COMMUNICATION & BROADCAST ENGINEERING

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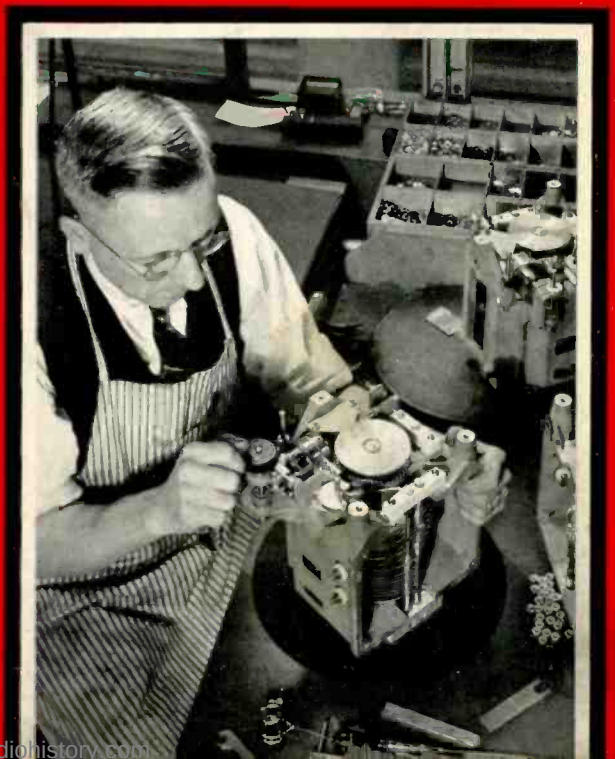
APRIL 1937



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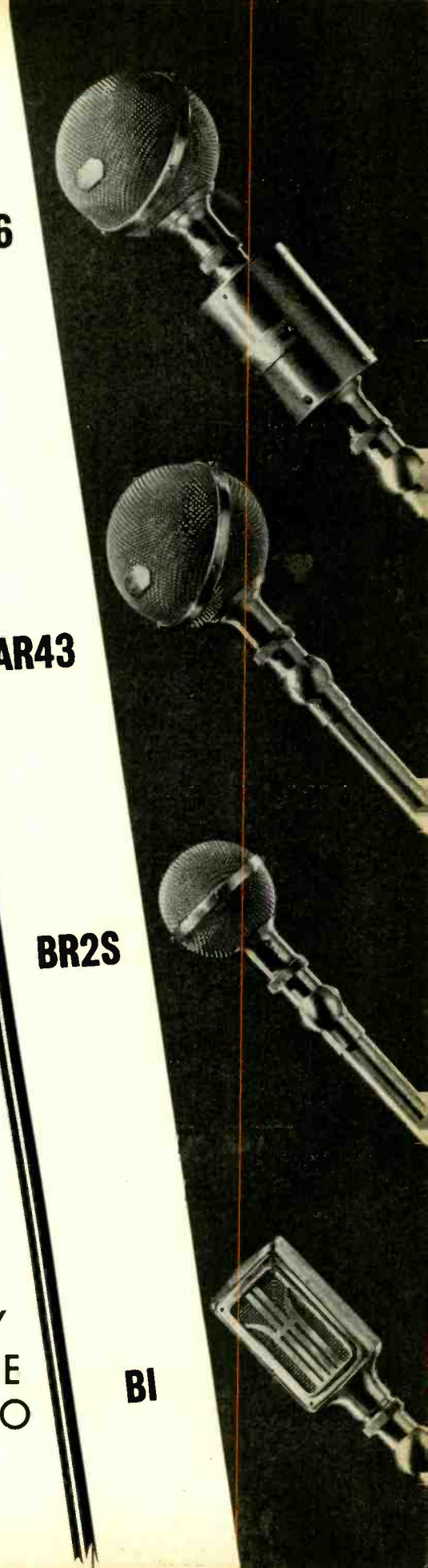

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RAY D. RETTENMEYER
Editor

F. WALEN
Associate Editor

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Cover Illustration: Making final mechanical adjustments on a precision condenser. Photo taken in laboratories of the General Radio Company.

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PAUL S. WEIL
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Chicago Office—608 S. Dearborn St.—C. O. Stimpson, Mgr.
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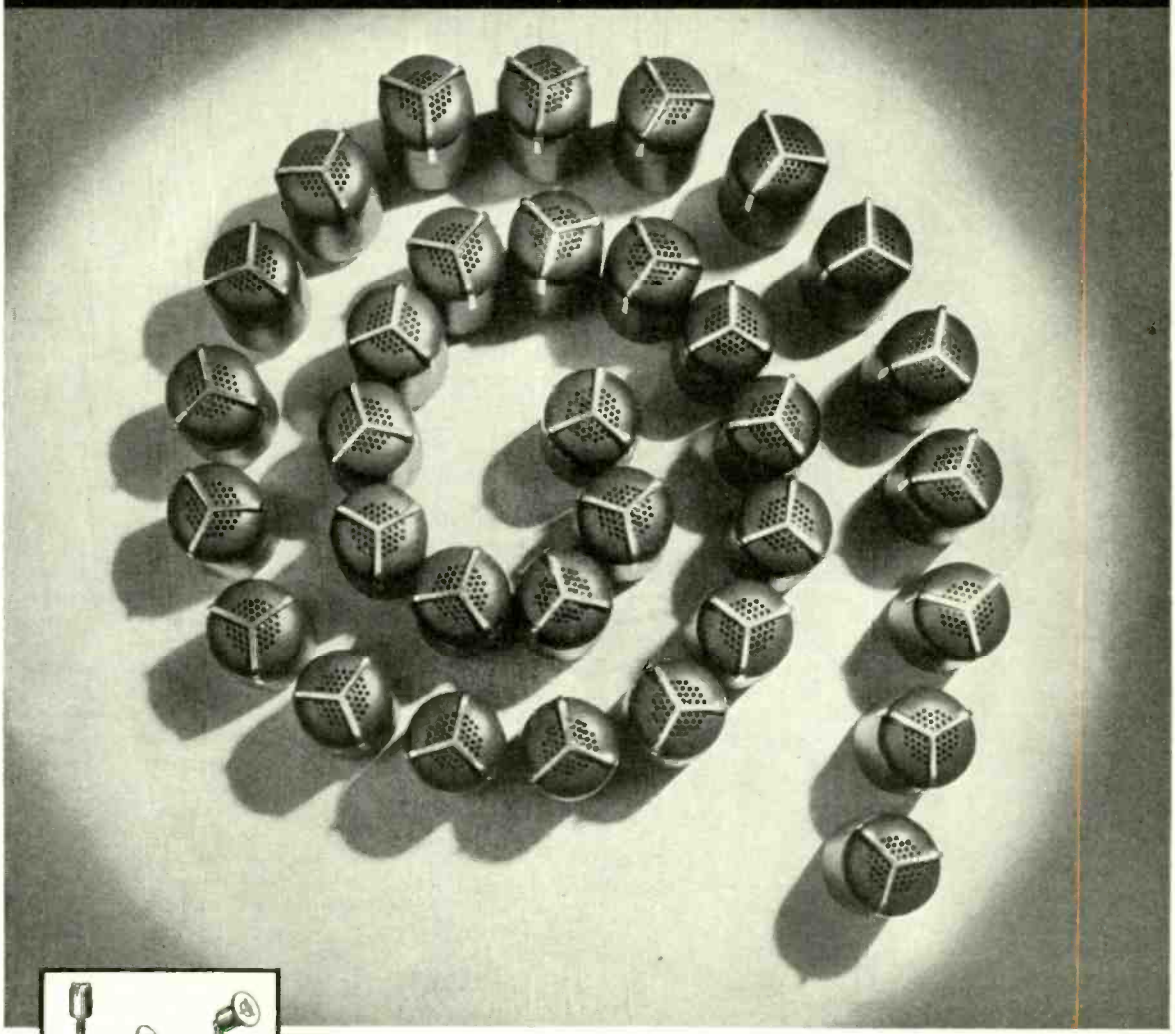
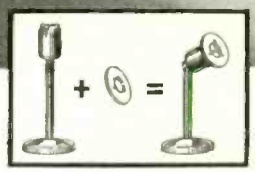
How many for you?





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RADIO TELEPHONE BROADCASTING EQUIPMENT

EDITORIAL

TELEVISION STUDIO CONSIDERATIONS

IN THIS ISSUE we are presenting the first of a series of articles on "Television Studio Considerations." The author of these articles, Lieutenant W. C. Eddy, has had considerable experience in both the engineering and non-engineering phases of the subject and we feel that he is very well qualified to handle this series.

To some the subject may seem somewhat out of place in a technical radio publication, since it involves art, music, dramatics, and the like; however, let us remember that it also includes photography, optics, illumination, and radio engineering as well. It is true that in present-day broadcasting production is, for the most part, handled by non-technical personnel. However, in television broadcasting the situation will probably be considerably different. The close cooperation necessary between the technical and non-technical phases of video broadcasting will require that the production end be handled by the engineering department. Hence, it would seem that the subject should be of considerable interest.

Since this series of articles will be somewhat different from the type of material usually appearing on these pages, the comments of our readers would be greatly appreciated. May we hear from you?

CONVENTIONS

CONVENTIONS seem to be the order of the day. The Annual Joint Meeting of the Institute of Radio Engineers and the American Section of the International Scientific Radio Union heads the list, being held at Washington, D. C., on April 30. Following this the Institute of Radio Engineers will hold their Silver Anniversary Convention at the Hotel Pennsylvania, New York City, from May 10-12 inclusive . . . a list of the technical papers to be presented at this gathering will be found elsewhere in this issue, and for those members who will not have the opportunity to attend the meeting, a convention report will appear in the May issue. Final arrangements for the Thirteenth Annual RMA Convention and membership meetings at Chicago, June 8-9, were made at a recent meeting of the RMA Board of Directors. The fourth assemblage of interest has just been announced . . . the Annual Convention of the National Association of Broadcasters . . . for June 20, 21, 22 and 23 at the Hotel Sherman in Chicago. Details of this latter meeting will appear in a later issue.

AUTOMATIC NOISE CONTROL

SINCE James Lamb, of the technical staff of QST, first announced his noise-silencing system a little over a year ago, a great deal of material has been published on the subject and a number of circuits advanced. In our opinion, the most logical system to date is one which operates on a principle similar to avc action. In this system the noise bias automatically adjusts itself to the signal level with the result that maximum silencing action is obtained regardless of actual changes in signal voltage. Details of this automatic silencing system will be found in Mr. Dickert's article on "Noise Control" which appears in this issue.

AUTOMATIC VOLUME COMPRESSION

IN OUR EDITORIAL for February, 1937, we urged the broadcasters to start a move towards increased volume range; we pointed out that receiver engineers have had considerable experience in designing volume expanders in connection with phonographs, and that if the broadcasters were to adopt some uniform system of automatic volume compression, it seemed logical to believe that the receiver manufacturers would soon place expanders in their receivers.

In this connection it is interesting to note that an apparatus to automatically limit volume has already been announced. This device, which has been designed mainly to prevent excessive peaks of over-modulation, is said to effect an increase in a station's effective signal level of about 3 db, and to be capable of compression within limits.

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COMMUNICATION & BROADCAST ENGINEERING

FOR APRIL, 1937

NOISE CONTROL

By J. E. DICKERT

AN INVENTORY of developments in the general field of communications during the past few years shows progress along two rather definite but inter-dependent lines. The actual, though not so immediately obvious, aim in most experimental planning is to use existing facilities and newly discovered transmission media to the best possible advantage or commercial utility. In either method of approach the defeat of noise, whether a natural physical phenomena or man-made, is the hidden "bogey man" constantly prodding the engineering brains to further accomplishments.

The two lines of approach are: efficiency, fostered by the demand for transmitting the most intelligence in the least possible time for each dollar spent by the consumer; and fidelity, which concerns the accuracy with which a given signal is transmitted and measured by the change, addition, or deletion at the terminal as compared with the character at the source. Because fidelity is normally associated only with the entertainment aspect of communication its bearing on efficient systems is often overlooked. Printer circuits and high-speed telegraph cables require a frequency bandwidth acceptance approximating a normal audio line, while television taxes the best of present transmission facilities.

Any interruptions to the intelligent and faithful transmission from point to point, such as extraneous noise induced or otherwise superimposed on the signal, makes necessary, in the absence of means for reducing the interference at its source, either an increase in power of the signal source, by which means the signal-to-noise ratio is improved, or a restriction in fidelity capability, by which noise is reduced through distortion and band-pass to a greater degree than is the more intelligible component of the signal.

In the case of increased power, the economical point of diminishing returns varies with the type of service offered. Increased revenue for broadcast facilities allows considerable investment in power against primary, or uninterrupted, coverage area. However, in point-to-point commercial communication over fairly great distances a value of power investment is soon reached where the cost of increasing this power is not warranted by the increase in utility and revenue.

In the latter case an efficient method for transmitting intelligence becomes the more economical. Such systems are based on the assumption that unwanted noise pickup is roughly proportional to the received bandwidth, but that a large percentage of the transmitted intelligence is contained within the limits of a comparatively narrow band. One outstanding example of this means is the widespread use of crystal filters in the intermediate stages of communications type receivers. Such arrangements can conceivably accept bands of less than a hundred cycles, and if the transmitted signal is modulated by a steady tone, this tone frequency, plus or minus a few percent, can be amplified tremendously with practically complete rejection of other tones or noises regardless of their source. It is an extreme method applicable generally only to slow-speed code signals, but is not necessarily useful only in the intermediate-frequency amplifier. Mechanical resonant filters can be applied to acoustic transducers to attain extremely high efficiency within the desired narrow frequency range. Also, audio amplifiers in general can be highly peaked very economically—even to the extent of controlled regeneration and associated high gain.

A tempered treatment of this method is the justly popular, highly-selective intermediate-frequency amplifiers used in some receivers, the justification being that while some noise rejection is accomplished, there is still enough band acceptance left to amplify certain voice-frequency components of a modulated carrier. Selectivity of this type also can be combined conveniently with a high degree of sensitivity, and in conjunction with a restricted audio response, by means of tone control or otherwise, added to the intermediate response, pleasing and fairly quiet reception can be had.

Another efficient method has long been used by the telephone companies. Noise picked up in wire lines comes from many sources and consists of alternating voltages of many frequencies. However, since the most necessary voice frequencies occupy a comparatively narrow band, from approximately three hundred to two thousand cycles, all equipment is designed to be most efficient at these frequencies. With the resultant peak in the vicinity of eight hundred to one thousand cycles, transmission is very inefficient both at low frequencies where hum pickup would be objectionable and at very high frequencies where cross-talk and capacity pick-up may be noticed. In the light of more recent investigations and because of additional uses for subscriber equipment, frequency response has broadened noticeably, particularly in urban installations.

Any attempt at noise reduction in radio reception must start necessarily with a search for some discriminating characteristic of noise not found in the signal. Diversity reception is as old as radio and as new as this year's automobile receiver. It depends for its efficacy on the assumption that radio signals are unlike noise or static in directional qualities. Generally two antenna systems are used, each picking up the same amount of noise but different amounts of signal. If the energy from

one antenna is combined out of phase with the other with such accuracy that the noise is balanced out there still exists an unbalance in signal which passes on to the receiver by an amount which will depend upon the unbalance. Certain other advantages accrue to make this method advantageous for fixed-station use, and the variety of its applications is enormous.

Another method, and quite similar to the diversity system, assumed that noise picked up ten or twenty kilocycles from the received carrier could be combined with noise present with the carrier in such a way as to balance out. The fallacy was that noise is not identical at different frequencies, but strangely enough a slightly different application of the theory has been used successfully on the ultra-high frequencies quite recently.

While common static is still with us as much as ever, the effects of it in many cases are submerged by the barrage of high-powered transmitters. Coincident, however, with the general increase in power is an even greater increase in man-made noises caused by home and commercial electrical appliances. The answer to this from the commercial radio and communications angle is to locate the receiving system away from the noise area, but the answer from the man-on-the-street angle is to purchase "noiseless" antennas offered by many manufacturers. The latter depend upon the assumption that radio-frequency transmission lines can be so well balanced that when properly terminated they are immune to alternating fields or radiation and that they will conduct, without serious attenuation, radio-frequency energy from an antenna located far enough away from the noise source. This method is successful, particularly if the input to the receiver is properly balanced and shielded against capacity coupling.

Significantly, as reception means for ultra-high frequencies improves, interference energy picked up by the flat-top antenna increases. In the case of motor-car and airplane ignition system, radiation is destructive to fairly high signal intensities over comparatively great distances. In the vicinity of fifty to sixty megacycles ignition interference has been experienced from planes flying at distances up to five miles and from automobiles within a radius of more than a half-mile.

The distinguishing characteristic of this type of interference is the high ratio of peak to root-mean-square value, together with a comparatively long time interval between individual pulses. Because of this feature such noise is not psychologically objectionable until the peak voltage exceeds the received carrier level. Noise which is of greater value than the signal, then, possesses the discriminating characteristic used for suppression by the limiting method.

In the category of noise limiters comes first non-linear electro-acoustic transducers giving rise to a high degree of amplitude distortion, which definitely determines the maximum output of the device. The assumption is that auditory response for ordinary sounds is masked by extremely loud noise which, if suppressed in level, would render the underlying signal intelligible though distorted. Practical distortion means, such as, easily overloaded audio stages, saturable core reactors, gaseous discharge tubes, and in fact most all non-linear devices, constitute limiters of this type. The obvious disadvantage is severe distortion and more or less lack of control. Limiting is applied not only to noise but to the modulation component of the signal as well, without planned regard to the possible deleterious effect on the intelligibility and consequent fatigue to the listener.

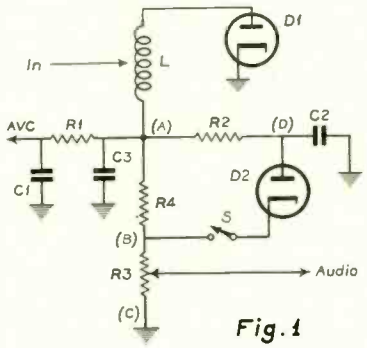


Fig. 1

In consideration of the needs of noise control and with a view toward simplicity and reliability, a method for such control is herein submitted.

In Fig. 1 L and D-1 represent a normal diode detector circuit where L is the inductance which may be the secondary of an intermediate-frequency transformer. Elements R-4 and R-3 constitute the resistive diode load. The constants of R-1 and C-1 may be any suitable value for normal automatic-volume-control voltage. C-3 is indicated as an intermediate-frequency filter and audio load capacity. Also R-2 and C-2 make up a separate automatic voltage reservoir determined by the rectified carrier voltage in the same manner as the regular automatic-volume-control circuit. However, both values are made rather large in order that the time constants of the combination will be somewhere between a tenth and one second. Element D-2 represents, what we shall term, the noise diode and may ordinarily be combined in the same envelope with D-1, such as, the type 6H6 tube.

The switch and the cathode lead of D-2 indicates the proper position for breaking the noise-silencer circuit. To obtain an idea as to the action of the circuit let us assume a signal of such magnitude that after rectification, a negative potential of 10 volts appears at point A in Fig. 1. Then at point B the potential would be a function of the ratio of R-3 and R-4, since point C is already at ground potential. If R-4 be made equal to R-3, it is obvious that point B would have an average potential of minus 5 volts. Point D, which is the reservoir for noise diode bias voltage, also will be at a potential of minus 10 volts. This leaves the plate of D-2 five volts more negative than the cathode so that the diode is essentially non-conductive. If, however, a high instantaneous noise-voltage peak reaches a value of, let us say, minus 40 volts after rectification, the instantaneous value at point B will be half of that, or minus 20 volts, which at the same time is the instantaneous potential at the cathode of the noise diode. The plate of the noise diode, however, remains at the original value of minus 10 volts due to the delay occasioned by the ratio of R-2 and C-2. In other words, the plate of D-2 is instantaneously 10 volts more positive than the cathode, which allows a current to flow through the lowered impedance of the diode. What happens essentially is that the alternating-current impedance for point B through D-2 and C-2 to ground is instantaneously much lower than the impedance of R-3 which is normally the audio load circuit to ground. At the termination of the noise pulse, which may last for only a thousandth of a second or even less, the circuit returns to normal almost instantly. Condenser C-2 because of its high capacity contains a sufficient amount of energy so that its normal charge is not altered materially by noise voltages appearing via R-2.

Assuming our original 10-volt rectified carrier is one hundred percent modulated, the pulsating voltage appears at point A as varying at modulation frequencies between the values of minus 20 volts and zero. At point B these values are divided by two, making a total variation from minus 10 volts to zero, so that even during one hundred percent modulation peaks the cathode of D-2 never is more negative than the plate, but merely approaches that value. In other words, this system is capable of squelching noise peaks of higher than carrier value but still does not distort the demodulated signal.

Since the action is a function of signal strength, the threshold value of

noise suppression changes with signal strength. Hence, if the received signal strength goes down, the potential at point D goes down with it, and the differential audio potential at point B maintains automatically its proper ratio. Carrying the illustration to the extreme, or to no-signal value, point D is essentially at zero potential, so that any instantaneous noise present between carriers will automatically take the path to ground through D-2. Thus the system operates as a practical squelch for inter-carrier noises.

In the preceding illustration we have made R-4 equal to R-3, the reason being that the noise circuit was not to distort a rectified signal. We can assume, however, in most cases that modulation on sustained tones will seldom exceed the fifty percent value. Therefore, R-4 can be only half the value of R-3, thus immediately improving the noise-silencing action to something below the one hundred percent modulation level. Heavy modulation peaks of instantaneous character will be by-passed through D-2 the same as noise. However, these peaks much like noise go quite unnoticed by their absence. This does not mean that one hundred percent modulation is not the ideal value for commercial and broadcast stations, but that in practice the full capabilities of modulation are seldom obtained.

For many types of communication work, where some audio distortion is acceptable, R-4 can be left out or maintained at a very low value, thus suppressing all noise down to the average unmodulated carrier level, with the positive modulation peaks as well. In practice—particularly on voice modulation—the deletion of the positive modulation peaks does not detract from the intelligibility of the rectified signal, nor is the resulting quality displeasing even after long periods of listening.

Fig. 2 shows a more desirable method of obtaining a high degree of noise suppression along with some audio distortion. Elements R-4 and R-3 can still be maintained at equal values, but R-4 is shunted by a small capacity C-4 which is of such a value as to equalize for the difference in modulation for the various voice frequencies. It has been shown that the percentage of modulation of an average voice varies with frequency to the extent that above 500 cycles the percentage curve drops very rapidly to a point in the neighborhood of a fraction of one percent at 5000 cycles. While this procedure in itself distorts the received frequency characteristic, it adds rather than detracts from the intelligibility since the higher modulation frequencies are given a rising characteristic, as far as the load circuit R-3 is concerned. It is significant that the noise-suppression ability is increased at the same time so that the effect is just the opposite from what might be expected by those accustomed to tone controls and drooping characteristics for practical noise suppression.

Since all peak-type noises are characterized by exceedingly steep wave fronts and high damping, a pulse is similar to a single lobe of a very high-frequency wave. The appearance of this noise, as regards point B, is the same as if R-4 were not present, since C-4 offers such low impedance. Thus in most cases the full noise voltage appears at B and the cathode of D-2, allowing more complete suppression. Condenser C-3 is the intermediate-frequency filter capacity in a new position. This change is necessary in order that C-4 may exhibit its full effect without shunting action through the filter capacity. Note that in Fig. 2 the type of audio coupling indicated is prescribed where the grid bias is obtained from the drop across

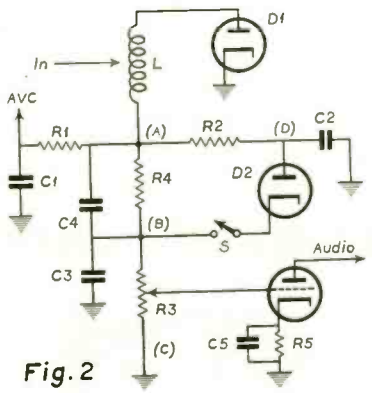


Fig. 2

R-3, and known generally as diode-biasing. Elements C-5 and R-5 merely determine the limiting bias for the audio tube. By the use of C-4 under certain conditions of instantaneous voltages, the potential at B can even go slightly positive—at which time the audio tube becomes non-linear due to a positive grid, and the resulting bucking bias obtained through R-5 from change in plate current.

A few precautions in the installation and use of the circuit in either Fig. 1 or Fig. 2 may not be amiss. C-3 should be kept as small as possible. The reason for this is that in order to obtain good silencing action the original characteristics of the noise pulse must be retained. The discriminating characteristic used in this type of suppression is due to the fact that the noise pulses have a very high ratio of peak voltage to total power. The steepness of the wave front in making the pulse appear as a very high frequency means that any shunting capacity tending to attenuate high frequencies will distort the characteristic of the pulse and reduce the difference between it and the signal. This applies also to small inductances used in conjunction with capacities for intermediate-frequency filtering.

The aim should be to maintain high fidelity in the associated circuits of both signal and noise diodes whether or not such fidelity is warranted by intermediate-frequency sideband cutting and audio restrictions. To aid this condition the sum of R-3 and R-4 should be made fairly low in resistance—in the neighborhood of 100,000 to 150,000 ohms. While this necessitates a fairly high value of signal to be rectified with good fidelity, the attenuation of high frequencies is less pronounced due to stray capacity in the circuit. Leads to the resistors or noise diodes and to the audio amplifier should be kept short in order to eliminate the necessity for shielding.

In obtaining the proper time constant for the noise diode bias reservoir at D, R-2 should be a rather high value of resistance up to perhaps one megohm in order not to shunt the signal diode load. C-2 should also be a large value in order that the a-c impedance from the noise diode to ground be minimized. It is important that C-2 be non-inductive in order to be a low impedance also at very high frequencies, and good practice is to shunt this capacity with a mica condenser of smaller capacity. In any case, diode biasing of the first audio is recommended where at all possible, since coupling capacity and grid leaks complicate the detector load.

As applies to communications receivers the circuit of Fig. 2 allows practically quiet operation on all frequencies regardless of the signal strength received. Since the action is entirely automatic no controls are indicated with the exception of the switch S to cut the silencer in or out.

Noise of a sine wave character, as differentiated from the peak spark-discharge type, is suppressed to a lesser degree since the character constitutes what is more like a signal in its action on the second detector. In other words, the type of noise which changes the normal avc voltage of the receiver to any great degree is difficult to suppress by this method, but happily is the type noise not ordinarily picked up by an antenna in the clear, coupled to the receiver through an efficient transmission line.

Obviously, when using the type of circuit herein described, a fraction of the audio voltage available at the plate of the signal diode is used for control bias on the noise diode so that a slight loss—never more than three decibels—is ap-

parent in audio gain. Ordinarily such loss is negligible and can be made up easily if thought necessary. Standard practice indicates total receiver sensitivity to include audio gain, whereas radio-frequency and intermediate-frequency gain—admittedly most important—can be measured at the input to the second detector just as easily, and it may be a more accurate yardstick for receiver excellence.

Using this standard, inclusion of the suppressor circuit causes no loss whatever to sensitivity, and in fact may apparently increase it. High noise pulses at fast interruption rates, which ordinarily reduce sensitivity through avc action, due to the relatively fast time constant of the avc resistance-capacity network, are rendered ineffectual to this end by virtue of suppression. Also, because of the lack of noise, audio gain may be maintained at a higher level with more comfort.

None of the remaining high-frequency functions are disturbed. Selectivity is not changed by addition of shunt intermediate circuits, and the suppressor has no feature which conceivably can cause unstable operation in any part of the receiver.

Size and space are important considerations when installation is contemplated for portable and mobile use. A few ounces at most are added to the weight of airplane equipment and, if the noise diode is combined in the same envelope with the signal diode, the extra space necessary is only that used for a few resistors and capacities.

As regards aviation, it has been noted that when a suppressor-equipped receiver is left idling on one of the three or five megacycle channels, the stand-by between transmissions is remarkably free from normal inter-channel noise. Even key-clicks from adjacent or image channels are attenuated satisfactorily. No trouble was experienced with delay on quick break-ins on these channels, but since these transmissions are audio equalized for efficiency it may be advisable to decrease the time constant of R-2, C-2 by making C-2 a lower value.

While ultra-high-frequency installations in police cars can well use suppression of this type it is anticipated that some additional suppression will take care of the source of ignition interference. It is found that, while such exceedingly heavy noise is limited to the pre-determined value, the length of the silent period during pulses may become objectionable unless the ignition system is maintained at perfect adjustment. Happily, interference from passing cars is practically eliminated—which is not the case with the diversity method of noise control as installed in some mobile receivers.

It is suggested that all-wave and multi-band amateur-commercial receivers incorporate, as part of the band change switch, means for allowing suppression with high-fidelity response for the broadcast frequencies and varying degrees of suppression for the other bands. The automatic feature otherwise will take care of different signal levels encountered within certain bands including the rapid fading encountered above ten megacycles.

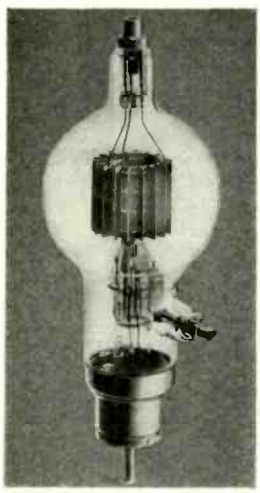
It is believed that no single method for noise reduction can be expected to accomplish complete satisfaction. Because of the various types of interference encountered—each with a favored method for elimination—the ultimate must necessarily be a combination of tactics. Hundreds of thousands of dollars are spent annually in noise research by aviation, communications and television companies. New methods are known to be in the laboratories and it is hoped that, when television becomes a reality, extraneous noise must cease to exist.

A NEW ULTRA-HIGH-FREQUENCY TUBE

THE SUCCESSFUL EXPLOITATION of the ultra-high frequencies has been greatly curtailed because of inadequate equipment to produce dependably an order of power output that meets with current demands.

It has long been appreciated that as the frequency of an r-f generating device is increased the efficiencies and consequent outputs have been reduced. The critical frequencies of different types of triode tubes vary with the physical characteristics. In some cases high-capacity tubes suffer at frequencies as low as 7 mc. Although low-capacity triodes have been built to work on frequencies as high as 300 to 600 mc, the physical sizes of most of these tubes have been reduced (in order to minimize lead inductances and inter-electrode capacities) to such an extent that the power capabilities are of the order of a few watts.

To fill the demand for a tube that will give an output of a kw or more at frequencies in the vicinity of 100 mc the tube shown in the accompanying illustration has been developed by Eitel-McCullough, Inc. Appreciating the limitations placed upon current tubes by high-frequency operation, a description of this tube, known as the 1000-UHF, should be of interest.



The 1000UHF tube is a radiation-cooled tube having an overall height of 13 inches and a bulb diameter of 5 inches. The plate dissipation is rated at 1000 watts, provided the bulb is cooled by a blower. The anode is made of degassed tantalum and is designed to operate with a bright orange color at its maximum rating. In order to increase the heat-radiating surface and at the same time keep the interelectrode capacities low, the anode is provided with 18 cooling fins which are said to increase the radiating capabilities of the anode over twice that obtained with a cylindrical anode.

In this tube the grid and filament are mounted as a unit with ample insulation being provided by a special type of stem. The unusual mounting arrangement was adopted in preference to the more conventional type of clamp because of the high grid-to-filament capacities that would result from the use of a clamp.

The amplification factor is 30, high enough to make unnecessary a high order of grid-excitation voltage and at the same time not so high as to affect the electrical characteristics of the tube. The filament operates at a potential of 7.5 volts and at a current of 16 amperes. The filament is of thoriated tungsten of high thermionic efficiency.

The usable value of plate current is 700 ma d-c and the grid current is

(*Continued on page* 19)

Rule 127: The approved power ratings of vacuum tubes for operation in the last radio stage of broadcast transmitters are fixed as set out in the following tables:

TABLE A*

Power Rating of Vacuum Tubes for High-Level Modulation or Plate Modulation in the Last Radio Stage

POWER RATING (Watts)	Amperex	Collins	De Forest	Eitel McCullough	Federal Telegraph	Heintz & Kaufman	Hygrade Sylvania	RCA Mfg. Co.	United Electronics	Western Electric	Taylor Tubes, Inc.		
50	—	—	—	50T	—	—	—	—	—	211D 211E 248A 276A	T55 841A		
75	HF-100 203-A 211 838 852 860	C-203A C-211	503-A 511 552 560		F-303-A F-311-A F-352-A	154	203-A 211 852 860	203-A 211 838 850 852 860	303-A 311 361-A 938 952	242A 242B 242C 260A 261A 284A 295A	203A 211 211C		
100	—	—	—	100TH 100TL	F-102-A F-108-A	—	—	—	—	—	—		
125	HF-200 203-H 211-C 211-D 211-H 805	C-200 C-201 C-211D	—	150T	—	—	—	803 805	905	—	T155 HD-203A		
250	204-A HF-300	C-204A C-300	504-A 561 571	—	F-204-A F-212-E F-331-A	354	204-A 212-D 831 861	204-A 831 861	304-A 312-E	212D 212E	T200 204A 814 822		
350	849	—	549	250TH 250TL 300T	F-100-A F-349-A	—	849	849	949	270A	—		
500	—	—	—	—	—	255	—	—	—	251A	—		
750	851	—	551	500T	F-351-A	—	851	851	951	279A	—		
1000	—	—	—	—	F-346-A	1554	846	846	—	—	—		
2500	—	—	520-B 520-M	—	F-328-A F-3652-A	3054	820-B	1652	—	228-A	—		
5000	—	—	507 548 563	—	F-307-A F-320-A F-320-B F-348-A F-363-A	—	207 848 863	207 848 863 891 892	—	220B 220C	—		
10,000	—	—	—	—	F-101-B F-110-A F-110-X F-116-A F-332-A F-332-B F-332-C F-358-A	—	—	858	—	232A 232B	—		
40,000	—	—	—	—	—	—	—	898 862	—	298A	—		

TABLE B*

Power Rating of Vacuum Tubes for Low-Level Modulation or Last Radio Stage Operating as Linear Power Amplifier

25	—	—	—	—	—	154	—	203A	—	—	203A 211 211C 841A		
50	HF-200 203-H 211-H	—	—	100TH 100TL 150-T	—	354	—	803	—	242B 242C	HD 203-A		
75	HF-300 212-E	—	504-A	—	F-304-A F-312-A	—	204-A 212-D	204-A	304-A 312-E	212D 212E	T200 204A 814 822		
125	—	—	549	250TH 250TL 300-T	F-100-A F-349-A	—	849	849	949	270A	—		
250	—	—	551	500-T	F-351-A	255 1554	851	851	951	251A	—		
500	—	—	—	—	F-346-A	3054	846	846	—	279A	—		
1000	—	—	520-B 520-M	—	F-328-A F-3652-A	—	820-B	1652	—	228A	—		
2500	—	—	507 569	—	F-307-A F-320-A F-320-B F-363-A	—	207 863	207 863 891 892	—	220B 220C	—		
5000					F-358-A			858					
8500	—	—	—	—	F-101-B F-110-A F-110-X F-116-A F-332-A F-332-B F-332-C	—	—	—	—	232A 232B	—		
25,000	—	—	—	—	—	—	—	862 898	—	298-A	—		

TABLE C*

Power Rating of Vacuum Tubes for Grid Bias Modulation in the Last Radio Stage

50	—	—	—	250TH 250TL	—	354	—	—	—	212E 270A	—		
100	—	—	—	300T	—		—	—	—	—	—		
125	—	—	—	500T	—	255	—	—	—	—	—		
250	—	—	—	—	—	1554	—	—	—	—	—		
500	—	—	—	—	—	3054	—	—	—	—	—		
2500	—	—	—	—	F-307-A	—	—	—	—	—	—		

* These tables apply only to tube ratings for use in the last radio stage of broadcast transmitters and may not be applicable to any other service.

If in an application to the Commission a vacuum tube of a type number and power rating not given in in the foregoing tables is specified for operation in the last radio stage, it may be accepted provided there is also submitted to and approved by the Commission the manufacturer's rating of the vacuum tube for the system of modulation or class of service contemplated. These data must be supplied by the manufacturer.

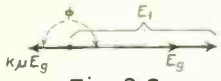


Fig. 2-C

Fig. 2-A

AUDIO FEEDBACK

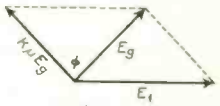


Fig. 2-B

By A. R. RUMBLE

Transmitter Engineer

WNEW

THERE HAS BEEN an increasing interest shown in audio feedback. It has often been stated that degenerative feedback will improve the frequency characteristic, reduce noise and amplitude distortion, and make the overall amplification more nearly independent of variations in tubes and tube voltages. It is the purpose of this article to show in as simple a manner as possible why these things are so.

In Fig. 1 is shown a simple circuit in which a fraction of the output voltage of an amplifier is fed back to the input. In order to keep the diagram simple only audio circuits are shown. Also, in order to further simplify matters, a very high input impedance, such as the grid of a tube, is used so that no appreciable current flows. The same principles apply when feeding into a finite load but allowance has to be made for the effect of the input impedance.

The input voltage and the feedback voltage combine vectorially to produce the resultant voltage E_g. To understand this requires only a knowledge of simple addition of two vectors.

The following symbols will be used:

μ = voltage amplification of amplifier at any given frequency, without feedback

k = fraction of output voltage fed back

E_1 = magnitude of input voltage

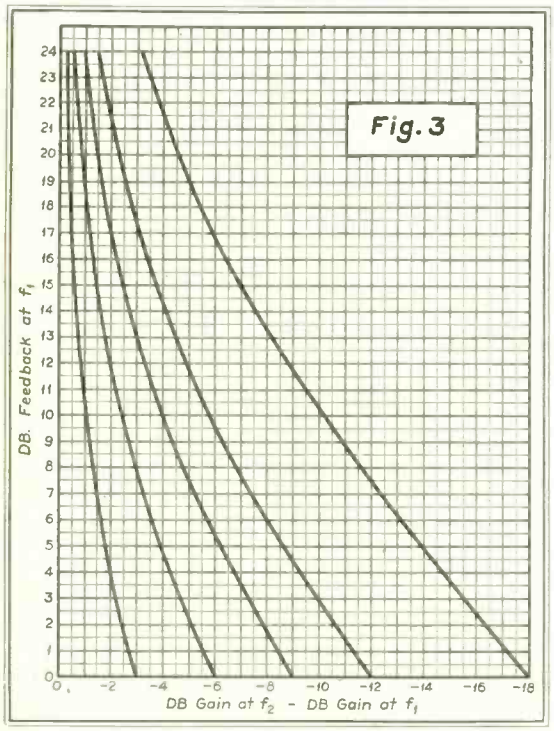
E_g = magnitude of resultant voltage

$E_o = \mu E_g$ = magnitude of output voltage

ϕ = phase shift in the amplifier and feedback circuit at the given frequency. In other words, if we start at the grid with a voltage E_g and go through the amplifier and feedback circuit, the voltage will then have a magnitude $k\mu E_g$ and will have been shifted by an angle of ϕ degrees.

The circuit is generally arranged so that frequencies in the middle of the audio spectrum are shifted very nearly or exactly 180 degrees, i.e., reversed. Frequencies on the ends of the audio spectrum are shifted somewhat more or less than 180 degrees. At these frequencies μ generally happens to be less than at the medium frequencies.

The output voltage is μE_g and the feedback voltage is $k\mu E_g$. The feedback voltage is out-of-phase with the grid voltage E_g by the phase-shift angle ϕ (ϕ may be any angle). Figs. 2-A, 2-B and 2-C show typical vector diagrams for cases where ϕ is less than 90 degrees, more than 90 degrees, and exactly 180 degrees.



NORMAL (180°) SHIFT

The normal phase relations for medium frequencies in a correctly operating amplifier with degenerative feedback are shown in Fig. 2-C. This might be called phase reversal rather than phase shift. This phase reversal may be secured by using an odd number of stages or by

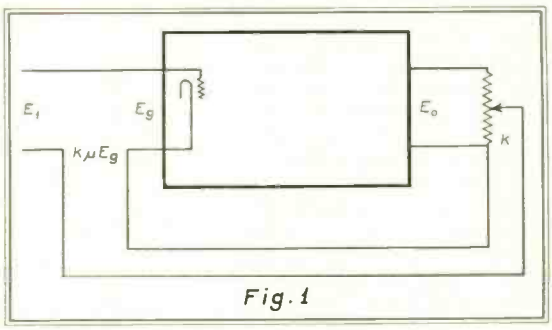


Fig. 1

other means. From inspection of Fig. 2-C it is obvious that

$$E_1 = E_g + k\mu E_g = E_g\,(1 + k\mu) \quad \ldots\ldots(1)$$

$$\text{voltage gain} = \frac{E_o}{E_1} = \frac{\mu}{1 + k\mu} \quad \ldots\ldots(2)$$

$$\frac{\text{gain without feedback}}{\text{gain with feedback}} = 1 + k\mu \quad \ldots\ldots(3)$$

$$\text{db feedback} = 20 \log (1 + k\mu) \quad \ldots\ldots(4)$$

COMPARISON OF TWO FREQUENCIES AT NORMAL SHIFT

Suppose that at some reference frequency f_1, say 1,000 cycles, the amplifier has an amplification (without feedback) of μ_1 and a fractional feedback of k_1, and at some other frequency f_2 an amplification and feedback of μ_2 and k_2. At both frequencies it is assumed that the amplifier has the normal phase reversal. From (2) we can calculate the gain at each frequency. Dividing one gain by the other we obtain

$$\frac{\text{gain at } f_1}{\text{gain at } f_2} = \frac{\mu_1}{\mu_2}\,\frac{1 + k_2\mu_2}{1 + k_1\mu_1} \quad \ldots\ldots(5)$$

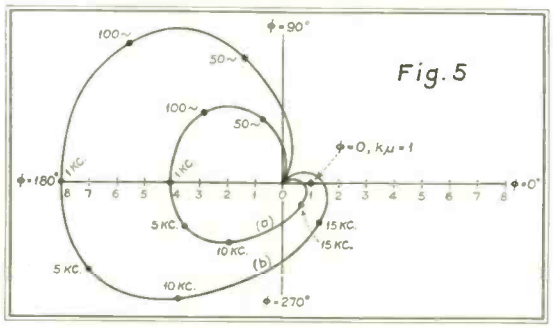
In case the feedback ratio is the same at the two frequencies $k_1 = k_2 = k$

$$\frac{\text{gain at } f_1}{\text{gain at } f_2} = \frac{\mu_1}{\mu_2}\,\frac{1 + k\mu_2}{1 + k\mu_1} \quad \ldots\ldots(6)$$

$$\text{db gain at } f_2 - \text{db gain at } f_1 = -20 \log \frac{\mu_1}{\mu_2}\,\frac{1 + k\mu_2}{1 + k\mu_1} \quad \ldots\ldots(7)$$

Fig. 3 is plotted from this equation by substituting different values of $k\mu_1$ and $\frac{\mu_1}{\mu_2}$. For the abscissae we use the feedback at f_1 which is $20 \log (1 + k\mu_1)$. For the ordinates we use the values calculated from the above equation. These curves show that as the feedback is increased the gains at the two frequencies approach nearer and nearer to each other. For example, if the gain at f_2 with no feedback is 6 db less than the gain at f_1, then with 18 db of feedback the gain at f_2 is only 1 db less than the gain at f_1. What is true of these two frequencies is true of all frequencies. The gain at all frequencies which have a feedback ratio k the same as at f_1 and a normal phase reversal will approach the gain at f_1 for large values of feedback.

$$\text{db gain at } f_1 = 20 \log \frac{\mu_1}{1 + k\mu_1} \quad \ldots\ldots(8)$$



For great amounts of feedback 1 becomes negligible compared to $k\mu_1$ so that (8) becomes approximately

$$\text{db gain} = 20 \log \frac{1}{k} \quad \ldots\ldots(9)$$

Thus we have arrived at a peculiar property of feedback: with large amounts of feedback, the overall gain is almost independent of μ, the amplification of the amplifier proper. Thus it can be seen that variations in tube constants and supply voltages which cause variations in μ have very little effect on the overall gain. The greater the amount of feedback the less effect these variations have on the overall gain.

GENERAL CASE WITH ANY PHASE SHIFT ϕ

Consider now Figs. 2-A and 2-B. By means of the ordinary trigonometry of triangles or parallelograms we can solve for one side in terms of the other two and the angle.

$$E_1 = \sqrt{E_g^2 + (k\mu E_g)^2 - 2E_g(k\mu E_g)\cos\phi}$$

$$= E_g\sqrt{1 + (k\mu)^2 - 2k\mu\cos\phi}$$

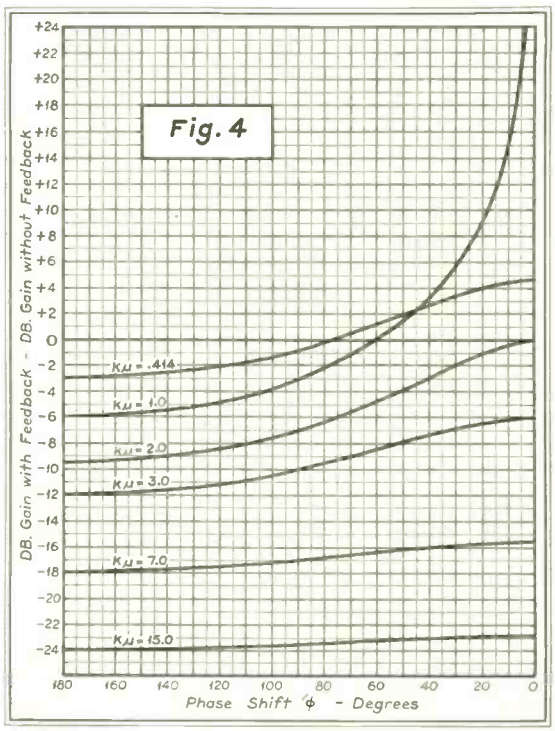
$$E_o = \mu E_g$$

$$\frac{E_o}{E_1} = \frac{\mu}{\sqrt{1 + (k\mu)^2 - 2k\mu\cos\phi}} \quad \ldots\ldots(10)$$

This gives the voltage gain at any frequency where the voltage amplification is μ, the feedback ratio k, and the phase shift ϕ.

$$\frac{\text{gain with feedback}}{\text{gain without feedback}} = \frac{1}{\sqrt{1 + (k\mu)^2 - 2k\mu\cos\phi}} \quad \ldots\ldots(11)$$

$$\text{db gain with feedback} - \text{db gain without feedback} = 20 \log \frac{1}{\sqrt{1 + (k\mu)^2 - 2k\mu\cos\phi}} \quad \ldots\ldots(12)$$



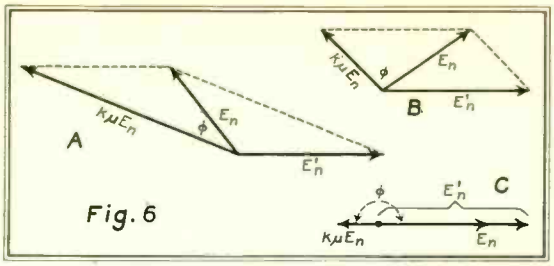


Fig. 6

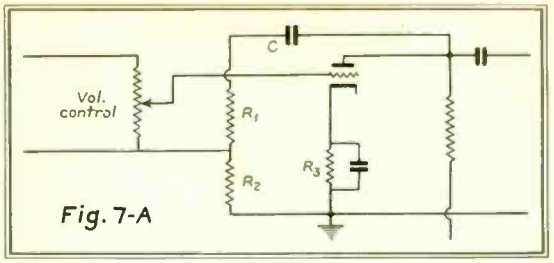


Fig. 7-A

To show the effect of phase shift, the above equation has been plotted against ϕ for several values of $k\mu$ (Fig. 4). These curves indicate that where the phase shift does not differ from 180 degrees by more than 60 degrees, the difference in gain is not more than approximately 1 db. On these curves plus values of db would indicate regeneration, while negative values of db would indicate degeneration. These curves as well as all previous calculations are based on the assumption that there is no self-oscillation in the amplifier and that steady-state conditions exist; i.e., there are no transients.

CONDITIONS FOR OSCILLATION

The conditions under which an amplifier will oscillate have been dealt with both theoretically and practically in articles previously published[1]. Two of the conditions are simple. For an amplifier to oscillate there must be some frequency at which

$$\phi = 0 \text{ (or some multiple of } 360°)$$
$$k\mu = 1$$

According to the articles just mentioned an amplifier will not necessarily oscillate when the above conditions are fulfilled. It is necessary to know ϕ and $k\mu$ at all frequencies. A polar diagram is plotted with ϕ as the angle and $k\mu$ as the radius vector. If the figure thus drawn encloses the point $\phi = 0$, $k\mu = 1$ then the amplifier will oscillate; otherwise it will not oscillate. In Fig. 5 are shown two typical curves for an amplifier. Curve (a) does not enclose the point 1,0 and hence under these conditions the amplifier will not oscillate. Curve (b) is for the same amplifier with more feedback. In this case the point 0,1 is enclosed and the amplifier will oscillate. It is possible to draw a curve with two points where $\phi = 0$ and $k\mu$ is greater than 1 but which does not enclose the point 0,1. However, the ordinary amplifier will not have a characteristic of this nature. Hence most amplifiers will probably oscillate if there is any frequency at which $\phi = 0$ and $k\mu$ is equal to or greater than 1. It is usually at the very high frequencies that ϕ becomes shifted enough from the normal 180-degree value to equal 0 or 360 degrees. At these very high frequencies μ and hence $k\mu$ is much smaller than at the medium frequencies in the usual amplifier. Hence we can usually use a fairly high value of $k\mu$ at the medium frequencies before the value of $k\mu$ at the very high frequencies reaches 1. In practical cases the feedback is kept below that value which causes the amplifier to oscillate.

REDUCTION OF NOISE AND HARMONICS

Suppose that at some point in the circuit a voltage E_n' is introduced. This may be a noise or hum voltage, a harmonic of some fundamental input frequency, a voltage caused by microphonics of a tube, or any other extraneous voltage. It may be introduced at any point in the circuit: at the input, in any stage, or in the output. Let the resultant of this introduced voltage and the feedback voltage (i.e., feedback of extraneous voltage, not feedback of signal voltage) be E_n. By the time this voltage E_n has made the circuit of the amplifier and feedback loop back to the point of introduction of the extraneous voltage, it has a magnitude of $k\mu E_n$ and has been shifted by an angle ϕ. k, μ, and ϕ of course have to be the values corresponding to the particular frequency of the extraneous voltage. In Fig. 6 are shown the vector diagrams for the combination of the introduced and feedback voltages. It is obvious that these diagrams are similar to those of Fig. 2. The resulting equations are the same as those for Fig. 2 if we substitute E_n' for E_1, E_n for E_g. Therefore the extraneous noise is reduced by a factor $1 + k\mu$. For a given output of signal voltage, adding feedback to an amplifier reduces the medium-frequency noises, harmonics, tube microphonics, hum, etc., by this factor $1 + k\mu$. For frequencies other than medium ones the extraneous voltages are divided by the factor $\sqrt{1 + (k\mu)^2 - 2k\mu\cos\phi}$. As to whether this constitutes a reduction or an increase in the harmonic or noise depends on ϕ, k, and μ at that frequency. Very high-frequency harmonics are often accentuated by feedback. However they are usually of very small amplitude so this is generally not serious.

CIRCUITS

There have been so many feedback circuits published that it would be impractical to reproduce them here. In

(*Continued on page 20*)

[1] "Regeneration Theory" by Nyquist in the *Bell System Technical Journal*, Vol. 11, p. 126.

"Regeneration Theory and Experiment" by Peterson, Kreer and Ware in the IRE Proceedings, Oct., 1934.

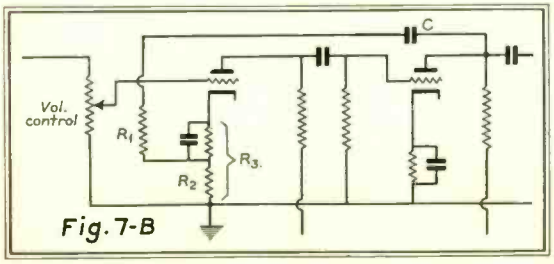


Fig. 7-B

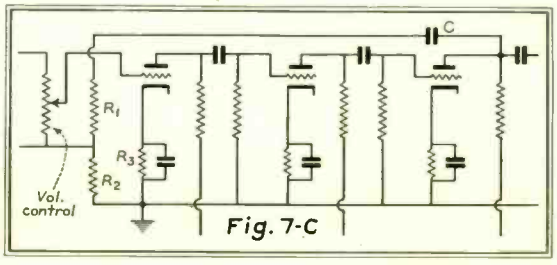
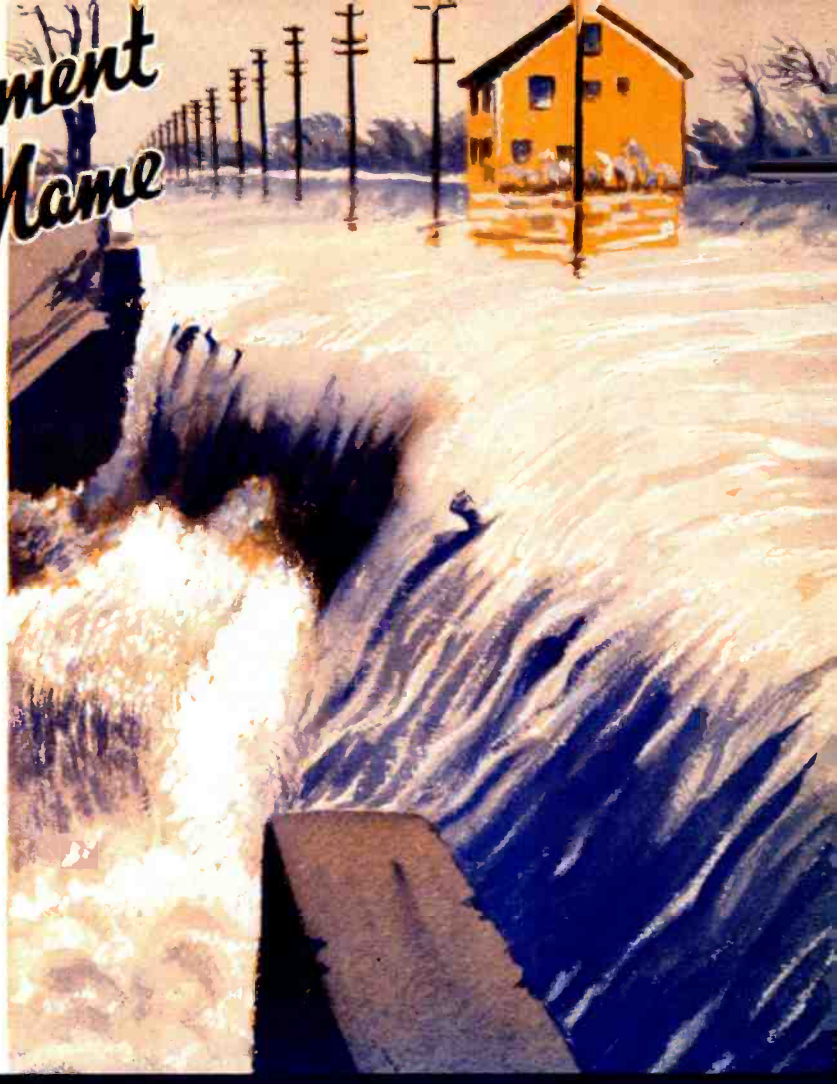


Fig. 7-C

A New Achievement for a Famous Name



A great drama of life and death was enacted when the raging waters of the Ohio and Mississippi spread terror and disaster during the recent flood. Out of this great drama emerged the nation's cast of heroes whose efforts saved thousands of lives from watery graves and controlled the inevitable aftermath of disease. ☆ Bendix is proud to have been able to play a part in the timely rescue efforts of the many governmental and independent agencies. The Coast Guard rushed men, boats, planes and communication trucks, some equipped with Bendix transmitters, receivers and other equipment to the flooded area. In cooperation with the Naval Reserve, Army and Amateurs, they established a joint emergency radio net-

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work to facilitate rescue work and relieve human suffering. ☆ Such occasions as this bear testimony to the reliability and efficiency of Bendix Radio products under all conditions. Bendix Radio Corporation provides complete research, engineering and manufacturing facilities for every type of radio equipment.

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  - Transmitters
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IRE SILVER ANNIVERSARY CONVENTION

THE INSTITUTE OF RADIO ENGINEERS will hold their 1937 Spring Convention at the Hotel Pennsylvania in New York City from May 10-12 inclusive. This is the Institute's Silver Anniversary Convention and, appropriately, it promises to be one of their best.

While complete details of the convention have not been released as we go to press, the list of papers to be presented at this gathering should be of interest. The papers are as follows:

"A Basis for Vacuum Tube Design", by M. A. Acheson, Hygrade-Sylvania Corp.

"A Circuit for Studying 'Kinescope' Resolution", by C. E. Burnett, RCA Manufacturing Co.

"A Multiple Unit Steerable Antenna for Short-Wave Reception", by H. T. Fries and C. B. Feldman, Bell Telephone Labs.

"A New Antenna Kit Design", by W. L. Carlson and V. D. Landon, RCA Manufacturing Co.

"A New Method of Measurement of Ultra-High-Frequency Impedance", by S. W. Seeley and W. S. Barden, RCA License Division Lab.

"A Wide-Range Beat-Frequency Oscillator", by J. M. Brumbaugh, RCA Manufacturing Co.

"An Oscillograph for Television Development", by A. C. Stocker, RCA Manufacturing Co.

"Automobile Receiver Design", by F. D. Schnoor and J. C. Smith, RCA Manufacturing Co.

"Characteristics of the Ionosphere and Their Application to Radio Transmission", by T. R. Gilliland, S. S. Kirby, N. Smith and S. E. Reymer, National Bureau of Standards.

"Concentric Narrow Band Elimination Filter", by L. M. Leeds, General Electric Co.

"Development of the Projection 'Kinescope'", by V. K. Zworykin and W. H. Painter, RCA Manufacturing Co.

"Effects of Space Charge in the Grid-Anode Region of Vacuum Tubes," by Bernard Salzberg and A. V. Haeff, RCA Manufacturing Co.

"Ground Systems as a Factor in Antenna Efficiency", by G. H. Brown, R. F. Lewis and J. Epstein, RCA Manufacturing Co.

"High-Current Electron Gun for Projection 'Kinescope'", by R. R. Law, RCA Manufacturing Co.

"Higher Program Level Without Circuit Overloading", by O. M. Hovgaard, Bell Telephone Labs.

"Measurement of Condenser Characteristics at Low Frequencies", by W. D. Buckingham, Western Union Telegraph Co.

"Radio Methods for the Investigation of Upper-Air Phenomena with Unmanned Balloons", by H. Diamond, W. S. Hinman, Jr., and F. W. Dunmore, National Bureau of Standards.

"Relation Between Radio Transmission Path and Magnetic Storm Effects", by G. W. Kenrick (University of Puerto Rico), A. M. Braaten and J. General (RCA Communications).

"Simple Method for Observing Current Amplitude and Phase Relations in Antenna Arrays", by John F. Morrison, Bell Telephone Labs.

"Study of Changes of Contact-Potential", by E. A. Lederer, D. H. Wamsley and E. G. Widell, RCA Manufacturing Co.

"Television Pickup Tubes with Cathode-Ray Beam Scanning", by Harley Iams and Albert Rose, RCA Manufacturing Co.

"The Brightness of Outdoor Scenes and Its Relation to Television Transmission", by Harley Iams, R. B. Jones and W. H. Hickok, RCA Manufacturing Co.

"The Development of Radiotelephony", by Lloyd Espenschied, Bell Telephone Labs.

"The Developmental Problems and Operating Characteristics of a New Ultra-High-Frequency Triode", by Winfield G. Wagener, RCA Manufacturing Co.

"Theory and Performance of the 'Iconoscope'", by V. K. Zworykin, G. A. Morton and L. E. Flory, RCA Manufacturing Co.

"Time Division Multiplex in Radio Telegraphic Practice", by J. L. Callahan, R. E. Mathes and A. Kahn, RCA Communications.

"Transoceanic Radio Telephone Development", by Ralph Bown, Bell Telephone Labs.

A NEW ULTRA-HIGH-FREQUENCY TUBE

(*Continued from page* 10)

100 ma. The grid, fabricated of degassed tantalum, is of the vertical bar type in order to reduce grid inductance. The plate and grid leads are somewhat unusual inasmuch as steps have been taken to reduce the r-f resistance to a minimum. The plate of the tube is suspended from the top of the bulb by means of three tungsten rods which extend through the glass. To these rods are welded solid copper bars which in turn are terminated in a solid copper button. As flexible connections of any kind are unsatisfactory at ultra-high frequencies, the copper button is drilled through so that a small piece of glass tubing may be inserted through which air under pressure may be directed on the seals. The copper button does not contact the glass thus minimizing the possibilities of puncture of the glass due to corona effects.

The grid lead consists of a ½-inch copper ribbon inside the tube and three tungsten leads through the glass. It is terminated in a similar manner to the plate connection already described. A hole drilled through the copper button permits the use of an air jet on the seal as described for the plate connector.

The socket in which this tube fits is a standard 50-watt type. Provision is made in the base of the tube to admit air which is directed on the filament press.

At the present time the 1000UHF is used principally in the push-pull arrangement because of the ease with which circuit symmetry can be achieved. Resonant lines for both the grid and plate circuit have been found to give the best results. Because of the rather short rods necessary for obtaining resonance at frequencies of 100 mc the grid and plate leads form an appreciable part of these circuits, hence the necessity for low-loss grid and plate connectors. While neutralization is obtained in the conventional manner, a great deal of precaution is necessary to prevent excessive power loss through radiation at these points.

While the 1000UHF provides an answer to the development of a reasonably high order of power at the ultra-high frequencies, it should not be construed that it will in itself assure successful operation at these frequencies. All circuit difficulties of lower frequencies are multiplied many times when one attempts to build an ultra-high-frequency transmitter. Circuits with apparently the same components may vary as much as 1000 percent in results obtained and unless the engineer is capable of considerable patience and possesses a thorough understanding of what he is trying to accomplish the ultimate results may be far from gratifying. In the hands of competent engineers this tube is said to be extending the useful range of communication frequencies, such as, for television transmitters.

AUDIO FEEDBACK

(*Continued from page* 16)

Fig. 7 are shown several of the simpler types for one, two and three-stage amplifiers. For amplifiers with an odd number of stages the feedback is made most easily from the plate of the last tube to a resistor in the grid return of the first stage. For an even number of stages the feedback is best made from the plate of the last stage to a resistor in the cathode return of the first stage. The feedback is divided between R_1, R_2, and C in proportion to their respective resistance or reactance. R_3 is the usual self-bias resistance of a tube. These diagrams serve merely to show the principles of feedback. There are numerous variations of these that can be used to fit particular cases.

From the foregoing simple mathematical treatment of feedback we may draw a few conclusions as to feedback.

(1) Only that portion of an amplifier which is included in the feedback loop is affected by feedback. Thus feedback may be applied to one stage of an amplifier without affecting the rest of the amplifier. However, by applying feedback to one portion of an amplifier in such a manner that that portion has a frequency characteristic which rises at the high- and low-frequency ends of the spectrum, we can make up for deficiencies of these frequencies in the other portions of the amplifier.

(2) With normal 180-degree shift and a k which is constant over the whole band of frequencies being used, an amplifier or a portion of it can be made to have a practically flat frequency characteristic by applying sufficient feedback . . . but it cannot be made to rise. Therefore with constant k and $\phi = 180$ degrees we cannot apply feedback to a portion of an amplifier and secure a rising characteristic to make up for deficiencies in other portions of the amplifier. The best method of securing this over-equalization in order to obtain a frequency characteristic which rises at the low and high frequencies is to design the feedback circuit so that it discriminates against these frequencies. Then k will be less at these frequencies and the characteristic for that portion, in which feedback is being applied, will rise at the ends of the spectrum. Of course this will also probably change ϕ and make the amplifier more susceptible to oscillation, particularly in a multi-stage amplifier. But this means may be used to make up for deficiencies of high and low frequencies caused by the input or output transformers or both, when they are not included in the feedback loop. A simple method of reducing k at the low frequencies is to reduce the capacity of C in Fig. 7.

(3) If feedback is applied to a single resistance-coupled stage, there is no danger of oscillation since the maximum shift away from the normal would be 180°.

(4) If feedback is applied to two resistance-coupled stages there is very little likelihood of oscillation since the shift only approaches 0 or (360) degrees at extreme frequencies where μ is very low. Therefore it would require an extremely large feedback to cause oscillation.

(5) With feedback applied to three stages there is more susceptibility to oscillation since a 0 or 360-degree shift is reached at a less extreme frequency and hence μ will probably be greater at that frequency. However, it will generally stand considerable feedback before oscillating.

(6) Including an input, output, or interstage transformer in the feedback loop will introduce more phase shift and hence make the circuit more likely to oscillate.

(7) The volume control must not be included in the feedback loop since feedback tends to keep the overall

amplification constant and hence it will tend to nullify any change in gain produced by varying the volume control.

(8) Feedback may be applied to a radio-telephone transmitter by picking up a little modulated r-f from the output, rectifying it to obtain a-f, and then feeding this back to the speech amplifier or modulator. From experience it may be stated that the amount of feedback that may be applied in this case without oscillation is much smaller than with a straight audio amplifier. This seems to be due to phase shift in the resonant circuits chiefly. In any case approximately 6 db can be applied and this will cut medium frequency distortion in half and hence is worthwhile.

•

CORRECTION

A TYPOGRAPHICAL ERROR occurred in Mr. C. B. Aiken's article on "Some Notes on Tuned-Coupled Circuits" which appeared in the March, 1937, issue of COMMUNICATION AND BROADCAST ENGINEERING. On page 30 the last part of equation (13) should read

$$v_d = \frac{4\pi L}{\sqrt{R_1 R_2}} |f_c - f_1| = \frac{4\pi L}{\sqrt{R_1 R_2}} |f_2 - f_c|$$

•

VECTOR ADDITION CHARTS*

ON THE two following pages are charts designed to facilitate rapid evaluation of equations having the form:

$$Y = \sqrt{(X_1^2 + X_2^2)}$$

In vector nomenclature the expression $Y = a + jb$ frequently occurs. The graphical representation is a right-angled triangle having sides equal to "a" and "b" respectively and the hypotenuse equivalent to Y. The magnitude of the resultant Y is obtained by taking the square root of the sum of the squares of "a" and "b". This vector notation is most frequently used for the representation of impedances composed of resistance and reactance, as $Z = R + jX$.

The charts may be employed to evaluate the magnitude of the impedance by using the right- and left-hand scales for setting a straight-edge between the known values of R and X, the resultant impedance being found at the intersection with the middle scale.

A second application is the computation of the percentage of total harmonic distortion when percentages of each harmonic involved are known. In terms of the percentages of individual harmonics:

$$\text{Percent total distortion} = \sqrt{(\%2\text{nd})^2 + (\%3\text{rd})^2 + (\%4\text{th})^2 + (\%5\text{th})^2 + \ldots}$$

This calculation may be readily handled in successive steps, the number of applications of the chart depending upon the number of harmonic terms involved. Thus, let

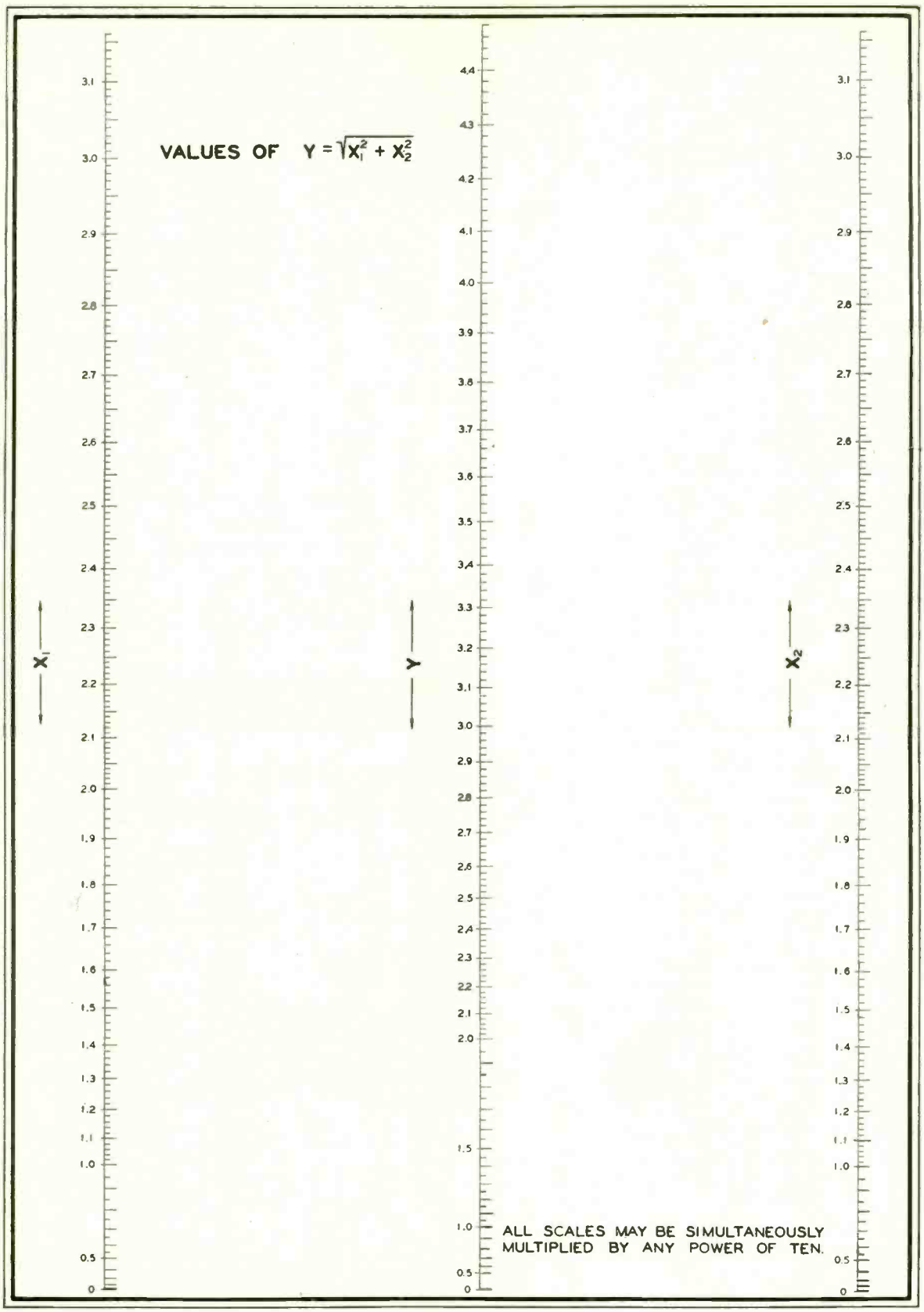
$$a = \sqrt{(\%2\text{nd})^2 + (\%3\text{rd})^2}$$
$$b = \sqrt{(\%4\text{th})^2 + (\%5\text{th})^2}$$

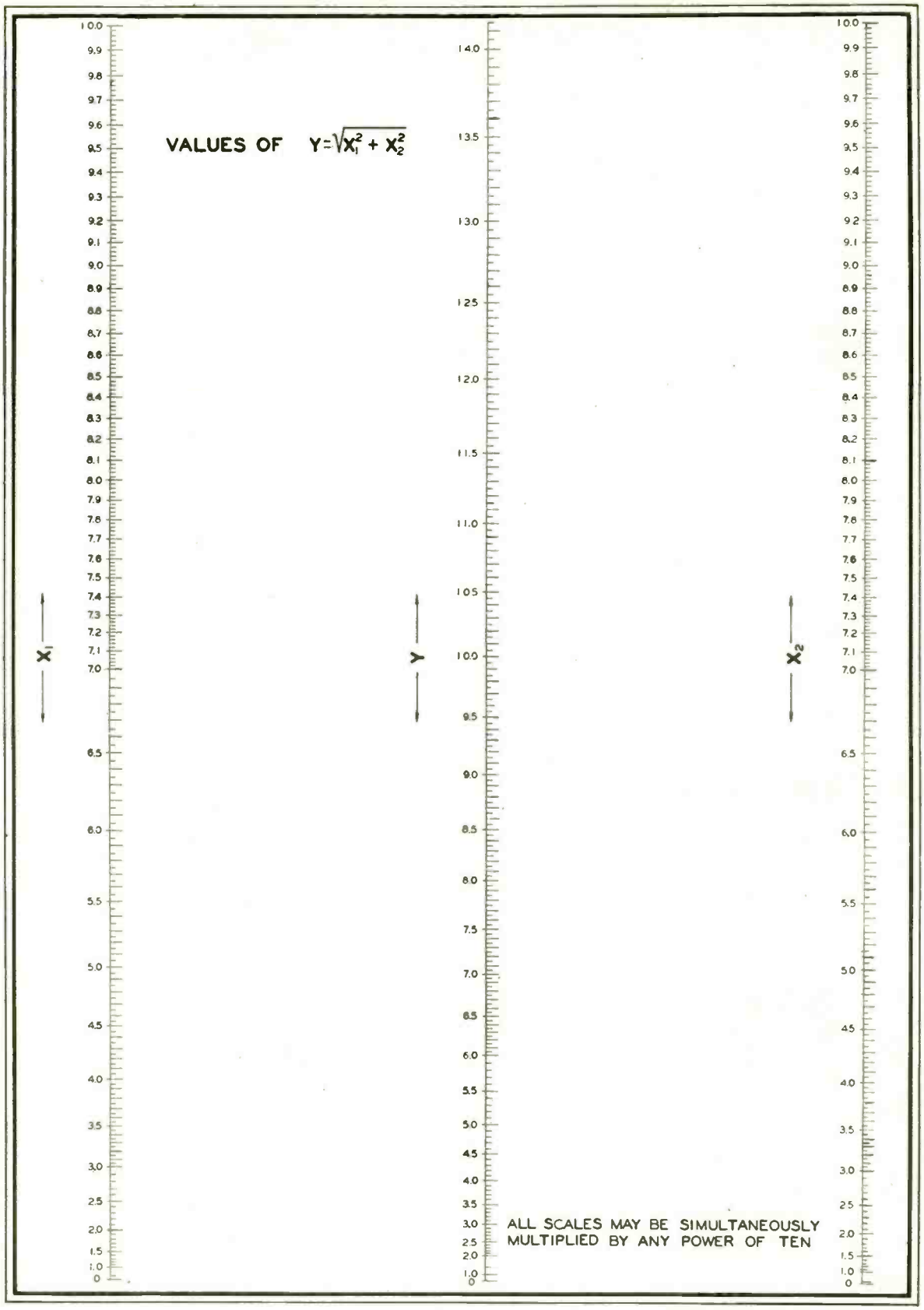
Then,

$$\%\ \text{Total distortion} = \sqrt{(a^2 + b^2)}$$

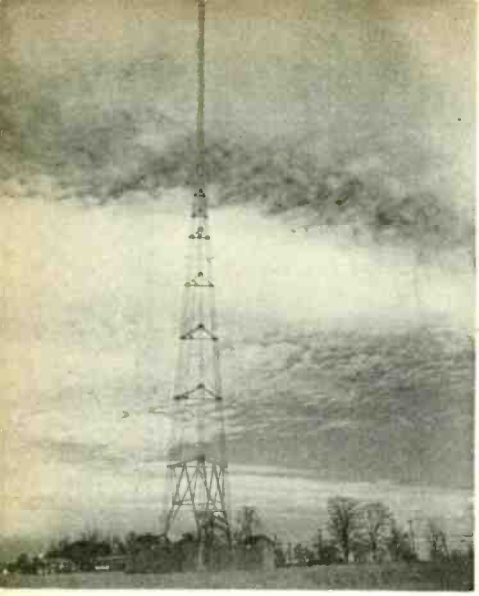
It should be noted that two different charts are provided, one to facilitate accuracy in reading whenever the quantities to be added vectorially are less than 3.0.

*Material prepared by Engineering Department, Hygrade Sylvania Corporation.



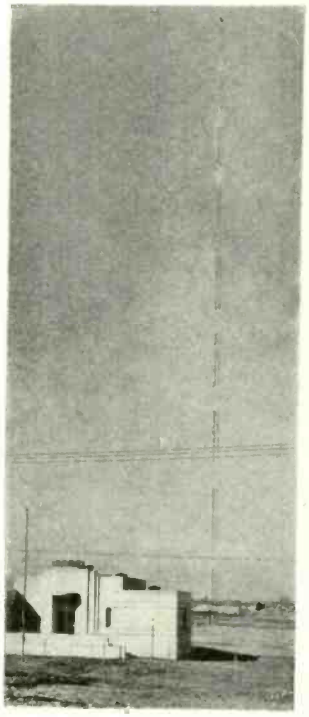


SOME TYPICAL BROADCAST-

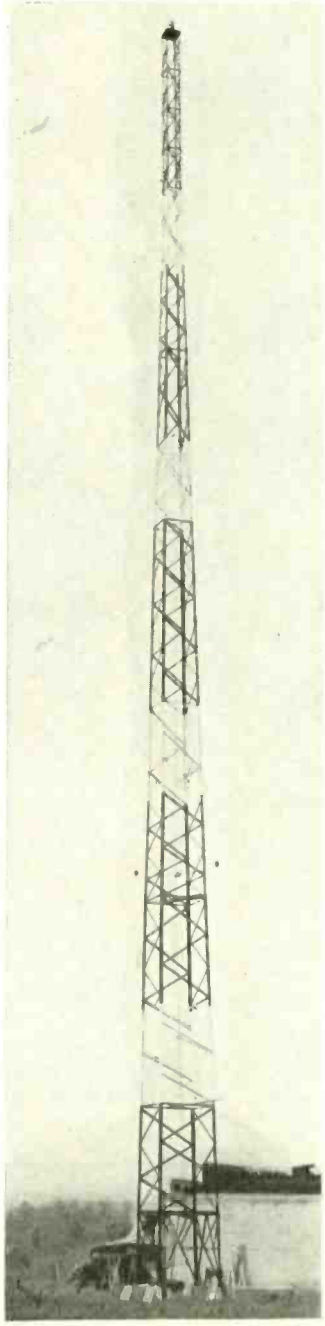


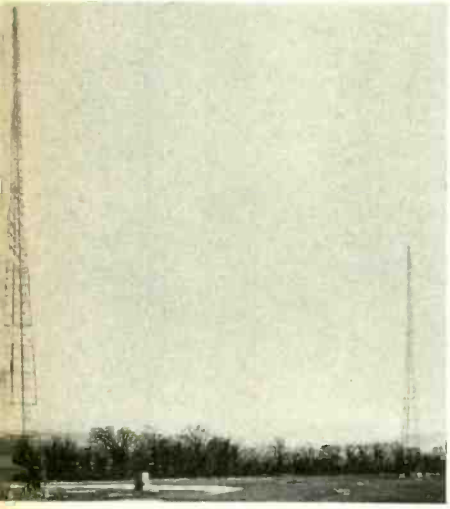
RADIO STATION WDRC, HARTFORD, CONN. THIS TRUSCON RADIATOR IS 308 FEET HIGH.

THE 475-FOOT IDECO UNIFORM CROSS-SECTION TYPE GUYED WELDED ROD VERTICAL RADIATOR AT KEHE, LOS ANGELES, CALIF.



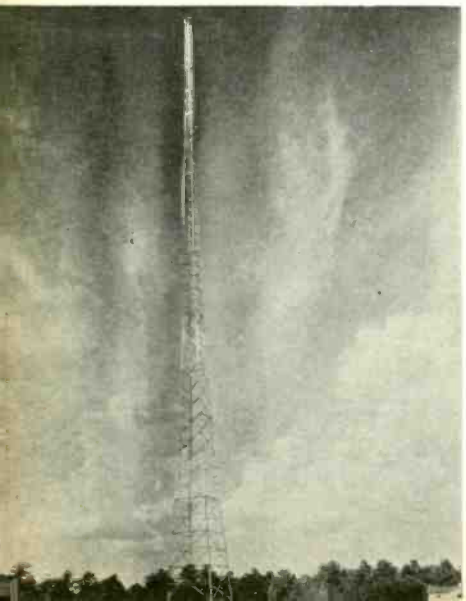
THE 170-FOOT LEHIGH VERTICAL RADIATOR AT WSAN, ALLENTOWN, PA.





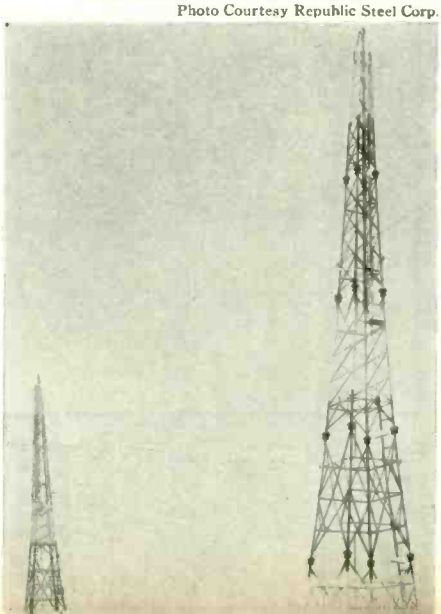
WSYR'S (SYRACUSE, N. Y.) DIRECTIONAL ANTENNA SYSTEM. EACH OF THESE IDECO SELF-SUPPORTING VERTICAL RADIATORS ARE 330 FEET HIGH.

THE 279-FOOT BLAW-KNOX TYPE CK VERTICAL RADIATOR INSTALLED AT RADIO STATION WBRC, BIRMINGHAM, ALABAMA.

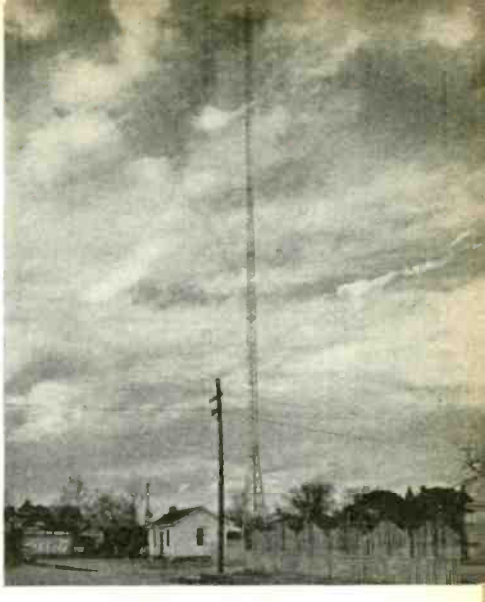


THE ORIGINAL WHK (CLEVELAND, OHIO) TOWERS BEFORE CONSOLIDATION WITH WJAY. THE HEIGHT OF EACH TOWER HAS NOW BEEN INCREASED 100 FEET. . . . SEE ILLUSTRATION ON OPPOSITE PAGE.

Photo Courtesy Republic Steel Corp.

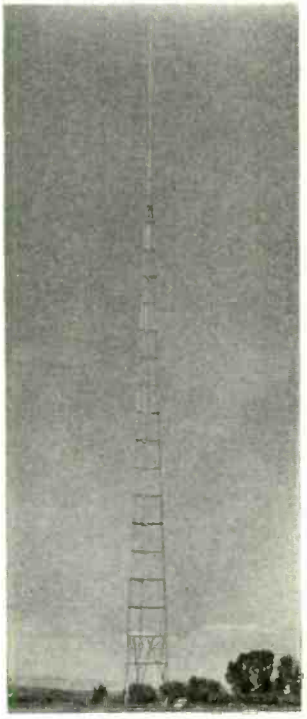


ANTENNA INSTALLATIONS

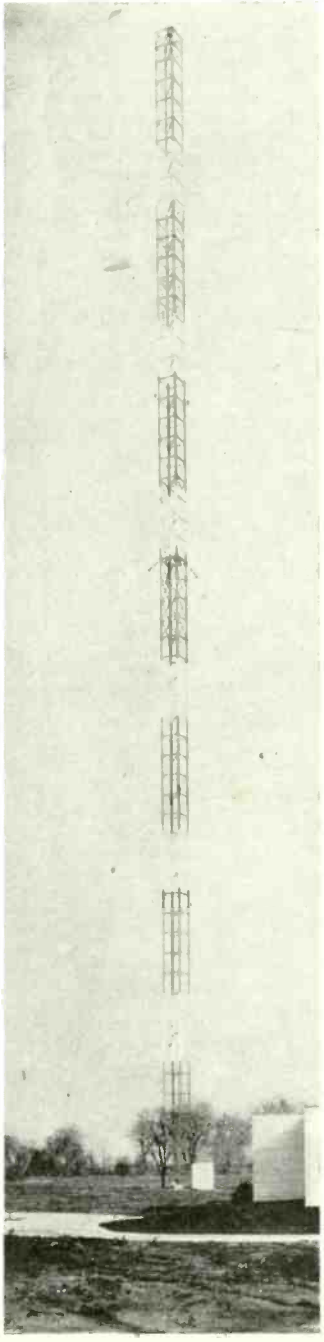


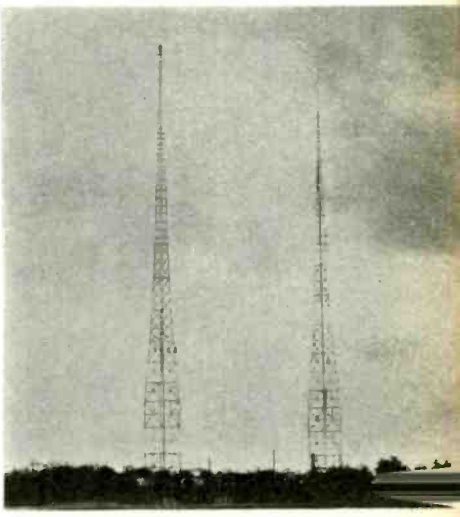
RADIO STATION WSIX, NASHVILLE, TENN. THIS TRUSCON RADIO TOWER IS 195 FEET ABOVE THE GROUND.

THE 556-FOOT TRUSCON SELF-SUPPORTING TYPE VERTICAL RADIATOR INSTALLED AT RADIO STATION KGHL, BILLINGS, MONTANA.



THE 390-FOOT BLAW-KNOX GUYED VERTICAL RADIATOR AT KWK, ST. LOUIS, MO.

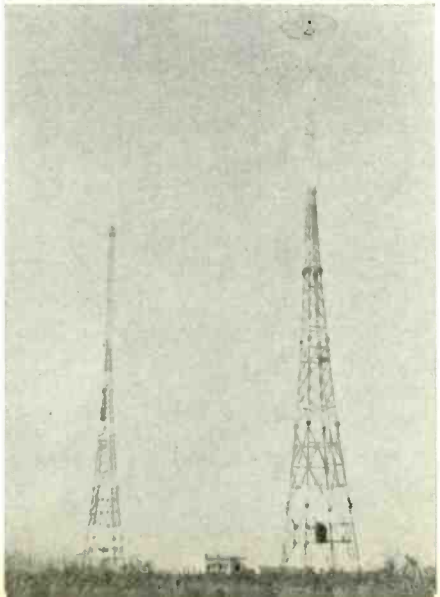




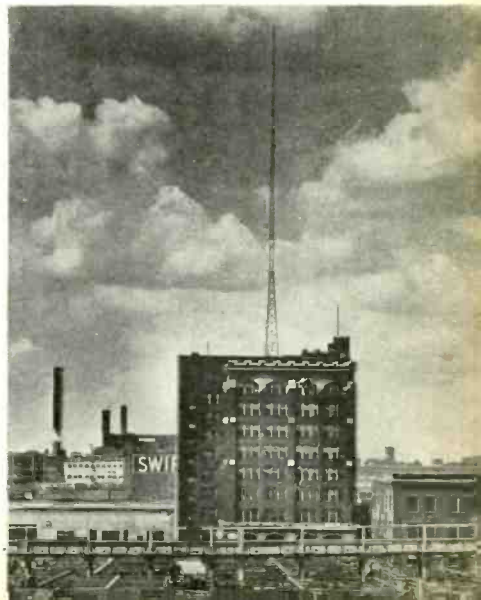
THE SHUNT-EXCITED DIRECTIONAL ANTENNA SYSTEM OF WEAN, PROVIDENCE, R. I. EACH OF THESE BLAW-KNOX STRUCTURES IS 325 FEET HIGH.

THE 300-FOOT WHK TOWERS SHOWING THE 100-FOOT EXTENSION AND INDIVIDUAL CIRCULAR RADIATORS. SINCE THE MERGER, WHK AND WJAY BROADCAST SIMULTANEOUSLY EACH USING ONE TOWER.

Photo Courtesy Republic Steel Corp.



SHOWING THE 231-FOOT SELF-SUPPORTING TRUSCON RADIO TOWER OF RADIO STATION WAAF, CHICAGO, ILL.



VETERAN WIRELESS OPERATORS ASSOCIATION NEWS

W. J. McGonigle, President, RCA Building, 30 Rockefeller Plaza, New York, N. Y.

MIAMI

V. H. C. EBERLIN, Miami Chapter secretary, informs us: "Among those present at a recent meeting were Karl Baarslag, Alexander Vadas, Steve Kovacs and Maurice Schatt—all of the New York group now in Miami on yachts or company business.

"Congratulations to the new officers and directors from the Miami Chapter and all good wishes for a successful term in office.

"Our second annual cruise was a huge success, despite the ultra wetness of the outside atmosphere. Ole Pluvius would have it—that he attend our otherwise sufficiently wet evening. The terrific downpour, however, did not deter our staunch supporters except in one instance—two couples driving along the beach road were forced to turn back after a sudden drenching caused by an unruly wave breaking over the sea wall at Baker's Haulover and entering their car through an open window.

"Companies represented at the affair: Pan American Airways, Eastern Airlines, Tropical Radio and Telegraph Company, Thurow Radio, Inc., Electric Sales and Service, Major Appliances, Little River Radio Company, and broadcasting station WQAM, "The Voice of Tropical America."

Among new members enrolled by C. J. Corrigan, chairman, and V. H. C. Eberlin, secretary of the Miami Chapter, are the following: W. Donald Thomas, who started commercial radio operating in 1925, and subsequently operated for the Independent Wireless, Radiomarine, Mackay, Dollar, Tropical, Eastern Air and several broadcasting companies in the south; Thomas J. Roberts, with RMCA, Mackay Radio, Globe Wireless, Eastern Airlines and presently with Pan-Airways, covering a period of nine years in commercial radio; Martial Alfred Honnell, on numerous ships, operating at broadcast stations and now with Pan-Airways in Miami, his initial commercial assignment being in June, 1927; Stark Totman, who numbers among his assignments one with the Department of Commerce and others with Radiomarine and the Independent Wireless Company, in radio since 1926; Frank F. Reb, a real oldtimer, having commenced his commercial radio operating career in November, 1912, and since on numerous ships and at several coastal stations of the Radiomarine Corp.—almost twenty-five years' continuous radio service; Manuel Fernandez, in the United States Coast Guard in 1920, and later in commercial operating with Radiomarine, Tropical, United States Lighthouse Service and presently with Pan-Airways; Andrew J. Albertson, Jr., in aircraft radio maintenance work since October, 1935; Edmund P. Dronzek, with Radiomarine in 1925, and then with Pan-Airways and Tropical Radio; H. M. Vanderver, who (if we read his abbreviations correctly) was with the Seattle and San Francisco Railroad in 1926 and followed with assignments with Tropical Radio Company, and now with Pan-Airways in Miami; William A. Durio, who if he had continued in his initial commercial radio assignment would now be a member of the Honolulu Chapter, his connection with the Mutual Telephone Company of Honolulu, however, was followed by assignments with Radiomarine, and Eastern Airlines in radio work; George Nelson Robinson, another real oldtimer, having started with the Marconi company and later with the Radiomarine Corp., has a record extending back twenty-five years; Miles Arthur Newton, who started in 1918, including among his assignments periods with RCA, Independent, and the Ship Owners Radio Service."

Splendid work, Messrs. Corrigan and Eberlin!

KARL BAARSLAG

FARRAR AND RINEHART announced on March 2, 1937, the publication of a second book, "Coast Guard to the Rescue," which enumerates the various functions of the United States Coast Guard forces from the Gulf of Mexico to the Arctic Ocean, on land, at sea and in the air, and describes in dramatic fashion innumerable incidents of devotion to duty displayed by these "unsung heroes" and includes in its pages many illustrations of the value of radio communication to this branch of the government service in making more effective their efforts at rendering succor to the distressed—a historical, authentic resume of the development of the Coast Guard Service which has for its slogan "Semper Paratus"—profusely illustrated with official photographs, by Karl Baarslag, veteran member of our Association, author of "SOS to the Rescue."

Congratulations, Karl, on a splendid literary accomplishment.

SPECIAL AWARD

ON WEDNESDAY, March 31, 1937, our Association presented a special Testimonial Scroll to Bjarne Sverdrup, master of the ill-fated Norwegian freighter *Bjerkli* which sank in a gale about 700 miles east of Boston. Mr. Sverdrup's foresight in learning about radio and radio operating some time before the disaster brought about the rescue of the entire crew of the distressed vessel. The presentation was made by Mr. Kolster, chairman of our Boston Chapter, and was broadcast over the Yankee Network and WINS in New York. The captain of the Coast Guard Cutter *Chelan* which effected the rescue, Commander Spencer, spoke and paid tribute to the resourcefulness of the Norwegian captain and the effectiveness of the radio equipment aboard the sinking vessel in guiding them to the wreck. Mr. Kolster outlined the aims and purposes of our Association and the inscription on the Scroll was read by the announcer after which Captain Sverdrup expressed his deep appreciation of the award. Thanks are due Commander Spencer for permitting the broadcast direct from the Ward Room of the *Chelan* which was at her berth in Boston.

PERSONALS

THANKS to Benj. Beckerman for his good wishes . . . We learn with deep regret of the recent death of Charles B. Weaver only recently retired superintendent of the RCA Communications' New York Operations office and offer his family our deepest sympathies . . . We learn that "Flying Bill" Ehmer has resigned from Pan Airways in Miami, where he has been radio operator, flight mechanic and co-pilot for several years, to join PanAmerican-Grace Airways as junior pilot. Bill will base at Panama for the present. He also advises that we might expect his check for a Life Membership in the very near future. Mrs. Ehmer, Bill's pretty wife, sailed Saturday to join him at the Canal Zone . . . Very happy to hear of Harry Chetham's recovery and return to his position as Chief Radio Operator of the Somerville, Mass., police department, and wish to thank him for his kind thoughts. He informs us that he started as an amateur way back in 1897 and has had call letters WIHC since August, 1911. We're looking forward to his proposed visit to New York this summer . . . The following names were inadvertently omitted from the otherwise complete list of Testimonial Awards included in the 1937 *VWOA Year Book*: Arthur F. Wallis, Mathew L. Bergin, and Harry Sadenwater. Excuse please . . . Many thanks to Gilson Willets for his untiring efforts in promoting the development of an enlarged West Coast membership and his recent interesting letter outlining work already accomplished and objectives to be striven for . . . Grateful appreciation to C. W. Horn for his purchase of a dinner ticket after he returned to New York a week or so too late to attend . . . A fine turnout at Bonat's for the April meeting. Several guests with interesting stories of recent activities. Bill Campbell with Steve Wallis and Albert Baker with H. T. Hayden. Al just recently returned from an assignment in Persia and is with the M. W. Kellogg Oil Refining Company . . . Glad to see A. A. Isbell there and V. P. Villandre, J. B. Varian, Harvey Butt, Paul K. Trautwein, "Bill" Simon, Fred McDermott, "Bob" Frey, Joseph Appel, "Bill" Fitzpatrick, and others, too. All present expressed their desire to have a smoker some time in May. Details of the smoker will be mailed shortly and we hope that a goodly number will turn out to make it an outstanding success. Let's hear from you!

TELEVISION STUDIO

(*Continued from page* 13)

eral stage technique. The artiste, given an opportunity will always work center, for here she knows she is in the dominant interest point, and in every case of a solo dance or specialty number, the singer or dancer works away from the chorus. This rule can be applied to set design and composition in the same manner. If the props and setting are necessarily complicated, go to the other extreme on the details that you wish to stress. If your set can be represented as a complicated system of circles, draw emphasis to the central thought by making it severe and straight. Incidentally, subject matter of simple geometric construction is more emphatic than complicated structures probably because it is easier for the eye to encompass.

In this same thought then, let us consider simple curves versus complex. Again the optic system responds to simplicity over its antithesis. Our third rule of emphasis then, concerns degree of complexity and can be stated—"in most cases, the simple geometric design is emphasized when coupled with a non-geometric complicated background."

Comparative size must be considered. The eye of course is immediately attracted to large objects by reason of the fact that they fill our field of vision. But add to this large mass a smaller figure and see what happens. The audience after a preliminary glance at the larger, focuses its attention on the smaller, thus putting emphasis on the lesser of the two. This can be proved easily. Walk down Fifth Avenue and look at the Empire State. Your eye of course is first attracted to the building, but let a window washer on the fortieth floor appear, and he becomes the center of interest and the building a mere background. Rule five, then, dictates that in comparison, the smaller of two objects takes the final interest.

Our last two general considerations have to do with psychology. The nearer of two objects takes emphasis from the more distant. Why? Because we for self preservation have become accustomed to consideration of problems in the order of their position. Rule six covers this by stating that proximity determines emphasis, the stress lying with the closer of two objects.

Rule seven needs no explanation. Of two objects, one in motion and one static, the emphasis goes to the active part of the picture.

These seven rules cover only the fundamental considerations of emphasis in art. They are necessarily abstract when viewed from a cold engineering standpoint but in reality constitute the difference between a strong and a weak picture. The application of these rules to the fast moving, dynamic picture that the television stage represents cannot in every case be successfully carried out. On the other hand, consideration of these laws in formulation of plans, in designing sets and in staging productions will result in a picture carrying out the thought around which it was created.

(*To be continued*)

OVER THE TAPE

NEW FIRM

In order to devote his time to the formation of a new corporation, John S. Meck has announced his resignation as general sales manager of the Clough-Brengle Company. The new firm will engage in the manufacture of precision radio test apparatus.

UNITED ELECTRONICS BULLETIN

United Electronics Company, 42 Spring St., Newark, N. J., have available a 4-page bulletin giving the characteristics of the United line of transmitting tubes. This bulletin may be obtained free of charge by writing to the above organization.

1937 SHURE CATALOG

An up-to-date copy of their new 1937 complete catalog may now be secured by writing to Shure Brothers, 225 West Huron St., Chicago, Illinois. Several important revisions are contained in this new catalog, and it also contains information on the new Shure Zephyr crystal record reproducer and the Model 66 A Stethophone.

AMPEREX BULLETIN

Amperex Electronic Products, Inc., manufacturers of transmitting tubes, have just released a bulletin giving the general ratings and characteristics of 12 new types of Amperex water-cooled tubes. The bulletin may be obtained from the above organization. The address is 79 Washington Street, Brooklyn, N. Y.

BRUSH MOVES TO OWN BUILDING

On April 1st The Brush Development Company, Cleveland, moved to its own building at 3311 Perkins Avenue.

The growth of this Cleveland company which has made its name and products known throughout the world has kept pace with the growth of the electronic industry.

PURCHASING DIRECTORY

The following pages contain information which we believe will be of value to broadcast stations, recording and sound studios, and all phases of communications. The companies listed are recognized sources of supply whose products have acquired a reputation for satisfactory performance.

In presenting this information, COMMUNICATION AND BROADCAST ENGINEERING *assumes no responsibility for omissions. We have attempted to give comprehensive and accurate information in a usable and complete form. If we have unintentionally omitted information, please bring it to our attention.*

Acoustic Material and Treatment

ACOUSTICAL ENGINEERING CO.
8259 Melrose Ave., Los Angeles, Calif.
Acoustic correction and control.

ARMSTRONG CORK PRODUCTS CO.
Lancaster, Pa.
Acoustic material and insulation.

SAMUEL CABOT, INC.
141 Milk St., Boston, Mass.
Sound deadening material.

CELOTEX CO.
919 N. Michigan Ave., Chicago, Ill.
Acoustic material and treatment.

COMPO BOARD CO.
4400 Lyndale Ave., N., Minneapolis, Minn.
Constructional material for studios.

Acoustic Material (Continued)

DENCOSE, INC.
29 W. 57th St., New York, N. Y.
(See *Recording Equipment.*)

ELECTRICAL RESEARCH PRODUCTS, INC.
250 W. 57th St., New York, N. Y.
(See *Recording Equipment.*)

GENERAL INSULATING PRODUCTS CO.
8821 15th Ave., Brooklyn, N. Y.
Acoustic materials and treatments, sound deadening material.

INSULITE CO.
Builders Exchange Bldg., Minneapolis, Minn.
Acoustic material.

JOHNS-MANVILLE CO.
22 E. 40th St., New York, N. Y.
Acoustic treatment, sound and vibration isolation treatment.

NATIONAL GYPSUM CO.
190 Delaware Ave., Buffalo, N. Y.
Constructional material for studios.

NORTHWEST MAGNESITE CO.
Thermax Division
1912 Farmers Bank Bldg., Pittsburgh, Pa.
Acoustic material, insulation.

UNION FIBRE CO.
Winona, Minn.
Acoustic material.

UPSON CO.
Lockport, N. Y.
Material for studio construction and insulation.

UNITED STATES GYPSUM CO.
300 W. Adams St., Chicago, Ill.
Acoustic material.

WEYERHAUSER SALES CO.
First National Bank Bldg., St. Paul, Minn.
Construction material for studios.

Amplifiers and P-A Equipment

AUDIO PRODUCTS CO.
4189 W. Second St., Los Angeles, Calif.
Amplifiers, speech-input equipment.

BELL SOUND SYSTEMS, INC.
61 E. Goodale St., Columbus, Ohio.
Portable and permanent p-a systems, intercommunication systems, microphones.

H. G. BRACE & CO.
801 Fourth Ave., Seattle, Wash.
Intercommunication systems.

BRAINARD-WALDER CO.
1056 Venice Blvd., Los Angeles, Calif.
Public-address equipment.

THE BRUSH DEVELOPMENT CO.
3311 Perkins Ave., Cleveland, Ohio.
Microphones, tweeters, headphones. (See *Microphones.*)

BURNSTEIN-APPLEBEE CO.
1012 McGee St., Kansas City, Mo.
Amplifiers and public address equipment.

CLOUGH-BRENGLE CO.
1134 W. Austin Ave., Chicago, Ill.
Amplifiers, p-a equipment. (See *Meters.*)

COLLINS RADIO CO.
2920 First Ave., Cedar Rapids, Iowa.
Amplifiers, speech-input equipment. (See *Transmitters.*)

S. H. COUCH CO., INC.
North Quincy, Mass.
Centralized radio and sound systems.

DANIEL ELECTRICAL LABS.
148-150 W. 50th St., New York, N. Y.
Portable amplifiers (a-c, d-c & a-c/d-c). amplifiers for electronic musical instruments.

DENCOSE, INC.
29 W. 57th St., New York, N. Y.
Public-address systems.

ELECTRO-ACOUSTIC PRODUCTS CO.
2131 Bueter Rd., Fort Wayne, Ind.
Monitoring equipment, speakers, bridging amplifiers.

ELECTRONIC DEVICES, INC.
626 Broadway, Cincinnati, Ohio.
Intercommunication systems and amplifiers.

ELECTRONIC SOUND LABS., INC.
5912 Melrose Ave., Hollywood, Calif.
Audio amplifiers, complete p-a systems, intercommunication systems, microphones.

FEDERATED PURCHASER, INC.
25 Park Place, New York, N. Y.
Amplifiers, microphones, etc.

FOX SOUND EQUIPMENT CORP.
3120 Monroe St., Toledo, Ohio.
Speakers, horns, theatre sound equipment. (See *Speakers.*)

FULTON RADIO CORP.
100 Sixth Ave., New York, N. Y.
All types of amplifiers, intercommunication systems.

GATES RADIO & SUPPLY CO.
Quincy, Ill.
Amplifiers, speech-input and remote equipment. (See *Transmitters.*)

HARRISON RADIO CO.
12 W. Broadway, New York, N. Y.

LANSING MFG. CO.
6900 McKinley Ave., Los Angeles, Calif.
Theatre and public-address speaker systems.

MAGNAVOX CO.
2131 Bueter Rd., Fort Wayne, Ind.
Amplifiers, speakers.

MORLEN ELECTRIC CO., INC.
60 W. 15th St., New York, N. Y.
Amplifiers and p-a equipment.

OPERADIO MFG. CO.
St. Charles, Ill.
Sound equipment.

OXFORD-TARTAK RADIO CORP.
915 W. Van Buren St., Chicago, Ill.
Speakers, horns. (See *Speakers.*)

PHILCO RADIO & TELEVISION CORP.
Philadelphia, Pa.
Amplifiers, intercommunication systems.

RACON ELECTRIC CO., INC.
52 E. 19th St., New York, N. Y.
Horns, all types of loudspeakers, p-a equipment.

THE RADIART CORP.
Shaw Ave., Cleveland, Ohio.
Amplifiers.

RADIO ENG. & MFG. CO.
26 Journal Sq., Jersey City, N. J.
Amplifiers, speech-input equipment.

RADIO ENG. LABS., INC.
25-14 41st Ave., Long Island City, N. Y.
Amplifiers.

RADIO RECEPTOR CO., INC.
251 W. 19th St., New York, N. Y.

Products

Centralized radio, sound equipment, radio-range beacons, dynamic microphones.

Personnel

President ..... L. Arnson
Chief Engineer ..... W. G. McConnel
Sales Manager ..... L. Arnson

RADIOTONE RECORDING CO.
6103 Melrose Ave., Hollywood, Calif.
Amplifiers. (See *Recording.*)

RADOLEK CO.
601 W. Randolph St., Chicago, Ill.
Amplifiers, preamplifiers.

RCA MANUFACTURING CO., INC.
Camden, N. J.
Amplifiers, speech-input equipment, p-a systems. (See *Transmitters.*)

REMLER CO., LTD.
(see *Transmitters*)

SEGEL SOUND, INC.
235-7 Pine St., Gardner, Mass.
Sound systems, intercommunication systems.

SOUND ENGINEERING CORP.
412 N. Leavitt St., Chicago, Ill.
Amplifiers.

SOUND SYSTEMS, INC.
6545 Carnegie Ave., Cleveland, Ohio.

Products

Amplifiers, microphones, loudspeakers, turntables, intra-office communicating systems, complete portable p-a equipment, centralized radio and sound systems.

Personnel

President ..... E. L. Gove
Chief Engineer ..... S. C. Carpenter
Sales Manager ..... P. R. Baus

Export

C. O. Brandes, 5716 Euclid Ave., Cleveland, Ohio.

STROMBERG-CARLSON TEL. MFG. CO.
Rochester, N. Y.
Sound equipment, amplifiers.

SUNDT ENGINEERING CO.
4238 Lincoln Ave., Chicago, Ill.
Audiocall p-a systems. (See *Meters.*)

SMITH & SMITH
702 N. Garey Ave., Pomona, Calif.
Sound engineering, p-a equipment

THORDARSON ELEC. MFG. CO.
500 W. Huron St., Chicago, Ill.
Amplifiers. (See *Transformers.*)

THE TURNER COMPANY
909 17th St., Cedar Rapids, Iowa.

Products

Crystal microphones, preamplifiers, power amplifiers, speech-relay inter-office equipment, two-way talk systems, call systems.

Personnel

President ..... David Turner
Chief Engineer ..... H. W. Johnson
Sales Manager ..... F. W. Clemens
Advertising Manager ..... F. W. Clemens

Export

Ad. Auriema, Inc., 116 Broad St., New York, N. Y.

TRIMM RADIO MFG. CO.
1770 W. Berteau Ave., Chicago, Ill.
Electro-acoustic products for radio and p-a.

UNITED SOUND ENG. CO.
2233 University Ave., St. Paul, Minn.
Public-address and intercommunication equipment.

UNITED TRANSFORMER CORP.
72 Spring St., New York, N. Y.
Amplifiers. (See *Transformers.*)

THE WEBSTER COMPANY
3825 W. Lake St., Chicago, Ill.

Products

Portable and fixed sound systems, factory call systems, interoffice communication systems, speakers, microphones, phonograph motors and assemblies.

Personnel

Vice-president ..... John Erwood
Chief Engineer ..... Joe Erwood

Branch Offices

Representatives in all principal cities.

WEBSTER ELECTRIC CO.
Racine, Wis.
Amplifiers.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
P-A equipment. (See *Transmitters.*)

WHOLESALE RADIO SERVICE CO., INC.
100 Sixth Ave., New York, N. Y.

Products

Sound systems, p-a amplifiers, theatre equipment.

Personnel

President ..... A. Pletman
Chief Engineer ..... Frank Lester
Sales Manager ..... A. Orlich
Advertising Manager ..... Ben Lehman

Branch Offices

901 W. Jackson Blvd., Chicago; 430 W. Peachtree St., N. W. Atlanta; 219 Central Ave., Newark; 542 E. Fordham Rd., Bronx; 90-08 165th St., Jamaica, L.I.

FOUR RCA "MIKES"

AT NEW LOW PRICES!

JUNIOR VELOCITY MIKE, 74-B

Popular priced. Velocity operated. For studio service, permanent or indoor remotes. High output level, universal mount for different angle pickups. Chromium plated case, rubber cushioned.

$25.00

INDUCTOR MIKE 50-A

Diaphragm-type Mike. Particularly well suited to announcing or field use. Unaffected by wind, mechanical vibrations, temperature and humidity. Requires no closely-linked amplifier

$50.00

STANDARD VELOCITY MIKE, 44-B

The standard of the Networks. Produces High Fidelity, velocity type performance, smooth, without peaks. Higher output level and improved bass response. Minimizes room reverberations.

$65.00

UNI-DIRECTIONAL VELOCITY MIKE, 77-A

Uni-directional pickup at *all* frequencies without shielding. Eliminates reverberation pickup in large rooms. Ideal for near wall use in smaller studios.

$95.00

MIKES FOR OUTSTANDING PERFORMANCES—IN EVERY TYPE OF SERVICE

THESE FOUR RCA High Fidelity Microphones have been designed and constructed to give you highest quality performance, no matter what your requirements. Each may be used for general service. But each has been designed for a particular type of use—designed to give you the greatest satisfaction.

Quantity production on these four RCA Mikes makes new low prices possible. No longer need you be satisfied with just average results from a general service Mike. Now you can select a Mike for outstanding performance in each particular type of work. These RCA Mikes have attained a position of superiority through high quality performance. Each is recognized leader of its field!

RCA *Broadcast Equipment*

RCA MANUFACTURING CO., INC., Camden, N. J. • A Service of the Radio Corporation of America

Antennas, Antenna Erection, Antenna Arrays

AMERICAN BRIDGE CO.
Frick Building, Pittsburgh, Pa.
Radio towers, steel structures for every purpose.

VICTOR J. ANDREW
7221 S. Francisco Ave., Chicago, Ill.
Coaxial cable, antenna coupling equipment, lighting filters.

JOHN F. BEASLEY CONSTRUCTION CO.
Muskogee, Okla.
Vertical radiator installation, lighting, foundations.

BENDIX RADIO CORP.
9th and Kearny Sts., N. E., Washington, D. C.
Antenna arrays. (See *High-Frequency Transmitters.*)

BLAW-KNOX CO.
Pittsburgh, Pa.

Products

Vertical Radiators.

Personnel

President.....W. P. Witherow
Chief Engineer.....L. A. Prescott
Sales Manager.....H. B. Laxterman
Advertising Manager.....D. C. Grove

Branch Offices

New York, Chicago, Philadelphia, Birmingham.

GENERAL ELECTRIC CO.
Schenectady, N. Y.
Tower-lighting chokes.

HARTENSTINE-ZANE CO., INC.
225 Broadway, New York, N. Y.

Vertical radiator installation, including: preliminary estimates for all designs and locations; radial ground system and counterpoise; reinforced concrete foundation piers; erecting, painting and lighting all radiator designs.

Personnel

President.....H. J. Zane, Jr.
Chief Engineer.....Chas. J. Hartenstine

HOKE VERTICAL RADIATORS
Petersburg, Va.
Fabrication and erection of vertical radiators.

THE INTERNATIONAL DERRICK & EQUIPMENT CO.
875 Michigan Ave., Columbus, Ohio.

Products

Vertical broadcast towers.

Personnel

President.....L. J. Brown
Chief Engineer.....Chas. E. Schuler
Sales Manager.....Chas. E. Schuler
Advertising Manager.....C. R. Athy

Branch Offices

New York, Los Angeles, Beaumont (Texas). Dallas.

E. F. JOHNSON CO.
Waseca, Minn.

Products

Insulators, sockets, plugs, jacks, inductors, condensers, antenna-coupling units.

Personnel

President.....E. F. Johnson
Chief Engineer.....L. W. Olander

Branch Offices

Chicago, Memphis, Minneapolis, University City (Mo.), Philadelphia, Atlanta, Buffalo, Kansas City, New York City, Riverdale (N. Y.), New Orleans, Dallas, Boston, Fort Wayne, Long Beach, Winnipeg and Toronto, Canada.

Export

M. Simons & Son Co., Inc., 25 Warren St., New York, N. Y.

LEHIGH STRUCTURAL STEEL CO.
17 Battery Place, New York, N. Y.

Products

Radio towers, vertical radiators.

NEW JERSEY ERECTORS
346 Broadway, Newark, N. J.
Tower erection, lighting, painting, ground systems, foundations.

RADIO ENGINEERING & MFG. CO.
26 Journal Square, Jersey City, N. J.
Antenna coupling units.

RADIO RECEPTOR CO., INC.
251 W. 19th St., New York, N. Y.
Antenna tuning houses. (See *Amplifiers*)

RCA MANUFACTURING CO., INC.
Camden, N. J.
Antenna surveys. (See *Transmitters.*)

HECTOR R. SKIFTER
St. Paul Hotel, St. Paul, Minn.
Consulting radio engineers, field-intensity surveys, station analysis.

TIMBER ENGINEERING CO.
1337 Connecticut Ave., N. W., Washington, D. C.
Wood radio towers and connectors.

TRUSCON STEEL CO.
Albert St., Youngstown, Ohio.

Products

Radio antennas and a complete line of steel building products.

Personnel

President.....Myron A. Wicks
Chief Engineer.....Robert D. Snodgrass
Sales Manager.....Grover J. Meyer
Advertising Manager.....Richard P. Dodds

Branch Offices

In all principal cities.

Export

Chrysler Building, New York, N. Y.

U. S. WIND ENGINE & PUMP CO.
Batavia, Ill.
Radio towers.

WASHINGTON INSTITUTE OF TECHNOLOGY
McLachlen Bldg., Washington, D. C.
Directional antennas and exciter systems.

Ceramics

AMERICAN LAVA CORP.
Chattanooga, Tenn.
Ceramics to customers design by machining, extruding or molding processes. Vacuum tube insulation in magnesia, alumina, and other oxides.

HENRY L. CROWLEY CO.
1 Central Ave., West Orange, N. J.

ELECTRONIC MECHANICS, INC.
201 E. 12th St., New York, N. Y.
Radio products from Mycalex, also Mycalex machined to customers specifications.

THE FORMICA INSULATION CO.
4614 Spring Grove Ave., Cincinnati, Ohio.
Insulating sheets, tubes, rods, laminated phenolic type.

ISOLANTITE, INC.
233 Broadway, New York City, N. Y.

Products

Ceramic insulators of all types for radio applications, coaxial transmission line, oil-burner ignition equipment, mechanical tower packing, vacuum-tube bases, thread guides, switches.

Personnel

President.....W. D. Waltman
Vice-president & General Manager..R. S. Bicknell
Sales Manager.....H. G. Beebe
Advertising Manager.....H. G. Beebe

Representatives

C. E. White & Co., Cleveland; All branches of Graybar Electric Co.; Electric Specialties Co., Calif.

Export

Rocke International Electric Corp., 100 Varick St., New York, N. Y.

MYCALEX CORP. OF AMERICA
101 W. 31st St., New York, N. Y.
Mycalex.

STUPAKOFF LABORATORIES, INC.
6617 Hamilton Ave., Pittsburgh, Pa.
Filament insulating material, ceramic spacers for tubes, refractory oxides, conductive ceramics, thermocouple insulators.

Condensers—Fixed

ACME WIRE COMPANY
New Haven, Conn.

AEROVOX CORP.
70 Washington St., Brooklyn, N. Y.

Products

Dry and wet electrolytic condensers, paper condensers, mica condensers, transmitting condensers, oil condensers, motor capacitors, carbon resistors, fixed wire-wound resistors (vitreous enamel), adjustable wire-wound vitreous enamel resistors, interference filters.

Personnel

President.....S. I. Cole
Chief Engineer.....Howard E. Rhodes
Sales Manager.....Chas. Golenpaul
Advertising Manager.....Wm. G. Many

Branch Offices

Boston, Pittsburgh, Atlanta, Chicago, Detroit, Cleveland, St. Louis, Minneapolis, Tulsa, Dallas, Salt Lake City, San Francisco, Los Angeles, Seattle.

BENDIX RADIO CORP.
9th & Kearny Sts., Washington, D. C.
(See *High-Frequency Transmitters.*)

THE ALLEN D. CARDWELL MFG. CORP.
81 Prospect St., Brooklyn, N. Y.
(See *Condensers—Variable.*)

CONTINENTAL CARBON, INC.
13912 Lorain Ave., Cleveland, Ohio.

CORNELL-DUBILIER CORP.
South Plainfield, N. J.

Products

Oil condensers, Dykanol condensers, mica condensers, wet and dry electrolytics, power factor condensers, paper tubular condensers, paper bypass condensers, filter condensers, transmitting condensers.

Personnel

President.....O. Blake
Vice-president.....Wm. Dubilier
Chief Engineer.....Wm. Bailey
Sales Manager.....L. Adelman

Branch Offices

Los Angeles, San Francisco, Seattle, Chicago, Buffalo, Cambridge (Mass.), Washington (D. C.), Pittsburgh, Cleveland, Toledo, St. Louis, Atlanta, New Orleans, Dallas, Milwaukee, Cincinnati, Toronto (Canada).

Export

100 Varick St., New York, N. Y.

HENRY L. CROWLEY CO.
1 Central Ave., W. Orange, N. J.

CURTIS CONDENSER CORP.
3088 W. 106th St., Cleveland, Ohio.

TOBE DEUTSCHMANN CORP.
Canton, Mass.

Products

Condensers, filters, testing and laboratory equipment.

Personnel

President.....Tobe C. Deutschmann
Sales Manager.....Tobe C. Deutschmann
Advertising Manager.....C. W. Metcalf

Export

105 Hudson St., New York, N. Y.

DUMONT ELECTRIC CO., INC.
514 Broadway, New York, N. Y.

A. M. FLECHTHEIM & CO., INC.
692 Broadway, New York, N. Y.
Paper filter, bypass and tubular condensers; transmitting condensers; wet and dry electrolytic condensers.

GIRARD-HOPKINS
1437 23rd Ave., Oakland, Calif.

ILLINOIS CONDENSER CO.
3252 North Ave., Chicago, Ill.
Complete line of electrolytic condensers.

MAGNAVOX CO., LTD.
2131 Bueter Rd., Fort Wayne, Ind.
All types.

Condensers (Continued)

P. R. MALLORY & CO.
3029 E. Washington St., Indianapolis, Ind.
All types.

MICAMOLD RADIO CORP.
1087 Flushing Ave., Brooklyn, N. Y.
Dry and wet electrolytic, molded bakelite mica and molded bakelite paper condensers.

J. W. MILLER CO.
5917 S. Main St., Los Angeles, Calif.

MORRILL & MORRILL
30 Church St., New York, N. Y.

RCA MANUFACTURING CO., INC.
Camden, N. J.
Mica condensers. (See *Transmitters.*)

SANGAMO ELECTRIC CO.
Springfield, Ill.
Mica condensers.

SOLAR MFG. CORP.
599 Broadway, New York, N. Y.
Wet and dry electrolytic condensers, paper condensers, mica condensers.

SPRAGUE SPECIALTIES CO.
North Adams, Mass.
All types.

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
High-voltage condensers.

Condensers—Variable

AUDIO PRODUCTS CO.
4185 W. 2nd St., Los Angeles, Calif.

BENDIX RADIO CORP.
9th & Kearny Sts., Washington, D. C.
(See *High-Frequency Transmitters.*)

THE ALLEN D. CARDWELL MFG. CORP.
81 Prospect St., Brooklyn, N. Y.

Products

Fixed and variable air and oil dielectric condensers for radio transmission and reception. Radio electrical and electro-mechanical devices on contract manufacturing basis.

Personnel

President.....Allen D. Cardwell
Chief Engineer.....Allen D. Cardwell
General Manager.....William H. Smith
Sales Manager.....Raymond L. Morehouse

Branch Offices

Representatives in all principal cities.

Export

Ad. Auriema, Inc., 116 Broad St., New York, N. Y.

DEJUR-AMSCO CORP.
Shelton, Conn.

DWYER ELECTRIC PRODUCTS CO.
Waukegan, Ill.

GENERAL INSTRUMENT CO.
Elizabeth, N. J.

GENERAL RADIO CO.
30 State St., Cambridge, Mass.
(See *Meters.*)

EDWIN I. GUTHMAN CO., INC.
400 S. Peoria St., Chicago, Ill.

HAMMARLUND MFG. CO., INC.
424 W. 33rd St., New York, N. Y.
(See *High-Frequency Transmitters.*)

E. F. JOHNSON CO.
Waseca, Minn.
(See *Antennas.*)

NATIONAL COMPANY, INC.
Malden, Mass.

RADIO CONDENSER CO.
Davis St. & Copewood Ave., Camden, N. J.

RADIO ENGINEERING LABS.
25-14 41st Ave., Long Island City, N. Y.

RELIANCE DIE & STAMPING CO.
1260 Clybourne Ave., Chicago, Ill.

Crystals, Crystal Holders, Etc.

AMERICAN PIEZO SUPPLY CO.
3921 Agnes Ave., St. Louis, Mo.
Crystals, associated apparatus.

BELLEFONTE RADIO ENG. & MFG. CO., INC.
Bellefonte, Pa.

BENDIX RADIO CORP.
9th & Kearny Sts., N. E., Washington, D. C.
Quartz crystals, crystal holders. (See *High-Frequency Transmitters.*)

BLILEY ELECTRIC CO.
Union Station Bldg., Erie, Pa.

Products

Quartz oscillating crystals and associated equipment.

Personnel

General Manager.....F. D. Bliley
Chief Engineer.....C. C. Collman
Sales Manager.....G. E. Wright
Advertising Manager.....F. A. Lennberg

COLLINS RADIO CO.
2920 First Ave., S. E., Cedar Rapids, Iowa.
Quartz crystals. (See *Transmitters.*)

COMMERCIAL RADIO EQUIPMENT CO.
216 East 74th St., Kansas City, Mo.

Products

Frequency-control units, low-temperature coefficient crystals, broadcast amplifiers, preamplifiers, high-frequency monitors, police monitors, heater ovens, T-pads (balanced and unbalanced), metal boxes.

Personnel

President.....Everett L. Dillard
Chief Engineer.....Everett L. Dillard
Sales Manager.....Herbert Steinmetz
Advertising Manager.....Robert Wolfskill

GENTRY LABORATORIES
803 W. Maple Ave., Independence, Mo.
Crystals and frequency-control equipment.

HIPOWER CRYSTAL CO.
2035 Charleston St., Chicago, Ill.
Broadcast, commercial and amateur crystals and holders.

HOLLISTER CRYSTAL CO.
Wichita, Kansas.
Crystals and mountings.

INSULINE CORP. OF AMERICA
25 Park Place, New York, N. Y.
Crystal holders.

OMAHA CRYSTAL LABS.
North Platte, Neb.
Crystals, crystal holders.

PIEZOELECTRIC LABORATORIES
612 Rockland Ave., New Dorp, N. Y.
Crystals, temperature-control ovens.

PRECISION CRYSTAL LABS., INC.
1211 Liberty St., Springfield, Mass.
Crystals and holders.

PRECISION PIEZO SERVICE
427 Asia St., Baton Rouge, La.
Quartz crystals, holders, temperature-controlled ovens.

PREMIER CRYSTAL LABS., INC.
55 Park Row, New York, N. Y.
Crystals, crystal holders, ovens, oscillators.

SCIENTIFIC RADIO SERVICE
124 Jackson Ave., University Park, Md.

Products

Piezo-electric crystals and holders for general communication frequencies and for standards.

Personnel

Owner & Manager.....Harry D. Eisenhauer

THE STATES COMPANY
19 New Park Ave., Hartford, Conn.
Crystal oven heaters, resistors for oven heaters.

THE VALPEY CRYSTALS
377 Summer St., Medway, Mass.
Quartz crystals and mountings.

Export Organizations

AD. AURIEMA, INC.
116 Broad St., New York, N. Y.

ROCKE INTL. ELECTRIC CORP.
100 Varick St., New York, N. Y.

THE M. SIMONS & SON CO., INC.
25 Warren St., New York, N. Y.

Frequency Measuring and Monitoring Equipment and Services

BENDIX RADIO CORP.
9th & Kearny Sts., Washington, D. C.
Frequency monitors, meters. (See *High-Frequency Transmitters.*)

COMMERCIAL RADIO EQUIPMENT CO.
216 East 74th St., Kansas City, Mo.
Frequency monitors including high-frequency and police units. (See *Crystals.*)

DOOLITTLE & FALKNOR, INC.
7421 S. Loomis Blvd., Chicago, Ill.
Frequency-control equipment, frequency-measuring service.

GENERAL RADIO CO.
30 State St., Cambridge, Mass.
Frequency monitors. (See *Meters.*)

PETERKIN RADIO LABS.
13176 Manor Ave., Detroit, Mich.
Frequency measurements, frequency indicator calibration service.

PIEZOELECTRIC LABORATORIES
612 Rockland Ave., New Dorp, N. Y.
Frequency-control units, monitors.

PREMIER CRYSTAL LABS., INC.
55 Park Row, New York, N. Y.
Frequency meters, control-units, etc.

RCA COMMUNICATIONS, INC.
66 Broad St., New York, N. Y.
Frequency-measuring service.

RCA MANUFACTURING CO., INC.
Camden, N. J.
Frequency monitors. (See *Transmitters.*)

WASHINGTON INSTITUTE OF TECHNOLOGY
McLachlen Bldg., Washington, D. C.
Frequency monitoring.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
Frequency monitors. (See *Transmitters.*)

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
Frequency monitoring.

High-Frequency Transmitting and Receiving Apparatus (including Aeronautical, Marine and Police Radio)

AIRPLANE & MARINE DIRECTION FINDER CORP.
304 S. 16th St., Lindenhurst, L. I., N. Y.
Radio receivers, transmitters and direction finders for air and marine craft.

BENDIX RADIO CORP.
9th and Kearny Sts., N. E., Washington, D. C.

Products

Antennas and antenna arrays, quartz crystals, crystal holders, variable condensers, fixed condensers, inductances, frequency standards, frequency monitors, frequency meters, synchronizers, audio analyzers, modulation monitors, tube testers, set testers, remote-control devices, capacity standards, field-intensity meters, aircraft

transmitters and receivers, direction finders, blind-landing systems for aircraft, radio instruments, radio-mechanical devices, intercommunicating telephones, aircraft ground station equipment, amplifiers, sound-effects equipment.

Personnel

President .....Vincent A. Bendix
Vice-President & General Manager..L. A. Hyland

Branch Offices

Dayton, Chicago, Oakland, New York.

BRAINARD-WALDER CO.
1056 Venice Blvd., Los Angeles, Calif.
Aircraft transmitters and receivers, marine depth finding equipment.

CANNON ELEC. DEVELOPMENT CO.
420 West Avenue 33, Los Angeles, Calif.
Cable connectors for airplane, geophysical research, signal equipment.

COLLINS RADIO CO.
2920 First Ave., S. E., Cedar Rapids, Iowa.
Transmitters for police and aircraft. (See *Transmitters.*)

COMMERCIAL RADIO EQUIPMENT CO.
216 E. 74th St., Kansas City, Mo.
High-frequency monitors, police monitors. (See *Crystals.*)

GENERAL ELECTRIC CO.
Schenectady, N. Y.
High-frequency transmitters and receivers.

HAMMARLUND MFG. CO., INC.
424-438 West 33rd St., New York, N. Y.

Products

Midget and micro single and split-stator variable condensers, high and medium voltage single and split-stator transmitting condensers, Isolantite plug-in coil forms (broadcast, short-wave and ultra-short-wave), wound plug-in coils, transmitting coil forms, standard and acorn tube sockets, condensers, receiving and transmitting r-f chokes, aluminum coil and tube shields, flexible couplings, air-tuned variable-coupling i-f transformers, standard i-f transformers, trimming and padding condensers. "Super-Pro" and "Comet-Pro" short-wave and all-wave crystal and standard precision receivers.

Personnel

President.....Oscar Hammarlund
Chief Engineer.....Donald K. Oram
Sales Manager.....Lloyd Hammarlund
Advertising Manager.....Lewis Winner

Branch Offices

Buffalo, Philadelphia, Boston, Chicago, Detroit, Cleveland, Atlanta, Dallas, Denver, Los Angeles, San Francisco, Portland, Hamilton (Ontario, Canada).

Export

Rocke International Electric Corp., 100 Varick Street, New York, N. Y.

HARVEY RADIO LABS., INC.
12 Boylston St., Brookline, Mass.

Products

Radio transmitting equipment for the high and ultra-high frequencies. Airport, amateur, general communication equipment.

Personnel

President.....Clifford A. Harvey
Chief Engineer.....C. A. Harvey
Sales Manager.....Frank Lyman
Advertising Manager.....James B. Parker

Export

The M. Simons & Son Co., Inc., 25 Warren St., New York, N. Y.

HYGRADE SYLVANIA CORP.
Electronics Division
64 Lakeview Ave., Clifton, N. J.
Aviation radio parts.

LEAR DEVELOPMENTS, INC.
121 West 17th St., New York, N. Y.

Products

Aircraft transmitters and receivers, radio compass, aircraft ground-station equipment, blind-landing systems for aircraft.

Personnel

President & General Manager.....Wm. P. Lear

MARINE RADIO CORP.
117-19 168th St., Jamaica, N. Y.
Marine radio transmitters.

NATIONAL COMPANY, INC.
Malden, Mass.
High-frequency receivers.

RADIO APPARATUS CORP.
240 Central Ave., Newark, N. J.
High-frequency apparatus.

RADIO ENGINEERING LABS., INC.
25-14 41st St., Long Island City, N. Y.
Short-wave radio apparatus.

RADIO MANUFACTURERS ENGINEERS
306 First St., Peoria, Ill.
Receivers, preselectors.

RADIO RECEPTOR CO.
251 W. 19th St., New York, N. Y.
Radio-range beacons. (See *Amplifiers.*)

RADIO TRANSCEIVER LABS.
(see *Transmitters*)

RCA MANUFACTURING CO., INC.
Camden, N. J.
Aircraft and police transmitters and receivers. (See *Transmitters.*)

RADIO MARINE CORP. OF AMERICA
75 Varick St., New York, N. Y.
Marine radio equipment.

RADIO NAVIGATIONAL INST. CORP.
500 Fifth Ave., New York, N. Y.
Radio direction finders, blind-landing equipment.

STANDARD TRANSFORMER CORP.
850 Blackhawk St., Chicago, Ill.
High-frequency transmitting equipment.

TRANSMITTER EQUIP. MFG. CO., INC.
130 Cedar St., New York, N. Y.
Radiophone and telegraph transmitters for police, amateur operation.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
Police, marine and aviation radio transmitters and receivers. (See *Transmitters.*)

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
Police and aircraft transmitting and receiving apparatus.

Insulators

AMERICAN LAVA CORP.
Chattanooga, Tenn.
(See *Ceramics.*)

CORNING GLASS WORKS
Corning, N. Y.
Radio and power insulators.

COTO-COIL COMPANY, INC.
229 Chapman St., Providence, R. I.

HENRY L. CROWLEY CO.
1 Central Ave., West Orange, N. J.

ELECTRONIC MECHANICS
201 E. 12th St., New York, N. Y.
(See *Ceramics.*)

GENERAL RADIO CO.
30 State St., Cambridge, Mass.
(See *Meters.*)

ISOLANTITE, INC.
233 Broadway, New York, N. Y.
All types of ceramic insulators. (See *Ceramics.*)

CHARLES F. JACOBS
270 Lafayette St., New York, N. Y.
High-frequency antenna spreaders.

E. F. JOHNSON CO.
Waseca, Minn.
(See *Antennas.*)

LAPP INSULATOR CO., INC.
LeRoy, N. Y.
All types of insulator, water coils

LOCKE INSULATOR CORP.
S. Charles & Cromwell Sts., Baltimore, Md.
Tower base insulators, guy insulators, antenna insulators, wall insulators.

NATIONAL CO., INC.
Malden, Mass.
Standoff and strain insulators.

OHIO BRASS CO.
Mansfield, Ohio.
Tower insulators.

Meters, Measuring and Laboratory Equipment, Cathode-Ray Tubes and Oscillographs, Photo-Electric Cells

ACME ELECTRIC & MFG. CO.
1440 Hamilton Ave., Cleveland, Ohio.
Insulation breakdown testers.

AMERICAN TRANSFORMER CO.
178 Emmet St., Newark, N. J.
Electronic devices, transformer testing sets. (See *Transformers.*)

AUDIO PRODUCTS CO.
4185 W. 2nd St., Los Angeles, Calif.
(See *Resistors.*)

BENDIX RADIO CORP.
9th & Kearny Sts., Washington, D. C.
Frequency meters, field-intensity meters, capacity standards, tubes and set testers. (See *High-Frequency Transmitters.*)

BOONTON RADIO CORP.
P. O. Box 344, Boonton, N. J.
Q-meters, QX-checkers, converter test oscillators, inductors, Hi-Q radio parts.

THE BRUSH DEVELOPMENT CO.
3311 Perkins Ave., Cleveland, Ohio.
Oscilloscopes, vibration pickups, heartbeat pickups. (See *Microphones.*)

BURTON-ROGERS COMPANY
755 Boylston St., Boston, Mass.
Meters.

THE ALLEN D. CARDWELL MFG. CORP.
81 Prospect St., Brooklyn, N. Y.
Condensers. (See *Condensers—Variable.*)

CELLUTONE RECORD & MFG. CO.
1135 W. 42nd St., Los Angeles, Calif.
Recording microscopes.

CLOUGH-BRENGLE CO.
2815 W. 19th St., Chicago, Ill.

Products

Power-level indicators, a-f and r-f signal generators, cathode-ray oscilloscopes, voltmeters, ammeters, ohmmeters, vacuum-tube voltmeters, frequency modulators.

Personnel

Pres. & Chief Engineer.....Kendall Clough
Vice-president.....Ralph T. Brengle
Sales Manager.....Robert L. Barr

Branch Offices

Clough-Brengle Co., 53 Park Pl., New York City; W. Bert Knight, Inc., 115 Venice Blvd., Los Angeles.

CONTINENTAL ELECTRIC CO.
715 Hamilton St., Geneva, Ill.
Photo-electric cells.

TOBE DEUTSCHMANN CORP.
Canton, Mass.
Automatic a-f graphic recorders.

DOOLITTLE & FALKNOR, INC.
7421 S. Loomis Blvd., Chicago, Ill.
Cathode-ray oscilloscopes.

ALLEN B. DUMONT LABS., INC.
532-540 Valley Rd., Upper Montclair, N. J.
Cathode-ray tubes and oscillographs.

ELECTRONIC SOUND LABS., INC.
5912 Melrose Ave., Hollywood, Calif.
Laboratory equipment.

EMAR INSTRUMENT CORP.
29 W. 57th St., New York, N. Y.
Equipment for station and recording laboratories.

THE ESTERLINE-ANGUS CO.
P. O. Box 596, Indianapolis, Ind.
Graphic recording instruments.

FERRANTI ELECTRIC, INC.
30 Rockefeller Plaza, New York, N. Y.
Electrostatic voltmeters, clipon ammeters, frequency meters, phase rotation indicators. (See *Transformers.*)

Meters (continued)

FERRIS INSTRUMENT CORP.
Boonton, N. J.

Products

Standard signal generators, microvolters, laboratory equipment.

Personnel

President.....Malcolm Ferris

GENERAL ELECTRIC CO.
Schenectady, N. Y.

Photo-electric cells, cathode-ray oscilloscopes, meters, etc.

GENERAL RADIO CO.
30 State St., Cambridge, Mass.

Products

Measuring instruments, frequency monitors, modulation monitors, distortion-factor meters, oscillographs, transformers, power-level indicators, mixers, volume controls, wave analyzers, oscillators.

Personnel

President.....Melville Eastham
General Manager.....H. B. Richmond
Sales Manager.....C. T. Burke
Advertising Manager.....J. M. Clayton

Branch Offices

90 West St., New York, N. Y.

G-M LABORATORIES, INC.
1731 Belmont Ave., Chicago, Ill.
Photo-cells.

HAMMARLUND MFG. CO., INC.
424-438 W. 33rd St., New York, N. Y.
(See *High-Frequency Transmitters.*)

THE HICKOK ELEC. INSTRUMENT CO.
10514 Dupont Ave., Cleveland, Ohio.
Meters, cathode-ray oscillographs.

LAMPKIN LABORATORIES
Bradenton, Florida.
Heterodyne-type frequency meters.

LEEDS & NORTHRUP CO.
4901 Stenton Ave., Philadelphia, Pa.
High-frequency resistance boxes, limit bridges, capacitance and conductance bridges.

LITTELFUSE LABORATORIES
4238 Lincoln Ave., Chicago, Ill.
Neon testers and pilot indicators, fuses. (See *Transformers.*)

DR. F. LOEWENBERG
10 East 40th St., New York, N. Y.

Products

"Electrocell" self-generating photo-electric elements.

PIEZOELECTRIC LABORATORIES
612 Rockland Ave., New Dorp, N. Y.
Piezoelectric crystal equipment.

PRECISION PIEZO SERVICE
427 Asia St., Baton Rouge, La.
Crystal laboratory equipment.

PREMIER CRYSTAL LABS., INC.
719 Pulitzer Bldg., New York, N. Y.
Reactance meters, crystal heterodyne frequency meters, crystal laboratory equipment.

RADIO APPARATUS CO.
240 Central Ave., Newark, N. J.
Cathode-ray equipment.

RADIO ENG. & MFG. CO.
26 Journal Square, Jersey City, N. J.
(See *Transmitters.*)

RADIO ENGINEERING LABS., INC.
25-14 41st Ave., Long Island City, N. Y.
Wavemeters.

RAWSON ELECTRICAL INSTRUMENT CO.
110 Potter St., Cambridge, Mass.
Ammeters, voltmeters, wattmeters, fluxmeters, dynamometers, thermocouples, electrostatic voltmeters, timers, cable testers, earth current meters, ohmmeters.

RCA MANUFACTURING CO., INC.
Camden, N. J.
(See *Transmitters.*)

SHALLCROSS MFG. CO.
10 Jackson Ave., Collingdale, Pa.

Products

Wire-wound resistors, megohm decade boxes, Wheatstone bridges, radio testing equipment, rotary instrument switches, kilovoltmeters, surge resistors, high-voltage X-ray equipment.

Personnel

President.....D. H. Shallcross
Chief Engineer.....Paul Shallcross
Sales Manager.....R. D. Leonard
Advertising Manager.....R. M. Malin

Export

15 E. 26th St., New York, N. Y.

SHURE BROTHERS
225 W. Huron St., Chicago, Ill.
Acoustic laboratory equipment. (See *Microphones.*)

HECTOR R. SKIFTER
St. Paul Hotel, St. Paul, Minn.
Field-intensity measuring equipment.

SOUND APPARATUS CO.
150 W. 46th St., New York, N. Y.
Recording microscopes.

STRUTHERS DUNN, INC.
131 N. Juniper St., Philadelphia, Pa.
Electric counters, timing devices.

SUNDT ENGINEERING CO.
4238 Lincoln Ave., Chicago, Ill.

Products

Neobeam oscilloscope, neon tuning wands, neon specialties, surge protectors, arc suppressors, fractional horsepower variable-speed motors, "audiocall" p-a systems.

Personnel

General Manager.....E. V. Sundt
Manager.....B. Kollath
Sales Manager.....Louis J. Fohr, Jr.

TECH LABORATORIES
703 Newark Ave., Jersey City, N. J.
Output meter volume indicators, special bridges and switches. (See *Resistors.*)

TELETOUCH CORPORATION
37 W. 54th St., New York, N. Y.
Photo-cells, electronic control devices.

THORDARSON ELEC. MFG. CO.
500 W. Huron St., Chicago, Ill.
Oscilloscopes. (See *Transformers.*)

THE TRIPLETT ELEC. INST. CO.
Bluffton, Ohio.

TRIUMPH MANUFACTURING CO.
4017-19 W. Lake St., Chicago, Ill.

Products

Cathode-ray oscillographs, test oscillators, signal generators, meters.

Personnel

President.....James J. McCarthy
Chief Engineer.....Edward J. Doyle
Sales Manager.....James P. Kennedy
Advertising Manager.....James P. Kennedy

UNITED SOUND ENGINEERING CO.
2233 University Ave., St. Paul, Minn.
Audio oscillators, cathode-ray oscillographs.

UNIVERSAL SIGNAL APPLIANCES
64 W. 22nd St., New York, N. Y.

Products

Automatic tape recorders, automatic keying devices; automatic signalling, counting and controlling devices designed and built to specifications; photoelectric devices.

Personnel

President.....Thomas A. Ryan
Chief Engineer.....Boris A. Sidoroff
Sales & Advertising Manager.....William McClenahan

Export

Joshua B. Powers, Inc., 220 E. 42nd St., New York, N. Y.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
Frequency monitors, meters. (See *Transmitters.*)

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
Instruments and meters.

WESTON ELECTRICAL INST. CORP.
614 Frelinghuysen Ave., Newark, N. J.
Ohmmeters, voltmeters, oscillators, combination volt-ohm-milliammeters, powel-level indicators, output meters, panel and switchboard type meters.

WRIGHT'S ELEC. INST. LAB.
Reed College, Portland, Oregon.
Special indicating instruments.

Microphones, Microphone Stands, Accessories

AMERICAN MICROPHONE CO., INC.
1915 South Western Ave., Los Angeles, Calif.
Carbon, condenser, crystal, dynamic and electrostatic microphones; microphone stands; accessories.

AMERICAN PHENOLIC CORP.
500 S. Throop St., Chicago, Ill.
Microphone connectors. (See *Sockets.*)

AMPERITE COMPANY
561 Broadway, New York, N. Y.

Products

Velocity microphones, microphone stands, preamplifiers, regulators.

Personnel

President.....Elliot Leeds
Chief Engineer.....Samuel Ruttenberg
Sales Manager.....William Ruttenberg
Advertising Manager.....H. J. Gold

Branch Offices

520 N. Michigan Ave., Chicago; 500 King St., West Toronto, Ontario, Canada.

ASTATIC MICROPHONE LABORATORY, INC.
830 Market St., Youngstown, Ohio.

Products

Crystal microphones and crystal phonograph pickups.

Branch Offices

Representatives in all principal cities.

Export

C. O. Brandes, 5716 Euclid Ave., Cleveland, Ohio.

AUDIO RESEARCH, INC.
105 E. 16th St., New York, N. Y.
Dynamic microphones.

BEACON MICROPHONE CO.
590 Summer St., Akron, Ohio.

BENDIX RADIO CORP.
9th & Kearny Sts., Washington, D. C.
Microphones. (See *High-Frequency Transmitters.*)

BELL SOUND SYSTEMS, INC.
61 E. Goodale St., Columbus, Ohio.
Crystal and velocity microphones.

BRUNO LABORATORIES, INC.
30 W. 15th St., New York, N. Y.
Velocity and static-velocity microphones, connectors, microphone stands.

THE BRUSH DEVELOPMENT CO.
3311 Perkins Ave., Cleveland, Ohio.

Products

Sound-cell microphones, microphone stands, oscilloscopes, vibration pickups, headphones, transfilters, heart-beat pickups.

Personnel

President.....A. L. Williams
Vice-president.....C. B. Scott
Chief Engineer.....Charles K. Gravley
Sales Manager.....W. H. St. Clair
Advertising Manager.....John Altmayer

Export

C. O. Brandes, 5716 Euclid Ave., Cleveland, Ohio.

BUD SPEAKER CO.
1112 Jackson St., Toledo, Ohio.
Microphones.

Microphones (Continued)

CARRIER MICROPHONE CO.
525 S. Commercial St., Inglewood, Calif.
Microphones.

COLOR-TONE, INC.
Sturgis, Michigan.
Microphones, microphone stands, microphone controls.

EASTERN MIKE-STAND CO.
56 Christopher Ave., Brooklyn, N. Y.
Microphone stands.

Personnel

President & General Manager.....S. Sherman

Export

Rocke International Electric Corp., 100 Varick St., New York, N. Y.

EASTERN SOUND CO.
94 Portland St., Boston, Mass.
Transverse velocity microphones.

ELECTRONIC SOUND LABS., INC.
5912 Melrose Ave., Hollywood, Calif.
Microphones.

ELECTRO-VOICE MFG. CO., INC.
324 E. Colfax Ave., South Bend, Ind.

Products

Velocity, carbon and dynamic microphones; microphone stands.

Personnel

President.....A. R. Kahn

Branch Offices

Representatives in all principal cities.

Export

Rocke International Electric Corp., 100 Varick St., New York, N. Y.

GATES RADIO & SUPPLY CO.
Quincy, Illinois.
Dynamic and velocity microphones. (See *Transmitters.*)

GENERAL CABLE CORP.
420 Lexington Ave., New York, N. Y.
Shielded and unshielded microphone cable.

MAGNAVOX CO., LTD.
Fort Wayne, Indiana.
Microphones.

RADIO RECEPTOR CO., INC.
108 Seventh Ave., New York, N. Y.
Microphones. (See *Amplifiers.*)

RADIOTONE RECORDING CO.
6103 Melrose Ave., Hollywood, Calif.
Microphones. (See *Recording.*)

RCA MANUFACTURING CO., INC.
Camden, N. J.
Microphones. (See *Transmitters.*)

REMLER CO., LTD.
2101 Bryant St., San Francisco, Calif.
Microphones. (See *Transmitters.*)

SHURE BROTHERS
225 W. Huron St., Chicago, Ill.

Products

General-purpose and wide-range diaphragm and sound-cell type crystal microphones, general-purpose and high-fidelity condenser microphones, single- and double-button carbon microphones, power supplies, preamplifiers, microphone stands and accessories, microphone cable, crystal record reproducers, acoustic laboratory equipment, engineering and commercial acoustic devices.

Personnel

General Manager.....S. N. Shure
Chief Engineer.....Ralph P. Glover
Sales Manager.....E. L. Berman

Branch Offices

Representatives in Atlanta, Dallas, Boston, Cleveland, Chicago, Detroit, Minneapolis, San Francisco, Seattle, Tulsa, Los Angeles, Philadelphia, New Orleans, Pittsburgh, New York City, Memphis, St. Louis, Winnipeg and Toronto, Canada.

SOUND SYSTEMS, INC.
6545 Carnegie Ave., Cleveland, Ohio.
Microphones. (See *Amplifiers.*)

SUPREME SOUND LABS.
20 Liberty St., Newburgh, N. Y.
Microphones.

TRANSDUCER CORPORATION
30 Rockefeller Plaza, New York, N. Y.
"Bullet" microphones.

THE TURNER COMPANY
909 17th St., Cedar Rapids, Iowa.
Crystal microphones, preamplifiers. (See *Amplifiers.*)

UNIVERSAL MICROPHONE CO.
424 Warren Lane, Inglewood, Calif.
Microphones, microphone stands, and accessories. (See *Recording.*)

THE WEBSTER COMPANY
3825 W. Lake St., Chicago, Ill.
Microphones. (See *Amplifiers.*)

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
Microphones. (See *Transmitters.*)

Power Supplies, Batteries, Rectifiers, Voltage Regulators, Motors, Etc.

THE ACME ELEC. & MFG. CO.
1440 Hamilton Ave., Cleveland, Ohio.
Voltage regulators.

AMERICAN TRANSFORMER CO.
178 Emmet St., Newark, N. J.
Rectifiers, voltage regulators. (See *Transformers.*)

AMPEREX ELECTRONIC PRODUCTS, INC.
79 Washington St., Brooklyn, N. Y.
(See *Tubes.*)

BODINE ELECTRIC CO.
2264 W. Ohio St., Chicago, Ill.
Motors.

BOND ELECTRIC CORP.
New Haven, Conn.
Radio batteries, dry cells.

BRIGHT STAR BATTERY CO.
200 Crooks Ave., Clifton, N. J.
Radio batteries, dry cells.

BURGESS BATTERY CO.
Freeport, Ill.
Radio and aircraft batteries.

CARTER MOTOR CO.
361 W. Superior St., Chicago, Ill.

Products

Genemotors for police, aircraft, transmitters, farm radio, etc.

Personnel

President.....A. J. Carter
Chief Engineer.....Tony Schiffer
Sales Manager.....E. J. Carter
Advertising Manager.....A. J. Carter

Branch Offices

N. W. Agencies, 2603 3rd St., Seattle; Harry Adelman, 16 Hudson St., New York; P. O. Everson, Wynyard, Sask., Canada.

CONTINENTAL ELECTRIC CO.
715 Hamilton Ave., Geneva, Ill.
Mercury rectifiers.

DELCO-REMY CORPORATION
Anderson, Indiana.
Motors.

THOMAS A. EDISON, INC.
Belleville Turnpike, Kearney, N. J.
Batteries.

EITEL-McCULLOUGH, INC.
798 San Mateo Ave., San Bruno, Calif.
(See *Tubes.*)

ELECTRIC SPECIALTY CO.
Stamford, Conn.
Generators, motor-generators, dynamotors, rotary converters.

ELECTRONIC LABORATORIES, INC.
122 W. New York St., Indianapolis, Ind.
Vibrators.

FEDERAL TELEGRAPH CO.
200 Mt. Pleasant Ave., Newark, N. J.
Mercury-vapor tubes, power rectifiers.

FERRANTI ELECTRIC, INC.
30 Rockefeller Plaza, New York, N. Y.
Voltage regulators. (See *Transformers.*)

FRANKLIN TRANSFORMER MFG. CO.
607 22nd Ave., N. E., Minneapolis, Minn.
Fractional hp motors.

GATES RADIO & SUPPLY CO.
Quincy, Ill.
Low and high-voltage power supplies. (See *Transmitters.*)

GENERAL ELECTRIC CO.
Schenectady, N. Y.
Motor-generators, regulators.

GOULD STORAGE BATTERY CORP.
35 Neoga St., Depew, N. Y.
Storage batteries, battery chargers, rectifiers.

HEINTZ & KAUFMAN, LTD.
South San Francisco, Calif.
(See *Tubes.*)

IDEAL COMMUTATOR DRESSER CO.
1062 Park Ave., Sycamore, Ill.

Products

Motor armature and commutator cleaners and dressers, motor tools, and equipment.

JANETTE MFG. CO.
556 W. Monroe St., Chicago, Ill.
Rotary converters.

KATO ENGINEERING CO.
Mankato, Minn.
Motors.

KENYON TRANSFORMER CO., INC.
840 Barry St., New York, N. Y.
Power supplies.

LYCOMING MANUFACTURING CO.
Williamsport, Pa.
Natural gas motor-generator plants ranging from 10 kw to 60 kw.

P. R. MALLORY & CO., INC.
Indianapolis, Ind.
Vibrators, rectifiers.

NATIONAL CARBON CO., INC.
30 E. 42nd St., New York, N. Y.
Batteries and dry cells.

D. W. ONAN & SONS
43-51 Royalston Ave., Minneapolis, Minn.
Electric generating plants.

PERRINE QUALITY PRODUCTS CORP.
55 Rumford Ave., Waltham, Mass.
Storage batteries.

PIONEER GEN-E-MOTOR CORP.
466 W. Superior St., Chicago, Ill.
Genemotors.

THE RADIART CORP.
Shaw and E. 133rd Sts., Cleveland, Ohio.
Vibrators.

RADIO ENGINEERING & MFG. CO.
26 Journal Square, Jersey City, N. J.
Mercury-vapor rectifiers.

RADIO ENGINEERING LABS., INC.
25-14 41st Ave., Long Island City, N. Y.
Power supplies.

RAY-O-VAC CO.
2317 Winnebago St., Madison, Wis.
Dry batteries.

RAYTHEON MFG. CO.
Electrical Equipment Division
190 Willow St., Waltham, Mass.
Voltage regulators, battery eliminators, power supplies.

RCA MANUFACTURING CO., INC.
Camden, N. J.
(See *Transmitters.*)

SHURE BROTHERS
225 W. Huron St., Chicago, Ill.
Power supplies. (See *Microphones.*)

SOLA ELECTRIC CO.
2525 Clybourn Ave., Chicago, Ill.
Voltage compensators.
(*Continued on page 38*)

Power Supplies (continued)

SPEER CARBON CO.
1937 Theresia St., St. Marys, Pa.
Carbon, graphite and metal brushes for motors and generators, slip-ring brushes for generators and rotary converters, battery carbon.

SUNDT ENGINEERING CO.
4238 Lincoln Ave., Chicago, Ill.
Surge protectors, arc suppressors. (See *Meters.*)

TAYLOR TUBES, INC.
2341 Wabansia St., Chicago, Ill.
Rectifier tubes. (See *Tubes.*)

UNITED ELECTRONICS CO.
42 Spring St., Newark, N. J.
Mercury rectifiers. (See *Tubes.*)

UNITED TRANSFORMER CORP.
72 Spring St., New York, N. Y.
Regulators, rectifiers for broadcast and industrial use. (See *Transformers.*)

UNIVERSAL BATTERY CO.
3410 S. LaSalle St., Chicago, Ill.
Storage batteries.

UTAH RADIO PRODUCTS CO.
812 Orleans St., Chicago, Ill.
Vibrators.

WARD LEONARD ELECTRIC CO.
37 South St., Mt. Vernon, N. Y.

Products
Fixed and adjustable resistors, rheostats, relays, voltage regulators, rectifiers, controls.

Personnel
President.....L. Kepler
Chief Engineer.....W. W. Miller
Sales Manager.....A. A. Berard
Advertising Manager.....J. R. Jones

Branch Offices
In all principal cities.

Export
Ad. Auriema, Inc., 116 Broad St., New York, N. Y.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
Rectifiers. (See *Transmitters.*)

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
Motor-generators, voltage regulators.

WILLARD STORAGE BATTERY CO.
E. 131st St., & St. Clair Ave., Cleveland, Ohio.
Storage batteries.

Recording and Transcription Equipment, Needles, Records, Pickups, Etc.

H. W. ACTON CO., INC.
370 Seventh Ave., New York, N. Y.
Transcription needles.

ALLIED PHONO. & RECORD MFG. CO.
1041 N. Las Palmas Ave., Hollywood, Calif.
Recording blanks.

ALLIED RECORDING PRODUCTS CO.
125 W. 46th St., New York, N. Y.

Products
Sound recording equipment for portable and permanent installations, transcription turntables, amplifiers, recording blanks, acetate and aluminum cutting stylii, reproducing needles.

ANSLEY RADIO CORP.
240 W. 23rd St., New York, N. Y.
Radio-phonograph combinations.

ASTATIC MICROPHONE LABS., INC.
830 Market St., Youngstown, Ohio.
Crystal phonograph pickups. (See *Microphones.*)

AUDAK COMPANY
500 Fifth Ave., New York, N. Y.

Products

Microdyne and Micromatic pickups, magneto-induction pickups, cutting heads.

Personnel

President.....Maxmilian Weil
Vice-President .....George Sullivan
Chief Engineer.....Maxmilian Weil

Branch Offices

Representatives in all principal cities.

Export

M. Simons & Son Co., 25 Warren St., New York, N. Y.

BENDIX RADIO CORP.
9th & Kearny Sts., Washington, D. C.
(See *High-Frequency Transmitters.*)

BRAINARD-WALDER COMPANY
1056 Venice Blvd., Los Angeles, Calif.
Disc and film recorders.

E. V. BRINCKERHOFF & CO., INC.
29 W. 57th St., New York, N. Y.
Cutting heads, reproducing heads, reproducing equipment.

LAB. OF E. P. CARTER, INC.
112 Cedar St., Pitman, N. J.
Electrical recording laboratory equipment, chemical laboratory equipment.

CELLUTONE RECORD & MFG. CO.
1135 W. 42nd St., Los Angeles, Calif.
Acetate recording blanks, acetate and wax recording stylii, recording microscopes, reproducing needles.

CENTRAL TRANSCRIPTION CO.
307 W. Walnut St., Louisville, Ky.
Electrical transcriptions and sound recording equipment.

F. L. COOK
606 Parkman Ave., Los Angeles, Calif.
Recording discs, needles and associated supplies.

DENCOSE, INC.
29 W. 57th St., New York, N. Y.
Portable recording and reproducing units, alloy recording discs.

ELECTRICAL LAB. CO., INC.
49 E. 21st St., New York, N. Y.
Phonograph pickups, recording heads, feed mechanisms.

ELECTRICAL RESEARCH PRODUCTS, INC.
250 W. 57th St., New York, N. Y.
Western Electric broadcast reproducing systems, including 33-1/3 rpm lateral and vertical, and 78 rpm turntable and associated equipment.

ELECTRONIC SOUND LABS., INC.
5912 Melrose Ave., Hollywood, Calif.
Recording equipment.

EMAR INSTRUMENT CORP.
29 W. 57th St., New York, N. Y.
Recording heads, recording and reproducing equalizers, monitoring systems, recording equipment.

FAIRCHILD AERIAL CAMERA CORP.
62-10 Woodside Ave., Woodside, L. I., N. Y.

Products

Fairchild-Proctor portable recorders, studio recorders, and crystal pickups.

Personnel

Vice-president.....F. W. Lutz
Chief Engineer.....George Rattray
Sales Manager.....R. H. Lasche

GATES RADIO & SUPPLY CO.
Quincy, Ill.
Transcription equipment. (See *Transmitters.*)

HOLLOWAY CO.
72 Spring St., New York, N. Y.
Recorders, recording amplifiers, turntables.

MIRROR RECORD CORP.
58 W. 25th St., New York, N. Y.
Recording discs.

PHONOGRAPH NEEDLE MFG. CO.
42-46 Dudley St., Providence, R. I.
Cutting and reproducing needles, discs.

PIEZOELECTRIC LABS.
612 Rockland Ave., New Dorp, N. Y.
Recording equipment, transcription turntables.

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Recording (continued)

POINSETTIA, INC.

P. O. Box 301, Philadelphia, Pa.
Sound recording equipment and supplies.

Personnel

President.....E. Poinsett
Chief Engineer.....E. Poinsett
Sales Manager.....F. H. Warner
Advertising Manager.....H. Griffin

Branch Offices

307 W. Walnut St., Louisville, Ky.; 4451 Irving Park Blvd., Chicago.

PRESTO RECORDING CORP.

139 W. 19th St., New York, N. Y.

Products

Instantaneous recording discs, recording and reproducing equipment, recording and playback needles.

Personnel

President.....S. Sholes
Executive vice-president.....M. M. Gruber
Chief Engineer.....George J. Saliba
Sales Manager.....R. C. Powell
Advertising Manager.....R. C. Powell

Branch Offices

Norman B. Neely, 1656 N. Serrano St., Los Angeles; A. M. Clubb & Co., Sydney, Australia.

Export

M. Simons & Son Co., Inc., 25 Warren St., New York, N. Y.

B. A. PROCTOR CO., INC.

17 W. 60th St., New York, N. Y.
Sound and recording engineers.

Personnel

President.....B. A. Proctor
Sales Manager.....Ferd. C. W. Thiede

RADIOTONE RECORDING CO.

6103 Melrose Ave., Hollywood, Calif.

Products

Recording machines (wax—acetate), recording amplifiers, p-a amplifiers, automatic phonograph combinations, recording discs and supplies.

Personnel

President.....W. H. Snow
Chief Engineer.....W. H. Snow
Sales Manager.....F. H. Brown

Export

Ad. Auriema, Inc., 116 Broad Street, New York, N. Y.

RANGERTONE, INC.

201 Verona Ave., Newark, N. J.

Products

Recording equipment, cutting needles, electric organs, electric automatic chimes, amplified chimes.

Personnel

President.....R. H. Ranger
Chief Engineer.....E. P. Schmidt

RCA MANUFACTURING CO., INC.

Camden, N. J.
Transcription equipment. (See *Transmitters.*)

REMLER COMPANY, LTD.

2101 Bryant St., San Francisco, Calif.
Transcription turntables. (See *Transmitters.*)

SHURE BROTHERS

225 W. Huron St., Chicago, Ill.
Crystal record reproducer. (See *Microphones.*)

SOUND APPARATUS CO.

150 W. 46th St., New York, N. Y.

Products

Recording and reproducing machines, cutting heads, reproducing heads, disc recording material, amplifiers, equalizers, filters, automatic high-speed level recorders, cutting and reproducing needles, synchronous recording motors, recording microscopes.

Personnel

President.....Arthur W. Niemann
Chief Engineer.....Max Wastl
Sales Manager.....J. Sampson
Advertising Manager.....Helen Reichel

SOUND SYSTEMS, INC.

6545 Carnegie Ave., Cleveland, Ohio.
Turntables. (See *Amplifiers.*)

TALKING DEVICES CO.

4451 Irving Park Blvd., Chicago, Ill.
Sound recorded products and sound novelties.

TECHNA CORP.

926 Howard St., San Francisco, Calif.
Transcription and recording equipment.

PAUL K. TRAUTWEIN

58 W. 25th St., New York, N. Y.
Acetate discs.

U. S. SOUND RECORDING SUPPLY CO.

1730 Venice Blvd., Los Angeles, Calif.
Sound recording motors and chassis, recording blanks, cutting and playback heads and needles.

UNIT REPRODUCERS MFG. CO.

999 E. Main St., Rochester, N. Y.

Products

Magnetic phono pickups, permanent-magnet speakers.

Personnel

Manager.....F. A. Terwilliger
Chief Engineer.....Howard Corts
Sales Manager.....F. A. Terwilliger

Branch Offices

Detsch & Company, San Francisco: Bittan Sales Co., New York City.

UPCO ENGINEERING LABS., INC.

254 Canal St., New York, N. Y.
Pickups.

UNIVERSAL MICROPHONE CO.

424 Warren Lane, Inglewood, Calif.

Products

Microphones, microphone stands and accessories, recording machines, amplifiers, blank discs, needles, etc.

Personnel

President.....James R. Fouch
Chief Engineer.....Earl E. Griffin
Advertising Manager.....Ralph L. Power

Branch Offices

540 N. Michigan Ave., Chicago; 259 W. 14th St., New York City; 109 Bell St., Seattle; 437 Eleventh St., N.W., Washington (D. C.).

Export

Frazar and Co., 7 Front St., San Francisco, Calif.

THE WEBSTER CO.

3825 W. Lake St., Chicago, Ill.
Phonograph motors and assemblies. (See *Amplifiers.*)

WEBSTER ELECTRIC CO.

Racine, Wis.
Phonograph pickups.

Resistors, Attenuators, Relays, Fuses, Etc.

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Carbon resistors, fixed wire-wound and adjustable wire-wound resistors. (See *Condensers.*)

ALLEN-BRADLEY CO.

1326 S. Second St., Milwaukee, Wis.
Fixed and adjustable resistors, adjustable carbon rheostats, attenuators, L, T and H pads, overload relays.

ATLAS RESISTOR CO.

1423 Broome St., New York, N. Y.
Wire-wound tubular resistors.

AUDIO PRODUCTS CO.

4185 W. Second St., Los Angeles, Calif.
Attenuators.

THE CARBORUNDUM CO.

Globar Division.
Niagara Falls, N. Y.
Resistors.

(*Continued on page 42*)

Resistors (continued)

CENTRALAB
900 E. Keefe Ave., Milwaukee, Wis

Products

Variable resistors, volume and tone controls, composition fixed resistors, pads, wave change switches, socket contacts.

CLAROSTAT MFG. CO., INC.
285 N. 6th St., Brooklyn, N. Y.

Products

Wire and carbon type volume controls, L and T pads, series mixers, output attenuators, fixed wire-wound resistors.

Personnel

President.....John J. Mucher
Chief Engineer.....George J. Mucher
Sales Manager.....Victor Mucher

Export

M. Simons & Son Co., 25 Warren St., New York, N. Y.

COMMERCIAL RADIO EQUIPMENT CO.
216 E. 74th St., Kansas City, Mo.
T pads. (See *Crystals.*)

CONTINENTAL CARBON, INC.
Lorain Ave., Cleveland, Ohio.
Resistors.

THE DAVEN CO.
158 Summit St., Newark, N. J.
Potentiometers, rheostats, variable and fixed attenuators, resistances.

ELECTRAD, INC.
175 Varick St., New York, N. Y.
Attenuators, volume controls, faders, resistors.

ERIE RESISTOR CORP.
664 W. 18th St., Erie, Pa.
Resistors.

A. M. FLECHTHEIM & CO., INC.
692 Broadway, New York, N. Y.
Carbon resistors.

GENERAL RADIO CO.
30 State St., Cambridge, Mass.
Mixers, volume controls. (See *Meters.*)

GUARDIAN ELECTRIC CO.
1625 W. Walnut St., Chicago, Ill.

Products

Relays, solenoids, contact switches, time delays, step-up switches, electrical controls.

Personnel

President.....F. F. Rowell
Chief Engineer.....Marvin Nelson
Sales Manager.....F. F. Rowell, Jr.
Advertising Manager.....J. J. Rowell

Branch Offices

17 E. 42nd St., New York City; 610 Case Building, Rochester; 918 Union St., New Orleans; 130 Hewitt St., Los Angeles; 32 — 10th St., Oakland; 524 S.W. Pine St., Portland; 2107 Grand Ave., Kansas City.

HARDWICK, HINDLE, INC.
40 Hermon St., Newark, N. J.
Resistors and rheostats.

INTERNATIONAL RESISTANCE CO.
401 N. Broad St., Philadelphia, Pa.

Products

Insulated metallized and wire-wound resistors, metallized-type volume controls, precision wire-wound resistors, cement-coated wire-wound resistors, low-range insulated wire-wound resistors, ultra-high-range resistors.

Personnel

President.....Ernest Searing
Chief Engineer.....J. Marsten
Sales Manager.....Harry Ehle

Branch Offices

Representatives in all principal cities.

Export

1078 Drexel Building, Philadelphia, Pa.

THE JEFFERSON ELECTRIC CO.
Bellwood, Illinois.
Fuses.

More than machines..

Efficient machines can be acquired rather easily by anyone who has the money to purchase equipment.

But, on the other hand, intelligence and experience cannot be bought. It is these . . . plus invention and the love of work . . . combined with the best mechanical equipment . . . that have made CARDWELL a constant source of supply to leaders in the industry. (Not only for variable condensers but also for numerous types of communication equipment.)

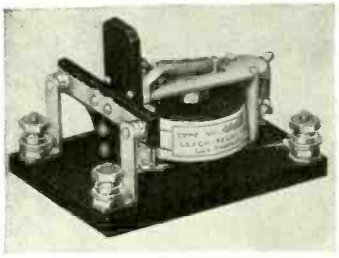
And now, these same CARDWELL facilities are offered to manufacturers who have production problems to "farm out".

Write, Phone or Wire specifications for convincing estimates.

THE ALLEN D. CARDWELL
MANUFACTURING CORPORATION
89 PROSPECT STREET, BROOKLYN, NEW YORK

LEACH LR RELAYS

POSITIVE PROTECTION



For Your Power Tubes. These light duty overload trip relays have a wide field of use as safety devices on electronic apparatus. Operation is unusually dependable. Scores of nationally known concerns rely on Leach Relays for protection.

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5915 Avalon Boulevard,
Los Angeles, Calif.

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LEACH RELAY CO.
5915 Avalon Blvd., Los Angeles, Calif.

All types of relays.

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4238 Lincoln Ave., Chicago, Ill.

Products
Fuses, fuse mountings, fuse clips, neon tattelite testers, neon tattelite pilot indicators.

Personnel
General Manager.....E. V. Sundt
Manager.....B. Kollath
Sales Manager.....Louis J. Fohr, Jr.

MICAMOLD RADIO CORP.
1087 Flushing Ave., Brooklyn, N. Y.
Molded bakelite wire-wound resistors, ceramic coated wire-wound resistors, carbon resistors.

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Resistors.

THE MUTER CO.
1255 S. Michigan Ave., Chicago, Ill.
Wire-wound resistors, resistance bridges, resistance indicators.

OHIO CARBON CO.
12508 Berea Rd., Cleveland, Ohio.
Resistors.

OHMITE MFG. CO.
4838 W. Flournoy St., Chicago, Ill.
Resistors.

PRECISION RESISTOR CO.
334 Badger Ave., Newark, N. J.
Potentiometers, wire-wound resistors, multipliers, shunts.

REMLER CO., LTD.
2101 Bryant St., San Francisco, Calif.
Attenuators. (See *Transmitters.*)

SHALLCROSS MFG. CO.
10 Jackson Ave., Collingdale, Pa.
Wire-wound resistors, bridges. (See *Meters.*)

SIGMA INSTRUMENTS, INC.
388 Trapelo Rd., Belmont, Mass.
Relays.

SPEER CARBON CO.
1937 Theresia St., St. Marys, Pa.
Insulated and uninsulated fixed carbon resistors.

STACKPOLE CARBON CO.
Tannery St., St. Marys, Pa.
Carbon resistors, volume and tone control.

THE STATES CO.
19 New Park Ave., Hartford, Conn.
Resistors for tank circuits, for dummy antennas, for rhombic antennas, for oven heaters.

STRUTHERS DUNN, INC.
131 N. Juniper St., Philadelphia, Pa.
Relays.

TECH LABORATORIES
703 Newark Ave., Jersey City, N. J.

Products
Attenuators for volume control, measurements, precision laboratory use. R-F attenuators, fixed-loss pads, gain sets, impedance-matching networks, output-meter volume indicators, tap and special switches, decade condensers and resistance boxes, r-f precision resistors, mixing and switching panels, line equalizers, special bridges and instruments.

Personnel
President.....M. Bjorndal

Branch Offices
1623 S. Hill St., Los Angeles; 9 S. Clinton St., Chicago; 191 Starin Ave., Buffalo; 3750 Urban Ave., Dallas; 1014 W. 37th St., Kansas City.

UTAH RADIO PRODUCTS CO.
820 Orleans St., Chicago, Ill.
Resistors and volume controls.

WARD LEONARD ELECTRIC CO.
37 South St., Mt. Vernon, N. Y.
Rheostats, relays. (See *Power Supplies.*)

WESTON ELECTRICAL INST. CORP.
614 Frelinghuysen Ave., Newark, N. J.
Relays.

(*Continued on page 44*)

PRECISION *plus* PORTABILITY

Net $56.50
Complete—Ready to Operate

Model 79B

Beat note audio oscillator, 25 to 15,000 cycles per second. 27 Volt output. Less than 5% distortion. Output curve essentially flat over entire range.

Laboratory Type

MODEL OB audio oscillator. Hand calibrated dial. 15 to 15,000 cycles per second. 5 Volts Output to 500 ohm line. Complete with separate power supply. Net $136.80

Net $28.00
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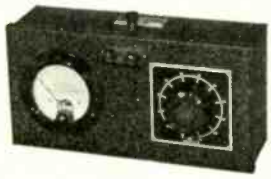

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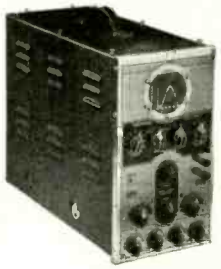
Constant impedance power level indicator. Calibrated —15 to +40 db. Frequency range 20 to 15,000 cycles without correction. May be used across any impedance line.



Net $92.50

Instantaneous pictures of circuit performance insure correct operation under all circumstances.

Model CRA

Cathode-ray oscillograph. Incorporates dual power supplies, dual amplifiers, and dual beam centering controls. Higher input sensitivity .38 rms volts per inch deflection. For checking wave form distortion, frequency characteristics, etc. C-B amplified and compensated sweep circuit offers a higher degree of linearity.

Write for complete details.

The CLOUGH-BRENGLE CO.

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STREET .....
CITY..... STATE.....

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WIRT CO.
5221 Greene St., Philadelphia, Pa.
Resistors.

YAXLEY MFG. CO.
Indianapolis, Ind.
Resistors.

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ACME WIRE CO.
New Haven, Conn.
Magnet wire, varnished insulation.

ALDEN MFG. CO.
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ALUMINUM GOODS MFG. CO.
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Dials, escutcheons, coils shields, tube housings, transformer housings, etc.

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500 S. Throop St., Chicago, Ill.

Products

Molded bakelite and steatite sockets, cable plugs, microphone connectors, magic-eye plug assemblies.

Personnel

President.....Arthur J. Schmitt
Chief Engineer.....P. C. Chamberlain

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ANACONDA WIRE & CABLE CO.
25 Broadway, New York, N. Y.

BASTIAN BROTHERS CO.
1600 N. Clinton Ave., Rochester, N. Y.

BEST MFG. CO.
1200 Grove St., Irvington, N. J.

BIRNBACH RADIO COMPANY
145 Hudson St., New York, N. Y.

BUD RADIO, INC.
1936 E. 55th St., Cleveland, Ohio.

CENTRALAB
900 E. Keefe Ave., Milwaukee, Wis.
Switches, sockets. (See *Resistors.*)

CINCH MFG. CORP.
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Tube sockets, plugs.

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Vacuum power switches.

COTO-COIL CO., INC.
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Dials, transmitting parts, coil winding.

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Dials, scales, nameplates, escutcheons, tuning units.

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158 Summit St., Newark, N. J.
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THE H. H. EBY MFG. CO.
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EDDIE MFG. CO.
9 W. Illinois St., Chicago, Ill.

A. W. FRANKLIN MFG. CO.
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All types of wire.

Single and Double Button

HANDI-MIKES

. . . the handiest microphone ever built. Thousands in daily use for paging—window demonstrations—sports events—amateur 'phones—mobile transmitters, etc. With cord and switch as shown.

Dealer's cost, single button $5.88 net

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AT YOUR JOBBERS.
SEND FOR CATALOG.

Universal Microphone Co.
LTD.
424 WARREN LANE
INGLEWOOD, CALIF., U. S. A.

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Full Automatic Siphon Tape Recorder

For Commercial and Amateur Use

Let Visasig solve your code reception problems

Model VI-B—records code signals from a radio receiver up to and in excess of 100 WPM. Complete as pictured above

$59.00

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Providence, R. I.
Flexible insulated wire, rubber connecting plug.

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Coil forms, sockets, coil and tube shields, flexible couplings. (See *High-Frequency Equipment.*)

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Electronics Division.
64 Lakeview Ave., Clifton, N. J.
Switches, sockets, dials and drives, flexible insulated couplings.

INSULINE CORP. OF AMERICA
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ISOLANTITE, INC.
233 Broadway, New York, N. Y.
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Waseca, Minn.
Tube sockets. (See *Antennas.*)

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Indianapolis, Ind.

THE MUTER CO.
1255 S. Michigan Ave., Chicago, Ill.

NATIONAL CO., INC.
Malden, Mass.

OHMITE MFG. CO.
4835 Flournoy St., Chicago, Ill.

RADIO ENGINEERING LABS., INC.
25-14 41st Ave., Long Island City, N. Y.
Sockets.

RCA MANUFACTURING CO., INC.
Camden, N. J.
(See *Transmitters.*)

REMLER CO., LTD.
2101 Bryant St., San Francisco, Calif.
Plugs, sockets. (See *Transmitters.*)

SHALLCROSS MFG. CO.
10 Jackson Ave., Collingdale, Pa.
Rotary instrument switches. (See *Meters.*)

TECH LABORATORIES
703 Newark Ave., Jersey City, N. J.
Tap and special switches. (See *Resistors.*)

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Jacks, switches, mike and phone plugs.

WARD LEONARD ELECTRIC CO.
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Controls. (See *Power Supplies.*)

WHOLESALE RADIO SERVICE CO.
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(See *Amplifiers.*)

Speakers, Headphones, etc.

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1770 W. Berteau Ave., Chicago, Ill.

ARISTON MFG. CORP.
4049 Diversey Ave., Chicago, Ill.

BEST MFG. CO.
1200 Grove St., Irvington, N. J.

BRUSH DEVELOPMENT CO.
3311 Perkins Ave., Cleveland, Ohio.
Tweeters, headphones. (See *Microphones.*)

C. F. CANNON CO.
Main St., Springwater, N. Y.
Headphones.

CHICAGO TEL. SUPPLY CO.
H. H. Frost, Inc.
Elkhart, Ind.
Headphones.

CINAUDAGRAPH CORP.
Stamford, Conn.
Permanent-magnet speakers.

CONTINENTAL MOTORS CORP.
12801 E. Jefferson Ave., Detroit, Mich.
Permanent-magnet dynamic speakers.

FOR RAPID TURNOVER

Profits come from turnover . . . Merchandise sold not merchandise bought and collecting dust on the shelf. Get into the Sound Business right . . . with the fastest moving line.

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ALL-PURPOSE SOUND SYSTEM

—For Both 6 V. D.C. and 110 V. A.C.

IDEAL FOR SOUND TRUCKS

This new 30 Watt system has the advantage of being usable anywhere and under all conditions. Only change necessary is to plug in right power pack. All necessary accessories are included, the phonograph turntable being an integral part of the amplifier cabinet.

With this one system dealer can accommodate all demands for rentals.

30 WATTS Undistorted Output System includes: 4-Stage 30 Watt High Gain Amplifier Crystal Microphone

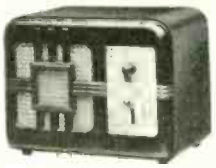
Two Heavy Duty P. M. Speakers
Dual Electronic Mixing System—Mixes microphone and phonograph
For audiences of any size to 10,000 people.

WEBSTER-CHICAGO'S

INTER-COMMUNICATION SYSTEMS AC-DC OPERATION

Webster-Chicago offers four types—two types for two-station installations and two types for multi-station installations (up to 10 points). Both types have—

- No hum or noise
- Adjustable volume control
- Beautiful plastic cases
- Natural voice reproduction
- Sensitive pick-up



Model OCM ...1 to 10 Stations With this system each station can talk to each other station. System can be started with two or more stations and additional stations added, one or more at a time, to 10. A sales repeater for dealers.

SPECIAL SALES HELPS

All kinds of productive dealers' helps available free of charge—write for more information.

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- STRICT DEALER POLICY
- FULLY LICENSED
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.....Please send me more information on.....
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Address .....
City ..... State.....

Speakers (continued)

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Speaker units, trumpets, exciters, adapters, theatre sound equipment baffle-type horns.

Personnel

President.....J. J. Kendricks
Chief Eng. & Sales Mgr.....H. N. Rowl

Export

Ad. Auriema, Inc., 116 Broad St., New York, N. Y.

JENSEN RADIO MFG. CO.
6601 S. Laramie Ave., Chicago, Ill.
Speakers.

LANSING MFG. CO.
6900 McKinley Ave., Los Angeles, Calif.
Loudspeakers.

MAGNAVOX CO., LTD.
Fort Wayne, Ind.
Speakers.

OPERADIO MFG. CO.
St. Charles, Ill.
Speakers.

OXFORD-TARTAK RADIO CORP.
915 W. Van Buren St., Chicago, Ill.

Products

Dynamic, magnetic and permanent magnet replacement, auditorium and p-a speakers, aluminum exponential horns, speakers in cabinets, field exciter units, speaker test units.

Personnel

President.....Paul H. Tartak
Chief Engineer.....Maurice Swift
Sales Manager.....J. S. Gartner
Advertising Manager.....J. S. Gartner

Export

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Tioga and C Sts., Philadelphia, Pa.

QUAM-NICHOLS CO.
1623 W. 74th St., Chicago, Ill.

RACON ELECTRIC CO., INC.
15 E. 19th St., New York, N. Y.
Horns and all types of loudspeakers.

RCA MANUFACTURING CO., INC.
Camden, N. J.
(See *Transmitters.*)

THE ROLA CO.
2530 Superior Ave., Cleveland, Ohio.

SOUND SYSTEMS, INC.
6545 Carnegie Ave., Cleveland, Ohio.
Loudspeakers. (See *Amplifiers.*)

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Rochester, N. Y.

TRIMM RADIO MFG. CO.
1528 Armitage Ave., Chicago, Ill.
Headphones.

UNITED PRESSED PRODUCTS CO.
407 S. Aberdeen St., Chicago, Ill.

UNIT REPRODUCERS MFG. CO.
999 East Main St., Rochester, N. Y.
Permanent-magnet speakers. (See *Recordina.*)

UTAH RADIO PRODUCTS CO.
820 Orleans St., Chicago, Ill.
Speakers.

VICTORY SPEAKERS, INC.
7131 E. 14th St., Oakland, Calif.
Speakers.

VOICE OF THE AIR CO.
730 Phillips Ave., Toledo, Ohio.

THE WEBSTER CO.
3825 W. Lake St., Chicago, Ill.
Speakers. (See *Amplifiers.*)

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
(See *Transmitters.*)

WRIGHT-DeCOSTER, INC.
St. Paul, Minn.
Loudspeakers and accessories.

Transformers, Chokes, Reactors, Filters, etc.

ALLOY TRANSFORMER CO., INC.
135 Liberty St., New York, N. Y.
Transformers, chokes, equalizers, castings.

THE ACME ELEC. & MFG. CO.
1440 Hamilton Ave., Cleveland, Ohio.
Step-down transformers, safety transformers, r-f and a-f transformers and chokes, luminous tube (neon) transformers, high-intensity mercury-vapor lamp transformers.

AMERICAN TRANSFORMER CO.
178 Emmet St., Newark, N. J.

Products

Transformers: a-f, plate-supply, filament-supply, modulation, air-cooled power, distribution, furnace, instrument, testing. Other apparatus: audio and filter reactors, rectifiers, electronic devices, testing sets, spot welders, voltage regulators, soldering sets.

Personnel

President.....Thomas M. Hunter
Electronic Engineer.....Walter J. Garlick, Jr.
Advertising Manager.....Fred H. Canfield

Branch Offices

30 Rockefeller Plaza, New York City.

Export

Ad. Auriema, Inc., 116 Broad St., New York, N. Y.

CHICAGO TRANSFORMER CORP.
2626 W. Washington Blvd., Chicago, Ill.
Transformers.

COLLINS RADIO CO.
2920 First Ave., N. E., Cedar Rapids, Iowa.
Transformers. (See *Transmitters.*)

COTO-COIL CO., INC.
229 Chapman St., Providence, R. I.
All type of coil winding to specifications.

DELTA MFG. CO.
Waltham, Mass.

TOBE DEUTSCHMANN CORP.
Canton, Mass.
Filters. (See *Condensers.*)

DONGAN ELEC. MFG. CO.
2987 Franklin St., Detroit, Mich.

FERRANTI ELECTRIC, INC.
30 Rockefeller Plaza, New York, N. Y.

Products

Audio transformers, inductors, plate and filament transformers, filter chokes, high-Q reactors, modulation equipment, filters, equalizers, repeaters, distorters, electrostatic voltmeters, clip-on ammeters, frequency meters, phase rotation indicators.

Personnel

President.....V. Z. DeFerranti
Chief Engineer.....W. R. Spittal
Sales Manager.....W. R. Spittal

Associated Companies

Ferranti, Ltd., Hollinwood, England; Ferranti Electric, Ltd., Toronto, Ontario, Canada.

FRANKLIN TRANSFORMER MFG. CO.
607 22nd Ave., N. E. Minneapolis, Minn.
Commercial (air-cooled) audio, power, transmitting and amateur transformers, filter reactors.

GENERAL ELECTRIC CO.
Schenectady, N. Y.
Reactors, transformers.

GENERAL RADIO CO.
30 State St., Cambridge, Mass.
Transformers. (See *Meters.*)

GENERAL TRANSFORMER CORP.
500 S. Throop St., Chicago, Ill.
Transformers.

THE HALLDORSON CO.
4500 Ravenswood Ave., Chicago, Ill.
Transformers.

HAMMARLUND MFG. CO., INC.
424-438 W. 33rd St., New York, N. Y.
Transformers. (See *High-Frequency Transmitters.*)

HYGRADE SYLVANIA CORP.
Electronics Division.
64 Lakeview Ave., Clifton, N. J.
Power transformers, special r-f and a-f transformers, inductances, chokes.

JEFFERSON ELECTRIC CO.
25th Ave. and Madison St., Bellwood, Ill.
Transformers.

KENYON TRANSFORMER CO., INC.
840 Barry St., New York, N. Y.
Audio and power transformers, reactors.

J. W. MILLER CO.
5917 S. Main St., Los Angeles, Calif.
Intermediate-frequency transformers, r-f coils and chokes, filters.

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60 W. 15th St., New York, N. Y.
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NATIONAL CO., INC.
Malden, Mass.
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PHELPS DODGE COPPER PRODUCTS CORP.
Inca Mfg. Division
2375 E. 27th St., Los Angeles, Calif.
Power and audio transformers, chokes.

RACON ELECTRIC CO., INC.
52 E. 19th St., New York, N. Y.
Filters.

THE RADIART CORP.
Shaw Ave. and 133rd St., Cleveland, Ohio.
Transformers.

RAYTHEON MFG. CO.
Electrical Equipment Division
190 Willow St., Waltham, Mass.
Transformers, chokes.

SOLA ELECTRIC CO.
2525 Clybourn Ave., Chicago, Ill.
Transformers.

SOUND APPARATUS CO.
150 W. 46th St., New York, N. Y.
Equalizers, filters. (See *Recordina Equipment.*)

STANDARD TRANSFORMER CORP.
850 Blackhawk St., Chicago, Ill.
Transformers.

TECH LABORATORIES
703 Newark Ave., Jersey City, N. J.
Equalizers. (See *Resistors.*)

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

Products

Power, audio, driver, output, filament, exciter, plate, auto, transceiver, and modulation transformers and chokes; amplifiers; oscilloscopes; neon equipment; bombarding equipment; voltage regulators.

Personnel

President.....C. H. Thordarson
Chief Engineer.....M. Heald
Sales Manager.....C. P. Cushway
Advertising Manager.....H. C. Johnson

Branch Offices

Representatives in San Francisco, Denver, Kansas City, Dallas, Minneapolis, Dayton, Chicago, St. Louis, New Orleans, Detroit, Philadelphia, Washington (D. C.), Buffalo, Atlanta, New York City, Boston, Portland, Los Angeles.

UNITED TRANSFORMER CORP.
22 Spring St., New York, N. Y.

Products

Audio transformers, rectifiers for broadcast and industrial use, reactors, regulators, plate and distribution transformers, equalizers, television transformers, amplifier kits, field exciters, battery chargers.

Personnel

President & Chief Engineer.....I. A. Mitchell
Sales & Advertising Manager.....S. L. Baraf

Branch Offices

Boston, Buffalo, Pittsburgh, Atlanta, Dallas, St. Louis, Cleveland, Detroit, Denver, Milwaukee, Seattle, Los Angeles.

Export

100 Varick St., New York, N. Y.

Transformers (continued)

UTAH RADIO PRODUCTS CO.
820 Orleans St., Chicago, Ill.
Transformers.

WEBSTER ELECTRIC CO.
Racine, Wisc.
Transformers and chokes.

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
Transformers and reactors.

Transmitters and Associated Apparatus

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Coaxial cable, antenna coupling equipment, custom built radio transmission equipment.

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BRAINARD-WALDER CO.
1056 Venice Blvd., Los Angeles, Calif.
Broadcast speech-input equipment.

COLLINS RADIO CO.
2920 First Ave., S.E., Cedar Rapids, Iowa.

Products

Broadcast transmitters, speech-input equipment, remote-pickup amplifiers, power tubes, transformers, quartz crystals, transmitters for police and aircraft use, high-frequency transmitters, concentric transmission lines.

Personnel

President.....Arthur A. Collins
Advertising Manager.....Arnold Pyle

Branch Offices

11 West 42nd St., New York, N. Y.

COMMERCIAL RADIO EQUIP. CO.
216 E. 74th St., Kansas City, Mo.
Broadcast amplifiers, preamplifiers. (See *Crystals.*)

THE DAVEN CO.
158 Summit St., Newark, N. J.
Speech-input control apparatus, mixer panels, line equalizers.

DOOLITTLE & FALKNOR, INC.
7421 S. Loomis Blvd., Chicago, Ill.
Transmitting and associated equipment.

ELECTRONIC SOUND LABS., INC.
5912 Melrose Ave., Hollywood, Calif.
Radio transmitters.

FEDERAL TELEGRAPH CO.
200 Mt. Pleasant Ave., Newark, N. J.
Transmitters.

GATES RADIO & SUPPLY CO.
Quincy, Ill.

Products

For broadcast stations: speech-input equipment, remote equipment, transcription equipment, monitoring equipment, dynamic and velocity microphones, low and high-voltage power supplies, accessories. For theatres: amplifiers, exciter lamp rectifiers.

Personnel

President.....Parker S. Gates
Chief Engineer.....Paul L. Tourney
Sales Manager.....C. B. Gates
Advertising Manager.....P. S. Gates

Branch Offices

1913 Washington St., St. Louis; 1239 S. Gary Place, Tulsa; 4 Avenida Sur No. 3, Guatemala City, Guatemala.

GENERAL RADIO CO.
30 State St., Cambridge, Mass.
Frequency and modulation monitors, power-level indicators, volume controls. (See *Meters.*)

Transmitters (continued)

RADIO ENGINEERING & MFG. CO.
26 Journal Square, Jersey City, N. J.

Monitoring devices, program distribution panels, program amplifiers, mixing panels, portable amplifiers and mixers, harmonic suppressors, portable transmitters and receivers.

RADIO TRANSCEIVER LABS.
8627 115th St., Richmond Hill, N. Y.

Products

Ultra-high-frequency transmitters and receivers.

Personnel

President.....Frank Jacobs
Chief Engineer.....Frank Jacobs
Sales Manager.....F. A. Flickinger
Advertising Manager.....Frank Jacobs

Branch Offices

Fred E. Gaines, 43 East Ohio St., Chicago, Ill.

RCA MANUFACTURING CO., INC.
Camden, N. J.

Products

Transmitters, tubes, microphones, speech-input equipment and associated apparatus, field-intensity meters, frequency monitors, modulation monitors, beat-frequency oscillators, cathode-ray oscillographs, mica condensers, transcription turntables, laboratory and test equipment, public-address equipment.

Personnel

Chief Engineer.....L. M. Clement
Manager Transmitter Sales.....I. R. Baker
Advertising Manager.....T. F. Joyce

Branch Offices

490-492 Peachtree St., N.W., Atlanta; 170 Ninth St., San Francisco; 589 E. Illinois St., Chicago; 2211 Commerce St., Dallas; 1270 Sixth Ave., New York City.

Export

International Division, RCA Manufacturing Co., Inc., Camden, N. J.

REMLER CO., LTD.
2101 Bryant St., San Francisco, Calif.

Products

Broadcasting and public-address equipment, inter-communication systems, radio receivers, bakelite and screw-machine products, speech-input and remote equipment, microphones, transcription turntables.

Personnel

President.....E. G. Danielson
Chief Engineer (Radio Division).....H. E. Greene
Chief Engineer (P-A Division).....D. H. Hall
Sales Manager
(P.A. Broadcast).....F. G. Hawkinson
Sales Manager (Radio).....R. C. Gray

Branch Offices

1056 Venice Blvd., Los Angeles; 2125 Fifth Ave., Seattle; 1322 Lincoln St., Denver; 430 W. Diversey Pkwy., Chicago.

Export

Frazar & Co., 7 Front St., San Francisco, Calif.

HECTOR R. SKIFTER
St. Paul Hotel, St. Paul, Minn.

Audio and transmitting equipment, field-intensity measuring equipment.

TECHNA CORP.
926 Howard St., San Francisco, Calif.
Speech-input equipment.

TRANSMITTER EQUIPMENT MFG. CO., INC.
130 Cedar St., New York, N. Y.
Broadcast transmitters.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.

Products

Broadcast transmitters and auxiliary equipment, public-address systems, program sound distribution systems, police radio telephone, marine radiotelephone, aviation radiotelephone, vacuum tubes, microphones, and other communication equipment.

Personnel

President.....E. S. Bloom
Gen. Commercial Mgr.....D. F. G. Eliot
Advertising Manager.....W. A. Wolff

Distributors

All branches of Graybar Electric Co.

Export

Northern Electric Co. of Canada; International Standard Elec. Corp.

WESTERN RADIO ENG. CO.
5th & St. Peters Sts., St. Paul, Minn.
Broadcast equipment.

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
Transmitting equipment.

Transmission Lines

VICTOR J. ANDREW
7221 S. Francisco Ave., Chicago, Ill.

Coaxial cable, antenna coupling equipment, custom built radio transmission equipment.

COLLINS RADIO CO.
2920 First Ave., S. E., Cedar Rapids, Iowa.

Concentric transmission lines and accessories. (See *Transmitters.*)

DOOLITTLE & FALKNOR, INC.
7241-43 S. Loomis Blvd., Chicago, Ill.
Concentric cable transmission lines.

RUSSELL A. GRAY
10 Clinton St., Homer, N. Y.
Transmission lines.

HEINTZ & KAUFMAN, LTD.
South San Francisco, Calif.
Concentric transmission lines. (See *Tubes.*)

ISOLANTITE, INC.
233 Broadway, New York, N. Y.
Coaxial transmission line. (See *Ceramics.*)

GENERAL CABLE CORP.
420 Lexington Ave., New York, N. Y.
Radio transmission feeder cable.

CHARLES F. JACOBS
270 Lafayette St., New York, N. Y.
Feedline separators.

WESTERN ELECTRIC CO.
195 Broadway, New York, N. Y.
(See *Transmitters.*)

Tubes, Receiving

ARCTURUS RADIO TUBE CO.
Newark, N. J.

CHAMPION RADIO WORKS, INC.
90 Holten St., Danvers, Mass.

HYGRADE SYLVANIA CORP.
500 Fifth Ave., New York, N. Y.

HYTRON CORP.
Salem, Mass.

THE KEN-RAD TUBE & LAMP CORP.
Owensboro, Ky.

NATIONAL UNION RADIO CORP.
570 Lexington Ave., New York, N. Y.

RCA MANUFACTURING CO., INC.
RCA Radiotron Division.
Harrison, N. J.

RAYTHEON PRODUCTION CORP.
420 Lexington, Ave., New York, N. Y.

TRIAD MFG. CO., INC.
Pawtucket, R. I.

TUNG-SOL RADIO TUBES, INC.
95 Eighth Ave., Newark, N. J.

Tubes, Transmitting

AMPEREX ELECTRONIC PRODUCTS, INC.
79 Washington Street, Brooklyn, N. Y.

Products

Transmitting tubes—air and water-cooled for broadcasting, amateur, experimental, and industrial uses.

Personnel

President.....N. Goldman
Chief Engineer.....A. Senauke
Sales Manager.....S. Norris

Branch Offices

Los Angeles, Seattle, Atlanta, Chicago

Export

100 Varick Street, New York, N. Y.

EITEL-McCULLOUGH, INC.
San Bruno, California
Transmitting tubes.

FEDERAL TELEGRAPH CO.
200 Mt. Pleasant Ave., Newark, N. J.

Transmitting tubes, mercury-vapor rectifiers, power rectifiers.

HEINTZ AND KAUFMAN, LTD.
South San Francisco, Calif.

Products

Commercial and amateur transmitting tubes.

Personnel

President.....Ralph M. Heintz
Chief Engineer.....P. F. Scofield
Sales Manager.....W. N. Eldred
Advertising Manager.....W. N. Eldred

Branch Offices

51 Canton Rd., Shanghai, China.

NATIONAL RADIO TUBE CO., INC.
3420 — 18th St., San Francisco, Calif.

Products

Transmitting tube reconditioning.

Personnel

President.....Horace Wilbert
Chief Engineer.....Garrett W. Lewis

Export

Frazar and Co., 7 Front St., San Francisco, Calif.

RCA MANUFACTURING CO.
(see *Transmitters*)

SPEER CARBON CO.
1937 Theresia St., St. Marys, Pa.
Graphite radio tube anodes.

TAYLOR TUBES, INC.
2341 Wabansia St., Chicago, Ill.

Products

Complete line of low and medium power air-cooled transmitting tubes, diathermy apparatus.

Personnel

President.....Warren G. Taylor
Chief Engineers.....Warren G. Taylor
& Frank J. Hajek
Sales and Advertising Manager..Rex L. Munger

Export

Royal National Co., Inc., 16 West 61st St., New York, N. Y.

UNITED ELECTRONICS CO.
42 Spring St., Newark, N. J.

Products

Transmitting tubes, mercury rectifiers, industrial control and power tubes.

Personnel

President.....Charles Eisler
Chief Engineer.....Benjamin F. Steigen
Sales Manager.....Charles A. Rice
Advertising Manager.....R. H. Amberg

Branch Offices

600 W. Jackson Blvd., Chicago; 821 W. Olympic Blvd., Los Angeles; 440 Peachtree St., N.W., Atlanta.

WESTERN ELECTRIC CO.
(see *Transmitters*)

WESTINGHOUSE ELEC. & MFG. CO.
Chicopee Falls, Mass.
(See *Transmitters.*)

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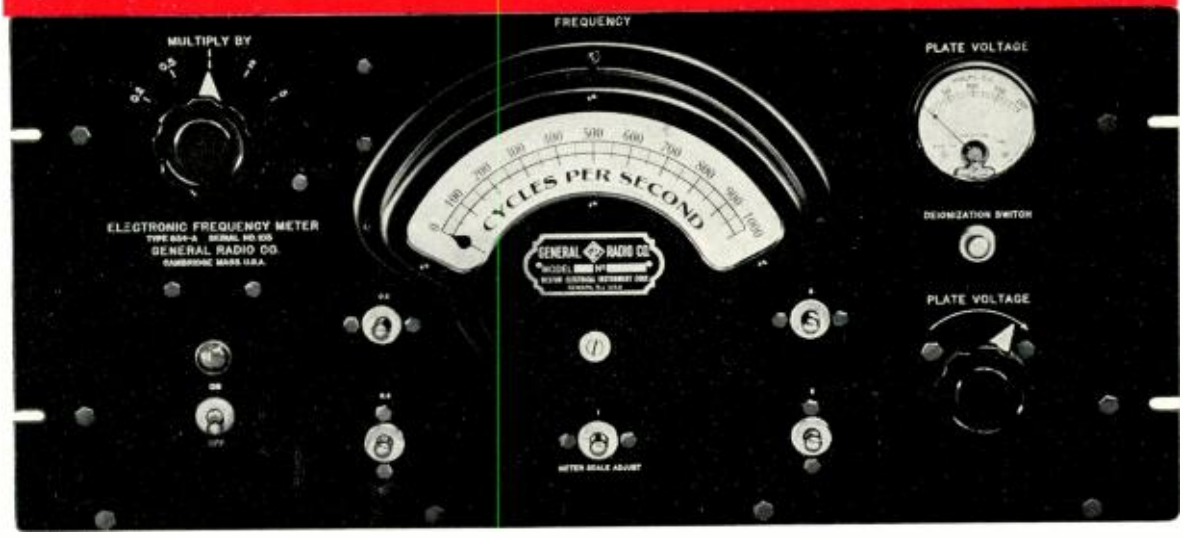
DIRECT READING—0 To 5,000 CYCLES



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- Analysis of vibration in machinery
- Studies of speech frequencies
- Tele-metering
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Write for Bulletin ST-66

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