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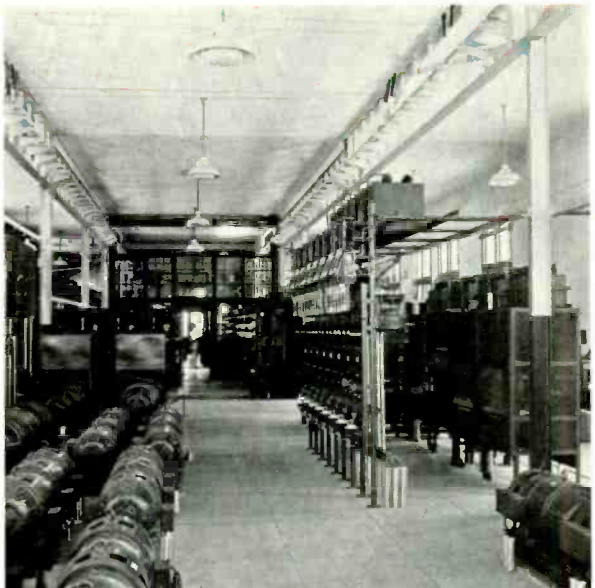

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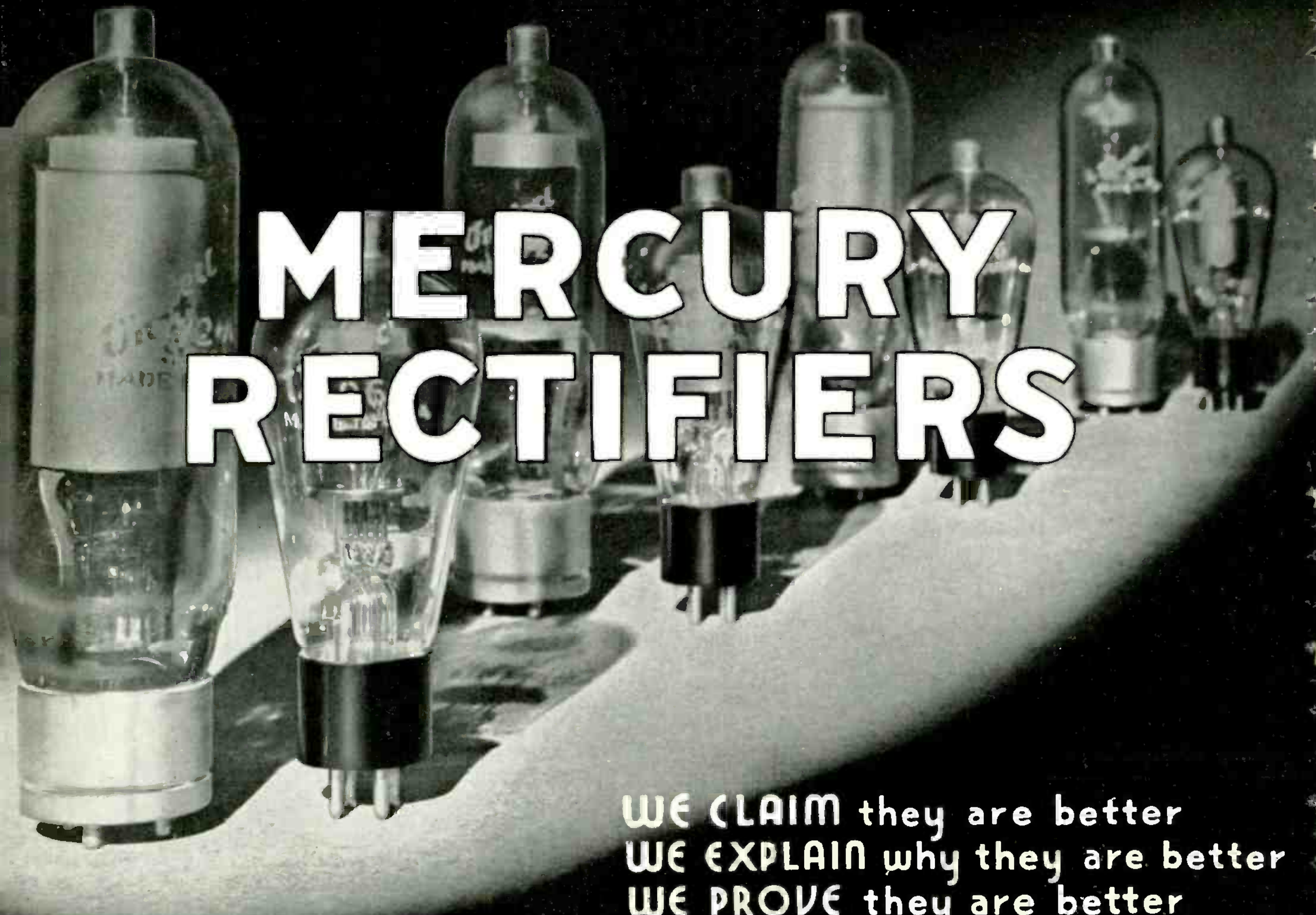

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DEPARTMENTS

COVER ILLUSTRATION

THE INTERIOR OF THE MACKAY RADIO AND TELEGRAPH COMPANY'S TRANSMITTING STATION AT PALO ALTO, CALIFORNIA.

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EDITORIAL

HIGH POWER

INCREASED POWER seems to have become the order of the day. Several stations have already applied to the Federal Communications Commission for power of 500 kilowatts. Among these stations are WJZ, New York City; WHO, Des Moines; WGN, Chicago; WHAS, Louisville; and KNX, Hollywood.

In super-power installations, the cost of the supply power and tube replacements will represent the major portion of the total operating expenses. It becomes imperative therefore to design transmitters in which the power consumed is reduced to a minimum as compared with the desired radiated power, and in which the overall efficiency of the system is as great as possible.

We believe that the first authoritative data published in this country on "modulation by phase difference," more commonly referred to as the Chireix system of modulation, appeared in COMMUNICATION AND BROADCAST ENGINEERING for August, 1935. Probably the most noteworthy feature of this modulation system is the high efficiency it is possible to attain in high-power radio transmitters. Mr. Chireix states that the 150-kw Luxembourg broadcast station, which employs his system of modulation, has a measured overall efficiency of 35 percent, including the power used for auxiliary apparatus.

Recently the Bell Telephone Laboratories announced a new high-efficiency power amplifier. With this new circuit the overall efficiency obtained in the tubes and output circuits is 60 percent for unmodulated carrier and a few percent higher with complete modulation. Mr. Doherty's article appearing on page 7 of this issue will be found both interesting and timely.

High power will also result in increased emphasis being placed on directional antenna systems. Not only will the individual stations want to secure the best possible coverage but numerous interference problems are likely to arise. WLW encountered such a problem (see November, 1935, COMMUNICATION AND BROADCAST ENGINEERING) soon after they increased their power to 500 kw, producing interference with the 690-kc Canadian station CFRB located about 400 miles from Cincinnati.

In our opinion it is not likely that too much emphasis will be placed on modulation schemes and on directional antenna systems.

PREDISTORTION

IT IS WELL KNOWN that the percentage modulation of high-modulated frequencies is very small with usual amplitude-modulated systems. Obviously this results in a poorer signal-to-noise ratio than would occur if the amplitude of the high-modulation frequencies were increased.

Predistortion is intended to over-emphasize the high audio frequencies before modulation in order that during transmission they will, in effect, be relatively deeply modulated. In the receiver, the high frequencies are attenuated to the same degree that they are emphasized in the transmitter. The result is a flat overall response characteristic for the entire system, but with the attendant advantage of improved signal-to-noise ratio. As was pointed out in our editorial for February, 1936, the greatest disadvantage of a system of this type appears to be the greater possibility of interference in adjacent channels.

On page 5 will be found an interesting article on "Applying Predistortion to Broadcasting." In this article, Loren F. Jones describes how the improvement actually obtained in an experimental setup at WCAU corresponded to an increase of 530 percent in transmitter power. While this improvement cannot be generally realized in the 550-1,500 kc band, because of adjacent-channel interference, it can be realized at ultra-high frequencies.

•

TRANSATLANTIC AIRSHIP TELEGRAPH SERVICE

IT IS INTERESTING to note that the first regular transatlantic airship telegraph service for commercial communications was inaugurated by Western Union and the Radiomarine Corp. during the first flight of the Zeppelin *Hindenburg*. Messages were accepted for transmission between the radio coastal stations and the *Hindenburg*, while messages from the Zeppelin showed the name of the *Hindenburg* as the place of origin. A fully-equipped office, connected by a number of direct circuits, was installed at the hangar at Lakehurst, N. J. A map of the Western Union cable and communications circuits will be found on page 25.

WHN steps up to 5KW

Chief Engineer G. R. Windham at WHN's new Western Electric 5KW installation. The two panels at right comprise the 1KW outfit formerly used—now serving as a standby transmitter.

Frequency monitoring units on desk at WHN, and station speech input equipment at right.

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For full details, write Graybar Electric, Graybar Building, New York.

Antenna coupling equipment at the base of WHN's antenna.

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COMMUNICATION & BROADCAST ENGINEERING

FOR MAY, 1936

APPLYING PREDISTORTION TO BROADCASTING

"Predistortion"—Can the signal-to-noise ratio be improved by over-emphasizing the high audio frequencies at the transmitter? This article describes how the improvement actually obtained corresponded to an increase of 530 percent in transmitter power. It is shown that this improvement cannot be realized in the 550-1500 kc broadcast channel, but that it can be realized at the ultra-high frequencies.

By LOREN F. JONES

RCA Manufacturing Co., Inc.

AS THE audio-frequency band transmitted and received by any transmission system, such as a broadcast system, is widened, the relative amplitude of the extraneous noises increases. This increase of noise energy is generally proportional to the width of the band. The noise energy may originate in parts of the transmission system, in tube hiss, in natural static and man-made interference. The most effective means for improving the signal-to-noise ratio is to increase the power of the transmitter to such an extent that the received signal is very strong in comparison with the extraneous undesired noise. Economically and otherwise, there are limits to the extent to which this can be carried.

Another means of reducing noise is termed "predistortion." It takes advantage of the fact that the energy distribution in music and normal speech is such that most energy is present in frequencies from a few hundred cycles to two or three thousand cycles, whereas very little energy is present in the higher audio frequencies. Thus it is possible to accentuate the quite high audio frequencies at the broadcast transmitter without appreciably increasing the modulation percentage, since the modulation is determined mainly by the lower frequencies. Having increased or "peaked" the high audio frequencies at the point of transmission, they may be, and in fact must be, correspondingly attenuated in the receiver so that the overall frequency characteristic from microphone to loudspeaker will be uniform. This type of predistortion will permit high-fidelity wide-band reception even though the overall audio characteristic of the receiver is purposely poor at the higher frequencies. Obviously this limitation of the receiver frequency characteristic is beneficial in reducing the amount of natural static and man-

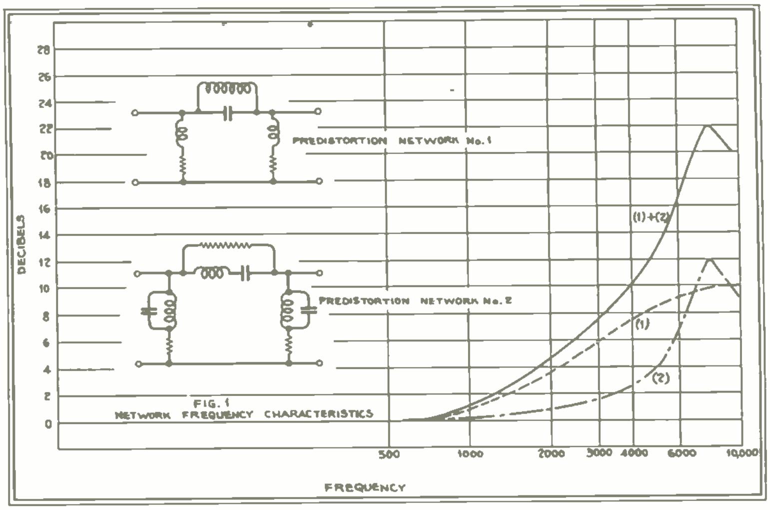


FIG. 1
NETWORK FREQUENCY CHARACTERISTICS

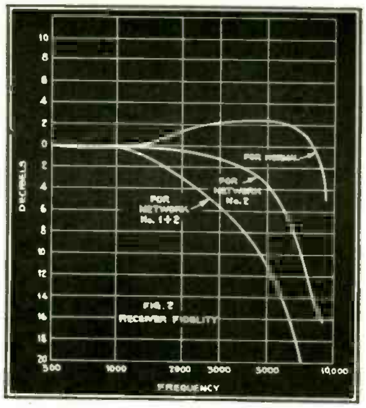
made static picked up by the receiver. Also, it reduces tube hiss originating within the receiver.

TESTS

Although it was known that the energy in the speech and music spectrum decreases rapidly above three or four thousand cycles, quantitative evidence as regards the instantaneous amplitude of high-frequency components was not very complete. Therefore a series of listening tests was considered desirable to find the practical extent to which the high frequencies could be peaked, as well as to demonstrate the overall advantages and disadvantages of the predistortion scheme. Therefore, tests were conducted in 1933 in cooperation with Doctor Wolff and Mr. Beers of RCA and Mr. J. G. Leitch, Technical Director of WCAU.

Predistortion networks were introduced between the studio and the 50-kw WCAU transmitter to obtain the desired characteristics. A cathode-ray modulation indicator was used at the transmitter to assist in holding the modulation percentage constant throughout the tests. Fig. 1 shows the circuits and frequency characteristics of the two predistortion networks. The input and output impedance of each network was between 450 and 500 ohms over the entire frequency range. These networks could be used either singly or in series, and an attenuation pad was associated with each so that when it was removed from the circuit an appropriate amount of attenuation was introduced to obviate the necessity of readjusting the modulation percentage. When both networks were in the circuit, a maximum relative gain or peak of 20 db was introduced at 7500 cycles.

The receiver used in making the listening tests was of the high-fidelity type with certain special controls. To obtain a given fidelity characteristic it was necessary only to adjust a special selectivity (not tuning) control until the desired fidelity was obtained. Tests were made to find the exact receiver settings required to give a comparatively flat overall frequency characteristic when the various predistortion-network combinations were used at the transmitter. Fig. 2 shows the overall electrical response of the receiver. Fig. 3 shows the overall electrical response of the entire system from microphone to loudspeaker input for normal operation, for a certain amount of predistortion and for the maximum amount (20 db) of predistortion. It is clearly seen that the overall frequency characteristics for these three conditions were essentially identical. The noise was varied, when desired, by producing controllable

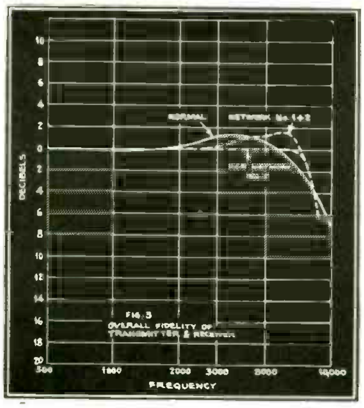


amounts of static with an interference device.

The following tests were made:

1. Using the maximum amount of predistortion at the transmitter, an ordinary 1933 receiver of good quality was tuned to WCAU and some normal types of programs were listened to. The considerable emphasis on the high frequencies did not lead to any disturbing effects, but, in fact, improved the program in the direction of increased fidelity. This was to be expected because the predistortion networks affected mainly those frequencies above several thousand cycles which were the very frequencies that were unduly attenuated by the 1933 receiver. With the higher-fidelity receivers available today there is no doubt that the predistortion signal would have sounded unpleasant unless the tone control of the receiver was set to appropriately attenuate the high frequencies.

2. Using velocity microphones at the transmitter, high-quality telephone lines and the special high-fidelity receiver, the predistortion networks were inserted and removed at two-minute intervals. The fidelity of the receiver was changed simultaneously with the insertion of the networks of the transmitter. Under this condition, very little change in the



fidelity of reproduction was noticeable, but the reduction in background noise was very apparent when networks No. 1 and No. 2 were used in series. A rough estimate, by listening, placed the reduction of background noise at 10 db. A calculation based on the exact frequency characteristic of the receiver indicated that the noise should have been reduced by 8 db. When networks No. 1 or No. 2 were used separately, the reduction in disturbing noise was noticeable but not outstanding.

3. A test was made to determine the adjacent-channel interference, since it was apparent that over-emphasis of the high audio frequencies in the transmitter would undesirably increase the sidebands most removed from the carrier. That is, the sidebands falling within the adjacent channels would be amplified. A receiver having selectivity approximately corresponding to the better receivers of today was tuned to a locally-supplied carrier 10-kc to one side of the WCAU carrier. The locally-supplied carrier was adjusted to have a strength equivalent to about three hundred microvolts and was modulated with a tone of very low-percent modulation for tuning purposes. Although no quantitative conclusions could be drawn from this test, it was evident that an acceptable amount of adjacent-channel interference during normal transmission became very objectionable when the transmission was switched to predistortion. This matter of adjacent-channel interference deserves further discussion.

ADJACENT-CHANNEL INTERFERENCE

The tests showed clearly that the application of predistortion at any single broadcast station would increase the high-fidelity service area of that station, but would simultaneously increase the adjacent-channel interference created by that station. Unfortunately the application of predistortion to *all* broadcast stations would increase interference to such an extent that in some cases the high-fidelity service areas would be *decreased*.

The interference produced in an adjacent channel by predistortion is somewhat similar to common high-pitched "monkey-chatter," but is more objectionable. With conventional transmission, where the greatest sideband energy is contained in the frequencies from one hundred to say four thousand cycles each side of the carrier, the major adjacent-channel interference is caused by the beating of these sidebands with the carrier in the adjacent channel. Obviously the beat frequencies that are

(*Continued on page* 13)

A NEW POWER AMPLIFIER

OF HIGH EFFICIENCY

By W. H. DOHERTY

Radio Development
Bell Telephone Laboratories

THOSE who are accustomed to operating vacuum tubes at the low power levels employed in wire transmission or in radio-receiving systems are frequently startled to learn of the extremes to which one must resort in the operation of power-amplifier tubes in radio transmitters. The transmitting tube, far from being operated over a small and linear part of its characteristic, is subjected to large alternating grid voltages which cause the plate current to be zero over approximately one-half of the radio-frequency cycle, and frequently to reach the saturation value determined by filament emission on the other half-cycle, with accompanying large grid currents. This extreme mode of operation makes possible much larger power outputs than could be obtained if operation were confined to the linear part of the tube characteristic.

W. H. DOHERTY.

Fig. 1 shows the circuit of a simple form of the conventional radio-frequency power amplifier, in which two tubes are connected in parallel and coupled to the transmitting antenna. The coupling circuit is so tuned as to be equivalent to a pure resistance load of the desired value over the relatively narrow transmission band occupied by the carrier and the side-frequencies due to modulation, while for frequencies much lower or much higher than the carrier, the impedance of the circuit is very low. Hence, although the radio-frequency plate-current wave contains large harmonic components due to the extremely non-linear operation of the tubes, only the fundamental component encounters any appreciable impedance, so that the plate-voltage wave is very nearly sinusoidal. The power delivered by the tubes to the circuit is therefore almost entirely at the fundamental frequency. High-quality amplification of a modulated wave then requires merely that the fundamental component of the plate current be proportional to the radio-frequency grid voltage. It turns out that if the tubes are biased nearly to the cut-off point, so that plate current flows only during the positive half-cycle of the alternating grid voltage, a close approximation to this requirement of proportionality is readily obtained.

Under these conditions, which are represented in Fig. 2, most of the plate current flows while the plate potential is near its minimum value, and if this minimum value is sufficiently low, i.e., if the amplitude of the plate-voltage wave is sufficiently great, the power lost in the tubes—which is proportional to the product of instantaneous plate voltage and current—will be small, and the efficiency correspondingly high. The efficiency is, in fact, very closely proportional to the amplitude of the plate-voltage swing. By permitting the plate voltage to swing down to a value as low as 10 or 15 percent of the applied d-c plate potential, large power outputs may be obtained at an efficiency of 60 to 70 percent; but unfortunately such large amplitudes correspond only to the peaks of modulation, and since these peaks at 100 percent modulation have amplitudes of twice the carrier amplitude, the plate-voltage swing for unmodulated carrier must not be more than half of its peak value.

The efficiency of the conventional power amplifier, then, is but 30 to 35 percent when the carrier is unmodulated, and only slightly more for the average percentage modulation of the usual broadcast program. An efficiency of 33 percent means that the d-c power supplied to the plate circuit of the amplifier must be about three times the carrier output, and two-thirds of this input power has to be dissipated at the anodes.

With power levels of 50 kilowatts and higher becoming almost commonplace in radio broadcasting, it has become very important to find means for increasing efficiency to reduce the cost of power. Since early in 1934 a succession of tests have been conducted at the Whippany Laboratory on a new power-amplifier circuit in which the usual practice of dividing the load equally between the tubes at all times was discarded. The idea was conceived that by obtaining the power from a reduced number of tubes up to a certain point—in particular, the carrier output—these tubes could be operated at this point at their maximum plate-voltage swing, and consequently at high efficiency; then if the remaining tubes were brought into action in a certain manner they would not only contribute to the output, but would so change the operating conditions for the original tubes as to permit the latter also to increase their output power without having to increase their output voltage.

Fig. 3 shows schematically the method of connecting the tubes to the load in the new high-efficiency circuit. V_1 and V_2 are two tubes that in the conventional amplifier might have been connected in parallel with a circuit whose impedance, for the fundamental frequency, may be represented by the resistance *R*. In the new circuit a network *N* is interposed between *R* and V_1, the tube which is to deliver the carrier power. This network is the equivalent of a quarter-wave transmission line, and like such a line has the interesting property that its impedance as measured at one end is inversely proportional to the impedance which is connected at the other end.

For all values of grid excitation from zero up to the carrier level, V_2 is prevented by a high grid bias from having any plate current, and the power is obtained entirely from V_1. The network *N* is so designed as to present to V_1 an impedance so high as to require this tube to operate at nearly its maximum possible radio-frequency plate-voltage swing in order to deliver the carrier power. The efficiency at the carrier output is accordingly high, and may be from 60 to 70 percent.

If we were to plot the current in the load impedance *R* against the radio-frequency voltage applied to the grids of the tubes, as in Fig. 4, the curve would be quite linear up to the carrier point A and then, if V_2 were not allowed to come into action, would flatten off along a path *AB* because the plate voltage swing on V_1 has attained its maximum value.

By permitting V_2 to begin coming into play at point *A* we obtain a twofold action: V_2 not only contributes power to the load, but in coming into play in parallel with *R* it effectively increases the impedance in which the network *N* is terminated. This increase in terminating impedance, by virtue of the inverse characteristic of this type of network, results in a decrease in the impedance presented to V_1, so that the radio-frequency plate current, and hence the power output, of V_1 may increase without any increase in its alternating plate voltage, which was already a maximum at point *A*. As the grid excitation on the tubes increases beyond its carrier value e_0, V_2 contributes more and more power to the circuit and thereby permits V_1 also to supply more power, until at point *C*, which corresponds to the instantaneous peak of a completely modulated wave, half of the power in *R* is being contributed by V_2. The network *N* is at that instant effectively terminated in *2R* ohms instead of the original *R* ohms, and the impedance presented to V_1 is half of its original value, permitting V_1 to deliver twice its original output power with no increase in its output voltage. The total power in the load, then, at the peak of modulation is the required value of four times the carrier power, corresponding to an increase in load current to twice its carrier value.

It is a characteristic of networks having the impedance-inverting property of network *N* that a definite current at either pair of terminals is associated with a definite voltage at the other pair of terminals, entirely without regard to the terminating impedances. From this rather remarkable property we may deduce that if the output voltage E_1 of tube V_1 is linear with respect to the grid excitation up to the carrier excitation e_0 of Fig. 4, and then remains constant up to the peak excitation $2e_0$, then the current I_3 fed into the load from network *N* behaves similarly, as shown in Fig. 5 (a); whence, in order to have the total load current I_4 linear with respect to grid excitation, the current I_2 fed into the load from tube V_2, which is zero at the carrier point, must rise linearly beyond this point and be equal to I_3 at the peak of modulation.

From this same property of network *N* we also deduce that if the voltage E_2, across the load and the second tube, is linear with respect to grid excitation, then the current I_1 fed into network *N* by tube V_1 must also be linear. Figs. 5(a) and 5(b) therefore give the complete picture of the conditions existing at the plates of the two tubes for all values of radio-frequency grid-input voltage to the amplifier, and the behavior of each tube during the modulation cycle may be studied by consider-

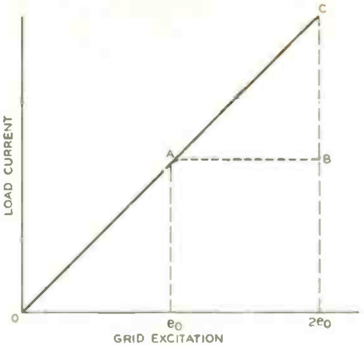
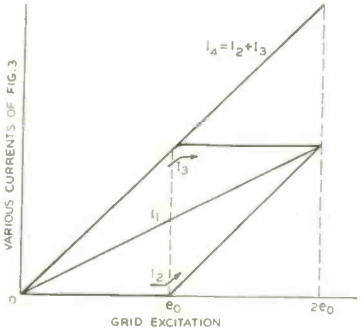


FIG. 4. IF SECOND TUBE DID NOT COME INTO ACTION AT E_0, LOAD CURRENT WOULD FOLLOW PATH OAB.

FIG. 5-A. CURRENT I_2, FURNISHED BY V_2, SUPPLEMENTS I_3, MAKING TOTAL LOAD CURRENT LINEAR WITH RESPECT TO GRID INPUT VOLTAGE.



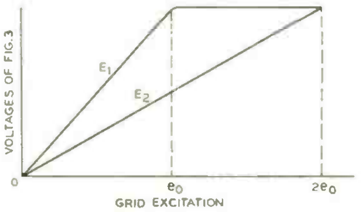


FIG. 5-B. AS GRID EXCITATION IS MODULATED ABOUT E_0, PLATE POTENTIAL OF V_1 DOES NOT RESPOND TO POSITIVE HALF-CYCLE OF MODULATION.

FIG. 2. MOST OF A POWER AMPLIFIER'S PLATE CURRENT FLOWS WHILE PLATE POTENTIAL IS NEAR MINIMUM VALUE. TUBE LOSS CAN BE MADE SMALL BY USING A LARGE PLATE-VOLTAGE SWING.

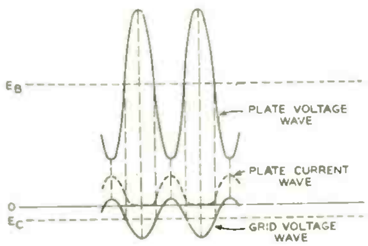


FIG. 1. R-F POWER AMPLIFIERS ARE COUPLED TO LOAD BY TUNED CIRCUITS WHICH PRESENT LOW-IMPEDANCE TO TUBES AT HARMONICS OF CARRIER FREQUENCY.

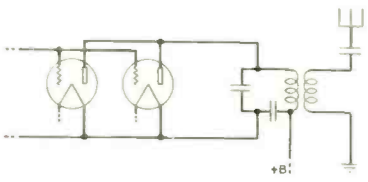
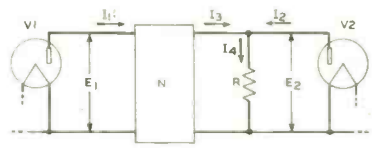


FIG. 3. IN THE HIGH-EFFICIENCY CIRCUIT, AN IMPEDANCE-INVERTING NETWORK, N, IS INSERTED BETWEEN ONE TUBE AND LOAD.



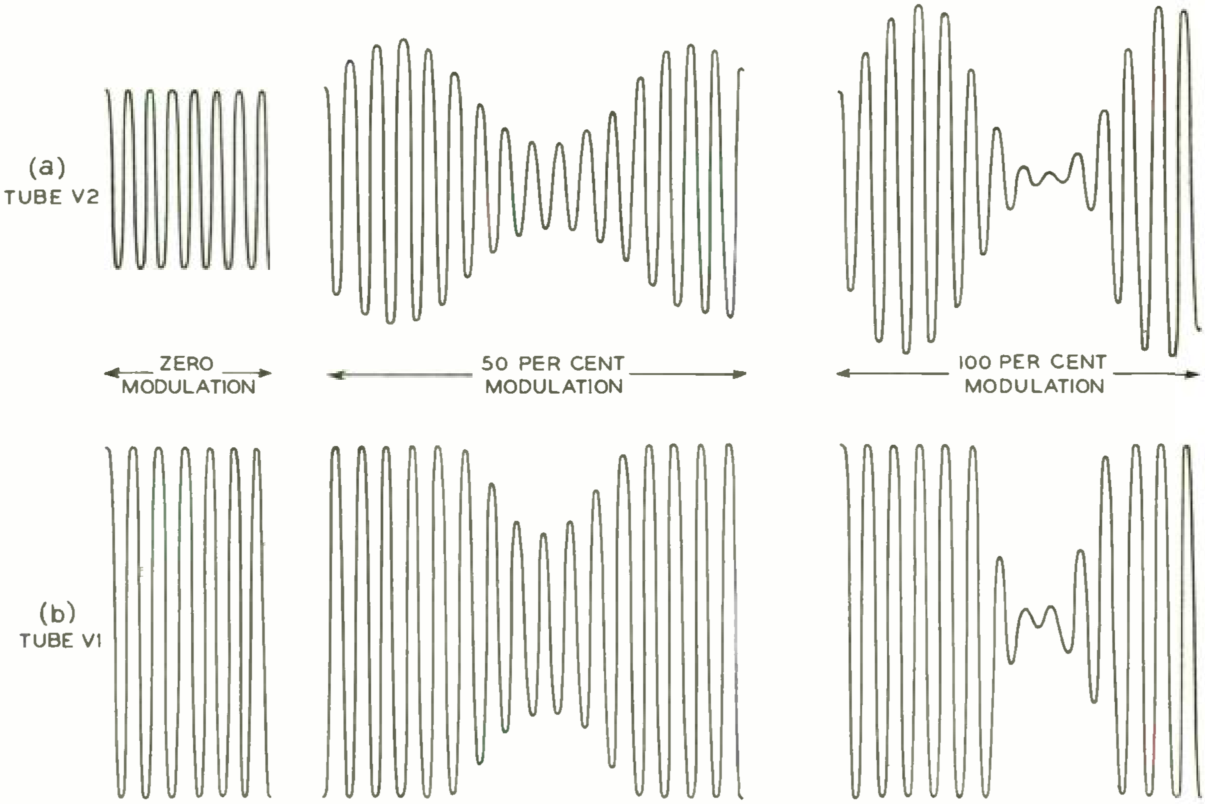


FIG. 6. CATHODE-RAY OSCILLOGRAMS OF PLATE POTENTIALS OF TUBES.

ing the grid excitation to vary at audio frequency about its average value e_0, to the extent corresponding to the percentage modulation.

When samples of the radio-frequency plate potentials on the two tubes during modulation are viewed on the screen of a cathode-ray oscilloscope the patterns are of the shape shown in Fig. 6. Patterns (a) represent the envelope of the plate potential of V_2, which, being directly associated with the load, is required to be sinusoidal when the modulating signal is a pure tone. Patterns (b) show the envelope of the plate potential of V_1, which, though sinusoidal over the negative half of the modulating cycle, is twice as high as that of V_2 over this range, and being unable to increase appreciably beyond its carrier value, remains flat during the upper half of the cycle of modulation.

The network N employed to obtain the impedance inversion may be one of a number of networks of which an example is given in Fig. 7. They always have a 90-degree phase shift, which means that the plate potentials on the two tubes are always in quadrature. This requires the insertion, in the grid circuit of one or the other of the tubes, of another 90-degree network in order that both tubes may be excited from the same source. The complete amplifier then assumes one of the forms indicated in Fig. 8.

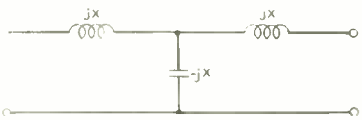


FIG. 7. A SECTION OF SIMPLE LOW-PASS FILTER AT 0.7 TIMES CUT-OFF FREQUENCY CONSISTS OF THREE EQUAL REACTANCES, AND HAS 90° PHASE SHIFT AND DESIRED IMPEDANCE-INVERTING CHARACTERISTIC.

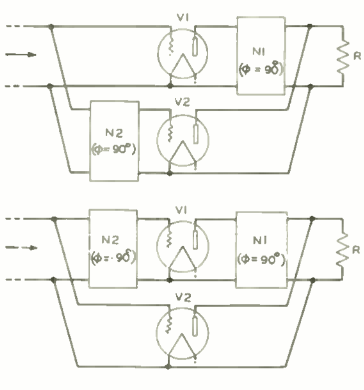
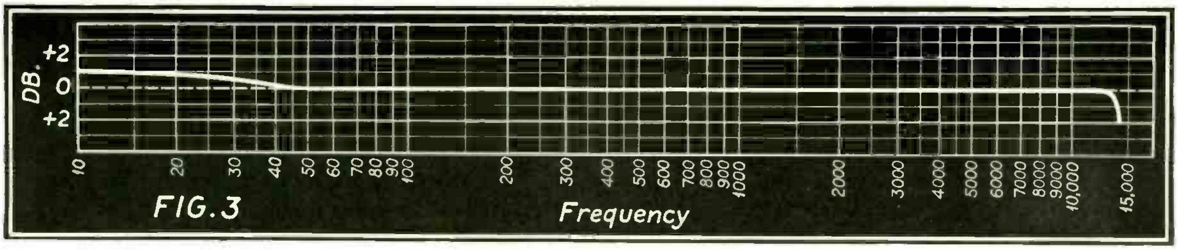


FIG. 8. WITH 90° PHASE SHIFT IN PLATE CIRCUIT OF ONE TUBE, A COMPENSATING PHASE SHIFT MUST BE INSERTED IN GRID CIRCUIT OF ONE OF TUBES SO THAT BOTH TUBES MAY BE EXCITED FROM SAME SOURCE.

The numerous tests conducted on the high-efficiency amplifier at various power levels have been uniformly successful, and the new circuit is being incorporated in the new high-power broadcasting equipment of the Western Electric Company. The overall efficiency obtained in the tubes and output circuits is 60 percent for unmodulated carrier and a few percent higher with complete modulation. This represents a reduction in the plate-power consumption of the final stage of a radio transmitter by nearly a factor of two, as compared with the power required by an amplifier of the conventional type. A 50-kilowatt amplifier, for example, with 33 percent efficiency, would require a d-c plate input of 150 kilowatts, of which 100 kilowatts would be dissipated at the anodes of the water-cooled tubes. With the new circuit the power input unmodulated carrier in 83 kilowatts, and the dissipation accordingly only 33 kilowatts, permitting a considerable saving in the water-cooling system as well as in power requirements.

(Continued on page 20)



THE FREQUENCY CHARACTERISTIC OF THE OSCILLATOR DESCRIBED IN THE ACCOMPANYING TEXT.

A BEAT-FREQUENCY OSCILLATOR

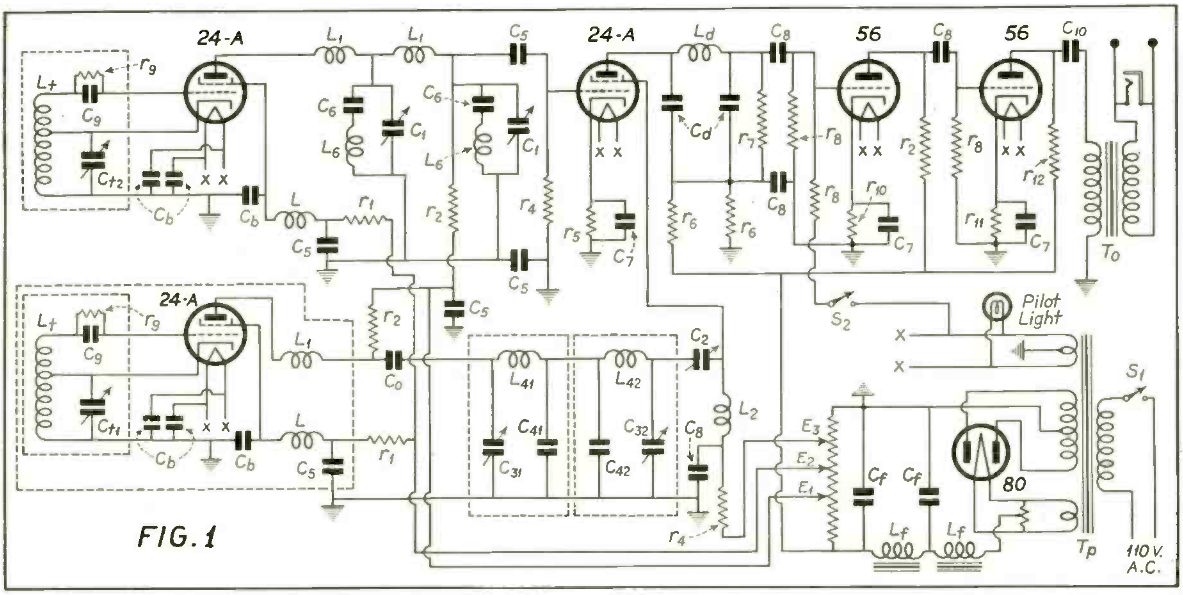
By L. B. HALLMAN, Jr.

THE UNQUESTIONABLE IMPORTANCE to sound and laboratory technicians of a readily variable source of audio frequencies, such as is provided in the beat-frequency oscillator, hardly warrants discussion. Such a source is essential to the satisfactory upkeep of any system of audio amplification. Practically all broadcast-transmitter performance measurements necessitate such apparatus and any radio engineer would, I dare say, place a good beat-frequency oscillator second in importance professionally only to his slide rule. The amount of published material dealing with the design or construction of beat-frequency oscillators is decidedly meager, however. It is the purpose of this article to present the results of several months of study and experiment in connection with the development of an oscillator suitable for the broadcast and sound technician.

REQUIREMENTS

The requirements of such an instrument are not necessarily the same as those of a precision laboratory instrument. The frequency range should extend upwards to at least 10,000 cycles. Somewhat higher frequencies are occasionally desirable, though not essential, for the application under consideration. Frequencies as low as 20 cycles are often useful. It is imperative for rapid work that the output voltage remain constant to within rather narrow limits throughout the frequency range. Harmonic content should be five per-

THE SCHEMATIC DIAGRAM OF THE BEAT-FREQUENCY OSCILLATOR.



cent or less. As a convenience in most installations the oscillator should be a-c operated and the power supply self-contained. Calibration should be accurate to within 2 percent.

The oscillator to be described fulfills these conditions. It delivers audio frequencies from below 10 to 14,500 cycles. The output is constant within one db from 10 to 13,000 cycles. The unit has a self-contained well-filtered power supply. After an initial warming-up period of 30 minutes the frequency is practically constant. The calibration may be checked and reset as often as desired, however, by using the 60-cycle frequency of the power source as a standard.

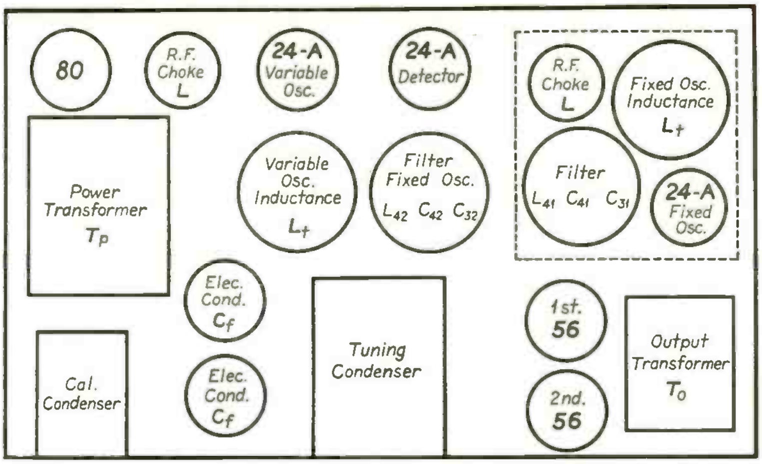


FIG. 2

THE BASE LAYOUT.

THEORETICAL CONSIDERATIONS

For the oscillator to deliver frequencies below 100 cycles, of satisfactory waveform, it is essential that the two r-f oscillators be well shielded and otherwise isolated from each other. Unless care is exercised as regards this point the two oscillators will tend to pull in step at low audio frequencies—that is, at frequencies where the two beating oscillators are only a few cycles apart.

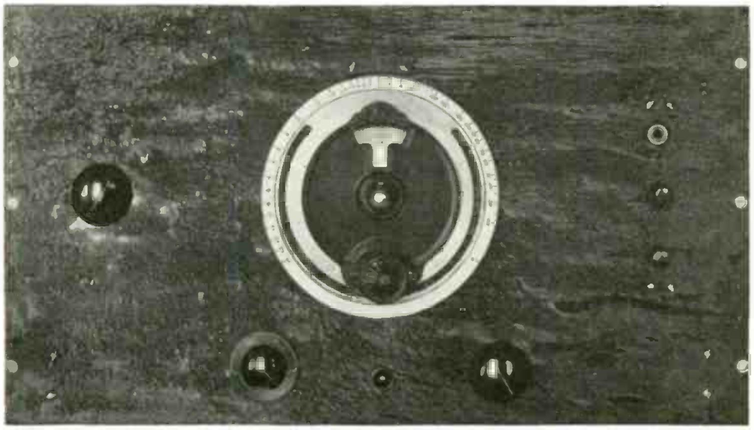
FIG. 5. THE TOP VIEW OF OSCILLATOR.

Brief consideration will show that the output audio voltage will tend to remain constant providing we make the voltage applied to the detector input by one of the beating oscillators much smaller than that applied to the other and hold the smaller voltage amplitude constant. Let A represent the amplitude of the higher voltage and B that of the weaker. Then the amplitude of the resultant voltage varies between $A + B$ and $A - B$. The amplitude of the audio component will then be proportional to $(A + B) - (A - B) = 2B$. That is to say, for a linear detector, the amplitude of the rectified beats is unaltered by a change in the amplitude of the higher voltage.[1] We may make the smaller voltage that of the fixed oscillator and the output is then more easily held constant as the frequency of the variable oscillator is shifted.

Aside from harmonics introduced by the detector and audio amplifier an important source of audio harmonics is that caused by harmonics of one r-f os-

[1]This is not rigorously true in practice since the demodulator characteristic is not linear, but over a portion of the usable range follows a parabolic characteristic. For this reason the audio output is to some degree proportional to the product of the two voltages, regardless of their relative amplitudes.

FIG. 4. THE FRONT PANEL LAYOUT.



cillator beating with those of the other. In general, if the order of the harmonic from one oscillator is n and that from the other m then if $25 < [nf_1 - mf_2] < 12{,}000$ an audio harmonic will exist in the output; f_1 is the fundamental frequency of one r-f oscillator while f_2 is that of the other. It is clear that if the harmonics from either oscillator are obliterated then the harmonics from the other oscillator can beat with no component to give an output in the audible range. Thus the danger of audio harmonics from this source is readily taken care of in most instances.

From purely mechanical considerations it is desirable to use a reasonably large tuning condenser to vary the frequency of the variable oscillator. Also, from the standpoint of frequency stability, it is essential that a reasonably large fixed capacity be used in the tuned circuits of both beating oscillators. A satisfactory compromise in these and similar factors makes essential the use of rather low frequencies for the two r-f oscillators, 150 kilocycles being a common value.

It is important from the standpoint of frequency stability that both r-f oscillators be constructed so as to be as nearly identical as possible. When constructed in this manner it is found that any outside factor affecting the frequency, such as voltage or temperature, will effect both oscillators to the same degree. Thus, although the frequency of both beating oscillators might be subject to change the audible beat, in which we are interested, tends to remain constant.

In designing the oscillator two factors were considered of paramount importance; namely, simplicity of layout and ease of obtaining component parts on the open market. Electron coupling for the oscillators is chosen because of the minimum of interaction between the load and oscillating circuits obtainable. Also the frequency variation with voltage variation can be made unusually small with this type oscillator. Electron coupling is also employed to couple the two oscillators into the detector. Triodes with resistance coupling are used in the audio amplifier. The fixed oscillator is adjusted to 147 kilocycles. A schematic of the complete unit is shown in Fig. 1.

The oscillator coils, L_1, were wound on a Morris coil winder using the larger cam supplied for the honeycomb or universal type winding. The coils consist of 188 turns on a 1½-inch tube wound with 7-38 Litz wire. The tap is taken off at 125 turns, with 63 turns in the grid coil. The 1½-inch form slips over a standard tube base which greatly simplifies the coil mounting. The entire oscillator coil assembly, consisting of the coils, fixed tuning condensers (0.002-mfd postage-stamp mica), grid condenser (0.002-mfd) and grid leak (10-megohm), is mounted above the chassis deck and shielded with a standard 2½-inch can. Leads are brought out below the chassis deck with four-pin tube sockets.

The tuning condenser shunted across the 0.002-mfd fixed condenser (C_{12}) consists of a National EC500. Calibration in the sub-100-cycle region is more uniform if the plates are reshaped.[2] Across this condenser we have connected a National SE50 midget to act as a calibrating condenser.

At this point it will be necessary to resort to a cut-and-try process to get zero beat when the main tuning-condenser plates are disengaged and the calibrating condenser set at about half. In this case it was found that an additional 0.00025-mfd shunted across the fixed oscillator condenser (C_{11}) did the trick. The exact value must be determined experimentally in each case, however. The bypass condensers, C_b, complete the oscillating circuits proper. They are 0.02-mfd micas.

The complete fixed oscillator including the oscillator coil assembly with can, tube, the first section of the filter C_{31}, C_{41}, L_{41} with its shield can and the r-f choke L_1 are all enclosed in a 5 x 5 x 6 inch electralloy can. This very effectively and economically isolated the fixed oscillator from the remainder of the circuit. The base layout shown in Fig. 2 illustrates the arrangement.

Anode chokes L are 250 millihenries. The L_1's are 80 millihenries, shielded, while the r_1's are 25 megohms and r_2's are 50 megohms, 2 watts. C_6's are 0.01-mfd 600-volt paper condensers. C_0 is a 50-mmfd mica.

The filter circuits deserve special consideration. A major difficulty in applying the electron-coupled oscillator to an instrument of this kind is the high harmonic content of the output waveform. This necessitates very careful filtering if the audio output is to be reasonably free of harmonics. The problem was most satisfactorily solved by using filtering networks in both the fixed and variable oscillators. A low-pass filter cutting off at 180 kc is used in the variable oscillator output. A sharply-tuned band-pass filter is used in the fixed oscillator.

The coils, L_{41} and L_{42}, of the band-pass filter have 150 turns. Otherwise they are wound and mounted in a manner similar to that described for the oscillator coils. L_{41}, C_{31} and C_{41} are mounted under the can inside the fixed oscillator shield (see Fig. 2). L_{42}, C_{32} and C_{42} are mounted under the can near the detector tube. C_{31} and C_{32} consist of 0.002-mfd fixed mica condensers shunted by 25-70 mmfd trimmers. C_{41} and C_{42} are 0.006-mfd fixed micas. C_2 is a 25-70 mmfd trimmer and L_2 is a 30-millihenry shielded r-f choke.

C_6 are 0.0007-mfd micas and L_6 are 175-kc i-f coils. The condensers C_1 are 25-70 mmfd trimmers. The adjustment of these condensers effects the audio-frequency characteristics of the oscillator. r_4 is 750 megohms. C_8 are 1-mfd paper condensers. r_5 is 50 megohms, 2 watts.

The filter in the detector output cuts off at approximately 15,000 cycles. L_d is a 250-millihenry r-f choke. C_d are 0.0008-mfd micas and r_7 is 12,500 ohms, r_6 is a 250-megohm 2-watt resistor, r_8 500 megohms, r_9 250 megohms, 2 watts.

The switch S_2 switches a 1.25-volt 60-cycle a-c component on the grid of the first a-f tube. This serves as a reference for setting the calibration of the dial at the 60-cycle point.

r_{10} is 3000 ohms and r_{11} is 2,500 ohms. Both are 2-watt resistors. C_7's are 25-mfd 60-volt dry-electrolytic capacitors. r_{12} is 50 megohms 2 watts. C_{10} is an 8-mfd 450-volt electrolytic capacitor.

Any high-quality triode-to-500-ohm output transformer will be satisfactory at T_0, the unit used being a U. T. C. LS-50.

The power-supply unit hardly requires comment, being of standard construction. The filter condensers, C_f, are each 16-mfd electrolytics. L_f are each 30 henrys. A 25,000-ohm variable voltage divider is used. E_1 is adjusted to 180 volts, E_2 to 100 volts and E_3 is set at 18 volts. T_p is a standard power transformer having 350-0-350, 5- and 2.5-volt (c.t.) windings.

When tuning the r-f filters connect an a-f voltmeter across the output terminals. First adjust C_{31} and C_{32} in the fixed oscillator band-pass filter for peak output. Next adjust C_1 in the variable oscillator low-pass filter until the output voltage is as nearly uniform as possible from 10 cycles to 14,000 cycles. Reasonable care in making this adjustment should provide an output constant to within approximately one db from 10 to 13,000 cycles. The frequency characteristic of the oscillator constructed is shown in Fig. 3. In making this adjustment the output transformer should be terminated in its correct load impedance.

The audio harmonics in this oscillator are not over five percent of the fundamental for frequencies between 30 and 14,000 cycles. It appears from measurements that the greater part of

[2] G. F. Lampkin, "Beat-Frequency Oscillator Control," *Electronics*, Vol. 5, No. 6, December 1932, p. 369.

the harmonic content is introduced in the audio amplifier. As the audio voltage applied to the amplifier is determined by the setting of the condenser C_2, it is clear that this adjustment is a critical one as regards the harmonic content of the output waveform. In this oscillator it was found that the output could not be pushed higher than +6 db (0.006-watt reference) without the harmonic content exceeding five percent over a portion of the range.

The dial used on the tuning condenser should receive special consideration. A six-inch aluminum disc attached to a National Type B vernier dial was used. This gives a satisfactory arrangement. However, there are several excellent six-inch vernier dials on the market that would be ideally suited to the purpose. The calibration should, as a matter of convenience, be marked directly in cycles on the dial. The calibration was marked with ink on a circular strip of drawing paper which was glued to periphery of dial.

The actual calibration may be made in a number of ways. The simplest, probably, is to obtain the use of an audio oscillator whose calibration can be relied upon to within one or two percent and use it as a standard. The outputs of the known and unknown oscillators are connected together across an a-c voltmeter. When the frequency of the unknown is near that of the standard the needle of the voltmeter will swing at a rate equal to the beat between the known and unknown frequencies. When the rate of swing becomes zero the two oscillators are in synchronism and the point on the dial of the new oscillator is marked to correspond with that of the standard. As a precautionary measure the 60-cycle reference point should be checked at frequent intervals during the calibration to be sure that any possible frequency drift is compensated by the calibrating condenser.

It is hardly necessary to go into further details as each reader will undoubtedly have individual ideas as to mounting and front-panel arrangement. However Figs. 4 and 5 should be of interest in showing the arrangement used. Fig. 4 shows the front panel. The main tuning dial is in the center with the calibrating condenser to the left. On the right we have output terminal and telephone jack. Below the dial, to the left, is the power switch, S_1. The pilot-light crystal is center while on its immediate right is located the calibrating switch S_2.

Fig. 5 gives a view of the chassis deck and rear panel with fixed oscillator shield cover partly removed. The various components are easily identified by referring to Fig. 2. The chassis base is 10 x 17 x 3 inches electralloy. A 10½ x 19 x 3/16 inch electralloy standard rack panel is used.

The fact that no volume control is shown will possibly bring objections. Experience in this connection indicates that it is more satisfactory to use a 500-to-500-ohm variable T pad in the output. The variable pad and output voltmeter, calibrated in decibels, is built into a separate unit. If the builder desires, this too can be incorporated in the oscillator proper. A separate unit containing, in addition to the variable pad and meter, several fixed pads of convenient losses and output impedances has been found desirable. The decibel meter can be made to do double duty by connecting to a d-p-d-t switch so that it can be quickly switched either to the oscillator output or to the amplifier output whose characteristic is being measured.

APPLYING PREDISTORTION TO BROADCASTING

(*Continued from page* 6)

heard tend to be six thousand cycles and higher. The resulting sound is the familiar monkey-chatter. In the case of predistortion transmission, however, the sideband energy radiated at seven thousand to ten thousand cycles each side of the carrier is exceptionally great. Thus the beats with the adjacent-channel carrier will include frequencies between zero and three thousand cycles where the sensitivity of the ear is high. The resulting noise is an extremely intermittent and undesirable guttural growl. Since this unpleasant sound consists largely of frequencies of 3000 cycles and below, it is apparent that the attenuation of the higher frequencies in the receiver does not alleviate this difficulty.

Thus we may conclude that if predistortion were universally applied to all transmitters in the present broadcast channels, the high-fidelity range of certain stations, especially high-power stations, would be increased in those cases where the adjacent channels contained only very weak signals incapable of producing interference in the desired channel. Conversely, the universal application of predistortion would decrease the high-fidelity range of those transmitters where the adjacent channels already contained signals of sufficient intensity to make monkey-chatter the present determinant of the service range. Unfortunately this is frequently the case. Thus it may be concluded that the universal adoption of predistortion in the present American broadcast channels would not be advantageous.

If broadcast-channel assignments were spaced more than 10 kc, as certainly will be the case with ultra-high-frequency broadcasting[1], any adjacent-channel interference would be of the straight crosstalk type rather than the monkey-chatter type and thus would not be adversely affected by the adoption of predistortion. Consequently it may be concluded that the application of predistortion to any broadcast system where the adjacent channels are spaced by 20 kc or more will result in an appreciable improvement in the signal-to-noise ratio. An improvement of approximately 8 db could be obtained. This would correspond to an increase in transmitter power of 530 percent. Receivers not designed for predistortion but having tone controls or other means of appropriately attenuating the high audio frequencies would receive at least as satisfactory a signal from predistortion transmitters as from conventional transmitters.

[1] See italics near end of April, 1936, editorial.—Editor.

IRE CONVENTION

THE ELEVENTH ANNUAL CONVENTION of the Institute of Radio Engineers was held at the Hotel Statler in Cleveland, Ohio, on May 11, 12 and 13, registration beginning on Sunday, May 10. The estimated enrollment on May 11 was 400, the final registration probably exceeding 500. An official welcome was delivered by President Alan Hazeltine, Mr. R. M. Pierce, Chairman of the Cleveland Section, and Mr. K. J. Banfer, Chairman of the Convention Committee.

The technical sessions began with an interesting paper on *High-Speed Motion Pictures of Mercury-Vapor Tube Operation.* This paper, delivered by H. W. Lord, discussed the motion of a cathode spot on the mercury pool of a thyratron tube used primarily for welding purposes. The pictures showed in slow motion the formation of the cathode spots over individual cycles.

RADIO TRANSMISSIONS

Two types of interruptions in high-frequency radio transmission have recently been observed, according to J. H. Dellinger. One type, a sudden and short-time interruption of the intermediate high-frequency transmission over the daylight side of the globe, is caused apparently by a temporary excessive absorption in the lower ionosphere. The other type of disturbance, a lowering of the maximum useful frequency for communication, is more protracted and is caused by a decrease in the maximum ionization density in the F_2 region of the ionosphere, accompanied by an increase in the virtual height of this region.

Mr. Dellinger discussed the low broadcast fields on frequencies of from 530-1300 kc which were obtained in this country from Europe as compared with fields obtained elsewhere from these same stations. General fields of 5-10 microvolts per meter were expected and fields of only 0.01-1 microvolt per meter were received. In order to get sufficient fields these tests were made on European broadcast stations between the hours of 6 and 9 a.m., European time, during the months of December and January. Fields from Argentine stations were about as expected.

Mr. Kirby of the National Bureau of Standards discussed some *Recent Investigations of the Ionosphere.* As between 1934 and 1935 there is a large difference in the critical frequency for the months of October, November and

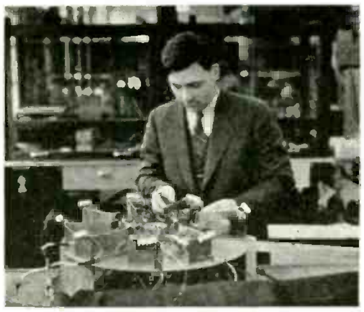


FIG. 2. P. D. ZOTTU DEMONSTRATING AN 8-TUBE ULTRA-HIGH-FREQUENCY OSCILLATOR.

December of 1935, and January 1936, being much higher in the more recent months with the advancing sunspot cycle. In general, too, the critical frequencies are higher in those months than for the summer months. For actual disturbed days, however, the critical frequencies are lower and the virtual heights higher. Results over several years indicate that the critical frequency is increasing with the advance of the 11-year sunspot cycle.

U-H-F HIGH-POWER TRANSMITTER

Considerable interest was evidenced in the ultra-high-frequency high-power transmitter described by John Evans. This transmitter is in the frequency range of forty to sixty megacycles with a final amplifier using AW-200 vacuum tubes, having a useful power output of approximately forty kilowatts for the Class "C" condition of operation. The frequency stability is in the order of 0.001 percent for changes of anode voltage of 20 percent and for changes of ambient of positive forty degrees Centigrade and for filament-voltage variations of 5 percent without recourse to the use of piezoelectric devices. The stabilizating of frequency is accomplished by the use of refined circuits involving short transmission lines. The transmission line used as the stable tuned circuit instead of a crystal consisted of a copper tube closed at each end. From the top and inside the tube was suspended an invar rod. This rod, in turn, supported at its lower end two copper conductors which were supported at the top and attached to the end of the outside tube. The outside tube was grounded through a resistance, the power tube being connected to the inner copper conductor. Various combinations and variations of this scheme were covered including push-pull arrangements.

POLICE RADIO

Also of interest was a two-way, ultra-high-frequency, police-radio system described by Stewart Becker, who also discussed the general problems and limitations encountered in two-way police communication. The desirable features of duplex operation were given as follows: (1) break-in permitted, (2) time element much shorter, (3) no switching elements, (4) car-to-car communication through headquarters permitted.

A headquarter's station antenna was described. It consisted of a vertical half-wave radiator with a $\lambda/4$ impedance match. The power was coupled between the center of a U-shaped impedance-matching section and a selected point up one leg of this section. See Fig. 1.

In general the headquarter-station transmitters have powers ranging from 15 to 150 watts, all being crystal-controlled with exception of 15-watt unit.

The car receiver described was a

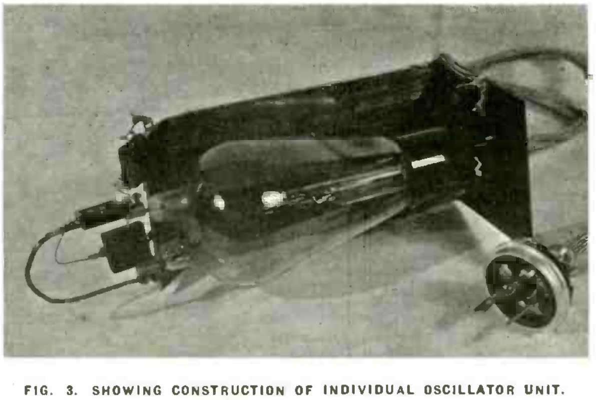


FIG. 3. SHOWING CONSTRUCTION OF INDIVIDUAL OSCILLATOR UNIT.

fixed-tuned unit and was a combination superheterodyne and super-regenerative. The intermediate-frequency of the superheterodyne amplifiers is from 8000-9000 kc, the receiving frequency, of course, being 30-40 mc. The frequency was then stepped up to 25,000 kc and fed into the super-regenerative part of the receiver.

MULTI-TUBE U-H-F OSCILLATOR

Next on the program was a multi-tube ultra-high-frequency oscillator. In the introduction of this paper, Mr. P. D. Zottu pointed out certain limitations to obtaining ultra-high-frequency power out of tubes . . . and that it is a case of balancing "dissipating ability" against dimensions. The greater part of the paper was concerned with the general problems of coupling a number of independent oscillators together sufficiently to pull them into step. A demonstration of a number of oscillator tubes mounted on a circular plate was given. Referring to Fig. 2 it will be seen that there are eight oscillator units resting on a brass plate. The construction of the individual unit is shown in Fig. 3. In the center of the metal plate is mounted a low-loss circuit tuned to 120 cm. Each oscillator unit has its oscillating circuit between the grid and plate, which is tuned to approximately 120 cm. A connection is made from each oscillator unit to the common low-loss circuit in the center. This serves to transfer the energy from the oscillator to the common low-loss circuit. Due to the common coupling the separate oscillators are made to pull in step, and, consequently, only one frequency is generated. With eight RCA-834 type tubes and 500 volts on the plates, an output of 80 watts at 120 cm with an efficiency of 20 percent was obtained. This efficiency is the same as that obtained from a push-pull type of oscillator with RCA-834 type tubes under the above conditions.

AVC

On Tuesday Mr. D. S. Bond presented a paper on *Effects of AVC upon the Measurement of Selectivity of Radio Receivers*. This paper dealt with several different types of avc circuits. Selectivity curves of each circuit were shown. The simplest circuit consisted of an intermediate-frequency amplifier

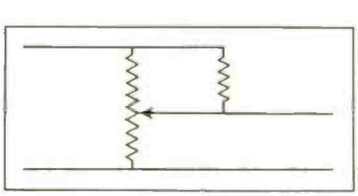


FIG. 4. A SIMPLE COMPENSATING CIRCUIT.

with a band-pass filter, the output of which was fed partly into an indicating device and partly into the avc amplifier which supplies the gain-control biasing circuit.

AFC

One of the most interesting papers presented at the convention dealt with automatic tuning and was discussed by S. W. Seeley. This paper was entirely too long to be discussed in any detail here. However, we refer our readers to the comprehensive description contained in the May issue of *Radio Engineering*.

AURAL COMPENSATION

Also of interest to radio receiver engineers was a paper presented by C. M. Sinnett on *Aural Compensation*. Mr. Sinnett determined from Fletcher's curves of aural response the amount of aural compensation necessary at various frequencies at various levels. Simple

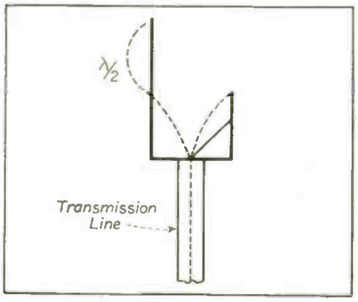


FIG. 1. A POLICE-RADIO HEADQUARTER'S STATION-ANTENNA.

compensating circuits were shown, one consisting of a resistance network alone (see Fig. 4) and one including inductances and capacities (see Fig. 5). Slides were shown depicting a simple bridge-type of expander, and a push-pull triode method.

DOHERTY AMPLIFIER

Probably the most outstanding paper presented at this convention dealt with *A New High-Efficiency Power Amplifier for Modulated Waves*. This paper was presented by Mr. W. H. Doherty. A complete article on this amplifier will be found elsewhere in this issue.

TRANSMITTING TUBES

Mr. W. G. Wagener gave some simplified methods for quickly computing with reasonable accuracy the performance of transmitting tubes in the usual radio-frequency and audio-frequency applications. More exact methods, making full use of tube characteristic curves, were indicated. Simplified methods were illustrated by calculations on a standard tube.

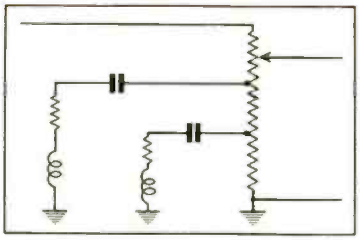


FIG. 5. A COMPENSATING CIRCUIT.

SHUNT-EXCITED ANTENNA

In presenting a paper on a shunt-excited antenna, Mr. J. F. Morrison indicated some of the advantages of using a grounded antenna with the lower portion used as a coupling impedance. Simplified schematic diagrams of the base-insulated and the non-insulated, or shunt-excited, antennas are shown in Fig. 6. The impedance of the base-insulated antenna is in series with the coupling circuit which must therefore either be especially designed for each installation or provided with sufficiently liberal adjustment features to allow it to meet the wide range of antenna characteristics. With shunt excitation, the antenna impedance is divided into two parallel sections by the coupling connection. This allows considerable control of the equivalent antenna impedance by proper selection of the point connection, and thus simplifies the coupling circuit. This method of excitation has no appreciable effect on the radiation characteristics of the antenna, but leads to a number of simplifications and economies.

ELECTRON OPTICS

The electron beam of a television cathode-ray tube is focused by means of an electron optical system of two coaxial cylinders. D. W. Epstein treated such a focusing system. Theoretical curves were presented giving the optical constants of the lenses equivalent to two coaxial cylinders of various diameters and at various voltages. A method of measuring these optical constants was briefly described. The approximation involved in substituting thin lenses was discussed and a simple method for the experimental determination of the location and focal lengths of the thin lens was given. It was shown that in a well designed tube, spherical aberration is the only aberration damaging spot size.

CATHODE-RAY TIME AXIS

A cathode-ray time axis for high frequencies was covered by L. M. Leeds. His paper discussed the use of a cathode-ray oscilloscope capable of operating up to 30 mc. The general schematic

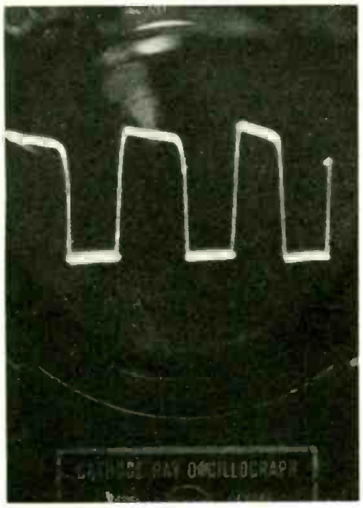


FIG. 10. THE OUTPUT VOLTAGE OF A SQUARE-WAVE GENERATOR.

of the timing circuit is given in Fig. 7. Briefly, the sweep circuit operates on only one part of the cycle so as to sweep in only one direction across the screen.

NOISE CHARACTERISTICS

According to Mr. Landon, noise may be divided into two classes: smooth noise such as that due to thermal agitation and tube hiss, and noise due to impulse excitation from widely separated impulses. There are, of course, noises which cannot be placed in either classification having characteristics midway between the two types. This latter type is the most difficult to deal with.

Smooth noise of the thermal-agitation type is uniformly distributed throughout the radio spectrum. As a result the hiss power output of a radio-frequency amplifier is proportional to the frequency bandwidth. It follows that the rms voltage output is proportional to the square root of the bandwidth. However, the variation of peak amplitude with bandwidth is not so easy to predict.

It is felt that Mr. Landon's paper is of sufficient interest to warrant the following brief abstract:

No method of calculating peak values has been developed, so the facts had to be found by experiment. To do this, a two-channel, high-gain, r-f amplifier was built. Each channel has five stages of amplification, with two tuned circuits per stage. One channel had a bandwidth of 4.1, and the other a bandwidth of 61.9 kc at 90 percent of the amplitude of the central frequency which was 150 kc in each case. The shape of the two selectivity curves is the same.

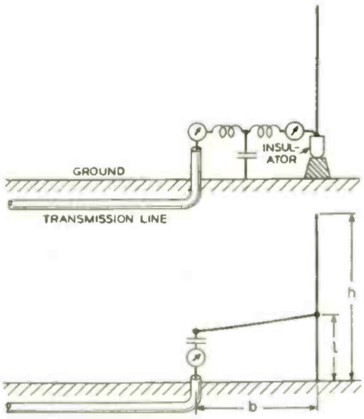


FIG. 6. SCHEMATIC DIAGRAMS OF BASE-INSULATED AND NON-INSULATED ANTENNAS.

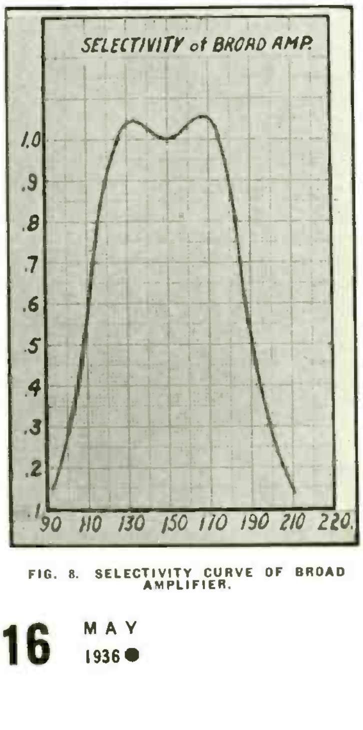


FIG. 8. SELECTIVITY CURVE OF BROAD AMPLIFIER.

The two channels are placed in operation alternately, by switching the B supply from one to the other. To minimize the chance of regeneration, a cascade resistance-capacity filter is used on the B supply. With this circuit the filtering of the first tube is improved by the filter for the second, etc. Each stage was separately shielded by a can over the transformer windings and a separate can over the tube and transformer constituting one stage. A bottom was made to shield against plate lead to plate lead feedback, but was found unnecessary. The available gain was about 50 per stage on the sharp amplifier and 25 per stage on the broad. This was more than enough to overload the final r-f amplifier tube with hiss, so that full gain could never be used. For most measurements four stages were found to be sufficient, and the first was disconnected. No trouble was experienced with regeneration, except when unduly long input and output leads were used, producing overall feedback.

The selectivity curves of the two amplifiers are given in Figs. 8 and 9. The ratio of bandwidths is approximately 15 to 1. The bandwidth of each varied slightly from time to time under different conditions. In each experiment, calculations were based on bandwidths as measured during that experiment. At all times the first tube of the amplifiers is the source of the noise being measured. This tube was moved from one channel to the other to insure the same effective noise input.

The output of the two channels feeds separate diode detectors which have a common audio amplifier connection. The bias on the diodes may be varied so that peaks have to exceed the bias before anything is heard.

In the first experiment the amplification of each channel was adjusted so that the highest peaks of hiss were barely audible with 22 volts bias on the diodes. The amplification of each channel was then measured and the ratio of gains compared to the ratio of bandwidths, and to the square root of the ratio of bandwidths.

The ratio of gains was 4.4 the ratio of bandwidths 15.1, and the square root of the bandwidth ratio 3.89. On a recheck at a lower gain, the square root of the ratio of gains was 3.85. This indicates that the peaks of hiss vary as the square root of the bandwidth, just as the rms value does. If the term crest factor is defined as the ratio of the amplitudes of the highest peaks to the rms voltage the indication is that this factor is a constant. However, the accuracy of this experiment is not very great, due to the difficulty of measuring such high

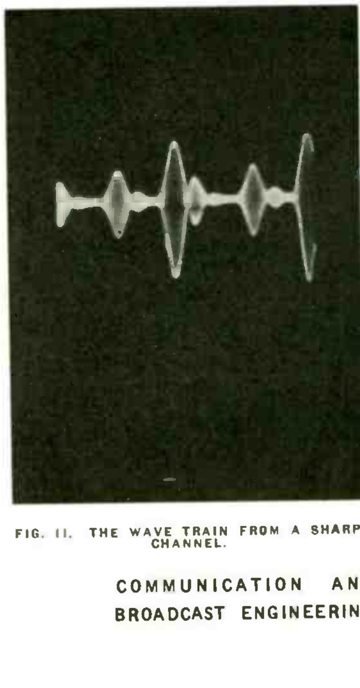


FIG. 11. THE WAVE TRAIN FROM A SHARP CHANNEL.

gains accurately. Hence it was decided to measure the crest factor directly.

In a second experiment, a tube voltmeter was connected across the diode circuit and moved from one side to the other when changing channels. This tube voltmeter is of the plate curvature type, with a bucking battery.

The gain of each channel was adjusted until the tube voltmeter read 2-volts of hiss. The diode bias was then increased until the noise barely disappeared. The bias required was exactly the same for the two channels, being 7.7 volts for silence, 7.3 volts for a few clicks per second, and 5-volts as the dividing line between a smooth and a rough hiss. The current in these diodes starts at —.9 volt, hence this figure must be subtracted from the biases given above to indicate peak values. This gives a crest factor of 3.4.

Thus we are led to the somewhat surprising result that the highest peak voltages in hiss are not more than 3.4 times the rms value, and that this ratio is independent of bandwidth. It is of some interest to note that an independent investigation by Mr. M. G. Crosby at Riverhead gave similar results except that a somewhat larger value was obtained for the crest factor. Mr. Crosby's factor was 4.47 instead of 3.4.

With irregular noise the original source is almost always equivalent to Heaviside functions repeated at irregular intervals. The voltage applied to the antenna may consist of pulses of varying shape and duration, but this is usually due to circuits at the source of noise applying a certain amount of frequency discrimination to the original Heaviside function pulses. Usually the circuits in the receiver are considerably sharper than any that may be present in the noise source. Hence, the shape of the envelope of the wave train in the output of the amplifier is usually almost independent of the waveform of the exciting voltages, provided the pulses are separated in time sufficiently to avoid overlapping decay trains.

The shape of the envelope of the wave train in the output of an r-f amplifier is then a function of the circuits of the receiver, and is subject to calculation on the basis of Heaviside function excitation.

A mathematical analysis leads to the conclusion that the amplitude of a wave train, due to impulse excitation, is proportional to the first power of the bandwidth and not to the square root of the bandwidth, as with smooth hiss. This

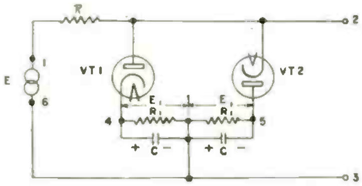


FIG. 7. SCHEMATIC OF TIMING CIRCUIT OF A CATHODE-RAY OSCILLOSCOPE.

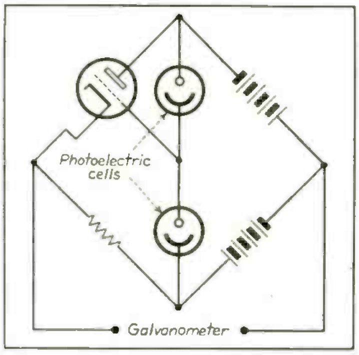


FIG. 14. A DIRECT-CURRENT AMPLIFIER.

apparent discrepancy made experimental confirmation desirable.

A preliminary experiment was made using the buzzer rectifier of an auto set to generate impulses. This gave results which are fairly consistent with what follows, but the buzzer contact was too irregular to make accurate measurements possible. Hence, a vacuum-tube impulse generator was thought desirable.

A square-wave generator was made, using a one-tube relaxation oscillator and a limiter to cut off the peaks. The frequency could be varied over wide limits by changing the setting of the gang condenser used in the resistance-capacity feedback network. The wave shape of the output voltage of this unit is shown in Fig. 10.

It is evident that the sides of this "square wave" are not sufficiently steep

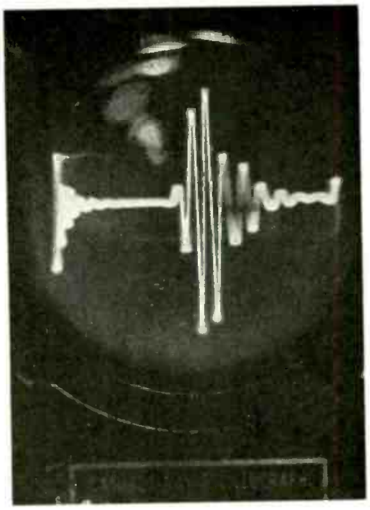


FIG. 13. THE OUTPUT OF A BROAD AMPLIFIER.

to simulate a Heaviside function to any great degree of accuracy. It is, however, a source of impulses which repeats with much greater regularity than any mechanical device.

It was found possible to synchronize the oscillograph scanning with the impulses so that the decay train appears to be stationary on the screen. Fig. 11 is a photograph of the wave train from the sharp channel. The large diamond-shaped figure followed by two "beads" of decreasing size is the wave train due to the up stroke of Fig. 10. The similar sequence of lesser amplitude is that caused by the down stroke, which is less effective in exciting the amplifier.

Fig. 12 is a photograph of the corresponding wave train from the broad amplifier, with reduced gain. This il-

(*Continued on page* 23)

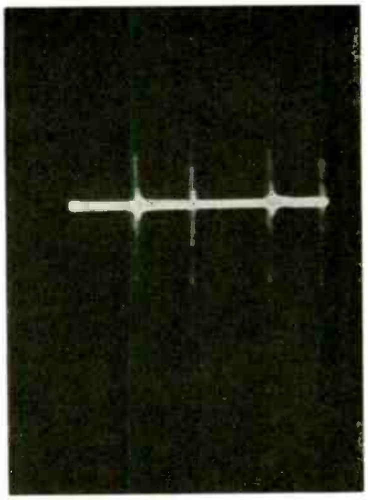


FIG. 12. THE WAVE TRAIN FROM A BROAD AMPLIFIER.

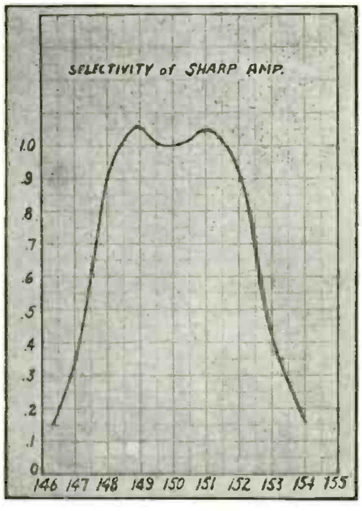


FIG. 9. SELECTIVITY CURVE OF SHARP AMPLIFIER.

BOOK REVIEWS

ENGINEERING HANDBOOK OF THE NATIONAL ASSOCIATION OF BROADCASTERS, by James C. McNary, published by the National Association of Broadcasters, National Press Building, Washington, D. C., price $10.00.

The "NAB Engineering Handbook," which has only recently been prepared and which is being furnished to member stations, is a collection of technical information dealing with broadcast problems. It has been prepared in a readily usable form. Loose-leaf arrangement has been provided for this handbook so that additional data may be incorporated from time to time.

Section A of this handbook has nine pages of text dealing with the subject of wave propagation. In addition, twelve full-page charts are provided on this subject. Day propagation and night propagation of waves for both low frequencies and high frequencies are included.

Section B also deals with the subject of wave propagation and more particularly with Rolf's graphs for ground-wave propagation. Attenuation curves, derived from Rolf's graphs, are given in the first seventeen charts. These are for values of ϵ (dielectric constant of the earth in electrostatic units) from 5 to 20 inclusive and for $\epsilon = 81$ (sea water). These curves are applicable to any frequency within the range ordinarily used for medium-frequency or low-frequency broadcasting. The earth-curvature correction factor is indicated in the eighteenth chart. Also several families of curves representing ground-wave field intensities at various distances for various frequencies are given in the remaining seven charts.

Next is a general section on wave propagation and consists of a chart of *radiation angle* versus *distance at which sky wave returns to earth* (single reflection).

Other sections are devoted to non-directional antennas, transmission lines, directional antenna arrays, pads and attenuators, and FCC empirical standards and rules and regulations, the last three sections being quite comprehensive in scope.

The "NAB Engineering Handbook" provides data on which little authoritative collected information has previously been available in a readily usable form. The information was originated or compiled by James C. McNary, Technical Director of the NAB, who deserves commendation for this work.

PHENOMENA IN HIGH-FREQUENCY SYSTEMS, by August Hund, published by the McGraw-Hill Book Company, Inc., 330 West 42 Street, New York City, N. Y., first edition, 642 pages, price $6.00.

Phenomena in High-Frequency Systems is a reference book that is written for the student and the instructor, as well as for those engaged in research. This book covers its subject matter in a critical manner, presenting the principles and fundamental laws applying to high-frequency apparatus and systems, together with a thorough discussion based on experimental evidence. The following, which is quoted from the author's preface, is an accurate summary of this book:

"Inasmuch as the title of this book is 'Phenomena in High-Frequency Systems,' not only high-frequency phenomena are dealt with, but also phenomena in parts of apparatus and systems which are used in the radio-frequency as well as the communication field. It was the aim to give a thorough, up-to-date discussion of phenomena occurring in high-frequency systems with many applications to problems arising in communication engineering. Phenomena and actions in tubes are discussed with respect to basic principles, without too much stress on tube design, which may change from time to time. Phenomena in filament—as well as filamentless—tubes are dealt with in detail. A discussion of piezoelectric phenomena, correlating the pioneer work of Voigt with present-day findings and applications, is presented. Ionic and electronic oscillations within tubes as well as within ionized regions of the upper atmosphere are discussed in detail."

Phenomena in High-Frequency Systems is an excellent book. It is highly recommended.

MEASUREMENTS IN RADIO ENGINEERING, by F. E. Terman, published by the McGraw-Hill Book Company, Inc., 330 West 42 Street, New York City, N. Y., first edition, 400 pages, price $4.00.

The purpose of this book is to present a comprehensive text on the measuring problems usually encountered in radio engineering work. The degree of difficulty and the method of handling are much the same as in the author's well-known book *Radio Engineering*. As a matter of fact, these two works may be considered as companion volumes, the earlier book being devoted to the general principles of radio, while this one deals with measuring apparatus and methods.

The following measuring problems are discussed in this book: voltage and currents; power output and power level; resistance, capacity and inductance; frequency; vacuum-tube coefficients; tube characteristics; amplification; amplitude distortion; transfer constants; receiver performance; modulation; field strength; antennas; and others.

Concerning instruments, the following measuring devices are covered: rectifier instruments, the multivibrator, vacuum-tube voltmeters, bridges, thermocouples, wavemeters, harmonic analyzers, signal generators, oscillators, and cathode-ray tubes.

This book places emphasis on methods which have proven to be practical, and considerable attention is given to the principles involved in the design and construction of laboratory equipment.

Measurements in Radio Engineering is intended for use as both a reference and as a textbook. It is recommended for these purposes.

THE STORY OF INDEPENDENT TELEPHONY, by Harry B. MacMeal, 4727 Montrose Avenue, Chicago, Illinois, published by the Independent Pioneer Telephone Association, 304 pages, size 5¾ inches by 8½ inches, cloth bound, price $3.00.

Harry B. MacMeal, founder of *Telephony* and its publisher for many years, has presented in *The Story of Independent Telephony*, the history of the beginnings of the Bell telephone, and the origin and progress of independent telephony.

For a background, the first three chapters of the book cover the origin of the telephone, Alexander Graham Bell, and Bell developments under monopoly. The main story presented, however, begins in 1893 with the coming of the independents. The book closes with a review of the 14,000 independent exchanges now in service and the manufacturers serving them.

The Story of Independent Telephony is written in a plain, understandable manner. It is both easy and interesting to read.

AIRPORT-STATION ANTENNAS

By ROBERT C. MOODY

THE SIMPLICITY of operation of aircraft receivers and transmitters and the modest knowledge required for a third-class radiotelephone operator's license, have tended to greatly increase the number of radio-equipped private planes, bringing a consequent increase in the number of transmitter-equipped airports catering especially to itinerant and private planes. Unlike broadcast and commercial installations, the location of airport transmitters is usually a fixed quantity and the choice of a good location relegated to pure chance. Restrictions in antenna design are almost inevitable. The following enumeration of limitations will serve to present the problem in a more orderly manner:

1. Airport stations are licensed for a maximum of 15 watts and on a frequency of 278 kc.

2. An antenna to be efficient at 278 kc must be of rather large proportions.

3. The low-power limit makes an efficient antenna necessary if reasonable service is to be had.

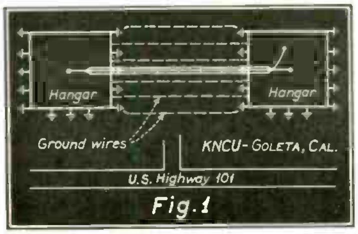
4. The ratio of antenna cost to transmitter cost must be kept within reason. This makes the outlay for an antenna quite small.

5. An antenna of very great height constitutes a hazard, frowned upon by Department of Commerce Inspectors, pilots, and consequently airport managers.

6. If, as usual, more than one runway is provided at an airport, the direction of approach for planes will be a large portion of a circle, restricting the antenna location to the remainder of the circle. When the antenna is of satisfactory dimensions this is a serious limitation.

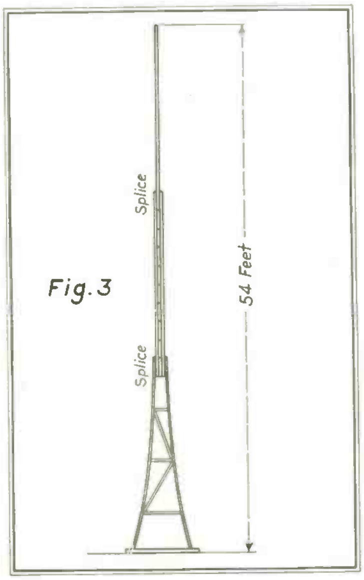
7. Airports are not usually in favor of plowing up their runways for laying a ground network.

8. The common sheet-metal hangar, unless thoroughly grounded, is a high absorption area.



In the two installations to be described, the above limitations were either answered or a satisfactory compromise worked out. Possibly the problem of the engineer, confronted with such an installation, will be lessened by this description.

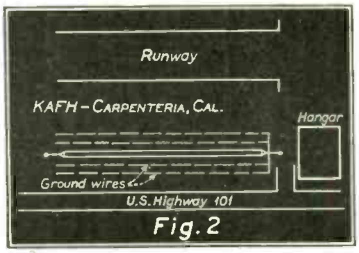
At KNCU, Goleta, California, the antenna was restricted to two places. One of these locations was about 75 feet behind the hangars. The other possibility was to erect the mast on top of the hangars themselves. It was believed that the hangars would have less effect on the propagation pattern and less absorption effects, if they were to become an integral part of the radiating system. Therefore, two poles projecting 40 feet above the hangar roof were installed. These were 4 by 4 vertical-grain pine. Spikes were driven in the sides to permit ascent. Two guys were fastened to the top to take up the antenna tension. A small tennis-net winch was installed on one mast to pull up the antenna. The base of the poles extended below the hangar roof and were bolted securely to the ceiling beams.



The antenna itself is a six-wire cage 180 feet long and one foot in diameter. It is used as an inverted "L" type. Spacers, made of ¼-inch copper tubing, were placed every 20 feet. The wire is No. 12 enameled solid copper. The safety factor is so high that there is no possibility of breakage.

Fig. 1 shows the position of the masts and the ground system. Stakes were driven down about six feet into moist earth at all points shown in the diagram as being grounded. These were strapped to the hangar sides. The corrugated iron sheets of the hangar were bonded wherever necessary. Five wires, buried 6 to 8 inches, were stretched from hangar to hangar. Subsequent investigation showed no sign of radio-frequency currents running rampant on either hangar. The installation is all that could be expected.

The other installation, Carpenteria, California, KAFH, is shown in Fig. 2. Here the antenna site was restricted to one possibility. The antenna is a two-wire flat-top, spaced eight feet, and 300 feet long. The masts are 54 feet high. The ground consists of five parallel wires spaced 10 feet and buried about 6 to 8 inches deep. These wires are paralleled rather than fanned at the far end because of the runway on one side, and the coast highway on the other. The hangar and water system were also tied to the ground. In this installation the antenna masts are of peculiar interest due to their low cost, good appearance and more than adequate strength. Fig. 3 shows the general construction of the masts. They were made of unsurfaced



2 by 4 select stock and bolted together at the splices. The guys were also connected to these bolts. Six guys were used, three at the top and three at the second splice up from the bottom. The upper ones serve to take up the antenna load while the lower ones straighten out the slight bowing of the mast due to the compression component of the load and prevent whipping of the mast in a high wind. The guys were anchored by driving down half-inch pipes 6 feet into the ground. They are driven in at an angle which will make the guy wire perpendicular to the pipe. They may be cemented in, or, if the ground is hard packed, cementing may be dispensed with. Guy insulators are inserted every 25 feet. The upper guys are 100 feet long. The two upper guys which extend toward the rear are spaced 90°. The lower guys are about 85 feet long. A small tennis-net winch was installed on one mast to pull up the antenna.

When designing such a mast it is often desirable to see just how much of a load or strain there is on the various parts, guys, etc. The simple formulas given will enable an engineer to roughly, but satisfactorily, calculate these stresses.

If the antenna has the same weight per unit length, it will hang in a curve called a catenary. As the spreaders and the insulators are lumped weight this curve will not be true, but it will be close enough for good approximation. To get the weight of the antenna which will be necessary in the calculations, find the weight of the wire in a wire table, add the weight of the insulators and spreaders and double their total. Doubling will take care of the extra stress due to wind load. A rough estimation of wind load can be had by figuring 6 pounds per square foot of projected area of the antenna wire, insulators, etc. Be certain that the wire chosen has a breaking point well over the pounds tension of the antenna.

The tension on the antenna is calculated as follows: half the total tension due to the weight of the antenna and the pull will act on each pole. A catenary curve of antenna is shown in Fig. 4. Here the force acting on the mast will be along the line *AP*, which is a tangent to the wire at the pole. We must resolve this tension into a horizontal component. Putting the wire tension along *AP* equal to *t*, the horizontal tension equal to *h*, and half the weight of the antenna equal to *k*, we have the following equations:

$$t \sin \Theta = k \qquad (1)$$

$$\text{or } t = \frac{k}{\sin \Theta}$$

$$\text{and } h = t \cos \Theta \qquad (2)$$

The angle Θ is the angle the line *AP* makes with the horizontal and can be approximated close enough by:

$$\Theta = \tan^{-1} \frac{(\text{sag in feet}) \times 4}{\text{length of antenna}} \qquad (3)$$

Part of the horizontal tension, *h*, will be taken by the guy wires and part by the compression load on the tower. The length of the guy wires, the load on each guy wire and the compression load on the tower can be obtained from the equations to follow:

$$s = \sqrt{h^2 - w^2} \qquad (4)$$

$$s^2 = 2p^2 (1 + \cos \Theta) \qquad (5)$$

$$\tan \Omega = \frac{w}{h} \qquad (6)$$

$$r = \frac{k}{\cos \Omega} \qquad (7)$$

$$r^2 = 2L^2 (1 + \cos \Theta) \qquad (8)$$

Where

h = Horizontal tension in pounds.
s = Portion of *h* taken up by guy.
w = Compression on tower in pounds.
p = Pull in pounds on each guy wire.
k = Height of mast in feet.
L = Length of the guy wires.
Θ = Angle made between guy wires.

It is not claimed by the author that this antenna is the ultimate in design, but it does serve the purpose admirably well, was easily and quickly erected, cost little and took but a short time to design.

As for actual erection, the masts are easily "walked up" with pulling help on two of the lower guys. It is well to have plenty of man power available if possible as this expedites the erection. In this case the foot of each mast was fastened to a 2 by 12 with large "barn door" hinges. The masts were easily "walked up" and propped from time to time to get a survey of the situation and see that there were no kinks in the guy wires.

When it is necessary to measure the sag in the antenna this simple rule can be used to fair approximation.

Agitate the antenna by yanking on it with a rope or some similar way, count the time in seconds that it takes a longitudinal wave to travel down and back three times, and multiply by 0.1118. This is the sag in feet. Lastly, the wind load can be calculated by allowing 8 lbs per square foot projected area of the mast in any direction.

A NEW POWER AMPLIFIER

(*Continued from page 9*)

These items are of great importance in modern high-power broadcasting, where the cost of apparatus and power constitutes a large part of the operating expense.

By the application to radio transmission of another Laboratories development, the feedback principle* of H. S. Black, to reduce the effects of non-linearity in the amplifier characteristics, the new high-efficiency equipment has been made to perform with a quality of transmission which satisfies the most rigorous requirements of high-fidelity broadcasting.

Finally, the new circuit, being purely an amplifying scheme, can be applied to special types of transmission, such as the single-sideband transmission employed in the transoceanic service of the Bell System. Other schemes that have been proposed for improving the efficiency of broadcasting radio transmitters do not appear to be of such broad applicability.

*Bell Laboratories Record, June, 1934, p. 290.

PHASE-SHIFTING NETWORKS

By CARL E. SMITH*

Assistant Engineer, WHK

MOST NETWORKS cause phase shift. Sometimes it is desirable to know the amount of this phase shift or it is desirable to have a variable phase-shifting network with certain characteristics.

Practical applications of phase-shifting networks are to be found in thyratron circuits, cathode-ray-tube circuits unidirectional crystal-microphone amplifiers, stablized feedback amplifiers, directional antennas, etc.

Networks containing resistance and reactance can be used to shift phase but if high efficiency is a prime requisite the resistance elements must be omitted. The following treatment is given for pure reactive elements used in the form of a T-section; however, the theory can readily be applied to a balanced H-section if the impedance values of the T-section are divided by two as shown in Fig. 1.

If the T- or H-section has a characteristic impedance[1] of

$$Z_o = \sqrt{\frac{L}{C} - \left(\frac{\omega L}{2}\right)^2} \qquad (1)$$

then the ratio of the input current to the output current will give the phase shift of the network.

The voltage drop across Z_2 in Fig. 1 is equal to the voltage drop around the right-hand branch. When the section is terminated in Z_o this equality is

$$(I_1 - I_2)\, Z_2 = I_2 \left(\frac{Z_1}{2} + Z_o\right). \qquad (2)$$

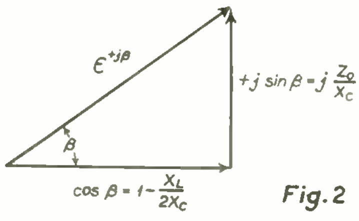


Fig. 2

Or solving equation for current ratio

$$\frac{I_1}{I_2} = 1 + \frac{Z_1}{2\,Z_2} + \frac{Z_o}{Z_2} \qquad (3)$$

Normally, the current vector I_2 will be smaller than the current vector I_1 and be rotated in phase. This is for the general condition when the network contains resistance and is usually expressed by the propagation constant γ[1]. If the network lacks resistance I_1 and I_2 will have the same magnitude but have a phase shift which we will call β. Mathematically this relationship can be written

$$\frac{I_1}{I_2} = \varepsilon^{+j\beta} = \cos\beta + j \sin\beta \qquad (4)$$

Now, if the values of X_L and X_C are substituted in equation (3) and used with equation (4)

$$\cos\beta + j \sin\beta = \left(1 - \frac{X_L}{2\,X_C}\right) + j\frac{Z_o}{X_c} \cdot (5)$$

If the vectors of this equation are drawn as shown in Fig. 2 it is readily seen that

$$\cos\beta = 1 - \frac{X_L}{2\,X_C} \qquad (6)$$

$$\sin\beta = \frac{Z_o}{X_c} \qquad (7)$$

Equations (6) and (7) if solved for X_l and X_c give

$$X_L = \frac{2\,Z_o\,(1 - \cos\beta)}{\sin\beta} \qquad (8)$$

$$X_C = \frac{Z_o}{\sin\beta} \qquad (9)$$

Curves of X_L and X_C, from equations (8) and (9), have been plotted in Fig. 3, as a function of the phase shift β when the characteristic impedance $Z_o = 1$. These are very convenient curves for the rapid determination of the reactance elements in a T- or H-section phase-shifting network.

In addition to being a phase-shifting network the above T- and H-section has the property of being a low-pass filter. In practice pure inductances do not exist, hence this type of network will not give infinite attenuation at any frequency. There is another type of network known as the lattice structure which does have this property of infinite attenuation and for this reason is superior to the T- or H-section in some phase-shifting and filtering networks.

*Author of a new home-study course for communication and broadcast engineers.

[1] W. L. Everitt, *Communication Engineering*, Chapter V.

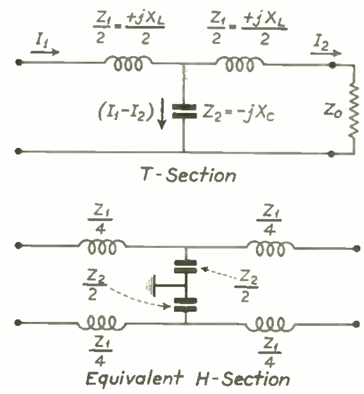
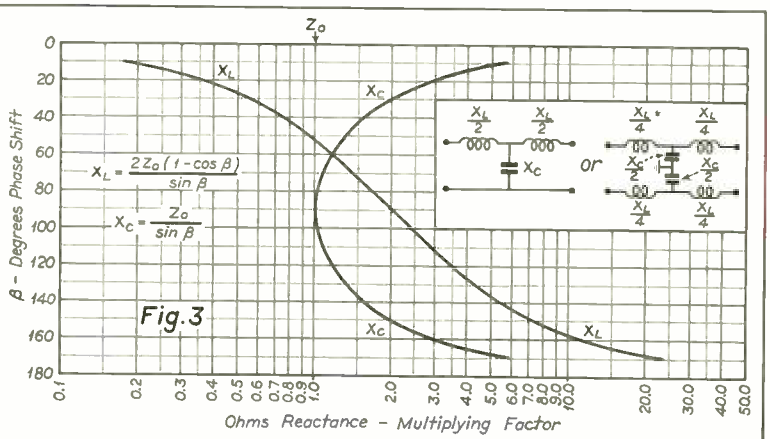


Fig. 1



"RELAYED-FREQUENCY" PICKUP

ELECTRICAL SOUND REPRODUCTION is based on the design and operation of a large number of components. It is generally assumed that the amplifier is the heart of a reproducing system and that the characteristics of the whole system are specified simply in terms of amplifier specifications. Under these conditions, one may forget that it is generally possible to construct a very good amplifier but not at all easy to use it to full advantage. The design of the other two links of the system, the microphone or pickup and the loudspeaker, have lagged behind amplifier research.

We are here concerned with one particular link of a reproducing system, the phonograph pickup. The author takes particular pride in presenting this development because he feels somewhat responsible for its inception. As chief engineer of an organization whose object is to design, build and install high-quality sound systems, it has been his duty to keep in close contact with other organizations engaged in developing components of such systems. The writer's constant criticisms and urgings have been somewhat instrumental in the development of this new unit, and it is believed that it represents the answer to the problem of high-quality phonograph-record reproduction.

As the first link of a reproducing system, the similarity of the pickup and the microphone is immediately apparent. Both constitute the first "electrical image-creating apparatus," the microphone being actuated by air vibrations and the pickup by record groove undulations. The difficult task of design of the phono pickup becomes apparent when one bears in mind that not only must it be mechanically coupled to the record groove, but also in a high-impedance pickup sufficient displacement or stress must take place within the unit to generate approximately 2.0 volts—about two million times more than the output of a high-grade microphone.

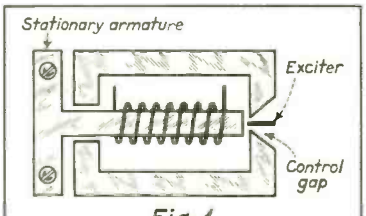


Fig. 1

The ideal pickup should make use of a principle which through long usage is known to have stability and dependability; it should have a response characteristic which is flat from 50 to over 8,000 cycles, maintaining this response under large amplitude variations and changing weather conditions. It should also be able to withstand a temperature rise of from 40 to 60 degrees above 72 degrees F without ill effects and with normal response. The needle-point impedance should be kept low and the needle pressure on the record should not exceed 2.75 to 3 ounces. The unit should be ruggedly built and adaptable to either low or high impedance. Further, it should be made as simple as possible to facilitate local servicing. The output of this ideal pickup could afford to be somewhat smaller than that of previously available models. Modern amplifier design scarcely calls for the necessity of large input voltages.

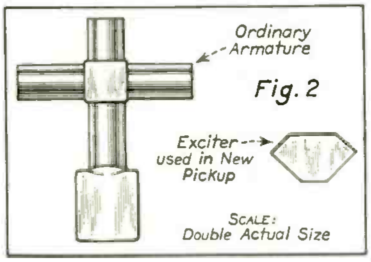


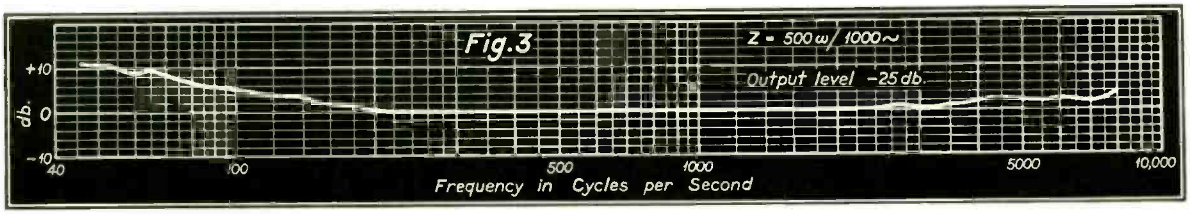
Fig. 2

The new unit to be described fulfills all the aforementioned conditions and represents, in the author's opinion, a considerable departure from conventional design.

The reader is no doubt aware of the importance of the principle of relay, trigger or valve action. It forms the underlying operating basis of vacuum tubes, relays, etc. A small amount of motion, a small amount of energy is made to control large effects. If it were possible, in the described pickup unit, to keep the general dimensions of the magnetic circuit the same, and yet control the flux paths by the motion of a very small element rather than by that of the bulky armature, the problem of inertia and limited frequency response would be solved. This is exactly what has been accomplished in the new unit as may be seen from Fig. 1.

The armature is broken up into two parts: the major part, on which is wound the coil, is permanently clamped and stationary, while a very small portion, which the inventor refers to in his patent papers as the "exciter," reflects the motion of the needle and changes the magnetic reluctance of the armature path by changing the size of the "control air gap."

The moving system is reduced to the needle in its pivot and to the small exciter. The inertia of this system is con-



siderably reduced, for not only is the mass of the exciter very small (see Fig. 2), but also the exciter is placed near the center of the axis of rotation so that the main part of the weight is that of the needle. The needle plays the controlling factor in inertia and therefore in the frequency response (see Fig. 3) of the system.

The output of the pickup is not controlled by changing the effective leverage, using "soft tone" or "loud tone" needles, and by introducing distortion and frequency discrimination by the use of a long or soft needle. A definite control of total effective inertia is obtained by using a longer or heavier needle for increased bass response, or a short and light needle for a flat overall response. The increased frequency range changes the surface scratch from standard records to a higher frequency hiss which is much less objectionable and easier to eliminate. The new unit when tested had a needle pressure of only 1.5 ounces on the needle point.

Finally, it is well to observe that the construction of this pickup unit is very simple. The main part of the armature being stationary and solidly clamped, the oscillating part is easier to adjust and maintain in its proper position. These factors might well become very important when the pickup is used in a remote location where easy and immediate local service may be a necessity.

Mirko Paneyko
Concert Installations, Inc.

TELEVISION DEMONSTRATION

ON APRIL 24 a special television demonstration was given in the laboratories of the RCA Manufacturing Company, Inc., at Camden, N. J. The equipment used in this demonstration represented the results of many years of research work by the RCA scientists, and it preceded the actual inauguration of the experimental transmissions scheduled to begin in June from the transmitter in the Empire State Building in New York City.

The apparatus used consisted of a transmitter operated at a power of approximately 35 watts and on a wavelength somewhere in the vicinity of 6 or 7 meters. The system was of the 343-line variety, 30 pictures being transmitted per second. The frequency band is from 60 to 1,500,000 cycles. At the receiving point, located a little over a mile away in order to simulate conditions existing at the edge of a service area, were two combination sound-vision receivers. These receivers still have the appearance of being complicated, employing 33 tubes, including the cathode-ray tube, and being equipped with 14 controls. The pictures which are of greenish color are about 5 by 7 inches.

The demonstration was divided into three parts. First several individuals came in front of the portable pickup camera. The next part of the demonstration was the most impressive and consisted of the pickup of an outdoor scene . . . staged through the courtesy of the Camden Fire Department. In this connection it was interesting to note that the outdoor pickup was nearly as good as the results obtained indoors under the proper lighting conditions . . . and, considerable detail could be distinguished at distances of 150 to 200 yards. The last part of the demonstration was devoted to the tranmission of motion pictures.

TRAFFIC SAFETY CAR

THE TRAFFIC SAFETY CAR, a specially constructed, 185-inch chassis Chevrolet sedan, equipped with a public-address system, will be a leading feature of the General Motors Parade of Progress, a veritable "world's fair on wheels," which this year will tour American cities over a route of 20,000 miles to stage a "scientific-circus" on industry's latest achievements in transportation and home-equipment.

The use of this broadcasting car will be tendered local police to help them in regulating local traffic along the lines employed in Detroit and a few other of the larger cities.

IRE CONVENTION

(*Continued from page* 17)

lustrates the shorter time duration of the wave train from the broad amplifier.

Fig. 13 is another photograph of the output of the broad amplifier, but was taken with a higher frequency square wave applied to the input. The individual r-f cycles can be easily discerned.

Returning to the input frequency used in obtaining Figs. 11 and 12, the gain required to give a certain amplitude of wave train on the oscillograph was next measured for each channel and the ratio of gains was calculated. One measurement gave 15.8 and a re-check 16.7; the ratio of bandwidths this time was 16.1.

It is important to note the apparent discrepancy in the results for the two types of noise. For both types, the rms amplitude is necessarily proportional to the square root of the bandwidth. With smooth noise, the peak amplitude is also proportional to the square root of the bandwidth, giving a constant crest factor. However the noise consisting of isolated impulses (with decay trains not overlapping) the peak, amplitudes are proportional to the first power of the bandwidth. This difference is due to the fact that the decay trains do not overlap for the second type of noise.

Another interesting factor brought out by the analysis is that the decay train due to a single impulse has a time duration which is inversely proportional to the frequency bandwidth.

The foregoing analysis of impulsive noise brings out an important point in regard to noise reduction by wide-band frequency modulation. It is generally agreed that the frequency-modulation system is inoperative if the noise peaks exceed the signal in amplitude. Widening the band improves the performance on smooth low-amplitude noise, but may make it worse if the noise peaks are of about signal amplitude.

A potentiometric direct-current amplifier was discussed by R. W. Gilbert. This instrument presents a method of d-c amplification wherein the output is maintained in a null potentiometric relationship to the input by means of an electronic balancing mechanism. In this way complete independence from the effects of the non-linear and variable electronic devices, upon stability and calibration, is obtained. The schematic of the fundamental circuit of the amplifier is shown in Fig. 14. The bridge was described as self-balancing.

In addition to the technical sessions several interesting inspection trips were arranged.

THE TRAFFIC SAFETY CAR.

VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGonigle, Secretary, 112 Willoughby Avenue, Brooklyn, N. Y.

MEMORIAL DAY

AT NOON EST on the East Coast and PST on the West Coast, a silent period of one minute will be observed by all of the communication services, government as well as commercial, in tribute to the many brave radiomen who have made the supreme sacrifice in the line of duty. Simultaneously services will be held by the Veteran Wireless Operators Association at the Wireless Operator's Monument in Battery Park, New York City, on Memorial Day, May 30, 1936.

At the services a plaque containing the name of Russell L. MacDonald will be unveiled on the monument. A eulogy to those whose names have been placed on the monument in the past will be delivered by our President. A chaplain from the Seamen's Church Institute will lead the assemblage in prayer.

Our membership and friends of the association are cordially invited to participate in those truly impressive services on this Memorial Day.

DETROIT

THERE ARE excellent prospects for the formation of a Detroit Chapter of the Veteran Wireless Operators Association in the very near future. Mr. C. H. Wesser, operator-in-charge of the Detroit station W8XWJ, wrote in recently and informed us that a group of veterans in that city were highly in favor of getting together under the VWOA banner. They should go far with the able assistance and guidance of Emery H. I. Lee, a former Director of the Association, who is at present stationed in Detroit as Radio Inspector-in-Charge for the FCC.

HONOLULU

AN AIR-MAIL LETTER from Arthur Enderlin, Secretary of the Surf Board Chapter, in which he tells us that they are going strong in the Pacific Paradise and wish additional supplies of application blanks and information to facilitate the furtherance of their truly representative group. At the moment Honolulu is second in numbers amongst the Chapters. A tribute to the zeal and enthusiasm with which George Street, Chairman, and Arthur Enderlin, Secretary, have applied themselves in organizing their unit of the VWOA. We hope to receive some extremely interesting anecdotes from them for an early future issue. Their membership includes some of the real pioneers in the field of radio communication.

MIAMI

V. H. C. EBERLIN, Chairman of the Miami Chapter, accompanied by his charming wife and young daughter, recently spent a week visiting relatives and friends in New York. We had several very pleasant visits with them and regret that they had to hurry back to the south. VHC had some interesting things to relate concerning the formation of the Miami Chapter and their first Cruise which was held on the 11th of February this year. He related that C. J. Corrigan, Secretary, was even then busily engaged in rounding up the Miami members for a little beer party before the summer takes hold.

BOSTON

CHARLES C. KOLSTER, Boston Chapter Chairman, was a guest speaker at the New England Division, ARRL Convention. . . . Mark MacAdam was Chairman of the Convention Committee. . . . Lieut. Col. Boyden delivered an interesting talk, too. . . . We had no idea there were so many of our members in Boston actively interested in amateur radio. Harry Chetham furnishes us the following facts regarding their participation in the recent floods.

"Arthur Stockellburg, W1SS, volunteered his services for radio duty in the flood area at Haverill, Mass. He and Frank Newton drove there with a five-meter rig in their car. They worked continuously for over forty hours. Mayor Dalrymple thanked them personally for their valuable assistance.

"At WPEH, Somerville Police Radio, Harry Chetham and Jack Tegins stood a 'listening watch' in the amateur bands.

"R. Keith Bullard, Chief Operator of the American Airways at East Boston, stood a 60-hour watch without 'batting an eyelash.'

"Arthur Ericson at Beverly, Mass., went on the air and relayed messages to and from the flood area. AE's station is one of the finest in the country. Among the messages handled by him was one addressed to Tom Stevens, Chairman of our San Francisco Chapter, for which he received a gracious letter of appreciation.

"Henri Jappe, who operates several radio stores in and around Boston, was kept busy supplying equipment and supplies of a radio nature to first district 'hams' during the emergency.

Arthur H. Vickerson, Chief Operator at Boston Police Radio, was busily engaged dispatching cars to the Springfield flood area.

"Lieut. Robert J. Hartshorn, N. G. Q. M. Corps, made things ready at the Somerville Armory where two engineer's companies are stationed.

"Wallace Battison did a fine job at his amateur station in Arlington during the emergency."

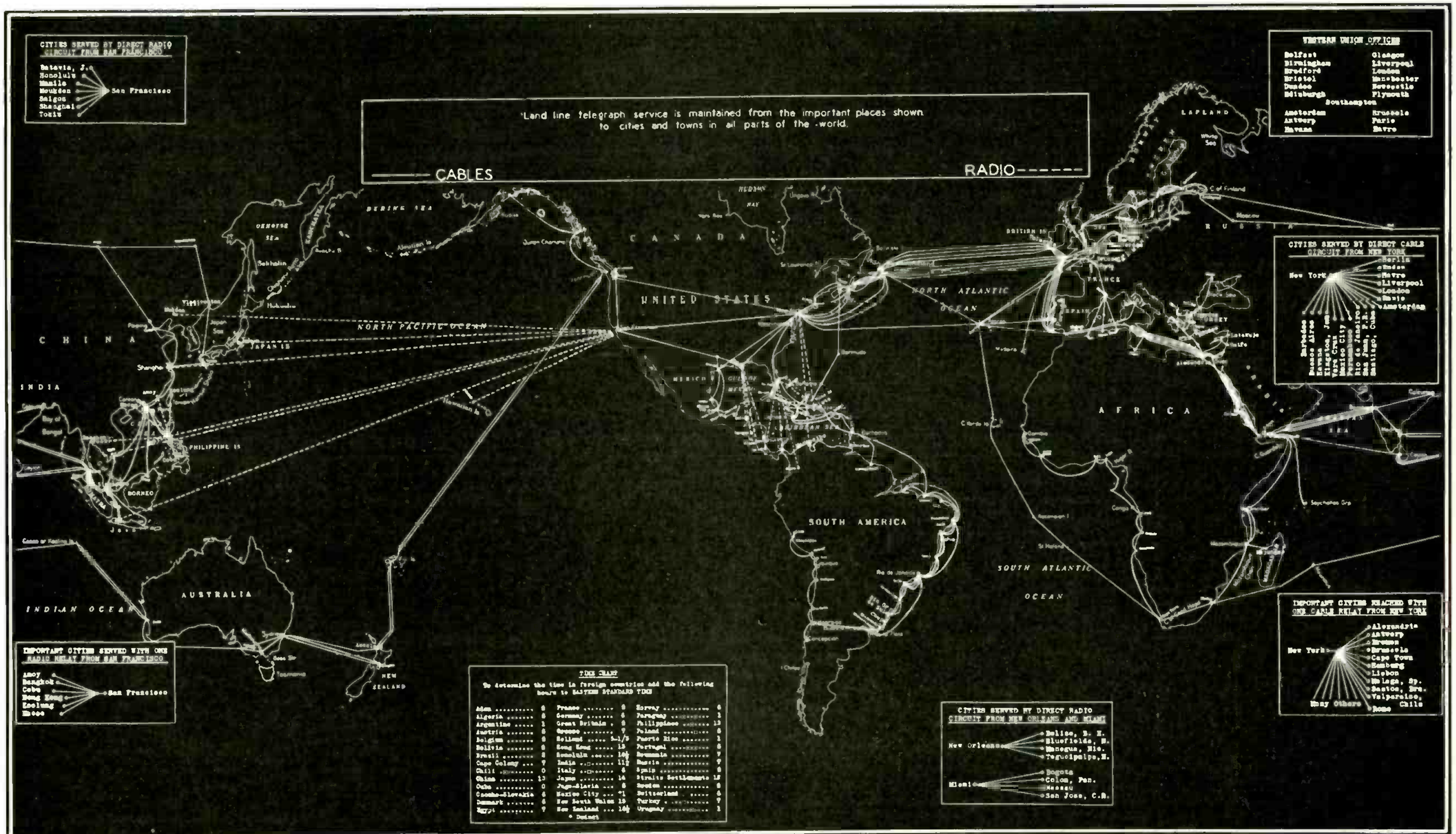
Among those "Ye Secretary" was pleased to meet at the Boston Convention of the ARRL—Mark MacAdam, Jack Dodge of WNAC, Willard S. Wilson, our Resident Agent who traveled up from Wilmington for the affair, Charles C. Kolster, Harry Chetham, Wallie Battison, Col. Boyden, Guy R. Entwistle, Samuel Curtis, Henri Jappe, and many others whose names fail us at the moment.

CHICAGO

A REPORT of Chicago's recent get-together is promised for the next issue. Early indications were that it would be a bang-up affair.

PERSONALS

KARL BAARSLAG just returned from another of his many trips to the South Seas, this time aboard the Yacht *Vagabondia*. His book, "SOS to the Rescue," continues to be a best seller. Glad to hear from you again, KB. Why not let us have some items from your experiences for use in this page? And the same goes for many others who could relate some fine bits of fact. . . . John C. Christianson, a real veteran, continues as Chief Operator at the A. T. & T. Company's station at Port Jefferson. He extends a cordial invitation to members to visit the station. We did last summer and just missed him. Better luck next time, JCC. . . . Pleased to hear from Arthur F. Rehbein again. . . . Steve Kovacs sends 73 and the necessary, and automatically transfers from Associate to Veteran membership. Congrats Steve and best of luck for the next ten years. . . . Thomas B. Linklater, formerly located at Sioux Lookout, Ontario, Canada, has transferred to Amos, Quebec, Canada, with the Canadian National Telegraphs. Good luck, TBL. . . . Lloyd A. Briggs write in from London, England. Thus far the London Chapter of our Association has not gained momentum, but we feel assured that under the able direction of Mr. Briggs it will not be long before we have a representative group organized in London. . . . There have been many requests for information and application blanks from all over the country recently. We anticipate a considerable increase in our membership which undoubtedly has been stimulated by the formation of Chapters in various cities throughout the country. . . . Arthur H. Lynch and "Ye Secretary" were in Boston recently attending the New England Division, ARRL Convention which was enjoyed immensely and during which we met a goodly number of our Boston members. which alone would have made the trip worth while.



MAP No. 18 -- The Western Union Cable and Communications System.

OVER THE TAPE . . .

NEWS OF THE RADIO, TELEGRAPH AND TELEPHONE INDUSTRIES

"RCA REVIEW"

A new quarterly publication devoted primarily to technical papers on communication, broadcasting, television and the electronic and audio arts will make its initial appearance in June, under the title of *RCA Review*. It will be published and distributed through the RCA Institutes Technical Press, a department of RCA Institutes, Inc., 75 Varick Street, New York.

In scope the new quarterly will be practically a record of significant developments in the engineering and research laboratories of the Radio Corporation of America and its associated companies. It also occasionally will contain papers presented before the radio, acoustical, optical and motion picture engineering societies. Among the special articles by RCA research engineers and executives in the first issue of *RCA Review* will be papers on television by L. M. Clement, Ralph R. Beal and Dr. V. K. Zworykin; the new micro-wave transmitter by O. B. Hanson; safety of life at sea by C. J. Pannill, radio communication by C. H. Taylor; and others.

Charles J. Pannill, President of the Radiomarine Corporation and of RCA Institutes, and Executive Vice-president of the Comite International Radio-Maritime, is Chairman of the Board of Editors, of which the other members are: Ralph R. Beal, Research Supervisor, Radio Corporation of America; H. H. Beverage, Chief Research Engineer, RCA Communications; I. F. Byrnes, Chief Engineer, Radiomarine Corporation; L. M. Clement, Vice-President in Charge of Research and Engineering, Victor Division, RCA Manufacturing Company; Dr. Alfred N. Goldsmith, Chairman of the Board of Editors of the Institute of Radio Engineers; Harry G. Grover, General Patent Attorney, Radio Corporation of America; O. B. Hanson, Chief Engineer, National Broadcasting Company; Willson Hurt, Assistant General Solicitor, Radio Corporation of America; Dr. Charles B. Jolliffe, Engineer-in-Charge, RCA Frequency Bureau; Frank E. Mullen, Manager, Department of Information, Radio Corporation of America; Charles H. Taylor, Vice-President in Charge of Engineering, RCA Communications; Arthur F. Van Dyck, Engineer-in-Charge, License Laboratory, Radio Corporation of America, and J. C. Warner, Vice-President, RCA Manufacturing Company, Radiotron Division.

NEW NAME

The Mirror Recording Supply Co., has been formed by Paul K. Trautwein, President of the Mirror Record Corp., manufacturers of the "Mirror" aluminum disc for direct recording. The new organization has tripled their floor space and is now in production on their improved coated disc which will be marketed at reduced prices under the trade name of "The Mirror Coated Disc." The new price schedule will be mailed upon request to the Mirror Recording Supply Co., at 58 West 25th St., New York City.

NEW OFFICES FOR WARD LEONARD

The Ward Leonard Electric Co.'s Chicago Office, under the management of Kline Gray, has taken larger quarters in the Monadnock Block at 53 West Jackson Blvd. This has necessitated moving their offices from Room 1257 to Room 1450.

AUDAK ORDER

The Audak Company, 500 Fifth Ave., New York City, N. Y., has been awarded a contract for 5,000 Audax magnetic pickups by the United States Government. These units are to be distributed to libraries throughout the country, to be used in conjunction with reading machines for the blind.

Prior to the awarding of this contract, it is said, manufacturers had to submit samples constructed to the high-quality demands of government specifications.

VOLUME-CONTROL GUIDE

The proper replacement for a defective volume or tone control in practically any manufactured set can be quickly determined by referring to the extensive listings in the Clarostat "Volume-Control Replacement Guide" just issued.

A copy of this guide may be obtained from the Clarostat Mfg. Co., Inc., 285 North 6th St., Brooklyn, N. Y.

KEN-RAD BULLETIN

An 8-page engineering bulletin telling of pentagrid converter oscillator considerations has just been issued by The Ken-Rad Corporation, Owensboro, Kentucky. This bulletin has been written to bring the attention of the circuit engineer to some of the facts that will be of benefit in future set designs. Those wishing a free copy of "Pentagrid Converter Oscillator Considerations" write to The Ken-Rad Corporation, Owensboro, Ky.

RCAM BULLETINS

The Aviation Radio Section, RCA Manufacturing Company, Camden, N. J., have recently issued two new bulletins on aviation radio. One bulletin describes the AVT-12 and 12A aircraft radio transmitters, while the second one is concerned with the Models AVT-7 and 7A.

The AVT-7 and 7A transmitters are of the crystal-controlled oscillator-power amplifier type, and either one will deliver 10 watts of r-f power to conventional aircraft antenna. Two types of power supplies are available: Model AVT-7 uses a vibrator power supply, Model AVT-7A uses a dynamotor for power supply.

The AVT-12 and 12A transmitters are of the crystal-controlled oscillator-power amplifier type and will deliver 50 or 30 watts of power to conventional aircraft antenna when telephone emission is used, and 90 or 60 watts cw telegraph emission. The equipment is designed to operate from power supplied by a standard aircraft 12-volt storage battery or any other 12-volt d-c source.

RADIOTELEGRAPH CIRCUITS

Four important new direct radiotelegraph circuits between the United States and other countries were opened by the Mackay Radio and Telegraph Company during the month of March, exchanging all classes of telegraph messages with Czechoslovakia, Brazil, Haiti and El Salvador. In Brazil, Mackay Radio operates with the radio associate of the International Telephone and Telegraph Corporation. In Czechoslovakia, Haiti and El Salvador the service is conducted with the radio stations and telegraph systems of the respective Government communication administrations.

The operation of the Company's transoceanic services are being transferred to the giant new Brentwood, L. I., station from the famous Sayville station, which Mackay Radio has outgrown. This move is a gradual one because of the extraordinary precaution against any momentary lapse of the radio service on any circuit. It is expected, however, that the Brentwood station will be in full operation late this year, and Sayville will have been replaced by a new and completely modern station which will be considerably larger and more powerful.

Mackay Radio now operates direct services with Denmark, Czechoslovakia, Austria, Hungary, Vatican City, Argentina, Brazil, Chile, Peru, Colombia, Cuba, Haiti, El Salvador, Hawaii, the Philippines, Japan and China.

Similar progress has been made by Mackay Radio recently in the field of domestic radio with a network interconnecting fifteen of the principal cities of the United States, and in the Marine field, too, with its new shipboard equipment, new Kolster Radio Direction Finders, and five powerful new coastal stations on the Atlantic seaboard added to its three Pacific stations since 1929, as well.

NEW AGENT FOR S. H. COUCH

S. H. Couch Company, Inc., N. Quincy, Mass., have appointed Wesley Block and Co., 15 East 26th Street, New York City, as their sales agent for the metropolitan district of New York. This agency will handle the apartment house telephone and mail box line, private telephone, amplifiers, centralized sound equipment, fire-alarm apparatus, and other signaling specialties.

W. J. Clifford Company, 39 Cortlandt Street, New York City, will continue as sales agent for the Blake Insulated Staples and "Number 200" line of telephones.

CRYSTAL MICROPHONES

The American Microphone Company, 1915 South Western Avenue, Los Angeles, California, have recently been granted a license by the Brush Development Company permitting them to manufacture crystal microphones.

In addition to the American Models AG and AH microphones, several new models are in the course of development and will be announced within the near future.

THE MARKET PLACE

NEW PRODUCTS FOR THE COMMUNICATION AND BROADCAST FIELDS

STATIONARY RECORDING MACHINE

The Presto Recording Corporation, 139 W. 19th St., New York City, N. Y., are manufacturing a special stationary recording machine. This reasonably-priced machine, which is shown in the accompanying illustration, is designed to cut not only the acetate or coated disc and aluminum disc, but also wax blanks.

The feed mechanism is heavily constructed and is mounted on a heavy cast-iron pedestal upon which all other component parts are mounted.

The motor is an integral part of the mechanism and is flexibly mounted to eliminate all vibrations. The counter-shaft mechanism constitutes a part of the heavy base and contains the drives for the 78 or 33⅓ pulleys respectively.

The slide carriage is mounted on heavy ways and contains the carrier for the cutter. Adjustments are provided for raising or lowering the entire cutter mounting to compensate for the varying thicknesses of waxes. The cutter itself is mounted on a

bracket which can be adjusted for angular position. The cutter mounting is counter balanced and in addition is provided with spring adjustment for fine pressure adjustment. Advance ball brackets are attached to the cutter mounting for the purpose of adjusting the depth of groove as required in wax. This bracket may be removed when cutting acetate. The advance ball can be adjusted either for "inside-out" or "outside-in" feed.

The base of this equipment is provided with three-point suspension-leveling screws butting against three flanges.

COATED DISC

Paul K. Trautwein of the Mirror Record Corporation, of 58 West 25th St., New York City, announces an improved coated disc for instantaneous recording. It is stated that this new disc has all the good features of the present discs on the market but in addition it is ready for use at any time. Another feature of the new Mirror disc is that the base material is not heavy thereby effecting a saving of shipping charges.

TECH ATTENUATOR

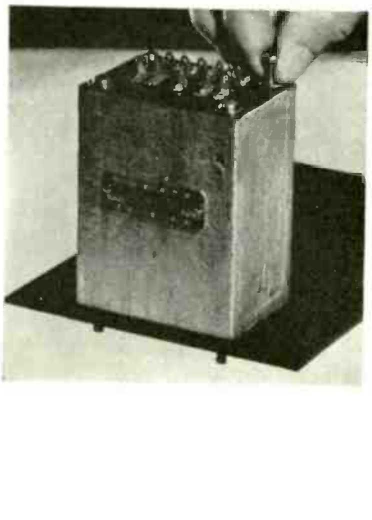
A new attenuator of improved design is announced by the Tech Laboratories, 703 Newark Avenue, Jersey City, N. J. This new unit is said to be especially designed for broadcast and high grade sound recording purposes. It has a larger number of steps, lower noise level, better frequency characteristics, better terminals, easier wiring and smoother operation.

AUDIO TRANSFORMERS

Ferranti Electric, Inc., has announced a new series of audio transformers and reactors known as "Ultra-High-Fidelity—Series B." These units have a frequency response of ± ½ db from 30 to 16,000 cycles, it is said.

Each unit is housed in the new Ferranti completely reversible case with through-type mounting and is supplied with four 8/32 bolts and nuts.

The new Ferranti line of transformers include: a unit for coupling a photocell to an adjustable line, high "Q" reactors where a "Q" of 35 can be obtained in a standard unit, as well as a "Distorter" transformer which may be used in conjunction with broadcast work to obtain telephone sound distortion effect.

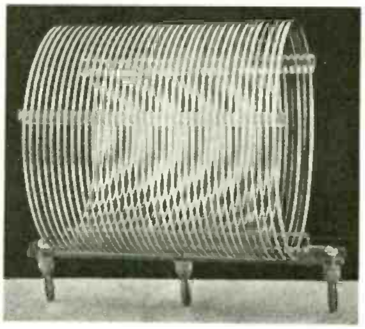


The transformers are fitted with electrostatic shields between windings and are designed for low insertion loss. Weights and dimensions for the majority of the transformers in this line are as follows: weight, 2¼ lb; width, 2¾"; depth, 1⅞"; height, 3⅝"; mountings, 2⅛" x 1⅜".

A four-page folder on request. Address the above organization at 130 W. 42nd St., New York City, N. Y.

TRANSMITTING INDUCTANCES

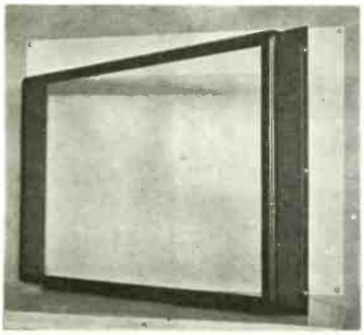
In keeping with the trend toward all-band operation Coto-Coil, Inc., are offering a complete line of transmitting inductances, equipped with plugs for rapid band changing. Coils are wound with bright copper wire protected from oxidation by a coating of colorless baked enamel, and cemented in slots in narrow strips of Cellulose Acetate. Clear enamel was chosen as a coating for Coto inductance



wire because it could be skinned for taps without marring the appearance of the coil. The good electrical and mechanical properties of Cellulose Acetate make it suited for the supporting strips in these "Lo-Loss" inductances. Porosity is extremely low, tests showing less then 1.5% by weight absorption in water after 24 hours immersion, it is said.

Coto "Lo-Loss" inductances are available in four types covering all amateur bands from 160 to 10 meters. All coils are equipped with plugs on standard mounting centers, while the "T" and "BT" series have an additional plug connected to the electrical center for push-pull or neutralized amplifiers. The "T" coils are designed to handle the output of a one-kilowatt final amplifier. The "B" and "BT" series are intended for oscillator, buffer, and low-powered stages not exceeding 300 watts. They are also suitable for constructing pi-section networks. The "A" coils are for antenna coupling.

Further information may be obtained by writing to the above organization at 2 Broadway, New York City.



METER ENCLOSURES

Special meter enclosures, fitted with plate glass, and available in any size to order, may now be obtained from the Radio Engineering and Mfg. Company, 26 Journal Square, Jersey City.

These enclosures should not be confused with the ordinary "bent" metal types, as special dies were made in order to produce an enclosure with heavily rounded corners, with all seams welded and filed smooth, it is stated.

Standard finish is dull rubbed black, with any other color supplied upon order. Write for price list.

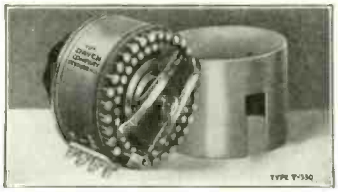
WIRE-WOUND RESISTOR

The introduction of the new Type "MW" insulated flat wire-wound resistor by the International Resistance Company, of Philadelphia, has just been announced.

Complete protection of the resistance element, great mechanical strength, full adaptability to virtually any wire-wound resistance need, up to 60 watts, and the ability to combine several resistances in the same case are but a few of the features of this new unit, according to its manufacturers.

Complete "MW" data sheets, ordering instructions, temperature curves, section ratings, and dimension charts may be had by writing the International Resistance Company, 401 North Broad St., Philadelphia.

DAVEN "T" ATTENUATOR



A 30-step "T" network is available from The Daven Company, Newark, New Jersey. This unit, known as type "T-330," is applicable to low-level mixing due to its zero insertion loss, constant input and output impedance at all settings of the dial, wide attenuation range, and extremely low switch noise level, it is stated.

A new wiping-type, balanced, multi-leaf, switch has been developed requiring low but constant torque at all settings. A new type of switch stop is employed which removes the strain from the switch blades.

The attenuator is offered in all popular impedances from 30 to 600 ohms with attenuation of 1.5 db per step. To provide a smooth complete fade-out the loss per step is increased on the last few contacts. Unequal input and output impedances designed for minimum loss may be obtained upon request.

This unit is interchangeable electrically and mechanically with the popular ladder-type attenuators. The size is only 2$\frac{11}{16}$ inches diameter, 2$\frac{5}{16}$ inches back of panel space. The net weight is 12 ounces. Send for Bulletin TRE-534.

NEW DIELECTRIC TESTER

The new dielectric or breakdown tester manufactured by The Acme Electric and Mfg. Co., of Cleveland, Ohio, not only indicates shorts, opens, or grounds but also checks circuits at approved standard testing voltages. The manufacturer states that this unit is entirely different in principle from the common insulation testers in present-day use in that it will permit actual application of the standard testing voltage of double the rated voltage plus 1,000 to the appliance, device or equipment under test, and thus prove the dielectric strength of the insulation to meet standard safety limits.

The Acme dielectric tester is a compact complete unit. A 6-foot primary cord is plugged into a 110-volt, 60-cycle convenience outlet. Secondary connections are supplied with four-foot high voltage cable leads each equipped with test prong.

DENCOSE RECORDER

Dencose Incorporated, 1650 Broadway, New York City, have just announced their Model 30A single-unit recorder. This recorder, which is shown in the accompanying illustration, comes complete with crystal microphone, an 8-inch loudspeaker mounted in the top cover, a heavy-duty motor, and a 3-stage, 5-tube, wide-range amplifier. The range of recording is 50 to 5500 cycles per second.

This unit requires no pre-amplifier for operation from the crystal microphone. The 12-foot speaker cable may be extended to 200-feet, while the microphone cable may be extended to 100 feet, it is stated. The unit is said to have good playback, having a range of from 50 to 9000 cycles.

Complete information may be secured from the above organization.

OHMITE R-F PLATE CHOKES

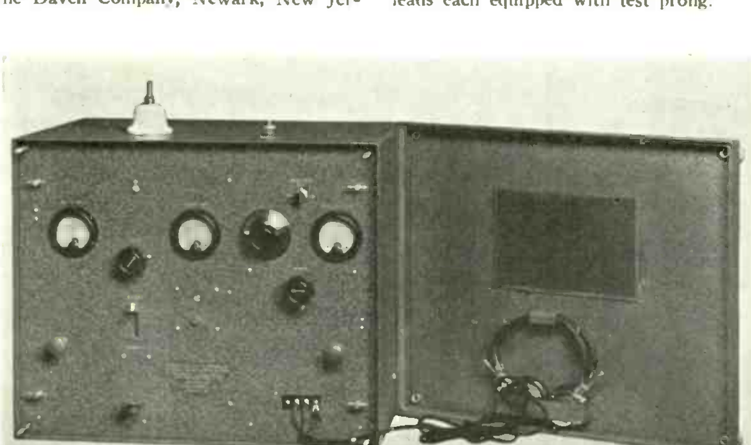
The Ohmite Manufacturing Company, 4835 Flournoy Street, Chicago, has recently brought out a complete line of single-layer wound chokes. These units are wound on porcelain tubes and covered with an insulating moisture-resisting material which holds the turns firmly in place. Because of the single-layer winding the difference in potential between adjacent turns is said to be very small and possibility of breakdowns between turns or collapse due to inductive effect are eliminated. There are four sizes as follows: Z-1, 5 meters; Z-2, 10-20 meters; Z-3, 20-40 meters; and Z-4, 20-160 meters.

All of these, with the exception of the 5-meter unit, are furnished with non-magnetic mounting brackets and have sufficient spacing between the winding and brackets to insure against breakdown even when the chokes are mounted on metal panels.

LIFEBOAT TRANSMITTER-RECEIVER

In the accompanying illustration is shown a new lifeboat transmitter and receiver developed by the Federal Telegraph Company, 200 Mt. Pleasant Street, Newark, N. J.

The unit is self-contained and has been designed to provide two-way radio communication between the lifeboat and rescue vessel. The equipment meets all the requirements of the Federal Communications Commission and consists of a radio transmitter for operation on a fixed frequency of 500 kc, a radio receiver capable of satisfactory reception over long distances and the self-contained power supply.



THE FEDERAL LIFEBOAT TRANSMITTER-RECEIVER.

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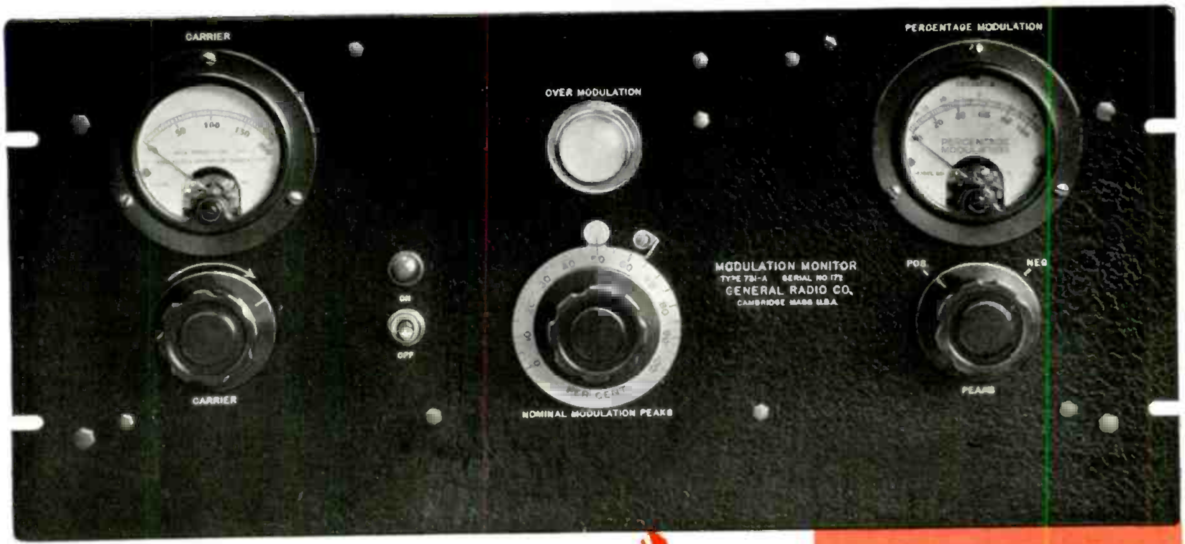


GENERAL RADIO TYPE 731-A MODULATION MONITOR

NOW officially approved by the Federal Communications Commission, after tests at the National Bureau of Standards, as complying with all of the requirements for modulation monitors in accordance with FCC Rule 139 as amended, paragraph B.

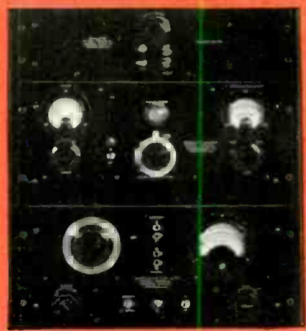
The General Radio Modulation Monitor has these features:

- A d-c meter for setting the average rectified carrier and for indicating percentage carrier shift during modulation.
- A peak indicating light which flashes on all peaks exceeding a predetermined value.
- A new-type high-speed meter indicating, continuously, the percentage modulation either on positive or negative peaks, selected at will.

A limited stock is available. Orders are being filled in rotation.

General Radio Type 731-A Modulation Monitor .... Price: $195.00

Address orders to: General Radio Company, 30 State Street, Cambridge, Massachusetts.



COMPLETE TRANSMISSION MONITORING ASSEMBLY

The complete General Radio Type 730-A Transmission Monitoring Assembly enables the operating staff to measure distortion, noise and hum in the station equipment from microphone to antenna. A complete run for these measurements may be made in less than 10 minutes.

The assembly comprises

Type 731-A Modulation Monitor, which gives continuous indication of percentage modulation and provides positive visual indication of over-modulation peaks.

Type 732-A Distortion and Noise Meter for measuring total harmonic distortion and noise and hum levels present in the transmitter or in the audio-frequency system.

Type 733-A Oscillator, a stable 400-cycle oscillator of excellent wave-form.

Each of the three units operates separately and is electrically and mechanically self-contained.

Type 730-A Transmission Monitoring Assembly will assure you that your station is operating at peak efficiency at all times.

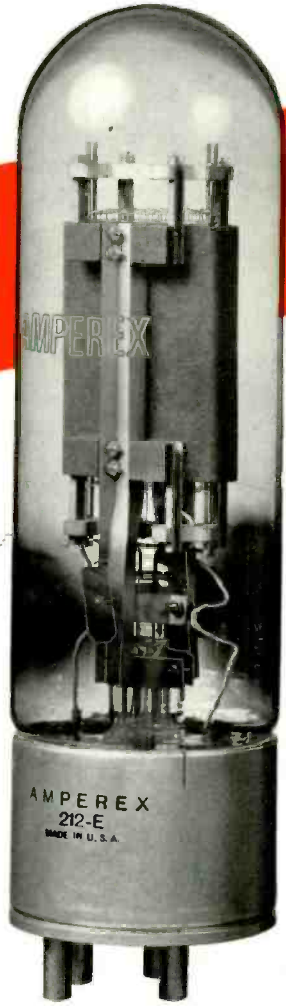
Price: $462.00, complete.

Write for Bulletin 12-K for Details

GENERAL RADIO COMPANY

The new

AMPEREX 212E



GRAPHITE ANODE

Thoriated Tungsten Filament

For Long Life and Cool Operation

The design and structure of the AMPEREX 212E is radically different from any other similar tube type. The anode, because of its greater size, rough surface and black body heat radiating properties, assures a much greater wattage dissipating capacity. Channel supports lend themselves to this simple, rigid structural design, retaining the fixed space relationships between anode, grid and filament, thereby removing the possibility of varying characteristics.

The AMPEREX 212E is interchangeable with the WE 212D or 212E of any other make.

$75

CHARACTERISTICS

Filament Voltage	14
Filament Current, Amperes	6
Average Characteristics with plate Potential of 1500 volts and Grid Bias of -60	
Amplification Factor	16
Plate Resistance, Ohms	1900
Mutual conductance, Micromhos	8500
Maximum D.C. Plate current, Milliamperes	300

AMPEREX

ELECTRONIC PRODUCTS, INC.

79 Washington Street Brooklyn, N. Y.