OCTOBER, 1934

Radio Engineering

DESIGN • PRODUCTION • ENGINEERING

- Broadcast Receivers
- Auto-Radio Receivers
- Electric Phonographs
- Sound Recorders
- Sound Projectors
- Audio Amplifiers
- P-A Equipment
- Electronic Control Devices
- Testing and Measuring Equipment
- Television Apparatus
- Loudspeakers
- Components
- Tubes
- Photocells

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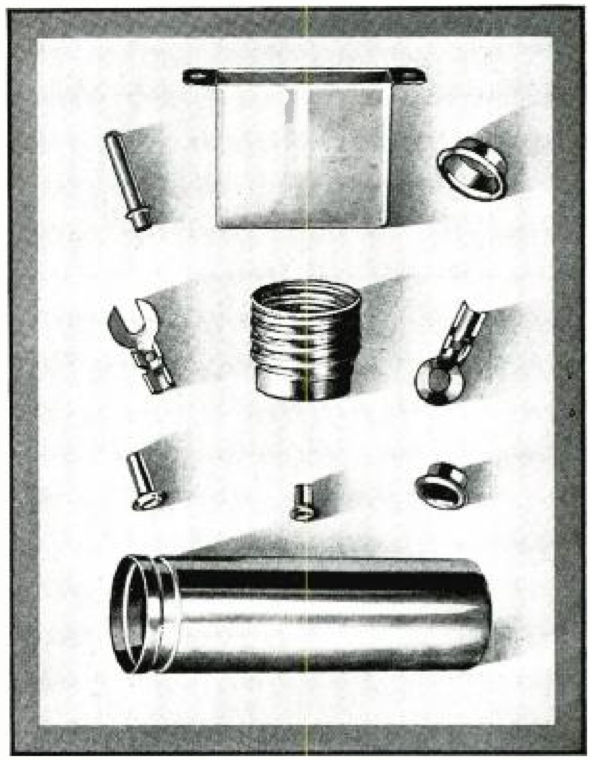

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EDITORIAL

SOUND EFFECTS

RECEIVER MANUFACTURERS have been seeking justification for a high-priced set. Many are of the opinion that "high fidelity" is the answer, whereas others feel that improved quality alone is not sufficient to move high priced receivers—the public being as it is.

More than likely the sale of high-fidelity receivers will not reach any great proportions for a while to come. The radio listener is not as yet "quality conscious" and until such time as it is possible to carry on an effective industry campaign, with the purpose of educating the public to quality standards of reception, little can be expected.

It will be no easy matter to create a taste for quality reception. The present state of affairs may be likened to the problem faced by the wine growers who, much to their grief, have learned that the average American has no taste for fine wines. It is their task to see that a taste is developed, that the American shall learn to appreciate delicate flavors. That will not be easy, for the majority of the American palates have been coarsened by strong drink to the point where the appreciation of delicate sensations is next to impossible.

Much the same thing has happened to the Great American Ear. It is, alas, used to "radio music" and, having become used to it, likes it tremendously.

It does not take one very long to acquire a taste for olives. A confirmed gin drinker can, after a few doses of fine wine, pass through the same delightful experiences as a connoisseur, particularly if he is put through the paces by one who can select properly. The feat can be accomplished most rapidly by introducing the student to one of the more vital wines which ordinarily carries a punch along with the thrill.

If the public is ever to appreciate high-fidelity reception, a similar lesson will have to be given. The introduction to this new phase of reproduction should also contain a punch along with the thrill. We mean by this that the matter of quality reception should be carried much further than it has been, with attempts made to incorporate the other two essentials; namely, volume range and auditory perspective.

The volume range of the average transmitted program is about 40 db, which is equivalent to the volume range of speech. The volume range of an orchestra is 70 db—much beyond reproduction in broadcast practice. The receiver, therefore, is capable of presenting a naturalness to speech, but falls short of presenting the same naturalness to orchestral music.

The volume range could be extended considerably, and with little added expense, if broadcast stations were to employ volume-range contractors and receivers were equipped with volume-range expanders. Systems of this sort have been suggested and certainly should be given trial over an extended period to determine their effectiveness.

Auditory perspective is a tougher nut to crack. Artificial systems at the receiver to simulate perspective, such as high- and low-frequency filtered loudspeakers set apart in the room, could not be expected to accomplish much. In the case of a dialogue between a man and woman, a sense of separation would not be apparent to the listener since there is practically no difference in the frequency range of the male and female voice—the ranges being 120 to 8,000 cycles and 200 to 9,000 cycles respectively. The frequency separation afforded by the combination would, on the other hand, be undesirable in the case of musical renditions and would probably produce some rather droll effects.

True auditory perspective appears to be the only satisfactory answer. Fortunately, two broadcast channels are not necessary to accomplish the purpose. The binaural effect may be obtained on a single carrier frequency by the separate modulation of the two sidebands (Patent No. 1,717,064). The additional equipment required at the transmitter would be comparatively inexpensive.

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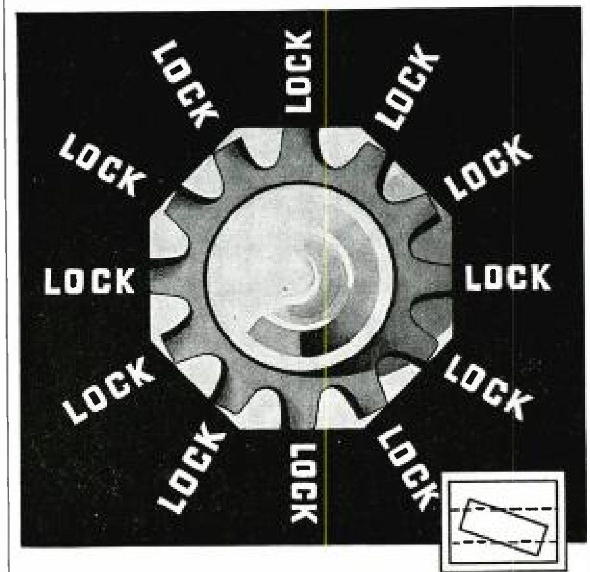

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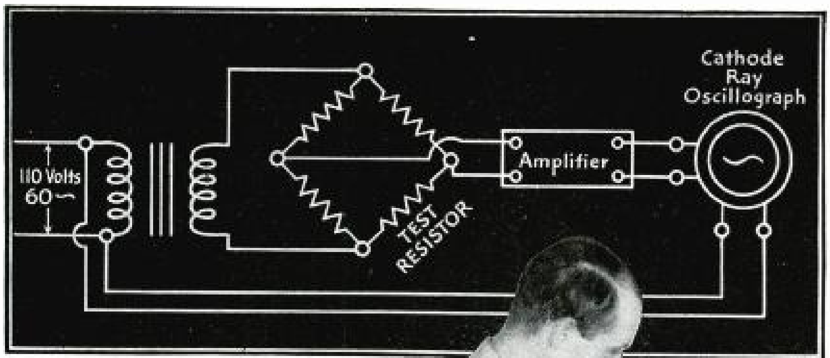

The oscillograms shown below were made with a cathode ray oscillograph. The circuit diagram is shown at the left. Constant test conditions were maintained for the three tests, the only change being the insertion of test units of identical resistance in the arm of the bridge marked "test resistor."

VOLTAGE CHARACTERISTIC TESTS

—that reveal the inherent superiority of Allen-Bradley Radio Resistors

Actual Oscillograms

The following oscillograms, produced with a cathode ray oscillograph, show graphically the superiority of Allen-Bradley fixed resistors over ordinary resistance units. All tests were made under identical conditions of resistance, voltage, amplification, etc.

No. 1 — This oscillogram shows the constancy of resistance with varying potentials across the terminals of a wire-wound type of resistor, using an alternating E.M.F. Note how closely oscillogram No. 3 of an Allen-Bradley resistor approximates this performance.

No. 2 — This oscillogram shows the wide changes of resistance with variations in voltage obtained in testing an average composition unit; note how inferior is its performance when compared with the Allen-Bradley fixed resistor as shown in oscillogram No. 3.

No. 3 — This oscillogram shows the small variation of resistance with varying voltage with an Allen-Bradley composition fixed resistor when an alternating E.M.F. is applied. Note how closely the Allen-Bradley resistor approximates the performance of a wire-wound resistor.

Allen-Bradley radio resistors have an exceptionally low voltage coefficient. As every radio engineer knows, if the inspection tests of suppliers and users of radio resistors are made with differing potentials across the resistors, wide discrepancies occur unless the units under test possess low voltage characteristics. Allen-Bradley resistors, of the order of 1 megohm, show variations in resistance of not more than 1½% between the zero voltage and the maximum or peak voltage of the cycle, whereas average resistors of the same resistance show changes exceeding 2½ times the Allen-Bradley values.

What LOW Voltage Coefficients mean to your receivers . . . . .

A low voltage characteristic reflects the inherent quality of the fixed resistor and is an indication of the stability of resistance with age. It usually indicates a minimum of microphonic disturbance, a factor of increasing importance in high fidelity receivers.

In applications where large audio voltages exist across resistors, it is necessary that the resistors have low voltage characteristics to minimize the introduction of harmonics which result from the variation of resistance under varying audio voltages. For the best performance of your receivers, specify Allen-Bradley fixed resistors.

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RADIO ENGINEERING

FOR OCTOBER, 1934

Selectivity Measurements

A COMMON SOURCE OF ERROR IN MEASUREMENTS OF RECEIVER SELECTIVITY*

By EDWARD N. DINGLEY, Jr.

Bureau of Engineering

U. S. NAVY DEPARTMENT

ABSTRACT: Receiver selectivity is usually determined by measuring the amplitude of the input signal, at resonance and at various percentages off resonance, required to maintain a constant audio output. The audio output contains a certain amount of noise resulting from thermal agitation (so-called "first circuit noise"). The presence of the input signal causes an increase in noise output, the amount of increase being variable and dependent upon the frequency of the input signal in relation to the resonant frequency of the receiver. If, in measuring selectivity, the total audio output is maintained constant, then the signal component of the output is variable and the selectivity so obtained may have considerable error. This error may be eliminated by requiring the input signal to maintain a constant increment of final detector dc plate current rather than a constant audio output.

THERE SEEMS TO BE, at present, no one standardized procedure rigidly applicable to the selectivity measurement of all types of radio receivers, except that in general the volume control is set at some arbitrary position and there is applied to the receiver input terminals a modulated resonant-frequency signal of sufficient amplitude to produce an arbitrary "standard audio output." The frequency of the input signal is then changed consecutively to other frequencies which differ from the resonant frequency by given percentages, and there is recorded the amplitude of the input signal required, at each of these frequencies, to maintain a constant audio output.

AUDIO-OUTPUT STANDARDS

In the case of broadcast receivers, the Institute of Radio Engineers has adopted a "standard audio output" of 50 milliwatts. In the case of the so-called "code receivers," there are at least two "standard audio outputs," one of 5 milliwatts and one of 6 milliwatts; there are probably others.

As for the setting of the volume control, one laboratory specifies (for code receivers) that with no input signal, the volume control shall be set at full volume unless the resulting audio output, consisting of receiver noise, exceeds 0.6 milliwatt, in which case the output volume shall be reduced to this level. The specifications of another laboratory are the same except that the maximum noise output is 0.5 milliwatt. The Institute specifies no standard volume-control setting.

In making receiver selectivity measurements, it is of considerable importance that the setting of the volume control should be not only specified, but also standardized, for the reason that if the volume control varies the transconductance of the radio-frequency amplifier tubes, it likewise varies the apparent selectivity of the tuned circuits coupled to such tubes; and also for the reason that the volume-control setting determines the ratio of the amplitudes of signal and noise voltages impressed on the grid of the final detector under the condition of constant signal-plus-noise audio output. The first named action of the volume control is well recognized; the second is considered in the following paragraphs.

THERMAL-AGITATION VOLTAGES

Consider the conductors which comprise the coils and connections of each tuned circuit of a receiver. As a result of thermal agitation, there appear in these conductors minute voltages of all conceivable frequencies. Each of these thermal-agitation voltages will produce a current flow through the series circuit comprising the coil and its tuning capacitor. Those thermal-agitation currents whose frequencies are at and near the resonant frequency of the tuned circuit will be much larger than the currents of other frequencies and they will produce much larger voltages across the tuning capacitor than will the currents of other frequencies. By this hypothesis, the total thermal-agitation voltage existing across any tuning capacitor, as the result of thermal-agitation voltages generated within its own circuit, may be represented by a resonance curve of that tuned circuit; the area of the curve being completely filled with voltage ordinates of all frequencies represented by the limits of the abscissa.

The first r-f tube, of the average receiver, has its grid and cathode bridged across the tuning capacitor of such a circuit; consequently, each thermal-agitation voltage existing across the tuning capacitor is amplified by this first tube and delivered to the grid circuit of the following tube, but the amplification of each voltage depends upon its frequency relationship to the resonant frequency of the tuned circuits which couple the plate of the first tube to the grid of the second tube.

VOLTAGE RELATIONSHIPS

The thermal-agitation voltages originating in the tuned circuit between the first and second tubes will be identical

* Paper delivered at the Ninth Annual Convention of the Institute of Radio Engineers.

with those originating in the first tuned circuit, but will be small compared to the voltages delivered to the second tuned circuit from the first circuit after amplification by the first tube. Assuming that the effect of thermal-agitation voltages arising in later circuits is negligible compared to the effect of those arising in the first circuit, it may be stated that the receiver noise output due to so-called "first circuit noise" is produced by a series of alternating voltages impinging on the grid of the final detector and that these voltages may be represented by an over-all receiver resonance curve, the area of which is completely filled with voltage ordinates of all frequencies represented by the limits of the abscissa. The noise contribution of the tubes themselves and of the subsequent tuned circuits will little change the picture.

Assuming that the final detector is essentially a square-law device, these agitation voltages impressed on its grid will produce the following currents in its plate circuit:

Group A. Currents having like frequencies and amplitudes proportional to each grid voltage.

Group B. Currents having double frequencies and amplitudes proportional to the square of each grid voltage.

Group C. Currents having frequencies equal to the sum of each grid-voltage frequency added to each of the other grid-voltage frequencies, and amplitudes proportional to the product of each two voltages so combined.

Group D. Currents having frequencies equal to the difference of each grid-voltage frequency subtracted from each of the other grid-voltage frequencies, and amplitudes proportional to the product of each two voltages so combined.

Group E. Direct currents, each having an amplitude proportional to the square of each grid voltage. These currents add algebraically to produce a total increment of dc plate current proportional to the sum of the squares of all of the grid voltages.

R-F AND A-F CURRENTS

The first circuit thermal-agitation voltages reaching the grid of the final detector are radio frequencies so that the detector output currents of Groups A, B and C will also be radio frequencies which cannot be amplified by the audio system, *but* the detector output currents of Group D consist of all conceivable audio frequencies, some of which are amplified by the audio system to a greater degree than others.

Of the thermal-agitation voltages on the grid of the final detector, those whose frequencies lie close together near the peak of the receiver over-all resonance curve will have the greatest amplitudes and detector plate currents proportional to the products of their amplitudes will be larger than any others, but the Group D frequencies of these plate currents will be very low because of the small frequency separation of the voltages under discussion. A thermal-agitation voltage at the center of the over-all resonance curve beating with one further removed from resonance will produce a higher frequency detector plate current but its amplitude will be less because the amplitude of the further removed grid voltage is less. A detector plate current of any one frequency is produced by the beating together of many grid voltages, each one separated from its partner by a frequency difference equal to the audio frequency under discussion, and the resultant plate current of that frequency is the vector sum of the individual plate currents of the same frequency.

In general, the Group D detector plate current consists of a series of all conceivable audio frequencies, the lowest frequencies having the greatest amplitudes and each higher frequency having a lesser amplitude. The audio amplifier, however, will not amplify the lowest frequencies nor will it amplify the highest frequencies, and consequently the audio output of the receiver depends not only on the detector plate currents of Group D but also on the fidelity; i.e., selectivity, of the audio system.

INCREASED NOISE OUTPUT

With these facts in mind, suppose that a receiver is adjusted so that its audio noise output, resulting from first circuit thermal-agitation, is 0.5 milliwatt as read by a root-mean-square milliwattmeter. (In passing, it is well to note that rectox voltmeters calibrated in milliwatts seldom read the true power of distorted waves). Then suppose that an unmodulated signal is applied to the receiver input terminals and suppose it to have a frequency and phase identical with the thermal-agitation voltage at the center of the receiver over-all resonance curve. Then those components of all the detector plate current frequencies which resulted from the beating of this agitation voltage with all the other agitation voltages will be increased by an amount proportional to the effective increase of this agitation voltage, and because many of these detector plate current frequencies lie within the amplification range of the audio system, there will be a resultant increase of noise output.

EFFECT OF OFF-RESONANCE SIGNAL

If, on the other hand, there is introduced an unmodulated input signal whose amplitude, upon reaching the grid of the final detector, is the same as before, but whose frequency places it far to one side of the receiver over-all resonance curve, then those components of the detector plate current frequencies which resulted from the beating of all the other agitation voltages with the agitation voltage which this carrier increases in amplitude, will be also increased by an amount proportional to the effective increase of this agitation voltage. But those detector plate currents whose amplitudes are thus increased may have frequencies above the amplification range of the audio system and consequently there will be no increase in audio noise output resulting from the introduction of this off-resonance unmodulated carrier.

CONFIRMATION BY TEST

If the resonant input signal is modulated, the increase in noise output caused by the carrier may completely mask the presence of the modulation frequency. This fact is well illustrated by the test of a certain receiver wherein the volume control was adjusted to produce a noise output of 0.5 mw and then there was applied a 30 per cent modulated resonant input signal of sufficient amplitude to produce a signal-plus-noise output of 5 milliwatts. Upon removing the modulation but leaving the carrier amplitude fixed, the audio output dropped not to the original 0.5 milliwatt, but to 4 milliwatts. Upon making the same test at a frequency 2 percent above resonant frequency, the audio output dropped from 5 milliwatts to 0.6 milliwatt.

From the foregoing test, it is evident, that the amplitude of the input signal at resonance was not as large as would have been required had the noise level not increased, while the input signal at 2 percent off resonance was very near its true value because the noise level was not appreciably increased at that frequency.

If there had been no increase of noise output when the resonant input signal was applied, there would have been required an input signal about twice as large in order to produce the standard 5-milliwatt output and, consequently, the selectivity of the receiver at 2 percent off resonance as measured by the "constant audio output" method, appears to be about twice as great as the true selectivity.

MAKING MEASUREMENTS

If a true root-mean-square milliwattmeter is available, it might be proposed to increase the input signal until the act of modulating this carrier causes a 5-milliwatt increase in the total audio output. This method is not usually acceptable because the total audio output is so greatly increased as to possibly overload the audio system and, further-

(*Continued on page* 24)

Pre-Amplifier Design

By HUBERT L. SHORTT
Chief Engineer
WHOLESALE RADIO SERVICE CO., INC.

● This article deals with the findings of a research into the design of a wide-range, high-gain pre-amplifier for all ac operation. The author has interpreted each design step

THE ADVANTAGES of all ac operation for high-gain pre-amplifiers intended particularly for condenser and ribbon microphones are so obvious that it is hardly necessary to dilate on them. It was, therefore, with considerable interest that the writer and members of his staff specializing in p-a amplifiers read a recent article in a contemporary publication dealing with this very subject.

The author of the article discussed the problem of hum in a rather nonchalant manner and created the general impression that the design and construction of such amplifiers really wasn't as difficult a job as many engineers seem to think. He showed a number of amplifier circuits using various sequences of tubes, with resistance-capacity and transformer interstage coupling and combinations of these.

POINTS OF DESIGN LISTED

The eight important points of design to be religiously followed were stated as follows:

(1). 57 tubes, in triode connection.

(2). Heater connections in lead cable on the under side of a copper chassis.

(3). All grid connections above chassis and completely isolated from heater connections.

(4). Bias resistors shunted by 25-mfd or larger electrolytic condensers to reduce degeneration on low frequencies.

(5). Amplifier completely enclosed in a copper case.

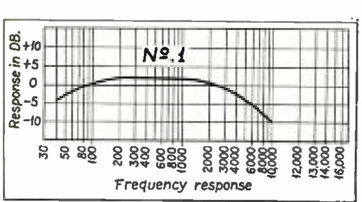
(6). Input completely shielded connecting to completely shielded microphone.

(7). Heater and high-voltage supply isolated from amplifier (3 ft. or more) and feeding through shielded cable.

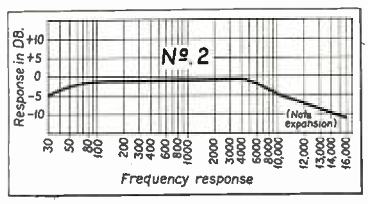
(8). Completely filtered high-voltage supply.

PRE-AMPLIFIER REQUIREMENTS

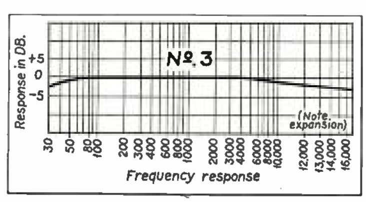
As the present writer happened to be right in the middle of a perplexing design job on a high-gain, high-fidelity pre-amplifier just at the time this article appeared, he thought he would save himself a lot of work by applying the data given in such conclusive fashion. The sales department wanted a unit with these features: (1) ac-operated; (2) hum-free; (3) work with a power amplifier of 70 db gain or more; (4) be capable of raising level of velocity microphone to at least that of a carbon mike; (5) have a frequency response as flat as possible and preferably at least equal to that of the velocity mike itself. Even if the first four requirements were met the last was a big one all alone, so the aforementioned article was read and re-read for all the assistance it could give.



Frequency curve of pre-amplifier with 79 triodes and ordinary transformers.



Frequency curve of pre-amplifier with 6C6 pentode and 6C6 triode connection, and ordinary transformers.



Frequency curve of pre-amplifier with special transformers.

TRIAL CIRCUIT

Accordingly, the simple circuit of Fig. 1 was selected as a starter and carefully constructed of the best available parts. The 57's were used as triodes, as recommended. An audio oscillator was used for input. The output was coupled through a 200-ohm line to a 15-watt amplifier having a gain of 70 db, the output of the latter in turn working into a high-quality dynamic speaker.

The residual hum produced by the combination was enough to completely overshadow the oscillator input. The conclusion was drawn that a gross error had been made somewhere in the wiring, but repeated checking by different people revealed nothing.

At about this time the sales department started making the usual wisecracks about the engineering ability of the engineering staff (what would we ever do without the prodding of the dear, old sales department?), so all efforts toward the elimination of the hum were doubled and Army cots and coffee percolators were requisitioned. As the final curves involved some ideas not previously described, other engineers faced with similar problems will undoubtedly like to learn about them.

POSSIBLE REASONS FOR HUM

The possible reasons for hum were listed as follows:

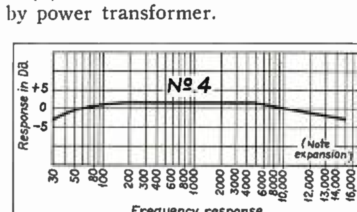
(1). Ripple from high-voltage plate supply.

(2). Hum induced in cathode by heater.

(3). Inductive pick-up by leads.

(4). Inductive pick-up by input and output transformers.

(5). Static hum induced into chassis by power transformer.



Response of entire system illustrated in Fig. 3 and Fig. 4.

To determine the extent of (1) and (2), batteries were substituted for the heater and plate supplies, and surprisingly enough the hum dropped only about one-half. It was evident, then, that (3) and (4) would need a lot of investigation.

After attempts to isolate the amplifier from all existing wiring by actually mounting it in a cast, high-permeability case ¼-inch thick, and also shielding all input and both plate and grid leads, it was found that the hum was still too high for practical purposes. (Battery supply still used.) Shielding alone obviously was not sufficient.

TRANSFORMER DESIGN

As a remedy, hum cancellation right in the transformers themselves was suggested, the shielding of a case alone not being adequate with the amplifier working at the necessarily high gain expected of it. A lot of money was spent on experimental designs, and the final transformers were made with symmetrical primaries and secondaries poled in such a manner that externally induced emf's cancel out in the windings while the primaries continue to induce properly in the secondaries because of their correct phase relationships. As an added measure of protection, the cases of these special transformers were made of special iron having five times the permeability of ordinary stamped sheet iron cases.

When these input and output transformers were installed (batteries still used, remember), the hum dropped to a negligible level, proving conclusively that cause (4), formerly so troublesome, was now overcome.

When ac supply was reconnected to the unit, the hum level came up again, but this time to only about half the level of the first test. Was the hum due to high voltage ripple or cathode modulation by the heater? Juggling of power supplies showed that the heater hum, while appreciable, was small compared to the effect of the rectified plate supply, yet any amount of filter up to 100-mfd of condensers and five or six heavy chokes did not reduce the hum a bit and was no better than the simple three-step brute-force filter used in the final amplifier.

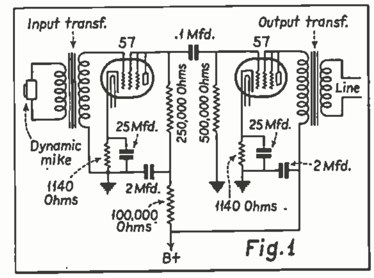
STATIC HUM

It became evident that while the hum was induced by the high-voltage supply it was not due to ripple voltage, and therefore it was static hum of one sort or another. The primary and the high-voltage secondary of the power transformer were separated by the usual static shield, so it was reasonable to believe that static emf from the primary would not be impressed on the secondary independently of the straight phenomenon of electro-magnetic induction. It was therefore assumed that any form of static emf in the *other* windings must come from the high-voltage winding, a reasonable assumption because the high voltages developed are *high*, after all. It might be possible for this winding to induce a static emf in the filament winding, for instance, the hum thus riding into the amplifier by way of the whole filament circuit. There was also a possibility of static emf's being established in the chassis by this route because of differences of impedance between various grounded points. A similar action takes place in some types of multi-stage r-f amplifiers and is well known. Even the slightest hum is so aggravating with a high-gain amplifier system that no possibility could be overlooked.

A special transformer was made with all the windings electro-statically shielded from each other. When this was installed in place of the previous unit about 90 percent of the remaining hum disappeared—a most gratifying result that called for more coffee, this time with cream, not black!

HEATER-CATHODE HUM

The remaining hum was definitely heater-cathode hum, and its elimination was merely a matter of tube choice.



Circuit of the experimental set-up, based on previously printed data.

Hundreds of tubes of all standard makes were tried. Although the article mentioned earlier in this paper favored the 57, this type was found to be exceeded only by the 77 for noise. It was finally found that the type 6C6 was by far the quietest. This can be attributed to production accuracy rather than to design. Tube manufacturers who were contacted furnished selected tubes that were quite satisfactory.

PRE-AMPLIFIER GAIN

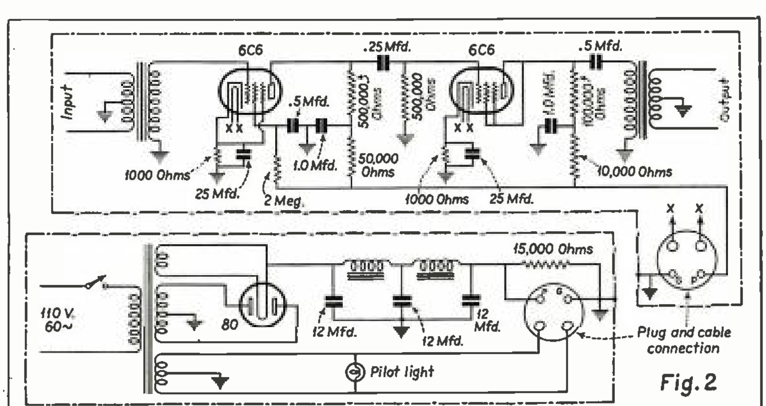
With the hum brought down to the point where an experimental pre-amplifier feeding a 15-watt power amplifier was just as quiet with the power switch on or off, the next problem was that of gain, which, after all, is what the amplifier was built for in the first place. The gain must be 40 db or more if a 70 db amplifier is to be driven with sufficient reserve in the background. The circuit of Fig. 1 had only about 38 db gain at the top, which was not enough for a velocity mike. An extra stage did not prove successful because of terrific microphonic effects.

The final circuit chosen for the commercial wide-range, high-gain, pre-amplifier is shown in Fig. 2. The first 6C6 is operated as a pentode, the second as a triode. The overall gain was found to be 62 db, which was sufficient for a 70-db power amplifier.

FREQUENCY RESPONSE

The final problem was that of frequency response. Curve No. 1, of an amplifier using the two triodes of a type 79 in cascade with good transformers, is shown to illustrate how tube choice can affect amplifier performance. The impedance of the input-transformer secondary in this case is about 100,000 ohms. Curve No. 2 shows the same transformer with a pentode and pentode-triode combination, such as employed in the final amplifier. The reflected input capacity of a triode is influenced by the mutual conductance of the tube; with a pentode it is the actual input capacity as determined by the mere physical construction of the tube.

The practicability of using a pentode first-stage amplifier was a bit of luck, from the standpoint of microphonics as



The final circuit of the ac-operated pre-amplifier.

well as frequency response. The high gain makes an intermediate stage unnecessary.

TUBE CAPACITY

The amplifier response represented by Curve No. 2 was still not ideal for a high-fidelity mike. The possible frequency losses in the amplifier were investigated, and the transformers under ideal conditions were found *not* to possess the discrepancies shown in the curve. It was also found that a response varying only 1 db from 30 to 17,000 cycles was obtained with the input transformer eliminated and the test input fed directly to the grid circuit of the first amplifier. The input transformer was then held responsible, but since it showed no such loss as mentioned under ideal conditions, the blame was put on the distributed capacity of the tube, its wiring, etc. To lower the distributed capacity of the transformer secondary and also to reduce the shunting effect of the tube, the secondary impedance was reduced from 100,000 to 40,000 ohms. The final frequency response as shown in Curve No. 3 is believed to be as good as anything obtained heretofore, and the writer is quite proud of it.

The gain naturally suffers with reduced secondary impedance, but the final amplification of 56 db (instead of 62 as originally measured) proved altogether sufficient.

As the output transformer is worked at low impedance values, no difficulties with frequency discrimination were experienced with it.

MECHANICAL FEATURES

Most of the preceding discussion has been of electrical features, but the mechanical arrangement is also of extreme importance. The completed amplifier as produced commercially is shown assembled and disassembled in the accompanying photographs. Nothing less than 1/8-inch structural steel is used throughout. The pre-amplifier components are mounted on a chassis that slides into sponge-rubber guides inside a heavy cabinet measuring 10¼ x 7¼ x 5½ inches. The front panel, containing the input and output connections and power receptacle, is screwed to the corners of the box, not to the amplifier chassis. The latter thus floats perfectly free. The whole unit weighs 25 pounds, and nothing short of a deliberate kick affects it microphonically.

The power pack is furnished as a separate unit and is equipped with an on-off switch and a pilot light. Its schematic diagram is self-explanatory. The same rigid construction as found in the pre-amplifier is used here also. The pack measures 8¼ x 6½ x 6½ inches.

CONCLUSIONS

From the experiences undergone by the writer, it can be seen that the design and successful operation of a high-gain, ac-operated pre-amplifier is by no means the nonchalant job pictured in the paper originally mentioned. There is a lot more to it than merely throwing together some parts and following a few arbitrary rules! The most unexpected things turn up, and the designer has to make up some rules of his own to meet them.

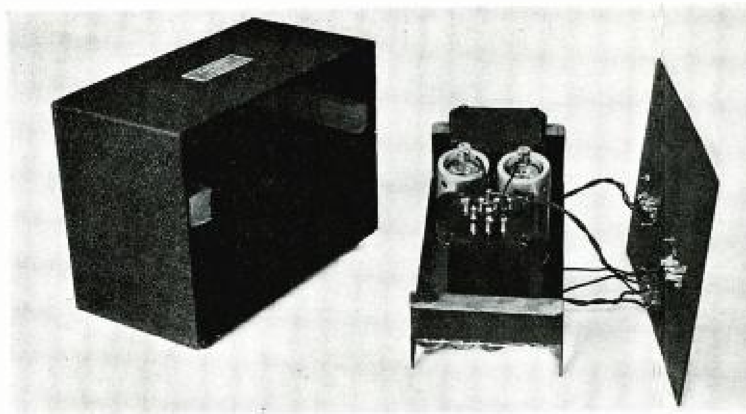


Fig. 4. The pre-amplifier opened up to show its construction. Note the sponge-rubber mounts in the channel guides inside the 1/8-inch steel box.

Fig. 3. The encased Lafayette wide-range, high-gain pre-amplifier with its separate power pack on the left.

I.R.E. FALL MEETING PROGRAM

THE ANNUAL FALL meeting of the Institute of Radio Engineers is to be held at the Sagamore Hotel, Rochester, New York, November 12, 13, 14, 1934. All engineers should plan to attend.

An outstanding program has been arranged for this year's meeting. A number of important conferences will be conducted by the RMA, with the RMA Engineering Committees officiating.

RADIO INTERFERENCE DISCUSSIONS

Considerable time is to be given discussions on the desirability of the reduction of radio interference, from the viewpoint of the Consumer, the Public Utilities, the Radio Manufacturer, the Radio Dealer, and the Federal Communications Commission.

The complete program follows:

MONDAY, NOVEMBER 12

9:00 A. M. Registration
Opening of Exhibits
10:00 A. M. Technical Session
IRON CORE TUNING SYSTEMS
A. Crossley, Consulting Engineer
HIGH-FIDELITY REPRODUCERS WITH ACOUSTICAL LABYRINTHS (With Demonstration)
B. Olney, Stromberg-Carlson Telephone Mfg. Co.
12:30 P. M. Group Luncheon
2:00 P. M. Technical Session
AUTOMATIC REACTANCE CONTROL SYSTEMS
Charles Travis and *Murray Clay*, RCA License Laboratory
PUTTING THE ULTRA-HIGH FREQUENCIES TO WORK (With Demonstration)
L. C. F. Horle, Consulting Engineer and *C. J. Franks*, Radio Frequency Laboratories
DIODE COUPLING CONSIDERATIONS
J. R. Nelson, Raytheon Production Corporation
4:00 P. M. Inspection of Exhibits
Meeting of RMA Committee on Receivers
Meeting of RMA Committee on Television
6:30 P. M. Group Dinner
8:00 P. M. Joint Session with Radio Club of America
TRANSMISSION AND RECEPTION OF CENTIMETER WAVES (With Demonstration)
I. Wolff, E. G. Linder and *R. A. Braden*, RCA Victor Company

TUESDAY, NOVEMBER 13

9:00 A. M. Registration
9:30 A. M. Technical Session
THE USE OF CATHODE RAY TUBES IN RECEIVER DISTORTION MEASUREMENTS (With Demonstration)
Henry W. Parker, Rogers Radio Tubes, Ltd., and *F. J. Fox*, Rogers Majestic Corporation
(*Continued on page* 24)

IMPEDANCE-MATCHING NETWORKS

By BERNARD EPHRAIM

THE AUTHOR OF THIS ARTICLE HAS PROVIDED A COMPARATIVELY SIMPLE METHOD FOR THE DESIGN OF IMPEDANCE-MATCHING NETWORKS FOR VARIOUS APPLICATIONS. THE MATHEMATICS OF THE DESIGN HAS BEEN MATERIALLY LESSENED BY THE INCLUSION OF A TABLE OF CONSTANTS

IN ALL TYPES OF networks used in radio and communication engineering, little published material has been given to impedance-matching networks. One of the main reasons why this type of network design has not been popularly treated has, no doubt, been due to the complex equations from which the resistive impedances are derived. Here, the mathematics have been materially lessened and a table has been arranged in Fig. 1 for use with simple formula from which it is possible to design these sections having values of attenuation from 1 to 50 decibels.

ADVANTAGES OF NETWORK

An impedance-matching network is an electrical resistive-impedance consisting of three pure resistances unsymmetrically coupled so that line terminations having different surge impedances can be connected without reflections to the input or output of the network. The advantage of using the network is that its action is independent of frequency variations within the limits of the resistive impedances to frequency. (No transformer has this characteristic.) A disadvantage of the network is that it introduces a small loss; however, this loss is of little consequence because it can be counteracted by simply working the input or output circuits at a higher level. In view of this disadvantage the network can be appropriately used in any circuit as a substitute for an impedance-matching transformer, or like device

DESIGN OF "T" NETWORK

In Fig. 2 is seen an impedance-matching network consisting of an unsymmetrical "T" section coupled to an input R_S and output R_L. Note that the terminal impedances *look into* the network so that they are matched toward each other. It is very important that the resistors R-1 and R-2 be correctly placed in the configuration, otherwise the impedances will be mismatched and reflections will occur in the system.

To design an impedance-matching network for coupling between two different line impedances, the following relations are given for the three resistive arms R-1, R-2 and R-3.

$$\text{R-1} = \frac{(R_S + R_L)\ K_1 + (R_S - R_L)}{2}$$

$$\text{R-2} = \frac{(R_S + R_L)\ K_1 - (R_S - R_L)}{2}$$

$$\text{R-3} = \frac{(R_S + R_L)}{2K_2}.$$

where R_S is the input impedance; R_L, the output impedance; and K_1 and K_2 are constants taken from the table. These constants appear directly opposite the amount of attenuation in the N_{db} column.

ILLUSTRATION OF DESIGN

Applying the above relations, take the following example:

It is desired to couple a 200-ohm output impedance to an amplifier mixing circuit of 50 ohms impedance by use of an impedance-matching network. It is assumed that a transmission loss of 15 db is desired in matching. The values of the individual resistors will be found below.

SOLUTION:

$$\text{R-1} = \frac{(200 + 50)\ .697 + (250 - 50)}{2}$$

$$= \frac{250 \times .697 + 150}{2} = 162.2 \text{ Ohms.}$$

$$\text{R-2} = \frac{(200 + 50)\ .697 - (250 - 50)}{2}$$

$$= \frac{250 \times .697 - 150}{2} = 12.2 \text{ Ohms.}$$

$$\text{R-3} = \frac{250}{2 \times 2.720}$$

$$= \frac{250}{5.440} = 46.2 \text{ Ohms.}$$

From the tables $K_1 = 697$, and $K_2 = 2.720$.

N_{db}	K_1	K_2
1	0.057	0.115
2	0.114	0.232
3	0.171	0.352
4	0.226	0.477
5	0.280	0.609
6	0.331	0.747
7	0.382	0.897
8	0.430	1.055
9	0.476	1.233
10	0.519	1.422
11	0.560	1.634
12	0.598	1.863
13	0.634	2.122
14	0.667	2.404
15	0.697	2.720
16	0.726	3.075
17	0.752	3.468
18	0.776	3.907
19	0.798	4.398
20	0.818	4.952
21	0.835	5.555
22	0.852	6.262
23	0.867	7.013
24	0.880	7.868
25	0.893	8.870
26	0.904	9.977
27	0.914	11.188
28	0.923	12.484
29	0.931	14.091
30	0.938	15.734
31	0.945	17.744
32	0.950	19.810
33	0.956	22.339
34	0.960	24.939
35	0.965	24.121
36	0.968	31.393
37	0.972	35.397
38	0.975	39.515
39	0.978	44.555
40	0.980	50.237
41	0.982	56.079
42	0.984	63.230
43	0.985	70,583
44	0.987	78.792
45	0.988	88.836
46	0.990	100.165
47	0.991	111.813
48	0.992	126.070
49	0.992	140.729
50	0.993	158.672

$$K_1 = \tan h \frac{db \times .1151}{2}$$

$$K_2 = \sin h\, db \times .1151$$

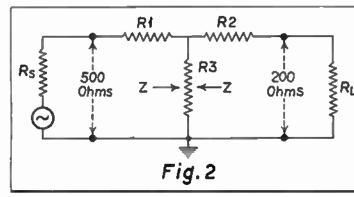
where 1db = .1151 Neper

FIG. 1. A TABLE OF CONSTANTS FOR USE IN CONNECTION WITH THE EQUATIONS GIVEN IN THE BODY OF THE ARTICLE. THIS TABLE MATERIALLY REDUCES THE AMOUNT OF CALCULATION NECESSARY IN THE DESIGN OF PADS.

If the transmission loss in the above problem were 10 db, instead of 15, the network could not be designed because the resistance R-2 would then be negative; that is, less than unity. In most all cases it will be found that the most perfect design can be obtained when a transmission loss of 20 db is assumed.

INSERTION LOSS

Many times it is possible to use the loss in an impedance-matching network as an insertion loss in a circuit and at the same time utilize the section as an impedance-matching device. A scheme of this kind is shown in Fig. 3. Here, an amplifier having an input

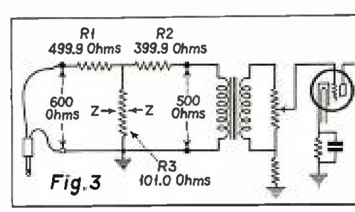


TYPICAL IMPEDANCE-MATCHING NETWORK CONSISTING OF AN UNSYMMETRICAL "T" SECTION COUPLED TO AN INPUT AND OUTPUT CIRCUIT, R-S AND R-L RESPECTIVELY.

signal level of —40 db at 500 ohms impedance is driven by a phonograph pickup having a terminal impedance of 600 ohms at an output level of —20 db. The network inserted between the source and load absorbs the excess 20 db that would normally overload the amplifier, and at the same time provides a proper termination for the unequal line impedances.

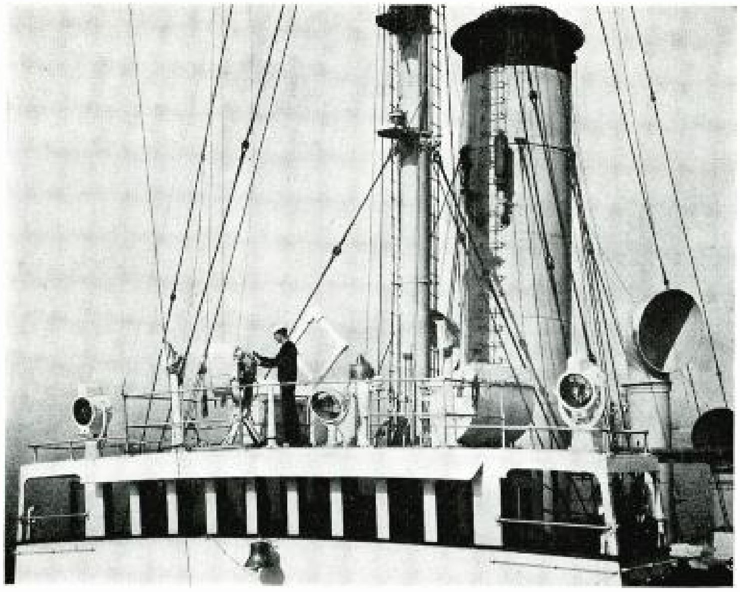
ADVANTAGES

If the matching network were not employed it then would be necessary to use an impedance-matching transformer between the output and input devices, or it would be necessary to change the input transformer to



THE PAD IN THIS CIRCUIT FUNCTIONS AS AN INSERTION LOSS ASIDE FROM ITS ROLE AS AN IMPEDANCE-MATCHING NETWORK. THIS TYPE OF CIRCUIT, AND ITS SPECIFIC APPLICATIONS, IS DESCRIBED IN THE ACCOMPANYING TEXT.

match the impedance of the pickup. In either case it still would be necessary to employ an insertion loss of either a "T" or "H" type configuration to absorb the excess 20 db; assuming, of course, that no losses were introduced in the matching transformer. However, in practice it will be found that the average impedance-matching transformer introduces a loss of approximately 5 db; accordingly then, this would lower the insertion loss to about 15 db. From this comparative illustration it can be seen how useful an impedance-matching network can be.



A NEW LOUDSPEAKER HAS BEEN DEVELOPED WHICH IS SO POWERFUL THAT IT CAN AMPLIFY THE VOICE 1,000,000 TIMES, AND MAY BE HEARD A DISTANCE OF SEVERAL MILES. THE TOTAL FORCE IS EQUAL TO THE BLOW OF A FIFTY-POUND HAMMER. IT SHOULD PROVE OF GREAT VALUE FOR THE CONTROL OF MASS MOVEMENTS OF PEOPLE OR SOLDIERS, FOR FIRE FIGHTING AND RESCUES AT SEA. IN THE ILLUSTRATION AT THE LEFT, A SAILOR IS "POINTING" THE "BULL HORN" ON THE BRIDGE OF THE COAST GUARD CUTTER TAMPA.

VOICE BROADCASTING

A NEW LOUDSPEAKER has been developed which is so powerful that it can amplify the human voice 1,000,000 times, and over flat country in still air be heard at a distance of several miles.

GIANT UNIT EMPLOYED

Compared to the results obtained with loudspeakers now in general use, this one is a giant among pygmies. It is 500 times more powerful than the average and is intended primarily for outdoor use, as such sound power is usually too great for an enclosed space. Through the vibration of the diaphragm, words spoken in a conversational tone are hurled into the air with a total force equal to that of a fifty-pound hammer blow.

The speaker has been developed by engineers of Bell Telephone Laboratories for the Western Electric Company. It follows the general principles of those used in talking pictures and public-address systems. However, in addition it embodies other unique features aimed to increase its penetration and intelligibility in the presence of other sound.

POWERS OF PENETRATION

Speech projected over the speaker is altered in such a way as to penetrate other noise more easily. It can actually cut through a din which itself borders on the deafening, and reach the ear intelligibly without adding appreciably to the ear's burden. The loudspeaker accomplishes this by sacrificing naturalness of reproduction and throwing its maximum energy into that part of the voice frequency range which is most essential to intelligibility. Speakers designed for fidelity reproduce sound frequencies ranging from 40 to 10,000 cycles. This new speaker, however, concentrates its power in the band of from 400 to 4,000 cycles.

The amplifier and microphone are also designed to emphasize the desired frequencies of sound. The microphone, of the moving coil type, is virtually a miniature of the loudspeaker operating in reverse. It does not respond efficiently to low frequencies and consequently transmits into the system only those frequencies most vital to intelligible speech.

The purpose of the speaker is both to shout long distances and to out-shout a tumult of noise, thus making it possible to give instructions, warnings, etc., where the spoken word even as amplified by previously existing speakers would be completely drowned out.

Few sounds produced by nature and classically associated with loudness can match the volume of the new speaker. It can make the voice louder than a clap of thunder. Measured at the mouth of its horn, the sound it produces is about 1,000 times louder than the roar at the foot of Niagara Falls.

FIELDS OF APPLICATION

Large crowds which stretch beyond the range of existing loudspeakers or are in the presence of enough din to drown them out could be handled by

(Continued on page 17)

Making an announcement over the 500-watt loudspeaker from the pilot house of the Tampa.

SOUND AMPLIFIER DESIGN for Public-Address Applications

By I. A. MITCHELL
Chief Engineer
UNITED TRANSFORMER CORP.

● The author of this article has given consideration to the present-day high-fidelity requirements of public-address amplifiers in the design of the equipment described, which includes a pre-amplifier and a power amplifier.

THE USE OF AUDIO amplification systems for sound reinforcement and sound projection has increased tremendously over the past few years. New uses of this modern electrical voice are being discovered daily.

In addition to public-address systems, we now have such audio applications as the reproduction of clock chimes and carillons over large areas; the aiding of docking of vessels; announcing and call systems; inter-vessel communications; advertising from airplanes, dirigibles, boats, and trucks; and the numerous other uses which we encounter daily in modern cities. The value of amplification equipment designed for such purposes generally depends not on the acoustical output, but on the undistorted acoustical output. This is particularly important at the present moment, when the public is being educated to high fidelity.

HIGH-FIDELITY REQUIREMENTS

The requirements for high fidelity were ably discussed by Frank Massa in a recent article*. For true high fidelity, it is found that a frequency range of at least 80 to 8000 cycles must be transmitted, that the harmonic content should not exceed 5 percent, and the volume range of reproduction must be approximately 70 db. In addition to this, it is also necessary that the volume level be sufficiently great to deliver satisfactory sound at the maximum transmission distance required.

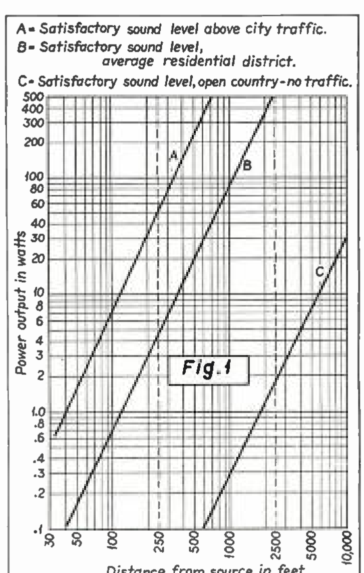
This article covers only the audio amplifier requirements for high fidelity and does not treat of accessory requirements, such as pickups and reproducing devices. If we examine the above design requirements in sequence, the corresponding controlling factors can readily be determined. Frequency discrimination in audio amplification is almost entirely controlled by the audio transformers used. Many years of research in this field have resulted in the development of transformers having extremely wide frequency range. Commercial production of such units requires specialized production equipment and rigid inspection, including shop transmission measurements under the actual conditions of use.

*Acoustics and High Fidelity, by Frank Massa, page 10, RADIO ENGINEERING, May, 1934.

HARMONIC CONTENT

Harmonic content is primarily a function of the tubes used and their operation. When properly used, a vacuum tube is practically a linear device (at the point of linearity deviation harmonics are introduced). Consequently, it is essential that the power output be normally kept below the point of maximum allowable deviation. This, in turn, to meet our high-fidelity requirements, makes necessary the use of proper vacuum tubes correctly operated so that not over 5 percent harmonic distortion is effected at the highest power output normally required. In addition to this, care must be taken in the design of audio transformers, particularly those operating at high level, so that the transformer will operate over an essentially linear portion of the core material magnetization curve.

With a volume range of 70 db, it is necessary that the noise level be at least 70 db below maximum output. Modern quality resistors and condensers have practically a negligible noise level, narrowing noise difficulties almost entirely to ac hum. Precautions for reduction of ac hum are described below in conjunction with actual application to an audio amplifier.

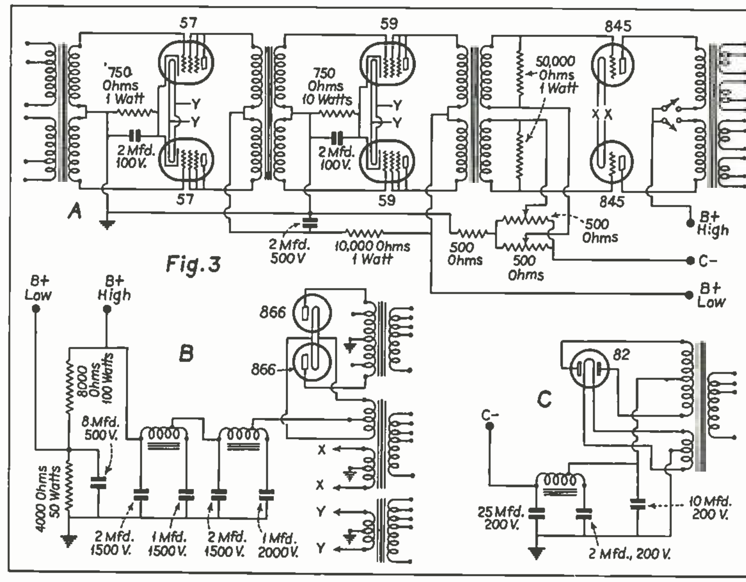


Power output required to cover various distances as compared to the surrounding noise level.

NOISE-LEVEL CONDITIONS

Power-output requirements are unfortunately greatly dependent upon external noise-level conditions. As the human ear has a logarithmic sensitivity, it is apparent that a sound level readily heard in a quiet town would not be sufficiently great to cover the same area in a noisy city. Fig. 1 illustrates the amount of amplifier power output required to cover various distances as compared to the surrounding noise level, using a cluster of modern dynamic speakers. It is seen from these curves that a sound source will cover in an average residential district more than 2½ times the distance it would cover in city traffic. Compared to very quiet areas, such as open country with no traffic, the difference is even more apparent. Power which is satisfactory over a mile distance under such conditions would barely be suitable for half an average city block.

In many cases, amplifiers have to be constructed for use at various locations at different times. This is particularly true in the public-address field. For satisfactory operation under the worst normal conditions, an amplifier must therefore have comparatively high power output. To cover a distance of 300 feet under noisy conditions, as per Fig. 1, or 100 feet where heavy street traffic is encountered, 100 watts of electrical audio power would be required.



Circuit of the power amplifier (A), its high-voltage supply unit (B), and the C-bias supply unit (C).

HIGH-FIDELITY AMPLIFIER

Figs. 2 and 3 illustrate the complete circuit diagram of a high-fidelity audio amplifier suitable for raising the input level of a crystal, condenser, dynamic or carbon microphone to an output level of 100 watts at 5 percent distortion. This amplifier employs standard tubes and A-Prime amplification in the output section. It is extremely economical both in original cost and operation. The overall gain of this amplifier system is approximately 120 db.

It is desirable in high-gain amplification equipment to isolate the low- and high-level stages. In addition to the reduction of increased hum and feedback tendencies, this allows the control of gain and mixing at a level higher than that of the original source. The reduction in noise level is generally considerable. The low-level amplifier is commercially termed a voltage or pre-amplifier.

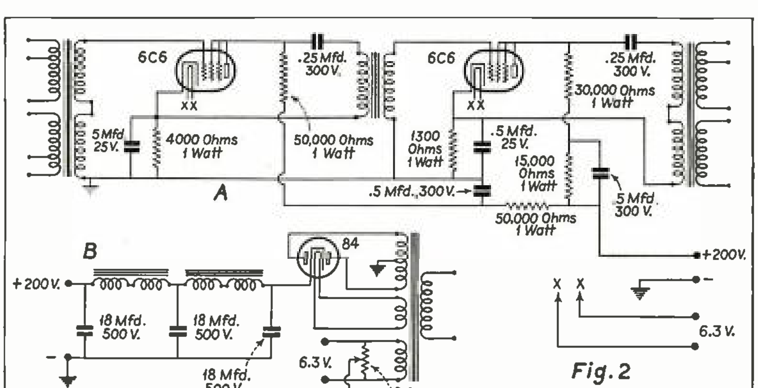
AC OPERATION

Until quite recently, quality pre-amplifiers were invariably battery-operated. However, research and development work has perfected both tubes and associated components so that quality performance can be obtained from all ac-operated equipment. The development in tubes is well exemplified by the type 262-A, which has an extremely low hum level. However, an analysis of the more common and less expensive tubes indicates that some of the standard tubes released during the past year are also quiet from the ac hum standpoint. Notable among these are the 6-volt heater types, among which is included the 6C6 tube used in the amplifier circuits illustrated. As is well known, the triode tube properly used is cleanest and most stable of amplifiers. By connecting up the elements of the 6C6 as a triode, we obtain a tube having an amplification factor of 20 and a mutual conductance of 1700. At a plate voltage of 180 volts, the normal bias and plate current are, respectively, 5.7 volts and 4.75 ma. Operated in this manner, the tube plate impedance is only 12,500 ohms. This is one of the factors which makes the tube an excellent voltage amplifier.

AMPLIFIER DESIGN

The two-stage pre-amplifier illustrated in Fig. 2 is standard in general design. Transformer coupling is used throughout, with resistance-capacitance parallel-feed for the two transformers in the tube output circuits. An additional 9-db gain can be obtained where desired by using inductance parallel feed. The terminations of the input and output transformer are universal, affording impedance match to 50, 125, 200, 250, 333, or 500 ohms. It is evident that a number of different lines can be accommodated individually or simultaneously with this unit. Negligible hum is obtained in the pre-amplifier through careful and liberal design. Tube hum, while inherently low, is reduced still further through the use of the filament potentiometer which allows unbalance of the filament-to-ground connection. The plate supply uses a two-stage condenser input filter which is highly effective. The chokes shown have an inductance of 200 henrys *at the normal dc current.* Fifty-four microfarads of a 500-volt electrolytic condenser aids the filtering and also assures ample safety factor.

The inductive pickup, when operating at low levels becomes quite important. The transformers indicated are housed in balanced high-permeability, cast alloy shields having five times the shielding



Circuit of pre-amplifier with triode-connected 6C6 tubes, and the high-voltage supply unit.

effect of normal cast iron. To augment this magnetic shield, the internal transformer structure incorporates electrostatic shielding.

It is very desirable that the power supply and audio section of a low-level amplifier be spaced appreciably. The power supply and audio sections of the amplifier shown can each be placed on a chassis 3⅜ by 13½ inches so that they in turn can be mounted on individual 19-inch rack panels 3½ inches wide and spaced some distance on a rack.

THE OUTPUT SYSTEM

Due to its excellent fidelity and low harmonic content the 845 tube has been very popular in both theatre and public-address work, where a power output of 30 to 50 watts was required. However, few people realize that properly used in push-pull connection a pair of these tubes can deliver 100 watts with only 5 percent distortion operating with only 1250 volts on the plate, and 260 volts bias. While some attempts were made in the past to increase the power output from 845 tubes, the tubes were invariably operated above the manufacturers' plate voltage rating of 1250 volts, so that tube life was appreciably shortened.

The above method of overbiased operation of the 845 tubes is normally termed "AB" or Class A Prime. Its efficiency depends upon the fact that while high second harmonic is developed, the push-pull connection tends to balance out this distortion. It is desirable that the tubes be well balanced and provision for this balancing is afforded in the circuit of Fig. 3.

The unusual simplicity of this circuit is apparent. Push-pull, transformer-coupled stages are used throughout. The push-pull connection tends to balance out plate hum and also eliminates the necessity for parallel feeding the audio transformers. The 59 tubes have sufficient power to drive the 845's to maximum output with a negligible introduction of distortion from themselves. The loading resistors in shunt with the 845 input transformer secondary stabilize the load reflected to the 59 tubes (triode connected). A separate power supply is used to provide bias for the output tubes and the two 500-ohm potentiometers shown are adjustable so that the tube plate currents can be perfectly balanced.

The filter circuits for both plate and bias supply of the main amplifier use tuned filters having extremely high efficiency. The output transformer shown has ideal universal impedances for public-address use; namely, 1.2, 2.5, 5, 7.5, 10, 15, 20, 30, 50, 125, 200, 250, 333, and 500 ohms.

IMPORTANT FEATURES

If we summarize the actual important factors in this amplifier, they may be noted as follows:

High gain—120 db suitable for all p-a applications.

Low distortion—less than 5 percent at all levels below normal maximum output.

True Class A Prime operation in output stage.

High power output—100 watts.

Plate supply having good regulation.

Low hum level.

Unusual simplicity of construction.

Inexpensive tubes, and economical operation.

The amplifier system will faithfully transmit all frequencies from 40 to 10,000 cycles at levels from the barely audible pianissimo effects to the resounding orchestral clashes of ten million times greater power, without any underlying noise or hum. As such, it is ideal for any sound amplifier application having high-fidelity requirements.

VOICE BROADCASTING

(*Continued from page* 14)

means of the new speaker, as could mass movements of people or soldiers. Fire fighters within burning buildings or deafened by the crackle of flames could be directed by the giant voice.

In rescues at sea instructions could be bellowed from the rescuing vessel to the distressed crew or to those in life boats, and if substituted for the usual fog horn the giant voice could give detailed advice rather than a simple warning.

THE MICROPHONE AND AMPLIFIER

The diaphragm of the microphone is made of duralumin, .01 of an inch thick. Though driven by great power, the diaphragm actually moves no more than about .025 of an inch in either direction. When so moving, it generates a sound pressure of about one pound per square inch. The mechanical force required to set up these pressures is about 50 lbs.

The amplifier of the new system is capable of delivering 1,000 watts of speech current to the loudspeaker and the speaker of delivering 500 watts of energy to the air. Thus the efficiency is 50 percent as compared to 25 percent in most commercial devices. When operating at full capacity the diaphragm coil dissipates about the same amount of heat as an electric flat-iron. This is radiated through an air gap to the magnet, which in turn passes it off to the outer air.

THE SPEAKER

The speaker and horn combined are 30 inches in diameter by 30 inches deep. The horn is of the folded type, and is made of cast aluminum and weighs about 125 pounds compared to 375 pounds for the speaker unit itself.

The speaker and horn are mounted on a swivel mast and can be pointed in any direction. The entire system is controlled at the microphone by a single push-button which through a series of relays performs all the various operations necessary to start up or shut off the amplifier.

The new Western Electric 500-watt speaker or "bull horn" which was used for the first time at the International Yacht Races.

EVOLUTION OF EARLY SYSTEM

The system is the outgrowth of a steady evolution in the reinforcement of sound which had one of its first public demonstrations on Victory Way, Park Avenue, New York, during the 1919 Liberty Loan Drive. In the public-address system used at the Republican National Convention in Chicago the following year the horns were ten feet long. They were designed with four flat sides enlarging uniformly towards the mouth. Later the "morning glory" type of horn with the flaring mouth was adopted. Subsequently, the folded horn, considerably more compact, was found to be superior.

The first commercial loudspeakers were about one per cent efficient. Their diaphragms were made of bakelized linen and were 1¾ inches in diameter.

The system which was used to shout across the Hudson River, a distance of about a mile, from the roof of Bell Telephone Laboratories' building early in 1928 consisted of ten loudspeakers hooked into one horn. The new giant voice with its single speaker is many times more powerful.

Receiver-Component Tests

METHODS AND EQUIPMENT FOR THE FACTORY TESTING OF COILS AND CONDENSERS

By S. BAGNO
and
J. SADOWSKY
WIRELESS EGERT ENGINEERING

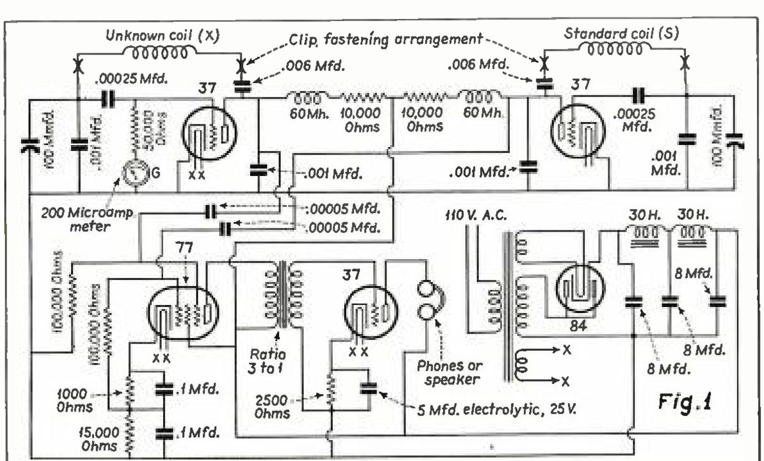
THE PROBLEM OF testing a radio receiver is by no means simple, as the testing requires more time than any other single operation in the making of the receiver. There are very few companies large enough to manufacture everything they use and therefore the problems involved are the problems first of checking the equipment received from parts manufacturers, such as transformers, coils and condensers—because the assumption that they come up to specifications is not always valid.

CIRCUIT CONSTANTS

After the set is assembled, there are a number of tests, depending on the type of set and where it will be used. First let us consider the equipment for checking parts. Due to the fact that there are sometimes as many as fourteen circuits to a line in the construction of a set, it is imperative that the constants of the resonant circuits should always be the same. These constants are inductance and capacity and therefore we shall discuss the methods employed in the production test of these units first. Although there are a great many methods of measuring these characteristics in the laboratory, only the factory tests used for production will be mentioned here.

COIL TESTING

Perhaps the most important single factor in determining the proper alignment of the set is the coil. There are several methods of testing the inductance of coils and very little choice between them. The standard bridge method for laboratory determinations is too cumbersome for factory production use; as a result, methods depending on the property of resonance have been used. These methods consist in tuning the inductance with a condenser and determining the frequency of resonance. This is the most general method and several modifications of this scheme have been employed, such as, making use of two oscillators, oscillating at radio frequencies, obtaining an audible beat between them; both oscillators employ two equivalent fixed condensers whose capacities are exactly equal. Two inductances are placed, by means of clip-leads or some other fast method of connection, into these resonant circuits; one of these inductances is a standard and the other the unknown. If they are exactly equal, there will be no audible beat between them. In practice, this condition is seldom obtained and as a result, the pitch of the audible note determines the amount that the unknown inductance is removed from the standard. A diagram of this type of coil tester is shown in Fig. 1.

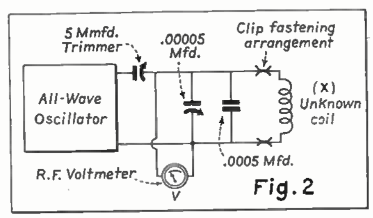


Circuit of beat-frequency oscillator for coil testing.

ADVANTAGES AND DISADVANTAGES OF METHOD

The above mentioned coil tester has several advantages. They are: Simplicity of operation; the percentage difference can be determined instantly with a single control which pads one of the oscillating circuits with a small trimmer condenser. The audible method of detecting a condition is often to be preferred to any visual indication because the visual attention of the operator may be applied to adjusting the coil to the proper inductance.

There are several inherent disadvantages to this method as well as advantages. Since there are two separate and



Checking coil value through the use of an oscillator and a condenser of known value.

distinct oscillating circuits, it is possible that one of the circuit constants and one of the oscillators may vary with time, and with temperature and humidity conditions. In this way, the results can be varied to such an extent as to make the test valueless. This disadvantage can be overcome by employing two standard inductances and adjusting both oscillators to zero beat by means of an additional trimmer in the standard coil circuit.

THE OSCILLATORS

In order to make this type of tester as universal as possible, the oscillation must be independent of the absolute value of the inductance. Therefore, the type of oscillator employed is limited to a Colpitts (or ultra-audion) oscillator, or a dynatron oscillator.

The dynatron oscillator has the disadvantage of oscillating within a limited frequency range since at high frequencies the power factor of the tank circuits becomes so great as to dampen the negative resistance of the dynatron and kill the oscillation. Also, since it is desired to use a high-capacity circuit for stability purposes, this effect is accentuated. Even the ultra-audion circuit has its frequency limitations, and a low-Q coil cannot be tested below three microhenrys due to the fact that the oscillation is completely damped out.

In order to obtain an indication of the Q of the coil with this type of instrument, a grid-current meter in the oscillating circuit of the unknown coil serves as an excellent indicator, and, although it cannot be calibrated directly in terms of the Q of the coil for all frequencies without a great amount of difficulty, it is still sufficiently accurate to show the effect of a misplaced lug, on the power factor of the coil at the frequency employed.

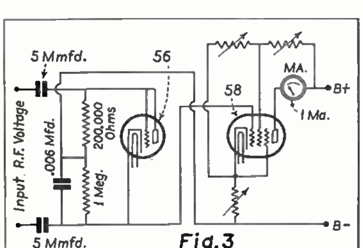
ANOTHER COIL TESTER

Another type of coil tester that has proven equally effective consists of a wavemeter with a voltage indicator across the resonant circuit. By means of a continuously variable oscillator, a frequency can be obtained that is exactly at the resonant period of the coil and a fixed condenser which is connected across it.

This fixed condenser is made high enough so that the distributed capacity of the coil itself (which can never be properly controlled) does not affect the frequency indication. This circuit is shown diagrammatically in Fig. 2.

There are also several disadvantages as well as advantages to this method. In order to get a sufficiently sharp indication of inductance of low power-factor coils, it is necessary to use a type of voltmeter whose resistance is far from linear. A square-law meter may even be insufficient for the proper indication. As a result, it is necessary to buck the initial voltage out by some sort of bridge arrangement so that only the peak voltage may be read. This, in itself, is disadvantageous because the sensitivity of the instrument depends on the Q of the coils, and two coils having equal inductances may require entirely different bias adjustments in order to be read properly.

A method of overcoming this objection is to employ a variable-mu tube, such as the 58, as a bias detector (see Fig. 3). Due to the semi-logarithmic characteristic of this type of tube, the peak is very much accentuated and the resonance curve assumes a peculiarly steep effect.

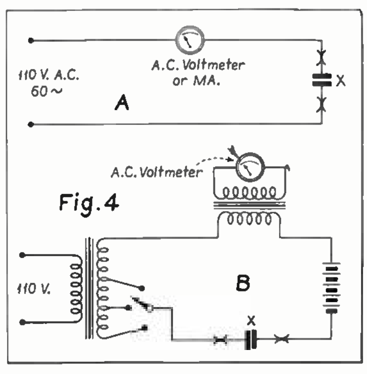


Circuit for accentuating r-f resonance peak of coil.

CONDENSER TESTS

The next most serious problem is the condenser. Condensers can be tested by methods analogous to those where the inductance is fixed and the capacity varied. Due to the fact that the condenser must be varied over a wide range, an instrument adapted for the testing of condensers must be more flexible than that used for inductances.

The condenser is generally placed in some form of mold, fixed rigidly to a dial, and the capacity is checked at three or four points on the dial setting. These points must be fixed within a small fraction of a degree. In checking a multi-gang condenser with equal capacity segments, it is possible to compare one condenser against the next throughout the entire swing of the condenser without taking any fixed points.

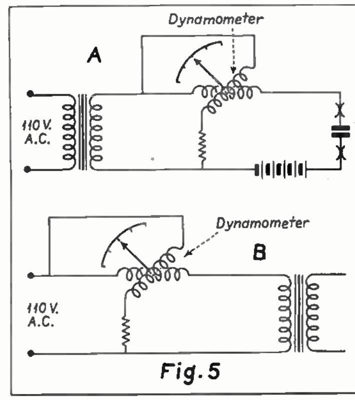


Circuit arrangements for capacity tests.

A beat-note oscillator, a modification of the type used for coil checks, can be used quite successfully in checking condensers. In order to check at more points than one, instead of using two fundamental frequencies, we can use the beats of the harmonics of one oscillator in order to obtain points on a dial which have the same capacity as a standard given condenser by properly arranging the two oscillators, the fixed and the variable. As many points as are desired can be obtained by means of squeals and zero beat. This method is probably not as fast as the other due to the fact that a vernier scale must be adjusted in order to read the points with any accuracy.

TEMPERATURE AND HUMIDITY

A method very much analogous to this is employed by a leading condenser manufacturer in the production testing of all their condenser output. The factors discussed above are essential tests since only the simplest type of receiver can work when these constants are beyond certain tolerances. However, the difference in quality between a good receiver and one that is barely satisfactory, consists in the testing of other parts as well. The resistors, fixed condensers, transformers, tubes and various other electrical parts come under this category. An ohmmeter test is often sufficient for this purpose, although it may be desirable to determine the effect of temperature and humidity on samples. When it is possible to control the conditions of humidity and temperature of a given enclosure, these tests can easily be made by the use of a standard ohmmeter.



Circuits for, (A), power-factor test and, (B), transformer test.

CONDENSER CHECKING

Perhaps the simplest and quickest check for fixed condensers consists of an ac voltmeter or milliammeter in series with the condenser in an ac line, as shown at A in Fig. 4. This test is often satisfactory. However, there are a great many circuits in which the power factor of a fixed condenser is as important as its absolute capacity, such as, a grid condenser used in a high-frequency circuit. The power factor of a condenser under these conditions may be sufficient to kill the effect of oscillation entirely. Power-factor check is also important in the case of an electrolytic condenser used in a filter system.

POWER-FACTOR TEST

The difference between a poor power-factor condenser (mostly due to insufficient moisture content) and a condenser of good power factor, lies in the hum component that is audible in the completed receiver.

The simplest check for a condenser of any type consists in the use of a dynamometer instrument, such as a wattmeter and a phase-rotating device. One coil of the dynamometer is connected in series with the 110-volt line

(*Continued on page* 24)

Loudspeaker installation in stands 3000 feet long, at National Air Races. Arrows indicate locations of loudspeakers.

P-A SYSTEM PLUS

DESCRIPTION OF SPECIAL INSTALLATION AT NATIONAL AIR RACES

AS THOUSANDS CHEERED, motors roared and military bombardments and smoke screens filled the air, the public-address system at the National Air Races became an integral part of the "show", more important than such a system in any other use. Every one of the 100,000 people viewing the races daily heard every word uttered throughout the events which lasted from the starting gun at noon each day until the rocket ship bid farewell after the night show, in spite of a noise level which was almost deafening at times.

THE AIR RACES

Let us follow the procession for a brief period. Not merely as a description of the National Air Races but to show the unusual demands placed upon the p-a system. A full squadron of Marines takes the air. Bombers, Scouts, and other types of planes in complicated maneuvers.

A Marine Officer steps to the microphone and tells you what each is doing and what to expect. Your attention is called to a tiny speck in the sky. The delayed parachute jumper would not be seen if the man at the mike did not tell you where to look for this tiny speck two miles up. The p-a control room gets a signal over short-wave from the squadron leader in the air. Short-wave is fed into the p-a system. The ground mike is fed into the p-a system and the short-wave transmitter and 100,000 people hear the two-way conversation between the ground commander directing the flight and the squadron leader in the air.

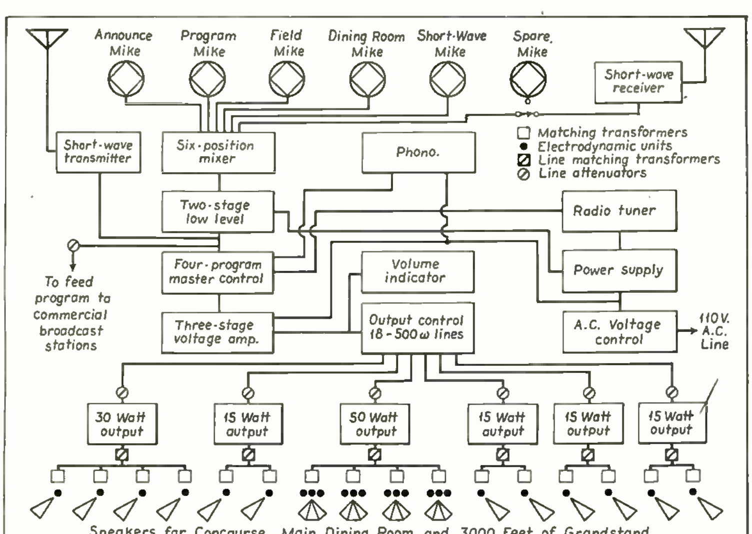
There is a commotion on the field. Amelia Earhart lands, first of the Women's Derby flyers. Crowds keep her on the field but spectators want to hear her and a mike must be run out on the field to hear her description of her flight.

The Thompson Trophy race is started, but first the announcer calls your attention to two dots in the sky . . . men's cross-country flight which left the west coast the same morning. You wonder why one ship takes off immediately, and the announcer tells you that he is off to New York to break a transcontinental record.

The Thompson Trophy race is tightening and the timer gives you the time on each of the twelve laps. One of the microphones high on a tower is manned by an ex-pilot. Doug Davis and Roscoe Turner fighting for first place. Eighth lap and Davis turns a pilon and goes into a spin far off the course, out of range of the spectarors. He has crashed and for the first time in the day the p-a system is silent and listeners strain themselves to catch the next word. Only part of the Air Races are visible and the rest comes over the p-a system.

Another commotion on the line and Mary Pickford arrives from the coast. Police bring her to the p-a microphone still out of vision of many in the long stands. The chain broadcasting mikes are rushed in but first she must address the spectators over the p-a for they paid their admission and radio listeners did not.

What is going on in the p-a booth? The operator wearing headphones and watching for the uplifted hand at six microphones, answering telephones, short-wave, mixing voice and music, an impossible task without the most modern equipment. A temporary system set up for a few days' use, yet far more complicated than most systems in permanent use today.



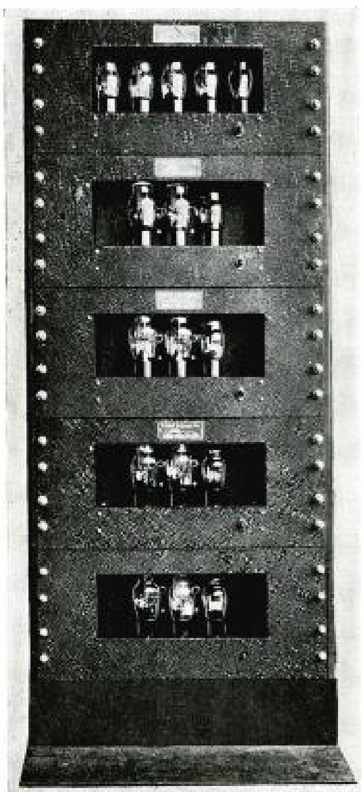
Public-address system as installed at the National Air Races.

THE P-A SYSTEM EMPLOYED

To supply a more comprehensive idea of the extent of this system, we are submitting a block diagram and a brief explanation of its use and flexibility.

It will be noticed that six microphone positions head this list. The first one for the announcer is the conventional two-button carbon microphone. Second is the program microphones, which consist of two or three crystal microphones with pre-amplifiers, each consisting of two stages, double push-pull and completely ac-operated, being mounted in portable cases. The output level of the crystal microphone is somewhat below 80 db and the impedance is extremely high. This being the case it is necessary to use a low-capacity shielded microphone cord which should not be more than 50 feet long. These microphones run directly into the grids of type 53 tubes, used as triodes and resistance coupled to a second stage which in turn is coupled to a push-pull output transformer with a 500-ohm secondary.

It is necessary to provide one pre-amplifier for each of the microphones used. The three secondaries of these output transformers are set up in the conventional three-position parallel mixer which is coupled to a line-to-line transformer with a master gain control on the output. With this equipment it is possible to make any type of set-up, either for program work in the grandstand, in the field, or in the main dining room where banquets were held.



Output channel of the public-address system used at the National Air Races.

It was also necessary to set up a rather complicated arrangement with a microphone from the announcer's stand to feed through a low-level amplifier in the control room where the circuit is split and run through the rest of the p-a equipment as well as feeding a government short-wave transmitter through which the ground commander could keep in constant contact with the squadron leaders. At the same time the output of the short-wave receiver is also connected through the mixing panel so that programs received from the flyers in the air could be amplified through the p-a system, thereby making it possible for the crowd to hear the two-way conversation between the ground commander and the squadron leader.

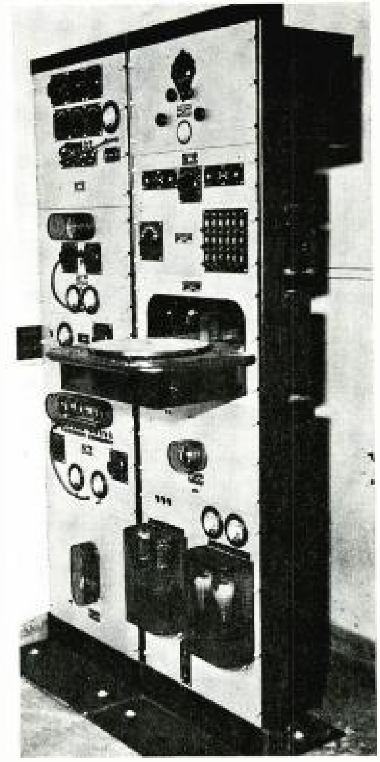
It was also necessary to extend another line with an attenuator to feed the commercial broadcast stations any programs that were primarily intended for the p-a system which the broadcast stations had difficulty in obtaining, as it must be kept in mind that the feature of the show was to provide program to the thousands of people in the stands rather than to provide programs to the various broadcast stations and chains.

Following the low-level amplifier, the program enters a master control panel which is also the master gain control for the total p-a set-up. However, it does not effect any gain fed to the short-wave transmitter or commercial broadcast stations. From the master control panel the program enters a three-stage, triple push-pull voltage amplifier with an over-all gain of 84 db and a power output level of 28 db (4½ watts). This voltage amplifier is completely ac-operated. The output of the voltage amplifier is fed directly into an output control panel having available eighteen 500-ohm lines. Each line terminates in a key position. A volume indicator is connected into one of these lines for monitoring purposes.

SPEAKERS USED

In each of three installations made, it was necessary to use twenty exponential horns with electro-dynamic units placed approximately 50 feet in front of the grandstand, along its entire length of 3,000 feet, to effectively override the tremendous noise level created by the various flying maneuvers

Directly in the center of the grandstand for a distance of about 400 feet each side, where the greatest number of spectators were seated, was installed



The speech input control and program panels of the public-address system described.

twelve 3½-foot trumpets with twelve dynamic units driven by a 50-watt output amplifier. It will be noticed that each of the three units have a separate voice-coil matching transformer and the four voice-coil matching transformers in turn are connected to a line-matching transformer. All of these transformers were placed as near to the speaker unit as possible and the 500-ohm line matching transformer was run into the control room where it connected directly on the output of the 50-watt amplifier. In addition to this, four, 15-watt amplifiers were utilized, each driving two six-foot trumpets and dynamic units with the matching transformer placed in the same manner as in the case of the 50-watt amplifier.

An additional 30-watt amplifier was used to supply program to the main dining room and the concourse in the Administration Building to drive four horns and dynamic units.

Each output amplifier was provided with a balanced H pad attenuator. To supply field current to all of these separate units, separate rectifiers were installed at each loudspeaker station with the exception of the twelve units driven by the 50-watt amplifier. In this case, rectifiers are provided to supply 7½ volts at 3½ amperes for each group of

(*Continued on page* 24)

NOISE INTRODUCED IN SUPERHETERODYNES WITH FREQUENCY CONVERSION

WHATEVER MIGHT BE done to reduce the noise content without diminishing the efficiency of the receiver is considered good practice. Although numerous sources of noise become apparent in a study of set performance, that associated with frequency conversion will form the basis for the present discussion. Closely allied with this phase of noise problems are those caused by the shot effect and thermal agitation.

CIRCUIT NOISE RATIO

It has been shown elsewhere that the thermionic current in a vacuum tube is subject to very rapid and irregular changes in magnitude. Such fluctuations, known as the shot effect, result from the random emission from the cathode and may be detected by current or voltage variations in any circuit of which the tube is a part. If the amplification is adequate to make the fluctuations audible in the speaker, a continual background noise of indefinite frequency results. The shot effect is a function of the square root of the plate current. Hence a high-gain tube with low plate current is to be preferred for the input stage of the receiver. For a given plate current, if the gain be doubled, the ratio of shot noise to amplified voltage is noticeably decreased.

Fluctuations set up in the grid circuit by thermal agitation may be a predominant source of noise. Grid-circuit thermal-agitation voltage is amplified with the signal voltage and is a direct function of electrical impedance. It is apparent that this effect is most important at the input portion of a receiver. Hence, the maximum antenna-to-grid gain that can be obtained for a given grid-to-filament impedance should give the best signal-to-circuit noise ratio.

CONVERSION NOISES

In general a frequency-converter stage gives less gain for a given plate current than does a well designed amplifier stage, regardless of the tube combination employed for conversion. This results in higher shot-effect noise in a converter stage, in addition to conversion noises resulting from the mixing operation, and irregularities in oscillator amplitude. For these reasons, a translator or mixer tube is to be avoided as the input tube of a receiver if the lowest residual noise is to be expected. Although much of the hiss resulting from the mixing operation is only present when a carrier is tuned in, its level compared to useful or signal modulation increases directly with increase in gain beyond the mixing point (this includes the translation gain) so that for quiet operation greater r-f and less i-f and translation gain is indicated.

ELECTRON-COUPLED TRANSLATORS

The advent of the 6A7, or electron-coupled translators, has made possible higher translation gains than were common previously. The first impression gained by most observers was a higher noise level due to the high gain following the mixing point. Many low-priced receivers appeared using little or no r-f amplification and having very high i-f and translation gains, resulting in unfavorable comments on high noise levels.

Previous work has shown that for two-tube converter systems of equal gain, no appreciable noise reduction could be effected by a change in tube types. The 6F7 triode pentode has been found to be representative of results obtained with two-tube converter systems, and has been chosen to be compared with the 6A7 or pentagrid converter (electron-coupled) systems. This was found to be a fortunate choice as it involves a minimum of circuit changes and allows a comparable layout of apparatus.

It is of utmost importance, in comparing the noise ratios of various systems, that they be compared at the same overall sensitivity using amplifiers with the same frequency characteristics. This is necessary because the noise ratio is a direct function of gain and of the frequency band passed.

The noise ratio in percent is defined as 100 times the ratio of power output of the system transmitting a non-modulated carrier to the power output with a thirty percent, 400-cycle, modulated carrier, the carrier strength being adjusted for 50 mw output with modulation applied.

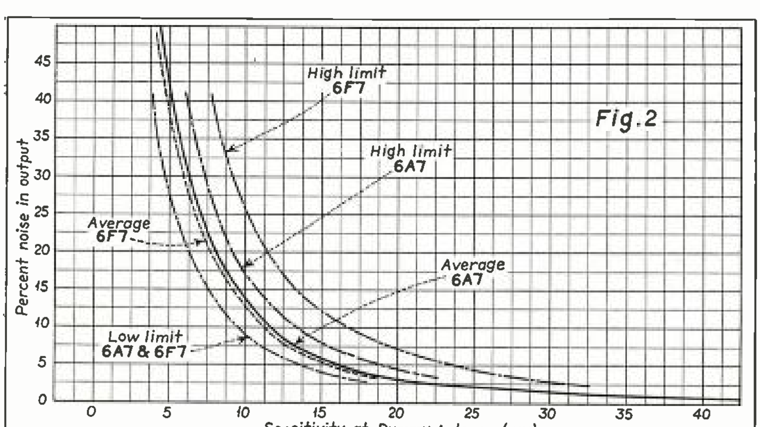
In Fig. 1 is shown a block diagram of the circuit used for comparing the noise ratios of different translation systems.

With the converter tube removed from the setup of Fig. 1, the noise level was so low that no reading could be detected on the output meter. It was therefore assumed that any measurable noise would come from the converter tube and its associated input circuits.

COMPARISON OF 6A7 AND 6F7

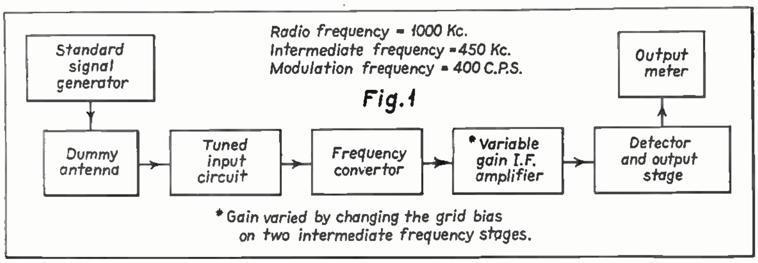
Fig. 2 shows the composite average noise with high- and low-limit curves for the two types of converters. Five different brands of tubes were tested. Although the average curve for Type 6A7 is slightly higher than for Type 6F7, the upper limit for normal tube variation is much lower in the case of the 6A7. The spread of the limits curves is an indication of the uniformity of noise to be expected.

When changing from tube to tube, or from one brand to another, the 6A7



Showing the composite average noise with high- and low-limit curves for the two types of translators used in the tests.

COMMENT . . *Production*



With the i-f gain set at maximum, and with the frequency converter tube removed from its socket, the residual noise level was too low to register on the output meter used.

was found to be very uniform with respect to:

1. Gain
2. Oscillator frequency
3. Input tuning.

When changing from one 6F7 to another, especially of a different brand, large changes in oscillator frequency and input tuning were noted. These tubes also were less uniform in gain and noise ratio.

EQUATION EVOLVED

An empirical equation, which closely fits the curves for composite averages, was determined in order to obtain a more accurate comparison of the two types of tubes.

For the setup used, the composite average for the five brands of tubes is represented to a close approximation by the equation:

$$\% \text{ Noise} = \left\{ \frac{Q}{X^2 + AX + B} \right\} \begin{matrix} X = 50 \\ X = 5 \end{matrix}$$

Where X = sensitivity in μv
$A = -3.8$
$B = +21$
Q for 6A7 = 1095
Q for 6F7 = 1030.

This would indicate that the average 6A7 is 6.3 percent noisier than the average 6F7. This relation, however, varies with different brands. Of the five brands tested, the distribution was found to be as follows:

2 brands 6A7 30% noisier than 6F7
2 brands 6A7 7% noisier than 6F7
1 brand 6F7 29% noisier than 6A7.

A limited number of tubes of each brand were tested. Indications are that if a large enough number of tubes were checked that the composite average, as well as individual brand averages, would be in closer accord. Also, the probability is that little or no difference in noise ratio would be observed between the two types of tubes.

RELATIVE GAIN

The 6F7 tubes were checked under two conditions of operation. In one case, a 16-turn pickup coil was used to couple the oscillator to the pentode, and in the other case, a 23-turn pickup coil was utilized.

Tube Type and Coupling	*Average Peak Osc. Grid Volts*	*Relative Gain*
6A7 electron coupled	25 volts	1.000
6F7 16-turn coupling	23 volts	.578
6F7 23-turn coupling	31 volts	.820

In other words, Type 6A7 gives 22% greater gain than the average 6F7 with the 23-turn pickup coil, and 73% greater gain than the average 6F7 with the 16-turn pickup coil. If a pickup coil of more than 23 turns is used in the above circuit, the pentode of the 6F7 will draw grid current; a cathode bias resistor of 3000 ohms was used on the 6F7, and 300 ohms was used with the 6A7.

The simpler circuit requirements, greater gain, and better uniformity of the 6A7 tube over other converter systems makes it a more desirable tube to use for frequency conversion. The only disadvantages over two-tube systems are the slightly higher input capacity and the higher grid-plate capacity. The former would limit the tuning range somewhat if low capacity tuned circuits are desired. The latter tends to cause i-f vs r-f reaction when these two frequencies are close together. If the r-f is close to but higher than the i-f, degeneration occurs. If the r-f is close to but lower than the i-f, regeneration results. In a few cases where this occurs corrective circuits may be used, although in general they will not be required.

C. A. Hultberg,
Engineering Dept.,
Hygrade Sylvania Corp.

SYLVANIA 6A6

THE TYPE 6A6 is a complete Class B output tube of the heater cathode type comprised of two triode units in a single bulb. Except for the heater rating, which is 0.8 ampere at 6.3 volts, the characteristics are the same as those for Type 53.

The Engineering Department of the Hygrade Sylvania Corporation has supplied the following data on circuit application and tube characteristics:

CIRCUIT APPLICATION

The 6A6 is used primarily as a Class B output tube for ac-operated receivers. Power output up to 10 watts may be obtained when the plate voltage is 300 volts. No grid bias is required.

The no-signal plate current of Type 6A6 is considerably higher than that for Type 79. This characteristic should be given consideration in the application of the former to automobile receivers.

By connecting the triode elements in parallel, Type 6A6 may be employed as a Class A tube, supplying sufficient power to drive another 6A6 in a Class B output stage to give high output with relatively low percentage distortion. The plate load for the driver tube should be two to four times the plate resistance, the value depending upon the design of the Class B stage. If self bias is employed, the maximum dc resistance in the grid circuit may be 0.5 megohm. When fixed bias is employed, this value should be limited to 0.1 megohm.

CASCADE AMPLIFIER

There are other special applications for which the 6A6 may be desirable. When used as a cascade amplifier each section of the tube is operated as a separate triode.

VOLTAGE AMPLIFIER—PHASE INVERTER

Type 6A6 may also be employed as a combination voltage amplifier and phase inverter.

Operating Conditions and Characteristics are:

CLASS B POWER AMPLIFIER

Heater Voltage	6.3 Volts
Plate Voltage	300 Volts
Dynamic Peak Plate Current (per plate)	125 Ma
Average Plate Dissipation	10 Watts

Typical Operation:

Plate Voltage......	250	300 Volts
Grid Voltage......	0	0 Volts
Static Plate Current (per plate).	14	17.5 Ma
Load Resistance (Plate-to-Plate).	8000	10000 Ohms
Power Output* ...	8	10 Watts

*With average input of 350 milliwatts applied between grids.

CLASS A DRIVER

(Both grids and both plates connected together at the socket)

Heater Voltage......	6.3	6.3 Volts
Plate Voltage........	250	294 Volts
Grid Voltage........	—5	—6 Volts
Plate Current........	6	7 Ma
Plate Resistance.....	11300	11000 Ohms
Mutual Conductance..	3100	3200 μmhos
Amplification Factor..	35	35

P-A SYSTEM PLUS

(*Continued from page* 21)

three speakers. Particular stress is placed on the fact that in all multiple hookups only parallel connections are considered as it has been found that there is less likelihood of complete or partial failure by this method rather than by the series method.

SUBSIDIARY EQUIPMENT

The ac voltage-control panel played a particularly important part in this set-up as a large part of the show was held at night and flood lights were used constantly. The operator had to be continually on the alert to regulate the current as the flood lights were being switched on and off. This is particularly true where mercury-vapor tubes are used for rectifiers.

It was necessary to have on hand at all times spare equipment, particularly electro-dynamic units and carbon microphones, as each event was started with an explosion of two bombs. The concussion quite frequently shattered the diaphragms which, of course, created considerable work for the operators in replacing units which were mounted some sixteen feet from the ground.

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SELECTIVITY MEASUREMENTS

(*Continued from page* 8)

more, it is difficult to measure a 5-milliwatt increase (resulting from modulation) in a total noise output of many times 5 milliwatts.

It is always possible to set the volume control sufficiently low so that the increase in noise output is negligible compared to the signal output, but then the selectivity measurement is not being conducted at the usual operating volume level (for code receivers) and, furthermore, the increased amplitude of the resonant input signal thus required reduces the total available voltage range of the signal generator and thus reduces the range of the selectivity measurement.

USE OF MICROAMMETER

In making selectivity measurements, a constant audio output is specified. What is really meant is that the signal voltage reaching the grid of the final detector tube shall be constant. It is suggested that a dc microammeter in the plate circuit of the final detector is the most accurate method of indicating constant detector grid signal. The detector plate currents of Group E are all direct currents and add algebraically to produce a total increment of plate current proportional to the sum of the squares of the amplitudes of all the grid voltages. The thermal-agitation voltages produce a certain total increment over and above the normal dc plate current of the detector. This increment will remain constant so long as the volume control setting remains unchanged. If an input signal reaches the detector grid, it will produce a further increment of dc plate current, which increment is entirely independent of the carrier frequency and is therefore ideally suited as a measure of the constancy of the detector grid signal. As a further advantage, it is unnecessary that the input signal be modulated in order to measure receiver selectivity by this method. Any reasonable arbitrary value of plate-current increment may be selected without changing the measured selectivity, although it is obviously advantageous to select the smallest increment which may be read accurately. Very small increments of plate current may be measured accurately by the use of a low-range sensitive microammeter shunted by a so-called "bucking battery" which is in series with a high resistance.

Selectivity measurements made in this manner will represent the true selectivity of the radio-frequency circuits of the receiver without the introduction of the errors which usually accompany the "constant audio output" method.

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PRODUCTION TESTING

(*Continued from page* 19)

and the condenser in the test (see Fig 5). The other coil is connected through the phase-rotating device to the 110-volt line. When the phase of the currents in both coils of the dynamometer is in quadrature, the dynamometer reads zero. When condensers of the same type are tested, it is sufficiently accurate to use the absolute reading of the dynamometer as an indication of the power factor. In the case of paper-type condensers, the power factor is especially important, since it seems to be a true index of the probable life of the condenser, as the power factor is an indication of the chlorine ion and moisture content in the paper.

In the case of electrolytic condensers, the alternating current used in these measurements must be incremental; that is, it must be super-imposed on a larger value of direct current. This is generally accomplished by having a battery or low-resistance potentiometer in series with the condenser in the test and the coil of the dynamometer, as in A of Fig. 5. Also, due to the fact that an electrolytic condenser requires a direct-current component, the method for testing these condensers for capacity, mentioned above, does not hold, as an alternating milliammeter will measure the direct current as well as the alternating current if connected in series with the circuit.

By the use of either a condenser and resistance, or transformer, to separate the alternating-current component and indicate what that component is alone, the measurements can be taken. This gives a fairly accurate indication of the capacity of the electrolytic condenser provided the frequency at which it is measured is low enough to make the power-factor error negligible. This is true at 60 cycles.

TRANSFORMER TEST

A great many transformer manufacturers have reached the conclusion that as long as a transformer works—it works, and therefore can be used and sold.

The temperature at which the transformer will work, its absolute efficiency, and several other minor considerations does not end there

As a result, we find capacities of transformers very highly overrated. The best way of testing the efficiency of a transformer consists in testing the power absorbed at no load. This is best accomplished by the use of a wattmeter. This power-factor indication will show whether the transformer is designed properly since all losses, except copper losses, are independent of the transformer load. The copper losses can be determined by the ohmic resistance of the unit.

The data presented is necessarily of an empirical nature. Should there be any questions relative to the test systems described, the authors will be pleased to answer them in detail.

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I.R.E. PROGRAM

(*Continued from page* 11)

CONVERTER TUBES AT HIGH FREQUENCIES
W. A. Harris, RCA Radiotron Company
INPUT LOSSES IN VACUUM TUBES AT HIGH FREQUENCIES
B. J. Thompson and *W. R. Ferris*, RCA Radiotron Company
12:30 P. M. Group Luncheon
2:00 P. M. Technical Session
NEW EQUIPMENT FOR THE RADIO DESIGNER AND ENGINEER
C. J. Franks, Radio Frequency Laboratories
DETECTOR DISTORTION
Kenneth W. Jarvis, Consulting Engineer
4:00 P. M. Inspection of Exhibits
Meeting of RMA Committee on Vacuum Tubes
Meeting of RMA Committee on Sound Equipment
6:30 P. M. Stag Banquet
W. E. Davison, Toastmaster Entertainment

WEDNESDAY, NOVEMBER 14

10:00 A. M. Joint Technical Session with RMA Engineering Division on Radio Interference
Brief Discussions on Desirability of Reduction of Radio Interference from the Viewpoint of:
The Consumer—*O. H. Caldwell*
The Public Utilities—*J. O'R. Coleman*
The Radio Manufacturer—*L. F. Muter*
The Radio Dealer—*Benjamin Gross*
The Federal Communications Commission—*C. B. Joliffe*
Summary—*A. N. Goldsmith*
INVESTIGATION AND SUPPRESSION OF INDUCTIVE INTERFERENCE
H. O. Merriman, Radio Branch, Department of Marine, Canada
12:30 P. M. Group Luncheon
2:00 P. M. Technical Session on Radio Interference (Continued)
Discussion by Interested Organization on Promotion of Interference Reduction

NEWS OF THE INDUSTRY

JOYCE APPOINTED RCA VICTOR ADVERTISING HEAD

G. K. Throckmorton, Executive Vice President of the RCA Victor Company has announced the appointment of T. F. Joyce as Manager of Advertising and Sales Promotion, succeeding Pierre Boucheron, resigned. In addition to his new duties, Mr. Joyce will continue to direct the advertising and sales promotion activities of the RCA Radiotron Company.

Mr. Joyce has for many years been identified with the merchandising of Cunningham and RCA Radio Tubes, and prior to that was with the Incandescent Lamp Division of the General Electric Company.

AIR EXPRESS AIDS IN NEWS SERVICE

That air express has become an important factor in every major news story is shown by the report of the Air Express Division of Railway Express Agency, which reveals the role air delivery of newsphoto played in informing the public of several recent events which commanded nationwide interest.

While the S. S. Morro Castle passengers and crew were still battling fire and storm for their lives, their pictures (taken from planes) were turned over to special representatives of the express organization for delivery by air express to papers throughout the nation, so that a horror-stricken public could visualize the disaster.

THORDARSON BULLETIN 345-A

The Thordarson Electric Manufacturing Company, 500 W. Huron St., Chicago, have recently released Bulletin 345-A, covering Sound Amplifier Transformers. This bulletin gives technical data on transformers for the following applications: Microphone-to-line, microphone-to-tube, line-to-tube, interstage coupling, impedance coupling, push-pull interstage, tube-to-line output, line-to-voice-coil output, tube-to-voice-coil output, plate-power supply, filament supply, filter choke coils, speaker-field supply, exciter-lamp supply, and voltage changers and boosters. *With the exception of the last two mentioned, all* transformers are illustrated. Free copies will be sent on request to the above company.

ALLEN-BRADLEY APPOINTS NEW CLEVELAND MANAGER

R. J. Roy, formerly Cleveland branch manager for the pump and electrical department of Fairbanks Morse and Company was recently appointed district manager of the Allen-Bradley Company Cleveland office.

Mr. Roy, a graduate of the Massachusetts Institute of Technology, has long been identified with the sales of electrical equipment in the Cleveland, Pittsburgh and Cincinnati territories.

This is the correct version of the writeup which appeared in the September issue of RADIO ENGINEERING.

UPCO BULLETIN

A bulletin on the Upco Electric Pick-Ups has recently been released by the Upco Engineering Laboratories, Incorporated, New York, N. Y. Copies may be had on request.

HAMMARLUND SHORT-WAVE MANUAL

The Hammarlund Short-Wave Manual, 1935 edition, has been copyrighted by the Hammarlund Manufacturing Company, Inc., 424-438 West 33rd Street, New York, N. Y. In this manual will be found the constructional details of what is said to be the most carefully selected and comprehensive group of inexpensive short-wave receiver designs ever published in a single volume.

The selections were made by the editors of five radio publications from among the most popular and efficient designs described in their publications within the last year or so. Models of these receivers were constructed and tested in the laboratory. The twelve designs appearing in the manual represent the selection of the best of the hundreds of receivers presented to the home constructor, it is said.

Copies of this new manual may be obtained for the nominal charge of ten cents each.

KASSON MOVES TO PERMANENT OFFICES

David M. Kasson, manufacturer's representative for the metropolitan area of New York, has just moved to permanent quarters at 140 Washington Street, New York City. He now has facilities for stocking merchandise for all the manufacturers he represents, is centrally located in the midst of the radio manufacturing district, and is able to assure real service for his accounts.

J. E. FRANCIS NEW PHOTOPHONE HEAD

James E. Francis has been appointed Manager of the Photophone Division of the RCA Victor Company, replacing E. O. Heyl, resigned, according to an announcement by Mr. G. K. Throckmorton, Executive Vice-President, who also announced the consolidation of the company's sound-on-film recording activities with those involved in the sale of theatre reproducing equipment within the Photophone Division.

Mr. Francis brings to his new duties experience in sound-on-film recording and reproduction dating back to the time before they were made commercially available to theatres. With the entrance of RCA in the sound motion picture equipment field, he was placed in charge of installation and service. When the RCA Photophone activities were consolidated with the RCA Victor Company at Camden, New Jersey, Mr. Francis was placed in charge of Photophone film recording operations and licensing, duties which he retains in his new position.

COUCH BULLETIN PAM-3

We have just received Bulletin PAM-3 on Microphones, Speakers, and Accessories for Sound Systems from S. H. Couch Company, Incorporated, North Quincy, Mass. Included is a great deal of interesting information on carbon microphones, condenser microphones, moving coil microphones, crystal microphones, speakers, microphone stands, microphone cables, and the like. Copies of the bulletin may be had on request.

ANDREWS TO NATIONAL UNION STAFF

National Union Radio Corporation of N. Y., has announced that Dr. V. J. Andrews has joined the Technical-Sales staff of the corporation.

Dr. Andrews was born in Ohio, and graduated from Wooster College in that State. After graduation, he spent some time on design and development work in the Radio Engineering Section of the U. S. War Department, Fort Monmouth, N. J.

CONSOLIDATED CATALOG

The Consolidated Wire and Associated Corporations of Chicago, Illinois, has just issued a new catalog that will be of interest to all distributors of Radio and Electrical Products. It contains a number of original and unique products.

Especially featured are a new series of antennas, both for house and auto use; a new line of auto filters; new short-wave wire; insulators; and antenna kits.

The listings of automotive cable have been expanded and magnet wire listings have been revised for easier selection.

It will be to the advantage of all manufacturers and distributors to write to the Consolidated Wire and Associated Corporations, Peoria and Harrison Streets, Chicago, Illinois, for the catalog.

ACHESON COLLOIDS CORP. MOVES

The New York City office of the Acheson Colloids Corporation, Port Huron, Michigan, has recently moved its location from 654 Madison Avenue to 444 Madison Avenue, where the entire 36th floor will be occupied. The increasing number of staff employees called for by the normal growth in business has occasioned this change.

The business of this office is devoted entirely to field research work, patents and trade-marks, finances, taxes, legal and corporate matters, and is not concerned with selling or manufacturing.

FRYLING STUDYING FOREIGN MARKETS

G. R. Fryling, of the Erie Resistor Corporation, Erie, Pa., recently sailed for Europe on an extended business trip. He will go directly to London for an inspection of the Company's subsidiary plant located there, after which he plans to visit several European centers to obtain first hand information on the market covered by the English factory.

"WHITE" FLEXIBLE SHAFTING BULLETIN

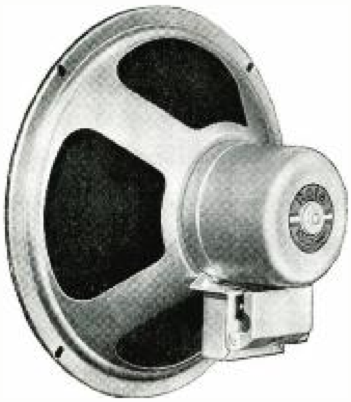
A bulletin on Flexible Shafts and casings for Remote Control of Radio has been brought to our attention. This bulletin gives data on the construction of shafts, specifications of the No. 150L53 flexible shaft and the No. 170A1 flexible casing, and information concerning their uses in automobiles, taxicabs, airplanes, motorboats and yachts. Information on applying the flexible shaft control to a radio set is also included. The bulletin comes from the Industrial Division of the S. S. White Dental Mfg. Co., 152 W. 42 Street, New York, N. Y.

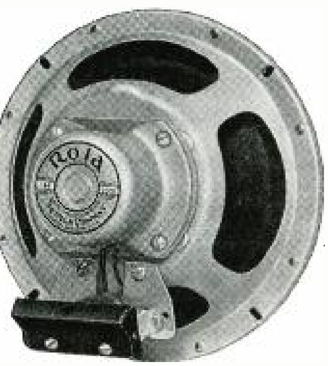
New Products

NEW ROLA SPEAKER MODELS

The Rola Company, 2530-70 Superior Avenue, Cleveland, Ohio, have recently announced two new loudspeaker models.

The Model K-12, shown in the accompanying illustration, is a 12-inch unit designed to meet the ever increasing demand





for fidelity of reproduction and power-handling capacity. Its specifications are:

Overall diameter..........12-⅛ inches
Overall depth............ 6-⅛ inches
Recommended baffle hole..10-¾ inches
Mounting bolt circle......11-½ to 11-¾ inches
Net weight...............6-¾ pounds
Voice-coil impedance at
400 cycles................2.8 ohms.

The Model F-6-B, also shown, is an 8-inch unit. Its specifications follows:

Overall diameter....8-3/32 inches
Overall depth.......4 inches
Weight packed......4-½ pounds
Weight net.........3-½ pounds.

The latter unit is said to be capable of filling the most exacting requirements.

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RADIO NOISE AND FAULT LOCATER

The Tobe Model 233 Noise and Fault Locater is a highly sensitive yet extremely compact and portable instrument which satisfies the requirements of electrical distribution engineers for reasonably priced apparatus capable of indicating quickly and accurately the many points at which extraneous radio-frequency fields originate, it is stated.

The Model 233 unit is 12 inches long, 12 inches high and 7½ inches wide. Within this space is contained the batteries, tubes, controls, output meter, and loudspeaker. It weighs 21 pounds fully equipped and ready for operation. Further, hinged covers are provided. The cover protecting the control panel, folds back out of the way of the operator under operating conditions. An adjustable carrying strap of broad webbing is also supplied.

Two controls are required for operating this unit; namely, noise selector and sensitivity adjustor. The noise selector allows adjustment of the instrument to maximum response at the desired frequency; the sensitivity adjustor enables the operator to obtain whatever degree of sensitivity is required for checking noise fields of any intensity up to 200,000 microvolts.

Further information on this unit may be obtained from the Tobe Deutschmann Corporation's (Canton, Mass.) Engineering Bulletin No. RE. L-834.

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"VENTILATED" ELECTRODES

"Ventilated" electrodes, which expose greater areas to the air and so withstand the heavier current drain imposed by some of the new all-wave receivers, are announced by National Carbon Company, Inc., as its latest improvement in the Air Cell "A" Battery.

The new heavy drain Air Cell Battery is known as No. SA-600 special, and it permits a current drain of 750 milliamperes as against the 650-milliampere capacity of the standard Air Cell "A" Battery, with a guarantee of 800 hours' life, it is stated.

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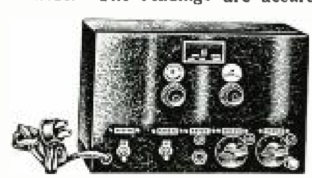
ALL-WAVE SIGNAL GENERATOR

The Clough-Brengle Company, 1134 West Austin Avenue, Chicago, has recently presented to the market an all-wave, continuously variable, signal generator covering the frequency range of 50 kc to 30 mc (6,000 to 10 meters). The model OC test oscillator features accuracy, stability, and convenience, it is stated.

There are 6 bands in the model OC each covered by a dial 25 inches long, divided into 400 divisions, each division being 1/16-inch wide. The readings are accurate to



1/10%. The unit is hand calibrated with crystal oscillators.

The output of this test oscillator is continuously variable from ½ microvolt to 2 volts, and the audio test note is 400 cycles. External modulation from a phonograph or beat-frequency oscillator may be used when desired. Operation is from 110-volt ac or dc line.

RUBBER "SANDWICHES"

Sheets of Synthane laminated bakelite and rubber are bonded together alternately to combine the extreme resiliency of rubber with the strength, rigidity and very desirable electrical and solvent resisting

properties of Synthane. These are known as Rubber "Sandwiches."

The number and thickness of the individual layers may be varied indefinitely to produce a section of any given thickness or characteristic.

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BODINE ELECTRIC GOVERNOR CONTROLLED MOTORS

A new addition to the Bodine line of electric governor-controlled motors was recently made by the Bodine Electric Company, 2264 W. Ohio Street, Chicago, Illinois, in ratings ranging from 1/10 to ¼ hp.

Heretofore, all Bodine governor-controlled motors were smaller than 1/10 hp.

The new line is available in series and compensated series types of motors with an approximate speed range from 500 to 7500 rpm.

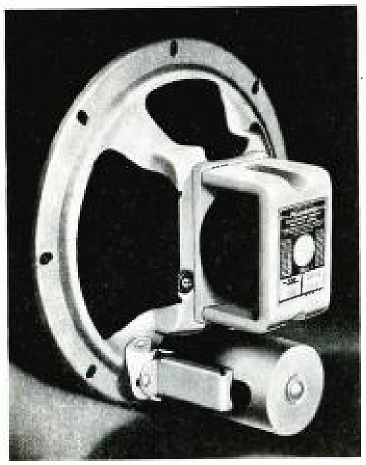
These motors are also available with built-in worm-gear speed reducers of various ratios, the highest of which is 60 to 1.

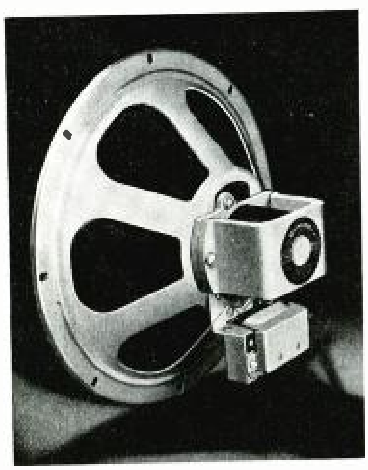
The accuracy of speed control closely approaches the performance of synchronous motors. The present speed is not readily affected by variations in load if the loads are kept within the capacity of the motor. The electric governors are of two forms—Form R can be adjusted while the motor is running; Form S can be adjusted only at standstill.

NEW MAGNAVOX SPEAKERS

The Magnavox Company has introduced two new models of dynamic speakers, which are illustrated in the accompanying photographs.

Magnavox Model No. 166, 6-inch dynamic speaker, has been introduced to fill the need for a low-priced speaker of the 6-inch size, having performance capabilities which are unusual as to fidelity and sensitivity, it is stated. This unit has the following dimensions: The overall diameter of the cone housing is 6-5⁄8 inches; diameter of the mounting hole circle is 6-7/32 inches; depth from front to back, 3-3/32 inches; maximum field coil weight accommodated, ½ pound; diameter of voice coil, ¾ inches; and impedance of voice coil at 400 cycles is 3.6 ohms.





The Magnavox Model No. 132, 12-inch dynamic speaker, is said to supply the need for a large speaker having unusual fidelity and sensitivity. It has the following principal dimensions of interest: Overall diameter of cone housing, 12-5/6 inches; diameter of mounting hole circle, 11-7⁄8 inches; depth from front to back, 6-1⁄8 inches; maximum field-coil weight accommodated, 1-¼ pounds (a larger field structure accommodating 1.75 pounds is optional); diameter of voice coil, 1 inch; impedance of voice coil at 400 cycles, 4.5 ohms; and power handling capacity is 8 watts continuous duty.

NEW METAL-TO-GLASS SEAL

A new metal-to-glass seal, developed by the Research Laboratory of the General Electric Company, has, because of the certainty with which tight and reliable joints can be made between glass and the alloy called Fernico, opened up many possibilities in the development of various classes of vacuum tubes and other devices wherein leading-in wires or conducting parts must pass through gas-tight insulating seals or themselves form part of a gas-tight chamber.

Fernico can be machined, forged, punched, drawn, stamped, soldered, copper-brazed, and welded.

The physical characteristic of Fernico which makes possible its successful fusion with glass, is its expansion curve, which coincides almost exactly with that of certain glasses. For this reason, no stresses are set up in either the glass or the alloy when cooling from the fusion temperature. This lack of initial internal stresses in the completed glass-Fernico seal makes the seal tight and sturdy, it is said. Furthermore, no more care in cooling the combination is necessary than in dealing with glass alone.

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NEW "LAYTEX" INSULATION

Laytex, a new insulation which, it is stated, promises to revolutionize the electrical industry and to play an important part in the progress of more than a score of allied industries, is announced by the United States Rubber Company.

Laytex is a new development in that it is said to possess properties so superior to those of ordinary flexible insulation that in time, the manufacturer believes, all existing codes and specifications on wire insulation will have to be re-written.

An idea of the value of Laytex may be gained from a few of the claims made for it. As for example, of all known flexible insulation:

1. Laytex is the most flexible.
2. Laytex has the greatest tensile strength and resistance to compression.
3. Laytex has the highest dielectric strength and insulation resistance.
4. Laytex permits thinner but superior walls which make possible finished conductors lighter in weight and smaller in bulk.

Laytex is derived from latex, the milk of the rubber tree. Through patented processes are removed all proteins, sugars and water solubles . . . the materials which are susceptible to moisture and which make a sieve of ordinary insulation.

A conductor is then run through a series of baths of liquid and during each bath the conductor takes on a film of insulation which is almost immediately converted from liquid to solid. The liquid is solidified on any given section of the conductor before the section is in physical contact with any mechanical support, and because of this, mechanical defects found in ordinary types of insulation are avoided.

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IMPROVED TRIAD 2B6 TUBE

A 2B6 tube that is said to have a fast heater cathode and improved life characteristics has recently been announced by the Triad Manufacturing Co., Inc., Blackstone, Middle and Fountain Streets, Pawtucket, R. I. This company have also a 10-page bulletin that gives complete and up-to-date information concerning the characteristics of the 2B6 tube and its application to circuits. Further information may be obtained from the above company.

CROWE RADIO COMPONENTS

The Crowe Name Plate and Manufacturing Company, 1749 Grace Street, Chicago, have a number of radio components, such as, tuning controls, automobile remote controls, dials, grilles, metal cabinets, escutcheons, and name plates, for broadcast receivers, skip-band receivers, all-wave receivers and the like.

The airplane style dial, No. 159, is especially interesting. This unit has a ratio of 7 to 1 in 180 degrees, the pointer traveling 270 degrees. The drive is of the wedge type with geared connection to the double pointer, the escutcheon is bronze or chromium, and the scale is peach with brown graduations.

The scale lists *Standard Broadcast Stations* and *Airplane and Police* in kilocycles, and the two *Foreign-Phone and Code* scales are calibrated in megacycles. These scales, of course, are made only to order to agree with customers' calibrations. Further information may be obtained from their catalog, No. 55.

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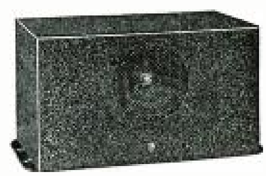
ORD-O-PAM SPEECH SYSTEM

The S. H. Couch Company, Inc., North Quincy, Mass., have announced a one-way speech-amplifying system that may be heard a distance of 25 to 100 feet from the speaker, according to the noise level of the premises.

The system is comprised of a speaker-amplifier unit, microphone with flexible cable and terminal box, six-foot flexible cable and attachment plug for power supply, and signal-back pear-type push button attached to flexible cord.



Views of the cased and uncased amplifier unit, and the two types of microphone.

Three different type microphones are available, namely, counter or wall type, desk type, and handset type.

The speaker-amplifier unit may be obtained for ac, dc, or universal operation, and measures 13" x 6⅞" x 8 1/16". The unit is mounted in an all-steel case with a black crystaline finish and comes equipped with tubes.

NEW "T" PAD ATTENUATOR

A new "T" Pad Attenuator, recommended for use in all input systems where it is necessary to maintain a constant impedance to both input and output, has recently been announced by the Central Radio Laboratories, 900 E. Keefe Ave., Milwaukee, Wis.

The resistance sections in this unit are made of a special graphite, contact being made by a patented non-rubbing band which insures a low noise level and requires no adjustment or cleaning. A black crackle finish steel cover provides an electrostatic and electromagnetic shield. This also acts as a double dust shield, the resistance elements being entirely enclosed in bakelite.

The attenuation is straight line for 95% of the rotation, a maximum of 95 db and then smoothly to infinity, it is stated. No appreciable attenuation of frequency is present until 16,000 cycles is reached, and no insertion loss.

The rating of this "T" Pad Attenuator is one watt. It is recommended that this control be used in the circuit at a level of not more than plus 22 db above the standard zero level.

The "T" Pad with dial plate is shown in one of the accompanying illustrations. The dial is 3 inches in diameter with black background and silver numerals.

The terminals, as shown in the other illustration, are screw-type mounted in a bakelite strip at the rear of the control.

A new booklet, "Series II Sound Projection Controls", covers a complete line of constant impedance "T" Pad Attenuators, "T" Pad Faders, "L" Pad Attenuators, Gain Controls, and Straight Faders. This booklet is free on request to the Central Radio Laboratories.

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NEW WIRE INSULATIONS

Two different insulations for electrical wire have been developed and applied by engineers of the DuPont Cellophane Company and the Belden Manufacturing Company.

The first is the development of a method of applying "Cellophane" to magnet wire, and the second the use of a new synthetic rubber—"Duprene"—as protective covering for ignition cable.

Celenamel, as the new magnet wire is called, is a great space saver, has greatly increased dielectric strength, and can be furnished at approximately the same cost as cotton covered enameled wire, it is stated. Tests show that Belden Celenamel has approximately the same space factor as silk enameled wire. In coils, Celenamel has approximately 64% the volume of double cotton covered wire and 88% of single cotton covered enameled wire. The "Cellophane" covering, which is sealed with a baked lacquer finish, protects the

enamel insulation against heat and varnish solvents.

The rubber substitute has certain properties that enable it to resist high heats, hot oil, and the decomposing effects of corona. Cable equipped with "Duprene" covering is not necessary for average automotive service but only for the use in such places where heat, oil, and corona conditions are most severe.

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NEW REMLER P-A AND REMOTE AMPLIFIERS

The unification of remote broadcasting and public-address amplification, made possible by the newly designed Remler High-Fidelity PAR-19 combination, shown in the accompanying illustration, is a convenience which measurably improves the quality of both p-a and broadcast performances, it is said.

The Remler PAR-19 consists of a public-address power amplifier and a remote amplifier housed in a single portable case designed to supply local public-address and remote broadcasts from the same microphone input. Three input channels are provided with main gain controls on both the p-a and the remote.

The public-address amplifier is a four-stage, push-pull resistance-coupled amplifier, using three type 6A6 tubes, two type 2A3 tubes, and one type 82 rectifier. The

remote amplifier consists of a three-stage, push-pull amplifier using type 6A6 tubes.

The new Remler PAR-19 weighs only 85 lbs. The unit is manufactured by the Remler Co., Ltd., 2101 Bryant St., San Francisco, Calif.

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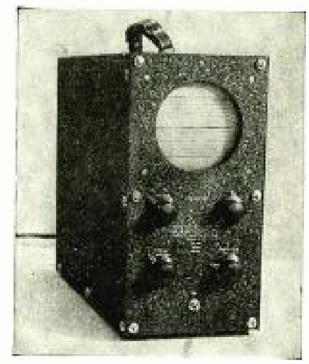
PORTABLE CATHODE-RAY OSCILLOGRAPH

The Allen B. Du Mont Laboratories of 542 Valley Road, Upper Montclair, New Jersey, announce a new portable cathode-ray oscillograph, Type 142, with a 5-inch cathode-ray tube, power supply and linear sweep circuit, that is completely self contained. This unit has been designed to meet the demand for a compact and self-contained instrument for general laboratory and industrial use. The only connections to the apparatus are the ac attachment plug and the wires necessary to connect the apparatus under test to the terminals on the unit.

A type 54-8 Du Mont cathode-ray tube utilizing an indirectly-heated cathode and equipped with two sets of electrostatic deflection plates and high-intensity screen is mounted in the unit. A graduated scale at the face of the tube enables accurate quantitative measurements to be made. A power supply, furnishing the accelerating electrode voltage as well as the necessary filament and focusing voltages, is incorporated in the unit together with a linear sweep circuit having a range from 10 to 5000 cycles per second. Means are provided on the unit to accurately focus the spot and control the amplitude and frequency of the sweep voltage. The sweep circuit is of the stabilized type which can



be made to lock in step with a recurrent wave-form if desired.

The terminals to the unit are mounted at the rear and the linear sweep may be connected or disconnected according to the use of the instrument. Separate leads from each deflection plate are brought out and are available for external connections, permitting operation of either set of plates, balanced or unbalanced, to ground.

For complete information write the Allen B. DuMont Laboratories of Upper Montclair, New Jersey.

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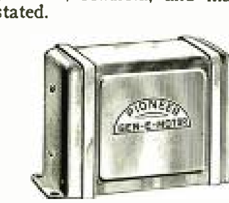
COMPACT MODEL GEN-E-MOTOR

The Pioneer Gen-E-Motor Corp. of 464 W. Superior St., Chicago, Illinois, has just announced the new Model JW Gen-E-Motor.

This unit has been designed to replace the vibrator power supply in all popular auto-radio sets. It will fit within the housing of over twenty receivers, including the Majestic, General Electric, RCA, Motorola, Bosch, Audiola, and many others, it is stated.



Only three connections to the set are required. No other changes must be made, and the set operates in exactly the same manner as with the vibrator power supply.

The Model JW has a full ball-bearing mounted armature and is unconditionally guaranteed for one year. There are no adjustments to make. Enough lubricant for life is sealed in the bearings.

INDEX TO ADVERTISERS

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF MARCH 3, 1933, OF RADIO ENGINEERING

Published monthly at New York, N. Y., for October 1, 1934.

State of New York, }
County of New York, } ss.:

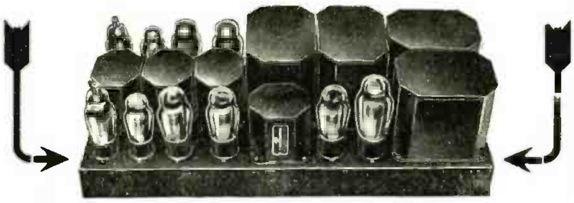
Before me, a Notary Public in and for the State and county aforesaid, personally appeared B. S. Davis, who, having been duly sworn according to law, deposes and says that he is the Business Manager of RADIO ENGINEERING, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit: 1. That the names and addresses of the publisher, editor, managing editor, and business manager are: Publisher, Bryan Davis Publishing Co., Inc., 19 East 47th Street, New York. Editor, M. L. Muhleman, Mt. Vernon, N. Y.; Managing Editor, Ray D. Rettenmeyer, Madison, N. J.; Business Manager, B. S. Davis, Scarsdale, N. Y. 2. That the owners are: Bryan Davis Pub. Co., Inc.; B. S. Davis, Scarsdale, N. Y.; Roy T. Atwood, Albany, N. Y.; G. R. Bacon, Douglaston, N. Y.; J. C. Munn, Union City, Pa.; J. A. Walker, Richmond Hill, N. Y.; A. B. Goodenough, New Rochelle, N. Y. 3. That the known bondholders, mortgagees, and other security holders owning or holding 1% or more of the total amount of bonds, mortgages, or other securities are: None. 4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where a stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given: also, that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

(Signed) B. S. DAVIS, Business Manager.

Sworn to and subscribed before me this 1st day of October, 1934.
(Seal) J. A. WALKER, Notary Public.
Queens Co. Clk's No. 2982, Reg. No. 7176.
New York Co. Clk's No. 655, Reg. No, 5-W-424.
Commission expires March 30, 1935.

UTC

High Quality Public Address Audio Components in a Parallel Push Pull 45 A Prime Amplifier



Ideal for broadcasting, recording, and public address applications. Will handle up to twenty dynamic speakers. High power output with low cost power tubes.

SPECIFICATIONS:

Input will match 50, 200, and 500 ohm lines. Center tap on 200 and 500 ohm lines for double button microphone. Output will match 500, 200, 16, 8, 5, 3, and 1.5 ohms. Three balanced push-pull audio stages. Tubes used: 2—57's triode connected; 2—56's; 4—45's in parallel push-pull fixed bias; 1—83; 1—45. Stable fixed C bias for output stage. Undistorted class A prime output 38 Watts. Gain +90 DB. Trap resonant filter affords maximum filtering efficiency. List price $63.50. Net to dealers, hams $38.10. Fully shielded drilled deck for audio and power sections. List price $9.00. Net to dealers, hams $5.40. Other 45-A prime components.

	List Price	Dealers Price
PA-233—driver 56 plates to 45 grids	$6.00	$3.60
PA-245—outout for fixed or self bias 45's A Prime (20 watt peak power) to 500, 200, 16, 8, 5.3, 1.5 ohms..	7.00	4.20

Write for Laboratory series sheet No. 10 which fully describes the construction and circuits for 45A prime amplifiers.

The UTC Engineering Laboratories have developed new:

- Television transformers linear from 30 to 200,000 cycles
- Controlled reactance D. C. Voltage regulators for automobile transmitters using class B modulation
- Two ounce audio units for aircraft and portable use
- High reactance coils for audio circuits
- Audio equalizers and filters
- Automatic line voltage regulators

UNITED TRANSFORMER CORP.

264 CANAL STREET NEW YORK, N. Y.

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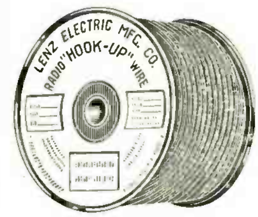
TAILOR-MADE TO YOUR ORDER



LENZITE Radio Hook-up Wire for All Wave and Auto Radio

LENZITE is the name of this new hook-up wire. The insulation consists of cellulose acetate treated textile plus cotton braids thoroughly saturated in moisture resisting compounds. This wire can also be furnished saturated in slow burning high di-electric lacquer.

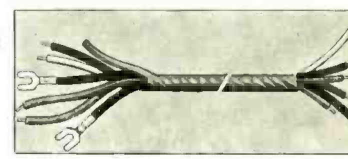
Write for price list C-634, on Various Types of Wire in Stock.

SPECIAL CABLE REQUIREMENTS

Let us do the "worrying." We like it. Submit your cable problems. We are fully equipped to manufacture all types of special cords and cables for radio installation.

RADIO ENGINEERS:

Send your specifications and blue prints to us.



BATTERY SET CABLE

LENZ ELECTRIC MFG. CO.

1751 NO. WESTERN AVE. CHICAGO, ILL.

—ELMET—

MOLY

FOR

GRID WIRES

SUPPORT WIRES

ELECTRIC FURNACE HEATING ELEMENTS

ALSO FOR

SCREEN GRIDS--CATHODE COILS MANDRELS---CONTACTS, ETC.

ALL OF THE ABOVE PRODUCTS MAY BE HAD IN VARIOUS COMPOUNDS OF

MOLYBDENUM-TUNGSTEN

Write for Information and Prices

American Electro Metal Corp.

Lewiston Maine

NOTE *the* FEATURES

IRC

VOLUME CONTROLS

USING TIME-PROVED RESISTANCE PRINCIPLE of *Metallized* RESISTORS

METALLIZED Resistors need no introduction to the radio trade. Now comes this same well-known resistance principle applied to Volume Controls to form units of outstanding quality.

Remember: For two years prior to this general announcement IRC Volume Controls in goodly quantity saw service in radio receivers made by numerous manufacturers *who now use them regularly.*

There can be no more convincing proof!

Samples to your specifications gladly sent. Write for Catalog M-26 describing this new IRC development in detail.

INTERNATIONAL RESISTANCE COMPANY

2100 Arch Street, Philadelphia, Pa.

In Canada: 187 Duchess St., Toronto, Ont.

RESISTANCE ELEMENT

Conducting material applied to *Bakelite base* with automatic machinery gives scientific control of taper. The use of Bakelite makes possible permanent bonding at high temperature.

HUMIDITY CHARACTERISTICS

Non-hygroscopic bakelite base prevents absorption of moisture. Only a small change in resistance occurs at 90% relative humidity at 40 C. Upon drying, the control returns to its original value.

QUIET OPERATION

Unique, three finger contact with spherical convex surfaces assure smooth change in resistance and low noise level.

NON-AGING

Practically unaffected by time. Nominal changes of only 1% or 2%.

WEAR

Average change in resistance is less than 10% with 50,000 rotations.

FLEXIBILITY

Standard controls from 200 ohms to 2 megohms. Can be made as high as 10 megohms. Special resistance curves supplied to order.

SWITCH

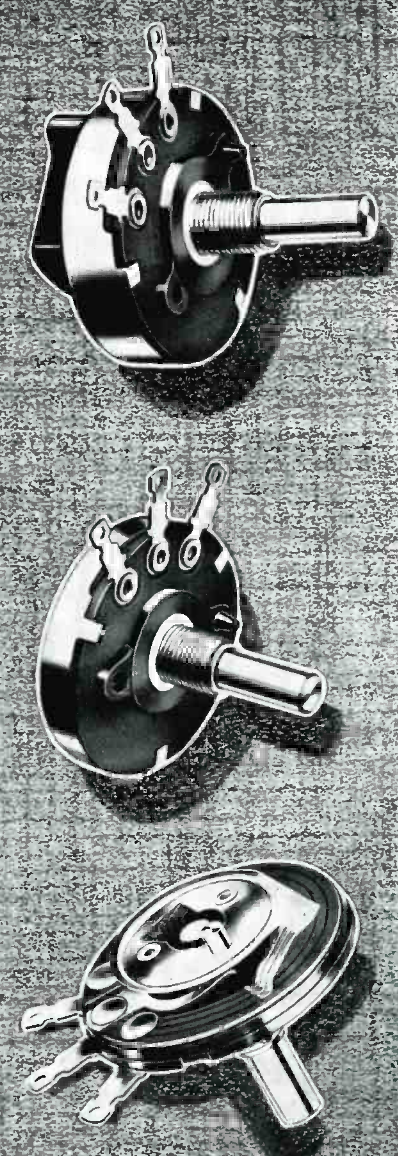
Underwriter's Approval. Low Internal resistance makes it suitable for auto radio use.

LOAD CHARACTERISTICS

Will carry up to 1 watt with power dissipated over entire element.

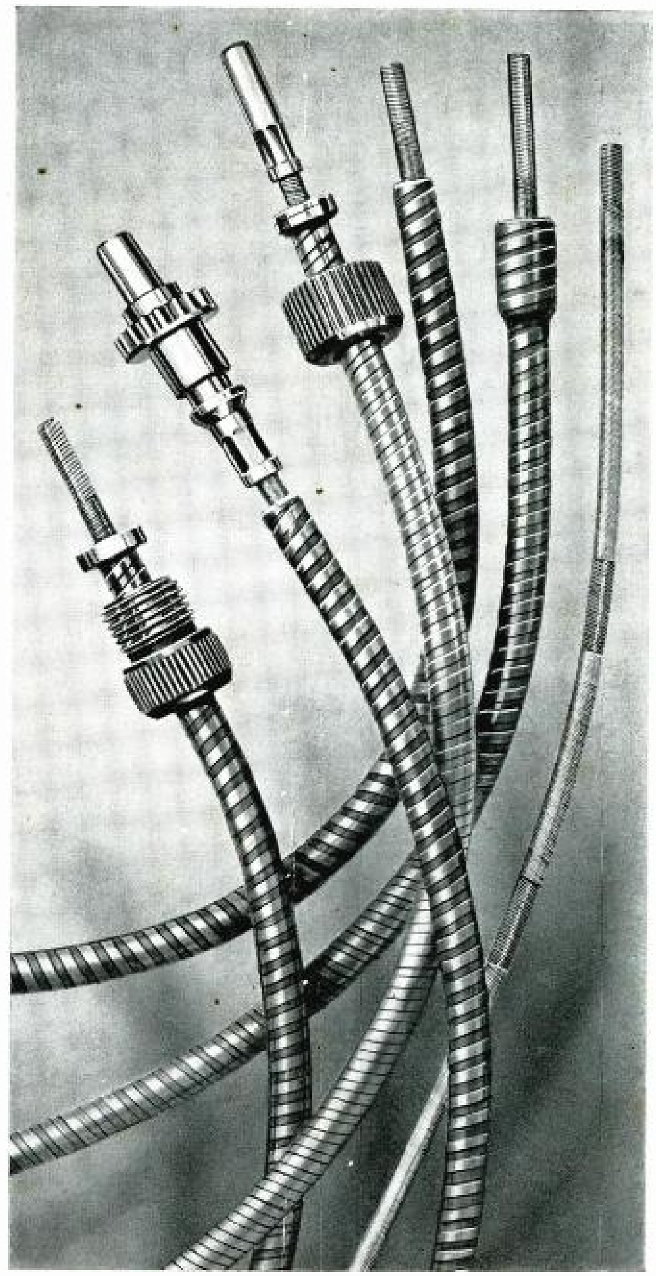
TAPPED CONTROLS

The IRC method of making fourth terminal contact eliminates obstructions in the path of the slider, thus allowing a smoother increase in resistance and lower noise level at the tapped point.



BY THE MAKERS OF METALLIZED, PRECISION AND POWER WIRE WOUND RESISTORS

In your new Auto Radio Designs incorporate these latest FLEXIBLE SHAFT *and* CASING *developments*



These developments, most of which are patented, include:

No. 150L53 Shaft, a 5-layer, 43-wire shaft having a minimum of torsional deflection under load, equal deflection when turned in either direction, and ample flexibility for free operation in curves of small radius.

No. 170A1 Parkerized Metallic Casing, a rugged, rust-resistant casing only .255" outside diameter.

Shown in the illustration, actual size, in order from the left:

1. Shafting with ends swaged accurately square for square hole, collet or set screw attachment. Casing with integral formed flange and male nut.
2. Conventional die-cast gear end fitting on flexible shaft. Casing with plain end.
3. Conventional machined shaft end fitting. Casing with integral formed flange and female nut. We are prepared to make machined ends to specifications.
4. Shafting with regular square swaged ends ready for attachment of end fitting. Casing with plain end.
5. Shafting with ends octagonally swaged making possible easy calibration of control unit, condenser or volume control. Casing with integral enlarged end.
6. Shafting with one or more intermediate square swages for cutting to length in the field.

No. 150L53—Shaft can be supplied with ends identical or with any combination of ends.

No. 170A1—Casing can be supplied with or without enlarged or flanged ends or with any combination of ends.

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ENGINEERING COOPERATION

Get the benefit of the broad, practical auto radio experience of our engineers. Submit your requirements or designs for recommendations. There is absolutely no obligation involved.

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INDUSTRIAL DIVISION
152-4 West 42nd St., New York, N. Y.

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