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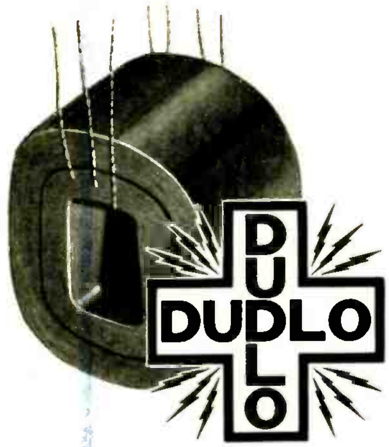

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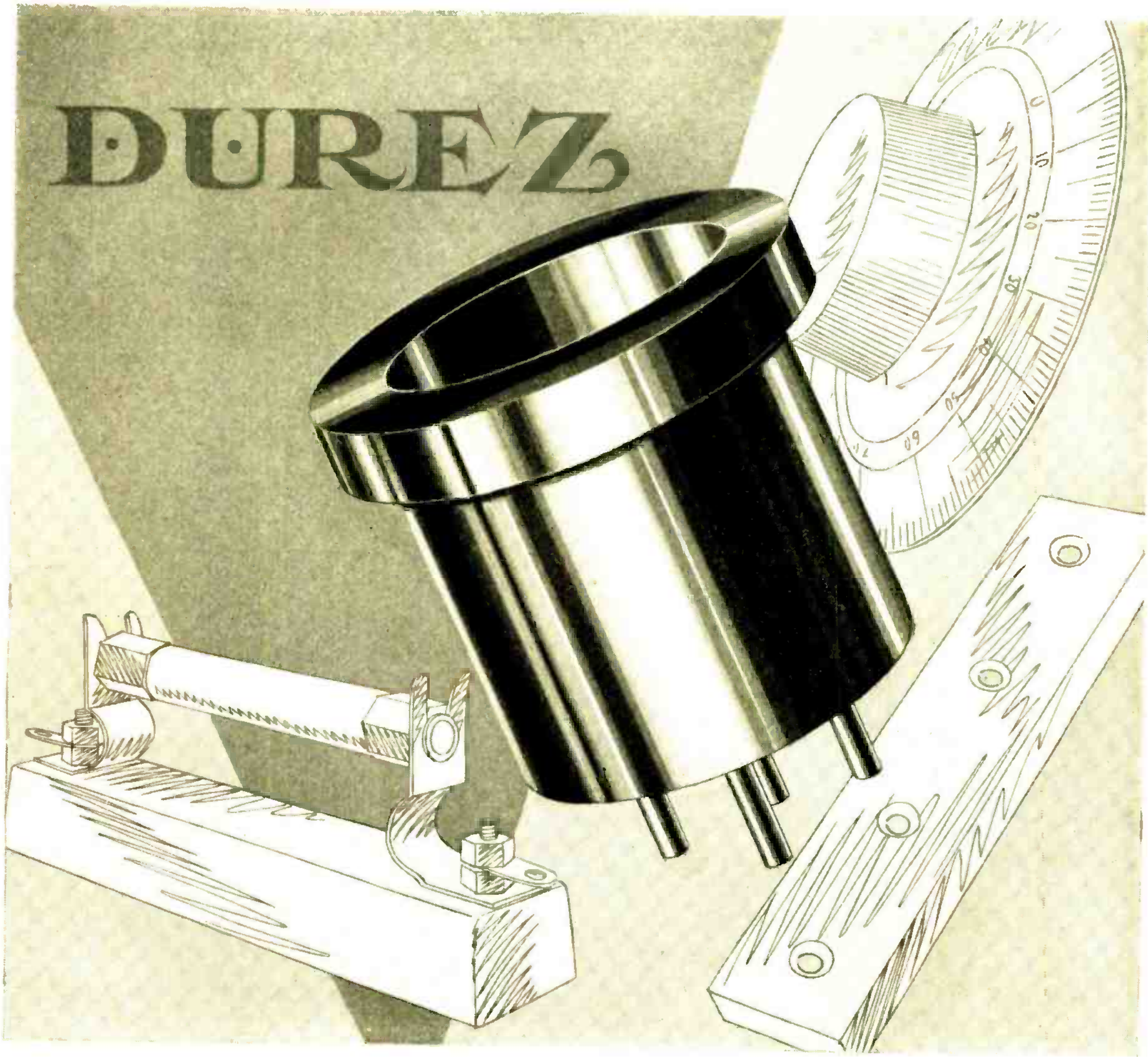

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52 Vanderbilt Avenue, New York, N. Y.

EDITED BY M. L. MUHLEMAN

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Vol. VII | NOVEMBER 1927 | Number 11

EDITORIAL

NOW that we are well along in the midst of the 1928 radio season, it might be well for all factors in the industry to take stock of the accomplishments—the progress—which the industry has made.

The radio industry might still be said to be in its infancy. Developments are in the offing along the lines of telephonic communication, picture transmission, television, etc., which five years from now may alter the aspects and aspirations of the entire industry.

To date, the radio industry has accomplished so much. Financially it is on a measurably sounder basis than at any time since its inception. The broadcasting situation, while not ideal, is, in the opinion of the "best minds" and apparently the vast majority of the program receiving public, in a happier condition than ever before. Merchandising is conducted on a sound, aggressive basis which is productive of returns for manufacturers, distributors, dealers and professional men alike.

The day of the weekly Ultra, Ultra Sedanafore as carried in radio publications and newspapers, is more or less a thing of the past. Developments for the past year have been along the lines of sound engineering and mechanical improvements—the lowering of production and assembling costs, with a large and greatly appreciated saving to the buying public—the employment by the manufacturers of competent engineering and technical personnel—the development of efficient servicing arrangements working from the manufacturers through the distributors to the dealers and the dealers' service men.

In times gone by, the radio industry was promoted by get-rich-quick financiers—engineered by youths with a mental quirk—publicised by advertising men with a merchandising conception based on established industries but disastrous to young developing ones.

However, today the industry itself, drawing from the best minds and most prominent factors in the electrical industry, utilizing the facilities of the furniture and cabinet manufacturers, drawing upon the resources of scores of other industries, assumes its rightful position as a leading industry. It is recognized as such by the large Universities, as evidenced by the addition of courses in radio as a part of the curriculum.

The trade organizations ably manned, ably headed, are doing fine developmental work. The industrial organizations, on a basis of mutual confidence and cooperation have succeeded in stabilizing the field.

The industry has become a power, through its main activities in the broadcast field. The two, which are dependent upon each other, work together as a beneficial influence on the entire country—and the world.

The engineers deserve a large amount of credit. Improvements in transmission and reception have done more than any other one factor in placing the radio industry on a sound basis.

Thus has the industry developed in the past few years. What will the next five years bring?—M. L. MUHLEMAN—*Editor.*

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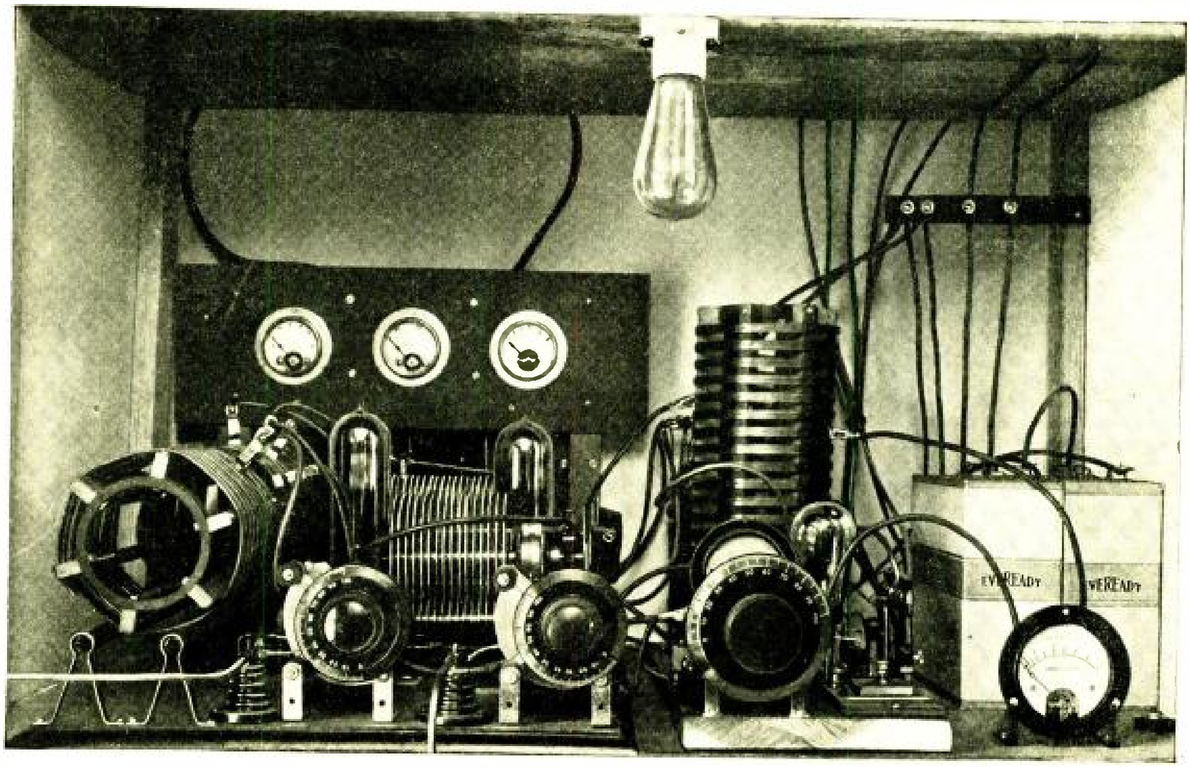

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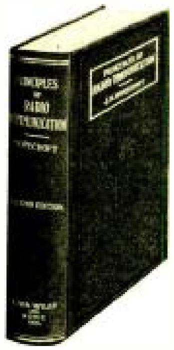

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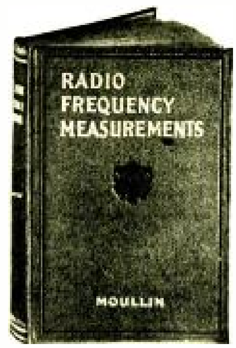

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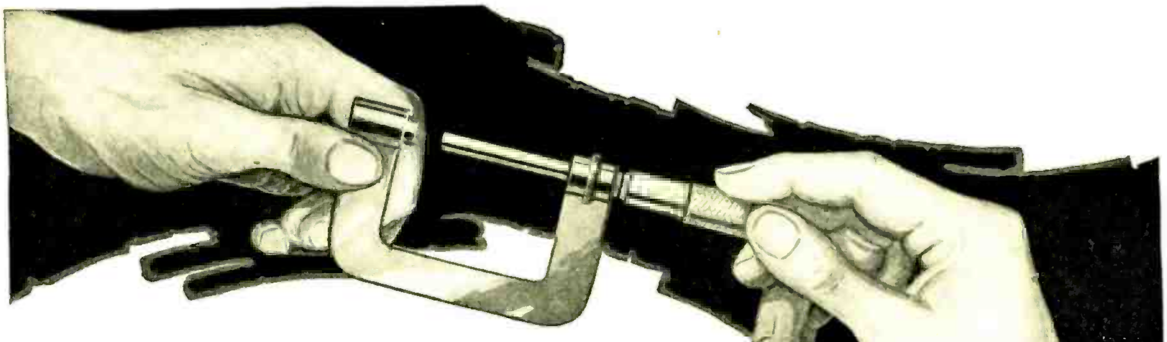

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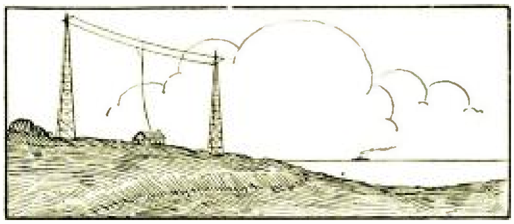


Notes on the Testing of Audio Frequency Amplifiers*

Testing Procedure, Curve Drawing Apparatus and a Discourse on Amplifier Distortion

By Edward T. Dickey[1]

FUNDAMENTALLY, the testing of audio frequency amplifiers consists of an examination of the operational and structural features of the amplifier with the view to determining the following points:

1. The voltage amplification, with special regard to the relative amplification at various points along the audio frequency range.

2. Ability to produce the necessary output power for the particular use for which it is intended, without distortion of the impressed wave form.

3. General operational and structural practicality with reference to such points as: freedom from audio frequency howling, susceptibility to howling through lengthening of the input and output leads, correct values of grid and plate potential for the particular tubes used, etc.

Of these points, the most important, and those requiring the most equipment and care in their determination, are undoubtedly the first two. The greater portion of this paper, therefore, will be devoted to consideration of these points.

It is, of course, understood that a test of the audio frequency amplifying system constitutes by no means the entire story on the fidelity of a complete receiving set. The various tuning, amplifying, and detecting stages preceding the audio frequency amplifier, all have their effect on fidelity. Those interested in a discussion of the other factors affecting fidelity and their measurement, are referred to a contemporary paper on "Notes on Receiver Measurements" by Messrs. T. A. Smith and G. Rodwin.

1. Voltage Amplification

It is not intended to discuss all the methods, or even all of the most important methods, of attacking this problem. Discussion will be confined to the methods which have been found by the author to give the best results in combined accuracy, speed of test, and simplicity of operation.

The apparatus necessary consists of the following three essentials:

A. A source of variable audio frequency potential, capable of supplying the required amplifier input potential, and producing oscillations whose wave form differs from the sinusoidal to a negligible degree.

B. Means for accurately measuring the potential impressed upon the input of the audio frequency amplifier under test.

C. Means for accurately measuring the output potential from the amplifier, without appreciably influencing any characteristic of the amplifier.

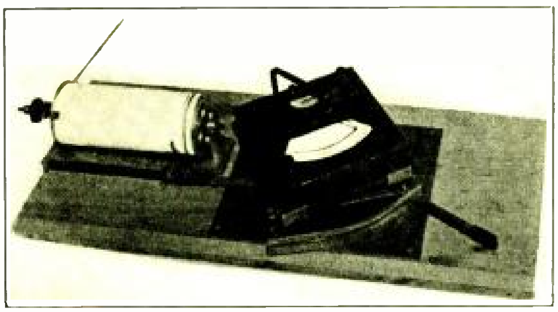


Fig. 9. Special curve drawing mechanism for obtaining frequency amplifier characteristic curves

Description of the apparatus considered most suitable for these three purposes is given below:

A. *The Oscillator.* The source of audio frequency potential found most satisfactory was an oscillator of the beat frequency variety, employing the difference frequency of two radio frequency oscillators. By combining and rectifying these frequencies, and then amplifying the resultant frequency, it was possible to obtain from the oscillator of the type used by the author, audio frequency potentials of the order of 50 volts. The wave shape of the oscillations obtained from a properly constructed oscillator of this type, can be made to contain not more than 1 or 2 per cent of harmonics, and the output potential will remain effectively constant over the frequency range from 30 to 10,000 cycles approximately, without readjustment.

It has become a fairly well established practice in radio laboratories, to use a logarithmic scale for the frequency in plotting audio frequency characteristic graphs. By properly shaping the plates of the frequency adjusting variable condenser, it is possible to make the frequency produced by the oscillator vary logarithmically with respect to the condenser dial. The advantage of this will be evident when the method of using this oscillator in testing audio frequency amplifiers is described. (See section on General Description of Amplification Test Method.)

B. *Input Potential Measurement.* The output of the oscillator used is adjustable internally, and thus for this measurement, it is only necessary to employ a thermo-milliammeter of reliable make, which is accurate over the audio frequency range. Associating this meter with the necessary series resistance, which must be accurate over the range of audio frequencies used, potentials over the desired range may be measured and applied to the amplifier input. As stated previously, the output potential of the oscillator when once set, will remain appreciably constant over the range from 30 to 10,000 cycles, which is sufficient for the usual amplifier measurements. It is considered good practice to read the input voltage again at the end of the test run, to make sure that the oscillator is working properly.

[1] (*Engineer, Technical and Test Department Radio Corporation of America.*)
* *Reprinted from Proceedings of The Institute of Radio Engineers, August, 1927.*

C. *Output Potential Measurement.* Considering the requirement that the measuring device used here shall not affect the characteristics or output of the amplifier, the most obvious instrument to use is a voltmeter of the vacuum tube type. To simplify the operation, and to permit readings to be taken rapidly, a direct-reading type of vacuum tube voltmeter is desirable.

To facilitate operation in connection with the curve drawing mechanism, which will be described later, a tube voltmeter having very nearly a linear characteristic is needed. By the use of a UX-171 tube, it was found possible to construct a voltmeter having a number of very desirable features for amplifier output measurement purposes. This tube has a low plate impedance, and a high grid bias potential, and it is possible, by its use, to obtain a tube voltmeter which is capable of measuring directly potentials up to approximately 70 volts, and which has a reasonably straight characteristic curve from about three volts to the end of the scale. A high plate potential, a high series plate resistance, and a microammeter having a full scale deflection of 100 microamperes, were contributing factors in producing the straight line characteristic.

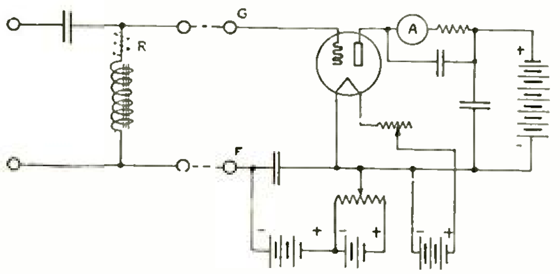


Fig. 1. Circuit of direct - reading vacuum tube voltmeter

The circuit used is shown in Fig. 1. Because of the relatively low plate current (maximum approximately 100 microamperes), it is possible to run the filament of the tube below its full rated value (4.5 volts permissible), thus prolonging its life and constancy of calibration. For increasing the accuracy with which the zero reading of the meter might be set, it was found best to use a reading of 10 microamperes as zero, calibrating the meter scale from that point. The tube voltmeter is calibrated using the oscillator and thermoammeter described before. On turning on the filament and grid potentials, it is merely necessary to make a slight adjustment of the potentiometer until the microammeter reads ten. Changes in the zero reading during operation are relatively negligible. The condensers connected across various points of the circuit are used to prevent inequalities in reading at the high and low frequencies. As shown, the instrument is equally accurate over the entire audio frequency range within observational error percentage.

At first glance it seems somewhat dangerous to use a plate meter of such high sensitivity in a circuit having such a high applied potential. By a very simple calculation, however, it will be evident that even if the plate and filament of the tube should become short circuited, the high value of series plate resistance would prevent the plate meter from being overloaded. As will be seen from the calibration curve (Fig. 2) the plate meter reading remains practically constant after it has reached a reading of approximately 104 microamperes. While slightly past the end of the scale, this will not injure the instrument.

In amplifiers where there is no direct current flowing through that portion of the output circuit across which the tube voltmeter is connected, the binding posts marked *G* and *F* are connected direct to the amplifier circuit. In cases where the amplifier output circuit contains a direct current component, use is made of the condenser and choke combination shown to the left of the circuit in Fig. 1. An inductance is used for the grid potential return, rather than an ohmic resistance, because of the trouble experienced with the condenser and resistance leak combination, due to the slowness of such a system in returning to normal, after a sudden high potential surge such as is often experienced through induction effects on sets operating on commercial lighting circuits. The resonant period of the inductor and capacitator combination must be outside of the range of audio frequencies used. Actual test has shown this circuit to give appreciable equality of operation over the usual audio range, if the impedance of the choke is kept at least ten times as great as that of the output device. This is quite easy if a loud speaker of usual type is connected to the amplifier output. In cases where the output potential is to be measured across a relatively high ohmic resistance, it is advisable to use an ohmic resistance leak in series with the choke as shown at *R* in Fig. 1. This resistor should have a value approximately 20 times as great as the resistance across which the potential is to be measured.

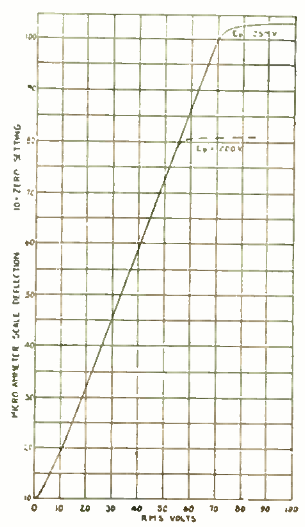


Fig. 2. Calibration curve of direct-reading vacuum tube voltmeter (0-70v. range)

By a simple alteration of circuit constants, the tube voltmeter may be arranged for the measurement of potentials of the order of a few volts. In Fig. 3 is shown a circuit making available two ranges by the mere throwing of a double-pole double-throw switch. While the low range will not have quite as straight a characteristic as the higher range, it is still quite satisfactory, as will be seen from Fig. 4, which gives the curve for a range having a maximum of about seven volts.

Like all vacuum tube voltmeters using a d-c. indicating instrument, the one described here will have its accuracy affected by the wave form of the potential under measurement. It will be found to be considerably better in this regard than some tube voltmeters, however. Those interested in the effect of wave form on the accuracy of various types of tube voltmeters, are referred to two recent articles on "The Thermionic Voltmeter" by Messrs. W. B. Medlam, and U. A. Oschwald, in the October and November, 1926 issues of *Experimental Wireless and the Wireless Engineer.*

If calibrated by the use of a potential of good wave shape, this tube voltmeter should retain an accuracy of approximately 1 per cent of full scale for a considerable period. Briefly, the points upon which retention of its accuracy depends are, in order of importance:

1. The accuracy of the plate meter, (directly dependent).

2. Retention of the same value of series plate resistance. This value can be checked quite simply, however. By merely connecting the plate terminal of the tube socket to the negative filament terminal, and lowering the plate potential somewhat, the resistance can be directly obtained by calculation from the impressed potential and plate meter reading.

3. Tube constants. If a tube with normal constants is selected, the low plate current and filament current result in retention of appreciably the same constants for a considerable period.

4. Filament potential. Variation of 10 per cent causes a variation of less than 1 per cent in reading, and there-

fore accuracy is relatively independent of this factor within these limits.

5. "Zero setting" of the plate meter. Setting for 10 microamperes is important, but is extremely easy to check and, when set, practically never varies over ½ per cent even over a considerable period of continued use.

6. Plate potential. As long as the zero setting is correct, a variation of as much as 20 per cent in plate potential will cause less than 1 per cent variation in reading, up to the "cut off" point. This point, i. e., the point above which the plate current will not rise with increased input potential, will be lowered. This can be noted in Fig. 2, where the horizontal line marked "200 volts" shows where this point would be for this value of plate potential.

7. Grid potential. It is not necessary to know the actual value, since this is set by watching the plate meter. Its numerical value is of interest only when one wishes to be sure that the tube is not acting as a load across the circuit under measurement, by drawing grid current.

in value compared with the impedance of the thermo-milliammeter and oscillator output circuit. In case R_2 is appreciable with respect to R_2 the sum of the two should be made equal to the desired series input resistance. By means of a source of adjustable potential E_1 and a milliammeter, a direct current, equal to the plate current of the tube feeding the input, may be set up in the input primary winding.

arranged at the point where the input potential is impressed on the amplifier.

In case the characteristics of the loud speaker with which the amplifier is to be used are not known, it is generally best to use a resistance in the output circuit of the value for which the output tube is designed. From the curve thus obtained, and a knowledge of the plate impedance of the output tube, it is possible to determine by calculation, the characteristics of the amplifier with any loud speaker whose impedance characteristics are known.

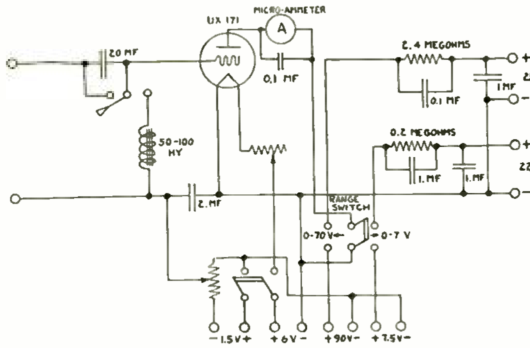


Fig. 3. Circuit of direct-reading vacuum tube voltmeter arranged for measurement of two ranges of potentials (0-7v. and 0-70v.)

Test of Multi-Stage A. F. Amplifier

It is important to arrange test conditions so as to approach, as nearly as possible, those which will exist in actual operation. In this connection, the following points are important:

1. Input and output impedances should be the same as in actual use.

2. Long input or output leads, or anything tending to produce interstage couplings which would not be present in normal operation, should be avoided.

3. Values of input potential should be chosen so as to avoid overloading the output tube, and tests should be made preferably using two or more values of input potential, to discover any alteration in operating characteristics with varying inputs.

4. If the amplifier input consists of a transformer winding, provision should be made to have normal direct current flowing through the winding, if the latter is to be connected directly to a tube plate circuit, as is usually the case.

5. Conditions of grounding or shielding should be similar to those of actual use.

In testing a complete amplifier, the types of tubes which are intended to be used in it are generally known. The only points which may be in doubt are usually the characteristics of the output device (loud speaker), and the tube (generally detector) which will precede the amplifier. Usually the amplifier input will be in the form of a transformer primary winding, in which case amplification curves may be taken with several values of series input resistance, and primary direct current.

A simple circuit for use in obtaining the amplification characteristic is shown in Fig. 5. The adjustable resistance R_2 provides means for simulating the plate resistance of the tube preceding the amplifier. R, should be small

If the amplifier input is a tube grid circuit, the oscillator potentials may be impressed directly thereon. In the case of resistance coupled amplifiers, the input will probably be in the form of a plate resistance. Various series resistances to imitate tube plate resistance, may be tried between this and the input potential source, but it will generally be unnecessary to put a direct current through the plate resistance. If there is doubt as to the ability of this resistance to carry the necessary current quietly, and without changing its resistance, it is advisable to investigate the resistance in question, separately.

In cases where the amplifier input circuit is not fed from a tube, electrical characteristics simulating as nearly as possible those of actual use, should be

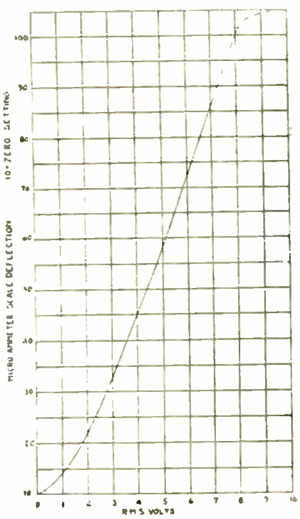


Fig. 4. Calibration curve of direct-reading vacuum tube voltmeter (0-7v. range)

Testing Individual Amplifying Transformers

While it is the primary purpose of this paper to discuss the testing of complete amplifiers, the testing of individual audio frequency transformers is believed to be of sufficient importance to warrant a brief separate treatment here. This is a more specialized problem than the testing of completed amplifiers, but is of particular importance for design purposes.

It should be noted that it is practically impossible to construct a test set-up which will simulate accurately the circuit reactions to which a transformer will be subjected in a completed amplifier. Thus it is recommended that not too much dependence be placed on results obtained from test of a single transformer, which is intended for use in a multi-stage amplifier. Features of interstage coupling, input and output coupling, tubes, transformers in other stages, and loud speaker characteristics, all enter into the problem, making it exceedingly difficult to duplicate in the test of a single transformer, the conditions under which it will work in the completed amplifier.

In Fig. 6 will be found a circuit which can be made to simulate to some extent, the characteristics of a single stage of a multi-stage amplifier.

The remarks made previously in connection with Fig. 5 regarding the input circuit adjustments, apply here also. It is recommended that the circuit be grounded at the points indicated, since these points will, in general, be at ground potential in the final amplifier. If the core of the transformer is to be grounded in the final amplifier, it should be grounded during the test. It is important that the grid potential battery of the output measuring tube voltmeter be connected at the point indicated, and not in the grid lead as is sometimes done, otherwise excessive capacity will exist across the transformer secondary. If the grid-filament capacitance of the tube-voltmeter tube is not sufficiently close to that of the tube which is to be used on the secondary side of the transformer, either of two possible expedients may be used:

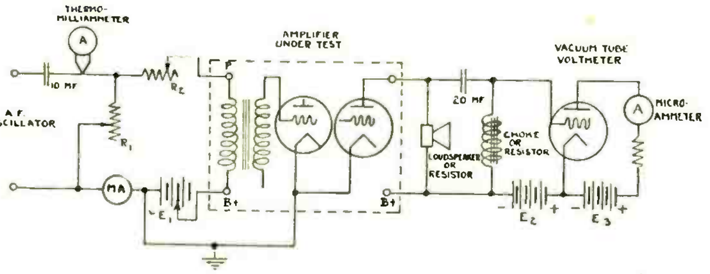


Fig. 5. Test circuit for transformer coupled amplifier of several stages

1. An extra frequency run may be made with a small condenser C connected across the transformer secondary. From the two curves obtained, and knowing the grid-filament capacitance of the tube voltmeter, and of the tube which is to be used with the transformer, it will be possible to determine the curve for the tube to be used by extrapolation.

2. Use the type of tube which will be fed from the secondary of this transformer in the final amplifier, and connect the tube voltmeter across a resistance in the plate circuit of this tube. Tested in this way, of course, the voltage amplification measured includes the amplification factor of the tube following the transformer. To get the voltage amplification of the transformer, it is therefore necessary to divide the values obtained by the amplification factor of this tube.

If it is desired to determine the general characteristics of a transformer, so that its behavior with various types of tubes may be deduced, this may be done with fair accuracy by calculations based upon certain measurements. To do this it will be necessary to find:

1. The curves of reactance and effective resistance variation with frequency of the primary winding, with the secondary open. These must be determined for two or more values of secondary shunting capacitance, within usual or desired range of filament to grid tube capacitance, and with several values of direct current through the primary winding. Values of direct current (simulating tube plate current) as high as the greatest which it is proposed to use, should be tried.

2. The ratio of potentials across primary and secondary windings should be obtained for the entire frequency range. Here also it will be necessary to take measurements with various values of secondary capacitance, and primary direct current, and curves for the complete frequency range should be plotted.

Then letting e_1 = Potential generated in plate circuit of the tube connected to primary winding,

e_2 = Potential across the secondary, as result of e_1 in tube,

r = Plate resistance of the tube,

R = Effective resistance of Transformer Primary,

X = Reactance of Transformer Primary,

E_2/E_1 = Ratio of potentials measured directly across Secondary and Primary respectively.

The following formula gives the relation between these factors:

$$e_2 = \left(\frac{E_2}{E_1}\right)\frac{e_1}{\sqrt{(r+R)^2+X^2}}\sqrt{R^2+X^2}$$

Thus, with the aid of the curves, and this formula, it is possible to predict with fair accuracy the action of a transformer with any tubes, knowing the plate resistance and plate current of the preceding tube, and the grid-filament capacitance of the tube following.

Two suggested methods of making the measurement of the reactance and effective resistance of the transformer primary winding are given below:

1. By means of the ordinary inductance bridge, arranged preferably with both the inductance and resistance values of its standards continuously variable.

2. It is often desired to perform this measurement with a definite value of a-c. potential applied to the primary. In this case, the well known three-voltmeter method can be used to advantage. Fig. 7 shows in outline the circuit, with means for applying a d-c. potential to the primary. The reactance of the choke L must be sufficiently high with respect to that of the transformer primary to make the effect of the shunting circuit negligible, or its inductance value must be known and its effect allowed for in the calculations.

The use of the tube voltmeter is recommended for obtaining the values of V_1, V_2, and V_3. The calculations involved in getting the values of primary reactance and effective resistance from these potentials is well known, and for the sake of brevity will not be repeated.

General Description of Amplification Test Method

After the apparatus and device under test is set up, and necessary adjustments to bring about normal operating conditions are made as described in connection with Figs. 5 and 6, there remains the choice of two methods of taking the amplification versus frequency characteristic.

1. The oscillator may be set at various frequencies throughout the desired range, and a reading of the tube voltmeter taken for each frequency. From the data obtained, a curve of the amplifier characteristic may be plotted. This may be plotted either directly in output volts, or, by dividing the output potentials by the constant input potential, a curve showing the voltage amplification at each frequency can be plotted. The closer together the points have been taken, the more nearly will the curve show the operation at all frequencies.

2. A quicker method, and one in which a continuous measurement is made of all points along the frequency range is shown in general outline, with the necessary apparatus arrangement in Fig. 8. Here the shaft of the oscillator variable condenser is geared, by some convenient means, shown here as the gears M and N, to

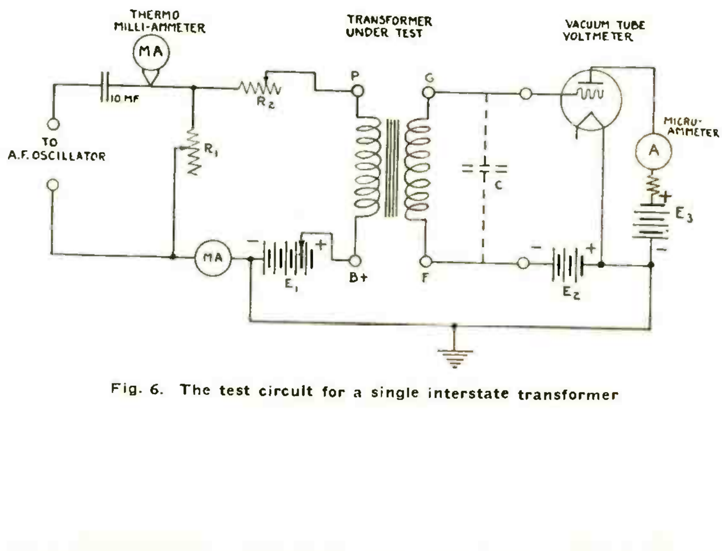


Fig. 6. The test circuit for a single interstate transformer

a drum which is of the proper size to hold a standard sheet of plotting paper. Paper having a logarithmic scale for frequency, and linear scale for amplification is used. The ratio of gears *M* and *N* is such, that the frequency lines on the plotting paper which come under the pen *P* as the condenser shaft is rotated, may be made to correspond with the frequency produced by the oscillator at the moment. If then the distance of the pen P above the zero axis of the paper, is made to correspond to the output voltage reading of the amplifier, we have a means for drawing the amplifier characteristic curve directly as the test is being made.

By means of the arm and pointer *H*, which is pivoted at *J*, it is possible to follow the movements of the tube voltmeter microammeter needle. The movements of the arm *H* are communicated to the pen *P* through the lever *L*, and by proper shaping of the guide template *K*, it is possible to have the voltages measured by the tube voltmeter correspond to the deflection of the pen *P* in terms of the ordinate divisions of the plotting paper. Since the templates for the 70-volt and 7-volt ranges differ somewhat in shape, they should be so constructed as to be removable and interchangeable within the curve drawing mechanism. Fig. 9 shows the drum, microammeter, pen, and attendant curve drawing mechanism.

If desired, the oscillator condenser may be rotated slowly by motor or clockwork, and the observer needs only to follow the movements of the microammeter needle carefully with the pointer *H*. Upon reaching the upper end of the frequency range, the condenser drive is disconnected, and the paper removed from the drum. Upon the paper, the curve of output voltage vs. frequency for the amplifier under test will be found.

2. *Test for Wave Form Distortion*

Returning now to the second of the tests which are necessary in examining the operation of an audio frequency amplifier, i. e., test of its ability to handle the necessary output energy without distortion of the impressed wave form, we find that test of this point includes determination of the input potential which will cause overloading distortion—and thus the permissible input potential—and for accurate data, involves determination of the percentage of harmonics which are added to the original frequency as it passes through the amplifier.

The principal points in a transformer coupled amplifier where wave shape distortion may occur are, in the magnetic circuit of the transformers due to excessive flux density, and in the tubes. If the transformers are well designed, the first point can be neglected. Distortion in the tubes will generally be caused by the non-linearity of the grid potential-plate current characteristic, or by the grids of one or more tubes becoming positive with respect to their filaments. On high input potentials, one or more of the grids will become positive, and the resulting grid current and lowered grid filament impedance of the tube, will cause very serious distortion. This type of distortion is by far the more serious of the two caused by the tubes, and is probably the only type which would be noticed by the average

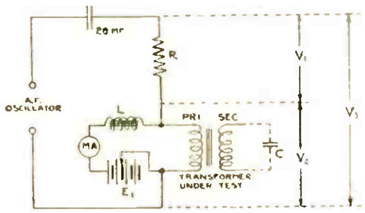


Fig. 7. Voltmeter method for determining reactance and effective resistance of transformer primary

person listening to the loud speaker output from the amplifier.

It is often desirable to test an amplifier only for this more obvious type of distortion, and such a test is quite simple. The tube which is generally the first to show signs of grid current is the one in the last stage. By putting a low reading d-c. milliammeter or microammeter in series with the grid of this tube, and gradually increasing the input potential, the maximum permissible input will be just below that value which causes the meter to read in a direction showing that the grid is positive (Most tubes have a small constant grid current in the opposite direction, which should be disregarded). It is advisable to make the test at several different audio frequencies, and if there is reason to believe that the grids of any of the other tubes in the amplifier are becoming positive, they should be tested in the same way.

For proper and safe operation, the amplifier should be capable of giving more output signal voltage than is normally required, before any of its tubes show signs of grid current at any point of the audio frequency range.

For those who prefer a method giving more accurate numerical indication of the amount of wave shape distortion present, analysis of the output wave by means of the cathode ray oscillograph is recommended. If potential from the source feeding the input of the amplifier under test, is impressed across the "horizontal motion" plates of the oscillograph, and potential from the amplifier output is impressed across the other set of plates, a figure will be traced on the oscillograph screen, which will show, by its shape, with what fidelity the amplifier reproduces the wave shape impressed upon its input. To facilitate tracing the curves which appear on the screen, a hood was built over the tube mounting cabinet.

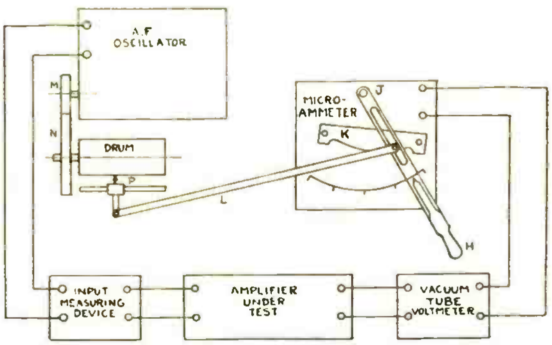
If a single straight line is traced, perfect fidelity and no phase shift is indicated. In cases where a phase shift occurs in the amplifier, the figure will assume an elliptical instead of a linear shape. This makes analysis of the figure more difficult, but the elliptical shape is no sign of wave distortion. It merely indicates that a shift in phase has taken place as the wave passed through the amplifier. Oscillograph figures should be obtained for several frequencies, and for several values of input potential. Then by an application of harmonic wave analysis to the figures obtained, it is possible to determine the percentage of harmonics present, for various input potentials and frequencies. Depending on the fidelity of output wave which is desired, the permissible input potential may then be determined.

It is believed that an oscillographic test of this kind should be applied more frequently than it has been in the past, to the testing of audio frequency amplifiers. As the scope of this paper prevents further or more detailed discussion, those interested are referred to a recent article on "Load Carrying Capacity of Amplifiers" by Messrs. F. C. Willis and L. E. Melhuish, in the October 1926 issue of *The Bell System Technical Journal*.

3. *General Operation*

The general points for test and examination mentioned under the third section are usually different for each amplifier, and no very definite rules for investigation procedure can be given. The method of investigation depends very largely on the particular amplifier, and no general rules can be laid down. The experience and ingenuity of the test engineer must be relied upon generally to determine the method of

Fig. 8. Audio frequency amplifier test set up. The curve drawing mechanism is illustrated in Fig. 9, on page 1033



test. Little if any definite apparatus can be recommended since these tests require, in many cases, merely intelligent and careful inspection. One important point may be mentioned in this connection, however, i. e., in regard to checking whether the proper plate potential is being used on the tubes in a resistance coupled amplifier. The plate potential may be measured with an electrostatic voltmeter at the plate of each tube while the amplifier is in operation, or else its value may be calculated from measurement of the plate current and plate coupling resistance value for each tube.

No attempt has been made in this paper to give anything but the essentials of audio amplifier testing. It will usually be found in practice that each amplifier constitutes to a greater or lesser extent a special problem, since each will differ from the others in certain points. The essential features to be tested for, together with a brief description of the apparatus found most suitable for making the tests, have been given. There are many other methods of taking amplifier characteristics, but it is believed that the methods described here are as good as most of the other methods, and perhaps excel some in points of accuracy, convenience, and speed of measurement.

In conclusion, the author wishes to acknowledge his indebtedness to the following members of the staff of this laboratory:—Dr. Walter Van B. Roberts for valuable suggestions regarding the methods of determining the general characteristics of individual amplifying transformers by combined measurement and calculation; Dr. Irving Wolf for the ideas embodied in the method of directly drawing amplifier characteristic curves described in this paper; and Mr. David Grelich for his assistance in connection with the development of the tube voltmeter described.

Summary

The more necessary of the various points which must be tested in examining the performance of audio frequency amplifiers are outlined, and a method of test procedure, found by the author to have desirable characteristics from the points of view of accuracy, speed, and simplicity of operation, is described.

The method used permits the complete curve of amplification vs. frequency for the amplifier under test, to be drawn directly by the test equipment in a very short time. A type of tube voltmeter found convenient for measurement of amplifier output potential is described. Brief discussion is given of the testing of individual audio frequency amplifying transformers, and some test methods applicable thereto are suggested. Amplifier wave form distortion, and overloading are discussed, and methods for the test thereof are recommended.

The Photo-Electric Cell

Special Circuit Arrangements Adaptable to the Photo-Electric Cell

By Dr. Robert C. Burt, E. E.

PART III

In the last article we saw that in the use of photo-electric cells we have four variables. They were light intensity, light wave length or color, applied voltage, and current. We saw the relation between wave length and current. At this point we might remark that while the eye is not sensitive to light of wave length less than 3900A°, the ordinary photo-electric cell is sensitive to light in the ultra-violet down to 3300A° which is about the shortest wave length that will pass through ordinary glass. The author has made photo-electric cells of fused quartz which are sensitive to light down to 1800A°. The limit here again is the inability of the quartz to transmit shorter waves.

Saturation Point

We also saw in the last article the relation between voltage and current. And it will be recalled that vacuum type photo-electric cells show a voltage current curve much like a vacuum tube curve, increasing rapidly as higher voltage is approached. The limiting value of current is called the saturation current, and this is reached at about 100 to 200 volts in the common type of cell. However, it is possible to design photo-cells which give saturation current at very low voltages. Below is given the voltage and current under constant illumination for such a low voltage cell which the author recently made.

Volts	Microamperes
0	—.1
.04	0
.1	.3
.4	.95
.8	2.0
1.0	2.0
2	2.2
20	2.4
80	3.1
200	3.3
500	3.3

It is evident that this cell is nearly saturated at 0.8 volts.

Gas Type Photo-Cells

In the gas type photo-cell, electrons are released from the sodium surface and accelerated by the applied voltage until they have such high velocity that upon collision with an atom of gas they ionize the atom; that is they break the binding force between the atom and one of its electrons, and the field then pulls the ionized atom back to the surface from which the electron came, while the newly released electron proceeds in the same direction as the colliding electron. This process may repeat itself many times and of course all this increases the current, but when the positive ion formed reaches sufficiently high velocity to cause ionization, then an arc is formed and no light is required in order that the cell pass a current. Furthermore, the current must be limited by an external resistance, otherwise the cell will be damaged if an arc should accidentally occur, due to a fluctuation in voltage.

The ionized atoms of all but a few rare gases are chemically very active, hence it is necessary in making gas type photo-cells to have extreme purity of gas, otherwise the gas will combine

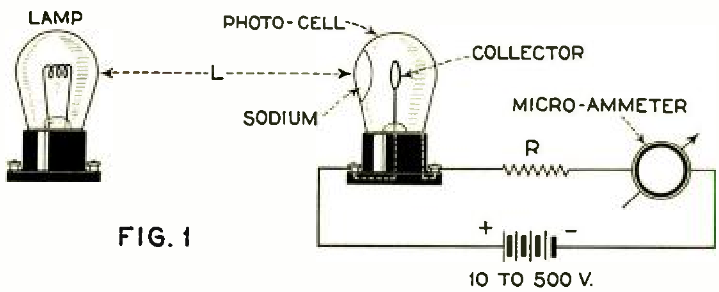


FIG. 1

Arrangement of photo-electric cell in circuit as a photometer; for measuring the candle power of lamps with the surface and the result will be a lack of constancy in the cell itself.

Even in vacuum type photo-cells it is necessary for the maker to use great precaution to get every trace of gas out of the metal before the cell is sealed, as all depends on the surface, and these photo-electric surfaces are very sensitive to contamination; being made of elements having extreme chemical activity.

Adaptations of Photo-Cells

To use a photo-cell as a photometer; that is to measure the candle power of various incandescent lights—connect as shown in Fig. 1.

The battery voltage depends upon the type of cell. For vacuum photo-cells it may be from 10 to 500 volts; 90 volts being convenient and satisfactory. Note that the negative terminal of the battery is connected to the sodium, while the positive terminal is

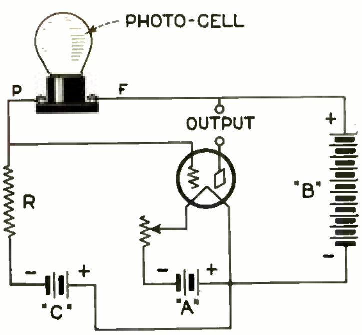


FIG. 2

Circuit for photo-electric cell to be used in conjunction with an amplifier, as in Fig. 3

connected to the collector. The distance L should be kept constant. The meter should have a sensitivity of about 20 microamperes for full scale. When weaker lights are to be measured, the circuit is the same, but a current sensitive galvanometer should be substituted for the microammeter, and when very weak light, like star light, is to be measured, an electrometer and guard rings are used.

The same circuit is used with a glass photo-cell for measuring light for photographic purposes, or for measuring and recording sunlight.

When ultra-violet is to be measured, a quartz photo-cell is substituted for the glass cell. Remember that the sensitivity curve of a photo-cell is more like that of a photographic plate than the eye, hence, if lights are of different types they should not be compared on this basis alone.

With a vacuum cell no resistance is required at R, as indicated in Figs. 1, 2 and 2-A, but with a gas filled cell, the resistance should be about one-half megohm. The voltage is critical and must be accurately set and held constant. If the light is pulsating rapidly the output may be put through a transformer amplifier, but if slowly changing phenomena is to be studied, the amplifier must be resistance coupled.

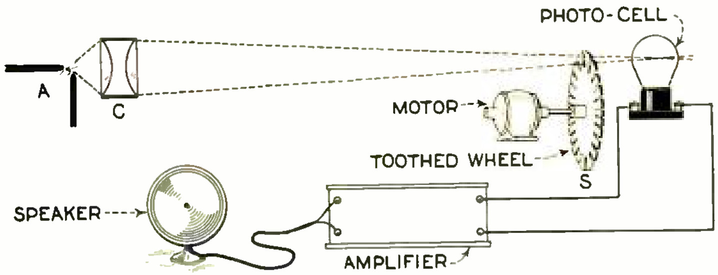


FIG. 3

An interesting arrangement for producing audio frequency notes. The pitch of the sound from the loud speaker can be varied by varying the speed of rotation of the toothed wheel

When the photo-cell is to be used with an amplifier it should be connected as in Fig. 2. The input of the amplifier connects to the output terminals shown.

Fig. 3 shows an interesting toy developed by the author and now on exhibition at Washington.

A is an arc lamp, C is a condenser which throws light on a motor-driven toothed wheel at S. The photo-current is amplified and applied to the loud speaker. With the wheel stopped the arc is lighted and the loud speaker gives the audible rendition of the flickering start. When the motor is started, the pitch of the tone goes up the scale finally going beyond the range of the amplifier and loud speaker. A puff of smoke or a shadow will diminish the sound enormously. The same wave which is used in the loud speaker may be analyzed by an oscilloscope; thus giving a visual picture of the wave form at the same time its tone quality is heard. A great variety of tone quality is possible with various shaped holes in the toothed wheel.

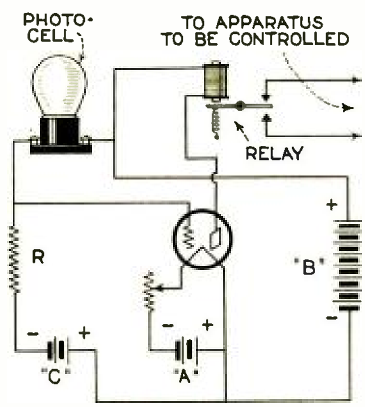


FIG. 2A

Photo-electric circuit as used in connection with a control relay for operating burglar alarms, etc.

The same circuit shown in Fig. 2 is used with a relay (see Fig. 2-A) and counting device or chronograph for counting or timing passing objects. It is also used with an amplifier for transmission of signal and speech over a beam of light. Either of these two circuits with the appropriate auxiliary equipment may be used for electric sign control and illumination control, burglar alarm, or storm detection.

For some problems the new grid glow tube is desirable. No general connections can be given because each case is unique in itself. From the examples already given it should not be difficult to make application of the photo-cell to specific problems.

DeForest Engineer Perfects New Radio Receiving System

The DeForest Radio Company, Jersey City, N. J. announce the development and perfection of a fundamentally new system of radio reception.

This new system is the conception of and the result of long research by Dr. George A. Somersalo, well known Finnish physicist and former Research Engineer of the DeForest Company.

"The Somersalo system, which is controlled by Arthur D. Lord, Receiver-in-Equity of the DeForest Radio Company, provides a fundamentally new method of obtaining radio frequency amplification without infringing any existing patents it is stated.

In the Somersalo system, selectivity is obtained by the use of a special form of high frequency tuning filter placed in the antenna circuit ahead of the first tube. The rest of the circuit is untuned, the only variable or adjustable apparatus or values being the rheostats if such method of controlling the filament supply be used.

An important feature is that the need of neutralization is practically eliminated. It is, of course, necessary to reduce the inherent feed-back in the first tube by one of the various well-known methods; not to prevent squealing, however, since there is hardly a tendency towards squealing, but in order to sharpen the tuning if such be necessary.

A New Factor

At this point we had best establish an advance line of operation since our claim of consumer saturation may be attacked with reference to the origin of the set in the home. Up to this present season we believe that there were just as many built-up sets installed in this country's homes as ever before. How did they get there?

To answer that is to come to one of the most important factors in the radio industry today—the professional set builder. This comparatively new factor in the distribution chain has and will continue to have an importance far beyond what many manufacturers are granting him and furthermore is entitled to consideration and a place in the selling scheme as much as any other single factor.

Where did the professional set builder or custom set builder come from in the first place? In the beginning of radio there were consumers who were greatly attracted to this new business and who soon found they had the ability and plenty of time to work at building radio sets. Soon the community learned that John Smith and Bill Jones knew enough about this "music-box" business to build one of the things, install it correctly and keep it going. Through word of mouth advertising the set builder's clientele grew until, in many cases, he gave up his regular work and opened a store and developed into a thoroughly efficient radio dealer. We must say, however, that today for every dealer who has a store we believe there are five professional set builders who do most of their work at home, in the evenings and over week-ends. The purchases of some of these men would stagger the imagination. This writer knows of one chaffeur whose account runs close to twelve thousand dollars yearly; another spare-time worker who buys kits in half-dozen lots. Almost any radio mail-order house executive can tell you of similar accounts by the score. So today we have the professional set builder as the parts buyer instead of the consumer, who was the big customer in the beginning, but who is practically a nonentity today.

Mail Order Business

Where does the professional set builder get his parts? As we have stated there always were and always will be too many parts. The electrical and hardware concerns, and other radio outlets soon found it hopeless to keep up with the constantly changing technical nature of the radio parts business and most of these houses found it easier to get big sales in complete sets and accessories with much less inventory loss than to attempt to get anywhere in the parts business. A second most important reason for the above type distributors relinquishing the parts business to others was that the consumer ceased buying from the dealers in the mad, furious way that was the early experience of thousands of retail dealers and the dealers found that for the business they could get from consumers the inventory it was necessary to carry was far beyond their physical, financial, or mental capacity. Probably it was the dealer's retirement from the field that hastened the ending of the jobber-dealer-parts-distribution method. But while the established dealer was getting out of the business the set builder was coming in strong and experienced something of a mushroom growth himself. Men receiving only an average working wage found that they could double and treble their income through radio and they certainly got busy. When the set builder began to find it difficult to get his parts from the nearby wholesaler he naturally took to writing the local wholesale houses in the metropolitan centers. Soon these houses found themselves doing almost as much if not more business through mail-order than they did locally and then came mail-order catalogues, broadsides with new items and co-operative schemes. Today the parts business that is done mail-order runs into millions of dollars. There are many dealers in downtown New York who will tell you that most of their parts business is done through and to set builders. An important but somewhat unknown reason for the cut prices that are parent to the parts business in the big centers is that the dealer is making a play for the set builders business and is obliged to give big discounts. The past season was probably the greatest set builders' year ever experienced and manufacturers and distributors are looking forward to an even greater business this coming season. But there are clouds on the horizon and the main purpose of this article is to inquire if the manufacturers are not beginning to defeat their own purposes and plans.

> **The Mathematics of Radio**
>
> A working knowledge of mathematics is of inestimable value to anyone dealing with the technical properties of radio. The engineer without this formulae is much in the same position as the carpenter without his rule.
>
> There are many of us who have not had the right opportunity for gaining simple yet concise information on the use of mathematics for working out our problems.
>
> Realizing the demand for material of this nature, John Rider is working on a series of reference articles explaining the use of formulae for calculating inductance values, impedance, capacity, reactance, resistance, voltage drop, etc.
>
> The first article of this series will appear in the December issue of *Radio Engineering*. We are sure you will find it of unusual interest.—*Editor.*

High Prices on Kits

As we have mentioned, the consumer can buy as good a complete set as he can build. And he can buy it cheaper, judging from the kit prices that are being established. It seems to us that the aggressive selling and advertising plans of the set manufacturer will soon get this point over to the consumers and the work of the local dealer, who is certainly more active this year than ever before, will seriously effect the market of the professional set builder. The local set dealer advertises, he uses many different mailing sales helps, the telephone and countless other methods of getting business that expert merchandisers are acquainting him with and there is enough competition right from his own kind to keep him stepping without even taking into consideration how the set builder may be effecting his business. But with all this competition we find that the list prices of parts, and kits especially, are going up and up. It seems to be the idea of the parts manufacturer to see how much he can get for his parts without attempting to increase sales and production to attain lower costs, so that the benefits can be passed on to the set builder. And at this time the idea of a parts manufacturer giving the professional set builder the sort of merchandising help he needs to work out his problem, as the set manufacturer gives his dealers, is unheard of. There may be some manufacturer who in his advertising tells the consumer set prospect to "go to your local professional set builder for your radio receiver" but so far we have not observed such an advertising tieup. There is very little advertising directed right to the consumer in genuine consumer publications with the object of getting him to buy a built-up set and how the parts manufacturers expect to get their equipment over is, therefore, something of a puzzle to this writer.

Price Competition

A second factor that is treated rather disdainfully, but like the proverbial dog "may have its day," is the manufacturer who knows how to make any sort of machine-made product, good and cheap. To him a condenser is no more than a colander or frying pan. His one thought is the use of automatic machinery to turn out whatever is desired at the lowest possible price and of the highest possible quality. Being almost what one could call a born manufacturer it is folly to say that his products will not be well-made and entirely satisfactory for the purpose in hand. It is from this type of manufacturer that the chain stores are buying much of their requirements and they are denting the radio parts business to the extent of millions of dollars every year. It seems that this type of competition makes it all the more urgent that the present-day radio parts manufacturer would do well to devote some thought to the development of the professional set builder along the same lines as the complete set dealers are constantly being urged. Otherwise it seems inevitable that the parts business shall suffer greatly in volume and profit.

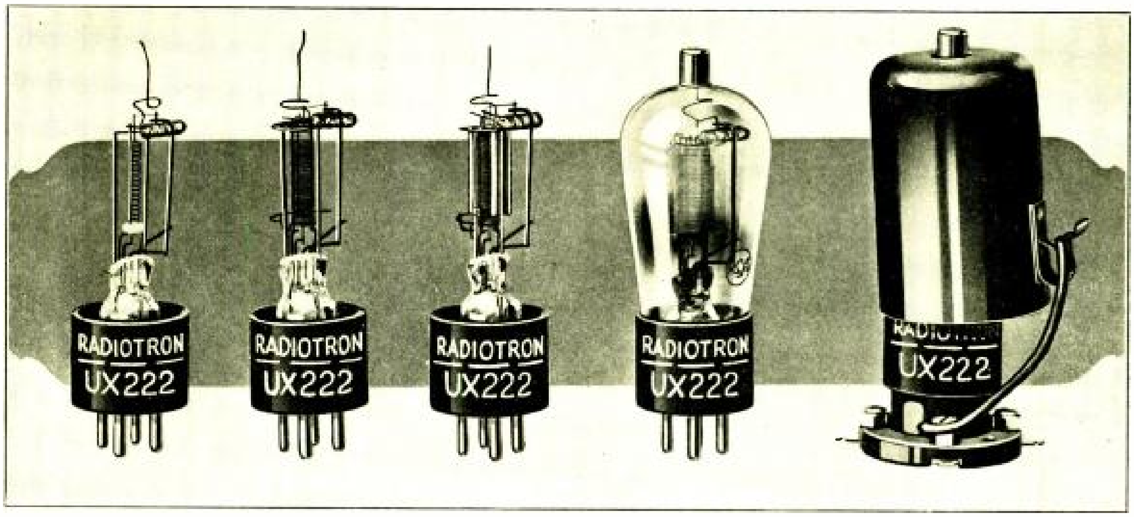


Fig. 1. A number of views of the U.X. 222 four element tube illustrating the step by step construction. The special shield is shown in the last view.

A New Four Element Vacuum Tube

A "Screen Grid" Tube, Self-Neutralized, With an Amplification Factor Exceeding 250

BEFORE the end of the present year, the Radio Corporation of America will have placed a new four element tube on the market. This new tube is the result of the developmental work carried on by Dr. A. W. Hull of the General Electric Company whose purpose in designing a tube of this nature rested primarily in an attempt to eliminate the effective capacity between plate and grid without having to resort to external means.

The present neutralizing schemes which we employ in our tuned radio frequency receivers would be unnecessary if that small capacity, in the order of 10 micro-microfarads, existing between the plate and the grid, were eliminated. This capacity is sufficient to allow the passage of radio frequency currents and the resultant feed back, if sufficiently large, will set the tube into oscillation.

Since this effective capacity actually amounts to the presence of electrostatic lines of force, it is obvious that this effect can be neutralized if the electro-static field is blocked. Since it is impossible to actually remove this capacity from the tube, the only allowable means for neutralizing is by the use of a proper shield between the major elements namely, the grid and plate.

The Screen Grid

In his early experiments, Dr. Hull employed a second grid, surrounding the control grid, and biased the second grid with a positive potential. Though this screen grid blocked the electro-static lines of force, it also prevented the normal flow of electrons between the filament and the plate. Dr. Hull's final design included a screen grid surrounding the plate of the tube and composed of thin metal slats which did not block the electron flow, but when biased with a positive potential effectively prevented appreciable capacity influence between elements through the passage of the electro-static lines of force.

The effective grid to plate capacity of the ordinary 201-A type tube is about 10 to 15 micro-microfarads. Through the use of the electro-static shield or screen grid, maintained at a potential of about 60 volts, this capacity was reduced to .0278 micro-microfarads.

A five-tube set, using these four element tubes, was rigged up for making measurements and it was found possible to obtain an amplification of 200 per tube at a wave length of 6,000 meters. At 300 meters the voltage amplification was between 40 and 45 as against a possible gain of 8 to 10 per stage when employing the ordinary 201-A type tubes in a standard radio frequency set.

The new Radio Corporation tube, known as the UX-222, is similar to Dr. Hull's four element tube. Referring to Fig. 1, it will be seen to have

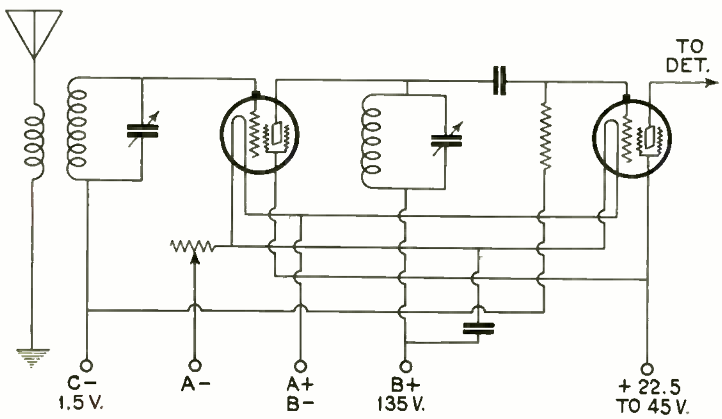


FIG. 2

Schematic diagram of a two stage tuned radio frequency amplifier using the four element tubes.

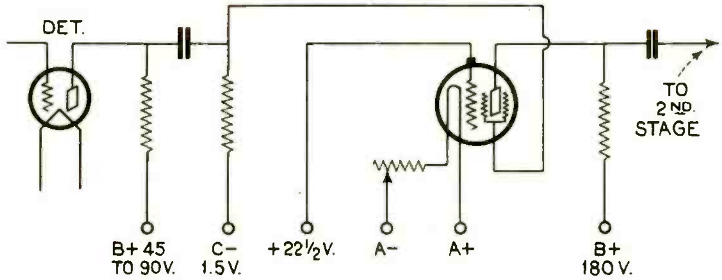


FIG. 3

Showing the manner in which the four element tube is connected in a resistance coupled audio frequency amplifier circuit. Note that the "Screen grid" is used as the control grid in this case.

a standard four-prong UX base and differs in external appearance from the ordinary tube by the addition of a small metal cap at the top of the glass envelope through which connection is made to the control grid. The screen grid is connected to one of the base prongs.

The tube is very sensitive to external influences and consequently is used with a shield. One of these shields is shown in the illustration of Fig. 1.

The filament terminal potential for this tube is 3.3 volts and the filament current consumption is .132 ampere. Due to the low filament voltage and current consumption, it can be operated from dry cells but is also adaptable to a six volt storage battery if the proper value of filament resistance is employed. In the latter case it is possible to obtain sufficient "C" bias for the control grid, when the tube is used as a radio frequency amplifier, by tapping the filament resistance. The recommended plate potential is 135 volts but the actual voltage employed depends upon the duty to which the tube is put.

High Amplification Factor

It is obvious that this tube is self-neutralized since the capacity between plate and grid has been practically eliminated and consequently no external neutralizing devices are required when the tube is employed in a tuned radio frequency circuit. Furthermore, due to its exceptionally high amplification factor, it has an efficiency much greater than the ordinary 201-A type tube.

No advantage is gained through the use of the standard type radio frequency transformer due to the high plate resistance of the new tubes. Consequently a high impedance tuning circuit is used in preference to a step-up transformer and the stages are coupled in the manner shown in the diagram of Fig. 2. It is surprising how much gain in sensitivity and selectivity can be had from a circuit such as the original Roberts circuit when one of the four-element tubes is employed as a radio frequency amplifier. Since the tube is self-neutralized and will not oscillate under most conditions, a greater amount of regeneration can be obtained in the circuit of the detector tube.

Space Charge Grid Tube

The adaptability of the new tube does not end here. It can be employed as a space charge grid tube in a resistance or impedance coupled amplifier when connected up as shown in Fig. 3. When used in this manner the screen grid is used as the control grid and the ordinary grid is given a positive bias of about 22½ volts. The plate potential can be 180 volts and the negative bias on the control grid about 1.5 volts. The amplification factor in this case will be in the vicinity of 150 and more than likely two stages will be sufficient for all purposes.

These tubes will prove to be excellent intermediate frequency amplifiers in a superheterodyne receiver, due to the high amplification factor and can be employed in conjunction with the usual intermediate frequency transformers or impedance coupled units.

First Survey of Radio Dealers' Stocks

According to a survey of radio dealers' stocks just completed by the Electrical Equipment Division of the Department of Commerce, the first of its kind ever officially undertaken, returns from 7,842 dealers out of a total of 31,485 indicate that there was an average of 9 receiving sets and loud speakers per reporting dealer on October 1, 1927. "B" and "C" battery's stocks showed an average of 31 per reporting dealer, in units of 45 volts, and 7 storage batteries for "A" power, whereas eliminators averaged 5 per dealer. Receiving set tubes, not A.C., averaged 63 per dealer, whereas A.C. ones averaged 4. The survey showed that other types of tubes for rectifying purposes averaged 5 per dealer.

A total of 936 jobbers was circularized of which 236 replied. The number of receiving sets per reporting jobber was 373, loud speakers 385, "B" and "C" batteries 1220—45 volt units, storage batteries, 105, eliminators 254, tubes other than A.C. ones 3,140, A.C. tubes 97, and rectifying tubes 171, all per jobber:

Herewith is a table showing combined dealers and jobbers' stocks, actually reported:

	No. on Hand
(1) *Receiving Sets.*	
(a) Radio Receiving Sets without accessories for battery operation	153,817
(b) Radio Receiving Sets wired for A.C. operation not including power supply	9,498
(2) *Loud Speakers.*	
(a) Loud Speakers only	153,001
(b) Loud Speakers with associated power amplifier	5,018
(3) *Batteries.*	
(a) Dry "B" and "C" Batteries in terms of 45 volt units	534,721
(b) Storage Batteries not associated with trickle chargers	77,143
(4) *Socket Power Units.*	
(a) "A" Socket Power Units using storage battery	15,560
(b) "A" Socket Power Units not using storage battery	7,503
(c) "B" Socket Power Units with or without "C"	51,979
(d) "A" and "B" Socket Power combined units with or without "C"	26,237
(5) *Vacuum Tubes (Receiving).*	
(a) Tubes designed for operation from 6 volts D. C.	1,008,278
(b) Tubes designed for operation from 4 volts D. C.	230,053
(c) AC Tubes (either heater or filament type)	52,147
(6) *Rectifying Tubes or Units.*	
(a) High voltage tubes or other rectifying units for "B" power supply	58,070
(b) Low voltage tubes or other rectifying units for "A" power supply	18,546

Reception of Short Wave Broadcasting

Introduction to a Frequency Conversion System Which Permits Short Wave Reception on a Standard Receiver, and Remote Control

*By Bert E. Smith**

PART I

SHORT wave broadcasting and its reception has for sometime been attracting the interest of those radio fans who formerly built every new circuit on which they could lay hands, as well as many of the recruits from the listeners ranks. More and more broadcasting stations have begun to resort to this field, lured by the tremendous distance and the freedom from fading and distortion which have been demonstrated by the pioneering of KDKA and WGY to be an inseparable attribute of wavelengths below a hundred meters.

The range of the average five hundred watt broadcasting station even at night is not much more than fifty or one hundred miles, if reliable reception be a criterion, but on sixty-two meters the signals are as reliable for more than ten times that distance. It is only rarely that radio listeners in foreign countries pick up American stations operating in the regular broadcast band, but the short wave station at Pittsburgh has been consistently received in Australia, half way around the world! Last winter the British Broadcasting Company made a regular practice of re-broadcasting signals from American short wave stations to their English listeners, and their plans for this winter are much more comprehensive.

Short Wave Broadcasting on the Increase

New short wave broadcasting stations all over the world are being built, and it seems probable that within a month or two of the writing of this article there will be at least twenty-five high powered, short wave stations which will be consistently on the air, and their programs will be almost free from fading, and most of them will be much louder than the long wave broadcasts from stations even a hundred to five hundred miles away. The Crosley station at Cincinnati is now on the air every night. A Canadian station at Drummondville, Quebec, has made remarkable records. A station in New York is very near completion and several others are in the process of construction in that part of the United States east of the Rocky Mountains. Stations in England, Germany and Holland are experimenting with short waves, and two stations in Japan are on the air quite frequently.

Reception of such distance as most of these represent is absolutely inconceivable to most broadcast listeners, but it must be remembered that, among the amateurs who have been utilizing these bands for several years, two-way communication half-way around the world is a regular occurrence.

R. F. Amplification Inefficient on Short Waves

Apparatus for the proper reception of short wave broadcasting has, up to the present time, received very little attention on the part of those who spend their time devising circuits for the ordinary broadcast receivers. This may be due to the much more complex problems of design which are encountered in the layout of receivers for short waves, or perhaps to a lack of realization of the tremendous popularity which such receivers will inevitably receive in the not too distant future. The receivers which have been placed before the public up to the present time have been simple amateur sets of a type admirably suited to the reception of code, but almost useless for the proper reproduction of music and voice transmission. Some of these have been touted under the name of "Short Wave Adapters," and have been attached to a plug which could be inserted in the place of the detector tube of broadcast receivers, thereby wasting the very excellent radio frequency amplifiers which are usually incorporated in such receivers and making use only of the audio frequency end of the broadcast set. Others have been laid out complete, but although every radio publication in the country comes to the writer's desk he has yet to see a short wave receiver or adapter which was more ambitious in it's conception than the usual amateur layout.

> ### *The Budlong-Smith Wave-lifter*
>
> *The present article is restricted to a discourse on the problems surrounding the reception of short waves but is introductory to a forthcoming article which will cover in detail a frequency conversion system adaptable to tuned radio frequency receivers and superheterodynes for the reception of short-wave broadcasting. With the same system it is also possible to control the tuning of the receiver from a remote point.*
>
> *The principle of this device is not entirely new; similar arrangements have been used before. However, it is an original adaption and should be of special interest to experimenters.*—EDITOR.

Unquestionably the development of apparatus for the reception of frequencies from three thousand to thirty thousand kilocycles involves much more complex problems than the design of receivers for five hundred to fifteen hundred kilocycles. Everyone knows that the cascade audio amplifier is far more easily stabilized than a cascade radio frequency amplifier—the former rarely causes trouble, while the latter has been the subject of innumerable devices for neutralizing and balancing, although it is safe to say that the tuned radio frequency amplifier is now here to stay. The same proportion of difficulty exists between the amplification of broadcast signals and that of short wave signals. *No system of radio frequency amplification has yet been found practical on short waves.* This means that the serious experimenter or engineer who proposes to place before the public a short wave receiver which will compare, in its amplifying properties, to the present day broadcast receiver; has taken upon himself a rather difficult problem. However, necessity is the mother of invention, and if nothing of the kind had ever arisen radio would never have reached its present stage.

In the solution of difficult problems of radio design a great deal can frequently be learned by investigating the accomplished solutions of earlier problems which approached being analogous to the one in hand, and following this line of thought we can go back through radio history until we reach the point where tuned radio frequency amplification was thought to be absolutely impractical for the reception of broadcast frequencies. The radio frequency amplifiers used for broadcast reception at that time were invariably composed of amplifiers utilizing "fixed transformers" which were very broadly tuned and supposedly gave even amplification over the whole boadcast band.

* *Allen D. Cardwell Mfg. Corp.*

Such "even amplification" by any fixed radio frequency transformer has always been more or less of a myth, and the system is absolutely useless now because the selectivity (if any) in such receivers was procured by no more than two highly damped tuned circuits placed ahead of the "fixed" amplifier.

Heterodyning

At that time investigators discovered that by introducing into their circuit an oscillator which was capable of emitting a very sharp wave the incoming signal from the detector could be heterodyned to any given longer wavelength regardless of its incoming frequency, and they could then amplify it by a series of sharply tuned long wave transformers which could be easily stabilized, and at the same time prove very efficient. The tuning of such circuits was frequently so sharp that side-bands were cut off, and the amplifier had to be broadened to secure good quality of reproduction.

The efficiency of this method—well known in its application to the Superheterodyne circuit, has been proven by the fact that Superheterodynes are still very popular for broadcast reception, even though several years have gone by since their introduction; and it is doubtful whether any radio circuit has yet been devised for the reception of broadcast frequencies which excels the Superheterodynes in selectivity and sensitivity. It has stood up in the face of the continued development of the many systems of neutralization which nowadays permit the efficient operation of tuned radio frequency amplifiers in the broadcast band, although tube for tube such amplifiers are now more efficient than the system of long wave amplification employed in Superheterodynes.

High Frequency Intermediate Amplifiers

Of late Superheterodyne designers have sought to profit by the greater amplification possible on wavelengths near the broadcast band and they are steadily increasing the frequency of their intermediate amplifiers. The thought immediately arises—can we not make a Superheterodyne which will alter the short waves of the present day to broadcast wavelengths where we can amplify them successfully and without a great deal of trouble? If some such system could be evolved we could make use of our present broadcast receivers in toto and thus gain the advantage of the many years of development and perfection of radio frequency amplification which are represented in our broadcast receivers. Furthermore, most of our broadcast receivers are much more efficient in some one part of the broadcast band than in others, and if we could figure out some method of moving our short wave signal to that band, we should be enabled to take full advantage of the maximum sensitivity of our broadcast receiver plus whatever previous amplification could be gained in the transfer.

Our problem then is a simple one on the surface. All we need is a unit which can be placed ahead of our regular broadcast receiver, to accept the incoming signals on all wavelengths from about thirteen meters up, and hand them out to the set somewhere between two hundred and five hundred and fifty meters.

Short Wave Heterodyning Impractical

It sounds simple, but just try and do it! Heterodyning of short wave signals is absolutely impractical; at least by any circuit as yet evolved. It has been tried with varying degrees of non-success by almost everyone of our thirty thousand amateurs who number among their ranks the most prominent engineers in the country, and most of them have finally given it up. The reasons are rather too long to include in this article, but suffice it to say that while heterodyning is a fine thing from two hundred meters up it is almost useless below one hundred meters. For one thing, there are many more "frequencies" to the "meter" of wavelength at thirty meters than there are at three hundred, and to heterodyne with any degree of success we should have to have more than microtuning in our oscillator system—so much more that it would be a ten minute job to tune in a station even if we knew exactly where to look for it on our dials. This is only one of the drawbacks there are; among many others which definitely bar heterodyning as a practical means of converting short waves to broadcast waves.

At this point we seem to run up against a blank wall. If we can convert our short waves to broadcast waves we can amplify them to almost any extent we please and the problem now is to accomplish the conversion of frequency without heterodyning, infradyning, or using any of the other more or less standard methods. Something new had to be worked out.

New Frequency Conversion System

The solution, when it was finally found, was so simple as to be almost comical, while at the same time it presented many other possibilities. It was merely the adoption of a system of conversion from one wavelength to another which is in regular use at the present time for another purpose—in fact it has already been mentioned in this article in that connection. By this new means it is possible to build a unit which can be utilized ahead of our standard broadcast receiver for the purpose we desire and will, incidentally, perform many other valuable functions.

We have called this unit the "BUDLONG-SMITH WAVELIFTER" as the system was developed by Mr. A. L. Budlong of the *American Radio Relay League Headquarters*, and the writer. It will act as a remote tuning control for the broadcast set, and incidentally will have only one wavelength and one volume control regardless of how complicated the tuning system of the broadcast receiver may be. It will utilize the most sensitive point of the broadcast receiver and will broaden its range to cover the whole radio frequency scale. It may be utilized to control the broadcast set, without any direct connections, either mechanically or electrically, from a remote point. It will constitute the input unit for a Superheterodyne. It will provide means of comparing the overall amplification of receivers. It can be used for calibrating purposes. In itself it makes a rather good short wave receiver. In other words it becomes an almost indispensable adjunct for the serious experimenter and a device of great value to almost every listener. And it accomplishes all these things with only one tuning control, one volume control, and one adjustment to be matched to the adjustment on the dials of the broadcast receiver with which it is used.

By the utilization of the Budlong-Smith system other units may be constructed, which have no tuning controls whatever, and can be inserted in the circuit of the regular broadcast receiver, utilizing the present radio frequency amplifier, and which will add any number of amplification stages without any great difficulty in stabilization or in the construction. The theoretical properties of this system are comparatively elementary and the circuit arrangements are not at all complicated. A complete explanation of the system, as well as the circuit details will be fully covered in the next article.

National Broadcasting Company Operates a Still!

An application to the Bureau of Prohibition at Washington, D. C., has been made by the National Broadcasting Company for a permit to operate a still at the new transmitting station, now nearing completion, at Belmore, Long Island.

Distilled water is necessary to cool the giant tubes as any other water leaves deposits on the plates. Recently, in discussing apparatus for the new transmitter, it was suggested that a small still be installed to distill three gallons of water an hour. This is, probably, the first record received by the Bureau of Prohibition from a radio station for permission to operate a still, as necessary equipment for broadcasting. (*Get your cup ready!*)

Audio Frequency Amplification

A General Review of the Fundamental Problems

By H. G. Cisin, Associate Editor

PART I

This is the first of a series of three articles by Mr. Cisin. In the present article he points out some of the misconceptions of audio amplification and further, fashions a vivid pattern of the active elements to form a perspective for the reader. His second and third articles will be less general in nature. Audio frequency amplifier systems and power amplifiers will be covered in detail.—EDITOR.

THERE is still a great deal of confusion in the minds of numerous people regarding the subject of audio frequency amplification. This is principally due to the fact that the major part of the developmental work on audio amplifiers has been done in a comparatively short space of time and the elements as they stand are not the result of one man's labor but rather the result of the labor of many.

The average man has not had sufficient time to digest all of the material covering the numerous systems and adaptions and is at a loss to know what can be expected of each and, under a given set of conditions, which will provide the most benefit. Since engineers are still disputing each other's assertions and furthermore, since no definite ground work has been laid from which further definite results can be gathered with an assurance as to their truth, it is impossible for anyone to lay down specific rules governing audio frequency amplification or state any individual conclusions as pure fact.

Audio amplification is a highly problematical subject as can be understood when we study the idiosyncrasies of the sense of hearing. What, in the first place, is good reproduction when we know that the hearing of one man may cover or may not cover as wide a range of frequencies as another man's hearing and that in either case the extent of the impression on the nerves may be distributed over entirely different bands of frequencies. One man notes distortion in the sound delivered by a loud speaker which others may not discern for the simple reason that he is able to hear lower or higher frequencies than the rest of the listeners.

What Is Good Reproduction

We can say that good reproduction is any distribution of sound which is an exact duplicate of the original for we all have our own conception of the original and judge solely by our sense of hearing as to the quality. In other words, it makes little difference if a man is unable to hear the extremely low or high fundamentals or harmonics produced by the instruments of an orchestra—they do not come within his sense of appreciation in the first place, since he never hears them.

Therefore, if we were to duplicate the original at the receiving end we would be satisfying everyone. That is a nice way of putting it but it is not necessarily a fact. There are too many other points to consider to make the above statement the truth, yet it amounts to an ideal—an ideal which so far is unrealized.

Frequency Considerations

We could say a great deal regarding the unhappy faculty the ear has of learning to "appreciate in its own way" music which is distorted, but let us drop the human element and observe how that which has been said is of importance in relation to audio frequency amplification.

If we design a transformer so as to have a cutoff at a frequency of 7,000 cycles and build up an amplifier using two of them, the resultant reproduction would not please a person who could hear well above the stated cut-off frequency. If we made the cut-off frequency way up around 10,000 or 12,000 cycles trouble would be experienced from audio frequency regeneration, tube noises and other extraneous sounds encountered in the frequencies bordering the super-audible. They might be bothersome and they might not, depending upon our own range of hearing but the audio frequency regeneration, if present and not intelligently controlled would create distortion at the lower frequencies through the presence of artificial harmonics developed by the overloading of the A. F. tubes, etc. Since it is considered that there is little of value to be heard above approximately 5,000 to 7,000 cycles, which is about the practical limit on the musical scale of the piano and the violin, transformers are designed to cut off at that frequency and the difficulties previously mentioned are not encountered.

Obviously, no attempt is made to cut off at low frequencies, under normal conditions, but rather, an attempt is made to increase the amplification at low frequencies as it is in this band that practically all audio amplifier systems are deficient.

If we employ an amplifier which has excellent frequency characteristics in the lower band the energy output from the last tube, at low frequencies, under certain set conditions, will be greater than normal and the resultant sound from the loud speaker will be improved, theoretically, and actually if the listener is physically able to hear the low frequencies well.

So far we have merely stated what the result may be, without giving any consideration to the loud speaker. Let us record this as a fact: any one audio frequency amplifier, irrespective of its type, when used in conjunction with a given loud speaker may prove unsatisfactory to one person yet highly satisfactory to another. The whole matter is dependent upon three factors, i. e., the frequency characteristics of the audio amplifier, including the tubes, the frequency characteristics of the loud speaker and, if we may say it—the frequency characteristics of the listener. The chances of the three of them matching up are not very good.

However, it is not essential to paint the picture quite so vivid. Audio frequency amplifiers are designed to conform as nearly as possible to the characteristics of the average loud speaker so that the resultant reproduction will have a fairly uniform amplitude over the frequency range from 32 to 5,000 or 7,000 cycles. How near they come to this is another story; there are very few, if any, loud speakers in popular use which reproduce any fundamentals below 200 cycles; any frequencies below this point which are heard are merely harmonics.

Getting back to the theme, the point we have been endeavoring to justify is, that no one as yet is quite sure as to what constitutes an ideal audio amplifier. Furthermore, that it is idiotic to state that any particular amplifier has ideal frequency characteristics.

Developments in Audio Amplification

It is unnecessary to cover the history of audio amplifiers except to mention that many fine amplifiers with what we call excellent frequency characteristics, were really decidedly poor in actual results because the tubes, and particularly the one in the last stage, were incapable of handling the peak energy and overloaded, thus creating tube distortion.

It will be remembered that the first real step towards the improvement of reproduction was the push-pull amplifier. In this amplifier, the load is distributed between two tubes, and due to the push-pull connection, harmonic distortion, produced in the first transformer stage, is nullified.

Shortly following the introduction

of the push-pull amplifier better audio transformers appeared on the market and the resistance and impedance coupled amplifiers, always noted for their practically straight line frequency characteristics, were resurrected from the past. Shortly afterwards the first real semi-power tubes and power tubes were marketed and today they are generally employed in the output stages of audio amplifiers.

Most everyone knows that excellent reproduction can be obtained from any of the three principal forms of amplifiers and that reproduction can be greatly improved by employing a power tube in the last stage and a considerably higher plate voltage. However, it remains a question to many as to what form of amplifier is the most satisfactory under a given set of conditions and whether or not it is actually worth the while to use say, a 210 tube in preference to a 171 tube. Among other questions on A. F. amplification I have been asked whether better results can be obtained from a power amplifier employing a single 210 tube or from an amplifier with a push-pull output, using two 171 tubes. Believe it or not, the answer is not a simple one and it is the purpose of this series of articles to satisfy just such questions.

Enough has been said regarding the characteristics and requirements of audio amplifiers to form a basis for the coming articles. Knowing the conditions it is an easier matter to form an intelligent conclusion regarding the three principal systems of audio amplification and their adaptability to general and specific use.

The next article will deal with the audio systems now in use and serve to point out the advantages and disadvantages of each.

A Versatile Testing Outfit

A compact unit for testing tubes, transformers, loud speakers and complete receivers

By John F. Rider, Associate Editor

THE writer has received numerous inquiries requesting constructional details on testing equipment, simple in operation, yet effective in results. The letters received pertained to tests on receivers, audio amplifiers, loud speakers, detector tubes and audio amplifier tubes. Were we to design a unit particularly suited for each test, the number of pieces would be in excess of that which can be carried by the service man on his daily rounds. With the above in mind, the writer has developed a testing unit suitable for all the tests mentioned above and can be housed in a cabinet 14" x 14" x 6" deep. The "B" batteries can be carried in another small battery case. The "A" supply is always available where the test is to be made. If the service man has been called because the "A" supply is faulty, there is no need for the testing equipment outlined below.

The unit to be described consists of a radio frequency oscillator which can be adjusted to be self-modulating, if desired. A regenerative detector system is also included, which can be converted into a radio frequency oscillator by advancing the regeneration control until the tube is oscillating. A variable characteristic, three stage audio amplifier is also contained in the cabinet. The last tube of this amplifier can be used either as an output tube or a vacuum tube voltmeter. Let us now see what we can accomplish with this unit.

Adaptability of Test Unit

First, we have the radio frequency oscillator producing an unmodulated wave. This unit can be arranged for calibration work on coils and condensers, determination of the wavelength of received broadcasting stations, etc. With the self-modulating unit in operation this radio frequency oscillator, now self-modulated, can be used for the calibration of receivers and as a broadcasting station for the testing of the receiver. It can be used for the checking of the various tuned circuits of a single or dual controlled multi-stage radio frequency receiver. By progressively feeding the modulated signal into the various stages, one can determine any variances in resonance settings.

Second, the regenerative detector unit, operating in conjunction with the modulated radio frequency oscillator, permits the testing of tubes intended for use as detectors. Their sensitivity, their ease of oscillation can be easily determined. Operating with the audio amplifier, the last tube of which is arranged as a tube voltmeter, the system can be adjusted to show visually the relative degrees of sensitivity of the tubes used as detectors. By means of a two-way switch either a positive or a negative

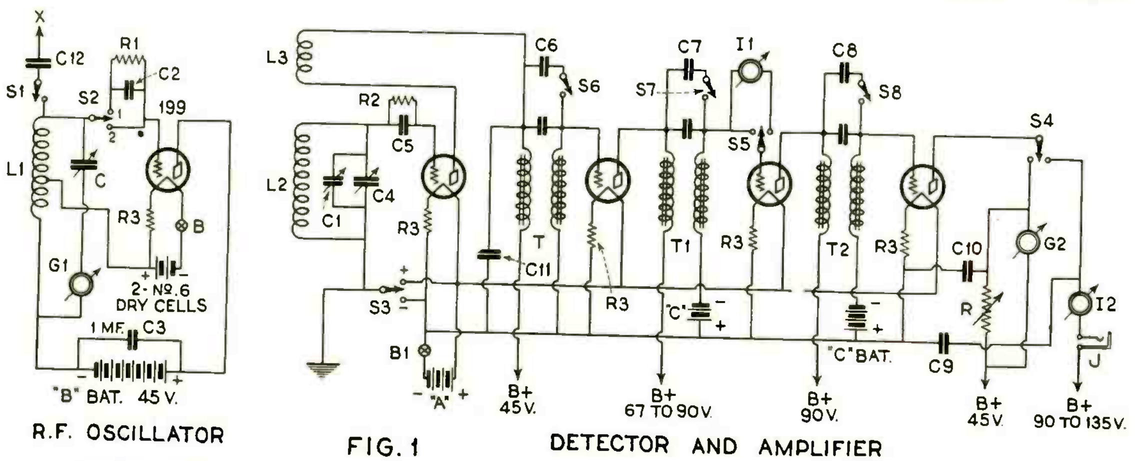


FIG. 1

Complete circuit diagram of the Versatile Testing Outfit. The R.F. Oscillator can be used as a modulated or unmodulated oscillator depending upon the position of switch S2. The outfit can be converted into a beat note oscillator by advancing the tickler coil L3 to a position where the detector tube will oscillate.

bias can be applied to the detector tube grid. When testing such tubes, the detector circuit is arranged to pick up the energy generated by the self-modulated radio frequency oscillator.

Third, the audio amplifier in the test unit can be used for the testing of amplifier tubes, that is to say, tubes intended for use as audio frequency amplifiers. The modulated radio frequency signal generated by the oscillator is fed into the detector tube and then into the amplifiers. Output indications are visible on the tube voltmeter meter.

Fourth, the signal from the radio frequency oscillator is fed into the detector of the test unit and then into the receiver amplifier. The operation of the receiver amplifier can thus be tested.

Fifth, by adjusting the radio frequency oscillator to generate an unmodulated carrier wave and by adjusting the regenerative detector of the test unit to beat against the radio frequency oscillator, the beat note can be fed into the receiver amplifier. In this manner certain frequency tests of the receiver amplifier are possible.

Sixth, by passing this beat note into the test amplifier and then into any speaker, it is possible to note response characteristics of speakers.

With the arrangement of the equipment, the utility of the system is even greater than that outlined, and additional uses will present themselves after the system is in operation.

Constructional layout of the testing outfit. The R.F. oscillator tube and the regenerative detector tube are mounted on the shelf. The A.F. tubes and impedance units are mounted on the base.

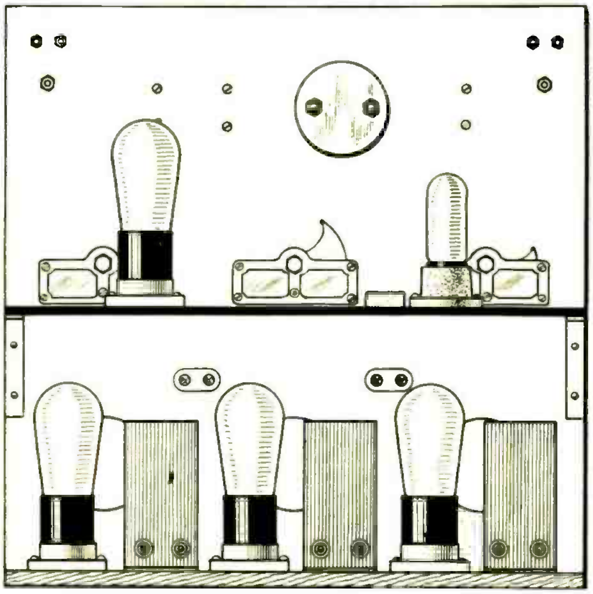


FIG. 2

Details of Test Unit

The complete wiring diagram is shown is Fig. 1. The switch S2 in the grid circuit of the radio frequency oscillator converts the oscillator into a generator of a carrier wave (unmodulated) or into a generator of a modulated carrier wave. When the switch is in position 1 the wave is modulated; in position 2 it is unmodulated. C is the main tuning condenser and has a capacity of .0005 mfd. C1 is a .00005 mfd. vernier condenser. It is used when obtaining a beat note between the radio frequency oscillator and the oscillating detector circuit. Automatic filament controls are used for each tube. The radio frequency tube is a 199. L is the center tapped inductance. When energy from the radio frequency oscillator is fed to the detector circuit (L2) the feed coil L1 is loosely coupled to L2. L3 is the variable tickler coil.

The switch S3 in the grid return circuit of the detector tube makes possible the application of either a positive or a negative bias. When the switch is in the plus position, the bias is positive; when in the minus position, the bias is negative. C4 is the detector tuning condenser, a .0005 mfd. unit. The grid condenser in the radio frequency oscillator and the grid condenser in the detector circuit are both .00025 mfd. units. The grid leaks associated with the two grid condensers are each 1 megohm in resistance. The tone of the modulating signal of the radio frequency amplifier can be varied by varying the value of the grid leak. The 1 megohm grid leak in the detector circuit provides for stable regeneration control with the variable tickler.

The switches associated with each coupling condenser of the tuned double impedance units permits the insertion of a 1 mfd. condenser as the coupling condenser and provides an amplifier with a flat characteristic from 30 to 6000 cycles. Actually, the curve has a peak, but the frequency of the peak is below 30 cycles, therefore out of the normal audio range. With these 1. mfd. condensers (C6, C7 and C8) out of the circuit, the audio amplifier has a peak at 80 cycles and is flat from approximately 130 to 6400 cycles. The switch S4 in the plate circuit of the output tube provides a means of placing the galvanometer G2 into the circuit when the tube is used as a tube voltmeter, and the milliammeter I2 into the circuit when the tube is used as an output tube. The speaker is plugged into the jack J. The "C" battery supplying the last audio tube with grid bias is variable. The switch S5 in the grid circuit of the second audio stage permits placing the milliammeter in the grid circuit to show grid current. The resistance R shunting the galvanometer G2 in the plate circuit of the output tube permits adjustment of the setting of the meter pointer. C9 and C10 are by-pass condensers of 1 mfd. each. The switch S1 and the .00001 mfd. condenser C12 permit the transfer of energy from the oscillator to radio frequency transformers in the receiver under test. The circuit diagram will be shown later.

Constructional Details

The list of parts required for the complete system are as follows:

2—.00025 mfd. grid condensers with grid leak clips (C2 and C5).
2—1 megohm grid leaks (R1, R2).
2—.0005 mfd. variable condensers (C and C4).
5—Sockets.
5—Filament resistors (R3).
1—.00005 mfd. vernier condenser (C1).
1—.00001 mfd. fixed condenser (C12).
2—Battery switches (B, B.)
1—1st stage tuned double impedance unit (T).
1—2nd stage tuned double impedance unit (T1)
1—3rd stage tuned double impedance unit (T2).
1—0 to 100 current squared thermocouple galvanometer (G1).
2—0 to 1.5 D. C. milliammeters (G2) (I1).
1—0 to 50 D. C. milliammeter (I2).
4—Single pole double throw switches (S2, S3, S4, S5).
4—Single pole single throw switches (S1, S6, S7, S8).
6—1 mfd. fixed condensers (C3, C6, C7, C8, C9, C10).
1—.001 mfd. fixed condenser (C11).
1—0 to 1000 ohm variable resistance. (Carry at least 3 mils) (R).
1—Open circuit jack (J).
1—50 Turn honeycomb coil—Tapped at midpoint (L1).
2—1000 turn honeycomb coils (L1 and L2) (L1 tapped at midpoint).
1—400 turn honeycomb coil (L3).

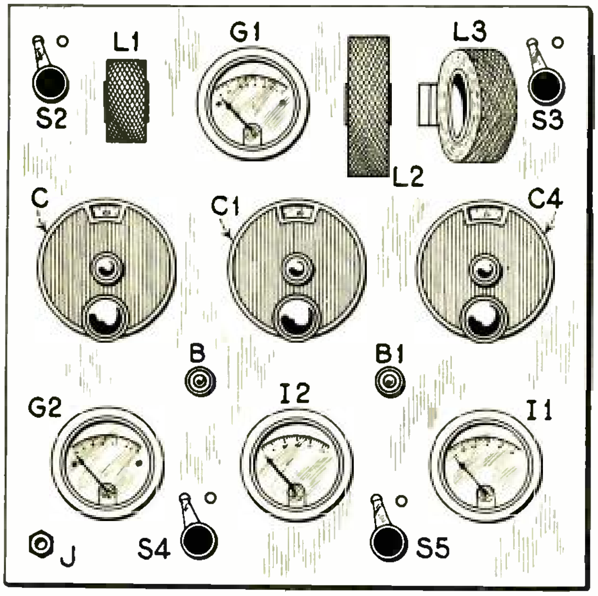


FIG. 3

The panel layout of the testing outfit. The mountings for coils L1 and L3 are movable so that the coupling between coils can be varied.

Detailed wiring instructions are unnecessary, since the readers of this paper are familiar with all the phases of wiring. The space conserved can be applied to better advantage. The equipment other than the batteries is mounted upon two shelves, as shown in Fig. 2. This is a rear view of the cabinet housing the equipment. The radio frequency oscillator and the detector circuit are mounted upon the upper shelf. The three audio stages are mounted on the lower shelf, which shelf constitutes the baseboard. The honeycomb coils are mounted on the front panel by means of plugs and sockets. Each coil is equipped with a plug. When the unit is placed into operation, the coils are plugged into position. The socket for coil L1 should be on a swivel so that it can be set at 90 degrees with respect to coils L2 and L3. The socket for L2 can be permanently fixed. L3 should be movable. The front view of the test unit, shown in Fig. 3, shows how the coils are mounted. By swinging coil L1 to some angle between parallel and 90 degrees we can vary the energy transfer between L1 and L2. When the equipment is being carried from one place to another, the coils are removed from their sockets and placed within a rack in the cover.

Using the Test Unit

The radio frequency coil designated as L1 is in reality two coils, that is, when tuned to the regular broadcast wavelengths to test the fans receiver, coil L1 is the 50 turn honeycomb coil. When producing the beat note for the testing of speakers or for the testing of tubes or other units in the test amplifier, coil L1 is the 1000 turn coil. The reason for operating with the 1000 turn coil, and consequently higher wave length, is the greater ease of producing the beat note, and obtaining a band of audio frequencies. Whereas on 300 meters an audio frequency beat note band of from 50 to 5000 cycles would constitute a small change in the setting of the tuning condenser, the same audio band on 15000 or 20000 meters is equivalent to a complete revolution of the vernier condenser dial. A separation of 6 or 8 inches between the coils L1 and L2, when they are parallel, is quite satisfactory.

Suppose we place the unit into operation. Let us assume that we have a single control, two stage tuned radio frequency receiver and we desire to determine if all the stages are tuned to resonance when the tuning dial is set to a certain wavelength. L1 is now the 50 turn honeycomb coil. The switch S1 is so placed that the .00001 mfd. coupling condenser C12 is connected to the coil. S2 is set to position 1. The radio frequency oscillator is now generating a modulated carrier wave, the carrier frequency of which is made variable by means of condenser C. In Fig. 4 we show the tuning system of the radio receiver to be tested. The oscillator is set to some wavelength within the broadcast band. We set the receiver into operation. Now remove the aerial from the receiver and connect the lead marked X in Fig. 1 (radio frequency oscillator output lead) to the aerial terminal of the receiver in Fig. 4. Tune the receiver to resonance with the locally generated signal. Note the dial setting. Now remove the lead X from the aerial terminal and place it upon the plate terminal of the first radio frequency amplifying tube in the receiver. This is marked Y1 in Fig. 4. Retune the receiver to resonance. Note the setting of the tuning condenser. Now remove the lead X from position Y1 and place it at Y2. Retune to resonance and note the dial setting. Repeat the process backwards to check the dial settings. The circuit off resonance can be easily decided upon, and correction made.

Testing Tubes

Suppose we wish to test a detector tube. Switch S1 (in radio frequency oscillator) is set to the "off" position. Switch S2 is set to position the same as before. Coil L1 is now the 1000 turn coil. The test detector-amplifier circuit is set into operation. Switch S4, in the plate circuit of the output tube, is set to the position O. A test speaker is plugged into the jack. The test detector circuit, with a standard detector tube, is tuned to resonance with the oscillator circuit. The tickler control is set to any desired point. The speaker output intensity is noted. The detector tube is now removed and the tube to be tested is inserted in its place. Note the difference, if any, between the signal output. If judgment is difficult in this manner switch S4 should be set to position V. The galvanometer G2 is now in the plate circuit and the last audio tube will be used as a tube voltmeter. Adjust the C bias to about 10 or 12 volts. Apply 45 or 67 volts to the plate. Adjust

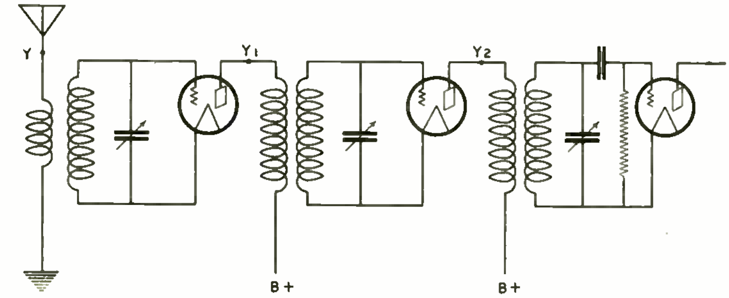


Fig. 4. If the lead x of the R.F. oscillator is connected in turn to Y, Y1 and Y2 it can be determined if any of the stages of R.F. are out of resonance.

the resistance R to be all in, thus minimizing its effect upon the galvanometer. Now vary the C bias until the plate current is about 50 microamperes. Place the standard detector tube in the socket. Tune the detector circuit to resonance with the oscillator. If the galvanometer goes off scale, adjust the resistance R until the needle shows about 80% of the total scale. Now remove the standard detector and replace the tube to be tested. Retune the detector circuit. The tickler coil should remain fixed as before. Note the galvanometer reading in the tube voltmeter circuit. If it is less, the output of the tube is less; if it is greater the tube output is greater. The tube voltmeter reading is indicative of the detector tube output since nothing else has been changed.

Amplifier tubes are tested in the same manner, except that the amplifier tube is inserted into the second audio stage. The meter 11 in the grid circuit of the second audio stage is included to check the presence of grid current, which, while not of great consequence with a tuned double impedance unit (unless the value of grid current is more than 100 microamperes) it affords a check upon the grid circuit.

Suppose we wish to check the ease of regeneration of a detector tube, or the regenerative powers of a detector tube. The same circuit is used, with calibrated tickler adjustment. By noting the setting of the tickler coil and the galvanometer reading we can observe the amplifying powers of the tube due to regeneration.

Beat Note Oscillator

To produce a beat note between the radio frequency oscillator and the oscillating detector, we must set switch S2 to position 2. The oscillator tube will now generate an unmodulated carrier wave. The coil L1 is the 1000 turn coil. The detector tube is adjusted to oscillate. Switch S4 is set to the position 0 and the "C" voltage is reduced to the normal value required for the applied "B" voltage, since the tube is now being used as an output tube. A 112 will be satisfactory as an output tube and as a tube voltmeter. The speaker is plugged into the jack J. The radio frequency oscillator and the detector tube tuned circuit are brought to zero beat on a high wavelength. If a wavemeter is handy, the detector tube circuit can be calibrated in wavelength for that tickler coil setting. A series of close calibrations at a progression of 500 cycles will give a series of beats of known frequency, when the radio frequency oscillator is held constant and the detector tube tuning circuit is varied. If calibrated beats are not required, the band of audio beats between 50 and 5000 cycles can be obtained by varying condenser C1. The zero beat between the oscillating detector and the radio frequency oscillator should be made with condenser C1 set at zero.

This equipment is very versatile. It can be applied to excellent advantage on a permanent installation in a service station. It can also be put to good use as a portable outfit. Many service men have automobiles and the weight of the "B" battery box is of no consequence. A service man without a car can easily carry these two units. The test cabinet can be arranged with a hinged cover, to fit over the front panel. Connection to the battery box is made by means of battery cables. The connections to the "C" batteries should be as short as possible. By using 7 volt "C" batteries, tapped at 1.5 volt values, a good variation is obtainable.

Australian Radio Trade Demands Revision of Patent Royalty Exactions

Royal Commission Condemns Policy and Demands of Patent Holders, but Refuses to Consider Evidence on Validity of Claims. British Manufacturers' Latest Move

THE future of the Australian radio trade is indissolubly bound up with the patent question, is the opinion of many competent authorities. Just how far this affects the American manufacturer is shown by the fact that radio exports to that destination reached $1,304,000 in 1926, while the chart below summarizes progress during the past few years.

The comparative American and British quotas revealed by this summary require considering in conjunction with recent propaganda put out by British makers that no patent royalties are paid by American manufacturers on radios exported to Australia, whereas British sets comply with the rules and regulations of the patent interests by contributions to the Marconi Company in London at the rate of $3 for every tube socket built into the instruments, of which amount 30 cents is paid over to the concern holding the Australian patent rights. This latter is Amalgamated Wireless (Australasia) Ltd., in which concern the Federal Government have a holding of £500,001. Over in Australia, some dealers handling certain sets have been called upon to pay patent royalties, and others have not been approached.

Conditions Unsettled

Conditions surrounding Australian radio have become so unsettled, and the policy and the demands of Amalgamated Wireless have been such that a Royal Commission was set up this year for the purpose of considering and reporting upon the whole situation. In connection with the patents, there was prepared for the Commission a report dealing comprehensively with the whole patent situation from an Australian standpoint, by Wilfred J. Spruson, partner in the firm of Spruson & Ferguson, Patent Attorneys, of Sydney, with the technical assistance of two radio engineers, E. G. Beard and E. Joseph. When submitted to the Royal Commission, certain of the paragraphs were struck out by order of the commissioners as being irrelevant as it was held that the scope of the inquiry did not extend to questioning the validity of the patents, but the opinions expressed in this report will be none the less interesting to the American manufacturer on this account.

Scope of the Investigation

The investigations in question covered the period 1904 (the date of the commencement of the Commonwealth patent system) to the end of 1926, the total number of patents examined being 734, of which Amalgamated-Wireless-Marconi interests are credited with 255. In the report, the position is considered in regard to (a) broadcasting transmission, and (b) the trade in receivers.

In the case of the former, if there is excluded the Meissner patent No. 12194 of 1914, and the Schloemilch & Von Bronck patent No. 9132 of 1913, which were both the subject of litigation at the time the report was drafted, there is in the investigators' opinion no patent which can be successfully propounded to interfere with the activities of broadcasting transmitters. After examining all the fundamental elements in a broadcasting transmitting station, the investigator considers that the Amalgamated Wireless claim rests entirely upon their achieving success in litigation founded on the Meissner patent.

Receiving Sets

In investigating the position with regard to receiving sets, these are divided into seven main classes, and the following is a summary of the views expressed upon each:

(1) Crystal sets without amplifiers. No patent whatever extends to these.

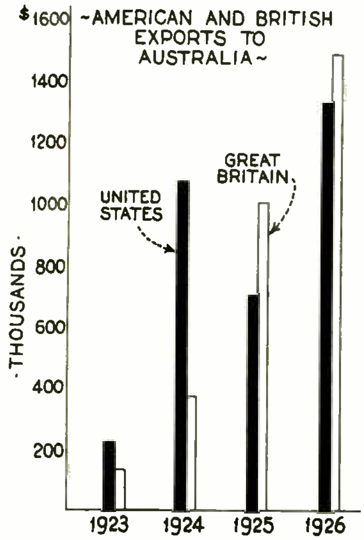
(2) Plain tube detectors without feed-back. The tube detector element in any set of whatever construction is not of itself subject to any patent.

(3) Plain tube detectors, with feed-back, and audio amplification. The feed-back feature raises the Meissner patent, and the amplification feature brings up the Schloemilch & Von Bronck patent, which are the subject of litigation against David Jones & Myers. It remains for the Court to decide the validity of both patents or their infringement.

(4) Radio-frequency sets. The first patent on radio-frequency amplification is the Schloemilch & Von Bronck No. 9132-14 already mentioned. Other patents are regarded as of little importance for various reasons.

(5) Neutrodynes. The investigator points out that the Hazeltine patents, which are five in number obtained in 1924 and 1925, were applied for in Australia when the neutrodyne system was known and in use there. These patents cover a particular form of neutrodyne, and do not extend to cover the neutrodyne principle. Neutrodyne sets have been in use in Australia since about 1922. The neutrodyne situation in general is considered to be clear for the trade as long as particular circuits covered by valid patents are not used.

(6) Heterodynes. The heterodyne principle is attributable to Fessenden, and has been known since 1902. There can be no patent operative for con-



American and British radio exports to Australia have been considerably influenced by the patent situation in that country

trolling heterodyne sets, though it is pointed out that the incidence of the Meissner patent must be considered if it is ultimately declared valid. Excluding this latter patent, the superheterodyne set is the property of no-one, though in this circuit as in the neutrodyne there are a number of patents covering minor features, and while traders and manufacturers are considered at liberty to deal in heterodynes, they must see that they steer clear of enforceable patents which attach to special features.

(7) As far as reflexes are concerned, the investigator considers that the interest of the Australian radio trade in these is a vanishing quantity, and that this being the case it would be of no material importance however broad and sound were the Amalgamated Wireless patents covering reflexes.

Summary

The investigator's summary with regard to receiving sets in general is that if the Meissner and Schloemilch & Von Bronck patents were eliminated, the difficulties of the situation dissolve! The crux of the matter is considered to be the Meissner No. 12194-1914, which will run out its 16 years' term on February 16th, 1930, and until the pending action is settled between the owners of the patents and the radio trade in general cannot be settled.

The Commission in their report have criticised both the general business policy of Amalgamated Wireless as well as the amount of royalties demanded, pointing out that a reduction in the latter is urgently needed. In Britain, with the object of enabling manufacturers to secure a firmer hold on the Australian trade, the news has been followed by a concession on the part of the Marconi interests by reducing the royalty in the case of radios or kits exported to Australia and New Zealand to 30 cents per tube socket, to operate from August 1st, 1927.

Selecting Filter Condensers*

The importance of selecting filter condensers having the proper working voltage

SINCE the radio power unit rests on a foundation of paper condensers, it stands to reason that those paper condensers must be of sufficient electrical strength to handle the job. It is not only a matter of working voltages, but also of peaks and surges that occur in most radio power units, due to the removal of the load that dissipates the output, or increased line voltage which is reflected in greatly augmented strain on the filter condensers.

It is well to be more than conservative in the selection of filter condensers. First of all, really good condensers should be employed. Such condensers cost more, of course, but will prove cheapest in the long run. Furthermore, it is well to employ filter condensers of twice the *working voltage*, throughout the circuit. Thus a 200-volt output radio power unit should be provided with 400-volt (working voltage, not test voltage) condensers throughout. It is especially important to provide ample reserve dielectric strength in the first condenser—the one nearest the rectifier, as this condenser is subjected to far greater strains than the others. Good practice calls for a higher voltage rating for the first transformer than for the other two, and condenser blocks are now being made with balanced sections so that there is ample dielectric strength for the various parts of a filter circuit, without increasing the cost unnecessarily by having the highest dielectric strength throughout. It appears that good practice is to have three times the output voltage for the *working voltage* rating of the first condenser, and twice the output voltage for the *working voltage* rating of the other filter condensers. This will provide a fair margin of dielectric strength, and properly built condensers should give many years of reliable service under such conditions.

The matter of buffer condensers, in the case of the gaseous type of rectifier, is a most important one which only too often receives scant consideration. Only too often the builders of radio power units employ cheap, low-voltage condensers as buffers, not realizing that these condensers are subjected to the greatest strain of all. After all, the capacity of these condensers is so low that there is little difference in first cost between condensers of ample dielectric strength, and those of weak dielectric strength. It will pay to use buffer condensers of not less than 600 volts D. C. working voltage, even in the usual 200-volt output eliminator, so as to preclude any possibility of condenser breakdown.

Properly selected and applied, the filter condensers should serve as long as the radio power unit exists.

* *Engineering Dept., Dubilier Condenser Corp.*

Austin C. Lescarboura--Our New Associate Editor

AT this time we present the latest addition to our editorial staff —Austin C. Lescarboura, who hardly needs introduction in radio circles. Lescarboura has a radio career which dates all the way back to the pre-historic days of 1907, when he was operating a two-inch spark coil with electrolytic interrupter for transmitting, and a double-slide tuning coil with crystal detector and ear-phones for receiving. He was virtually brought up in company with Armstrong, King, Pacent, DeForest, Logwood, Simons, Hogan and others. In 1908 and 1909, he was assistant engineer for the *Telefunken Wireless Telegraph Company*, handling installation of apparatus for the U. S. Navy and Signal Corps, as well as conducting some of the first radio telephone experiments in this country between Fort Hancock (Sandy Hook, N. J.) and Fort Wood (Statue of Liberty), with five kilowatts to span a distance of eighteen miles!

However, Lescarboura drifted out of radio and into the editing profession, feeling that the editorial end offered a greater opportunity for service. In 1911 and 1912, he was associate editor of *Modern Electrics*, and from 1912 till 1913 he was associate editor of *Dun's International Review*. In 1914 he became Editor of *The World's Advance* (now *Popular Science Monthly*). In 1915 he joined the *Scientific American* staff as associate editor, becoming Managing Editor of that publication in 1919, and holding that position until 1924. When he resigned that position to become active in his own business, he was also director of the Scientific American Publishing Company.

Since 1924, Lescarboura has been engaged in technical writing for the popular and technical press. He handles considerable editorial and reportorial work for various publications, as well as publicity and public relations for the leading radio and electrical companies. His headquarters are located at Croton-on-Hudson, N. Y., where he maintains a modern and well equipped office with a staff of girls and men, as well as a complete radio and electrical laboratory. This office, known as the "Wordshop," handles its own multigraphing, mimeographing and automatic addressing. It also handles its own printing, as well as the making of studio and outdoor photographs.

Lescarboura spends his time at the typewriter or in the laboratory, while at work. He goes into his laboratory to test out or check up on a certain statement which he is about to make, and then dashes back to the typewriter to tell it to the world. That's how he works—first-hand information, always. His laboratory is a model of radio efficiency, with switchboards that include all kinds of A.C. and D.C. power, amplifiers, receiving sets, jacks for taking voltage and amperage readings, indicating lights, and so on. Almost any test or setup can be made in minimum time, on the big work benches and by means of the switchboards. An impressive array of measuring instruments insures positive facts. Also, a large collection of tools indicates that things are really made in this shop.

In joining our staff, Lescarboura brings to us not only these laboratory facilities for the gathering of first-hand information concerning radio technique, but he also brings invaluable contacts in the industry itself. He is in constant touch with the leaders of the industry, and in that way can aid us in formulating an editorial policy which will be a true mirror of the progress of the radio industry. And we are in hopes, of course, that we can get a steady flow of material from his pen—or rather typewriter—in our columns.

Lescarboura, incidentally, is a member of the A. I. E. E., member of the I. R. E., and Fellow of the Radio Club of America, of which he is also director and in charge of publicity. He has been decorated by the French Government for wartime services. He is the author of several books, including "Radio Course in Twenty Lessons," "Behind the Motion Picture Screen," "The Cinema Handbook," "Radio for Everybody," "Scientific American Home Owner's Handbook," etc.

Absorption Point Long Way Ahead

*By William S. Hedges**

THERE are 20,800,000 American homes which have not yet been equipped with radio receiving sets. This fact, brought to the attention of the radio industry by Federal Radio Commissioner O. H. Caldwell, indicates that the industry has still much to accomplish despite its phenomenal growth during the last eight years.

According to the estimates of Commissioner Caldwell, which are based on careful surveys, there are 6,500,000 radio sets in use at the present time. To allay any fears of manufacturers that the absorption point may soon be reached a little study of the industry's own calculations will show that by the time that point is reached the surviving manufacturers will have long gray beards.

Soon after the radio trade show in Chicago last June statistics were issued showing that approximately $2,000,000 radio receiving sets will be sold during the year 1927-28. Half of the new sets will replace receivers which have become obsolete and the other half will be sold to customers who have not heretofore possessed radio sets.

15 Per Cent Replacement

Using these figures as a basis it would appear that the industry figures a 15 per cent replacement of receivers each year. If that percentage prevails and if production continues at its present swift pace replacements will pursue new-set sales to a vanishing point until the year 1970, when the 2,000,000 new sets will all be needed for replacement and there will still remain about 14,000,000 homes lacking in radio sets, in addition to the total of the new homes established between the present date and 1970.

Obviously the radio industry can expand as the years go by; can increase production and enjoy a healthy growth, provided, of course, that the growth is gradual. It will probably take all of the sales effort and intelligence that the radio industry can muster to sell the 2,000,000 sets this year—an observation made at this point to forcibly remind manufacturers against production of receivers beyond the capacity of their sales channels to merchandise.

Twenty-five Sell Output

The fact that twenty-five manufacturers have already sold their planned output for the year is an encouraging sign and will prove to be a great stimulus to the industry, provided there is no slump in energy devoted to advertising and merchandising of the products of the manufacturers. Failure to move the receivers on to the radio buyers will deal the industry a severe blow because of the demoralizing effect of dumping sets at the close of the season before next year's models make their appearance.

*Radio Editor, Chicago Daily News. Courtesy of R. M. A. News.

New Wire and Cable Organization

The organization of a large electrical wire and cable company under the name of General Cable Corporation was forecasted recently by the mailing of notices calling meetings of stockholders to approve action take by the Boards of Directors of certain of the Companies whose assets will be owned by General Cable Corporation. When the organization of General Cable Corporation is completed, it will own the assets and businesses now operated by Dudley Manufacturing Corporation, Rome Wire Company, Safety Cable Company and Standard Underground Cable Company, and the sheet and rod and wire mills of Baltimore Copper Smelting and Rolling Company. These Companies are among the most prosperous and strongest manufacturers of their several lines of product in the United States and have been favorably known for the high quality of their product and the efficiency of their management.

General Cable Corporation will have plants at the following strategic points in the United States and Canada: Bayonne, Perth Amboy, Newark and Harrison, New Jersey: Rome and Buffalo, New York; Pawtucket, Rhode Island; Baltimore, Maryland; Chicago, Illinois; Pittsburgh, Pennsylvania; St. Louis, Missouri; Fort Wayne, Indiana; Oakland, California; and Hamilton, Ontario.

The Company will be in a position to furnish all kinds of copper wires and cables, from the finest of enamel wire for delicate electrical instruments to the largest cable for aerial and underground service. Brass and bronze wires, tubing, copper rods and sheets will also be included in its manufacture.

Federal Radio Corporation Adds Six New Wholesalers

The Federal Radio Corporation, Buffalo, N. Y., announces the recent completion of wholesaling arrangements with six firms in the United States and Canada. These additions practically complete the Federal wholesale organization, and provide excellent representation for the Orthosonic line in several important centers. The new wholesalers are as follows: I. J. Haug & Sons, Limited, Calgary, Alberta; Radio & Automotive Equipment Company, Limited, Winnipeg, Manitoba; A. H. Marshall & Co. Inc., Plattsburg, N. Y.; The French Nestor Company, Jacksonville, Florida; Vonnegut Hardware Company, Indianapolis, and Northrop Hardware Company, Boise, Idaho.

New Samson Inductance Bulletin

The Samson Electric Company of Canton, Mass., have just published a very valuable bulletin on inductances, and it is one of the most complete treatises on the subject which has come to our attention for some time.

The first portion of the bulletin covers the design of coil forms, rotor bobbins and coil mountings. This forms the basis for the balance of the data which covers coil windings and their electrical characteristics, inductance calculations, special coil characteristics and mechanical considerations.

Included in the pamphlet are a number of tables such as a kilocycle-to-meter conversion table, inductance capacity table and a number of wire tables. From the information given in this book it is possible to design most any form of inductance which may be required. The tables, special graphs and the formulae are of great assistance in the determination of the value and characteristics of inductances to cover any wave length band. We are pleased to recommend this Bulletin to our readers.

R. P. A. Announces New Board of Directors

Announcement of the permanent board of directors to manage the affairs of the Radio Protective Association—the organization of the independent radio manufacturers—was made after a meeting of the membership at the Palmer House, Chicago, during the Chicago Radio Show.

As a result of the growth in the membership, the board was increased from five to eleven members, particularly to give representation to the new members of the association in the East.

The new board of directors follows:

Harry G. Sparks, Sparks-Withington Company, Jackson, Mich.

Fred S. Armstrong, Vesta Battery Corporation, Chicago.

R. W. Augustine, Joy-Kelsey Corporation, Chicago.

H. R. Rose, Shamrock Manufacturing Co., Newark, N. J.

H. Chirelstein, Sonatron Tube Co., New York, N. Y.

Duane Wanamaker, Grigsby-Grunow-Hinds Co., Chicago.

L. Mandel, Metro Electric Co., Chicago.

J. Wiechers, Western Coil & Electrical Co., Racine, Wis.

Arthur D. Lord, DeForest Radio Co., Jersey City, N. J.

Alexander Weiss, Marti Electric Co., West Orange, N. J.

Ernest Kauer, C. E. Manufacturing Co., Providence, R. I.

Mr. Armstrong remains treasurer of the association and Oswald F. Schuette, executive secretary in charge of the headquarters at 134 South LaSalle Street, Chicago.

Sixty-six representatives of independent manufacturers at the Chicago Radio Show attended the meeting. At a meeting held at the Hotel Astor in the preceding week, fifty-two were present. The association is only two months old, and its members point to its directorate as proof that as an organization it will have to be reckoned with in shaping the future of the radio industry.

Splitdorf Appoints New Sales Manager

Hal. P. Shearer, for many years an exceedingly well known figure in the piano industry and more recently closely identified with the selling end of radio, has been appointed sales manager for Splitdorf Radio Corporation. Mr. Shearer's appointment became immediately effective and he has taken up his new duties at the headquarters of the company in Newark, N. J.

Lynch Resistor Manual

Arthur H. Lynch, Inc., of 1775 Broadway, New York City, have released a thirty-six page booklet covering the use of resistances in radio.

The booklet opens with an elementary explanation of resistance and the manner in which resistance values are calculated to meet exacting requirements. Another portion of the booklet is given over to the manner in which resistors can be used in radio receiving circuits to increase efficiency.

Power resistors are also taken up

and valuable data is given on the design of "B" power units.

The latter portion of the booklet covers a description of the Improved Aristocrat circuit which employs a resistance coupled amplifier.

We recommend this booklet to our readers who are interested in obtaining facts regarding the use of resistances in radio.

Knickerbocker Talking Machine Company Selects Freed-Eisemann Line

The Freed-Eisemann Radio Corporation announces that the Knickerbocker Talking Machine Company, well known wholesale distributors in New York, will market the Freed-Eisemann line in Manhattan and the Bronx, in conjunction with the present Freed-Eisemann distributors in this territory.

A contract involving several carloads of receivers was the inaugural move of this new merchandising agreement.

Aerovox Acquires Globe Art

Announcement is made by Mr. S. I. Cole, president of the Aerovox Wireless Corporation, that the condenser equipment of the Globe Art Manufacturing Company, of Newark, New Jersey, has been acquired by his corporation.

The addition of this equipment to that previously owned greatly augments their manufacturing facilities. The Aerovox organization has leased additional floor space in the building they now occupy, and are operating three shifts a day.

George Lewis Made Vice-President of Arcturus Radio Co.

George Lewis, formerly President and General Manager of the Kenrad Corp., radio executive and engineer of long experience, has been made vice-president of Arcturus Radio Company of Newark, New Jersey, manufacturers of A-C tubes.

There is probably no executive in the field today whose radio activities antedate those of Mr. Lewis, or whose commercial associations are so adequately supported by extensive engineering experience.

The first commercial operator's license issued by the U. S. Government was made out to George Lewis. His prominence in radio, attained as an American Delegate to the First International Radio Conference at Geneva in 1913, has been maintained in subsequent activities.

Prior to association with commercial radio development, Mr. Lewis was in charge of important engineering work with the Navy. He was radio expert aid under Admiral Bullard, for a number of years in charge of radio engineering design at the New York Navy Yard.

The end of the war found him in charge of the Radio Design Division at the Bureau of Engineering of the Naval Department in Washington.

In 1923 Mr. Lewis joined Crosley as Assistant to the President, going to Kenrad three years later.

Mr. George Lewis has at various times been a manager of the Institute of Radio Engineers of which he is a member. His standing as an engineer has drafted him for various important duties as a radio legislator. He is chairman of the Vacuum Tube Committee of the R. M. A. and chairman of the National Electrical Manufacturers Association, vacuum tube section.

Federal Ortho-Sonic Wholesalers Conduct Retailer Meetings

In accordance with the custom established in 1926 by the Federal Radio Corporation, wholesalers of Ortho-sonic radio throughout the United States and Canada are now calling their quarterly retailer meetings to effect closer contact among the three elements of distribution: factory, wholesaler, and retailer. At these meetings the wholesaler acts as host to his Designated Federal Retailers, and executives from the Federal Radio Corporation are on hand to represent the factory sales, advertising and engineering departments.

These Federal gatherings will continue through October until every wholesaler has met with his retail group. Meetings during September were conducted by the following Ortho-sonic wholesalers: R. E. Tongue Bros., Philadelphia; Charles Rubel & Co., Washington; National E. & A. Supply Co., Peoria; Brown-Camp Hardware Co., Des Moines; Harry Alter Co., Chicago; B. W. Smith, Inc., Cleveland; and Hamburg Brothers, Pittsburgh.

Arborphone and Wells-Gardner in Merger

Wells-Gardner and Company, Chicago, Illinois, and the Precision Products Company, Ann Arbor, Michigan, have merged their radio manufacturing businesses and organized a new Delaware corporation known as The Consolidated Radio Corporation, with C. A. Verschoor, President; A. S. Wells, Vice-President; F. E. Royce, Secretary, and Frank Dillbahner, Treasurer. The merging companies will continue their present manufacturing plants in Chicago and Ann Arbor, but in the future the combined business will be conducted by the new Corporation operating the two plants, as separate units, one as the Wells-Gardner Division and the other as the Arborphone Division.

One of the first steps of the Consolidated Radio Corporation was the taking out of a license under the radio patents of the Radio Corporation of America, Westinghouse Electric and Manufacturing Company, General Electric Company and American Telephone and Telegraph Company. This license combined with their own patents places the new company in a very favorable position in the radio field.

Yale Electric Corporation Builds New Plant

The Yale Electric Corporation, manufacturers of dry batteries, have under construction a fireproof building six stories high and occupying an entire city block, with a floor of over 400,000 square feet. This new plant, in Jersey City, is more than double the size of the present Yale plant in Brooklyn. More than 1,600 men and women will be employed in this huge building when it is completed.

United States Civil Service Examination

The United States Civil Service Commission announces the following open competitive examination:

CHIEF OF PRESS SERVICE

Application for chief of press service must be on file with the Civil Service Commission at Washington, D. C., not later than November 29.

The examination is to fill a vacancy under the Federal Radio Commission, Washington, D. C., and vacancies occurring in positions requiring similar qualifications.

The entrance salary is $3,800 a year. A probationary period of six months is required; advancement after that depends upon individual efficiency, increased usefulness, and the occurrence of vacancies in higher positions.

The duties of the chief of press service will be to keep newspaper correspondents informed concerning the activities of the Federal Radio Commission, to answer their queries relative to the status of the various broadcasting stations, and to supply informative and timely articles to editors throughout the country regarding the radio situation. He will relieve the Commissioners, as far as possible, of the task of keeping the public informed through the press regarding changes in the broadcasting field. It will also be the duty of his office to maintain up-to-date newspaper and periodical mailing lists and to direct the preparation and issuance of the official Bulletin of the Commission as well as press releases and general orders.

Competitors will not be required to report for examination at any place, but will be rated on their education and experience, and a thesis and published articles to be filed with the application.

Full information may be obtained from the United States Civil Service Commission, Washington, D. C., or the Secretary of the United States Civil Service Board of Examiners at the post office or custom house in any city.

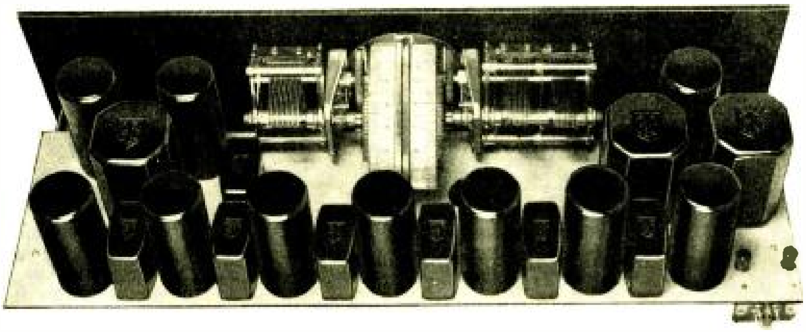
The Tyrman Ten

THE "one spot" idea has been made use of with a compromise to eliminate all critical features of shorter wave intermediate frequency amplification. The theory of this system is in the separation of the two beat notes to an extent where one of them will appear beyond the dial range.

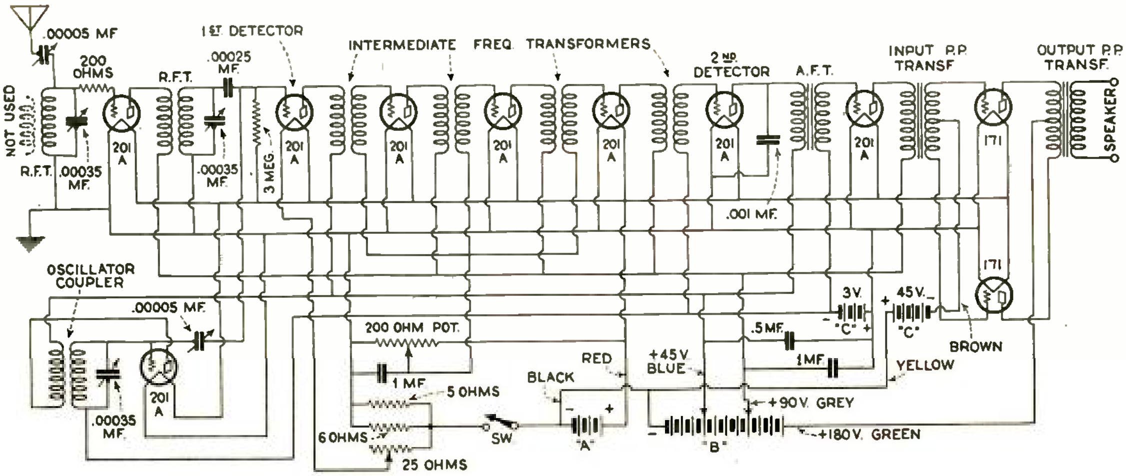
This system, instead of utilizing the difference of frequencies for intermediate frequency amplification, uses the same frequency for this purpose. An intermediate frequency amplifier of 3000 K.C. will require a beat frequency of 2300 K.C. for a 700 K.C. signal. It is seen that two critical features play their part in this circuit. First, the short wave oscillator, and, second, the short wave intermediate frequency amplifier. The difficulties can be overcome only with extremely careful design and expert layout.

A compromise had to be reached and finally a transformer of 340 K.C. maximum amplification has been decided on by the engineers, utilizing the stabilizing advantages of long wave amplification but remaining below that wave to avoid the double beat interference. The above 700 K.C. signal will require an oscillator frequency of 1040 respectively 360 K.C., the latter being outside of the dial range. Only signals above 890 K.C. (below 330 meters) can have a double setting on the oscillator tuner if the antenna dial is left in resonance. However, tuning both dials to the resonance no signals appear twice on the dial, as the 640 K. C. separation between beat notes will not allow duplication with a very selective antenna system.

A stage of radio frequency is built ahead of the long wave amplifying system. Although this was not carried out satisfactorily in previous amateur-built super-heterodyne circuits, it is greatly responsible for the success of this receiver. The designer's aim was to create selectivity on the antenna stage equal to that obtained by a directional loop and thus localize the tuning control to the dials. As it is well known by experimenters, there was a poor balance in selectivity between the antenna and oscillator circuits, and previous receivers had to rely on an extremely selective oscillator tuning, thus cutting into the side band and inflicting upon tonal performance. In our case the radio frequency stage is sufficiently sharp to allow more broadness in the oscillator for obtaining this selectivity.



Rear view of the "Tyrman Ten" receiver. Note that each tube is covered by a tall, metal shield. The I.F. transformers, the oscillator and the antenna coupler extend along the rear of the sub-base.



Schematic diagram of the "Tyrman Ten" receiver. One stage of tuned radio frequency amplification is employed to increase the selectivity of the input circuit. The output A.F. stage is push-pull, employing 171 type tubes.

The audio amplifying system consists of one stage of straight transformer coupled amplification and a push-pull stage for the second audio.

The push-pull stage of the second audio, and especially the output transformer, assures perfect tonal quality. It was more than useful to provide on these transformers a ground connection for their cores leading to a perfect stabilization of the audio frequency amplifying circuit.

The input circuit is composed of one stage of radio frequency and an oscillator.

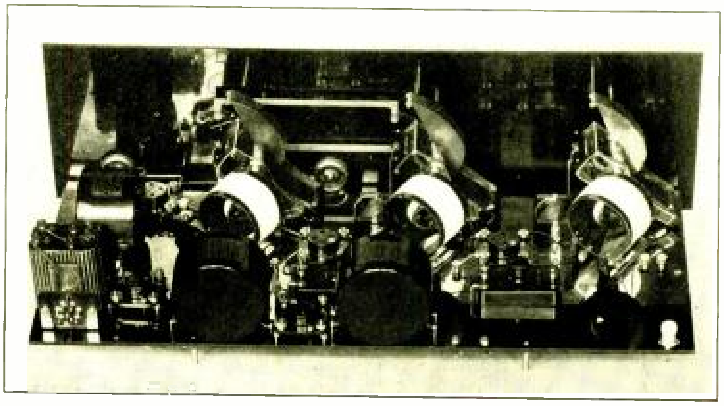
The oscillator stage, covering 900 to 1850 K.C., is coupled to the grid of the first detector by a 50-mmf. condenser. This capacity feed is the simplest and most efficient coupling method and has to be adjusted but once.

Two volume controls are provided on the front panel, the 25-ohm rheostat for the first detector tube and a 200-ohm potentiometer for the grid returns of the intermediate frequency amplifier. The rheostat can be left in one position except on the most powerful local signals. All tubes except the one mentioned are automatically kept at five volts by fixed resistances.

LIST OF PARTS REQUIRED

2 Tyrman Type 8-70 R.F. Transformers
1 Tyrman Type 8-71 R.F. Transformer
4 Tyrman Type 8-80 R.F. Transformers
1 Tyrman Type 3-30 Audio Transformer
1 Tyrman Type 3-50 Power Input Transformer
1 Tyrman Type 3-51 Power Output Transformer
1 Tyrman Double Vernier Drum Dial
10 Tyrman Shielded Tube Sockets
1 Kurz-Kasch Capacity Connector
1 Camfield Type 351 .00035 Mfd. Variable Condenser
1 Camfield Type 352 .00035 Mfd. Variable Condenser
1 7" x 26" x 3/16" Drilled and Engraved Front Panel
1 7" x 26" x 3/16" Drilled Ivory Sub-Panel
1 Pair Benjamin Type 8629 Shelf Brackets
2 Carter Type 110 1-Mfd. By-Pass Condenser
1 Carter Type 105 .5-Mfd. By-Pass Condenser
1 Carter .00025 Mfd. Mica Condenser
1 Carter .001 Mfd. Mica Condenser
1 Yaxley Type 660 Cable Connector
1 Yaxley Type 6L Filament Resistance, $1\frac{1}{2}$ Amp. 5 Volts.
1 Yaxley Type 5L Filament Resistance, $1\frac{1}{4}$ Amp. 5 Volts
1 Yaxley Type 200 200-Ohm Potentiometer
1 Yaxley Type 7200 200-Ohm Grid Resistance
1 Yaxley Type 125K Switching Rheostat
1 Muter 3 Megohm Grid Leak with Mounting
2 Eby Engraved Binding Posts
2 Hammarlund 50 M-mfd. Midget Condensers
2 Ceco Type J-71 Radio Tubes
8 Ceco Type A Radio Tubes
1 Package Kester Radio Solder
1 Ekko Ground Clamp
10 Feet Flexible Acme Celasite Wire
Miscellaneous Screws, Soldering Lugs, Etc.

The New 2-Dial Karas Equamatic

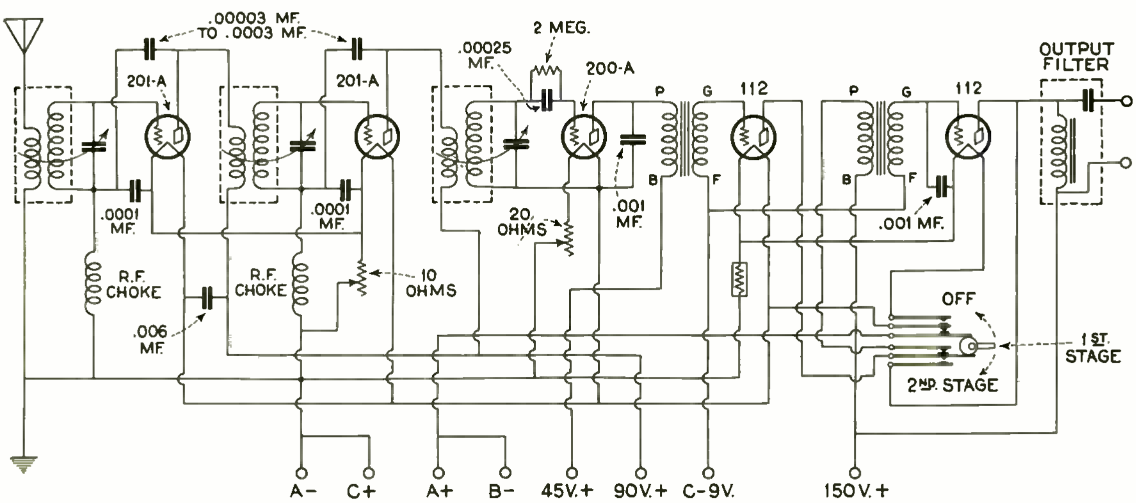


Rear view of the new 2-Dial Karas Equamatic receiver. The two variable condensers on the left are coupled together with a mechanical link which can be seen against the background of the front panel.

THE new Karas Equamatic receiver embodies numerous improvements over the Equamatic Receiver introduced to the radio public last year.

The tuning control has been simplified by incorporating a mechanical link into the receiver for the operation of the variable condensers tuning the radio frequency stages. The link itself allows for the necessary adjustment or alignment of the two variable condensers so that both of the radio frequency stages will, for every setting, be in resonance on the same wave length.

The original equamatic principle is still utilized but has been elaborated upon. As will be seen from the illustration, the primary windings of the two radio frequency transformers, as well as the primary of the antenna coupler, are mechanically coupled to the condenser shafts so that any move-



Schematic diagram of the 2-Dial Karas Equamatic. The primary coils of the antenna coupler and the two R. F. transformers are attached to the condenser shafts so that the coupling is automatically varied when the condenser dials are turned.

ment of the condensers displaces the position of the coil attached thereto in respect to the secondary winding. Thus automatic coupling over the entire frequency band is made possible.

This automatic coupling scheme is the basis of the circuit and the coupling is so adjusted that maximum efficiency is gained in the antenna circuit and the two radio frequency stages over the entire broadcast frequency band. Likewise, the application of this principle prevents the receiver going into oscillation at the low wave lengths and considerably simplifies the entire receiver in so far as the adjustments are concerned.

It will be noted from the schematic diagram that the two radio frequency tubes are neutralized by the use of small adjustable condensers. When the set is first put into operation, these two condensers are so adjusted that the receiver is just below the point of oscillation on the low wave lengths.

The audio frequency amplifier is of the two stage transformer coupled type employing an output filter. A cam switch is incorporated in this circuit which allows the use of one or both stages at will. The same cam switch turns the receiver off when thrown to the left position.

It is recommended that two 112-type tubes be used in the A. F. amplifier, with 150 volts "B" and a negative "C" bias of 9 volts.

LIST OF PARTS REQUIRED

2 New Karas Type 28 Audio Transformers
1 Karas Output Filter
3 New Karas Type 17 Variable Condensers
3 Karas Equamatic Coils
2 Karas Micrometric Dials 0-100
3 Karas Subpanel Brackets, per set of 3
1 Karas Control System Including Complete Hardware
2 Karas or Samson R.F. Chokes, 100 Milli-henry
1 Bakelite front panel, engraved (7 in. x 24 in.)
1 Bakelite subpanel, drilled (9 in. x 23 in.)
1 Carter or Yaxley 10 ohm rheostat (Gold Arrow)
1 Carter or Yaxley 20 ohm rheostat (Gold Arrow)
1 Yaxley No. 69B Interstage Switch (Gold)
2 Carter Tip Jacks No. 10, or Yaxley
1 Sangamo .00025 Fixed Condenser with clips.
1 Durham or other make grid leak, 2 Meg.
1 4-A Amperite
1 Yaxley Cable Plug
5 Benjamin Cushion Sockets
2 Samson Mica Neutralizing Condensers, 0-0007 mfd
2 .0001 mfd. Sangamo Fixed Condensers
1 .006 mfd. Sangamo Fixed Condenser
2 .001 mfd. Sangamo Fixed Condensers
2 Tubes, 201-A type
1 Tube, 200-A type
2 Tubes, 112 type

Magnaformer 9-8 Receiver

Front view of the Magnaformer 9-8 Receiver. Observe the neat drum dials. The knob to the extreme left is the volume control. The master rheostat for the I.F. tubes is controlled by the knob to the extreme right.

THE Magnaformer 9-8 Receiver, a development of the Radiart Laboratories, is a distinct improvement over the common form of super-heterodyne receiver. The set is composed of four stages of intermediate frequency amplification which may be converted at will to three stages for local work.

Referring to the schematic diagram, it will be seen that the oscillator is coupled directly to the grid circuit of the first detector tube. A radio frequency filter is connected in the output circuit of the second detector tube to prevent the possibility of any of the intermediate frequencies from entering the two stage transformer coupled audio frequency amplifier. This is a very important addition to the circuit as low radio frequency currents produce distortion in an audio amplifier.

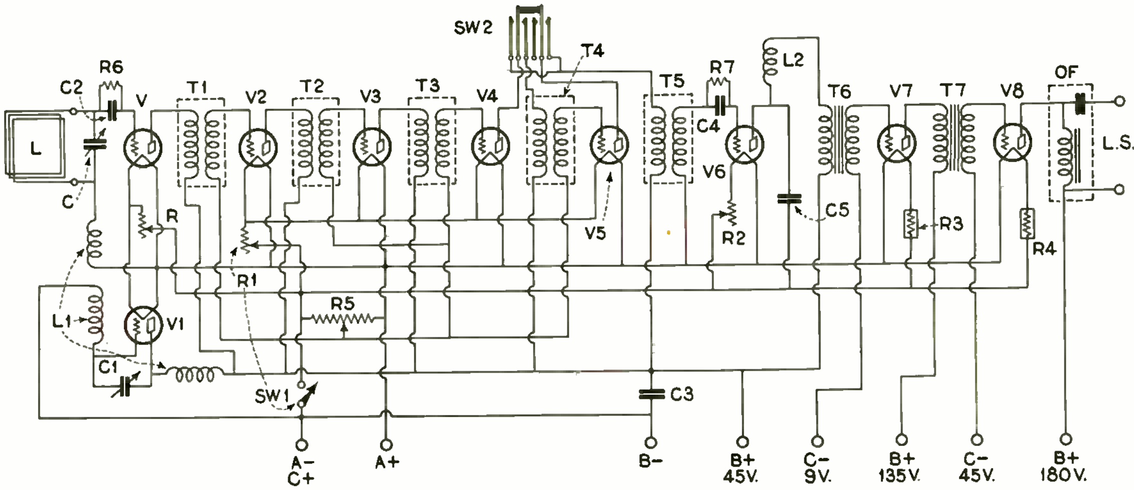
As mentioned, for local work one of the intermediate frequency stages can be cut out by means of the jack indicated in the schematic diagram as SW2.

The intermediate frequency transformers used in this receiver are laboratory matched and employ shields, in the form of metal bands around the outside of the coils. These shields tend to restrict the electro-magnetic fields of the coils and also improve the resonance effects.

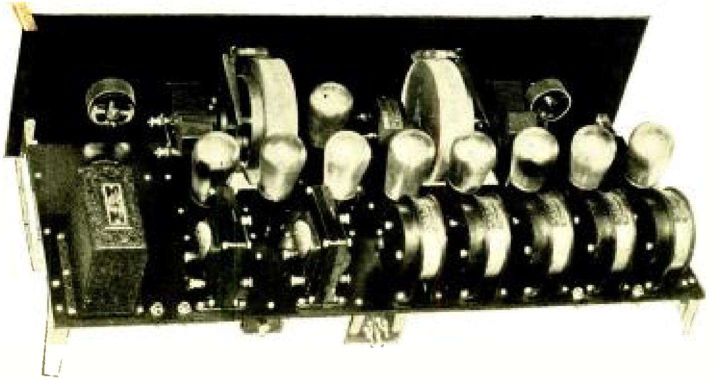
An output filter is included in the audio frequency amplifier so that a power tube may be used in the last stage. This filter is of the conventional type, comprising an audio frequency choke and a high capacity filter condenser.

The Magnaformer 9-8 Receiver is designed primarily for operation in conjunction with a loop aerial but may be as readily employed in connection with a regular antenna system by the addition of an antenna coupler.

There are two main controls: the variable condenser, which controls the



Schematic diagram of the Magnaformer 9-8 Receiver. By means of the cam switch SW2 one stage of I.F. amplification can be cut out. This switch is mounted on the front panel of the receiver, below the drum dials.



Rear view of the Magnaformer 9-8 Receiver. Note the perfect line up of apparatus. The two A.F. transformers and the output filter can be seen at the left of the row of Magnaformers.

frequency of the oscillator tube and the variable condenser, which tunes the loop circuit.

The volume control is in the form of a 400 ohm potentiometer (R5) and the main volume control is a 6 ohm rheostat.

LIST OF PARTS REQUIRED

- 1 Formica Front Panel 7" x 26" x 3/16"
- 1 Formica Sub Panel 9" x 25" x 3/16"
- T1—5— 5 Magnaformer Intermediate Transformers, Unit R F. No 61
- L1— 1 Unicoupler, Unit C.U. No. 71
- 2 Remler Universal Drum Type Dials with Controls, No. 10
- C,C1— 2 Remler .0005 mfd. Variable Condensers No. 639
- 9 Benjamin Sockets No. 9044
- 2 Benjamin Sub-Panel Brackets 2" high, No. 8629
- T6,T7— 2 Ferranti Audio Transformers, A.F. No. 4, or A.F. No. 3-A.F. No. 4
- OF— 1 National Tone Filter
- L2— 1 Samson Radio Frequency Choke Coil No. 125
- C2,C4— 2 Aerovox .00025 mfd. Grid Condensers, Type 1475, with Mountings
- C5— 1 Aerovox .001 mfd. Fixed Condenser, Type 1450
- C3— 1 Aerovox 1 mfd. By-Pass Condenser, Type 200 Short
- R6,R7— 2 Durham 2 megohm Grid Leaks
- R5— 1 Frost De Luxe 400 ohm Potentiometer, gold arrow knob No. 1824
- R1— 1 Frost De Luxe 10 ohm No. S1810 or 6 ohm No. S1806 Combination Rheostat and Battery Switch with gold arrow knob (6 ohm preferable)
- R— 1 Frost De Luxe 10 ohm Rheostat, No. 1810
- R2— 1 Frost De Luxe 30 ohm Rheostat, No. 1830
- 4 Frost Tip Jacks, No. 253
- R3,R4— 2 No. 112 Amperites, with Holders
- 1 Yaxley Cable Connector Plug No. 660
- SW2— 1 Yaxley Radio Jack Switch No. 60, Gold Plated
- 12 Feet Acme Bus Bar Wire No. 14 round tinned
- 25 Feet Acme Flexible Spaghetti covered wire
- 2 2" right angle supports for supporting rear of sub-panel Screws, Lugs, Nuts, Bolts, Solder
- 2 5/8" x 5/8" x 2" wood blocks for sub-panel center supports
- 1 Cabinet, 7" x 26" x 12"
- 7 Tubes, 201-A type
- 1 Tube, 112 type
- 1 Tube, 171 type

The 1928 "Standard Parts" Six

HERE is a standard six tube circuit, designed by *H. G. Cisin*, utilizing three stages of tuned radio frequency amplification, a detector, and two stages of transformer coupled audio frequency amplification. This circuit offers great possibilities. Ultimate results, however, will rest upon two extremely important factors. First of all, the design and layout must be technically correct; second, the parts used must be selected with the utmost care if the potentialities of the circuit are to be realized. Those who have experimented with three stages of tuned radio frequency know how important the above two considerations are.

However, no such difficulties will be encountered in building the 1928 "Standard Part Six." The layout has been predetermined for the set builder, scientific laboratory instruments having been used, to ascertain the minimum spacing of coils, location of various parts, etc. Parts for this receiver were selected only after careful check-up and trial.

For the purpose of stabilizing the tuned radio frequency circuits, three phasatrols are used. These are highly effective, but still they in no way impair the sensitivity of the receiver. Once the phasatrols have been adjusted, there is no longer any tendency to radio frequency oscillation or distortion.

An r. f. choke (29) is used, in accordance with standard present-day practice, for blocking r. f. currents from the audio circuits. A second r. f. choke is also inserted in the "B" plus 90 lead.

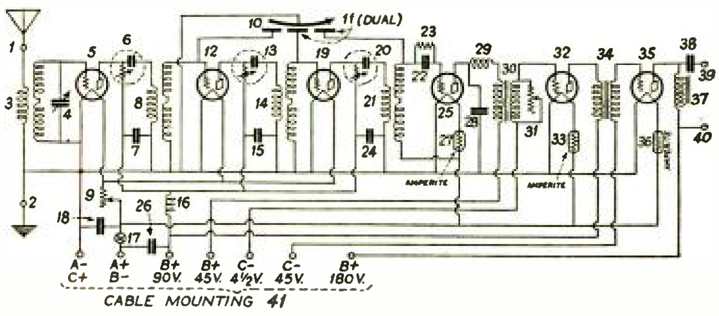
The audio circuit utilizes two A. F. transformers. A variable resistance, shunted across the secondary of transformer (30) provides smooth and effective volume control. The output filter consists of a choke combined with a 4 mfd. condenser.

In line with the modern trend towards simplification of control, the filaments of the detector and the two audio tubes are regulated automatically.

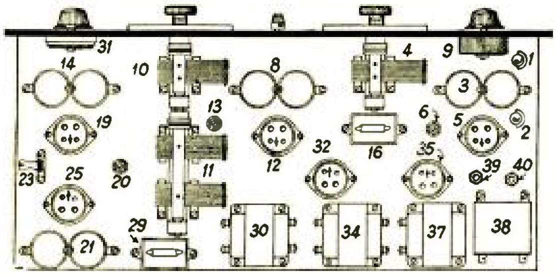
A dual and a single variable condenser are "ganged" together, thus reducing the number of tuning controls to two. Because of the accuracy of r. f. coils and tuning condensers, compensating condensers are unnecessary.

LIST OF PARTS REQUIRED

- 2 Amperites, No. 1-A, with mountings (27, 33)
- 1 Amperite, No. 112 with mounting (36)
- 4 Precision Double Solenoid Coupling Coils type 4B, (3, 8, 14, 21)
- 2 Mar-Co Vernier Dials, type 192
- 2 .00035 mfd. Hammarlund "Mid-Line" Condensers (4, 10)
- 1 .00035 mfd. Hammarlund *Dual* "Mid-Line" Condenser (11)
- 2 Samson R. F. Chokes, No. 85 (16, 29)
- 6 Eby Sockets, new style (5, 12, 19, 25, 32, 35)
- 3 Electrad Phasatrols (6, 13, 20)
- 1 Carter "Imp" Filament Switch (17)
- 3 .01 mfd. Sangamo By-Pass Condensers (7, 15, 24)
- 1 .00025 mfd. Sangamo Grid Condenser (22)
- 1 .001 mfd. Sangamo By-Pass Condenser (28)
- 1 1 meg. Durham Metallized Resistor Grid Leak with Vertical Durham Single Mounting (23)
- 2 Thordarson R-200 Transformers (30, 34)
- 1 Thordarson R-196 Choke (37)
- 1 Yaxley Air Cooled Rheostat, type No. 106 K (9)
- 1 Electrad Tonatrol (31)
- 2 1 mfd. Acme "Parvolt" series "A" cubical Condensers (18, 26)
- 1 4 mfd. Acme "Parvolt" series "A" cubical Condenser (38)
- 2 Carter "Imp" Cord Tip Jacks (39, 40)
- 2 X-L "Push-Posts" (1, 2)
- 1 Yaxley 7 Strand Cable, No. 660 (41)
- 2 Rolls Acme Celatsite Wire



Circuit diagram of the 1928 "Standard Parts" Six. The R.F. stages are stabilized by means of phasatrols. The volume is controlled by a variable resistance which is shunted across the secondary winding of the first A.F. transformer.



Top view of the 1928 "Standard Parts" Six. 9 is the rheostat for the R.F. tubes and 31 is the volume control. Note that 11 is a tandem condenser and 13 a single condenser coupled to 11.

1 Can Kester Radio Solder (By the Chicago Solder Co.)
1 Panel, 7" x 21" x 3/16" Westinghouse Micarta
1 Sub-Panel, 9" x 20" x 3/16" Westinghouse Micarta
1 Blue Ridge Cabinet, 7" x 21" x 10" (By Southern Toy Co., Hickory, N. C.)
5 "CeCo" Vacuum Tubes, type AX (5, 12, 19, 25, 32)
1 "CeCo" Output Tube, type "J-71" (35)

Tuned Audio Amplifier With Optional Equalizer Stage

THE development of the tuned double impedance unit has made possible the design of an audio amplifier which can be tuned to meet personal requirements for audio quality. The possibilities of this amplifier cannot be appreciated from the above meagre description. This audio amplifier can be tuned on the low frequencies to compensate for speaker deficiency on low frequencies, and it can also be tuned on the high audio frequencies, from 1000 to 5000 cycles to compensate for any degree of radio frequency side band suppression less than 100%. Furthermore, on the high frequencies, one can adjust the electrical characteristics of the amplifier to compensate for speaker deficiency on the high frequencies.

This "Tuned Audio Amplifier," designed by *John F. Rider*, can be arranged for either low frequency tuning or for both low and high frequencies. When arranged for the former, the amplifier utilizes four tubes, two tubes being apportioned for the tuned double impedance units and two for the push-pull output stage. The wiring diagram of the four tube unit is shown in Fig. 1 and the baseboard layout in Fig. 2.

The possibilities of the amplifier, however, are not concluded by the low frequency tuning. By adding another tube to the amplifier we can also obtain tuning on the high frequencies. This stage is the equalizer stage and is shown schematically in Fig. 3. The effect of this stage upon the operating characteristic of the amplifier is shown in Fig. 4. Any one of the peaks A, B, C or H, or any other, is obtainable on some low frequency and any one of the peaks D, E, F, or G is available on the high frequencies. As a matter of fact even a greater rise than G is possible. The low frequency peak is used to compensate for the loud speaker deficiency and the high frequency peak is used to compensate for the speaker de-

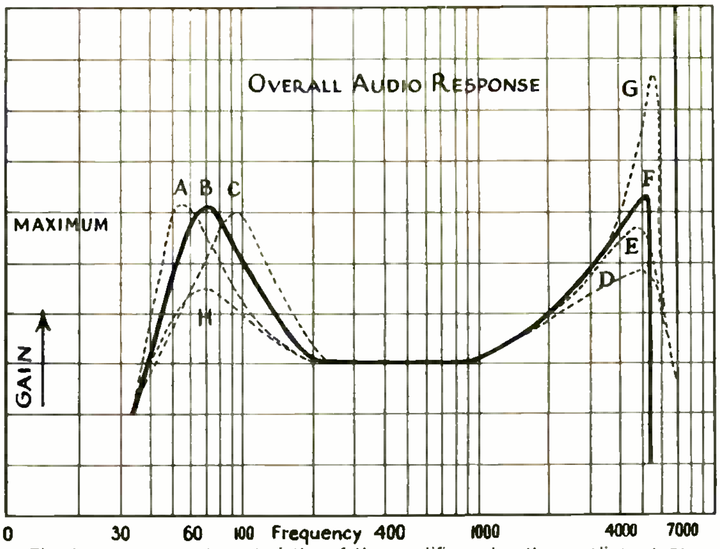


Fig. 4. Frequency characteristics of the amplifier using the equalizer stage.

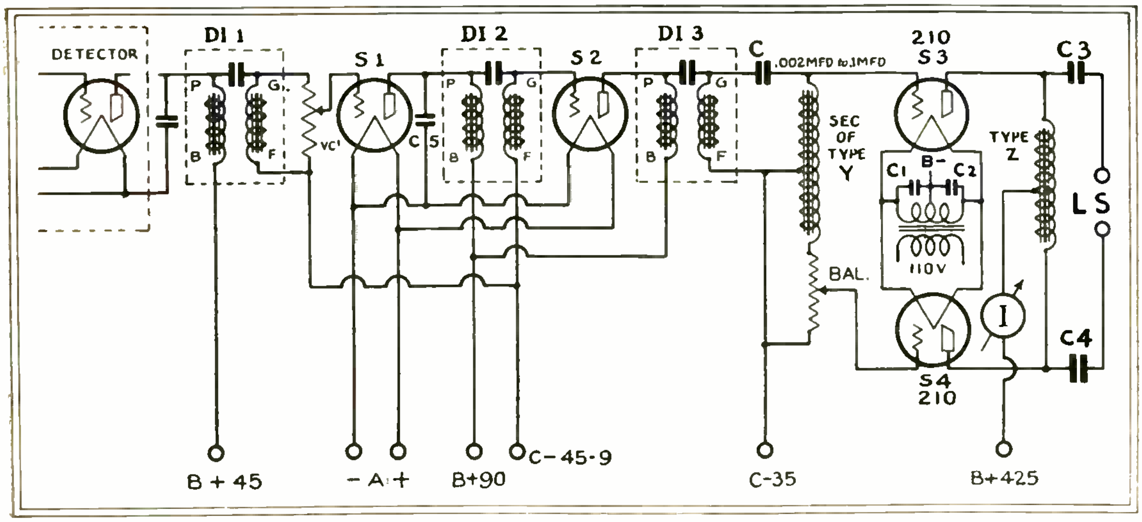


Fig. 1. Circuit diagram of the tuned double impedance push-pull amplifier without the equalizer stage. Note that the two 210 power tubes obtain their filament supply from an A.C. source.

ficiency and for side band suppression in the radio frequency system.

The amplifier is arranged for D. C. filament operation on the tuned stages and for A. C. filament operation for the push-pull output stage. The insertion of the equalizer stage does not alter the appearance of the front panel. It is only necessary to use a slightly larger panel to accommodate a larger baseboard. All of the equipment in the equalizer stage is mounted upon the baseboard. A volume control is provided to control the energy passed into the amplifier. A balancing control BAL is provided to facilitate adjustment of the energy passed into the two output push-pull tubes, in the event that their electrical constants are not identical. The equalizer stage is added between the detector tube and the first stage of audio amplification.

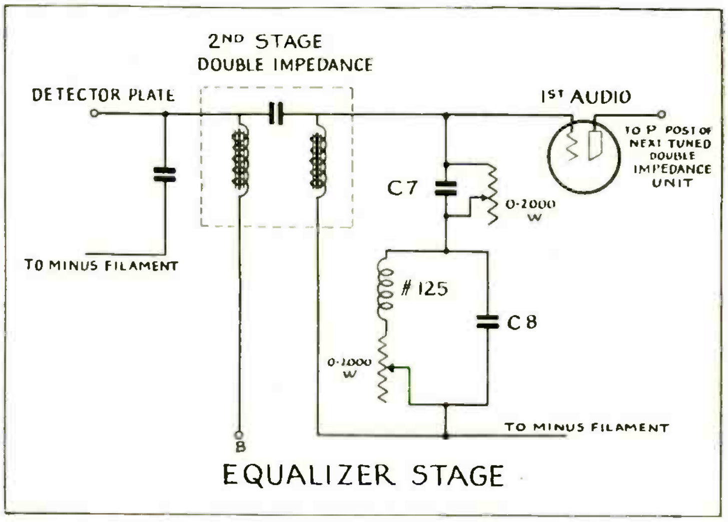


Fig. 3. Schematic diagram of the equalizer stage. This stage is connected into the circuit between the detector and the first stage A.F. amplifier.

LIST OF PARTS REQUIRED

1—1st Stage Tuned Double Impedance Unit. (K. H. Labs., Ford Mica, Kelford, Muter, Paragon)
1—2nd Stage Tuned Double Impedance Unit. (K. H. Labs., Ford Mica, Kelford, Muter, Paragon)
1—3rd Stage Tuned Double Impedance Unit. (K. H. Labs., Ford Mica, Kelford, Muter, Paragon)
1—Samson Push-Pull Transformer, Type Y
1—Samson Push-Pull Output Impedance, Type Z
4—Amsco Type A. X. 102 Sockets
2—Aerovox No. 1450 .001 Mfd. Fixed Condensers
2—Aerovox No. 602 .4 Mfd. 600 Volt Filter Condensers
1—Aerovox No. 1450 .002 Mfd. Filter Condenser
2—Aerovox No. 200 Short 1. Mfd. By-pass Condensers.
12—Binding Posts, as shown in Fig. 2.
2—Electrad Royalty Resistances, Type E
1—Electrad Battery Switch
1—Jewell 0 to 50 D. C. Milliammeter.
1—Filament Lighting Transformer, suitable for two 7.5 filaments.
1—7" x 18" x 3/16" Black, Westinghouse Micarta Panel.
1—9" x 17" x ½" Wood Baseboard
3—Boxes of Acme Celatsite Wire. (red, black and yellow)
2—Ceco Type A. X. Tubes
2—Ceco Type L 10 Power Tubes

The additional equipment required for the equalizer stage is as follows:

1—2nd Stage Tuned Double Impedance Unit (K. H. Labs., Ford Mica, Kelford, Mutter, Paragon)
2—Electrad Type E Variable High Resistances
1—Aerovox No. 1450 .004 Mfd. Fixed Condenser (C8)
1—Aerovox .1 Mfd. Fixed Condenser (C7)
1—Amsco Type A. X. 102 Socket.
1—Samson No. 125 R. F. Choke
1—Ceco Type A. X Tube.

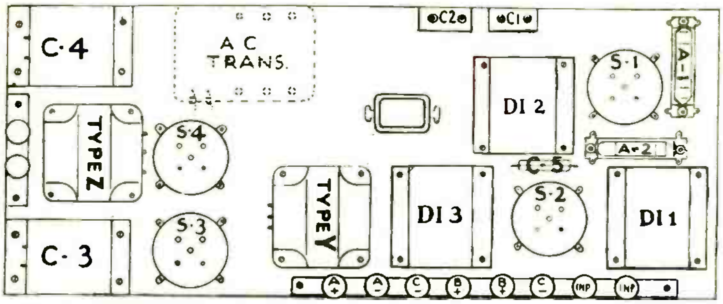


Fig. 2. Baseboard layout of the Tuned Double Impedance Push-Pull Amplifier. This does not include the apparatus for the equalizer stage.

used it is necessary to introduce some means whereby oscillations are prevented and, in general, when this is done the circuit does not function efficiently over the entire waveband of broadcast stations. When steps are taken to keep the signal intensity equal over the waveband, additional means for preventing interstage couplings must be introduced if a high degree of amplification is desired. Generally when this is done by adding several stages of cascade coupling side bands are cut off, and distortion results. Unless gang condensers are employed to get maximum efficiency, each stage has to be individually tuned, which in turn offers more complications.

The Super-Hilodyne circuit is the result of a great number of experiments. Not only can the electrical portion of the circuit be so designated, but the method of construction has been simplified to the greatest possible extent.

In the center of the schematic diagram (Fig. 1) may be seen the two tubes, V1 and V2, which are connected in push-pull. Let us consider the path followed by a signal after it is picked up in the antenna circuit L1. The variable condenser C1, which is in shunt across the secondary S of L1, tunes this circuit; and each side of the condenser is connected to the grid of one of the push-pull tubes.

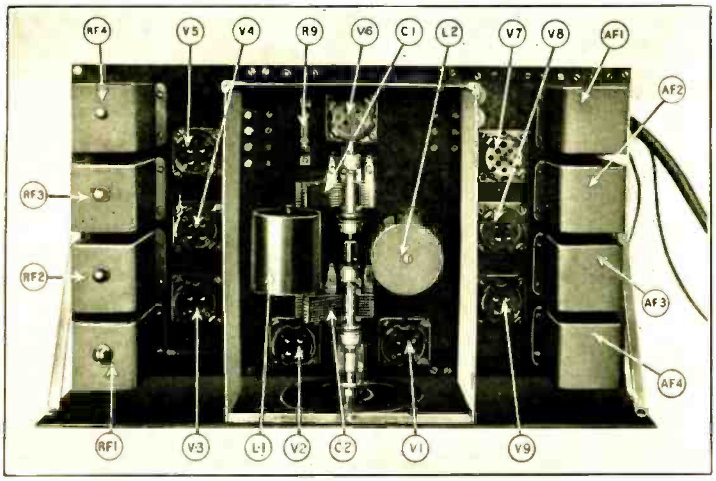
An incoming signal charges the grids of the tubes, V1 and V2, negatively and positively alternatively. When the grid of V1 is positive the grid of V2 is negative, and *vice versa*. When the grid of V1 is negative this will cause a drop in the plate current of that tube and the opposite effect will take place at the same instant in V2 with an increase in the plate current in the same proportion. Now, if the coil C is short-circuited by the resistor R1, the flow of current at the

The Super-Hilodyne Receiver

FULL constructional details for the building of the Super-Hilodyne Receiver, invented by Fred A. Jewell, are covered in an article appearing in the December issue of *Radio News*.

In the development of the Super-Hilodyne circuit no attempt has been made to evade the patent situation, as it was found that many of the previously patented circuits are not capable of producing the results that the writer had in mind, as a goal towards which to work. For instance, in the case of the superheterodyne circuit, which would be ideal if it were not for the fact that it has a double beat-note, reception is oftentimes spoiled, due to the undesirable beat-note from a station that is not wanted. It is possible to add one or two stages of radio-frequency amplification before the set to overcome this condition; but, if this is done, the circuit becomes more complicated than ever. However, tuned radio-frequency has many faults of its own.

When this type of amplification is



Top view of the Super-Hilodyne Receiver. The special untuned R.F. transformers are grouped together on the left side of the sub-base. The double impedance A.F. units are mounted on the extreme right of the sub-base. The entire tuning unit is mounted inside the shield, in the center.

point X, will be always the same; as the plates of V1 and V2 are in parallel just opposite to the input circuit. In other words this circuit is neutralized, as signals of all frequencies are balanced out.

If we were to allow the circuit to remain in that form it would be useless as a receiver. However, on further consideration it will be seen that a variation of current exists between the plate of each tube and the point X. Therefore, on connecting the coil C in series with the plate of V1, we have a variable signal flowing in this coil, if the resistor R1 is opened. The coil B, which is shunted by the variable condensers, C2 and C3 (the latter being a vernier) is tuned to the frequency which it is desired to get through to the loud speaker, and all others are cancelled out. This desired frequency is picked up by the coil A and charges the grids of the two tubes in the phase just opposite to that of the current picked up in the antenna coil. In this way the grid of V1 is reinforced by the current transferred through the coil system, A, B and C, while the grid input of V2 is balanced out, thereby causing no current flow from its plate to the point X, no matter to what frequency B is tuned. Therefore an amplified current, at whatever frequency is passed by coil B and its attendant condensers, flows in the primary of the radio-frequency transformer RF1; while all the other signals are cancelled out.

After the signal has passed through the tubes V1 and V2 it leaves the center panel (See Fig. 1) and goes to the left to the input of the intermediate radio-frequency amplifier.

The four radio-frequency transformers, RF1, 2, 3 and 4, are untuned and give high amplification between 220 and 300 meters. In order to eliminate oscillations, resistors are placed in the primaries of these transformers.

As the amplification factor begins to drop off, above 300 meters, a portion of the plate current is fed back to the grid circuits through the radio-frequency chokes, CK1, 2 and 3. This current is forced through these chokes and the condensers, C4, 5 and 6, to the coils, T and thence to the filaments or ground. This is because these chokes have a lower impedance than the resistors at the lower frequencies, or higher wave lengths.

The impedance of a choke coil drops when the frequency is lowered; therefore, the increase of current fed back to the grid circuit is in proportion to the drop in frequency. As the coil T is coupled through the secondary of the radio-frequency transformer, we have an electrically automatic form of regeneration that compensates for the drop in amplification at the higher wave-lengths; and therefore keeps the amplification factor at its highest efficiency for the entire broadcast waveband.

LIST OF PARTS REQUIRED

L1—1 Variocoil.
L2—1 Hilocoil.
C1—1 Variable Condenser, .00037 mfd.
C2—1 Variable Condenser, .00035 mfd.
C3—1 Midget Condenser, 9 plate.
R1—SW—1 Switch-Resistor Unit, 0 to 5,000 ohms.
RF1 to 4—4 Hilograd R. F. Units.
AF1—1 A. F. Transformer, Choke and Condenser.
AF2-3—2 Double Impedance A. F. Units.
AF4—1 Output Filter.
R2, R3, R4—3 Ballast Resistors, 5 volts—.75 ampere.
R8—1 Grid Leak, 1 to 3 Megs.
C7—1 Grid Condenser, .00025 mfd.
9 Sockets, UX type.
1 Vernier Dial.
1 Shield Cover.
1 Front Panel (Laminated iron, 8" x 21" x ¼").
3 Sub-base Panels (7" x 12" x ¼" each).
1 Six-Wire Battery Cable.
2 Braces for sub-base panels.
2 Brackets for Chassis Mounting.
2 Binding Posts.
2 Phone Tip Jacks.
1 Condenser Coupling (couples C1 and C2).
(All the above parts are manufactured by the Algonquin Electric Company).
8 Vacuum Tubes, 201-A Type.
1 Vacuum Tube, 171 type.

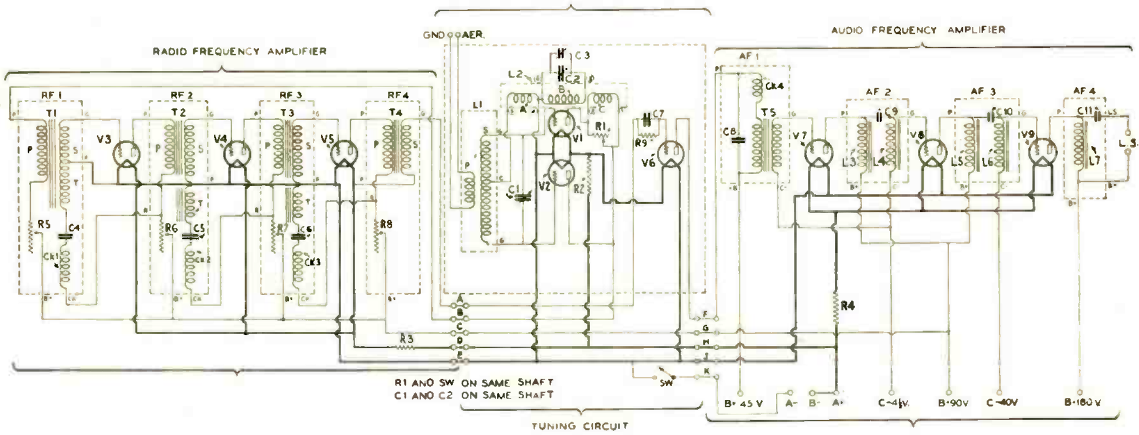
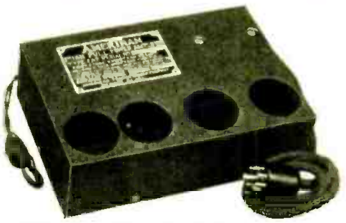


Fig. 1. Complete schematic diagram of the Super-Hilodyne Receiver worked out to correspond with the layout of the three units as shown in the illustration at the top of this page.

NEW DEVELOPMENTS OF THE MONTH

AmerTran Push-Pull Power Amplifier

The AmerTran push-pull power amplifier type 2AP, manufactured by the American Transformer Company, 178 Emmet Street, Newark, N. J., is a complete two stage audio amplifier employing an AmerTran DeLuxe



The AmerTran Push-Pull Power Amplifier

transformer in the first stage and the new AmerTran push-pull input and output transformers in the second stage.

This complete amplifier is so designed that a standard amplifier tube or a UY-227 A.C. tube can be used in the first stage and either two 171 tubes or two 210 tubes in the push-pull stage.

The entire amplifier is mounted in a metal case and is supplied with plug for making connection to the power supply.

Approximate weight, 20 pounds.

AmerTran ABC Hi-Power Box

The American Transformer Company have also placed on the market a new ABC power unit, known as the

The AmerTran ABC Hi-Power Box

type 21A, which supplies a maximum "B" voltage of 500 and will deliver plate currents up to 110 milliamperes. The unit is provided with intermediate voltage taps to supply the "B" power for the radio frequency and detector tubes.

The same unit will supply A.C. filament current for a 281 rectifier tube, two 210 power tubes and several 226 and 227 A.C. tubes. Adjustable negative bias voltages are provided for all tubes.

Approximate shipping weight, 50 pounds.

New Valley Automatic Charger

With the new Automatic Charger, manufactured by the Valley Electric Co., 4515 Shaw Ave., St. Louis, Mich., both "A" and "B" current supply are controlled automatically from the switch on the Radio Set. There is an automatic relay switch constructed within the Charger case. This unit is equipped with a "B" Power Supply receptacle mounted on the back of the case. The "B" Power Unit attachment plug is plugged into the receptacle. This arrangment makes the

The Valley Automatic Charger

radio receiver automatic in its operation.

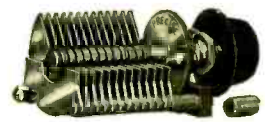
By action of the relay the Charger is disconnected from charging the battery and the "B" Power is connected to the set. When the switch on the receiver is turned to the "Off" position, the reverse operation takes place, and the Charger automatically continues to charge the battery. If "B" Batteries are used instead of a "B" Power Unit, the Charger can also be controlled from the Radio Set switch.

The toggle switch on front of the Valley Automatic Charger is used to start and stop the charge.

The Valley Automatic Charger is capable of delivering either 1½ or 2½ amperes, which are controlled by a high and low plug under the lid. The Raytheon element is employed in the Valley Automatic Charger. Small and compact. Fits all console set compartments—comes complete with cord, plug, leads and clips. Black enameled case.

Precise Midget Condensers

The Precise Manufacturing Company, of 254 Mill Street, Rochester, N. Y., announce a new line of Midget



Precise 135 m-mfd. Midget Condenser

condensers for use as neutralizers, stabilizers, balancing condensers, etc. The smallest type, having three plates, has a maximum capacity of 10 m-mfd. These condensers can also be obtained in maximum capacities of 30, 55, 100, and 135 m-mfd.

Each condenser is supplied with a small Bakelite knob. These condensers are of the one hole mounting type.

New De Jur Power Rheostats

The De Jur Products Company, 199 Lafayette St., New York, are marketing a new type power rheostat designed and made specially for high current carrying capacities. This rheostat has a large refractory base, 2¾ inches diameter, and is a single hole mount.

The new De Jur Power Rheostat

The manufacturer states that the resistance element is of the highest and best quality resistance wire obtainable (having the lowest rising temperature co-efficient), wound on best grade India Mica imbedded in grooves, and is covered with a high heat refractory cement, making the element permanent and everlasting, tightly fastened to the base.

The contact arm rides smoothly over the surface of the resistance. Soldering lugs are supplied for convenient connections.

Made in the following ohmages as standard: 2, 3, 5, 6, 10, 15, 20, 30, 50, 100 and 200 ohms. This rheostat can also be made up with an extra connection and used as a potentiometer in any of the above resistance values.

Polymet Hi-Volt Filter Condensers

Polymet Filter Condensers comprise a line of paper dielectric condensers for use in Radio Receivers,"B" Eliminators and Power-Packs.

The manufacturer states that only the highest grade of foil and specially prepared linen paper are used in their manufacture.

Polymet Condensers are non-inductive and the special process of impregnating insures a high working voltage,

Polymet Hi-Volt Filter Condenser

long durability and also prevents leakage.

Polymet Filter Condensers are made in all popular capacities. Made by Polymet Manufacturing Corp., 599 Broadway, New York City.

Samson Power Block No. 713

The Samson Power Block No. 713, manufactured by the Samson Electric Co., Canton, Mass., is designed to furnish the necessary energy from a 105—110—115—120-volt 60-cycle power supply for 180 volts direct current at 50 milliamperes. Although this block is rated at 50 milliamperes, it is capable of furnishing currents up to values as high as 80 milliamperes, it is stated. However, the inductance of the chokes which are used in this block decreases after the 50-milliampere point is reached, and the filtering effect is not so good. The Power Block No. 713 contains, in addition to the two chokes mentioned above, one special "B" eliminator transformer. All leads are brought to a terminal block on the face of the unit where connections are readily made. In addition, the transformer has windings

The Samson 713 Power Block

for supplying the filament current of a UX or a CX-380 tube, and an additional winding for supplying the filament current of one 171 tube. The transformer in this unit is rated at 30 watts.

Samson Power Blocks No. 718 and No. 210

The Samson Power Block No. 718 is arranged to supply from 105—110—115—120 volts 60-cycle power supply 200 volts direct current up to 80 milliamperes. The transformer included in this unit is the Samson No. 132, and the two chokes are Samson No. 380. The combination of these three units into a common block makes for compactness and durability, and at the same time the number of necessary connections is minimized. With this power block it is possible to build an eliminator to take care of the needs of the ordinary set. The value of the choke up to as high as 80 milliamperes direct current ensures good smoothing.

The Samson Power Block No. 210 is designed to furnish from a 105—110—115—120 volt 60-cycle power source 500 volts direct current up to 80 milliamperes. This combination is especially suited for a "B" supply for the 210 tube, and therefore may be associated with any amplifier where a large power output or a small relatively undistorted power output is desired. The fact that this power unit

The Samson type 718 and 210 Power Block

furnishes 500 output volts at 80 milliamperes, instead of the usual 400 or 300 volts, ensures a maximum of volume, or for a given volume a minimum of distortion, states the manufacturer. This block utilizes the Samson "B" Eliminator Transformer No. 162, and also two of the Samson No. 380 Chokes. The output terminal block is conveniently located, and furnishes a simple means of connecting to this block all necessary external equipment.

Majestic "A" Current Supply

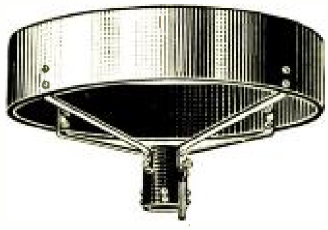
The Grigsby-Grunow-Hinds Company, of Chicago, Ill., manufacturers of the Majestic line, have developed a new "A" Current Supply which will supply power direct from the light socket for radio sets of from 5 to 8 tubes, including the power tube.

The rectifier used in the Majestic "A" is the dry plate type which has been in use for several years in battery charging devices.

The maximum output of Majestic "A" is 2½ amperes at six volts. A receptacle is provided on the front panel for plugging in a "B" supply, so that both the "A" and "B" units are operated with one light socket connection. A switch on the front panel of the "A" power unit controls both sources of power supply. The switch controlling the "A" and "B" units, therefore, acts also as a control for the entire radio set.

All-Direction American Antenna

The American Radio Hardware Company, of 135 Grand Street, New York City, have placed a new type antenna on the market. It takes the form of a condenser antenna, and as seen from the illustration, is made



The All-Direction American Antenna

of copper mounted on an insulated pole. The circular band is 14" in diameter and with its large width presents a maximum of conductive surface.

This antenna is non-directional and being of the condenser type has high efficiency. It has the advantage of taking up but a small amount of space.

The Amperite Adapter

The Amperite Adapter, manufactured by the Radiall Co., 50 Franklin St., New York City, comprises a base with clips to take two standard Amperite units complete, which are thereby connected in parallel so as to obtain their combined current-carrying

capacity. The Amperite units are selected in order that the combination may provide the desired amperage for the group of tubes in the receiver thus controlled. Combinations are avail-

The new Amperite Adapter.

able for the precise control of any set from the simple three-tube layout without power tube, to the six-tube layout with power tube.

M-C Tube Renewer

The Master-Craft Products Co., of 3803 N. Clark St., Chicago, Illinois, has a new vacuum-tube renewer which

The M-C Tube Renewer.

they are introducing on the market. The makers say that this compact instrument will rejuvenate any type radio tube on merely the batteries of the receiving set.

Vogue Model 12 Speaker

The Vogue Model 12 Speaker, manufactured by Richard T. Davis, Incorporated, of 5252 Broadway, Chicago, Ill., is a compact instrument employing a new principle of reproduction. Its reproducing unit is completely enclosed in a metal housing which prevents damage of any kind.

The speaker is done in rich antique finish; dark brown crackle with grilles and base highlighted with gold. The size is 17" high, 4¼" wide, with a base 10½" long and 7¼" wide.

The Vogue Model 12 Speaker.

Vogue Ortholian Speaker

The Vogue Ortholian Model Cabinet Speaker, also manufactured by Richard T. Davis, Inc., contains an air chamber 8 feet long. It employs the same unit as the Model 12 Vogue Speaker.

The Vogue Ortholian Speaker.

It is finished in shaded walnut and dark trim with a carved grille and legs. Ample space is available for radio batteries and eliminators. Dimensions are 48" high, 14" deep and 22" wide.

France "A" Eliminator

An "A" Eliminator employing a dry disc rectifier has been announced to the trade by The France Mfg. Co., Cleveland, Ohio. They have been licensed to use the electrolytic filter made under patents of the Andrews-Hammond Corp., this particular filter being the one most popularly used in such devices today. Made in two models for replacing both four and six volt batteries.

It is said this device occupies less cabinet space than the trickler-battery combination which it replaces. Under normal line voltage it will satisfactorily operate a set of eight 201-A tubes or equivalent, but for all practical purposes is recommended for use in connection with the popular five and six tube sets equipped with power tubes.

Operates only while set is in use and consumes no more current than the average house lighting bulb.

Polymet Molded Mica Condensers

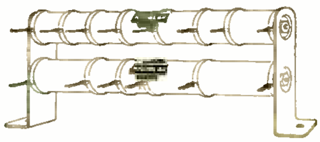
The Condenser section is composed of alternate layers of mica and foil, individually tested to insure accuracy and finally impregnated and compressed by a special process. This perfect condenser section is then molded in genuine bakelite. Every Polymet molded condenser is individually tested

Polymet Moulded Mica Condenser.

and guaranteed accurate states the manufacturer. They are also tested for high-voltage break-down. The soldering lugs are molded in the condenser. Polymet molded condensers are made in all capacities. Manufactured by Polymet Manufacturing Corporation, 599 Broadway, New York City.

New Kroblak Tapped Resistors

Shown here is the Kroblak Tapped Resistor No. 245. This unit embodies the necessary resistors for the new



Kroblak Tapped Resistor for "A-B-C" Eliminators

QRS and Raytheon "A" "B" and "C" Eliminators. The unit consists of two 75 watt tapped resistors mounted within brackets. The overall size is 10" x 3" x 2". Manufactured by C. E. Mountford, 30-32 Sullivan St., New York City.

What Do You Demand From a Resistor?

QUESTIONS:

1. How accurate is it?
2. How long will it maintain that accuracy under load?

ANSWERS: by Hardwick, Field, Inc.

1. Harfield Resistors can be supplied to you in any quantity as accurate as plus or minus 1%.
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Tapped resistors may be obtained to meet your individual need and specifications. Tell us about the resistor you want and let us make up a sample for you with prices. Write us.

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HAR-FIELD
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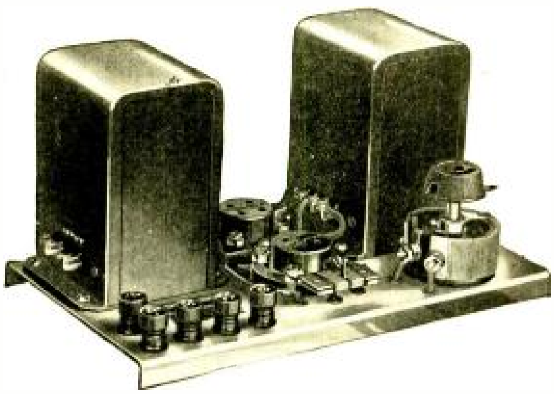
RESISTORS

PUSH-PULL AMPLIFICATION



In a search for an amplifier combination which would give the maximum in quality and volume, the push-pull method has proved particularly satisfactory.

While push-pull transformer coupling does not increase the amplification per stage, the maximum undistorted power output is greatly increased. The reason for this is that distortion due to tube overloading cancels out, permitting a greater output from each tube than would be possible if the tubes were used as in other methods of coupling. A further advantage of push-pull amplification when using an A. C. filament supply is that hum voltages also cancel out, rendering the amplifier very quiet.

The type 441 unit with two type 171 power tubes having a plate voltage of 180 will give more volume and better quality than a single transformer coupled stage using the type 210 power tube with 400 volts on the plate.

The General Radio Type 441 unit is completely wired and mounted (as illustrated) on a brass base-board with conveniently located binding posts so that the unit may be built into a receiver or connected with an existing set as a separate unit.

The type 441 may be used with either the UX-226, UX-326, or UX-171, CX-371 tubes.

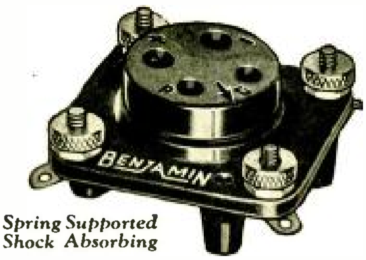
The Type 441 unit is licensed by the Radio Corporation of America for radio amateur, experimental, and broadcast reception only, and under the terms of the R. C. A. license the unit may be sold only with tubes.

Type UX-226 or CX-326 Amplifier Tube	$3.00
Type UX-171 or CX-371 Amplified Tube	4.50
Type 441 Push-pull amplifier	20.00

GENERAL RADIO CO. **Cambridge, Mass.**

Make Your Sets DISTINCTIVE with the New Benjamin

Red Top Cle-Ra-Tone Sockets



Spring Supported Shock Absorbing

Makes the socket stand out from the dead black of the base and panel.

Easier to establish correct position of tube and prongs.

Improves the appearance of the set.

Have all of the spring supported and shock absorbing features of the famous Cle-Ra-Tone Sockets. Non-microphonic. Unaffected by stiff bus wiring. Tube holding element "floats" on 4 finely tempered springs. ***Used in most of the leading circuits.*** Among the most recent for which Cle-Ra-Tone Sockets have been specified are:

Strobodyne 8 · Magnaformer 9-8
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Lynch Suppressor Circuit
World's Record Super 10
Melo-Heald Fourteen · St. James Super
Karas Two-Dial Equamatic · Knickerbocker 4
Hilograd Receiver · International One-Spot
Thompson Super 7 · Hot Spot Fourteen

PRICES

Push Type, on Mounting Base

Benjamin Cle-Ra-Tone Sockets	75c each
Without Mounting Base	50c each

Green Top Socket for A. C. Tubes

Specially designed for use with 5-pronged A. C. Radio Detector Tubes:

For direct attachment to panel	90c each
For mounting on top of panel	$1.20 each

Insist on the socket used by those who know and want the best. ASK for BENJAMIN "RED TOP" or "GREEN TOP"

At all Radio Jobbers and Dealers

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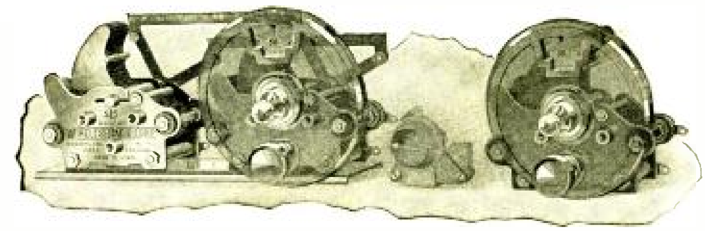
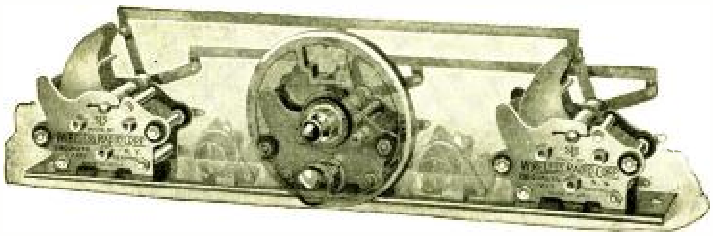


The Wireless Radio two dial Panatrol.



The Wireless Radio one dial Panatrol.

The Wireless Radio "Panatrol"

"Panattrol" is the name given to new one and two dial condenser control units manufactured by the Wireless Radio Corporation, Varick Ave. & Harrison Place, Brooklyn, N. Y.

The condensers used provide straight line separation. Three of them, matched, are mounted on a brass base and driven by a pantograph movement. By means of this and the absence of gears, belts, and pullies, a simple, foolproof, accurate drive with no changes due to lost motion is assured.

Holes are provided for mounting midget condensers and the base may be either anchored to sub-panel or supported by sub-panel brackets.

Wireless Radio Neutralizing Condenser

A neutralizing condenser is being made by the Wireless Radio Corporation, Varick Ave. and Harrison Place, Brooklyn, N. Y. The instrument is of

Wireless Radio Neutralizing Condenser.

the double stator type and features a locking device so that adjustment may be maintained at any point. It is particularly adaptable to inductive circuits requiring balancing.

Wireless Radio Midget Condenser

This midget condenser is rigidly constructed and very compact. Easy

Wireless Radio Midget Condenser.

handling is made possible by the combination stop and lug. The condenser can be used for neutralizing purposes or as a vernier adjustment when employed in conjunction with a large variable condenser. One-hole mounting is provided. Manufactured by the Wireless Radio Corporation, Varick Ave. & Harrison Place, Brooklyn, N. Y.

New Sangamo A. F. Transformer

The Sangamo Electric Company, of Springfield, Ill., announce a new audio frequency transformer.

The manufacturer states that the core is constructed of special alloy having a permeability many times greater than the best of silicon steels and has a greater core cross-sectional area than is usually found in transformers using alloys as core material.

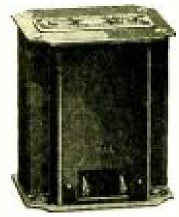
The unusual degree of bass note amplification is the result of the higher primary inductance of the Sangamo transformer under normal operating conditions, it is stated. Low leakage reactance insures uniform amplification of those frequencies in the upper part of the musical range.

The windings are of liberal cross-section insuring continuity of service even under excessive plate currents.

The axis of the transformer winding is in a horizontal plane, enabling the transformer to be oriented for the purpose of eliminating any hum that may be picked up from nearby socket devices.

The transformer is shielded in an iron case which insures minimum interference from stray fields.

Every transformer is tested at the equivalent of 1,000 volts direct current between primary and secondary and between primary and secondary and ground.



The new Sangamo A.F. Transformer.

These new transformers are built in 3 to 1 ratio and may be used with any kind of power tube in the last stage. Maximum undistorted power (1,540 milliwatts) is obtained by using a UX-210 tube in the last stage with 425 volts on the plate.

Electrical characteristics of the Sangamo type A transformer are as follows:

Approximate primary resistance	1,960 ohms.
Approximate secondary resistance	7,100 ohms.
Maximum plate current permissible	6 milliamperes
Turn ratio	3 to 1

Plate Current (Milliamperes)	Approximate Inductance (Henrys)
0	200
1	180
2	145
3	110

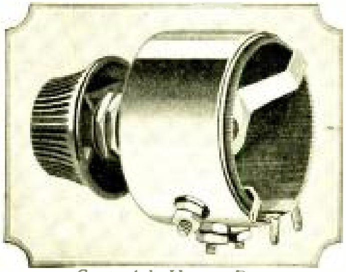
Dimensions:

Height	3 inches
Width	2.56 inches
Depth	2.36 inches
Depth over terminals	2.75 inches
Net weight	2 lbs. 2 oz.

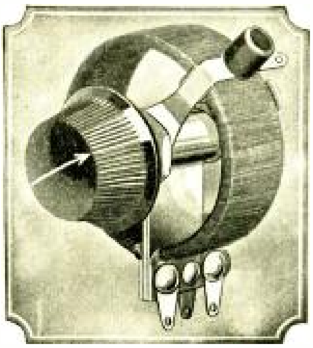
Sonatron A.C. Tubes

The Sonatron Tube Company of Chicago, New York, Detroit, Newark, and Windsor, Ontario, announces two new alternating current tubes—Nos. X-226 A.C. and Y-227 A.C., designed to operate direct from an alternating current socket, doing away with rectifier and filter. The X-226 A.C., for use in Radio Frequency and Audio Frequency amplifier circuits, takes a current drain of 1.05 amps at 1.50 volts, and operates with a plate voltage of 90 to 135, to a maximum of 180 under full power. The standard four-prong UX base is used.

Centralab—Consistently Good



Centralab Heavy Duty Potentiometer



Centralab 4th Terminal Potentiometer

CONSISTENT built-in quality, plus true statement of performance, have placed Centralab in ever-increasing favor of manufacturer and professional builder.

Accurate specifications, smooth unvariable performance, assure the users of Centralab products greater efficiency and long, trouble-free service.

There is a Centralab Resistance to fit every need in radio. Two of the latest types are pictured here. The Heavy Duty Potentiometer is a variable high resistance all wire wound with sufficient current carrying capacity to provide a true potentiometer control of "B" power voltages. The 4th Terminal Potentiometer is an ideal unit for use in power supply units as a control of output voltages. Two variable "C" bias taps can be obtained on one unit.

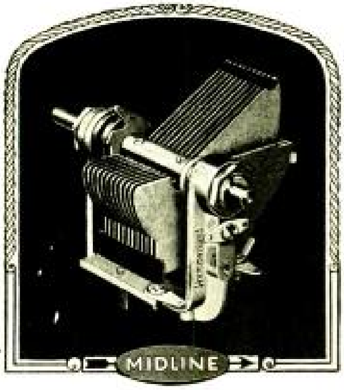
In addition to these, there is the Centralab Power Rheostat—a unit constructed of heat-proof materials with sufficient insulation to carry a continuous current load at a power dissipation of 35 watts or more. An ideal unit to place in primary leads as a line voltage compensator.

Other products are Centralab Radiohms, Modulators, Potentiometers and Standard Rheostats.

Send for Folder 328. It shows the correct application of resistances in receiver and power supply circuits.

CENTRAL RADIO LABORATORIES

25 KEEFE AVENUE MILWAUKEE, WISCONSIN



SUPREME

Specialization has won for Hammarlund Precision Products supremacy in their field.

Built with the nationally known Hammarlund Condensers, Coils, Chokes, Shields and Drum Dials, your receiver will be nationally known.

Send us your specifications.

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

For Better Radio
Hammarlund
PRECISION
PRODUCTS

NATIONAL
POWER UNITS

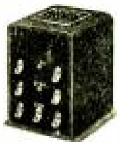
For conversion of Battery-Run Radio Sets to full Socket-Power Operation NATIONAL POWER UNITS are built for lasting service with ample factors of safety.

NATIONAL POWER TRANSFORMER

A heavy-duty transformer for 110-120 volts, 60 cycles A.C. Capable of handling the largest sets. Center tapped 7.5 and 5 volt secondaries are provided for filaments of both UX 210 and UX-171 Power Tubes. Dimensions 4⅛" wide x 4" deep x 4¾" high. Bakelite Panel; Black Crackle metal case.

Made in two types—Type R has 300 volts secondary each side of center, for Raytheon BH or UX-280 Rectifier Tube. List Price, $12.50. Type U has both 300 and 230 volts each side of center. List Price, each, $14.50.

Two heavy chokes in single case to match NATIONAL POWER TRANSFORMER. For all Power Supply Filter Circuits.
List Price.............$10.00



For heating the new A.C. Tubes direct from Lamp Socket, replacing the old A-Battery. Has 1.5, 2.5 and 5 volt taps for all types of A.C. Tubes.
List Price.............$10.00

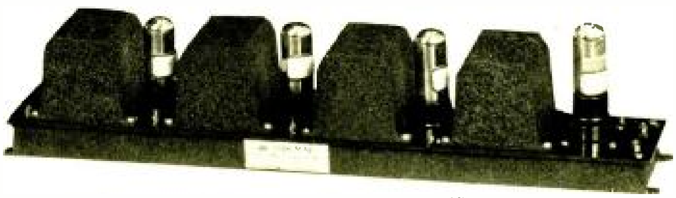
Write for Bulletin RR-124 to,

NATIONAL CO. INC., W. A. *Ready, Pres.,* Malden, Mass.

NATIONAL
RADIO PRODUCTS

Y-227 A.C. is designed for use as a detector in a receiver using X-226 A.C. tubes as amplifiers; though the Y-227 itself may be used with splendid results as an amplifier tube, particularly in first stage audio. It is a heat-principle tube, self-stabilizing to eliminate the hum noticeable when other types of A.C. tubes are used as detectors. Current drain in this type is higher than in the X-226 A.C., 1.75 amps at 2.5 volts being required for perfect performance. A five-prong socket base is used.

The rectifier is of the full wave type and charges the battery at a ¾-ampere rate.



The Dar-Mac Long Wave Amplifier.

Swan-Haverstick "A" and "B" Power Control

This unit is designed to give automatic control of any trickle charger and "B" eliminator. According to the manufacturers, with this unit in opera-

The Swan-Haverstick "A" and "B" Power Control.

tion the trickle charger starts as soon as the radio set switch is turned off—and an added feature prevents the chance of a reverse current flowing back and causing the battery to run down. There are no moving parts to wear out or get out of order. Manufactured by the Swan-Haverstick Co., Inc., Trenton, New Jersey.

Swan-Haverstick Automatic "A" Power Unit

The Swan-Haverstick Company, Inc., Trenton, N. J., have placed a new "A" power unit on the market for use with 110-volt 60-cycle house current. This unit employs a dry type rectifier together with a step-down transformer, and is designed to be employed in connection with the regular storage "A" battery.

This "A" power unit is automatic in operation and when the radio set is being used, the house current is automatically switched off.

The Swan-Haverstick Automatic "A" Power Unit.

Dar-Mac Long Wave Amplifiers

The Dar-Mac Laboratories, 19 South Wells St., Chicago, Ill., are making a new line of long wave amplifiers and high quality equipment for custom builders.

The long wave amplifier unit consists of a combination of four transformers encased in cast aluminum and mounted on a cast aluminum base. The sockets and all of the wiring is completed in the unit when it is made. These units are made to have band pass acceptances of 5, 10 and 15 kilo-cycles respectively, it is stated. The transformer amplification has a central point at 65 kilocycles.

The units are made to match several different types of tubes. These three different type units are designed for 199 tubes, 201-A tubes, and the recent 112-A tubes. The amplifier is extremely simple to install as a replacement in existing out-of-date superheterodyne receivers.

Interstate Metal Rectifier Tube

An indestructible metal rectifier has been designed by the engineers of the Interstate Electric Company, of St. Louis.

It is claimed to be made of solids—contains no glass, gas or liquids—not the slightest moisture—bone dry. It is contained in a heavy nickeled tube with standard Edison base to fit the socket of any bulb type rectifier.

It will deliver a rectified steady current of 2 amperes in a charger built to charge a 6 volt battery; and it will operate satisfactorily in any of the bulb type trickle chargers on the market.

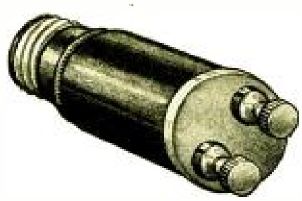
As to life—there is no filament or element to wear—no liquids to dry—no gas to leak—nothing to break—solid metals employed—and while the manufacturers do not claim everlasting life, should the rectifier depreciate in any manner after long use, it is refillable at a very nominal cost.

It is claimed that the watt consumption of a charger equipped with this Metallic Tube Rectifier is approximately half that of the same charger with gas filled bulb, thus the efficiency of the metal rectifier is double that of the glass filament bulb so commonly employed.

Messrs. E. Ballman and A. R. Zahorsky, pioneers in the rectifier field since 1910, are responsible for this new rectifier tube.

Swan-Haverstick Light Socket Antenna

The Swan-Haverstick Light Socket Antenna can be screwed into the nearest 110-volt A.C. or D.C. outlet and the lighting wires thereby utilized as the antenna. Two binding posts are mounted on the casing either of which



S-H Light Socket Antenna.

can be used and these are provided to compensate for the varying lengths of the lighting wires.

Swan-Haverstick Lead-in-Lightning Arrester

The Swan-Haverstick Company, Inc., Trenton, N. J., are marketing a

S-H Lead-in-lightning Arrester.

combination lead-in and lightning arrester as shown in the accompanying illustration.

The lightning arrester is contained in a molded casing and is connected to the end of the copper ribbon which extends out of the window.

An insulating sleeving is placed over the portion of the copper ribbon which comes under the window sash.

Vacuum Tube Directory

Name	Type	Use	"A" voltage Bat.	"A" voltage Fil.	Fil. current (Amps.)	Voltages (minimum) "B"	Voltages (minimum) "C"	Voltages (maximum) "B"	Voltages (maximum) "C"	Voltage "B" Det.	Grid return (Det.)	Plate current (milliamps) Min.	Plate current (milliamps) Max.	Output resistance (Ohms)	Mutual conductance (Micromhos)	Voltage amplification factor	Remarks
Arcturus Radio Co.	26	A. C. Detector		15	0.35	22	4.5	45	9	45				9500	1100	10.5	Positive "C" voltage
	28	A. C. Amplifier		15	0.35	45		90	1.5					9500	1100	10.5	R. F. and A. F. amplifier
	30	A. C. Power Tube		15	0 35	135		180	22.5					2700	1650	4.5	
Armstrong Electric Co. (Armor)	C. F. 501	General Purpose	6	5	0.25	22 5	4.5	135	9	45	F+			7000–9000	1000	8	
	C. F. 112	Power Amplifier	6	5	0.5	90		157			F+			4500–8000	1200–1700	7.5–8.0	
	C. F. 571	Power Amplifier	6	5	0.5	90		180						2500	1200–1700	3.0–3.5	Use output device above 135 v. "B"
	C. F. 510	Power Amplifier	8	7.5	1 0	180		450						3000–5000	1100–2500	7.0–8.0	Use output device
	C. F. 516 B	Half Wave Rectifier	8	7.5	1.0												85 M. A. output
	A. C. 100	A. C. Tube	1 0	1.0	2.5	22		157						6000–12000	800–1400	7.5–8.0	Step-down trans. for fil. supply
C. E. Manufacturing Co.	K	R. F. Amplifier	6	5	0.25	45	0.0	135	3.0	45–90	F+	3.0	4.8	11000–12800	975–1130	12.5	May be used as detector
	G.	Hi-Mu	6	5	0.25	90	0.5	180	5.0	67–90	F+	0.8		25000–	800–	20	Det., Res. Impedance Amplifier
	H	Special Det.	6	5	0.25	67	3.0	90	4.5	67–90	F+	1.2	3.0	14000–15900	910–1030	14.4	Detector only
	F	Power Amplifier	6	5	0.5	90	6	180	15	45	F+		5	5300	1500	8	
	J-71	Power Amplifier	6	5	0.5	90	16.0	180	45.0			9.0		2500–	1200–	3.0	Use output device above 135 v. "B"
	L-10	Power Amplifier	8	7.5	1.25	250		425	20					4500			Use output device
	AX	General Purpose	6	5	0.25	90	4.5	135	7.5	45	F+		3	10500	810	8.5	
	M-26	A. C. Amplifier		1.5	1.05	90	4.5	135	9								R. F. and A. F. Amplifier
	N-27	A. C. Detector		2.5	1.75	90	4.5	135	9	45							
	D-G	Full-wave Rectifier	85 milliamperes at 300 volts														Gaseous conduction type
	R-80	Full-wave Rectifier	6	5	2.0												125 M. A. at 300 V.
	R-81	Full-wave Rectifier		7.5	1.25												110 M. A. at 750 v.
Eureka T. & M. Co.			Full-wave Rectifier, 125 milliampere output														
Q. R. S. Music Co.	201-A	General purpose	6	5	0.25	20		180						8000	1000	8	
	200-A	Special Detector	6	5	0.25			45		45				5000		7.5	
	112	Power Amplifier	6	5	.5	135		180								3	
	171	Power Amplifier	6	5	.5	135		180						2500			Use output device above 135 v. "B"
		Full-wave Rectifier	60 milliamperes at 150 volts														Gaseous conduction type
		Full-wave Rectifier	85 milliamperes at 200 volts														Gaseous conduction type
		Full-wave Rectifier	100 milliamperes at 350 volts														Gaseous conduction type
		Full-wave Rectifier	100 milliamperes at 500 volts														Gaseous conduction type
		Full-wave Rectifier	400 milliamperes — for "B" and "C" elimination														Gaseous conduction type
		Glow tube	Voltage regulator tube														

WHAT'S NEW?

RADIO ENGINEERING asks manufacturers to send in monthly information about their new products, campaigns, changes in personnel, circuits, etc. At the same time the technical staff would like literature for the use of the Readers' Service and Information Bureau. Many already are sending RADIO ENGINEERING systematized monthly data. We want more—

Let "NEWS OF THE INDUSTRY" *and* "NEW DEVELOPMENTS OF THE MONTH"

Grow with You.

Platinum Radio **ARMOR** Filament Tubes

"A Tube For Every Need"

Quality **Selectivity** Volume

SUPERIOR

Desirable jobbing territories still open.

Armstrong Elec. & Mfg. Co., Inc., Newark, N. J.

KELVIN FULLWAVE NO FILAMENT RECTIFYING **TUBES**

ARE DIFFERENT

Longer life
Larger output
Quieter operation
Quicker pickup

125 M. A. Price $4.00

Uniform quality

Sole Distributors

Eureka T & M Co.,

42 Walnut St., Newark, N. J.

Guaranteed for one year

Tipless Construction

Independent Laboratories

Newark, N. J.

Oxide Coated Filament
for
All Tubes

Special Getter
for

Detectors — A.C. Tubes — Amplifiers
Power Tubes — Gas Rectifiers

Cerium Alloys

Exclusive Sales Representative

A. U. HOWARD

50 East 42nd St. New York City

Phone: Murray Hill 0342 & 0343

Your "B" Battery Eliminator will give you better service

with

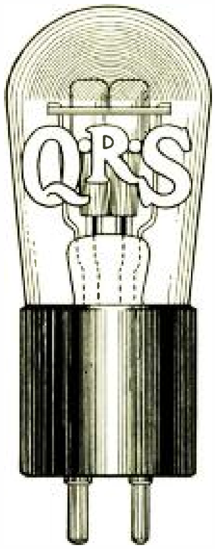
Q·R·S

Trade Mark Registered

Gaseous
Rectifier Tubes

ARE **BETTER**

60	Milliamperes -	$4.50
85	Milliamperes -	4.50
400	Milliamperes -	7.00



Ask for Catalog of full line of Standard Tubes.

Guaranteed

The standing of the Q. R. S. Company, manufacturers of quality merchandise for over a quarter of a century, establishes your safety.

Orders placed by the leading Eliminator Manufacturers for this season's delivery, approximating Four Million Dollars' worth of Q.R.S. Rectifier Tubes, establishes the approval of Radio Engineers.

Ask any good dealer.

The Q·R·S Company

MUSIC

Manufacturers

Executive Offices:

306 S. Wabash Ave., Chicago

Factories: Chicago—New York—San Francisco—Toronto, Canada—Sydney, Australia—Utrecht, Holland

Established 1900

References—Dun, Bradstreet, or any bank anywhere

OF IMPORTANCE TO SET BUILDERS

THE Wireless Radio Corporation has brought out a series of items which will prove of vital interest to Professional Set Builders who desire to use good parts yet still be able to make a reasonable profit.

The first item is the W. R. C. Universal Metal Panel, a handsomely finished article which will lend a real professional appearance to any radio set. It comes drilled and partly assembled each hole having an insulated bushing to prevent short circuits. The panel is equipped with two illuminated dials, rheostat, brackets for sub-panel mounting and all the necessary hardware. A great variety of circuits may be made without changing this panel or drilling additional holes. It has the further advantage that almost any make of coil or condenser may be mounted without change. Size, seven by eighteen inches.

We will be pleased to send you our complete price list upon application. This also includes all the other items made by W.R.C. All are in stock, ready for immediate delivery.

To match this panel comes the W. R. C. Metal Deck or Sub-panel which is equipped with five flush sockets, two audio transformers, binding post strip and all the necessary hardware. This deck has two insulated holes in it for mounting neutralizing devices if necessary. It is adaptable to many circuits. Size, six inches by twelve inches.

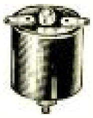
To complete either of these items, we have introduced the W. R. C. Duo-denserkit which contains two variable condensers, a midget condenser, panel switch, Volumeter and other items which might prove useful in the assembly.

A Tri-denserkit is also offered in which a single variable condenser and one double Panatrol, (two matched condensers), are included. In addition this kit has two midget condensers, push-pull switch, Volumeter and all the other necessities. The variable condensers for either kit may be supplied in either .0005 or .00035 microfarad.

WIRELESS RADIO CORPORATION, 41 Varick Avenue, Brooklyn, N. Y.

NEW AERO CHOKE COILS

The Aero Choke 60



Modern circuits of high sensitivity demand the use of radio frequency chokes in certain parts of the circuit. The Aero Choke-60 is designed to have a uniform choking action over a wide range of wave lengths, including Broadcast bands and Amateur Short Wave bands as well. Many chokes employed on short waves have an unpleasant characteristic of showing so-called "holes" in the tuning range, which is present also on the broadcast band but in a minor degree. These faults are corrected in the Aero Choke 60. Price, $1.50.

The New Aero Choke 248

The Aero Choke 248 is especially designed for operation in Aero Transmitter kits 2040K, 4080K, and 9018K, and other circuits. Aero Choke 248 presents a high impedance or choking action over the usual amateur wave lengths. It is wound with a conductor sufficiently liberal to handle transmitters up to 100 Watts. Price, $1.50.

AERO PRODUCTS, Inc.
Dept. 17
1772 Wilson Ave., Chicago, Ill.

Ensco

THE ORIGINAL AND WORLD'S FINEST 3 FOOT SPEAKER KIT

STANDARD KIT $10.00

WALL KIT with hardwood frame $11.00

Sell the Ensco 3-foot and 2-foot Kits—the original, best and most favorably known. Backed by a large and consistent national advertising. Accorded by far more publicity than any other speaker Kit. Complete line of roll, wall, console and pedestal models ranging in price from $10 to $17.50. Slightly higher in Canada.

SPECIAL DEALER'S PROPOSITION

To dealers and professional set builders we have a most interesting story—and a most attractive selling proposition. Write on your letterhead to the nearest office listed below for our booklet, prices, discounts, etc.

ENGINEERS' SERVICE COMPANY

25 Church St., New York
73 Cornhill, Boston
28 E. Jackson Blvd., Chicago
331 Bay St., Toronto, Canada

(Actual Size)
Designed for Manufacturers' Use

DRESNER COILS

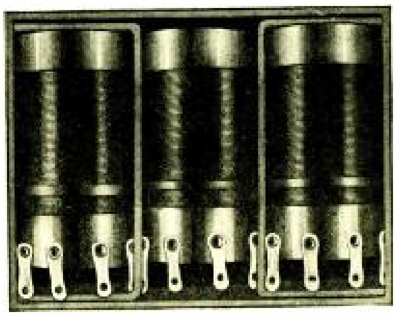
DRESNER space wound and threaded coils may be used with any type of .00035 MF maximum capacity condenser, whether it be single, triple or single and double factors. They are matched, machine wound and laboratory tested. The report of the testing laboratory of New York University, indicates the high electrical qualities of Dresner coils.

Their external magnetic field is the lowest.

We are equipped to design and wind special coils to set manufacturers' specifications. Write for complete details and

Send for prices, samples, etc.

DRESNER RADIO MFG. CORP.
564 Southern Boulevard, New York City



Packed in Sets of Three for Jobbers and Retailers

The biggest Edition—

The biggest edition ever published. Brimful of soundest information, latest circuits and hook-ups, new revised list of world's broadcasting stations with schedules and new wave lengths in meters and kilocycles. 264 pages of news, ideas, and valuable information for fans, set builders, radio dealers and everyone interested in radio's advancement.

Citizens Radio Call Book Magazine

November, 1927, Edition

Now on Sale at Newsstands and Radio Stores

First with the Latest

All receivers designed and tested in our laboratories

Complete constructional details on the newest radio circuits are given and include the Camfield Shielded Grid Seven Receiver using radio's latest tube development, Magnaformer 9-8 A. C. Super, R. G. S. Octamonic Receiver, Madison-Moore International "One-Spot", Thordarson Power Amplifier System, Three Foot Cone Speaker construction article, Silver-Marshall Laboratory A. C. Shielded Super, Victoreen, Tyrman Ten, World's Record Eight, Knickerbocker Four and many other interesting circuit arrangements for experimenters and professional set builders.

Wonderful Rotogravure Section

One of the big features of the new Call Book is the 16-page rotogravure section. It is replete with photographs and views. Your favorite radio artists, pictures of studio life, prominent announcers and other features are shown in actual photographic views.

A Complete Radio Cyclopedia

Be sure that you get the CITIZENS RADIO CALL BOOK MAGAZINE, the original and most widely circulated publication of its kind. Accept no substitutes. Published four times yearly, September, November, January and March. On sale at newsstands and radio stores the world over, or subscribe now and be sure of receiving each issue as published.

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CITIZENS RADIO SERVICE BUREAU, Inc., Publishers (RE)
508 South Dearborn St., Chicago, Ill., Dept. R, U. S. A.

Date.............................192....

Please enter my subscription for the CITIZENS RADIO CALL BOOK for [ ] one year, $1.75; [ ] two years, $3.25; [ ] three years, $4.50. Enclosed please find.............in payment for same, mailed postpaid four times yearly, January, March, September and November. Canada and Foreign, $2.00 yearly.

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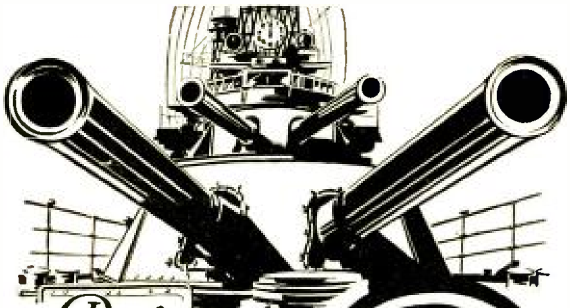
Address..

City...

State..



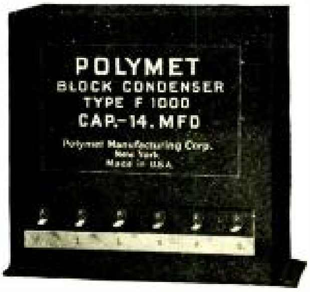
By their
POWER
you'll know them!

Polymet TRADE MARK

AS a powerful battleship plows its way through a stormy sea, **Polymet Condensers** take on the mighty power requirements of modern radio and deliver steady and continuous service at their rated working voltages. **Polymet Condensers** do not melt down or blow up—***they stand up,*** giving the utmost value for the money in working voltage, durability and dependability.

Polymet Block Condensers

The working voltage under which these condensers are to operate has been carefully studied and only the proper Condenser sections incorporated in these blocks. Poly Block Condensers not only improve the appearance of the set, but also simplify the wiring and save time and space in assembling.



Polymet High-Volt Filter Condensers

Polymet Condensers are Non-Inductive and our special process of impregnating makes them superior. Made in all popular capacities.

Write for complete information regarding Polymet parts and catalog of all Polymet Radio Essentials.

POLYMET MANUFACTURING CORPORATION
601 Broadway, New York City

POLYMET CONDENSERS

LYNCH

The famous Lynch 5 tube de luxe Deck. Simplifies home self-building at greatly reduced cost. Fully described in this booklet.

Send for this book —

Learn the Usefulness of "Resistance in Radio"

Radio fans, set-builders, and engineers will find a wealth of reliable, boiled-down, and interesting information in "Resistance the Control Valve' of Radio." Simply written and clearly illustrated. Concisely presents the latest information on resistance coupled amplification, the function of resistance in a circuit, circuit arrangements on equalizers, and other radio matters of interest and importance. This valuable handbook on resistance in radio is worth dollars—you can get a copy for only 25 cents.

Arthur H. Lynch, Inc.
1775 Broadway at 57th Street — General Motors Building, New York, N. Y.
Sales offices in most large cities

——————RETURN THIS COUPON——————

Mr. ARTHUR H. LYNCH, 1775 Broadway, New York City.

Dear Mr. Lynch: Please send me a copy of your new booklet "Resistance the 'Control Valve' of Radio. I am enclosing 25 cents.

Name ....

Street ....

City .... State ....

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HARKNESS

Tuned Double Impedance Audio Amplifiers and Parts

(Licensed under Hiler Patents)

Completely Wired Three-Stage

Hiler Audio Amplifier

With Output Filter

Type A-275 $16.50

Type A-325: Completely wired 4-tube Push-Pull Amplifier (2 stages Hiler Double Impedance and one stage Hiler Push-Pull)	**$19.50**
Special—Equalizer Stage, as described by John F. Rider. Completely wired unit, with two variable resistances for adjustment	**9.75**
Tuned Double Impedance Audio Couplers First, second or third stage types, each	**3.30**
Audio Output Filter Unit (protects speaker and improves tone of any set)	**2.70**
Pair of Push-Pull Units, Input and Output	**7.50**
Radio Frequency Choke, 85 millihenries	**.60**
250 millihenries	**1.10**

Above prices to dealers and set-builders only. Mail your order directly to the manufacturer, at the address below. Write for literature on new Harkness Counterfonic Six, the set with tuned double impedance audio amplification. Complete kits now ready for delivery.

KENNETH HARKNESS, Inc.
Suite 7A, 181 Sullivan Street, New York, N. Y.

Buyers Directory of Equipment and Apparatus

Readers interested in products not listed in these columns are invited to tell us of their wants, and we will inform the proper manufacturers. Address Readers' Information Bureau.

Addresses of companies listed below, can be found in their advertisements—see index on page 1086.

ADAPTERS:
Bakelite Corp.
Carter Radio Co.

AMMETERS
Jewell Elec. Inst. Co.
Westinghouse Elec. & Mfg. Co.

AMPLIFIERS, RESISTANCE:
De Jur Products Co.
Polymet Mfg. Co.

ANTENNAE, LAMP SOCKET
Electrad, Inc.

ARRESTERS, LIGHTNING:
Bakelite Corp.
De Jur Products Co.
Electrad, Inc.,
Jewell Elec. Inst. Co.

BASES, VACUUM TUBE:
Bakelite Corp.
Zierick Machine Wks.

BATTERIES, DRY:
National Carbon Co., Inc.

BINDING POSTS:
Bakelite Corp.
X-L Radio Labs.

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Electrad, Inc.
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Polymet Mfg. Corp.
Ward Leonard Electric Co.

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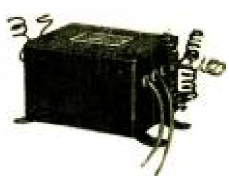

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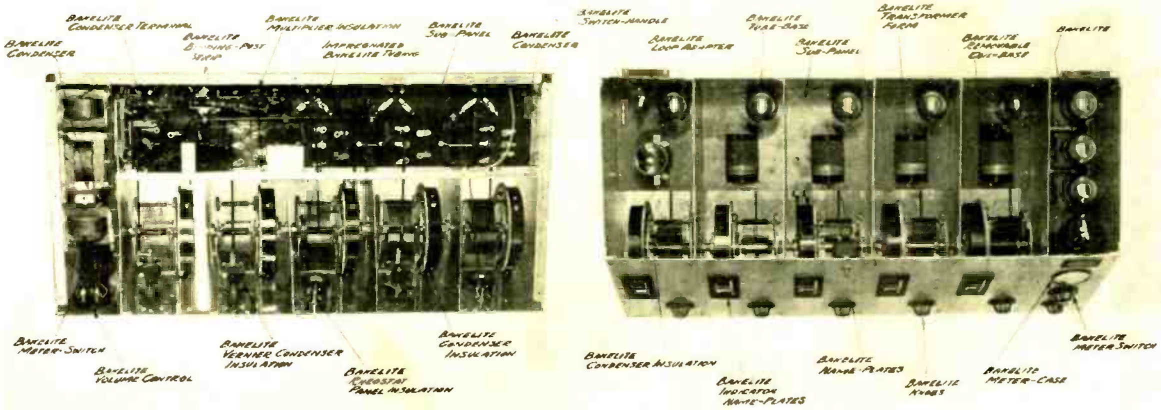

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