell Telephone Laboratories. However, disregarding the handicap just mentioned, Mr. Larner's book will be of value to those who wish to ascertain something about this new phase of radio.

He starts out with the historical background of television and covers the early attempts at transmitting and receiving still pictures. Selenium cells are discussed and the different types of photoelectric cells and their uses. Several different systems of television are then considered with a very complete description of that of John L. Baird, who, by the way, wrote the book's introduction.

The man who wishes to start in the television field and who has a slight knowledge of engineering, will appreciate this book, but it is not for those engineers who have been following the progress of the industry from day to day. It is an ideal "public library" book for the layman as the explanations of the various pieces of apparatus are concise and well illustrated.

MODERN RADIO RECEPTION. By Charles R. Leutz (2nd edition). Published by C. R. Leutz, Inc., New York; 6" x 9", 383 pages, profusely illustrated, cloth cover. Price $3.00.

To make this book more useful to the large majority of readers, it has been made as non-technical as possible, the mathematical equations confined to simple examples, and the descriptions of the apparatus given in an easy understandable manner. The work will prove valuable to custom set builders, service men, testers, and advanced experimenters.

As with most books, which profess to cover the entire subject of radio, the present work commences with fundamental material of a practical nature relating to various forms of antennas, grounds and counterpoise, followed by fundamental material of both a practical and theoretical nature covering inductances, condensers, and resistors.

The section of the book covering radio laboratory apparatus is very complete and also gives practical data on the construction and use of measuring devices. R.F. and A.F. oscillators, tube reactivators, battery chargers, together with a description of various forms of coupling methods and a review of all types of audio frequency amplifiers. Circuit diagrams and constants are provided.

The latter part of the book is taken up with vacuum tube data, including a batch of characteristic curves of standard type tubes, special circuit connections and fundamental calculations. There is also included a Chapter on radio standards and advances, radio symbols and a special section on the servicing of broadcast receivers though, not as complete as it might be, is nevertheless very concise.

NEW FEDERAL WHOLESALERS

Thomas H. Peacock will act as wholesaler for Federal Ortho-sonic Radio in the Canadian Territory of Calgary and Edmonton, in the province of Alberta, according to word from K. E. Reed, sales manager of the Federal Radio Corporation at Buffalo.

Other wholesalers whose names have just been added to the Federal list are: The Swanson Electric and Manufacturing Company, Evansville, Ind.; Brown and Sehler Company, Grand Rapids, Mich.; Sterling Electric Company, Minneapolis, Minn.; and The Fort Smith Radio Company, Fort Smith, Arkansas.

MOREY & CO. BECOME GREBE DISTRIBUTORS

Morey and Company, No. 27 Commercial Avenue, Cambridge, Mass., have been appointed distributors of Grebe products in the states of Massachusetts, New Hampshire and Vermont by A. H. Grebe & Co., Inc., the pioneer radio manufacturers.

W. T. KIRTON NOW WITH KELLOGG

Mr. W. T. Kirton has joined the Industrial Sales Division of the Kellogg Switchboard & Supply Company, Chicago, and will devote his efforts to the sale of condensers, parts and supplies to radio and electrical manufacturers.

KOBER, ALEXANDERSON'S ASSISTANT, NOW WITH DAVEN

The Daven Corporation, Newark, N. J., announce the appointment of Mr. Paul A. Kober as Television Engineer.

Mr. Kober comes to Daven with a wealth of experience in Television. For four years he was engaged on television development work with the General Electric Company and for a year and a half was an assistant to Dr. E. F. W. Alexanderson, Chief Consulting Engineer of the Radio Corporation of America and the General Electric Company in the development of Television. Mr. Kober was the first Edison Lamp Works Engineer of the General Electric Company to receive a Charles A. Coffin Foundation award for his outstanding services to the company for contributions in the electrical art.

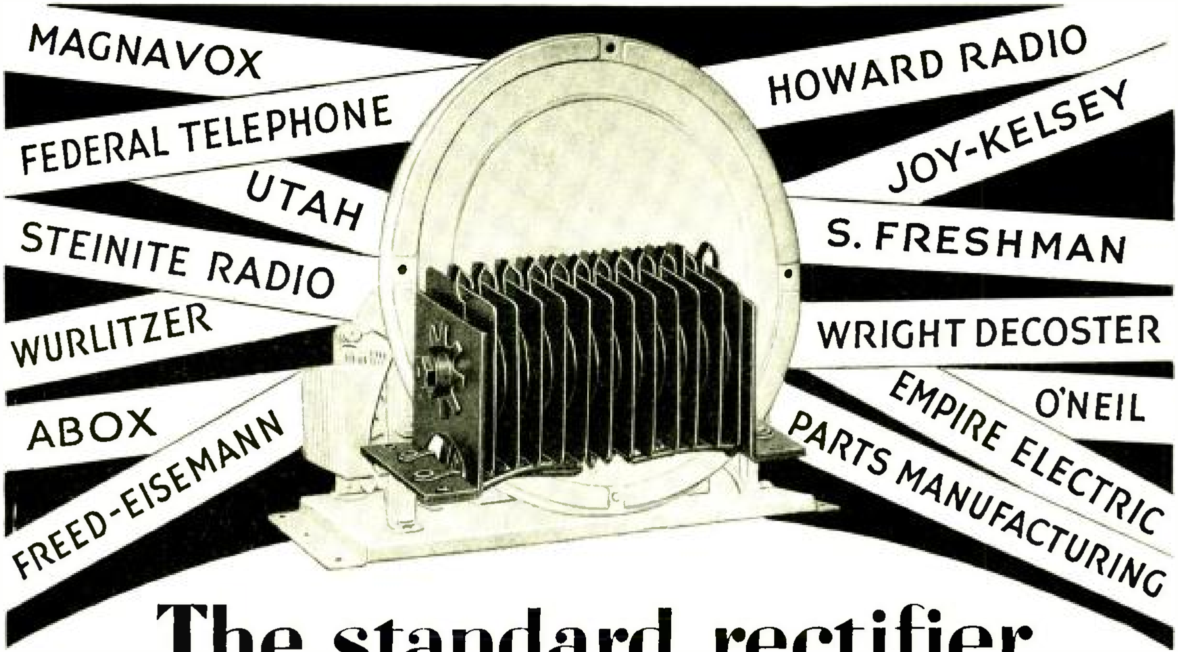
NEW JENSEN REPRESENTATIVES

Colley-Minnich Company, Norris Building, Atlanta, Georgia, have been appointed sales representatives for the Jensen Radio Manufacturing Company according to Thomas A. White, general sales manager for the dynamic speaker manufacturer.

Colley-Minnich are to represent the Jensen organization in the states of Tennessee, North and South Carolina, Mississippi, Alabama, Virginia, Georgia and Florida.

LOPEZ APPOINTED BENJAMIN REPRESENTATIVE

The Benjamin Electric Mfg. Co., of Chicago, Ill., announce that A. C. Lopez and Company, 40 West 33rd Street, New York City have been appointed sales representatives on Benjamin Radio Products for greater New York.



The standard rectifier adopted by the largest Dynamic Speaker builders

THESE leaders in loud speaker manufacture have swung to Kuprox rectifiers just as surely as have the large railroad, public utility and industrial leaders. Many more are now adopting Kuprox as fast as present stocks of other rectifiers can be worked into production.

Kuprox Dry Copper Oxide Rectifiers, vastly improved since their inception eighteen months ago, have proved conclusively in every competitive engineering test, their greater efficiency, absolute dependability and much longer life. Many manufacturers of dynamic speakers, who skeptically placed only sample orders, have since adopted Kuprox as standard, solely on the basis of their own tests and experiences.

We welcome inquiries and sample orders for test from all manufacturers who are selling dynamic speakers and want them to stay sold.

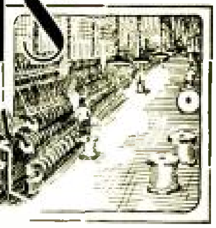
75% of all orders placed this year for railway rectifiers specified Kuprox. 90% of the dynamic speakers manufactured now use Kuprox. In every large time clock and recording system installation Kuprox is used. Kuprox is specified wherever absolute reliability, high efficiency and permanent operation are necessary.

THE KODEL ELECTRIC & MFG. CO. CINCINNATI, OHIO

KUPROX

DRY COPPER OXIDE RECTIFIERS

NEW DEVELOPMENTS OF THE MONTH

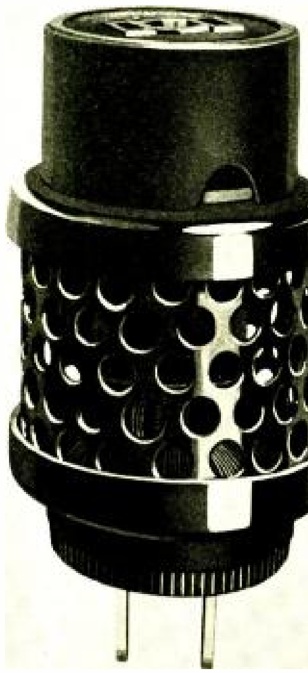


WARD LEONARD LINE VOLTAGE REDUCER

In response to the demand for a small, efficient and low priced device providing complete protection for A. C. tubes against excessive line voltage and consequent damage, Ward Leonard Electric Co., 41 South St., Mt. Vernon, N. Y., is marketing the new Vitrohm Line Voltage Reducer. The unit is little larger than a vest pocket flashlight, and the work of installation is a matter of no more than two minutes. Once in place in the wall outlet or lamp socket, the Line Voltage Reducer provides complete and permanent protection for any number of A. C. tubes in the receiver, it is claimed. There are no adjustments or replacements of any kind.

The new Ward Leonard unit reduces abnormal line voltages of 125 volts or less to a safe value for the operation of all A. C. sets drawing from 0.4 to 0.6 amperes. A. C. line voltage is seldom found in excess of that figure, and the unit is practically universal in its applications to A. C. sets now on the market. The resistive element is enclosed in a sturdy metal case. The entire unit is ruggedly constructed to insure lasting, trouble-free service.

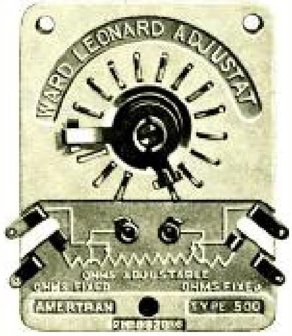
The list price of the Ward Leonard Line Voltage Reducer is $2.00.



Ward Leonard Line Voltage Reducer.

WARD LEONARD DUAL ADJUSTAT

In the new Vitrohm Dual Adjustat, Ward Leonard Electric Co., Mount Vernon, N. Y., introduces a simplified, efficient voltage divider which is universal in its applications. It is designed for use in all current supply units where adjustment of intermediate voltages is wanted. A single Dual Adjustat does the work of three or more separate resistor units, and is more accurate in voltage division. Its advantages over separate resistors where adjustable intermediate voltages are essential are: space saving, easier adjustment of intermediate voltages, and less cost than individual resistance units.



Ward Leonard Dual Adjustat

The Vitrohm Dual Adjustat consists of two fixed resistance sections each connected with an adjustable section. Sixteen adjustable resistance steps are covered by each of two moving contact arms, giving a range of intermediate voltages ample to meet the requirements of all types of receivers and amplifiers. Thus a single resistor unit, small and readily handled, supplies two fixed voltages and up to 32 adjustable voltages. Any of the adjustable values can be made fixed voltages by connecting permanently to the rheostat contact.

The Vitrohm Dual Adjustat is extremely flexible in use, and the resistance ranges are such that it will fill the requirements of all present day circuits. Two types of standard Dual Adjustats are available: for 200 volt and 400 volt service. The unit is also supplied to manufacturers in special resistance values to meet individual requirements.

The standard type Vitrohm Dual Adjustat lists at $8.50.

NEW TYPE VARIABLE CONDENSER FOR HIGH FREQUENCY CIRCUITS

The Radio Engineering Laboratories of 100 Wilbur Ave., Long Island City, N. Y., have developed a new model variable condenser with several interesting features.

The following specifications and data on the new REL condensers very readily show desirable features, which everyone connected with short wave work will greatly appreciate. These condensers can also be employed in wavemeters or frequency meters.

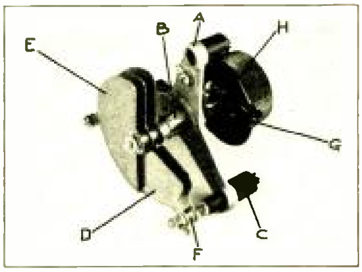
The model illustrated here consists of three rotary plates and two stator plates having a maximum capacity of 54 mmfd. Other types and sizes are manufactured. However the condenser illustrated here is typical of the construction employed in most models.

The die cast aluminum and casting "A" is ruggedly constructed and affords a wide three-cornered mounting to any panel. Due to this rugged construction and also to the thickness of the metal employed in the condenser plates, there will be no possibility of having difficulties with vibration in the condenser. It will also be noted that this condenser has insulated, panel stand-off bushings "C" which allow mounting to metal panels without necessarily grounding either the stator or rotor plates.

A very uniquely designed one piece bearing "B" supports the steel cadmium plated shaft "H." This is a double conical bearing with a specially designed spring adjusting tension device "G." This tension device may be set at any position to secure any desired degree of movement at the rotating dial.

The rotary plate contact employed in other condensers usually is of the pigtail, ball-bearing or friction type. By using contacts of these descriptions mechanical friction noises are usually experienced if such condensers are employed in receivers operating at 10,000 kilocycles or higher. To eliminate this non-positive contact the Radio Engineering Laboratories have devised and patented a very unique combination whereby the rotor shaft is continually immersed in a pool of mercury, which is held inside the bearing "B." There is no doubt regarding the positiveness of this contact. Shaft "H" is ¼" diameter. Any type of standard dial or knob may be fitted to it.

The condenser plates are of heavy brass stock. The stator plates are specially shaped, so that there will be no disturbing capacity increase when the rotor plates pass the point at which the stator plates are bound together. This is an important feature in low capacity condensers which are to be used in measuring instruments.



R.E.L. low capacity variable condenser.

To accurately spread the tuning range of a narrow specified frequency band a special two plate model of this condenser can be employed. This consists of a single rotor and single stator plate. The maximum capacity of this very small condenser may be regulated by moving the stator plate further away or closer to the rotor plate in accordance with the capacity desired. In this way an exceptionally wide spread tuning range is obtained. This is also desirous if a measuring instrument is to be designed which is to only cover a definite band.

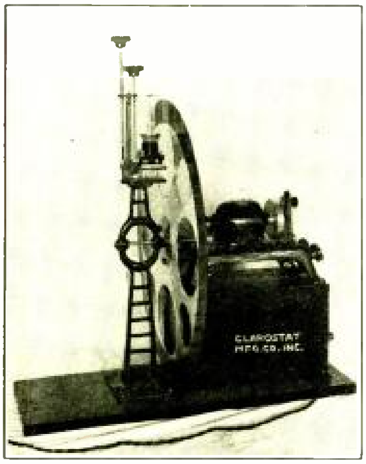
CLAROSTAT AUTOMATIC TELEVISION UNIT

The Clarostat Mfg. Co., Inc., of 285 N. Sixth St., Brooklyn, N. Y., announce the Clarostat Automatic Television Unit, comprising a driving motor, an automatic speed control, and an adjustable kino-lamp mounting, ready for use in any cabinet or simply exposed. The scanning disc is optional with the experimenter, since different television signals call for different scanning discs.

The motor is of 1/25 H.P., high-speed type, with suitable reduction gearing and flexible coupling for driving the scanning disc. This arrangement provides the greatest degree of correction, and eliminates alignment of drive shaft and scanning disc arbor. On the motor shaft is mounted a special centrifugal governor actuating a pair of contact points in series with the motor current supply. The contact points are shunted by an adjustable resistance. Thus when the speed of the motor rises above a given point, the centrifugal governor opens the contact points, thereby reducing the current to the extent of the resistance then thrown into the circuit. As the speed of the motor falls below a given point, the contact points close, short-circuiting the resistance and restoring full current to the motor.

Two special power clarostats are used as the controls for obtaining any desired speed and also for trimming the sparking at the contact points by varying the degree of short-circuited resistance. The knobs of the power clarostat are at the front end of the motor base. In addition, there is a small knob for adjusting the contact points, which serves as a vernier in obtaining precise speed even to one revolution.

Provision is made for mounting any scanning disc on the drive shaft. The kino-lamp is mounted on an adjustable platform which, by means of rack and pinion movements, may be micrometrically raised or lowered as well as shifted from side to side. In this manner the light source can be readily adjusted for any variations in the kino-lamp, as well as to align the image with the opening through which the image is visible.



Clarostat Automatic Television Unit.

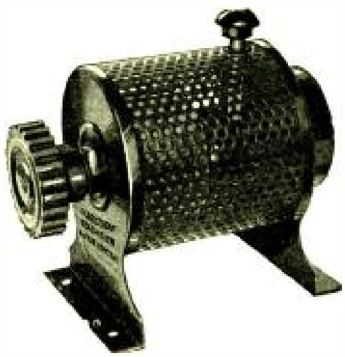
In operation, the speed control knob is adjusted for the necessary speed, which may be anything from a few revolutions to many hundreds. Vernier or delicate adjustments to within a single revolution or less, are made with the small knob that regulates the contact points. Finally, sparking at the contact points is reduced by the knob controlling the short-circuited resistance until it is almost imperceptible. A constant speed is now maintained with speed correction at every fraction of a revolution. It is claimed that the sparking at the contact points in no way interferes with the receiver employed for television signal reception.

TELEVISION CLAROSTAT

To fulfill the requirements of a precision control for the scanning disc of the television receiver, the Television Clarostat has been developed by the Clarostat Mfg. Co., Inc., 285-287 North Sixth Street, Brooklyn, N. Y.

The Television Clarostat comprises a special power type Clarostat, together with a short-circuiting push-button, contained in a sturdy, ventilated, metal housing with mounting feet. The device has a resistance range of from 25 to 500 ohms, or sufficient for the required range of speed. It dissipates up to 80 watts, and is capable of controlling either a universal or a condenser type motor, on AC or DC, up to ⅛ horsepower. Connections are made to screw terminals at one end, which are protected by a removable end plate.

In actual operation, the scanning disc is adjusted to the required speed by means



New Television Clarostat.

of the large knob, after which the push button is used for momentary acceleration in synchronizing the holes and the disc speed. The push button is also used for quick starting.

NEW DE FOREST AUDIONS

Four DeForest A-C Audions are announced by the DeForest Radio Company of Jersey City, N. J., as follows:

DeForest Audion 426: A-C filament type amplifier, characterized by study mechanical and electrical construction due to mica spacer at top of elements for maximum rigidity, together with special oxide-coated filament made in DeForest plant, which it is claimed will not flake or peel off.

DeForest Audion 427: Heater type A-C detector-amplifier, with five-prong base. A new insulating material, together with special heater wire, provides reliable, uniform and long service. Provided with mica spacer at top of elements for maximum rigidity.

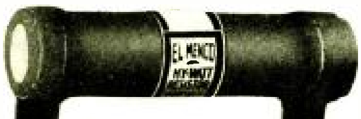
DeForest Audion 471-A: Power amplifier, with special oxide-coated filament which will not flake or peel off. Provided with mica spacer for maximum rigidity.

DeForest Audion 480: Full-wave rectifier, with special process oxide-coated filaments. Accurate positioning of elements claimed, insuring equal rectification of both halves of A-C cycle.

These four tubes, marking the beginning of a steadily expanding line of DeForest Audions for special and general purposes, are being shipped to the trade beginning September 15th. Other types will shortly be announced.

"CALOROHM" RESISTORS

The Electro-Motive Engineering Corp., 127 W. 17th St., New York City, announces a new line of vitreous enameled resistors known as the "Calorohm." These resistors



Electro - Motive "Calorohm" Resistor.

can be adapted for use in all power work and are especially recommended for heavy duty work. Calorohms are made to meet every requirement of resistance value and wattage dissipation.

GENERAL RADIO PORTABLE CAPACITY BRIDGE

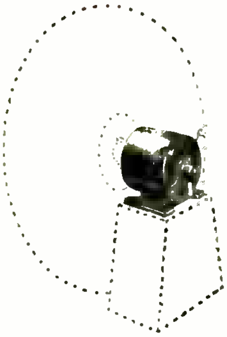
The Type 383 Bridge manufactured by the General Radio Co., Cambridge, Mass., is made in two models, suitable for two classes of capacity measurements commonly required in factory test work, i. e., the interelectrode capacity of vacuum tubes and the capacity of tuning condensers. The range of the Type 383 A is 30 M. M. F. and that of the Type 383 B 600 M. M. F.

The bridge circuit is of conventional type, requiring only the adjustment of one dial for balancing. The instrument is entirely self-contained, the battery being included within the cabinet.

NEW BODINE MOTORS FOR TELEVISION

The Bodine Electric Company, 2254 W. Ohio Street, Chicago, Ill., announce three new motors, Types TV-30, TV-20 and TV-12, to meet the demand of experimenters and manufacturers, for a reliable electric drive for television scanning discs.

The Bodine Television Motors provide unusual stability of speed, and yet with a suitable rheostat can be varied in speed 25 per cent above or below normal, thus enabling the scanning disc to be perfectly synchronized with the sending apparatus. As practically all television work is being



New Bodine Motor for television outfits.

done at 1080 R.P.M., these motors are designed to operate 18, 20 and 24-inch scanning discs at this speed. Although not an ordinary universal motor, the Bodine TV Motors can be operated on either alternating or direct current. This is accomplished by a special compensating winding. Rheostats and scanning discs are not furnished by the Bodine Electric Company.

NEW EBY ADAPTORS

A series of four and five prong adaptors suitable for connecting power audio amplifiers to the detector output of receivers, have been developed by the H. H. Eby Mfg.

Eby 4-prong adaptor.

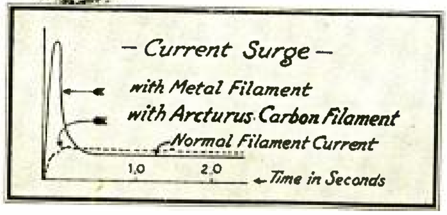
Co. of Philadelphia. These adaptors make possible the adaption of a power audio amplifier to either a four-prong or five-prong detector tube.

Eby 5-prong adaptor.

Such adaptors afford a decided convenience, since the 227 type detector tube requires a connection differing from that necessary for the four-prong tube.

AVERAGE LIFE OVER 2000 HOURS!

TESTS SHOW



Arcturus Tubes Immune To Line Surge

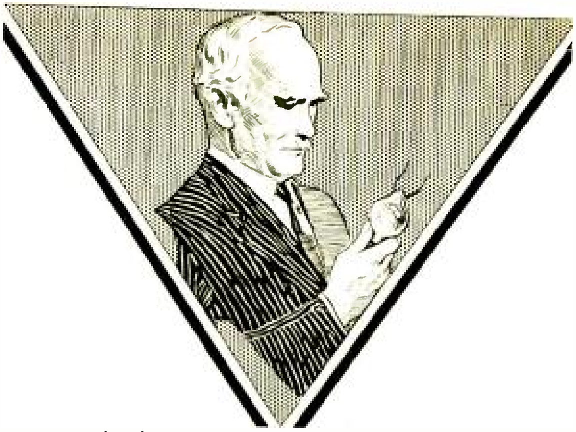
INVESTIGATION establishes that the majority of A-C tubes are destroyed by current surges set up as the voltage is applied. The extent of these surges is illustrated in the accompanying graph.

The probable life of a tube can only be determined by an intermittent life test in which the tube is turned on and off every hour or so, simulating normal operating conditions. A steady burning over a period of time is worthless. It is no indication of the performance of the tube under actual service (intermittent) conditions.

Under such tests Arcturus A-C Tubes, regardless of heater voltage, indicate an average life well in excess of 2,000 hours—a fact of interest to the engineer and of paramount importance to his ultimate judge, the broadcast listener! Arcturus Radio Company, 255 Sherman Avenue, Newark, New Jersey.

Engineering Facts Have A Utility Significance To The Ultimate Listeners

ARCTURUS
A-C LONG LIFE TUBES



ANOTHER ENGINEERING TRIUMPH

by Dr. Lee de Forest

NEW in design—NEW in construction, the NEW PERFECT De Forest Audions, have written a new page in radio history—of better vacuum tube performance—of more entertainment hours. ¶The new cathode design and construction of the AC 27 type asures 1000 hours of operation—establishing a new standard of operating life. ¶Write for technical data and curves on all types of De Forest Audions.

MANUFACTURERS, ENGINEERS

In order that we can give you the latest happenings in the industry in our several Departments, it is necessary that the Editor be supplied from time to time with news of *your* company. Such news as changes in personnel, address, etc.; new products or methods of manufacture is what *you yourself* are interested in: therefore, please cooperate with us and send us *your* news.

RADIO ENGINEERING
52 Vanderbilt Ave., New York City

POWER PLUS!

Giant Power Rheostat
Continuous Load Capacity of 75 Watts at 375 degrees Fahrenheit.

THE Centralab Giant Power Rheostat is as widely diversified in its application to difficult problems of heavy duty voltage control as it is efficient. The need for a unit of this type has been widely felt throughout the entire set building, experimental and amateur fields.

It is so mechanically constructed that it will carry a load without injury or break down up to the fusion point of the resistance wire. It is conservatively rated at 75 watts at 375 degrees Fahrenheit. This is ideal for such uses as primary line voltage control on any transformer used either for filament, plate or other power supply. In such a position it adjusts the secondary output to any desired potential.

Made with two or three terminals in resistances from 25 to 8000 ohms. May be had in the 5000 and 8000 ohm size with a fourth terminal for "B" eliminator control.

Priced very low. Wire or write specifications for your needs. Quotations and samples gladly furnished.

CENTRAL RADIO LABORATORIES
22 Keefe Ave., Milwaukee, Wis.

Centralab

Write Us Today

HY-WATT "Calorohm" Vitreous Enameled Resistors

are made in a wide range of resistance value and wattage ratings to fit every power supply need. These resistors are especially designed for heavy duty work.

HY-WATT Metallized Resistors

can be supplied in ohmages up to 10 megohms, and wattage ratings to 25 watts.

These units will dissipate their rated power without excessive heating or change in resistance value.

NOTE TO MANUFACTURERS: Special tapped resistors in either vitreous enameled or metallized types can be supplied on order to manufacturers only. In ordering please specify number of taps resistance per section and current drain.

Electro Motive Engineering Corp.
127 W. 17th St., New York

Quality Tells.

All the claims in the world do not affect the judgment of engineers.

. . . "it is specifically understood that you are authorized to use the endorsement of the BYRD ANTARTIC EXPEDITION" . . .

Richard Brophy
BUSINESS MANAGER

Dubilier

On the Byrd Antartic Expedition no chances could be taken with faulty condensers in their radio apparatus. It may be a question of life and death. The lines of communication *must* be kept open.

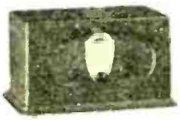
Dubilier Paper Condensers will do their part to bring the expedition to a successful termination.

Dubilier
CONDENSER CORPORATION
10 E. 43rd St. New York

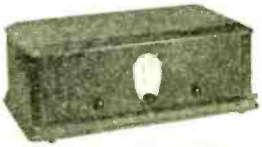
Standard

NATIONAL Velvet Vernier Dials

H. F. L. Isotone Set Equipped with NATIONAL Velvet Vernier Dials, High Frequency Laboratories, Chicago, Ill.



ACME AC—4
Acme Electric & Mfg. Co.
Cleveland, Ohio



AERO Seven-Twenty-Nine
Aero Products, Inc.
Chicago, Ill.

NATIONAL Velvet Vernier Dials

are Standard equipment with the following set manufacturers:

Acme Electric & Mfg. Co.
Atchison Manufacturing Co.
Colin B. Kennedy
Long Radio
Midwest Radio
Mission Bell Radio Mfg. Co.
Northland Mfg.
Patterson Radio Co.
Powrad, Inc.
Pioneer Radio Corp.
Smith Leonard

NATIONAL Velvet Vernier Dials

are specified by the following part manufacturers for use with their circuits:

Aero Products, Inc.
Ferranti, Inc.
The George W. Walker Co.—*Victoreen*
Haldorsen Co.
High Frequency Laboratories
Radio Construction Corp.
Scott Transformer Co.
Silver-Marshall, Inc.
Ultradyne Sales Co.

NATIONAL Velvet Vernier Dials

are no longer specialties in Radio—they are staples, of known, definite high quality—always the same, always good.

Send for Bulletin 130 R E

NATIONAL

RADIO PRODUCTS

NATIONAL · CO · INC · W · A · READY · PRES · MALDEN · MASS ·

Exclusively Licensed by Technidyne Corporation Under U. S. Patent No. 1593658

Volume that Satisfies!

A Complete Line of Volume Controls

TONATROL

Trade-Mark

SMOOTH, gradual control of intensity under all conditions will be your reward if you incorporate the Tonatrol Volume Control in your receiver. Tonatrols are variable resistors of the famous Royalty type, especially designed with the requirements of different circuits in mind. Furnished in standard types or with battery switch or power switch attached. From $1.50 to $3.00.

Electrad specializes in a full line of Controls for all Radio Purposes, including Television.

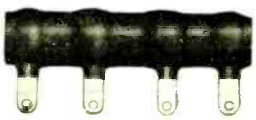
Write for your FREE Hook-Up Circulars

Dept. L-10
175 Varick Street
New York

ELECTRAD Inc.

L. M. C. RESISTORS

Vitreous Enameled *Wire Wound*



The wide acceptance and increasing use of "L.M.C." RESISTORS by the electrical and radio industry is attributable directly to the following facts—

We are not merely assemblers.
We are Metallurgists, making our own Alloys.
We are Ceramists, making our own Enamels.
We are Electrical Engineers, prepared to work out any problems pertaining to controlling devices.
We know there are other good resistors on the market, but invite manufacturers to judge the "L.M.C."
Our engineering department is at your service.
Send in your problems.
In fairness to yourself, let us quote on your requirements and send you samples.

LAUTZ MANUFACTURING COMPANY, Inc.
Electrical Alloy Products—Controlling Devices
245 N. J. R. R. Ave. Newark, N. J.

CONDENSERS · RESISTANCES

POTENTIOMETERS · PLUGS — RHEOSTATS · MOUNTINGS

One of the Polymet Products—the Filter Block Assembly. Made well, looks well, functions well. Ask for the Polymet Catalogue showing the complete line of Polymet Products.

Polymet TRADE MARK

It is in the Polymet factory that the radio industry's confidence in Polymet Products is built.

Tolerances are carefully set and rigidly adhered to. Precision machinery and inspection of the strictest, safeguard Polymet's reputation for dependable, high quality, power supply parts.

POLYMET MANUFACTURING CORP.
601 Broadway New York City

POLYMET PRODUCTS

The Best that Money can Buy

goes into Har-Field Resistors. Best both in brains and materials. That's why Har-Field Resistors are so uniformly accurate—why they bear our unqualified guarantee for one year—why more and more of the leading manufacturers are buying them in large quantities for use with their own apparatus. A few of the more prominent we list below.

Western Union Telegraph Co.	Stromberg-Carlson Tel. Mfg. Co.
A. H. Grebe & Company	Kolster Radio Corporation
Splitdorf Electric Co.	American Transformer Co.
Magnavox Corporation	Fansteel Products Co.
Electrical Research Lab's	Martin Copeland Co.
Samson Electric Co.	Zenith Radio Corporation
Philadelphia Storage Bat. Co.	Crosley Radio Corporation

Tell us about the resistor you want. If we can't supply you from our standard range of sizes, we shall be glad to make up samples for you with prices. Write to

HARDWICK, FIELD, INC.

Sales Office: 122 Greenwich Street, New York City.

HAR-FIELD WIRE-WOUND RESISTORS

Factory: 215 Emmet Street, Newark, N. J.

AMERTRAN

Completely wired Push-Pull Power Stage

HANDLES ample power to faithfully reproduce full frequency range without tube overloading. Eliminates hum caused by raw AC on filaments of Power Tubes. Increases clarity, reality and volume.

AmerTran gives you a unit in 4 types designed for practically any combination of speakers [including the new dynamic types], and power tubes. For complete information see any authorized AmerTran dealer or write to us direct, mentioning the speaker and tubes you intend using.

Price completely wired and ready to install in set $36.00 without tubes.

Licensed under Patents owned or controlled by R. C. A. and may be bought with tubes

AMERICAN TRANSFORMER CO.
186 Emmet St., Newark, N. J.
Transformer Builders for over 28 years

--POWER TRANSFORMERS--
for the UX 250 Power Tube

TYPE 565-A TRANSFORMER
(200 watts)

Price $13.50

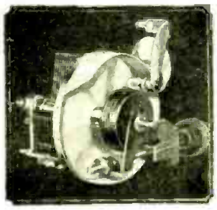
The General Radio Type 565 Power Transformers consist of two models for both half and full-wave rectification utilizing the 281 type of rectifier tube. The Type 565-A Half-Wave Transformer illustrated consists of one 600-volt secondary, two secondaries of 7.5 volts and one of 2.5 volts. It is designed for 105 to 125-volt, 50 to 60-cycle lines.

Bulletin No. 931 will be sent on request.

GENERAL RADIO CO.
30 STATE ST., CAMBRIDGE, MASS.
274 Brannan St., San Francisco, Calif.

The DIAL of Dials!

FRONT



BACK

Unusual beauty in front—a perfect mechanism back of the panel. Embossed bronze escutcheon. Illuminated scale. Knob-control can be placed in any position for balance. Driven by a silk and linen cable, which in laboratory tests has withstood ten years of normal use. No backlash or lost motion. The DIAL of dials—nationally advertised. Put it on your receiver.

HAMMARLUND MANUFACTURING CO.,
424-438 W. 33rd St., New York

For Better Radio
Hammarlund
PRECISION
PRODUCTS

Specify **Belden**

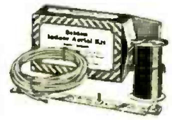
High Quality Radio Products
that are the choice of experienced set builders

Beldenamel Aerial Kit
R. M. A. Standard

A complete aerial kit that contains every item essential to an efficient outdoor antenna system, such as aerial, ground and lead-in wires, lightning arrester, lead-in strip, ground clamp, glass insulators, nail-on knobs, etc. The Beldenamel Aerial Wire cannot corrode in service. The Beldenamel Jr. Aerial Kit, Belden Bare Copper Aerial Kit, and Belden Jr. Bare Copper Aerial Kit are also furnished for your particular needs.

Belden Indoor Aerial Kit

An ideal assortment for an indoor aerial, containing aerial wire, ground wire, ground clamp and instruction sheet. The neutral brown braid on the aerial wire is easily concealed on the moulding or around a window frame.



Belden Colorubber Hookup Wire

Ideal for set hookups and wiring. Flexible and easily fitted. Different colored rubber insulations make circuit wiring easier. Tinned stranded wire and cotton serve under Colorubber keep wire free from rubber and make stripping and soldering easy.

Belden Radio Battery Cords

Consist of Colorubber insulated conductors inside overall braid of brown cotton. Conductors are coded R. M. A. Standard colors. Soldered ends suitable for any binding post, 54-inch length. Furnished with 5, 7, or 9 conductors.

Ask to see the New Belden Speaker Extension Floor Cord that lies flat on the floor under the rug.

Get them from your dealer!

Belden Manufacturing Company
2302-A S. Western Ave.
Chicago, Ill.

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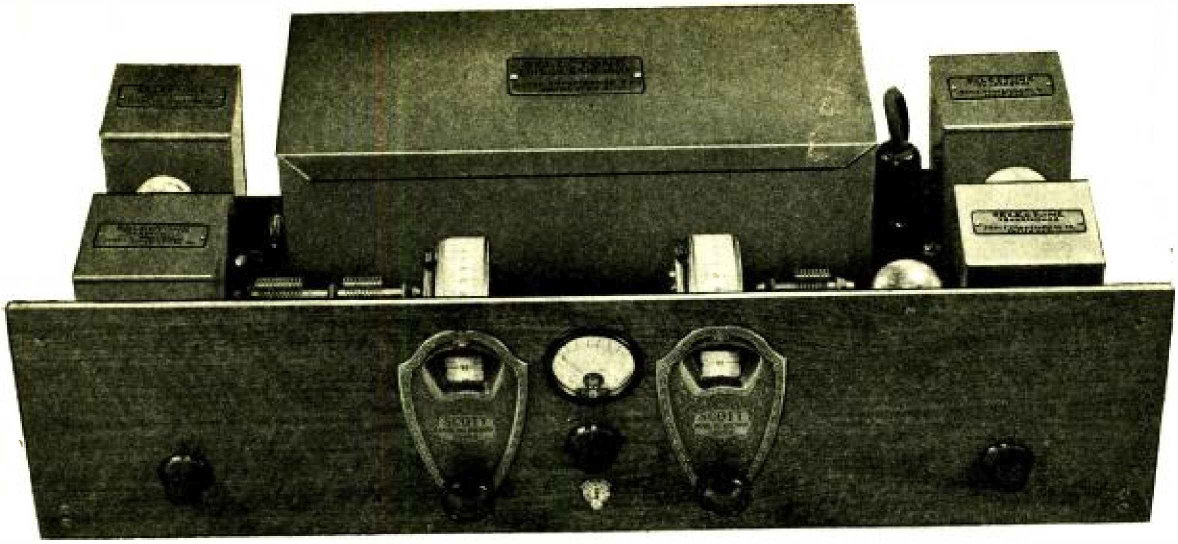


The NEW Scott Shield Grid 9

Radios Most Powerful Receiver

FOR those who want radio reception at its highest development, this is the set to build! Even more powerful than the preceding Scott receivers that established four world's records for DX reception. More selective. More superbly toned!

In range, the new Scott Shield Grid Nine is practically *unlimited*—the only range limit being the atmospheric noise level.

New shield grid tubes in improved circuit

The *new* Scott uses shield grid tubes in an improved circuit with *new* power pack and amplifier. Through the greater efficiency of the new tubes and circuit, many times the amplification obtainable with the ordinary circuit using 201A tubes is secured. The Scott Power Pack and Amplifier makes it possible to obtain enormous volume—yet so completely is this volume under control that the simple turning of one knob covers the entire range from merest whisper to full auditorium volume.

A new perfection in matching of parts

Not only is the Scott Receiver new in design, but it represents new ideals in accuracy of radio building. All parts are designed especially for this set and are *matched* with absolute precision. The extreme care taken in testing and matching the transformers is one of the reasons why the *new* Scott out-performs in competitive tests of distance and volume.

Maximum efficiency from highest to lowest wavelengths

Transformers as well as tubes are perfectly Shielded in the *new* Scott. The efficiency of the R.F. stage ahead of the first detector is increased through the use of a special Selectone Two-Gang Condenser and regeneration in the first detector. The Two-Gang Condenser matches the inductances of the antenna and R.F. coils so perfectly that they line up throughout the entire scale, affording *razor-edge* selectivity with maximum amplification from the lowest to the highest wavelengths.

One spot reception

All stations come in at one point only on the dial in this "one spot" super. A further improvement is evidenced in the fact that both dials track practically together—making tuning particularly easy.

Costs little to operate

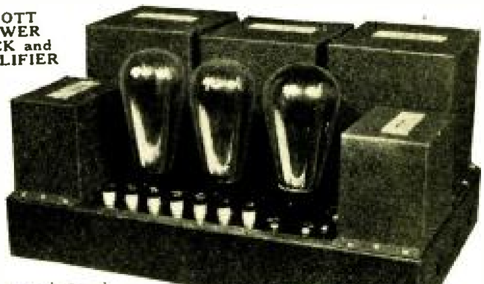
The Scott Shield Grid Nine can be economically operated with dry batteries if desired and will give ample volume for the average home. The eight tubes incorporated in the receiver draw only 29 mils. Maximum volume is obtained by the use of the Scott Power Pack and Amplifier, incorporating the ninth tube for the second stage of audio. This is the latest 250 power tube giving tremendous volume with perfect tone quality.

Build in four hours—RESULTS GUARANTEED

New and highly developed as the Scott receiver is, anyone can build it—*easily* and in four hours. Panel and sub-panel are drilled to receive each part; and the shielded grid amplifier unit comes fully tested and wired, ready for hook-up into the circuit. No adjustments whatever are needed. No chance for errors in the assembly.

We guarantee that you will get the same results we obtain from our laboratory models.

SCOTT POWER PACK and AMPLIFIER



Especially designed to supply B current for the new Scott set. Incorporates the second stage of audio, using 250 power tube.

SCOTT TRANSFORMER COMPANY
4458 Ravenswood Ave. Chicago, Ill.

FREE Circuit Diagram and Particulars

Write at once for particulars! Get the facts about this amazing new world's record set—its low cost—limitless range—tremendous power—10 kilocycle selectivity. Build this set *now* and enjoy radio at its best! FREE circuit diagram. Also copies of 6000 and 9000 mile reception verifications. Write today. NOW!

SET BUILDERS! We offer an unusual business building plan that will triple your custom set business. Ask your jobber. Or write us direct today.

Clip this and mail today

SCOTT TRANSFORMER CO.
4458 Ravenswood Ave., Chicago, Ill.

Please send me FREE circuit diagram, records, and full particulars of the new Scott Shield Grid Nine.

( ) I am interested in your proposition to professional set builders.

Name ....

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Town .... State ....

Williams Press, Inc., New York—Albany

QUALITY DONGAN PRODUCTS

If It's Sponsored by Dongan

The radio trade—manufacturers, jobbers and fans—have learned they can expect permanency of any new idea or design that is sponsored by Dongan. Keen judgment of trained and experienced engineers is required to select the real, constructive ideas from the myriads offered to the radio industry each year. It is through the acceptance and furthering of these ideas that such giant strides have been made.

As an exclusive specialist in parts engineering and manufacturing, Dongan, for years, has occupied a key position in the industry. New tubes, new hook-ups—new ideas by the hundred—come to Dongan for consideration. Every single idea then runs the gauntlet of Dongan's laboratory experiments; those meriting further trial are subjected to every test. Only when finally approved by the chief engineer is a new design offered to the market—a finished product.

If it's sponsored by Dongan it's O K

ONE OF THE MOST SUCCESSFUL DEVELOPMENTS OF 1928

Power Amplifiers Built Around UX 250 TUBES

The following are Approved Dongan Parts for use with UX 250 tubes:

No. 7568—Transformer for full wave rectification using 2 UX 281 tubes to supply B and C power to receiver and power for 2 UX 250 tubes	**$13.50**
No. 8529—Transformer similar to No. 7568 with the addition of 2 low voltage windings, one for 226 tubes and the other for 227 tubes so that you can build a power amplifier for either radio receiver or phonograph pick-up	**$16.50**
No. 6551—Double Choke, for use with above transformers	**$15.00**
D-600—Power Amplifier Condenser Unit	**$16.50**
D-307—A Condenser Block, used in connection with D-600	**$10.00**
No. 1177—Straight Power Amplifier Output Transformer	**$12.00**
No. 1176—Same as No. 1177 but of Push Pull type	**$12.00**

Custom Set Builders *can secure any of these items direct from factory at trade discounts.*
Set Manufacturers *are offered the full cooperation of Dongan engineering department for their individual requirements.*

DONGAN ELECTRIC MANUFACTURING COMPANY
2995-3001 Franklin St.,
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