RADIO BROADCAST

Willis Kingsley Wing, Editor

SEPTEMBER, 1928

Keith Henney, Director of the Laboratory

Edgar H. Felix, Contributing Editor

Vol. XIII. No. 5

CONTENTS

The contents of this magazine is indexed in *The Readers' Guide to Periodical Literature*, which is on file at all public libraries.

AMONG OTHER THINGS. . .

FOR a long time, readers of RADIO BROADCAST have been confused in buying the magazine on the newsstands because the magazine arrives on the newsstands on the 15th of the month and is dated the month following. That is, this issue, which is dated September, is on sale August 15th. In order to avoid confusion, beginning with the October RADIO BROADCAST each issue will be on sale on the first of the month. Look for your October issue on the first of October.

AT NO time since RADIO BROADCAST first appeared, which was in May, 1922, have so many letters of praise trooped into the editorial office. A great many of our readers are good enough to write us, telling exactly what they like in the magazine, and why. "Strays from the Laboratory," "Radio Broadcast's Home Study Sheets," and the "Service Data Sheets on Manufactured Receivers" are sharing honors at present. The "Home Study Sheets," the newest addition to the magazine, have been prepared because we have felt for a long time that radio readers wanted guidance in making their own home experiments. These "Home Study Sheets" are prepared by Keith Henney, director of the Laboratory. Both the author and the editor will be pleased to hear from readers who have suggestions on how the "Sheets" can be made more valuable to them.

IN 1925, when Carl Dreher was induced to begin preparing his department, "As the Broadcaster Sees It," the broadcasting art was very different from what we find it to-day. Since that time, more than 170,000 words dealing with broadcasting—both from the engineering and aesthetic point of view—have appeared under that department heading. The newest development of interest to the engineer and others associated with broadcasting and its problems is the talking movie. Beginning with October, Mr. Dreher's department "As the Broadcaster Sees It," will branch out. In addition to the material on broadcasting, which we are assured is widely useful, Mr. Dreher will treat of talking movies and in later issues of other fields closely related.

MANY of our amateur friends have hailed with delight the first article in the series of special short-wave contributions by Robert S. Kruse, formerly technical editor of *QST*. In the August RADIO BROADCAST, Mr. Kruse's first article appeared, dealing with the general aspects of 5-meter transmission. For our October number, Mr. Kruse expects to describe the construction and operation of an efficient and inexpensive battery-operated transmitter.

THE radio service man has found that a few simple instruments will make his task in the field much simpler. Many service men wrote us, praising Mr. Messenger's article in the July issue which described his set tester. On page 273 of this issue, a simpler unit is described which is useful for service men and those who would like to own a compact tester for general home experimental service.

WE APOLOGIZE for an error of our draftsman which we allowed to escape us in Fig. 2, page 218, RADIO BROADCAST for August in the article describing an r.f. stage for any set. The diagram will be correct if the reader removes the short vertical line which—now—short-circuits the A-battery.

—WILLIS KINGSLEY WING.

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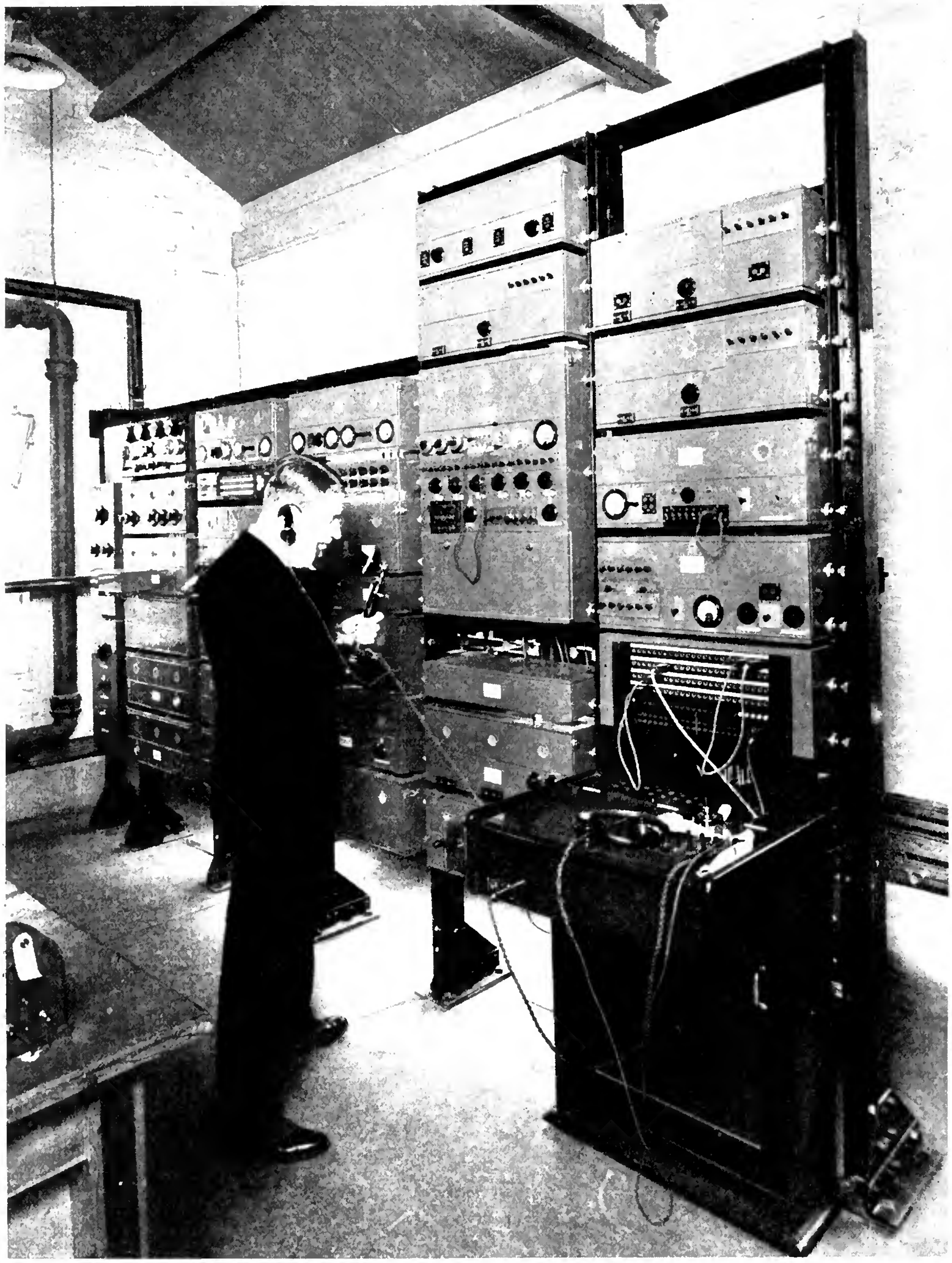
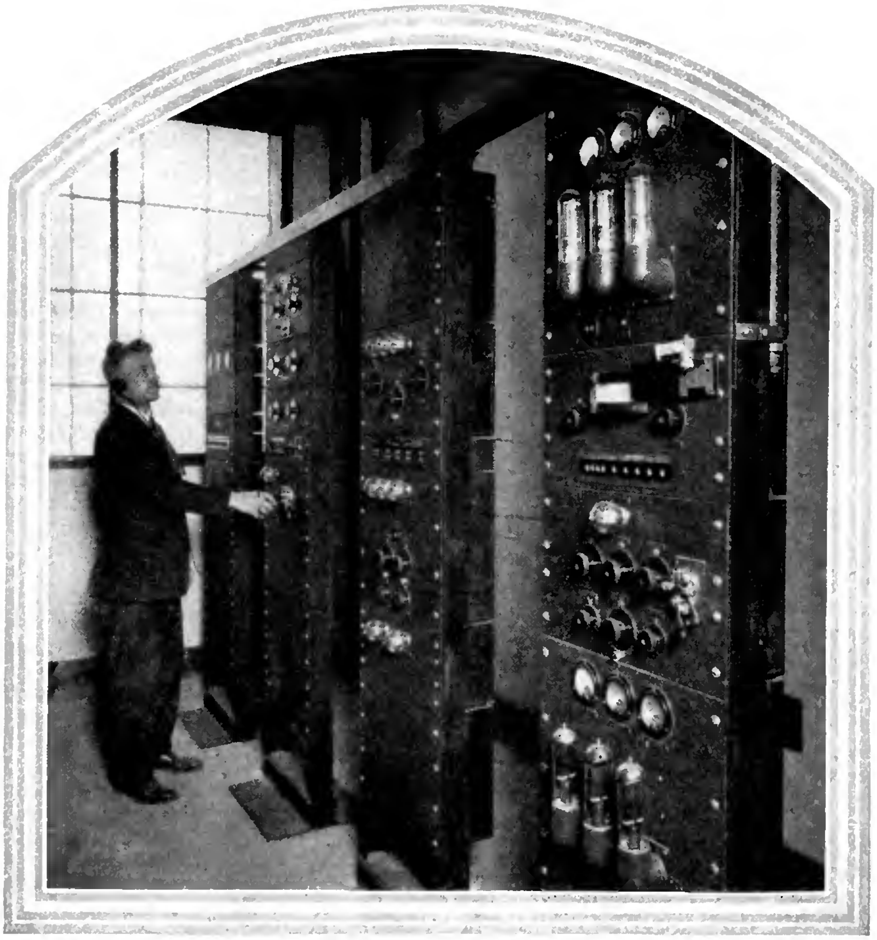


England Tackles the Multiplex Channel Problem

The simultaneous transmission of two high-speed telegraphic services and one telephone service over the same wavelength was recently demonstrated with this apparatus at the English Beam Station at Bridgewater. The demonstration, which was made in the presence of David Sarnoff, Vice-President of the Radio Corporation of America, was conducted between stations at Bridgewater, England (receiving), and Montreal, Canada (transmitting). Mr. G. A. Mathieu, who collaborated with Senatore Marconi in designing the system, is shown speaking into the telephone. It is claimed that this apparatus diminishes fading to a great extent, and thus gives constant volume of speech and signals. The engineering details of the system employed are not available at present.



A FILTER THAT SAVES 5 KILOCYCLES

This picture shows part of the speech input, modulating, filter and amplifying apparatus at the Rocky Point station of the Radio Corporation of America, where radiotelephonic transmission to Europe is carried on. The filter suppresses the carrier wave and one of the side-bands, thus halving the width of the channel necessary for transmission

Can We Multiplex Our Radio Channels?

By Albert F. Murray

THE progress of radio in the past has been so rapid, due to scientific genius and manufacturing skill, that a large part of the American public is now in the frame of mind in which it believes that almost anything is possible in the way of future developments. This attitude is held not only by the lay enthusiast for radio, but by some serious experimenters and technically minded men. New developments are expected to be realized almost by magic, and technical problems of the most difficult nature immediately solved by some new product of the inventor's skill. So it is that whenever some advance is made in radio, the press and the public immediately greet it as the herald of a new radio Utopia, without consideration of what technical, practical, or manufacturing obstacles are in the way.

We can understand then, in view of this attitude, the great stir of interest which some time ago was occasioned by press reports in which a well-known radio engineer outlined a "double tuning" system which was said would multiply each

THE solution of the problem of broadcast congestion is perhaps the most pressing of the needs of the broadcast listener to-day, and many people seem only too willing to believe that the solution will come, mysteriously, from some new invention. And so, when Dr. Lee DeForest some time ago made the statement that some 500,000 radiotelegraph stations could be disposed on the short-wave channels from 10 to 200 meters by means of a system of "double modulation," the press and general public believed that the long expected solution of the broadcasting problem was solved, and "double modulation" would soon multiplex all radio channels.

Mr. Murray considers the multiplexing of radio channels by means of "double modulation" from a technical and practical angle, shows how the system works, exactly what advantages may be realized from it, and what defects have kept it from being used so far. A method of multiplying channels—that of "single side-band" transmission—is also examined in a similar way. It is this second method which Mr. Murray considers most possible, its present practicality being limited by the need of skilful operation and precision instruments.

—THE EDITOR.

of the present radio channels by 100, thus making room for all those who are clamoring for space in the crowded ether. Concurrently, the question of finding space in the short-wave bands for the radio traffic of many corporations and private enterprises engaged the attention of the Federal Radio Commission. The natural result is that many of the radio public are now asking, "Is there really anything in these new radio systems?"

Regarding the proposed "double tuning" system, suppose we consider these questions: Is it a new or novel system? Will it multiply the existing radio channels? Are there good chances of this system being used in our country? How can more radio channels be made available?

IS THE SYSTEM NOVEL?

FIRST, the system referred to in the press reports as "double tuning" is usually more accurately described by the name of "double modulation" or "multiplex radio telephony." In radio, "modulation" means the "moulding" of the radio wave at the transmitter by voice frequen-

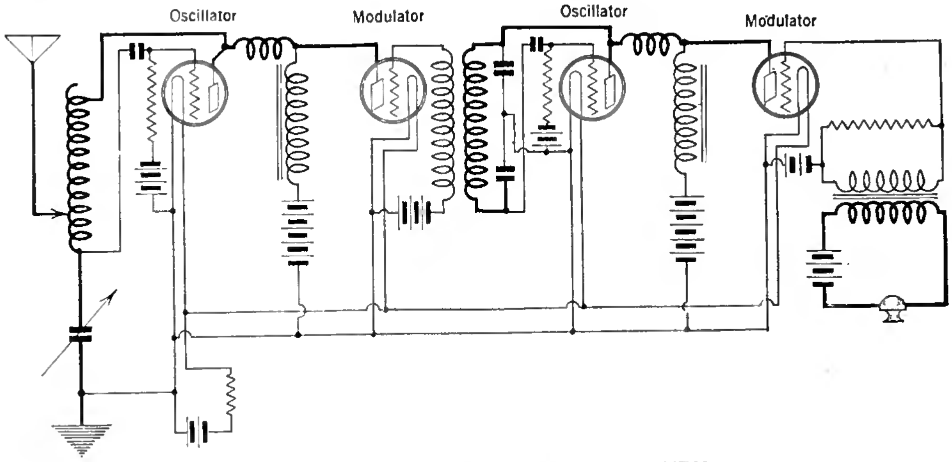


FIG. 1. A DOUBLE MODULATION SYSTEM

This diagram, which is reproduced from Morecroft's "Principles of Radio Communication," shows a circuit for transmitting by the double modulation system

cies picked up by the microphone. The device which allows the voice to be superimposed upon the radio wave is called the "modulator." The idea of double tuning or double modulation applied to a radio transmitter was shown in a patent by John Stone Stone more than 17 years ago. Just who was first to disclose a complete workable system, the writer does not know; but a sytsem similar to that described in the press reports was built by the Western Electric Company for the U.S. Navy prior to 1919. A description of this multiplex radio telephone system was given by Craft and Colpitts in the *Proceedings* of the A.I.E.E. (about 1919). For several years preceding and following this date, John Hays Hammond, Jr. was interested in double modulation systems, and his engineers developed complete multiplex radio telegraph installations which were tested by the U.S. Signal Corps and the U.S. Navy. It was while doing development work and research on these sets that the writer first became familiar with double modulation systems. In Morecroft's *Principles of Radio Communication* (pages 680–83, 1st ed.) written in 1921, complete diagrams for a double modulation system are shown. One of these diagrams is reproduced in Fig. 1. If the reader is interested in the actual connections to use in building such a transmitter or receiver, he is referred to these pages.

Just a few random references to the use of multiplex radio are given here. The engineer recently advocating its use, being a well-known pioneer in the radio field, famous for his inventions, must not have intended to claim novelty for this system. However, reporters of his address did infer that "double tuning" is new.

Before answering the next question, "Will double modulation multiply all existing radio channels?" it is necessary to describe briefly the arrangement of our present broadcasting system so as to form a background against which different systems may be viewed and compared.

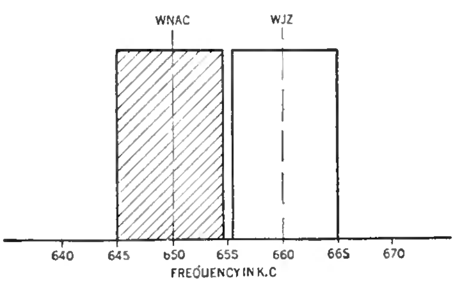


FIG. 2

WHAT IS A RADIO CHANNEL?

A RADIO channel is a band of radio frequencies, the width of which is determined by the type of transmission. Two such channels located in the broadcast "spectrum" are shown diagramatically in Fig. 2.

The word "spectrum," which is often employed in the study of light waves, has found increasing use in connection with radio waves. This is because a continuous electric wave appears in the radio spectrum as a straight line, located at a certain point in the frequency scale, exactly as a light line having a single color stands out in the light spectrum. Fig. 2 shows the location of the two radio channels assigned by the Federal Radio Commission to stations WJZ and WNAC. Each channel is designated by a number, which corresponds to the frequency (in kilocycles) or to the wavelength (in meters), of the point at which the *center* of the channel is located. Thus, looking at Fig. 2 we can say station WJZ (New York) operates on the 660-kc. channel and WNAC (Boston) on the 650-kc. channel.

Since the width of radio channel depends upon the type of transmission, a list of channel widths, in frequency, required by three well-known types of transmission is given as follows: (a) Radio telephony (broadcasting), 10 kc.; (b) Interrupted or tone-modulated c.w. telegraphy, about 2 kc.; (c) Unmodulated c.w. telegraph, less than 0.3 kc., depending upon the keying speed (words per minute). These widths remain the same whether transmission takes place in the longer or shorter wavebands, assuming precautions are taken to maintain the frequency of the radio generator constant.

The present broadcast spectrum extends from 550 kc. to 1500 kc. In order to provide for the maximum number of transmitting stations each channel is limited to 10 kc., the minimum width which will give satisfactory reproduction of music. The total number of channels available on this basis is 95. With our present serious station interference and hundreds of would-be broadcasters waiting for space in the ether, the question of the most economical use of this band is important, and it is this problem which we are considering.

THE RESULT OF MODULATION

WITH the help of Fig. 3, which shows one of the radio channels of Fig. 2 magnified, let us examine the nature of the wave disturbance caused in the ether by a radio telephone transmitting station. We will suppose that the spectrum resulting from a transmitter (such as WJZ) is shown here. When the microphone is idle, that is, no modulation taking place, the radio frequency carrier wave only is radiated. This is accurately located at the assigned frequency of 660 kc., and is represented by a single line in the spectrum. Now suppose the microphone at the station is energized by a steady musical tone of, say, 1000 cycles; the result is the formation of so-called "side-bands" shown in Fig. 3 by the shorter lines on either side of the central carrier-wave.

Digressing for a moment, if this is a picture of the frequency spectrum from a transmitter, how is it that we can hear at the receiver the musical tone impressed on the microphone? The reason we hear the 1000-cycle tone is because after the carrier-wave and either side-band has entered the receiver, they "beat" together in the detector (or de-modulator) circuit, and produce a tone of the original modulating frequency. This explanation of why the radio telephone receiver "works" is somewhat different from that usually given in popular radio articles which omit the important point of "beats" in the detector circuit and do not explain the need of the presence of the carrier-wave at the receiver.

The process of modulation at a radio transmitter is fairly complex, but it is not necessary for the reader to go into the mechanism of modulation in order to understand some of the simpler results of the process. It is necessary, however, to accept the fact that when a carrier-wave is modulated, upper and lower side-bands appear as shown in Fig. 3. Each of these is spaced from the carrier-wave by an amount equal to the frequency of the modulating tone. From this fact it is evident that, the higher the pitch of the musical note striking the microphone, the broader will be the band in the ether occupied by the transmitter at that moment. Those persons complaining that one local broadcasting station is much "broader" than another should note this point. Usually the alleged "broadness of wave" of a particular transmitter is due to the broader tuning of the listener's receiver at this frequency or to the greater power radiated by this particular transmitter.

If neither of the stations shown in Fig. 2 ever used modulation frequencies above the highest on the ordinary piano keyboard or the highest reached by the piccolo (that is, fundamental frequencies of about 4600 cycles) there would be no overlapping of one station into the channel of the other—provided, of course, both carrier waves were on their assigned frequencies. In many transmitters sudden modulation peaks may cause momentary shifting of the carrier frequency or other effects, resulting in intermittent interference being noted in neighboring radio channels.

It is understood, of course, that from the tone quality standpoint it is desirable, if permitted, to transmit modulation frequencies of higher than 5000 cycles because harmonics of various musical instruments range above this figure. And these add a great deal to the naturalness of broadcast music.

We have now defined a radio channel, shown

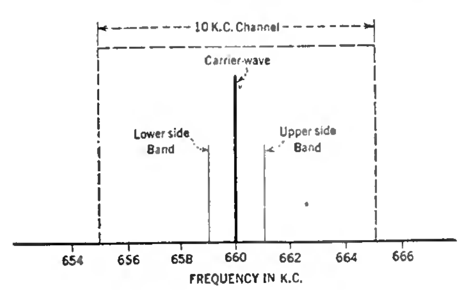
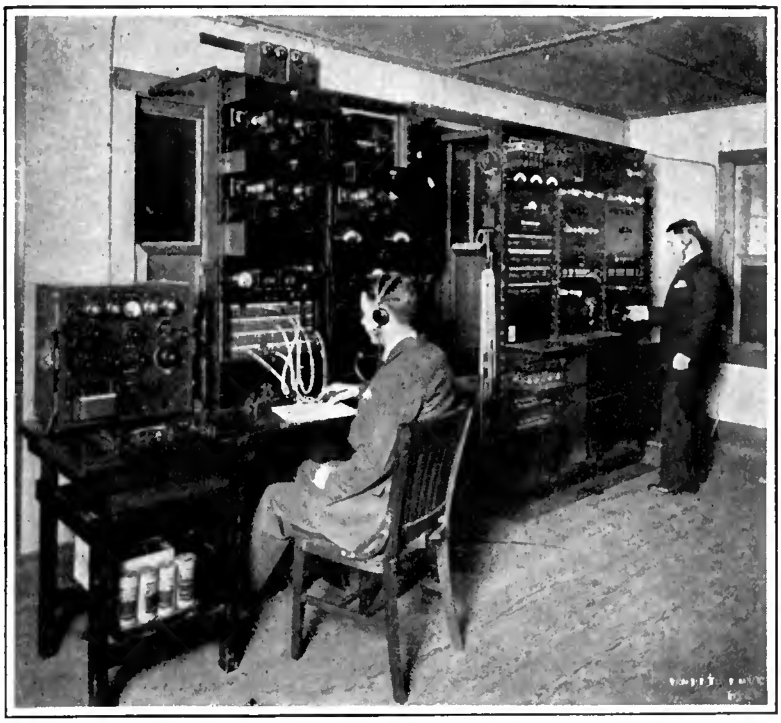


FIG. 3

that its width for broadcasting is 10 kc., and shown that the side-bands, which vary in response to the voice frequencies from 50 to 5000 cycles, occupy the full width of this channel. We are now ready to consider the more unusual system of double modulation, sometimes called "secret radio," "selective signalling," and "double tuning."



AT THE RECEIVING END

This apparatus is part of that used for the reception of single side-band signals at the Houlton, Maine, station of the American Telephone & Telegraph Co. The operator at the right is adjusting the apparatus used to pick up the signal, and the man at the left is responsible for the wire line to New York

THE DOUBLE MODULATION SYSTEM

A BRIEF outline of such a system will be mentioned so that the reader will understand how double modulation can be used at an experimental broadcasting station employing this system.

Instead of modulating the usual carrier wave by audio frequency currents, an intermediate frequency (i.f.), above the limit of audibility—say 20,000 cycles—is used. This intermediate frequency is, in turn, modulated by speech frequencies. The resultant is a modulated carrier wave superimposed upon another carrier which is radiated in the usual manner.

In receiving such a doubly modulated wave, it is necessary to tune to and detect the radio-frequency carrier wave, which could be, say, 660 kc.; then tune to and detect the intermediate frequency of 20 kc. and, if desired, amplify the audio-frequency signal resulting from the second detection.

A transmitter and receiver that work in the above manner are shown schematically in Fig. 4. The audio frequencies (50 to 5000 cycles) are picked up by the microphone, and are impressed on the i.f. oscillator (or generator) by means of the first modulator. The modulated output of the i.f. oscillator acts on the second modulator arranged to modulate the r. f. oscillator (or generator) so that a doubly modulated wave may be radiated from the antenna.

Only the bare fundamentals are shown at the receiver; namely, an r. f. tuner (660 kc.) and detector which feeds its inaudible output into an i.f. tuner (20 kc.) and detector. In the output of the latter are connected telephones in which the desired signal can be heard.

SEMI-SECRET TRANSMISSION

SINCE our radio receivers of to-day are intended for the reception of single-modulated signals, we do not have the second receiver unit of Fig. 4 (i.f. tuner and detector). Hence, by the use of certain combinations at the transmitter, intelligible signals from double modulated transmitters cannot be received with ordinary receivers. For this reason, engineers term such a system "semi-secret."

Some readers will doubtless ask the question, "What about the super-heterodyne—it possesses an intermediate tuner and detector." To convert a super-heterodyne into a double modulation system receiver, as in Fig. 3, it will usually be necessary, first, to alter the fixed-tune i.f. amplifier so that it can be tuned to any desired transmitted intermediate frequency (20 to 100 kc.), and, second, to eliminate the r.f. heterodyning oscillator, which is unnecessary.

An editorial in *Radio News* not so long ago stated that the rapid modulations necessary for television could be superimposed on the present carrier wave of a broadcast transmitter by means of double modulation so that *no additional channels* would be required. As we know, this same double-tuning system has been offered by others as a means for greatly increasing the broadcast channels now available in a given wave-band. The fallacy in both of the above views will be pointed out in the paragraphs to follow.

THE CHANNEL NEEDED FOR DOUBLE MODULATION

FIG. 5 illustrates the radio spectrum lines resulting from the radiation of a double-modulated radiophone transmission. In the center we have the r. f. carrier-wave located at the assigned frequency, which we will take in this example as 660 kc. Spaced equally, on either side, are the upper and lower i.f. waves separated from the carrier by the selected intermediate frequency of 20 kc. Associated with each of these are the usual upper and lower a.f. sidebands separated from the i.f. line by 1000 cycles, since, at the moment this radio spectrum was recorded, it is assumed that a steady 1000-cycle note was sounded at the microphone. If the highest fundamental musical note were played (about 5000 cycles), these side-bands would move to a position such that the two outermost bands would reach the dotted lines which indicate the limits demanded by a single channel when the double-modulation system is used. We note from Fig. 5 that this width is 50 kc. Compare this with the ordinary broadcast channel shown in Fig. 2, the width of which is only 10 kc.

Let us take this a step farther, both because it is interesting to see what happens in the ether when a single carrier-wave is multiplexed so as to carry several simultaneous conversations and also because we find that when more than one intermediate frequency is used the frequency band per conversation is less than 50 kc. wide.

Fig. 6 shows the location of the spectrum lines resulting from the simultaneous transmission of two independent audio signals, one on an intermediate frequency of 20 kc. (the lines for which

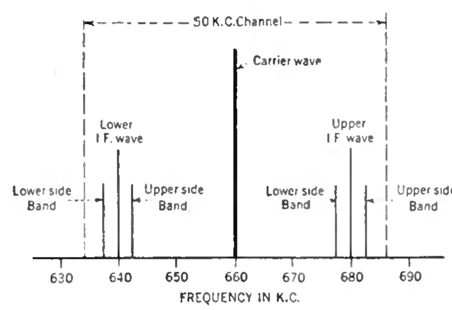


FIG. 5

are identical with those of Fig. 5), and the second on, say, 30 kc. The point to note is that the total band width here measures 70 kc., or 20 kc. more than that of Fig. 5, which is for a single conversation. To summarize, we may say the width of band required for the first multiplex channel is 50 kc. with an additional 20 kc. for each additional channel.

We conclude, therefore, that the number of broadcasters in any given wavelength band would not be multiplied if double modulation were used but actually decreased by more than one-half.

THE PRO AND CON OF DOUBLE MODULATION

LACKING the ability to glimpse into the future, we can only guide our speculations by the technical facts that we know about the infant radio developments of to-day. By weighing their advantages and disadvantages it

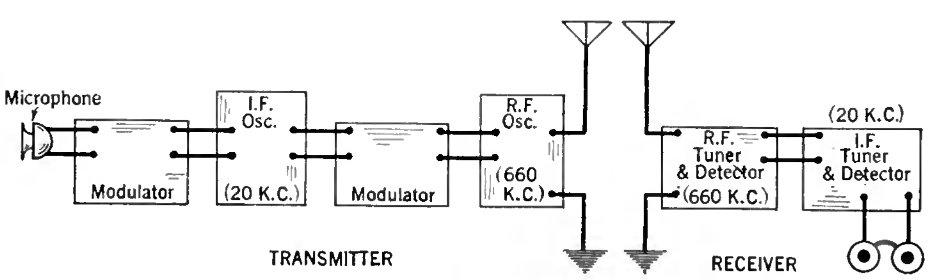


FIG. 4

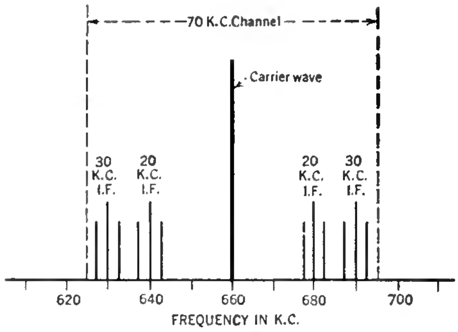


FIG. 6

should be possible to form an opinion of the likelihood of their future adoption.

The advantages of the double modulation system are:

1. Greater selectivity and freedom from static because of the double tuning feature at the receiver.

2. The advantage of semi-secrecy, if desired. Here is a system which could answer the question, "How can programs be sold to the listener?" It is very doubtful, however, if the listening public of the United States would react favorably to the proposition of paying for their radio programs.

The disadvantages of double modulation are:

1. The number of simultaneous broadcasts (or the number of conversations) would have to be greatly reduced because the width of radio channel per conversation is more than double that required for the present system of broadcasting.

2. The amount of local interference set up by a double modulation transmitter would be very serious if harmonics from the oscillators generating the carrier and intermediate waves were allowed to be radiated.

3. More costly and complicated transmitting and receiving apparatus due to extra tuning controls, tubes, and amplifiers.

Minor technical disadvantages have been omitted since these could probably be overcome by engineering development work. So far as the writer knows, there are no radio stations in our country making use of the straight double modulation system for other than experimental purposes. If this is the case, in spite of the fact that the system has been known for many years, we would infer that the disadvantages outweigh the advantages.

In concluding that our present system will not be supplanted by that of straight double modulation we see that the underlying reasons for this conclusion are based principally on the technical characteristics of this little-known radio system. It has been the object of this article to explain, as simply as possible, these characteristics.

THE SINGLE SIDE-BAND SYSTEM

Most of the advantages incorrectly attributed to the double modulation system can be realized in the "single side-band" system. Great interest surrounds any workable system which allows the same waveband in the ether to carry, without mutual interference, twice as many conversations as it can at present. This is what single side-band transmission will do. The following paragraphs answer the questions of: What is this system? How does it work? and What will it do?"

Single side-band transmission is the transmission of modulation frequencies by the radiation of only one side-band, the other side-band and carrier wave being suppressed at the transmitter. Refer for a moment to Fig. 3 showing the spectrum lines of the ordinary transmitter. At the instant Fig. 3 was recorded we assumed that a constant musical tone of 1000 cycles (1 kc.) was impressed upon the microphone. During a musical selection the audio frequencies, as we know, may vary erratically and rapidly from 50 to 5000 cycles (or more). To represent the resulting movement of the side-bands from moment to moment, they are shown in Fig. 8 as dotted lines occupying a frequency space of 4950 cycles. Also, in this figure it is indicated that the carrier-wave and lower side-band are suppressed, leaving only the upper side-band to be radiated into the ether. The width of radio channel required for this system of broadcasting is less than 5 kc., or half of that demanded by the present system. This is an important step in the right direction.

Let us see how such a telephone signal can be received. Due to the absence of a transmitted carrier wave, messages from such a transmitter would not be understandable on our ordinary receivers. However, the carrier wave, which is steady in frequency, can be supplied locally at the receiver by an oscillating tube. Its transmission through the ether is thus made unnecessary.

In receiving signals from a single side-band transmitter, using the receiver arrangement shown in Fig. 7, the local oscillator supplying the carrier-wave (which is no longer a "carrier") would be set by the operator at exactly 660 kc. to correspond in frequency with the suppressed carrier. This must be done by ear, since if the frequency of this local beat oscillator is even very slightly off, the received signal will not have its natural quality. For instance, the voice of the best announcer could, by misadjustment, be made to resemble that of an old woman!

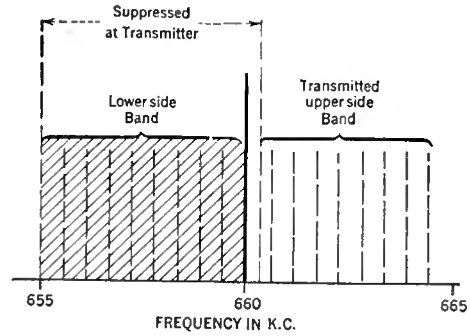


FIG. 8

To complete the answer to "How does it work?" brief mention will be made of the apparatus at the transmitter which accomplishes the suppression of the side-band and the carrier. Fig. 7 illustrates the schematic outline of one type of transmitter. The voice energy and that from the master r.f. oscillator is fed into a push-pull modulator, so connected as to suppress the carrier-wave (the frequency of which is determined by the master r.f. oscillator). Then the output of this modulator is passed through a filter and the undesired side-band is removed, leaving only one side-band (which varies in frequency from 50 to 5000 cycles as the voice frequency varies) to be amplified by the power amplifier and finally to be radiated from the antenna.

CAN IT BE PERFECTED?

This system affords radio telephony requiring only one-half the channel width required at present. It allows an increase in sharpness of tuning at the receiver without reducing fidelity, thus providing more selectivity. Much less power is necessary at the transmitter, since the carrier wave is not radiated. Generally there is less distortion and variation in received signal strength due to fading, because the locally generated carrier is steady. These are some of the advantages that occur with single side-band transmission. When it is coupled with double modulation still other advantages appear, one of which is the possibility of a high degree of secrecy when certain combinations are used.

The disadvantages are: Increased complication of apparatus; more skill required in the operation of the receiver; and, in our present broadcast band, the disadvantage that all our receivers would require modification. The most serious of these disadvantages is the difficulty of setting and maintaining the local oscillator at the desired frequency. Assuming transmission to take place at 1000 kc. the exactness with which the oscillator must be set is 1 part in 100,000. In the present state of technical development, this would require a highly skilled operator and precision instruments. Development work is needed to overcome the demand for such accuracy in order to make ordinary single side-band reception practical for everyone's use in the broadcast waveband.

It is the single side-band system (combined with double modulation) that has been selected for use in the American Tel. & Tel. Co.'s transatlantic radio link between the United States and Great Britain. The two photographs show parts of the apparatus used.

It seems logical to suppose that single side-band transmission will grow in use for point-to-point communication and the time will come when it will be used for the broadcasting of speech, music, and vision.

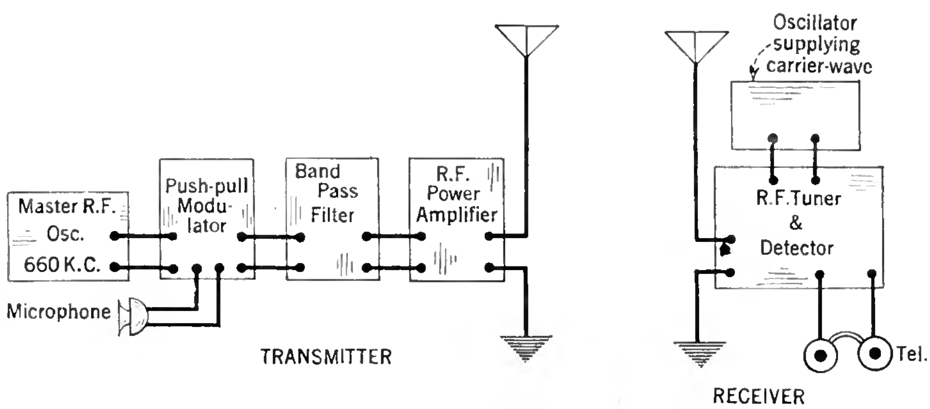
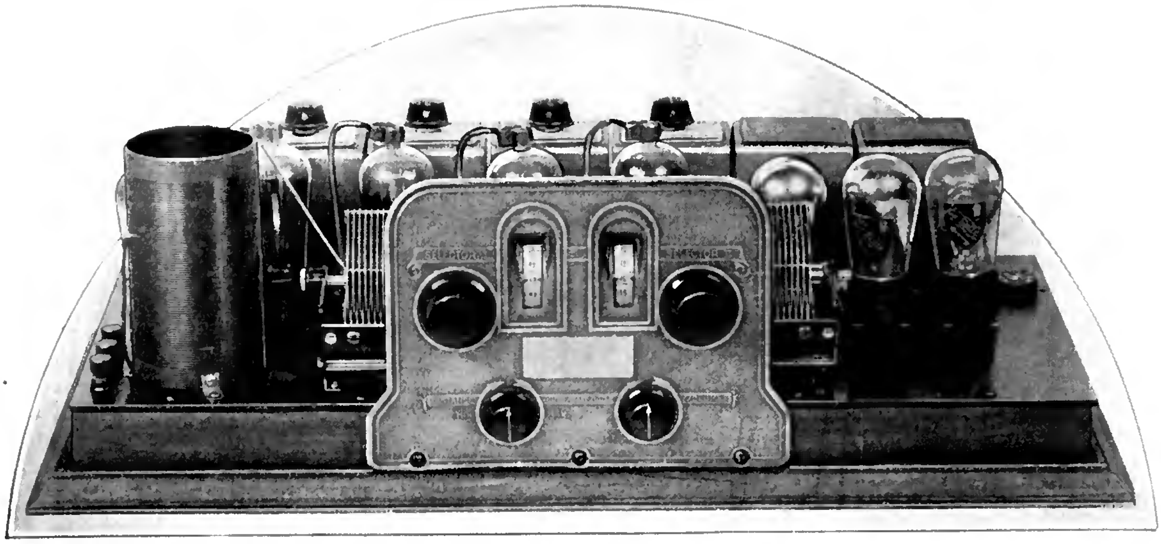


FIG. 7



SIMPLICITY IS THE KEYNOTE OF THIS SUPER-HETERODYNE

A "One-Spot" Screen-Grid Super

By W. H. HOLLISTER

FOR many years past the writer has been an ardent radio fan industriously building every new circuit which has been devised in the search for better and still better radio reception. Literally, every type of manufactured kit and every new circuit which has appeared from time to time has been built and tested, but no standard circuit ever quite came up to expectations of what radio reception should be. The author's expectations were certainly not unusual and are probably shared by the majority of radio fans, who have believed that a good radio set should give absolutely faithful reproduction of all musical frequencies, great enough amplification to bring in any station louder than local noise and play it on the loud speaker, and sufficient selectivity to cut consistently within 10 kilocycles of all normally interfering local stations. A qualifying requirement would be that the receiver satisfying these expectations must be easy to build, dependable in its performance, simple to tune, and low in initial cost and upkeep.

Early in the search for such a set, attention was attracted to the super-heterodyne system, which theoretically seemed to provide opportunity for high amplification and extreme selectivity without seriously impairing tone quality, and, at the same time, to provide a receiver simple of construction. Super-heterodynes without number were built and tried with many circuit variations tested in each receiver. One quite satisfactory set was evolved which was used by the writer in his home for several years. It employed a 50-kilocycle intermediate amplifier and with it Los Angeles and other Pacific Coast stations could be tuned-in almost any evening in the week with clocklike regularity and with volume equal to local stations. As time went on and more broadcasting stations came on the air, the repeat points upon the oscillator dial of this receiver made its selectivity less and less satisfactory, and the writer was forced to resume the search for a better receiver. At just about this time, the screen-grid tubes were made available, and birth was given to the hope of even greater amplification than was had with the old standby set using 201A tubes. Because many of the writer's friends have been so favourably impressed with the performance of the final receiver incorporating these new tubes, he has been led to prepare this article describing the processes by which it was developed, and telling how an exactly similar set may be constructed by the fan at home.

As previously stated, the goal of this receiver was to be 10-kilocycle selectivity against any local station (and within a few miles of the writer's home in Chicago there are some twenty powerful broadcasting stations operating every evening), the finest possible tone quality which could be provided consistent with 10-kc. selectivity, sufficient sensitivity to give a wide range of program choice, both local and distant; and all this to be had with absolute dependability, simplicity of control, and low initial and upkeep cost. The answer to all these requirements finally took shape in the form of an eight-tube super-heterodyne receiver having a screen-grid first detector, a conventional oscillator, three individually tuned 400-kilocycle "one-spot" intermediate amplifier stages, a second detector, and two audio stages using the new Clough system of audio amplification. The new super-heterodyne is pictured in the accompanying photographs and diagrams.

THE present article by Mr. Hollister describes the first really "one-spot" super-heterodyne which has appeared in RADIO BROADCAST. *Heretofore, the "bug" limiting the usefulness of most "supers" has been the upper and lower tuning points on the oscillator. Often, when receiving a station with the oscillator tuned to one of these points, the user would find interference from another station which would beat with the oscillator to produce perhaps a frequency similar to the intermediate frequency. The set described here is really "one-spot." It employs eight tubes, three of which are screen-grid tubes in the intermediate amplifier, which is designed to work at about 350 kc. (855 meters). Volume is satisfactorily controlled by a potentiometer which varies the voltage on the screens of the 222 type tubes. The high intermediate frequency is chosen to prevent double tuning points. The i.f. transformers are equipped with small midget condensers so that each may be adjusted by the user to the same frequency. In testing this set in the Laboratory it was found easy to do this. With all the transformers accurately tuned, the amplifier oscillates, which can be regulated by the volume control. In the Laboratory test, fidelity seemed to be improved when the i.f. transformers were slightly detuned, with, of course, a certain decrease in sensitivity. The cost of parts is about $90. Constructional details in leaflet form are available from the manufacturer of the intermediate transformers and requests should be addressed to* RADIO BROADCAST.

—THE EDITOR.

DESIGN FEATURES

AT THE outset the writer endeavored to use standard parts available on the open market for the construction of his receiver, but it soon became apparent that the requirements laid down for its performance could not be met with standard parts then available and it became necessary to enlist commercial aid in the development of special transformers for the receiver. The balance of the parts in the author's set are standard and may be easily procured upon the open market. As work upon the set progressed, it was given tests night after night and the results obtained averaged over a space of months. In final form, as pictured herewith, the eight-tube receiver operated satisfactorily in the steel frame office building where it was built and would regularly bring in stations within a thousand to fifteen hundred mile radius on the loud speaker, using a 15-foot wire strung up in the author's office, for an outside antenna could not be had. Stations such as WSN, only 10 kilocycles away from local WLS; WJZ, 10 kilocycles away from local WMAQ, only two miles away; KMOX and WDAF, 10 kilocycles away from local WEBH; WEAF 10 kilocycles away from local WCFL; and KWKH, 10 kilocycles away from WBBM, and WHO, 10 kilocycles away from local KYW, were received consistently on the loud speaker without interference from the neighboring local channel. Such stations as WGY, WOC, and KDKA could often be heard in the daytime and frequently with only a four-foot antenna at night. The set was then taken home and tested in a wooden residence. Even better results were obtained, and instead of only a comparatively few powerful out-of-town stations being heard, little 50-watt stations all over the country came in on the loud speaker, and reception of West Coast stations became the author's early evening amusement.

The receiver shown in Fig. 3 has eight tubes placed in a straight line ranging from left to right in this order: UX-201A oscillator, UX-222 first detector, three UX-222 screen-grid intermediate amplifiers, UX-201A second detector, UX-201A first audio tube, and UX-171A power tube. Behind the tubes are the transformers; at the left is the special oscillator, L_1, and to the right the four intermediate transformers, T_1, T_2, T_3, and T_4, with their tuning knobs projecting from their tops. At the right end of the subbase are the two audio transformers, T_5 and T_6, which are built following the specifications laid down by Mr. Kendall Clough, Director of the Research Laboratories of Chicago, in the July issue of RADIO BROADCAST.

At the left front of the chassis is the large antenna coupling coil, L_2, consisting of 80 turns of No. 16 enameled wire on a form 5″ long and $2\frac{3}{4}''$ in diameter. The losses of this coil are so low that extremely sharp antenna tuning is had without the necessity of regeneration, which it is almost impossible to add to a screen-grid first detector with any benefit, as the writer's investigations have revealed. At the front center of the chassis are the two tuning condensers with their drum tuning dials, the controls of which are brought out to a small compact bronze panel which also holds a filament rheostat and on-off switch, and a potentiometer for controlling the sensitivity of the intermediate amplifier and, consequently, the volume of the receiver. The curve in Fig. 1 shows the over-all r.f. amplification of the 3-stage intermediate amplifier (4 tuned circuits). This curve indicates just why the set is as selective and sensitive as it is.

The intermediate amplifying transformers are very interesting, inasmuch as the design finally evolved ran contrary to ordinary engineering theory in that the transformers themselves actually had a step-down turn ratio! This was worked out very carefully in an effort to gain the

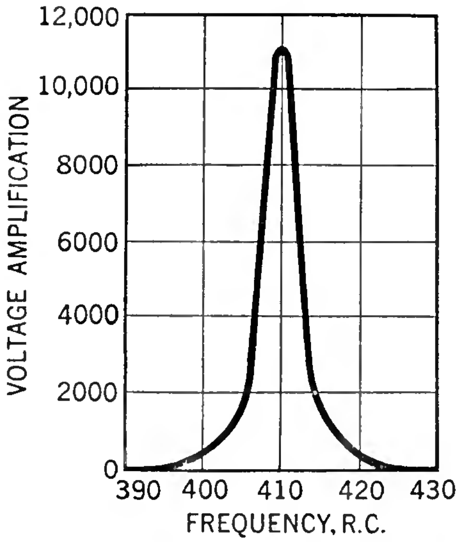


FIG. 1

required selectivity and is justified by the theory of the screen-grid tube used as an r.f. amplifier. The plate impedance of this tube is very high, running up into the hundreds of thousands of ohms, and it is almost an impossibility to build an r.f. transformer of the conventional type with a high enough primary impedance to obtain any great amplification. The writer therefore set out to use a tuned primary and used for this purpose a bakelite tube 2″ long and $1\frac{1}{2}''$ in diameter wound with 300 turns of No. 37 enamelled wire. This primary was tuned by a 75-mmfd. midget condenser, and the circuit provided showed such a high value of impedance at resonance as to obtain a far higher voltage drop across its terminals, when connected to a screen-grid tube plate circuit, than did ordinary types of i.f. transformers. If the grid of the succeeding i.f. tube had been connected directly to the plate end of this primary, with, of course, the necessary grid condenser and leak, the selectivity of the amplifier would not have been very good, and it was here that the idea of a step-down transformer worked out so very well. A small secondary upon a $1\frac{1}{4}''$ tube, consisting of 150 turns of No. 37 enameled wire, was slipped inside the primary and connected to the grid circuit of the next r.f. amplifier tube. The result was a circuit of high amplification with sufficient selectivity so that four such transformers provided positive 10-kilocycle selectivity. By using a very large primary and a smaller secondary, tremendous amplification can be had from the tube, a little of which is then sacrificed in the transformers to gain selectivity; this is an unusual but very practical theory, judging from the results obtained.

"ONE-SPOT" TUNING

THE intermediate transformers are tunable by means of small knobs on top of the copper transformer shields, which may be constructed at home of 0.014″ copper and which are $2\frac{1}{4}''$ wide, $3\frac{1}{2}''$ high and $2\frac{3}{4}''$ across. The transformers are placed upright inside these cans with the tuning condensers mounted on the top and insulated from the can by insulating washers. As each transformer is individually tuned after assembly of the whole receiver, no matching is necessary and the writer's set can be duplicated without any fear of poor results due to lack of proper matching equipment, which is totally unnecessary with this type of intermediate amplifier. The wavelength at which the transformers may be operated can be varied by the tuning condenser knob, and covers the range of 600 to 1000 meters, or 500 to 300 kilocycles. There are two distinct advantages to be had in using this frequency range for intermediate amplification in a super-heterodyne. The first is that the repeat points at which a station may be tuned-in on the oscillator dial are so far separated as to render the set practically "one-spot" in operation. Anyone who has ever operated a super-heterodyne will appreciate that the primary drawback of the super-heterodyne to-day is that the effectiveness of the oscillator dial is at least halved because each station is heard at two points upon the dial, instead of at only one, as in t. r. f. sets. This is due to the fact that with a 50-kilocycle intermediate amplifier, for example, the sum and difference settings of the oscillator will bring in a given station. The method of eliminating this is to raise the intermediate frequency until one set (lower) of oscillator dial heterodyne points are thrown so far away from the other set (upper) that the lower repeat points fall beyond the used tuning range. Just how this works out can be illustrated by considering the 400-kilocycle i. f. amplifier used in the author's super to cover the 200 to 550-meter band (1500 to 550 kilocycles, approximately). The oscillator settings for both extremes must be the highest and lowest signal frequency to be received plus and minus the i.f. Thus, for a 200-meter signal (1500 kilocycles) the oscillator must be tuned to 1900 or to 1100

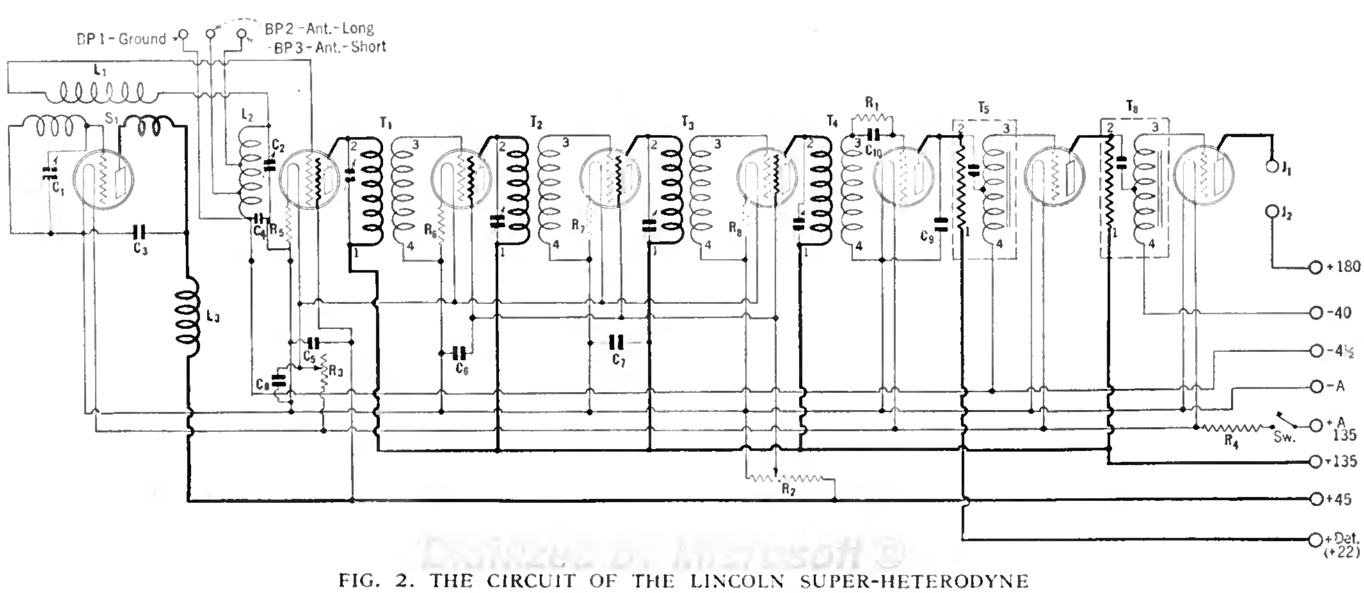


FIG. 2. THE CIRCUIT OF THE LINCOLN SUPER-HETERODYNE

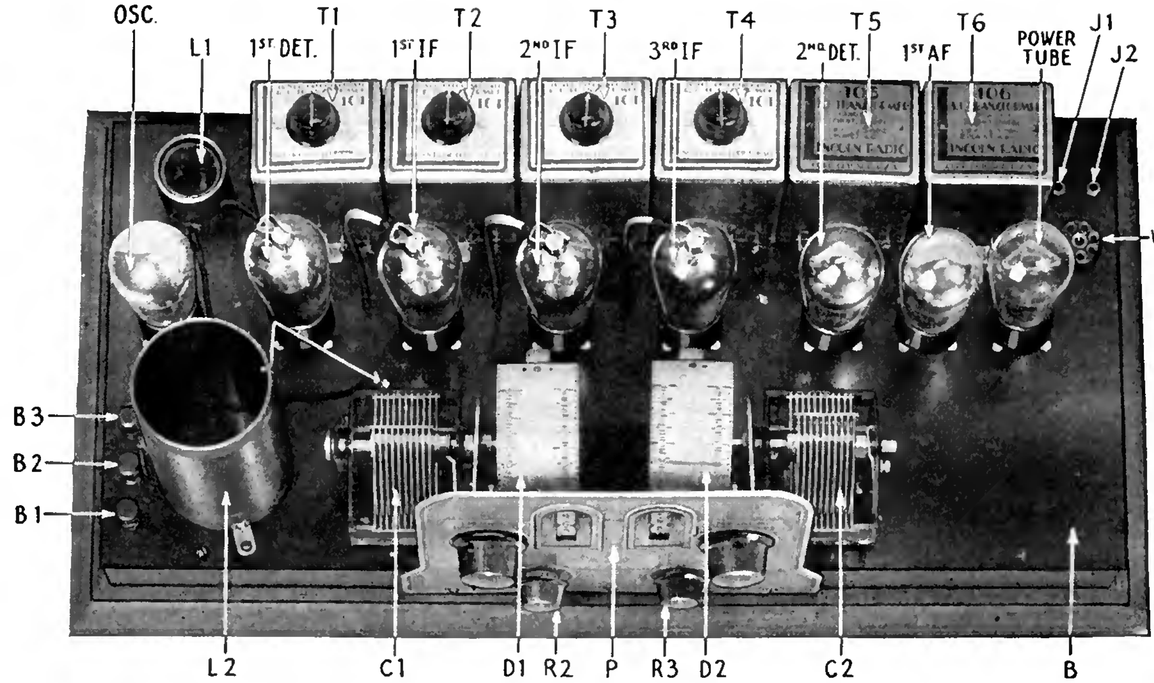


FIG. 3. HOW THE INSTRUMENTS ARE MOUNTED

kilocycles. For a 545-meter signal (550 kilocycles) obviously only the sum of the oscillator and signal frequencies can be had in a practical set, which is 950 kilocycles. Thus the oscillator tuning range must be 1900 to 950 kilocycles, or 157 to 315 meters, approximately. The 315-meter setting (950 kilocycles) will heterodyne either a 550-meter station, or a 1350-kilocycle station, which would be at 222 meters. Thus it is seen that a 400-kilocycle intermediate frequency will provide a super-heterodyne that will be truly "one-spot" for all stations above 222 meters, and that the oscillator settings for stations below 222 meters will be so far away that the input tuning circuit is only called upon to discriminate between signals at the extreme opposite ends of the broadcast wavelength band, which is not difficult with a good input circuit.

CONSTRUCTION OF THE SET

THE parts used in the writer's receiver are listed at the end of this article and, costing about $92.00 on the open market, justify the hope of having a receiver low in initial cost. The set is put together using a bakelite chassis, B, 1/8" thick and 21 7/16" by 9 15/16" wide, this size being chosen so that the set can be housed either in any standard table or console cabinet or in the new Silver-Marshall metal shielding cabinet which has been found to contribute much to the quiet operation of the receiver when operated near X-ray machines or other sources of local interference. At the rear of the chassis all r.f. and a.f. transformers are placed in a row, with the oscillator coil, L_1, at the left rear end of the chassis held in place by having its six connecting lugs pushed down through holes in the chassis, turned over on the under side, and all connections made to the turned over lug ends. The oscillator coil consists of a bakelite tube 1½" long and 1½" in diameter upon which are wound at the bottom a tickler consisting of 32 turns of No. 29 enamelled wire, while just above the tickler is a grid winding of 45 turns of No. 29 enamelled wire. Inside this tube is held another bakelite tube 1¼" in diameter, upon which is wound the pick-up coil of 32 turns of No. 29 enamelled wire, the pick-up coil being connected in the first detector grid circuit. The pick-up coil is spaced equally under grid and plate coils. The tube sockets are a part of the bakelite chassis, consisting of standard socket springs riveted or screwed to the bakelite at proper points. The two variable condensers, C_1 and C_2, are fastened to the chassis in the front center and to them are in turn fastened the drum dial brackets to which is attached the control escutcheon. To this escutcheon is fastened the filament rheostat, (with on-off switch attachment), R_3, and the 3,000-ohm potentiometer R_2, which, controlling the potential on the screen grids of the intermediate amplifier tubes, also serves to adjust volume and sensitivity. The neatness and simplicity of the wiring arrangement is very easily duplicated due to the convenient location of the various soldering lugs and connection points. All battery connections terminate in the multiplug at the right rear of the chassis. Battery connections are made to the set through a battery cable with receptacle plug. Antenna and ground connections are made through binding posts at the left end of the chassis. No panel has been shown for the receiver as it may be placed in any cabinet with wood, metal, or bakelite panel which must simply have a center slot 5¾" wide and 5½" high cut so that the panel will slip behind the bronze escutcheon plate of the set. If the Silver-Marshall shielding cabinet is used, the receiver chassis is simply placed upon the wood moulding and the cabinet slipped down over the whole assembly.

The receiver requires for operation any good B-power unit capable of delivering 22, 45, 135, and 180 volts, such as the Lincoln 110 type, as well as a 6-volt A battery or good A-power unit such as the Kodel, Abox, Balkite or Sentinel types. Four UX-222 screen grid tubes, three UX-201A tubes, one UX-171A, a 4½ and a 40-volt C battery complete the accessories, outside, of course, of a suitable loud speaker, antenna and ground. If the best possible results are desired, a slight improvement may be had by substituting a UX-112A detector tube for the UX-201A type at a slight additional cost.

In operation the receiver is simplicity itself. The rheostat need merely be turned up, the volume control knob adjusted to just below the oscillating point for the intermediate amplifier, and the two drum dials rotated at about the same dial settings to tune in station after station, near and far alike.

LIST OF PARTS

THE data for the coils used in this set is given in the text. They may be home constructed, if so desired. The rest of the parts are of standard design, and substitutions may be made. The complete parts are obtainable in kit form.

- B—1 Micarta sub-base, 21⅜" x 9⅞" x ⅛"
- BP_1, BP_2, BP_3—3 Binding posts
- C_1—1 Lincoln 104L (left) 0.00035-mfd. condenser
- C_2—1 Lincoln 104R (right) 0.00035-mfd. condenser
- C_3, C_4, C_5, C_6, C_7, C_8—6 Potter 104 1.0-mfd. condensers
- C_9—1 Aerovox 0.002-mfd. condenser
- C_{10}—1 Aerovox 0.00015-mfd. condenser with clips
- D_1—1 Silver-Marshall 806L (left) drum dial
- D_2—1 Silver-Marshall 806R (right) drum dial
- J_1, J_2,—2 Yaxley 420 tip-jacks
- L_1—1 Lincoln 102 oscillator coupler
- L_2—1 Lincoln 103 antenna coupler
- L_3—1 Silver-Marshall 275 r.f. choke
- P—1 Lincoln escutcheon control panel
- R_1—1 Aerovox 2-megohm grid leak
- R_2—1 Yaxley 3000-ohm potentiometer, No. 53000
- R_3—1 Yaxley 10-ohm midget rheostat
- R_4—1 Carter 0.57-ohm resistor, type H½
- R_5, R_6, R_7, R_8—4 Carter 10-ohm resistors, type RU10
- SW—1 Yaxley switch attachment, No. 500
- T_1, T_2, T_3, T_4—4 Lincoln 101 tuned i.f. transformers
- T_5—1 Lincoln 105 1st. a.f. transformer
- T_6—1 Lincoln 106 2nd. a.f. transformer
- W—1 Jones 8-lead battery plug and cable (special)
- Tube socket assemblies
- Wood sub-base supports, 21⅜" x 1⅜" x ⅝"
- Small parts assortment consisting of screws, nuts, lugs, bus-bar, spaghetti, flexible wire. Belden flexible shielding braid and screen-grid clips

The 222 Tube as an R. F. Amplifier

By GLENN H. BROWNING

> *THE author's purpose in this short article is simply to give the readers of this magazine some data and measurements which have been made using the screen-grid tube. Perhaps some of us have thought of using this tube in an impedance or resistance coupled amplifier, and to those the data given here will be especially interesting.*
>
> —THE EDITOR

AS THE readers of RADIO BROADCAST know, the screen-grid tube is designed primarily as a radio-frequency amplifier. The second grid screens the control grid from the plate, as its name indicates, so that the effective capacity between the two is very small. Consequently, the tendency to oscillate in a multiple stage tuned radio-frequency amplifier, due to the capacity between grid and plate in the amplifier tube, is considerably reduced.

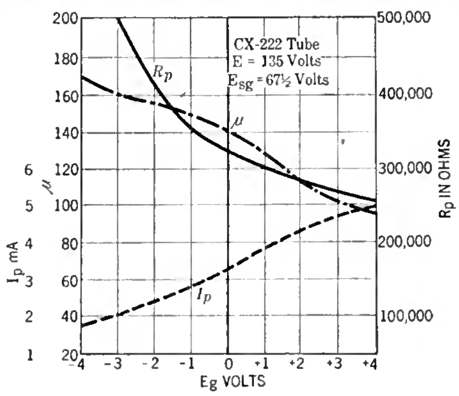
Another characteristic of screen-grid tubes is the high amplification factor. Coupled with this is a high plate resistance, so that the ordinary tuned radio-frequency transformer is not suitable if even fair efficiency is to be obtained.

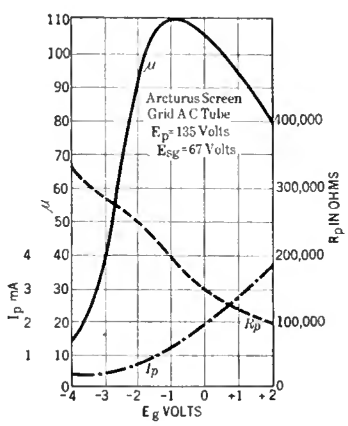
The writer has been able to obtain three distinct types of these tubes. The first type is the R.C.A. or Cunningham 222 tube. This is a d.c. operated tube requiring 3.3 volts across its filament. The essential dynamic characteristics are shown in Fig. 1. These curves were taken with 135 volts on the plate and $67\frac{1}{2}$ volts on the screen grid. The amplification varies, as will be noted, from 170 to 99, being about 152 with a grid bias of minus $1\frac{1}{2}$ volts. With this same grid bias, the plate resistance is 385,000 ohms and the mutual conductance 0.000395 mhos.

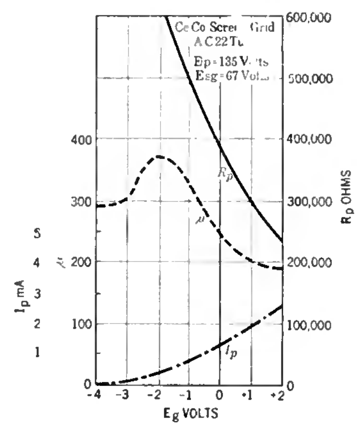
Fig 2 shows the dynamic characteristics of the Arcturus screen-grid tube. This is an a.c. 15-volt tube of the heater type. At the same operating point, i.e., 135 volts on the plate, $67\frac{1}{2}$ volts on the screen grid and $1\frac{1}{2}$ volts negative bias, the amplification factor is 106, the plate resistance 220,000 ohms, and the mutual conductance 0.000482 mhos.

Fig. 3 gives the same characteristics for a CeCo a.c. 22 tube. The heater operates at 2.25 volts a.c. as in the 227. With $1\frac{1}{2}$ volts negative grid bias, the amplification factor in this case is 362, the plate resistance 560,000 ohms, and the mutual conductance 0.000646 mhos.

It will be noted that both types of a.c. screen grid tubes have a higher mutual conductance than the d.c. tube and consequently are better from the theoretical standpoint of designing a suitable t.r.f. transformer for their use.







ABOVE—FIG. 1. LEFT—FIG. 2. RIGHT—FIG. 3

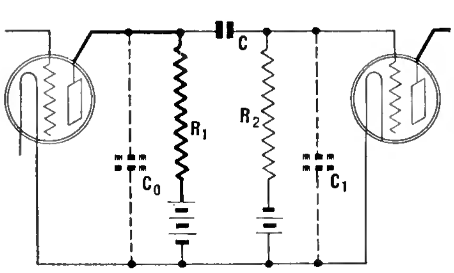
There are two general methods, aside from regeneration and the super-heterodyne principle, of obtaining radio frequency amplification. One is by an untuned amplifier such as is shown in Fig. 4, where a resistance, choke, or a fixed transformer is used as a coupling device. The second is a method of tuning the amplifier to the incoming signal by means of a tuned radio-frequency transformer coupled either directly or through a primary winding as shown in Fig. 6.

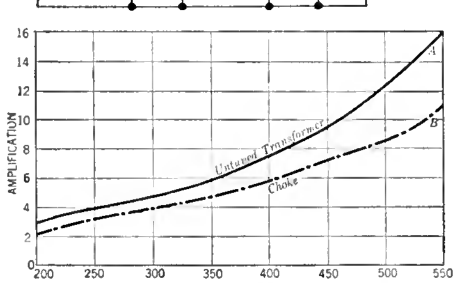
A mathematical analysis plus a few measurements on the capacities between the elements of the screen-grid tube will show that only a small amount of amplification may be expected at radio frequencies with either resistance or impedance coupling. The capacity, C_1, between the control grid and the filament of the screen-grid tube is about 10 mmfd., and the capacity, C_0, between plate and filament about 40 mmfd. under usual operating conditions. The first capacity, as far as alternating current is concerned, is across R_2 in Fig. 4, while the second is across R_1. Thus the maximum impedance obtainable in the coupling device is $\frac{1}{C\omega}$ where $C = 50$ mmfd. and $\omega = 2\pi \times$ frequency. At 200 meters $\frac{1}{C\omega} = 21{,}200$ ohms., and the maximum amplification of the system using a tube with a plate resistance of 560,000 (CeCo a.c. 22) ohms, and an amplification factor of 362, would be

$$\frac{\mu \frac{1}{c\omega}}{R_p + \frac{1}{c\omega}} = 13.2.$$

The amplification may also be simply calculated by multiplying the load impedance by the mutual conductance. 21,000 times 0.000646 gives 13.6 as the amplification, agreeing quite well with the former figure. This value of amplification can never be fully obtained, as the resistance or choke used as coupling is in parallel with these capacities and reduces the effective impedance slightly below 21,000 ohms. Fig. 5, curve A, shows the amplification obtained at different frequencies with one stage of choke coupled amplification using r.f. choke coils and a 0.006-mfd. coupling condenser. It is very apparent that tube capacities play an important factor, for at the long wavelengths or low frequencies a very fair amount of gain is observed while at the high frequencies almost no amplification is obtained. Fig. 6, curve B, shows the amplification measured with an untuned radio-frequency transformer.

Thus, analysis and measurements make us discard untuned amplifying systems at radio frequencies so that the solution of obtaining the highest gain possible with a high-mu tube must lie in tuning the amplifier to the signal.





ABOVE—FIG. 4. BELOW—FIG. 5

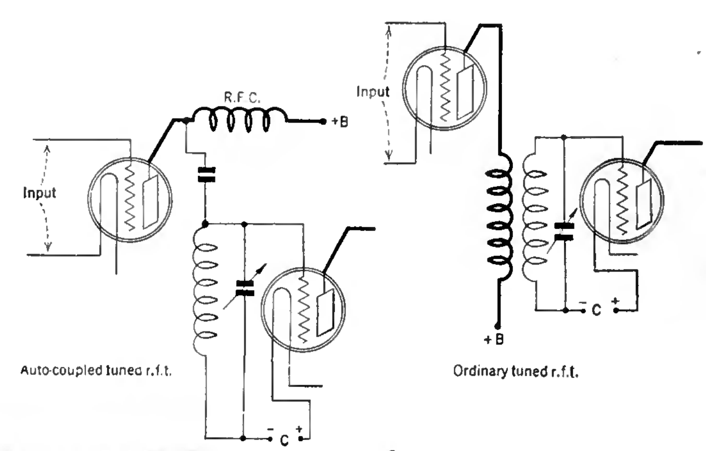


FIG. 6

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

The Laboratories Grapple with Aircraft Radio

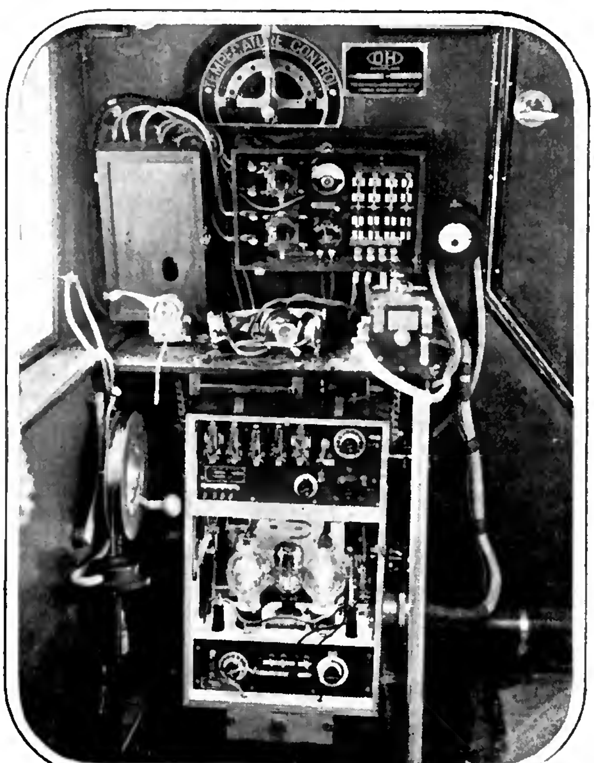
AIRCRAFT radio, during the last few weeks, has performed with such spectacular effectiveness that any aviator who now attempts a long distance flight without its aid is flaunting providence. Since the July *March of Radio* editorial, scoring aviation for neglecting radio, was written, the world has been able to trace, through frequent radio bulletins, the progress of several amazing long distance flights. Three aviators flew from San Francisco to Brisbane in three tremendous jumps, with the whole world rooting for their success as they fought through wind and storm. The first transatlantic flight with a woman passenger was similarly applauded. Nobile and his companions were found in the Arctic drift only through the effectiveness of radio directions. Radio has covered itself with glory as the faithful companion of the aeronaut, guiding him through storm to distant airport, reporting his progress to the world and, finally, performing incredible missions of rescue.

Spectacular feats are the vehicle by which the world is informed of the progress of science. The real advances are made in scientific laboratories where a few geniuses, aided by a staff of assistants, grapple with the problems which carefully tabulated study of known performance reveals as the need of the times. The world is startled into consciousness by its Lindberghs and Nobiles because technicians are not salesmen. Recent technical literature records victories of the laboratory as significant and important as the performances which make headline material for the press.

Two papers were presented before the New York section of the Institute of Radio Engineers on June 6, which set forth the present development of aircraft radio equipment in a comprehensive and authoritative manner. One of these, "Development of Radio Aids to Navigation," by Dr. J. H. Dellinger and Haraden Pratt, traces the history of aircraft beacons from their war service to the present. The interlocking type of directive beacon, which automatically gives visual indication to the pilot as he flies along any well equipped airway, is the culmination of years of practical development work by the Bureau of Standards. No bearings need be taken either by goniometric stations on the ground or by the aviator in flight, a dial in the plane's instrument board serving to show whether the plane is on its course or to the right or left of its course. Dr. Dellinger's beacon system will save more lives in the next ten years than the parachute.

Assisting Dr. Dellinger was F. W. Dunmore, who contributed basic ideas to the modulation type of beacon and did much of the laboratory work. Harry Diamond is credited with valuable contributions in the design and construction of airplane receiving sets and research incident to the practical operation of the beacon and its modulating arrangements. Dr. E. Z. Stowell is mentioned by Dr. Dellinger for his work with earlier circuit arrangements and studies of field intensity diagrams.

The second paper, delivered at the same meeting of the Institute, is entitled "Aircraft Radio Installations," by Malcolm P. Hanson of the Naval Research Laboratory at Anacostia. It describes the various transmitters installed aboard the dirigible *Shenandoah*, including the 2-kw. i. c. w. transmitter which gave good night reception on one occasion for a distance of 5000 miles. Mr. Hanson also describes the 150-watt transmitter aboard Byrd's plane, the *America*, those aboard the *Old Glory*, the *American Legion*, Wilkins' short-wave set and several transmitters developed by the Navy and the Burgess Laboratories. This comprehensive review indicates that aircraft radio equipment is in a high state of development and it is to be hoped that the radio industry follows up the advantage which it has gained by the recent practical demonstrations of radio's service to long distance flights. A nationwide net of radio communication to support commercial aviation is radio's newest mission which should be pursued with the utmost vigor. Only with such coöperation will radio demonstrate its true value as an adjunct to air navigation.



A MODERN AIRCRAFT INSTALLATION

This radio telephone and telegraph transmitter and receiver is installed on a British commercial air liner. The transmitter is rated at 150 watts. The instrument box below the table contains at the top the receiving unit. Below it are the transmitting tubes, and at the bottom the tuning controls for the transmitter. The reel at the left unwinds the trailing antenna

Guggenheim Fund Shows the Way to 'Frisco

THE Daniel Guggenheim Fund for the Promotion of Aeronautics has announced that it will install, along the Los Angeles-San Francisco airway, a complete aeronautic weather reporting service. Coöperating with the fund are the Aero Service of the Weather Bureau and the Pacific Telephone & Telegraph Company. Two terminal stations are to be erected at the ends of the route, supported by twenty-two observation stations. The total time for the collection of reports at both terminals and the exchange of complete data between them will be less than twenty minutes. The reports are to be made three times daily and are to be communicated by telephone and radio to trained meteorologists who will forecast flight conditions and advise departing pilots which of five alternate routes should be followed.

At the NEMA Convention

DURING its session in Chicago, the Radio Division of the National Electrical Manufacturers' Association adopted a number of resolutions which were based on sound commonsense, making a pleasing contrast to the stand taken by some of the radio industry's representatives last April, before the Federal Radio Commission, in practically opposing the Engineers' Plan of Allocations.

The Association recommended that "greater consideration be given to those stations which broadcast programs satisfying a wide variety of interests or groups," and it condemned those which "now act purely as house organs in selling merchandise for one firm or which exclusively broadcast programs devoted to furthering the interests of some particular group, creed or class."

This is a direct fling at stations acting as advertising mediums for one advertiser and those owned by a single political party, church or sectarian group. The Association directly approved the Engineer's Plan of radio broadcasting channel allocation.

DURING the convention, NEMA announced the publication of *The Radio Market*, which is a valuable analysis of how radio is distributed, the stocks of all classes of radio goods in the hands of dealers, classified both by geographical distribution and by cities of different sizes.

A study of the analysis shows that there are too many radio outlets in cities of a million and larger and that the dealers in cities of from 500,000 to a million appear to be in the most favorable position with regard to size of stocks and turnover. The dealers in the smaller communities usually combine associated lines in a manner which counterbalances their smaller radio turnover. The number of active radio retailing outlets seems to have been stabilized at a figure of 30,000.

It was also announced that the NEMA handbook of radio trade-in values would be distributed in a few months with a view to standardizing the allowances made for used radio receivers in the purchase of new ones. This step is necessary for tapping the re-sale market, which the industry has been able so far to neglect almost completely. So long as radio does not repeat the well nigh disastrous course of the automobile business, in over-valuing the second-hand product, the establishment of a regular second-hand market will open a new re-sale field comprising prospects who are already the owners of obsolete radio receivers and have minimum selling resistance. The automobile industry met the second-hand problem by over-valuing new cars sufficiently to make trade-in values as attractive as possible to the used car owners.

R. H. LANGLEY of the Crosley Radio Corporation presented a chart before the NEMA convention which illustrated the ridiculousness of the so-called Equalization Amendment, to which we referred in the July *March of Radio* under the caption, "The Inequalities of Equalization."

The Langley chart is reproduced below. The bottom cylinders in the diagram show the area and population of the five zones created by the Radio Act of 1927. The diameters of the cylinders are proportionate to the areas of the zones and the heights to the populations. The first four zones have an almost equal population, but the fifth zone is far below par. The areas of the zones differ greatly, the area of the fifth being approximately thirteen times that of the first. The upper cylinders show the number and total power of the broadcasting stations assigned each zone, the diameters being proportionate to the former and the heights to the latter. The Davis Amendment requires that the power assigned to the zones be equal; in other words, that the heights of the upper row of cylinders be the same, regardless of the proportions of the lower row of cylinders—that is, the areas or populations of these zones. Such is the task that the Federal Radio Commission now has on hand.

Keep Commercialism Out of the Amateur Bands

PAUL M. SEGAL, general counsel of the American Radio Relay League, has prepared a scholarly opinion as to the type of messages and the character of stations permissible in the amateur band. After carefully tracing the foundation for his opinion, he concludes that "an amateur operator, at an amateur radio station, may, under the law, accept for transmission, transit, relay or delivery a message of any kind of text, import or source, so long as no money or other valuable consideration is directly or indirectly paid or promised to him, or charged or accepted by him, subject, of course, to the general laws against obscene or profane language over the air."

Any experimental work, conducted for the benefit of manufacturers and not as the personal hobby of the amateur conducting it, is not therefore permissible in any of the amateur bands. In view of the great curtailment of frequency space recently experienced, the amateur is justified in resenting any invasion of these rights and, for his own protection, should jealously guard against any professional use of the limited space in the air assigned him. Such services as those performed by 6ARD for the San Francisco *Examiner* in reporting the flight of the *Southern Cross* are legal in the amateur band only if no emolument, direct or indirect, was paid to the amateur station, according to Segal's definition of an amateur station.

Harrisburg, Ill., Needs a 500-watt Station

A VAST preponderance of the letters we receive in comment in our policy of urging persistently the reduction of the number of stations express hearty approval on the part of our reader body. As a matter of fact, although we have frequently named names and condemned broadcasting congestion in no uncertain terms, only one listener not professionally connected with a broadcasting station has ever protested our fight for better broadcasting conditions. Therefore, the receipt of a letter from Joseph R. Tate, operator of Station WEBQ of Harrisburg, Ill., accusing the writer of prejudice against the small station and of not knowing what he is talking about, has, at least, an element of novelty.

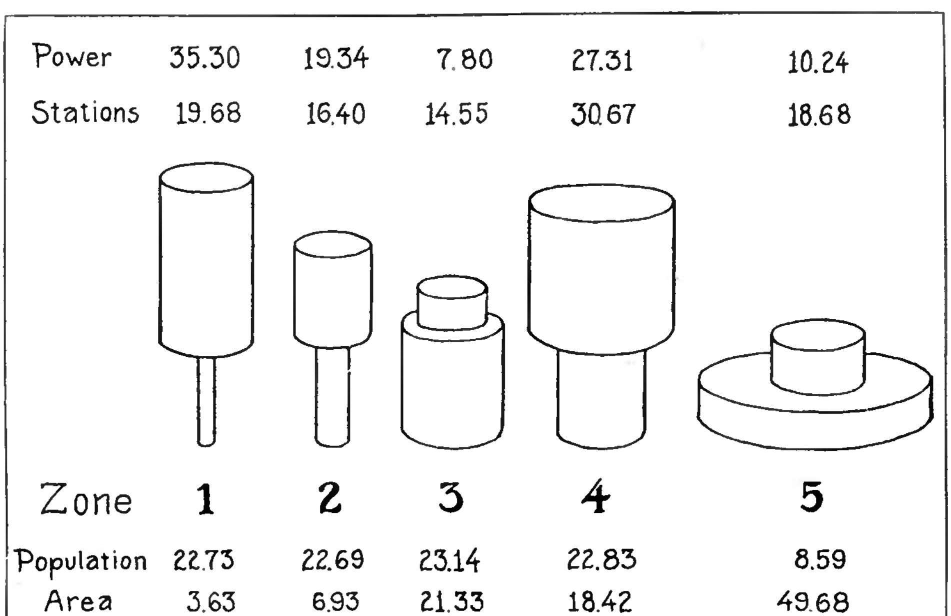
Mr. Tate's plea is based on a thorough survey of radio set owners in southern Illinois, covering every town and hamlet south of Springfield, Ill., and some in Kentucky and Missouri. This survey was made in the form of a petition to the Federal Radio Commission for an increase of power. According to Mr. Tate, who was much gratified at having secured the use of the names of 2800 set owners, this is only one-tenth of the owners in that territory. Even assuming that the 28,000 owners unanimously approved Mr. Tate's appeal—and this is not as impossible as it seems because most people will sign any kind of a petition—I am certain that WEBQ does not desire favored treatment, but merely an accommodation proportionate to what its service area deserves.

According to the latest estimates, radio sets are now available to 27,850,000 people in the United States. If one radio transmitter is deserved by every 28,000 radio listeners, the total number needed to give equal distribution would be about 1,000 stations. With the limited frequency space available, the operation of that number of stations would result in such hopeless confusion that, instead of radio giving service to nearly 28,000,000 people, it would simply deprive these people of the use of radio receivers. A lesser number of stations, properly distributed geographically, however, would assure good reception, not only to Harrisburg's 28,000, but to the entire listening audiences.

While we have not hesitated to make light of the service rendered by most of the smaller stations, our plea for the elimination of stations is based principally on the fact that the first step to good radio service is the elimination of congestion. We have no prejudice against the small station, if it could exist without curtailing service to the listener. Technical progress in the next few years will undoubtedly serve to increase the number of stations which can operate happily in the broadcast band, and then Harrisburg can maintain its pride of the air without depriving some other equally deserving locality of good radio service. But, faced with present conditions, we can only continue to urge an immediate reduction in the number of stations to the actual capacity of the band.

Many pleas are presented by various communities and organizations that they are of sufficient size and importance to be deserving of a broadcasting station of their own. The Socialists of New York City, for example, who in 1925–1926 had an enrollment of 11,943, feel they deserve a broadcasting station of their own and are raising a mighty howl of protest because WEVD was among the stations listed for the scrap heap by the Federal Radio Commission. Other bodies represented on the air in New York are the International Bible Students, the Paulist Fathers, the Italian Educational Association, the Seventh Day Adventists and various other special interests. If a station representative of Italians deserves a place of its own on the air, then rights also should be accorded to the forty or fifty other substantial nationalistic groups in New York. The same principle applies to a score or more of sectarian interests. Political bodies and fraternal organizations deserve like rights. A broadcasting structure based on such qualifications would obviously be a hopeless mess of confusion lacking public support. If Harrisburg, Ill., deserves a station for its 28,000 listeners, so does every other group of 28,000 listeners.

Those who view broadcasting as an inherent



HOW BROADCASTING POWER IS DISTRIBUTED TO-DAY

The heights of the five lower cylinders are proportional to the population of the five radio districts in the United States, and their widths to the areas of these districts. The upper row of cylinders indicate by their heights the relative broadcasting power in these districts, and by their widths the number of stations right, accruing to special groups, whether based on population, geographical area, religious creed, political association, fraternal membership or foreign extraction, overlook the fact that the only sound basis for a broadcasting structure is the greatest service to the greatest number. The most effective distribution is based upon stations which do not represent any special interest, commercial, political or sectional, which give equal opportunity to all types of program material having public favor and which are of sufficient size and power to serve an area and radio population worthy of the channel space which they occupy.

The Empty Pool

THE Radio Manufacturers' Association announced that a reduction in the cost of radio sets is in prospect because its plan of patent pooling was ratified by its Convention in Chicago with only one dissenting vote. The plan provides for a free exchange of patents without license fee. That is, we note, free exchange of what are called "Class B" patents, "not displaying invention of high order." Class A patents, considered basic, are not a part of the plan. Its approval by the Convention means that the plan will now be submitted to the members, of whom a majority must approve to make it official. Even then, such favorable action does not bind individual members to contribute their patents to the free pool. Apparently, those who have no patents will contribute them to the pool for the benefit of those who do possess patents. The latter, however, will not be required to pool their patents. It was a good publicity story, anyway.

Engineers in Quantity Production of Standards

THE preliminary draft of the report of the Committee on Standardization for the Institute of Radio Engineers has been circulated for comment and indicates an amazing amount of work performed by an extensive committee of experts. The first and major part of the report consists of several hundred carefully worked out technical definitions, applying to every phase of radio communication. A few pages are devoted to standard graphic symbols for the principal radio circuit elements, which we hope will be put into general use by all publications. The remainder of the report is concerned principally with standard methods of measuring the characteristics of vacuum tubes and the performance of radio receiving sets and electro-acoustic devices.

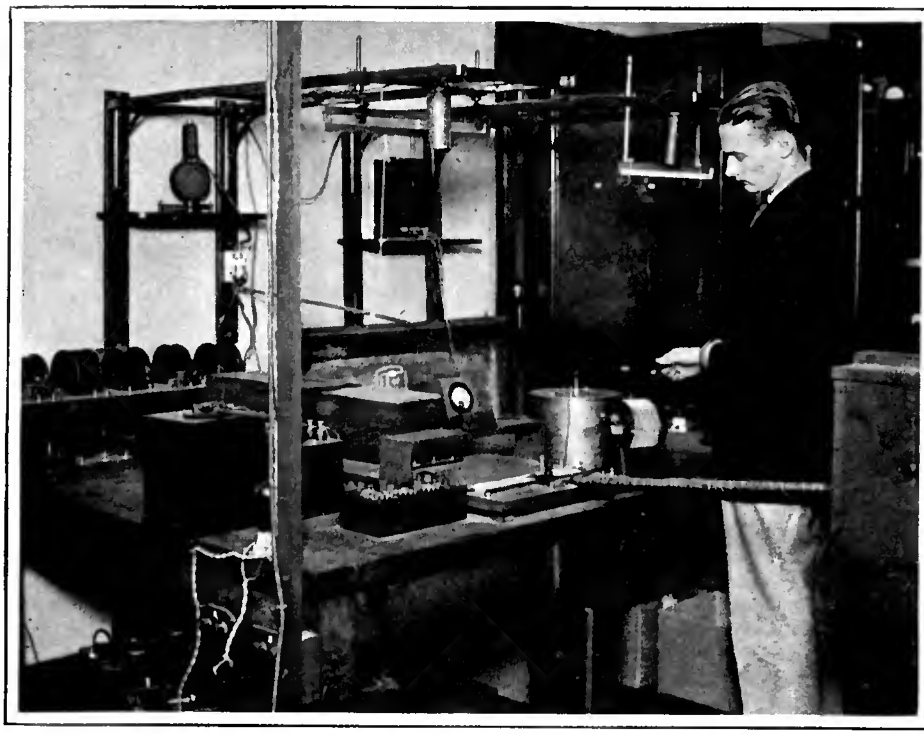
It is obvious that the Institute's committee and every one of those who have contributed their time and services to its problems are deserving of whole-hearted praise for this comprehensive piece of work.

Long Waves Needed in Transoceanic Service

SO MUCH attention has been given to the possibilities of short-wave channels in international communication that it is interesting to recite the expert opinion of O. B. Blackwell, transmission development engineer of the American Telephone & Telegraph Company, who has been identified in technical phases of transatlantic telephony since the first experiments conducted several years ago. Three short-wave channels, approximately 16, 22, and 35 meters, have been found to complement each other providing a good signal level during the hours that the 5000-meter long-wave communication channel is at its minimum effectiveness.

After relating in some detail experience with various frequencies and expressing the hope that the "reliability of short-wave channels can be made such as to some day eliminate altogether the necessity of the long-wave channel with its much more extensive plants. . . ." Mr. Blackwell continues: "So far, data available regarding short waves do not suggest that they ever will give a reliability of service comparable to that for similar distances over land wire circuits. It is our present expectation, therefore, that the giving of suitable service between America and Europe will require the continuation of the long waves, even though such waves demand a much more extensive and complicated plant than do the short waves."

Although short-wave transmitters perform with amazing efficiency under ideal conditions, the total percentage of time which any high-frequency channel serves between any two given points is distinctly limited.



A COIL TEST AT THE BUREAU OF STANDARDS

The Radio Section of the United States Bureau of Standards is doing valuable work in determining standards of accuracy and efficiency in all kinds of radio apparatus. H. B. DeGroot is shown testing a coil to determine the best shape for coil forms.

Here and There

SO LONG as broadcasting service is limited to tonal reception, its predominant function is musical entertainment. But even without means of transmitting graphic information through the eye, which is essential to the efficient distribution of specific facts and data, radio is already a valuable disseminator of education. According to L. R. Alderman of the Bureau of Education of the Department of Interior, more than 65 universities and colleges, enrolling over 5,000 students, have been using broadcasting for regular courses. Morse Salisbury, Chief of the Radio Service of the Department of Agriculture, says that 107 stations are broadcasting his market news service and 181 the weather reports. Ten thousand letters a month are the audience's response to these valuable services and, in the last year, 200,000 copies of a radio cook book have been distributed. The time is not far distant when Weather Bureau maps will be broadcast as a part of the weather forecasting service.

A DECISION of interest to broadcast managements was rendered by Judge Valente in an opinion denying injunction to George Frame Brown against WOR. It appears that George Frame Brown, while an employee of the station, appeared as a leading character in "Main Street Sketches." These sketches have been presented as a regular weekly feature with the same cast appearing in a new sketch each week. Mr. Brown, on leaving the cast, sought to prevent the continuance of the sketches with a new leading character. The court held that mimicry of the principal character "is no more the subject of exclusive appropriation than the method of portrayal of a new rôle in an opera by an artist who 'created it', in the sense of being the first to portray it." The obvious wisdom of this decision is generally agreed upon by all, with the possible exception of Mr. Brown.

THE cost of broadcasting the Republican National Convention through 42 stations amounted to $77,000., or a little over a dollar a minute, since the total time involved was 72,000 minutes. Forty-five thousand miles of telephone circuits were involved, which cost $1,650 an hour for 20 hours, or $33,000; rental of a special transcontinental circuit was $1,200 an hour, or $24,000; pick-up and input installation at Kansas City, $10,000; salary of technical and reporting personnel, $10,000.

ALTHOUGH of rather limited circulation, a telegraphic questionnaire by WBBM of Chicago confirms the expression of RADIO BROADCAST readers that only eight or nine stations are wanted in Chicago, with the following receiving the predominant number of favorable expressions; KYW, WGN–WLIB, WMAQ–WQJ, WLS, WBBM–WJBT, WENR, WEBH–WJJD and WCFL.

STATIONS WHAS and WLAC, both in the southern district, are installing 5,000-watt transmitters.

THE Van Sweringen interests and the Cleveland Electrical Illuminating Company are taking over the operation of WTAM-WEAR, according to a local news item.

STATIONS WEBJ and WLBM, in the first district, have done the most graceful courtesy to the radio audience by voluntarily surrendering their licenses. Hundreds of less considerate and less experienced organizations are quite ready to take their places as broadcasters.

THE Independent Broadcasters' Association has been formed in Chicago with the executives of stations WCRW, WPEP, WCBS, WHBL and WKBB represented among its officers. In its initial statement, the Association says "the right of communities to have local broadcasting stations, as they have local newspapers, is at stake. No one would suggest that 50 smaller newspapers should be destroyed to make room for a single national magazine."

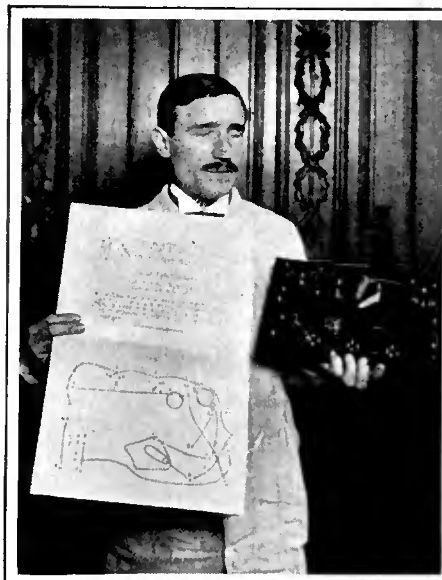
If the nation's available supply of printing presses were limited to 89, there is no question that the limited facilities would be doled out among the greatest and best possible newspapers. It begins to look like intentional stupidity when self-styled defenders of special groups proclaim their alleged right to frequency space which should serve millions. Broadcasting is wholly unsuited to take the place of a local meeting hall or a local newspaper. It is a national and regional medium and the sooner it ceases to be chamber of commerce ballyhoo, the sooner radio will grow to its true force.

A TEN per cent reduction in the rate applying to radiograms between the United States and Australia is the result of linking Rocky Point with the short-wave beam service between Montreal and Melbourne.

THE Dollar Lines are erecting twenty 1-kw. shore stations in New York, San Francisco, Manila, Honolulu and Shanghai, at a total cost of a million dollars, utilizing the new channels assigned them in the 20-meter band. They announce a combination radio and mail service to China at low rates, consisting of radio direct to ships en route to China and thence by mail on arrival at Shanghai.

REPRESENTATIVES of the Canadian Government are making another plea for additional inroads into our overburdened frequency allocations in order to extend still further their broadcasting services. Canada now has six exclusive channels and twelve shared channels, as compared with 77 exclusive channels and twelve shared channels for the United States. It has only 5.5 stations per channel as compared with 7.7 in the United States. Our frequency space is approximately five times as extensive as that assigned to Canada, but our population is twelve times as large and the number of radio sets twenty-five times as large. The total power of our broadcasting stations per channel is somewhat over three times that of the Canadian channels.

When the Canadian commissioners visited the United States, shortly after the appointment of the Federal Radio Commission a year and a half ago, we urged that they be given a just share of the broadcast band, particularly in view of the miserable pirating by American stations then current. They were dealt with generously and are not loading their channels nearly as heavily as we are. Hence their present plea is made without full appreciation of the justice of the situation.



A PICTURE WIRING DIAGRAM FOR THE BLIND

The large sheet of paper which the blind man holds is a receiver constructional data sheet printed in the Braille system for the blind, with a wiring diagram in relief dots. It was printed by the American Braille Press, in coöperation with French radio corporations, which furnished the skeleton framework in the blind man's left hand. The framework is furnished with tuning dials marked with raised characters.

THE Chairman of the Federal Radio Commission, Judge Robinson, during a visit of inspection in New York early in June with Commissioner Caldwell, issued a forceful statement to the effect that "on all hands it is conceded that, for the general public interest, there must be fewer stations. . . . The fulfillment of the law implies more than mere local interests, likes and dislikes. In major consideration, the problem is a national one. For the good of the whole country, not so many stations as formerly will be licensed in certain sections of the Union. The Federal Radio Commission knows exactly what it is doing and that it is acting within its definite powers."

Rumors reach us that this decisive opinion, expressed by the newest Commissioner, will be crystalized in a definite plan of allocation to be put in effect on September 1. Judge Robinson is to be congratulated upon the speed with which he has grasped the crux of the radio problem and for his definiteness in stating, in no uncertain terms, what course the Commission proposes to follow. The first public statements of most of the Commissioners have been farcical statements of optimism to the effect that radio is not as bad as it sounds.

A NEW 35,000-watt broadcasting station, operating on 1525 meters, has been placed in operation at Lahtis, Finland.

COMMANDER HOOPER, in a memorandum to the Federal Radio Commission on short-wave allocations, stated that the increase in foreign short-wave stations since March 20 has been fifty per cent as compared with two per cent in the United States. It must be realized, however, that the numerous American services established before that date serve to give us a predominant position in the short-wave field.

THE opening of direct radio telephone communication between Holland and the Dutch East Indies was staged at the International Press Exhibit at Cologne on May 28. The dispatch was so garbled that the exact locations of the stations in Holland and Java involved cannot be given.

RADIO was honored by a place in the Republican platform, drafted at Kansas City, with an innocuous platitude to the effect that the Republican party is in favor of radio broadcasting. The election of Candidate Hoover, however, would be a great blessing to radio because he understands its problems thoroughly by intimate contact therewith and has had actual experience with broadcasting problems. Governor Smith, the Democratic nominee, also appreciates the value of radio as a medium of political expression, although we would not like to see his private method of pronouncing the word "radio" become the generally accepted usage.

THE United States Customs Court sustained the protest filed by H. Scott Martin that the duty assessed on radio tubes should be 30 per cent. instead of 40 per cent. because they should be classified as "machines and parts thereof not specifically provided for" rather than "manufactures of metal, not specifically provided for" as they have been classified by customs collectors in the past.

THE Zenith Radio Corporation, in its annual report, covering the operations of the last ten months, reports net earnings of $727,995.29, after deducting depreciation, commissions, bonuses, royalties and taxes. Inventory amounts to about a quarter of a million.

THOMAS A EDISON will build combination - electric phonographs and radio receivers in coöperation with Splitdorf. Presumably these sets will be for listening to sporting events which, according to Mr. Edison's statement some months ago, is the only useful service so unmusical a device as radio can render.

J. D. R. FREED was recently issued patent No. 1,671,959, describing the use of bypass condensers as a means of eliminating reactive coupling in radio circuits. If this patent is sustained in the courts, practically every receiving set manufactured will fall within the scope of its claims. It looks like a great opportunity for a lot of lawyers to make a lot of money. . . . Judge J. Brewster of the U. S. District Court in Massachusetts held, in a decision favorable to the Hiler Audio Company and unfavorable to the General Radio Company, based on patent 1,589,692, that the patent is basic for all forms of double-impedance audio frequency when plate and grid impedance are located within one can or housing. The decision ought to please the can manufacturers. . . . A recent list of licensees under John V. L. Hogan's patent No. 1,014,002 reveals that over 90 per cent. of the radio sets manufactured this year are licensed under that single control patent. . . . The Lektophone Corporation has completed negotiations with Standard Telephones & Cables, Ltd., London, to represent the corporation in Europe.

—E. H. F.

A Resistance-Coupled Amplifier and Power Supply

By J. GEORGE UZMANN

Dubilier Condenser and Radio Corp.

HERE are the constructional details for a high quality audio and power amplifier together with a power supply unit which will supply B voltages to the r. f. amplifier with which it is used. If a.c. tubes are used in the r.f. and a.f. amplifier, the filament windings on the power transformer may be utilized for filament current, thus providing complete light-socket operation. The entire unit is one of good engineering practice as applied to both amplifier and power elements.

The combined unit was designed to meet the exacting requirements of an audio amplifier system which in itself should be capable of giving high quality reproduction; that is, this part of the assembly was expected to possess a fairly flat frequency characteristic over the range from approximately 50 cycles to about 5000 cycles. It was realized, of course, that the radio-frequency end of the receiver might appreciably alter this uniformity of audio-frequency characteristic.

Glancing at Fig. 1 and 2 it will be noted that the entire assembly of parts is such as to form several sub-groups; that is to say, the power transformer and filter condensers form one line-up; the rectifier tube, C-bias resistor and choke coils a second line; while a third group embodies a potential dividing resistor and bypass condenser network together with an anti-motorboating feature incorporated in the amplifier. The audio amplifier system makes up a final group assembly which, incidentally, is placed in a position as far away as possible from the transformer, so as to eliminate all stray field coupling. Further, the method of wiring largely helps in removing noise background from the audio output caused by stray fields, a.c. lines, etc.

Although the amplifier illustrated in this article employs d.c. type tubes, there is no reason why a.c. tubes cannot be used in the unit so as to make it completely a.c. operated; the filament windings on the power transformer may be used to supply filament current for the a.c. tubes. We have therefore indicated in Fig. 2 in dotted lines the circuit arrangement to use with a.c. tubes. No changes are necessary in the values of coupling resistors and the only additional parts required for a.c. operations are two resistors for C-bias, one with a value of 6000 ohms and another with a value of 1000 ohms. The a.c. tubes of course replace the type 340 and type 112 tubes and make it unnecessary to run C-battery or A-battery leads to the amplifier. For VT_1 we suggest the use of a CeCo type G high-mu tube. Tube VT_2 may be any standard type 227.

RESISTANCE-COUPLED amplification has not been used to any great extent in home constructed power amplifiers and its use in Mr. Uzmann's unit in combination with a push-pull output stage should prove interesting to many of our readers. Resistance-coupled amplifiers—properly designed—are noted for their excellent frequency response. The amplifier utilizes a circuit arrangement which prevents motorboating, a fault experienced with some resistance-coupled amplifiers and which has, in the past, perhaps made some builders hesitate to construct an amplifier of this type.

Storage battery type tubes are used in this amplifier because it was constructed before a.c. high-mu tubes were available, but tubes of this type can now be obtained from CeCo, Arcturus and others and may be used to make the amplifier completely a.c. operated. Their use in this amplifier is covered in the text of the article.—THE EDITOR.

THE AUDIO AMPLIFIER

THE audio amplifier system is made up of two stages of resistance coupling feeding into a high-grade push-pull output stage employing 310 type tubes. Such an arrangement generally fulfills the requirements of even the most exacting set owner.

This type of amplifier was adopted only after close study of the problem. It was felt that a properly designed resistance scheme of tube coupling in the detector and first audio stages would result in an amplifier having a flat characteristic, provided the number of high-mu tubes could be held at a minimum. For the latter reason either a 30 Mu or CX-300A tube should be employed as a detector, while a CX-340 high-mu tube is used in the first audio stage. A detector plate resistor of 100,000 ohms is suggested for the CX-300A detector, and a resistor of 250,000 ohms for the CX-340 tube. The grid leaks are of 2-megohm size.

Any three-stage audio amplifier system supplied from a common plate voltage source, and particularly from a socket power device, possesses characteristics which tend to throw such a circuit into audio-frequency oscillation—more commonly called "motorboating." In an effort to eliminate such a condition an anti-motorboating device was incorporated in the amplifier circuit. It consists of a 25,000-ohm wire wound resistor, R_2, connecting between the B plus 135-volt tap of the power supply and the detector plate resistor, together with a bypass condenser, C_3, of 1.0-mfd. capacity.

Incidentally, the audio input terminals of the amplifier do not include an r.f. choke and bypass condenser since it was believed that this practice is almost standard and usually included in the detector output. It is important, however, that such an arrangement be used.

The C-bias potential for the 340 tube, being small, is obtained by taking the voltage drop across its filament. For the second audio stage the bias voltage is obtained from a small external C battery.

A high-grade push-pull input transformer is used to connect into the CX-112A output circuit. The complete stage is of standard design and employs a push-pull output transformer, T_2. 310 type power tubes were adopted for this stage.

THE POWER SUPPLY SYSTEM

THE power transformer, A, has a tapped primary which readily permits of circuit adjustments suitable to meet varying line conditions without the necessity of variable resistors. Its high voltage winding outputs either 550 or 750 volts, making it suitable for a CX-381 type half-wave rectifier tube. For the audio and radio-frequency plate supply under discussion it will be found that the 550-volt tap is correct, otherwise the CX-310 plate voltage will be excessive and will result in poor tube life. Further, at this

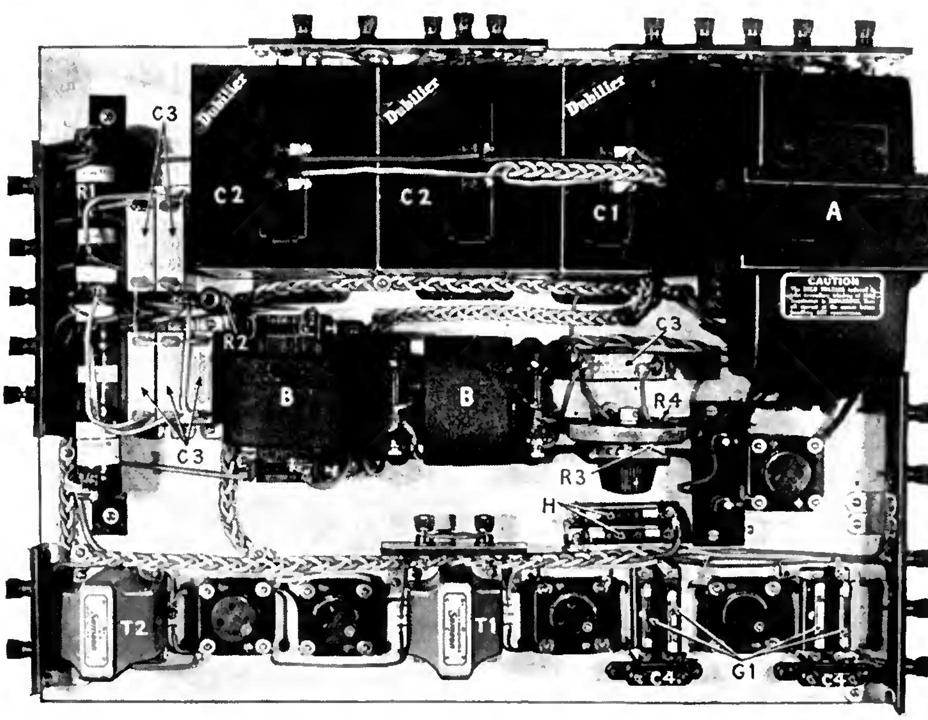


FIG. I. THE UNIT FROM ABOVE

voltage the rectifier tube will be operated well under its maximum rated value.

The power transformer, because of its several low-voltage windings, also supplies a.c. filament voltage for the rectifier tube, the power amplifier tubes, for a number of 326 types, and also sufficient current for two 327 tubes—thus complete receiving set electrification is available.

C-bias potentials for the power amplifier tubes are obtained in quite the ordinary manner by means of the several bypassed wire wound resistors going to the mid-point tap of the transformer filament winding feeding the power tubes. A fixed resistor in series with one of variable type efficiently prevents one from accidentally cutting out the entire resistance and thereby operating the CX-310 tubes without a C potential, which would result in damage to both tubes.

THE FILTER NETWORK

THE filter network is probably the most important unit of a power supply system. In the apparatus under discussion the writer employed choke coils of high inductance and of a type which could be operated at high current densities without fear of loss of inductance, or possible core saturation.

Across the filter output is connected an efficient wire wound potential dividing resistor, R_1. Its total resistance amounts to 41,000 ohms and is tapped to provide the more commonly required B voltages. Each tap point is bypassed by means of condensers, as shown.

Some readers may want to use this power amplifier in conjunction with a dynamic type loud speaker. Loud speakers of this type can be obtained, designed to operate with a field excitation of about 60 milliamperes. This current can be obtained by connecting the field winding of the loud speaker in series with the filter system at the point marked X in Fig. 2.

GENERAL ASSEMBLY AND WIRING

THE preceding remarks may be considered in the light of the writer's idea of a set of specifications for building a high-grade power supply and amplifier system. And from it the reader may readily determine if the layout meets his requirements,

As to making up the general assembly no working dimensions are necessary, as Fig. 1 shows the best part arrangements, considered from an electrical viewpoint, and just where each piece of apparatus is to be placed on the 17" x 21" inch drafting board used for mounting purposes.

The wiring plan adopted is somewhat novel and seldom seen. It will be noted that a series of braided lead wires are employed throughout, and in final form it is apparent that a neat and workmanlike job results. The scheme is also one giving maximum insulation, since each lead is kept in a definite position with freedom from short circuits, broken connections, etc. High-grade rubber-covered stranded copper wire should be used for this purpose. The wire employed in the author's model was called "Rise Wire," made by the Belden Company; of course, any other equivalent type should prove suitable.

Perhaps the reader shall wonder what part is played by the several two-post terminal blocks. The block shown in Fig. 1 to the right of the resistor R_3 is merely a simple arrangement for feeding either 550 or 750 volts to the rectifier plate. A similar block will also be found facing the input push-pull audio transformer, T_1.

A jumper normally closes the latter terminals, since these happen to be in the grid return circuit of the power tubes. If a galvanometer is placed in this circuit we at once have a visual indication of the flow of grid current and, of course, such a condition simply means a distorted power output.

Connecting a high-resistance voltmeter across points Y and Z of the power tube C-bias resistors, as shown in Fig. 2, permits a correct voltage adjustment by means of the variable resistor. At a plate potential of 425 volts for the 310 tubes the normal resulting bias voltage should be 35.

The only nut-clamped connection of the set wiring will be found to be the lead wire going to the first choke coil. Connecting a milliammeter between these points permits taking a reading of the total direct current drain of the system. It is most important to determine that in no case should the plate voltage of the power tubes ever exceed 425 volts; filament voltages, both a.c. and d.c., should also be measured; in this way high quality reproduction and long tube life will be realized.

If the above instructions are carefully followed out, and the arrangement used as indicated, the amplifier will show an overall voltage amplification of about 3450 or a gain of 71 TU; while in terms of power amplification it is capable of producing up to 3 watts of undistorted energy. The maximum input signal voltage from the detector to produce maximum power output will not have to exceed 115 millivolts r. m. s., so there is no possibility that the detector will be overloaded.

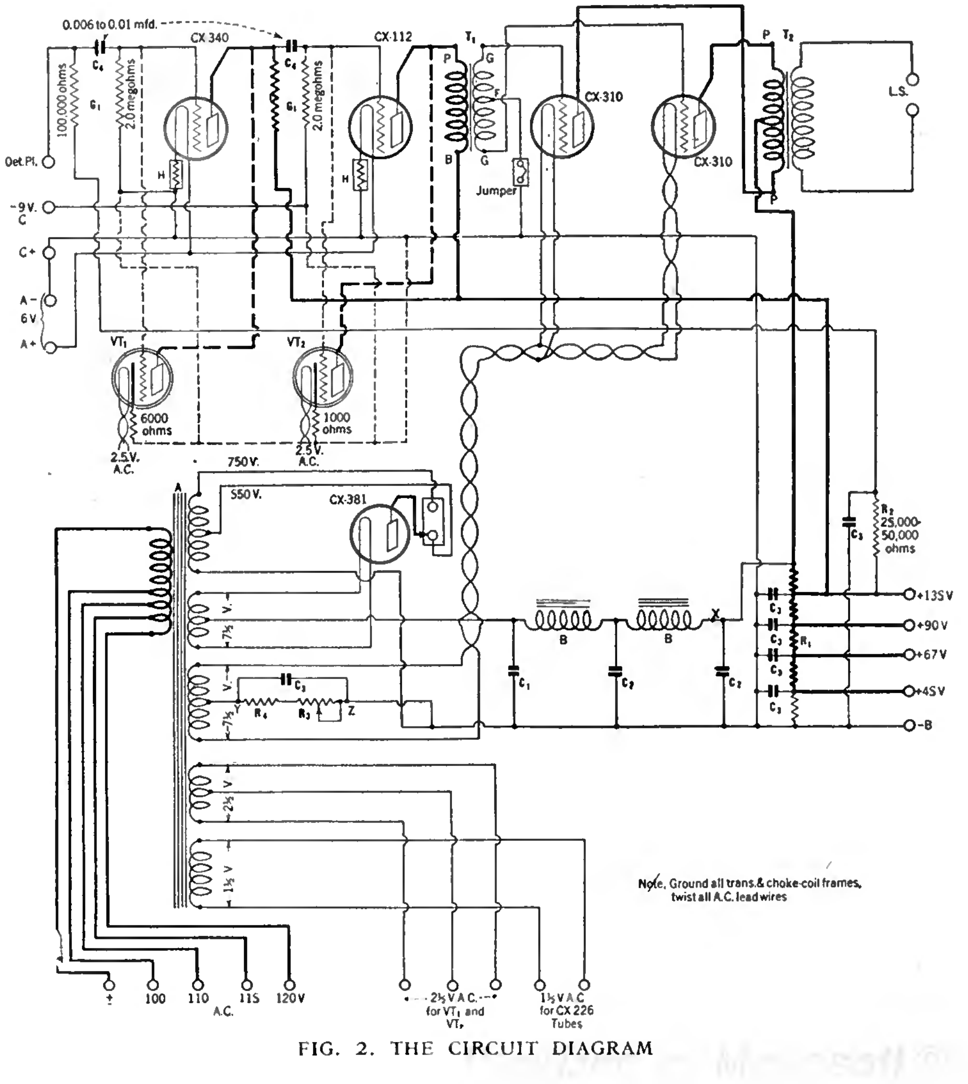


FIG. 2. THE CIRCUIT DIAGRAM

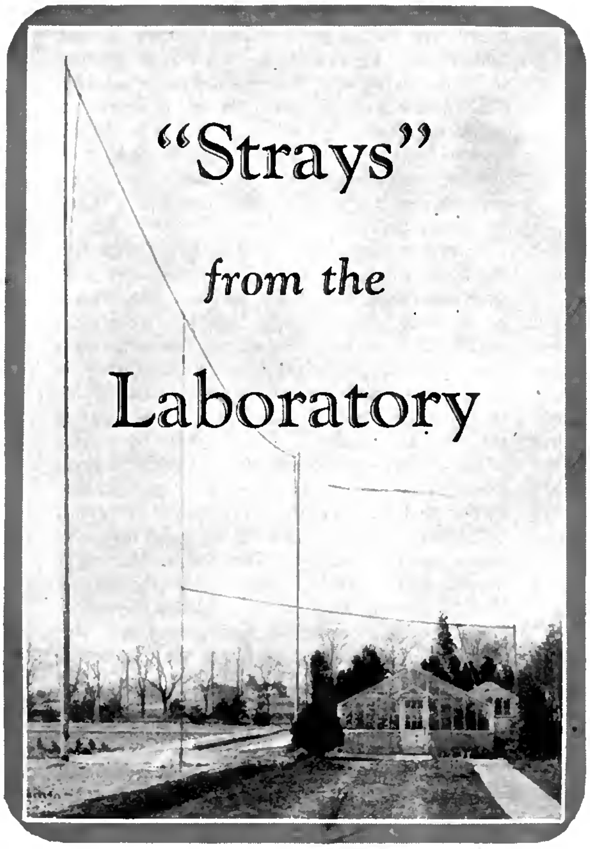
LISTS OF PARTS

THE parts listed below are those used in the particular unit described in this article, but since none of the parts are of special design there is no reason why the builder should not substitute for the parts indicated below, other units with equivalent characteristics. Frost, for example, makes wire-wound resistors that may be used for item R_1, and Centralab makes wire-wound resistors that can be utilized in place of resistor R_3.

- A —1 AmerTran power transformer, type PF281
- B —2 AmerTran choke coils, 20 henries, type 709
- C_1—1 Dubilier power condenser, 2 mfd., type 666
- C_2—2 Dubilier power condensers, 4 mfd., type 667
- C_3—6 Dubilier bypass condensers, 1 mfd., type 907
- C_4—2 Dubilier moulded Micadon condensers, 0.01 mfd.
- G_1—4 Dubilier Metaleak grid and plate resistors
- G_2—4 Daven grid leak mountings
- H —2 Amperites, 0.25 ampere, No. 1 A
- R_1—1 Ward Leonard AmerTran resistor, type 507-6
- R_2—1 Ward Leonard resistor, 25,000 ohms, type 507-65
- R_3—1 Ward Leonard Adjustat, 1000 ohms, type 507-7
- R_4—1 Ward Leonard resistor, 500 ohms, type 507-17
- T_1—1 Samson input transformer, type Y
- T_2—1 Samson output transformer, type 0-3
- 5 Benjamin 4-prong sockets
- 1 Mounting board, 17" x 21"
- 7 Composition terminal strips
- Hook-up wires, screws, nuts, etc.
- 1 CX-340 tube (Ceco type G high-mu tube for a.c. operation)
- 1 CX-112 tube (CX-327 tube for a.c. operation)
- 2 CX-310 tubes
- 1 CX-381 tube

NOTE: A 6000-ohm and a 1000-ohm C-bias resistor are also needed, as shown in Fig. 2, if a.c. tubes are used in the a.f. amplifier

"Strays" from the Laboratory



Screen-Grid and Automatic Receivers

WE HAVE already published some data obtained in the Laboratory on several of the a.c. screen-grid tubes which are appearing on the market. The curves shown in Figs. 1 and 2 are taken from the *Arcturus Bulletin* and give interesting facts on the Arcturus tube of this type. The electrical characteristics are given below:

Heater potential	15.0 volts
Heater current	0.35 amperes
Control-grid potential	−1.0 volt
Screen-grid potential	30.0 volts
Plate potential	135 volts
Plate current	1.0 mA
Screen-grid current	0.50 mA
Amplification factor	400
Plate resistance	700,000 ohms
Mutual conductance	570 micromhos

The interesting fact, shown on Fig. 2, is the marked peak in the value of mutual conductance and amplification factor at minus 1-volt bias on the control grid.

From all appearances there will be few commercial receivers using screen-grid tubes available for some time. As usual the home constructor is still able to keep far ahead of the commercial receiver manufacturer; he still has better audio amplifiers than the majority of receivers, and he can build one of several kits now on the market using screen-grid tubes.

It is interesting to note that English set manufacturers are ahead of the Americans in the use of the screen-grid tube. The Marconiphone 61 uses three screen-grid tubes, each with a voltage amplification of 30—which amounts to about 27,000 before the detector—and a two-stage resistance-coupled amplifier which brings up the total voltage amplification in the receiver to about three quarters of a million. The entire receiver is copper shielded, each stage being carefully isolated from the others except through the proper conductances. In a loop ten by twelve inches in size, it is possible, in London, to bring in WJZ and WGY with loud speaker volume. Set Data Sheet No. 8, on page 278 of this issue of Radio Broadcast, contains more information on this interesting receiver.

The Radio Exchange receiver—also sold in England—uses two screen-grid tubes, has six sets of circuits each of which is permanently tuned to a given station and which is connected with a switch on which is engraved the name of the station.

At the Radio Trade Show in Chicago there were several screen-grid receivers, and at least one automatically tuned receiver, the Zenith. So far as we could see, there was little interest in the latter, although many people wanted to learn more about the screen-grid tube sets. We hope to present data on these receivers soon. The fact that few people seemed to care for automatically tuned receivers is but a commentary on the American's point of view—he wants to do his own tuning! The automatic tuning feature seems best suited to nickle-in-the-slot radios which will probably appear in pool rooms, cigar stores, ferry boats, chop suey joints, etc.

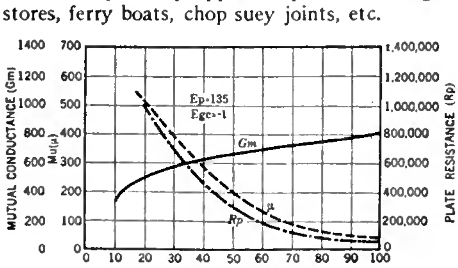


FIG. 1

Trailing "Power Leak" Interference

THE following letter from A. B. Chastian, Tulsa, Oklahoma, describes one source of what is usually called "power leak" interference, which may give many radio owners an opportunity to go through their own premises to see if occasional noises originate close to home in some unsuspected part of the house lighting system.

To the Editor:

You might be surprised to find your bothersome "power leak" interference very close at hand. Witness the following case:

A noise that sounded like a leak from wind blown wires scraping on a wet roof had been reported from widely separated points in the city. Because of the similarity of descriptions the trouble was believed to emanate from one source, but my part of it was traced to a swinging light fixture which had served for several years as both light and plug-in for various household appliances.

I did not suspect the lights for a long time, as the trouble would appear at any time, especially in wet weather, regardless of whether the lights were on or off. However, after much trouble shooting on an unusually damp day, in desperation I gave this fixture a gentle slap, and though it was turned off, the interference responded to the resulting motion of the fixture.

The old crumbly rubber insulation on the fixture wires was found to be chafed away in places by the metal parts of the fixture, causing a contact of high resistance which responded to weather conditions and vibrations of the room, sometimes as a loud continuous hum and again as an intermittent hum or sharp crackling.

Where interference sounds of this sort are heard, I would direct suspicion to any near-by fixtures, especially those having pull chain or key switches which jar the fixture when used. The joggling of the fixture chafes the insulation and causes these near-shorts, and in time will cause a real short that may prove dangerous.

More Radio Hoaxes

AFTER stating a number of complimentary things about Radio Broadcast, Mr. Ernest G. Kroger, Radio Operator on the *SS. J. L. Luckenback*, says, "I am particularly interested in 'Strays from the Laboratory.' That was a hot exposé of the output transformer in the July issue. I opened one I bought for $1.40 and found the same thing that you did. It carried the fancy name of 'Tone Filter.' Mr. A. H. Klingbeil's theory on fading due to street cars may be o. k. where he lives; maybe he can come forward now and give some explanation of fading on the high seas."

It is apparently Mr. Klingbeil's move.

While we are on the subject of radio hoaxes, we must congratulate *Radio News* on exposing the inner works and methods of sale of the Geppert "Kleer Tone" radio cure-all. We have already commented on devices that eliminated static, increased volume, increased d.x., and decreased the A- and B-battery consumption. In July *Radio News* the Geppert wave trap—selling at $4—is described, and as the editor states, better devices can be purchased for less than $1.

Another thing we should like to see exposed is the freak antenna, and we should like to get at the truth of this underground antenna business. Has anyone any data—not qualitative statements, but definite quantitative data—on relative signal strengths obtained from a 50-foot wire strung out in the open and the same length of insulated wire buried in the ground?

At Last—A Line Voltage Regulator

SEVERAL months ago we announced that automatic voltage regulator devices were soon to be on the market. The idea is to place one of these devices between the a.c. line and one's a.c. receiver or power supply or other apparatus requiring a constant input voltage. When the line voltage goes down, this device boosts the voltage, and when the line voltage goes up, the device reduces the voltage to that required by the receiver, let us say, and absorbs the additional voltage within itself. The data below is the result of a test in the Laboratory on the Acme Apparatus Company's unit.

Volts input from line	*Percent over-voltage*	*Output volts to 18-watt load*
96	−12.8	110
100	−9.1	110
110	0.0	110
120	+9.1	110
126	+14.6	110

Volts from input line	*Percent over-voltage*	*Output volts to 75-watt load*
94	−14.5	108
109	−1.0	109
123	+11.8	110

The device is designed to operate with apparatus requiring not over 60 watts, which would include all standard a.c. receivers getting fila-

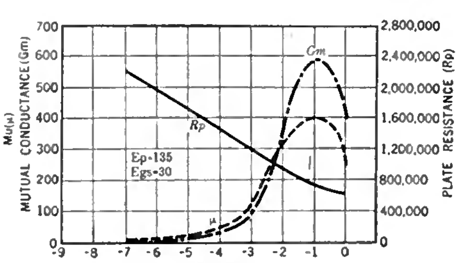


FIG. 2

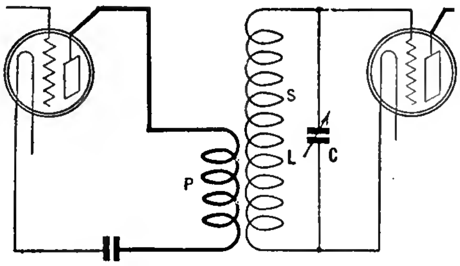


FIG. 3

ment and plate power from the house lighting lines. On a load of about 135 watts, the device did not regulate the voltage—but of course it was severely overloaded under these conditions, making the test unfair. The figures above are conclusive evidence that under the conditions for which the device was designed, almost perfect regulation is obtained by its use. We hope the Acme Company gets at least half the million dollar business we predicted for a device of this kind! It is the first such device tested in the Laboratory.

Some Coil Measurements

THE coils used in present day receivers control to a large extent both the selectivity and sensitivity of those receivers. All receivers with which we are familiar use the well known parallel tuned circuit—the "anti-resonant" circuit of the telephone engineers—shown in Fig. 3. The input to this circuit is usually a small coil acting as the primary, P, of a transformer whose secondary is the inductance, L, which is tuned by the variable condenser, C. The input of the following tube is placed across this shunt circuit.

The impedance of such a circuit, at resonance, is expressed as

$$Z = \frac{L^2 \omega^2}{r}$$

where L is the inductance of the coil in henries
ω is equal to 6.28 times the frequency in cycles
r is the series resistance of the coil and condenser in ohms.

The impedance at any other frequency than the one to which the coil and condenser are tuned is lower than the above formula gives. At higher frequencies the impedance is essentially capacitive and low; at lower frequencies the impedance is inductive and low. Currents of other than the resonant frequency, then, do not build up such high voltages which may be applied to the following tube. Therein lies the selectivity due to such a tuned circuit. It will be increased as we decrease the series resistance. This is the reason for the "low loss" craze. A good coil-condenser combination is one which has little resistance in it and which has, therefore, a sharp resonance curve.

Since a resistance in *shunt* to this circuit has the same effect as a smaller series resistance, the tube resistance, R_p, of the previous tube tends to decrease the selectivity of the circuit, especially if it is connected across the entire coil. This is one reason why a step-up transformer is used. It may be looked at as a kind of selectivity transformer. Instead of shunting the entire tuned circuit with R_p, which may be 10,000 ohms, we step-up this resistance to about 200,000 ohms by connecting it across only part of the coil or through a small primary coil. Multiplying R_p by the square of the effective turns ratio, N, which usually amounts to about 20, adds a much lower effective series resistance in the circuit than if the 10,000 ohms were across the whole coil. The greater the mutual inductance, the poorer the selectivity; the fewer the number of primary turns, or the looser the coupling to the secondary, the greater the selectivity.

It is also true that the greatest voltage amplification will take place in such a system when the effective impedance in the plate circuit of the amplifier is equal to the plate resistance of the tube. That is, for maximum amplification

$$N^2 \times R_p = Z = \frac{L^2 \omega^2}{r} = \frac{L}{Cr}$$

where N is the turns ratio of the transformer
R_p is the plate resistance of the tube
C is the capacity of the circuit

When these conditions are fulfilled, by means of the turns ratio of the transformer, the maximum voltage gain, K, is

$$K_{max} = \frac{1}{2} \frac{\mu}{\sqrt{R_p}} \times \frac{L\omega}{\sqrt{r}}$$

Under these conditions the series resistance of the tuned circuit is twice as great as it would be if the coil-condenser combination were unattached to the previous tube.

The expression K above may be divided into two parts, one giving the amplification due to the tube $\frac{\mu}{\sqrt{R_p}}$ and the other giving the amplification contributed by the coil $\frac{L\omega}{\sqrt{r}}$

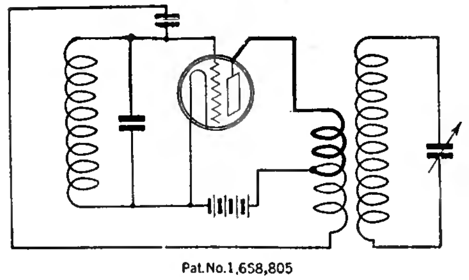


FIG. 4

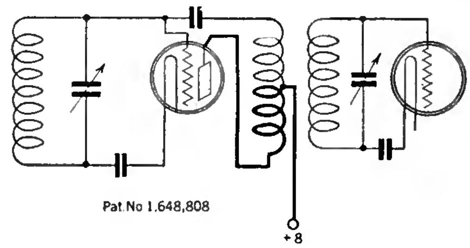


FIG. 5

The factor due the tube is not the same as the mutual conductance, which is μ/R_p, nor is the coil gain factor equal to the "Q" of the coil, which is $L\omega/r$. The selectivity of the circuit, however, is more nearly proportional to "Q" and so this figure of merit of a coil is useful.

In Table 1, the first three coils listed are Hammarlund coils; the remainder are inductances of other manufacturers. This information is sufficient to enable anyone to calculate the "Q" of the coils, to estimate their selectivity factors, and to calculate the maximum voltage amplification that can be secured from a tube and coil-condenser combination of this nature.

The effect of coil dimensions, of the L/D ratio, of the spacing of the wires, and of the size of wire will appear in these tables. It has been known for a long time that the most efficient coil is one whose length of winding is equal to the diameter, and it is interesting to note how nearly this rule holds for the coils listed in the tables.

As has been pointed out in Professor Hazeltine's patent No. 1,648,808, reducing the primary turns to half the number required for maximum voltage amplification at resonance, reduces the resonant values only twenty per cent. compared to 50 per cent. at other frequencies. This means, of course, a material increase in selectivity. And in these days what everyone needs is selectivity!

TABLE 1

Coil	F k.c.	R ohms	L	D	L/D	Wire No. B & S	Turns inch	N	Ins.	Ind.
3″ slight spacing	550 1000 1500	4.1 6.5 9.5	1.09	3	.36	24	41	45	D.S.C.	170
3″ Hammarlund Roberts	550 1000 1500	3.1 4.4 7.1	1.69	3	.56	22	29	50	"	"
3″ Special	550 1000 1500	2.6 3.7 6.0	2.25	3	.75	22	23	52	"	"
Coil No. 1	550 1000 1500	7.2 11.1 14.1	1.44	2	.72	26	56	80	Enam.	240
Coil No. 2	550 1000 1500	3.9 6.0 9.0	2.63	2	1.31	22	34.5	76	D.C.C.	168
Coil No. 3	550 1000 1500	3.7 5.7 8.9	2.1	2	1.07	24	35	74	S.S.C.	170

Note. F = frequency in kilocycles
R = high-frequency resistance in ohms
L = length of winding in inches
D = diameter of coil in inches
N = total number of turns
Ins. = insulation
Ind. = Inductance in microhenries

Another Patent Muddle

THE diagram in Fig. 4 is taken from Patent No. 1,658,805, issued to Lester L. Jones, on a capacitive-coupling control system, dated Feb. 14, 1928 (original filed Dec. 15, 1922) and in Fig 5 is a diagram taken from Patent No. 1,648,808, issued to L. A. Hazeltine on a wave signalling system, dated Nov. 8, 1927, filed Feb. 27, 1925. We should like some technical minded reader to tell us how these differ. It will be a good test not only of one's knowledge of radio circuits, but of how patent lawyer's minds work. On the basis of Mr. Jones patent, suit was filed against the Freed-Eisemann Company and an authorized Stromberg-Carlson dealer some time in May, 1928.

KEITH HENNEY

No. 5 RADIO BROADCAST'S HOME STUDY SHEETS **September, 1928**

Measuring the Amplification Factor of Vacuum Tubes

WITHIN the glass bulb of the majority of vacuum tubes used in receiving sets to-day are three metallic elements: the filament, which gets its voltage from the A-battery; the grid, which is connected to the radio circuit through a C-battery; and the plate, which takes current from the B-battery. Since each of these three voltages is variable, the actual operation of the tube is somewhat complex. The effect of varying the filament voltage has been determined in Home Study Sheet No. 3. (page 205, August RADIO BROADCAST). We shall now fix this voltage at some definite value, and notice the results of varying the other two voltages, one at a time. The apparatus needed will be as follows:

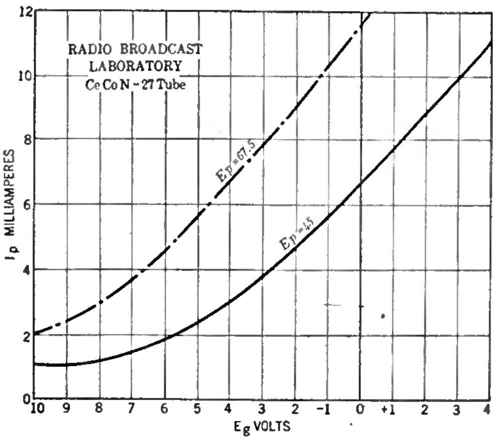


FIG. 1

LIST OF APPARATUS

1. The baseboard set-up used in Experiments No. 3 and No. 4.
2. A source of filament current, say a 6-volt storage battery.
3. A C-battery with taps at 1.5, 3.0 and 4.5 volts.
4. Two B-batteries with taps at 45, 67.5 and 90 volts.
5. A milliammeter reading up to 10 milliamperes. A Weston Model 301 5-milliampere meter was used in the Laboratory. A low range meter with the proper shunts may be used.
6. A filament resistor to reduce the 6 volts from the battery to the proper value for the tube, 5 volts. A rheostat or fixed resistor of the proper value may be used.

PROCEDURE

Connect up the apparatus in the following manner, as shown in Fig. 2:
1. Plus A to one end of the filament resistor.
2. Clip 1 to other end of resistor.
3. Minus A to clip 2.
4. Minus B to clip 2.
5. Plus C to clip 4.
6. Milliammeter between clips 6 and 7.

Connect leads with Eureka or similar clips on one end to terminals 5 and 8. These will enable the C and B voltages to be changed quickly and easily.

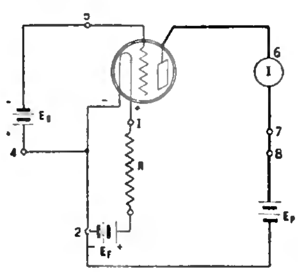


FIG. 2

If fresh B and C-batteries are used it will not be necessary to measure their voltages, and under any conditions we are more interested in the effect of varying these voltages than in their exact values. Inasmuch as the characteristics of two tubes of the same type from the same factory differ slightly, it is not necessary to know the C and B voltages with great precision.

Make the grid negative by placing the wire on clip 5 on the minus 4.5-volt tap of the C-battery. Read the plate current when the plate lead, clip 8, is placed on the 22.5 or 45-volt tap of the B-battery. Now increase the B voltage in steps up to 90 and then repeat the measurements with different values of C voltage, say minus 3, minus 1.5, zero, and plus 1.5 volts. Set down the data in the form shown in Table 1 which is the result of measuring a Ceco heater or 27 type of tube. Zero C voltage is obtained by connecting clip 5 to minus A or clip 2. Plus C voltages are obtained by reversing the C-battery connection, that is, connecting minus C to clip 4.

Now take data by changing the C voltage or bias, keeping the B voltage fixed. That is, fix the plate voltage at, say 45 and read the plate current as the grid voltage is changed from minus 4.5 to minus 3, etc., until the plate current is too great for the milliammeter to read. This data is tabulated in the form shown in Table 2. The data from these two tables should now be plotted as shown in Figs. 1 and 3.

DISCUSSION

The electrons which boil out of the filament when it is heated by the A-battery current flowing through it are negatively charged. The plate, which is charged positively by the B-battery, has a very strong attraction for these electrons. They, therefore, hurry toward the plate carrying with them their electric charges. If a certain number, 6.8 x 10^{18} per second, arrive at the plate, the flow of current out of the B-battery, through the plate current meter, and back to the negative side of the filament—where this part of the plate circuit is attached—is equal to one ampere. In receiving tubes the current is of the order of thousandths of amperes, or 6.8 x 10^{15} electrons per second. The greater the plate voltage, the greater the number of electrons that arrive per second. Consequently the greater is the plate current.

Between the plate and the filament is the grid, a sort of turnstyle which regulates the number of electrons that get past it. How? The voltage of this grid can be made positive or negative with respect to the source of the electrons. If it is negative, it tends to repel any electrons that come along on their way to the plate. They must either return to the positive side of the filament, or float around in the space between the grid and the filament. Some few of them get through to the plate. If the grid is made positive, it accelerates the flow of electrons from the filament, and either attracts a number of them to itself, producing a flow of current in the grid circuit, or hastens them on their way toward the plate.

Since the grid is closer than the plate to the source of electrons, it has a greater effect on their rate of travel. The relative effect of grid and plate upon the plate current is called the amplification constant (the symbol is the Greek letter mu, μ) and is determined from the above data in the following way. Let us consider the I_p-E_p curve in Fig. 3, which represents the variation of plate current with variation of plate voltage. Choosing values from the curve for Eg = minus 3, we note that at 67.5 volts the current is 7 milliamperes and at 50 it is 4 milliamperes. Thus a change of 17.5 plate volts causes a change in plate current of 3 milliamperes. Now the question arises, what change in grid voltage will cause the same change in plate current? Looking at the 67.5-volt curve of the I_p-E_g graph (Fig. 1) showing how the plate current changes with grid voltage changes, we see that at zero grid volts the plate current is 11.5 milliamperes and at minus 2.3 the plate current is 8.5 milliamperes. This represents a plate current change of 11.5—8.5, or 3 milliamperes caused by a grid voltage change of 2.3 volts. From these figures we can determine mu.

The amplification constant is calculated then as follows:

$$\text{Mu} = \frac{\text{change in plate volts}}{\text{change in grid volts}} \text{ to produce a given plate current change,}$$

$$\text{or} = \frac{67.5-50}{2.3} = \frac{17.5}{2.3} = 7.55 = \text{mu}$$

The important thing to note here is that it is the *change* in voltages that must be divided by each other, not the actual voltages at any particular point. These changes in voltages may be reckoned only over that part of the I_p-E_p and I_p-E_g curves which appear to be straight lines. The smaller the length of these straight lines that are used in our calculations, the greater will be the accuracy with which the value of mu will check that obtained on an accurate vacuum tube bridge.

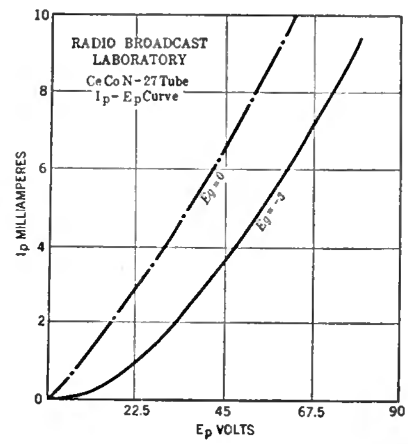


FIG. 3

PROBLEMS

1. Plot all of the data in Tables 1 and 2, and calculate the amplification factor at a number of points on the curve. Plot these values against plate voltage and then against grid voltage.
2. Calculate the value of the resistor needed to cut down the A battery voltage, 6, to the voltage required by the filament, 5.
3. Repeat the above experiment for other types of tubes in your laboratory.
4. Should the I_p-E_g curves be steep or flat for a high-mu tube? For a power tube?

TABLE 1

Data for E_p-I_p curves

E_p = plate volts	Grid volts 0	−1.5	−3.0	−4.5	+1.5
	Plate current (I_p) in mA.				
0					
22.5	2.8	1.5	1.0	.5	3.8
45	6.4	4.7	3.5	2.4	7.6
67.5	10.4	8.5	7.0	5.5	11.0
90			11.0	9.4	

TABLE 2

Data for I_p-E_g curves

E_g = grid volts	Plate voltages 22.5	45	67.5	90
	Plate currents (I_p) in mA.			
—10	.25	1.0	2.0	6.0
— 8	.3	1.2	3.2	7.0
— 6	.4	1.8	5.3	8.5
— 4	.55	3.0	6.6	11.0
— 2	1.4	4.7	8.8	14.0
0	2.9	6.8	11.5	17.0
+ 2	4.5	8.7	14.0	19.5
+ 4	6.2	11.0	16.5	22.0
+ 6	8.0			
+ 8	10.0			

No. 6 RADIO BROADCAST'S HOME STUDY SHEETS September, 1928

Vacuum Tube Characteristics

THE three important factors governing a vacuum tube's operation in a radio circuit are:

1. Amplification Factor, $\mu = \frac{\text{change in plate voltage}}{\text{change in grid voltage}}$ to produce a given plate current change.

2. Plate Resistance, $R_p = \frac{\text{change in plate voltage}}{\text{change in plate current}}$ or, the effect upon the plate current of changes in the plate voltage.

3. Mutual Conductance, $G_m = \frac{\text{change in plate current}}{\text{change in grid voltage}}$ or, the effect upon the plate current of changes in grid voltage.

Home Study Sheet No. 5 gives sufficient data to determine all of these factors.

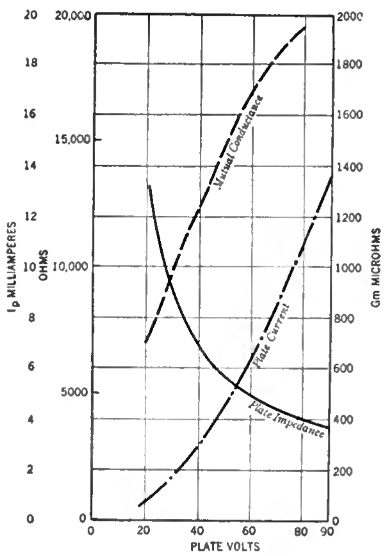


FIG. 1

Note: The word *microhms* at the right on this diagram is an error. It should be *micromhos*

The plate resistance, sometimes called the internal resistance or impedance of the tube may be determined by dividing a change in plate voltage by the corresponding change in plate current it produces. Care must be taken to use the proper units, that is, volts must be divided by amperes—not milliamperes. For example, let us determine the impedance of the tube used in Sheet No. 5 at minus 3 volts grid bias. We look at Fig. 3 on Sheet No. 5 and see that at minus 3 volts the plate current is 7 milliamperes when the plate voltage is 67.5 and about 3.5 milliamperes when the plate voltage is 45. Then,

$$Rp = \frac{67.5-45}{.007-.0035}$$

$$= \frac{22.5}{.0035} = 6457 \text{ ohms.}$$

This resistance varies with each change in plate and grid voltage. When it is determined by the above method, small changes in plate voltage should be used. More accurate results would be obtained if changes of ten volts were used instead of 22.5. At low plate voltages the plate resistance is relatively high and as the plate voltage is increased the plate resistance decreases, rapidly at first and then more slowly as the normal operating voltage is reached. This term "plate resistance" is a measure of the plate circuit's resistance to the flow of alternating current. The resistance of the plate circuit to the flow of direct current is equal to the voltage on the plate divided by the d.c. plate current in amperes. For example, in Fig. 3, Sheet No. 5, we see that the plate current is 7 mA when the plate voltage is 67.5 volts and the grid bias is minus 3 volts. Therefore the d.c. resistance of the plate circuit is

$$\frac{67.5}{0.007} = 9{,}643 \text{ ohms}$$

The mutual conductance may be determined by noting the effect on the plate current produced by a given change in grid voltage. Looking at Fig 1, Sheet No. 5, we note down the following data taken from the point where the plate voltage is 45.

$$\frac{\text{Change in plate current}}{\text{Change in grid voltage}} = \frac{.0064 - .0035}{3 - 0}$$

$$= \frac{.0029}{3} = .00097$$

The unit of conductance is the mho, so the above value is .00097 mhos, or as usually stated, 970 micromhos. This shows that with 45 volts on the plate of this tube a change of one volt on the grid in the region between minus 3 and zero produces a change of 970 microamperes plate current. This may also be obtained by determining the slope of the I_p-E_g curve in the vicinity of minus 3 volts. (See Home Study Sheet No. 4, for a definition of the term "slope".)

The mutual conductance varies with each value of plate and grid voltage, and will be more representative of what the tube actually does in a radio circuit if small grid voltage changes are used to determine its value.

The amplification factor may be found as in Sheet 5 or by multiplying the plate resistance in ohms by the mutual conductance in mhos, since a little juggling of the above formula for these values shows such a relation to exist, that is $\mu = R_p \times G_m$

PROCEDURE

Determine the plate resistance and mutual conductance for several values of plate and grid voltages, taking the data from that obtained in Sheet No. 5. Plot these values as shown in Fig. 1 and Fig. 2.

Determine the values of plate resistance and mutual conductance by taking the slopes of the curves at the proper points, and see how nearly these values check. (Note: The term "slope" was explained in Sheet No. 4.)

DISCUSSION

The curves made by plotting the data secured in the experiment in Sheet No. 5 are known as static characteristic curves, and the values of M_u, R_p, and G_m are called the static characteristics of the tubes under test. They tell us all we need to know about a tube to predict what it will do in nearly all kinds of electrical circuits.

The amplification factor gives us an idea of what happens when a small voltage is impressed on the grid. This voltage reappears in the plate circuit of the tube, multiplied by the amplification factor. For example if the tube has a mu of 8 and a signal with a value of one volt is impressed on the grid, then there appears in the plate circuit a signal with exactly the same form as that impressed on the grid, but with a value of eight volts. In bridge methods of measuring the mu of a tube, a voltage is introduced into the plate circuit which is opposite in direction to that appearing there due to the input voltage to the grid. When this opposing voltage in the plate circuit is equal to mu times the grid voltage, the two voltages cancel each other and silence is obtained in a pair of headphones. The mu of a tube is practically constant over the entire range of operating voltages, as can be seen by refering to Fig. 2 on this sheet. The other constants of a tube vary considerably with the applied plate and grid voltages.

The mutual conductance of the tube tells us how great a change in plate current will occur if the grid voltage is varied. For example, if the G_m of a tube is 600 micromhos a volt a.c. input to the grid will produce an a.c. current in the plate circuit of 600 microamperes. This change in current may be used to set up a new voltage which may be again amplified by succeeding tubes.

The plate resistance of the tube gives us an idea of what happens to these plate current changes produced by grid voltage changes. If the tube had no resistance, all of the a.c. plate current would be useful across the coupling device in the plate circuit of the tube. Since, however, the tube has a resistance, this a.c. current must flow through not only the coupling device, but through the plate resistance as well.

If the plate resistance of the tube is 30,000 ohms and the coupling resistance has a value of 60,000 ohms then the total signal voltage in the plate circuit is divided into two parts, two-thirds of the voltage appearing across the coupling resistance and one-third across the plate resistance. The total a.c. voltage developed in the plate circuit is divided between the load, or coupling device, and the tube resistance.

If a coupling device is used which has considerable resistance, the voltage actually on the plate is not the same as the B-battery voltage but is less by the drop in voltage across the coupling resistance; the voltage drop being determined by ohm's law. See Home Study Sheet 4, August RADIO BROADCAST.

The amplification factor of a tube varies inversely as the spacing between the wires forming the grid and directly as the distance between the plate and filament and between the grid and filament. Thus to obtain a tube with a high amplification constant it is necessary to use a fine mesh grid mounted close to the filament, as compared to the distance between the plate and the filament.

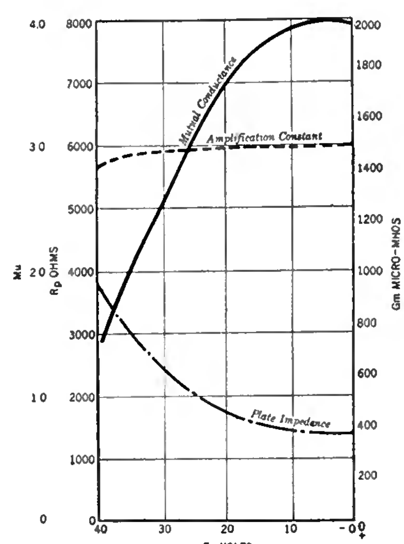


FIG. 2

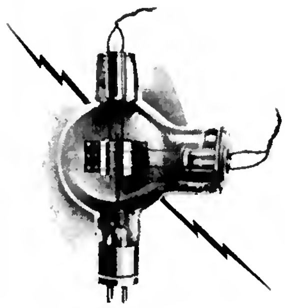
PROBLEMS

1. Suppose you are to design a series of tubes, each with a mutual conductance of 500 micromhos. Plot a curve showing how the plate resistances and amplification factors of these tubes will be related.

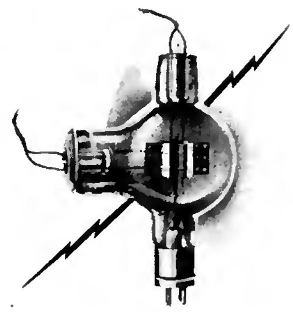
2. Suppose a tube had a 55,000-ohm resistor in the plate circuit, that one milliampere of current were flowing, and that the B-battery voltage were 90. What is the voltage actually on the plate?

3. Suppose you had a tube with a mu of about 30, and a plate resistance of 60,000 ohms. What is the mutual conductance? If the plate current is one milliampere, how much B-battery voltage will be required to put 90 volts actually in the plate, if a coupling resistor of 250,000 ohms is used?

4. The curve in Fig. 1 does not have the values of mu plotted on it. Calculate these values and plot. What kind of tube do you think it is?



Working on 5 Meters



By ROBERT S. KRUSE

THE preceding 5-meter story in August RADIO BROADCAST told of the ancestry, birth and childhood of the 5-meter band. All biographies are required to have such a first chapter, which the author expects the reader to skip. The reader usually does skip it; everyone is satisfied and ready to begin the main story, which shall happen here and now.

Since this present story is to undertake the large job of describing a complete radiophone or c.w. circuit operative at a wavelength of 5 meters (60,000 kilocycles, if you like bulky terms) we must needs proceed logically or become lost. It seems simplest therefore to start with the transmitter and proceed via the sending antenna, receiving antenna, receiver and headset to the Receiving Experimenter. It is hoped that this will leave over enough time to go back and see what curious things the wave has done en route.

THIS is the second of Mr. Kruse's articles to appear in RADIO BROADCAST, *supplying experimenters with data on transmission and reception on 5 meters. Now that the bread has been cast upon the waters, the editors and Mr. Kruse are anxious to know who is gathering in the loaves. We would like to hear from all of those to whom the articles have proved interesting. If you have done or expect to do any work on 5 meters—or if you are doing any work at all on short waves—drop us a note telling what you are doing and what material you would like to see published in future issues.*

—THE EDITOR.

THE TRANSMITTER

IT SEEMS like obvious nonsense to say that the business of the sending set is to generate a decent phone or c.w. signal, yet the average operator or experimenter never seems to think of this. He is perfectly happy if the meter in the antenna circuit moves far across the scale. That the speech or code being transmitted cannot be "unscrambled" seems to him to indicate that the man at the other end is distinctly dull and incapable.

This is then a plea for more than the usual attention to proper transmitter operation, whether the output carry speech or dots and dashes.

The usual way of getting at the 5-meter business appears to be that of "sneaking down on the wave." This unfortunate habit has just received new impetus by the opening of the amateur band of 10-10.7 meters, which is unfortunate for 5 meters, since the 10-meter band can be worked with normal circuits in the transmitter while 5 meters demands changes. The former therefore has little educational value toward learning to handle 5 meters.

The first requirement of the 5-meter circuit is of course that it work at 5 meters, the second that it do so steadily and the third that the apparatus be neither too special nor too anxious to "blow up" in operation. All of these needs are met by the circuits shown in Fig. 1. Little explanation needs to be made other than that provided by the caption of the figure, except in the case of the modulator, D. When telephony is desired this is interposed between the B supply and RFC_1 of any of the circuits shown. If the oscillator is a UX-210 or a UV-202, the modulator will be a similar tube and the transformer a modulation transformer. The C-bias on the modulator must be adjusted by ear until decent speech results. If such speech cannot be obtained the microphone or the transformer are to be suspected. If once abused many microphones never recover; on the other hand, many of the modulation transformers now available cannot operate properly with the normal microphone current flowing through them—having been designed for the costly double-button microphones or for some weird sort of "mike" that cannot be found on the market.

If the oscillator tube is of a larger sort, such as the UX-852 or the UV-204A we must use the same sort of tube as a modulator. Naturally such a tube cannot be operated directly from the modulation transformer; therefore we must put a stage or two of audio amplification in between to boost the gain to get a decent percentage modulation. Any good audio amplifier can be used. One has only to remember that the microphone can operate a 112A tube very nicely but that its plate current is a bit high for the average audio transformer; therefore the 201A is a good first tube when used with 90-135 volts and the appropriate bias. The second tube may be a 171 or a 210 and the third tube a 210 or an 852. In each case the last tube should be fed by the next smaller tube, but one can stand a jump from a first-stage 201A to a second-stage 210. Biases are in general a bit higher than for ordinary amplification and things are improved all around if there is a control in the shape of a 500,000-ohm Frost rheostat across the secondary of the first audio transformer. If at any point in the circuit it seems not possible to find a transformer to fit the job one can always rig up an impedance-capacity-impedance coupling as shown at E. The iron core choke in the B lead must be designed liberally enough to carry the plate current of the tube and have an inductance of at least 6 henries, while the condenser at its base should have a capacity 1 or 2 mfds. The grid choke going to C- can be almost anything, since the current is small. An audio transformer primary or secondary will serve if left on the original core.

STARTING THE OSCILLATOR

BEFORE the modulator is connected to the oscillator the latter should be working properly. This is easily found out by touching almost any part of the tuned circuit with an Eversharp pencil (advt.) while holding on to the metal parts of the pencil but staying well clear of any other metal work whatever, *especially* any electrical circuits. If the tube is oscillating the characteristic fizzing will appear at the point of the "lead." A bit of metal such as a screwdriver will serve if nothing better is available. The bare finger will do but takes time to heal.

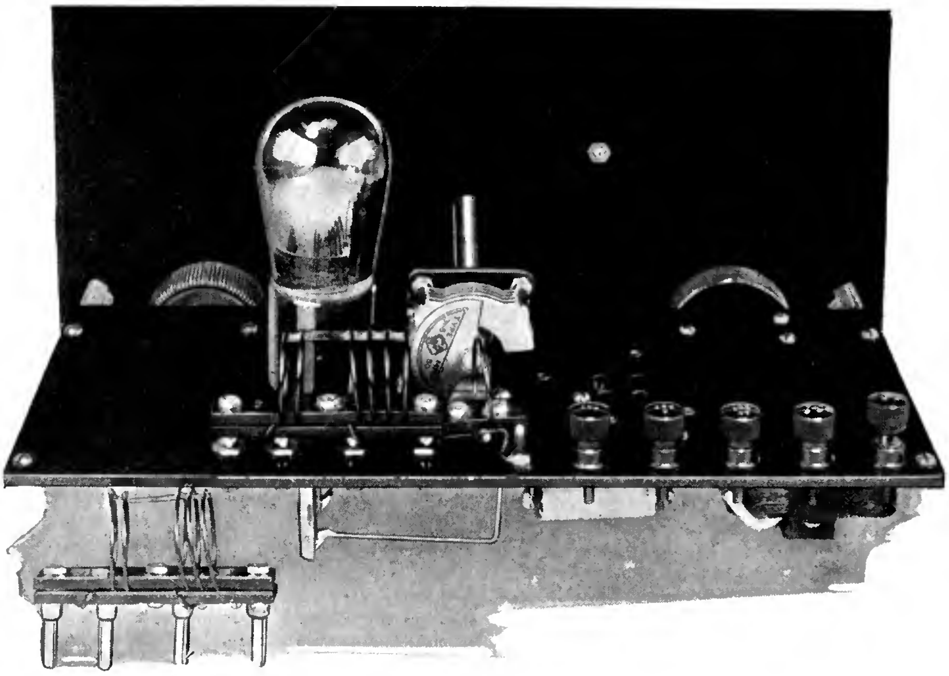
If the tube refuses to oscillate it can frequently be caused to start by changing the points at which RFC_1 and RFC_2 are connected to the tuned circuit, or by changing these chokes themselves or backing them up with other chokes. If this does not do the work one may change the grid bias or temporarily shift the adjustment of C_1 to a higher wavelength. Usually 5-meter oscillators using a UX-210 or a UX-852 give little difficulty. In fact the 852 was designed for just such work.

Having the oscillator in operation one next adjusts for reasonably steady operation and then with the aid of a General Radio 5-meter wavemeter gets the wave right. The further adjustments must wait until the receiver is ready, though we may get the sending antenna up meanwhile. Figure 2 shows some suitable antennas of which the types shown for the Phelps station and the West station are simplest and therefore recommended as desirable for the beginner in 5-meter work. One can gauge the proper length for any antenna system shown here or elsewhere by remembering that for each half-wavelength we will need roughly 100 inches of antenna. Thus the West antenna system must be about 100 inches long minus something to permit use of a coupling coil, while the Phelps arrangement can have almost any convenient length if a little loading, consisting of a few turns of wire, is done at the base. A length of 500, 700, 900 or 1100 inches works out well. The work at 2EB has been done to a large degree with the last of these lengths. In any case one *must* keep the antenna well away from things—trees, wires, hanging flower baskets, etc.—for absorption is severe at 5 meters. Depending on the combination chosen, one tunes the sending set up by setting the primary wavelength, i.e. the "tank" circuit, correctly with the General Radio wavemeter and then adjusting the antenna tuning condenser or cutting pieces off the antenna until the proper wavelength is obtained. In the Phelps arrangement in Fig. 2, one cannot well climb the mast to cut pieces off the antenna, so the adjustment is made by resetting the sending set condenser, C_1, and by using a loading coil of the proper number of turns at the base of the antenna.

When the lamp in the antenna glows steadily or the meter returns to the same reading promptly each time the plate supply is closed we are done for the time and can move on to the receiver.

THE RECEIVER

IT IS perfectly possible to build a 5-meter receiver with a stage of r.f. amplification using the UX-222 screen-grid tube, but the result is a receiver with two tuning controls, and until



A MANUFACTURED 5-METER RECEIVER

This receiver is of the detector-audio type, and is made by Parmeter Products, of Lansing, Michigan

one has a little practice in 5-meter reception and has gotten the sending set steadied up such a set is of little practical value because of the difficulty of following the transmitter wave—or finding it initially.

If radiophone is to be received the best device is certainly the double-detection receiver, and as second choice the regenerative detector with audio amplification, to which the stage of 5-meter r.f. may be added later. The perfectly commonplace circuit of such a 5-meter set was shown in the August RADIO BROADCAST article.

For c.w. reception we have a much more powerful tool in the form of the double-detection receiver which is shown in diagrammatic form in Figure 3. This consists simply of an oscillating detector ("autodyne") followed by an i.f. amplifier and a second detector with a single stage of audio. To secure a beat note from the c.w. signal there is provided a long-wave (intermediate frequency) heterodyne which beats upon the intermediate frequency. This heterodyne may be removed and a 5-meter heterodyne put in whereupon the set becomes suitable for 5-meter phone work. The first detector in such a case is left regenerative but not oscillating. However as it stands the set can receive phone in a somewhat "chewed" manner by careful adjustment of the first detector and removal of the tube from the heterodyne oscillator socket.

A further improvement is to replace the i.f. amplifier shown in Fig. 3 by a single UX-222 tube with a band-pass filter either before or after the UX-222.

MAKING THE RECEIVER WORK

THE troubles of a 5-meter receiver are those of any regenerative receiver or double-detection receiver plus the additional job of persuading the tube to oscillate without howling at 5 meters. The solution of this begins in making the receiver oscillate at all, and ends in eliminating the yelling. Usually it is easiest to start at about 7 meters, guessing at the proper coils, and then work down gradually to such dimensions as mentioned in connection with the receiver. Do not take the dimensions too seriously since such a trifling thing as a change in the make of socket may demand an entire turn to be taken off the coil. It is therefore a matter of "cut and try," with constant attempts to find a click or thump on the General Radio wavemeter by turning its dial slowly while it is held near (1" to 1') the tuned system and the phones are worn around the neck or otherhow far enough removed from the ears to prevent damage from a sudden savage scream. Changes in the tickler diameter, number of turns and location, together with alterations in the grid leak and filament current will finally produce a combination which can be taken in and out of oscillation quietly and at the same time has the proper range of tuning. It is well to spend an evening or two in getting this strictly right, after which the regeneration control condenser, C_2, should be left severely alone to prevent changes in calibration. Use the rheostat, R, to control the regeneration thereafter. In general it will be found best to use a tickler (L_2) which is rather close to L_1 and has turns between one half and three quarters of the diameter of L_1 made of a wire fine enough to handle easily when making changes but not "floppy." Both L_1 and L_2 should be substantially secured into position to avoid vibration noises. On the other hand the UX-112A tube must be mounted in a springless socket set on sponge rubber and fed by wires of the greatest softness, such as small bare or silk covered single strands of No. 30. These wires must be kept mutually apart since changes in their separation will cause noise and loss of signals. The filament wires need not be handled so carefully, but the grid and plate wires should depart at something like right angles from each other so that motion will not change their separation greatly. The grid leak and condenser may be mounted on the tuning condenser with a flexible lead to the socket, or on the socket with flexible leads to the tuning condensers. Leaks of a value above 8 megohms or below 1 megohm will work about equally well.

THE RECEIVING ANTENNA

HAVING caused the receiver to oscillate decently and smoothly we may now connect it to an antenna and see if it will continue to perform decently. Here we find from experi-

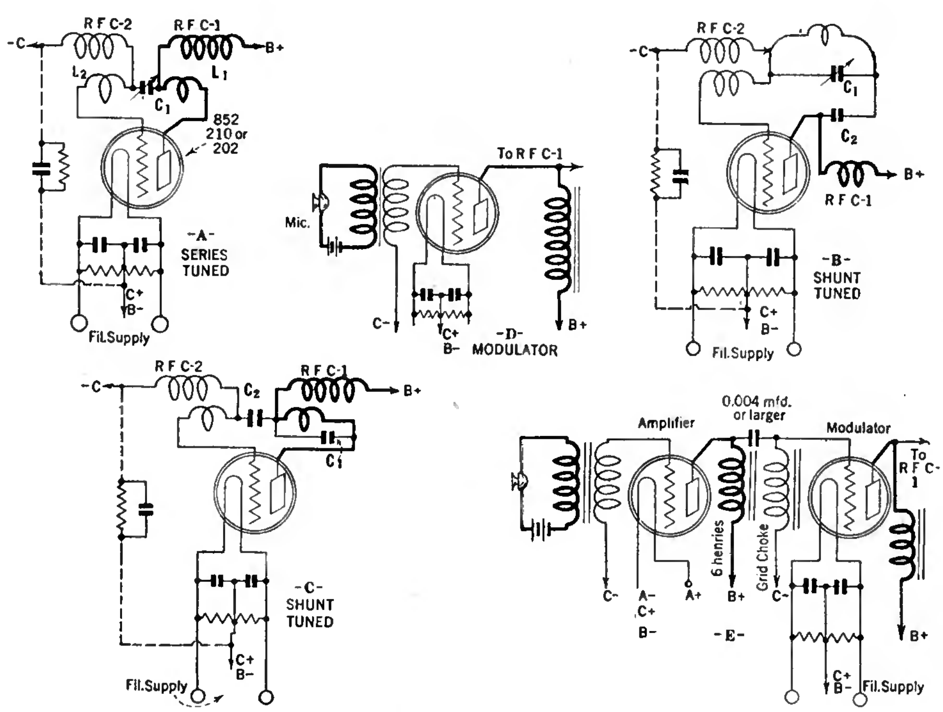


FIG. 1. TYPICAL TRANSMITTING CIRCUITS

All these circuits are of the ultraudion type. They operate smoothly after the chokes have been made correctly. As a starter these may be wound with No. 36 d.s.c. or s.c.c. wire spaced slightly on a ¼" form about 2" long. Sometimes a foot of small wire stretched out straight is almost as good. The center taps consist of double 100-ohm resistors with each half shunted by a capacity of about 0.001 mfd. The filament leads may be choked to advantage outside the diagram. For the tuning circuit, L_1, L_2, one may start with a total of 3 turns of 3" diameter in circuit A and a condenser, C_1, of 100 mfd. maximum. For circuits B and C the capacity, C_1, need not be above 25 mmfd. and the entire inductance from grid to plate need not be over a foot long. C_2 in B and C can be anything around 200 mmfds., capable of withstanding the plate voltage. Make good connections. Ordinary grid leaks make trouble and a grid leak and condenser consisting of two aluminum wires immersed 1" in water is a good thing to use. Changes may be made; the inductance of A may be a single turn 10" across. The chokes in these diagrams are not coupled to the tuning coils.

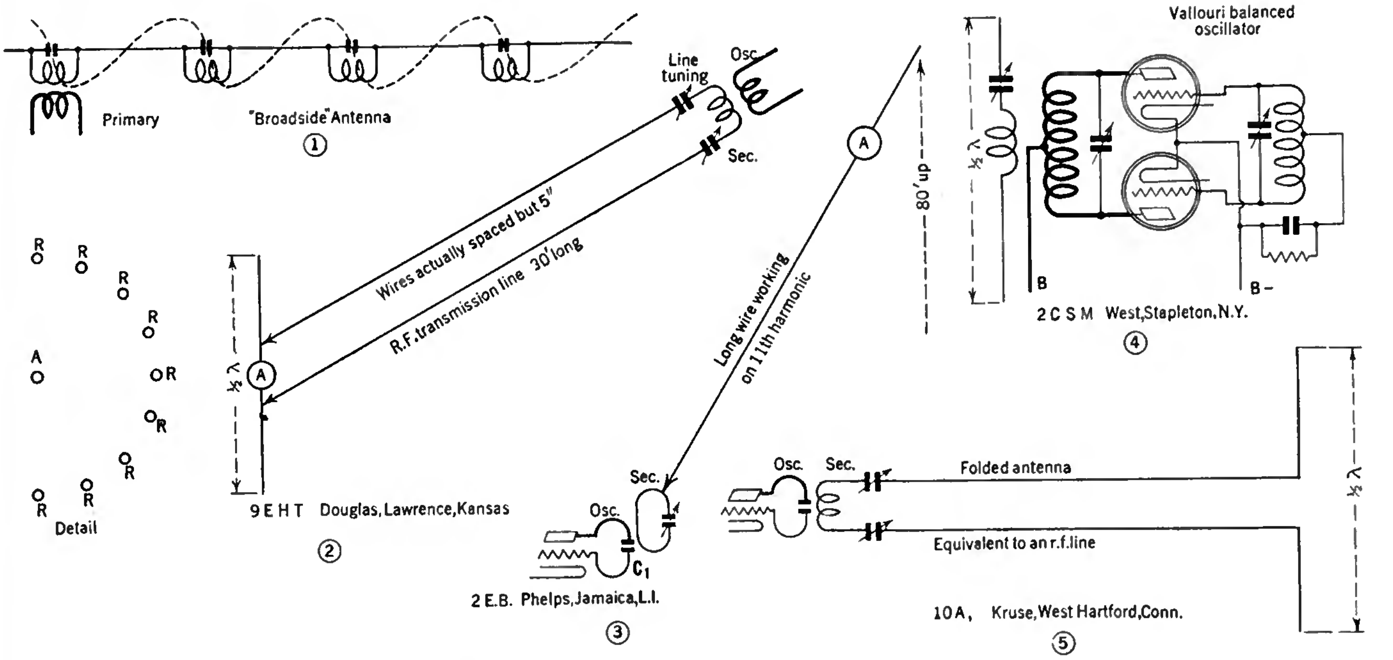


FIG. 2. TRANSMITTING ANTENNAS FOR 5-METER WORK

The Douglas antenna was equipped with the feeder system shown in the diagram to permit its erection a long way from the badly screened station. The "detail" shows a cross-sectional view of a reflector system occasionally used with this antenna. The circle A represents the antenna and the circles RRR represent reflector wires parallel to the antenna and arranged in an approximate parabola. The number and placement of the wires, R, was varied. The whole arrangement can be laid on its side to become a horizontal system.

The West antenna is a normal ½-wave antenna with a coupling and tuning system at its center. The condenser needs but two plates. The system is roughly 90 inches long, counting the coil length. The balanced Vallauri oscillator needs no r.f. chokes.

The Phelps antenna is voltage fed at one end by a tuned circuit coupled to the oscillator. The antenna ammeter, A, is 50" from the high end.

The "broadside" antenna consists of a series of 100" half-wave antennas connected by 5-meter tuned circuits. All of the half-wave sections operate almost in phase and give broadside transmission almost like that of Marconi's beam stations.

In all the diagrams "osc" is the oscillator as shown in Fig. 1. In all cases the inductance and capacity in the secondary circuits must be such as to tune to 5 meters.

ence that a long wire such as is normally used for broadcast reception is as good as anything. It may be connected to the coil, L_1, as suggested in the diagram of the double-detection receiver (Fig. 3) or may be given a separate primary. There seems to be little choice. The antenna series condenser, C_3, when used, consists of a "vernier" condenser with all but one fixed and one movable plate removed. If the attachment of the antenna to the set stops oscillation one may be sure that the antenna is too closely coupled. It should then be clipped on nearer the filament end of L_1, the setting of C_3 made smaller, or the primary coil (if any) put farther from L_1.

RECEPTION AND TRANSMISSION

HAVING the apparatus all together with some current in the sending antenna and some sign of proper action on the part of the receiver, we are ready to try communication by radio to supplement the letter communication that has previously taken place with other 5-meter experimenters.

Before going on with this it is well to make sure of the thing first preached about—that the set really turns out a signal that it is possible to make head or tail of. To do this the sending set is put into action with some kindly neighbor or friend to punch the key or talk into the "mike" and the receiver is set up in another part of the house or perhaps in the front yard. The friend or neighbor had better be warned that he is in for a session of several hours and must not get impatient at the long silence that opens the proceedings.

First of all the receiver will probably take a notion not to oscillate, though there is no real justice in this as it does not have an antenna at the moment. The second discovery is probably in the nature of noise in the receiver, or unsteadiness at the transmitter which must be remedied. However, be of good heart—it is far easier to do this than to go through the silly performance we staged. We did not take the precaution just suggested and when our first sets were in operation we spent a month or so in listening at 120 miles for signals that eventually turned out to be wholly in the Choctaw language.

Eventually the transmitter and the receiver will be gotten into decent shape and will agree to work on a sporting basis—half the time. Then one is ready to take the field.

WHAT CAN BE DONE AFIELD

BEFORE another transmitter is available to work with, one may do some very enchanting things near the station by wandering about with receiver, wavemeter and screwdriver, testing for the manner in which the radiated power is scattered about the vicinity—which is usually surprising enough.

These tests require the set to run while the owner is absent, and as the patience of the friend or neighbor was exhausted in the first tests one must make up an automatic key of some sort. C. H. West of station 2CSM created some sort of an affair from an alarm clock and a relay which made dashes for hours at a time and later drove a disc with the station call on it. He says it was not artistic but effective. Boyd Phelps at 2EB went to the opposite extreme and created a motor-driven key with a notched cam 18 inches across and half an inch thick, transmitting therewith the station call and the word "test." One need not feel at all guilty about such operation, or even about "laying a book on the key," *provided that* the thing is done outside broadcast reception hours, for there are not enough 5-meter men about to worry over.

Having the set operating under automatic keying one may first take the screwdriver or the metal-shell pencil (not an advt.) and go about the house testing the lighting sockets, water faucets and other metal objects for the presence of r.f. Usually it will be found. This effect should be cut down as far as possible by getting the sending set clear of all wiring, including that in the walls. When the pencil test or screwdriver test does not reveal r.f. about the house try opening the circuit of the General Radio meter and putting in a flashlamp or a little Walbert "panelite" (60 mA, 5 volts) bulb. Tune the wavemeter to the transmitter and go about hunting along wires, pipes, etc., with it. Do not be too sure that you have removed r.f. when a "hot spot" disappears; it may only have shifted.

Having finally gotten as much r.f. as possible out of the pipes, wires, metal lath, bathtub and kitchen stove we may hope that some fair part of the power is in the antenna and departing from it. At about this point it will be found that this is so, at least to the degree that the antenna transmits the stuff to nearby houses and causes hot spots to appear in them. If one of them happens to be in the family radio receiver that receiver will not work when the 5-meter set is going—or rather it will produce loud grunts and growls in place of music. For this reason it was said that these things should be checked up and the busy broadcast hours avoided. In some cases the thing is bad—in others totally absent. Be sure.

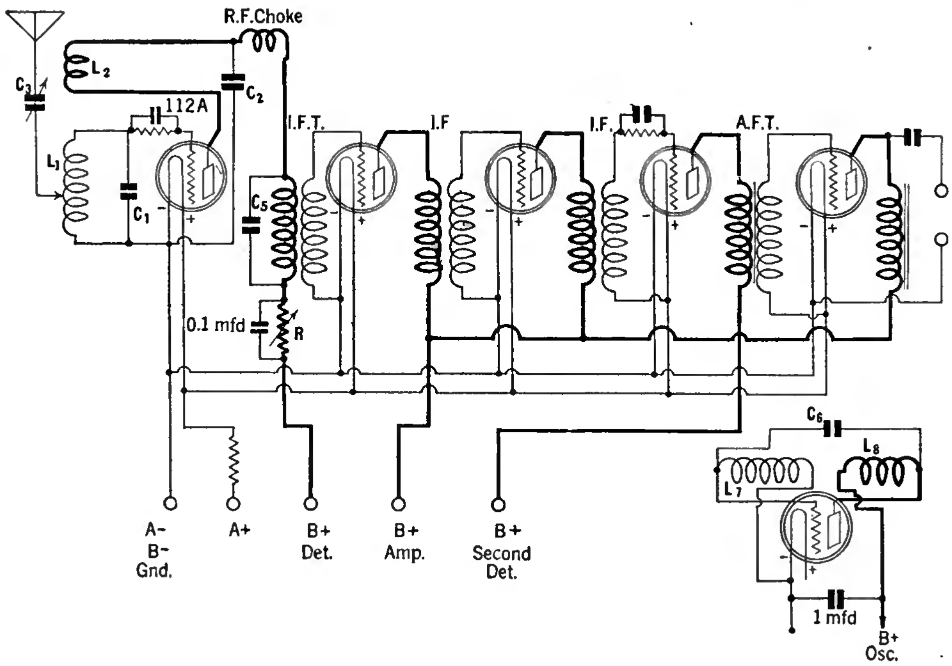


FIG. 3. A 5-METER RECEIVER CIRCUIT

This receiver, which is of the double-detection variety, is primarily a c.w. set, as explained in the text. It may be altered to a phone set by dropping off the heterodyne and adding a 5-meter heterodyne to beat with the incoming signal as in the more usual broadcast receivers. C1, C2 and C3 are trimmed vernier condensers with a maximum capacity of 15 mmfd. L1 consists of from 1 to 4 turns on a 1" diameter, depending on the rest of the circuit. C5 should not be over 0.0001 mfd., if used. Some primary turns may have to be removed from the first i.f. transformer to compensate for the effect of C5. The second and third i.f. transformers, I.F., will not need this. C6 is a 25-mmfd. variable condenser tuning oscillator coils L7 and L8, which are an i.f. transformer similar to the others. Work first without the oscillator and with a.c. plate supply at the transmitter, and then change the transmitter to d.c. and use heterodyne. The sensitivity may be improved by returning the i.f. grids to a potentiometer across the A-battery. A metal panel and baseplate are very desirable.

FARTHER AFIELD

NOW it is time to put the receiver into the family car and to go around the neighborhood exploring. Here each man may be his own guide and I will go no further than to show some of the local effects we have found around 2CSM, 2EB and 10A.

In Figure 4 are shown some curves taken near 10A to show that the 5-meter wave *signally* fails to act as had been predicted. It does not die off 100 yards from the station as we had been told by all authorities, but compares very nicely with normal waves. It does not, in fact, die off as fast near the station as does the 20-meter wave which we all know to be so effective at great distances.

Similar curves were run at 2EB at least 18 months ago with very similar results, but the data for these is not at the moment available to me. They are here mentioned because they brought out another very interesting point, which is to say they showed us that normal points would fall on the curve even though measured behind houses where bad screening had been expected. On the other hand points behind hills were weak, as one might expect.

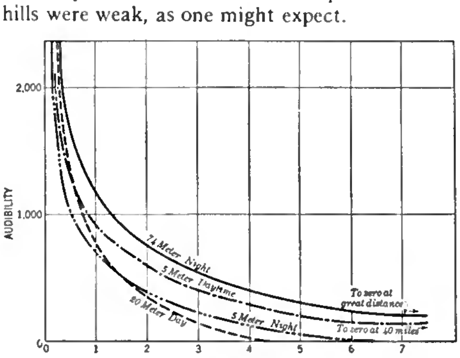


FIG. 4

When the effect of a hill in the line of transmission is investigated one finds effects such as shown in Fig. 5, which shows the effect of a certain round knob of a hill near Hartford. The shadow shape indicates the area in which the screening effect of the hill made reception weak or impossible, while the light lines are drawn in to suggest the general manner in which the wave fronts are deformed. Note the similarity to that of water ripples passing a rock.

A variety of curious effects can be observed. With a 160-meter signal one loses a great deal of intensity when the receiver is carried through a street crossed by an elevated railway structure. The 5-meter signal, on the other hand, cheerfully ignores the structure, probably because the openings in the structure are very large as compared to the wavelength.

Again, when passing under wire lines coming from the general direction of the transmitter one finds a very strong "bump" in the 160-meter signal and little or none in the 5-meter signal—which is rather difficult to explain.

Many such explorations were made in the radio flivver mentioned in the first article, likewise with various other cars. The intensities were measured and curves plotted from them. Reflector systems were tried and the general result obtained shows that the parabola does not seem to be the best reflector shape, also that the reflector wires are of best effect when not of the antenna length but a trifle longer.

DISTANCE EFFECTS

ALL of the foregoing is not spoken of to discourage attempts at long and medium distance work. On the contrary it seems that what has ailed the 5-meter game is that there has been entirely too much short-distance work and too little attempt at long distance work.

Not only must it be remembered that in turn the 200, 100, 40, 20, and 10-meter waves have defied theory and been of practical use, but in addition there has already been not a little reasonably good long distance 5-meter work. Of course we know that 20-meter work has limitations as to time and distance, and we suspect that this is even more the case with the newer 10-meter wave. Hence it is quite possible that the 5-meter wave will show its usefulness at a distance under such restricted combinations of time, weather, and distance that we may not utilize these possibilities at all and confine it to local "beam" work only. However, in view of the limited work that has been done, the few failures do not warrant dropping the wavelength.

For those that care to try it there is another possibility. Somewhat over a year ago the *Jahrbuch* described some Telefunken experiments in which various short waves were projected upward by a huge reflector that could be rolled about on the German field which acts as an equivalent for the WGY "radio-acres" at Schenectady. Some very high angles were found successful for transmission to Buenos Aires. Norvell Douglas thereupon suggested a test with the same device at 5 meters and the possibility that a slightly diffused beam shot vertically or nearly vertically upward might have a rather good chance of covering a considerable area, no matter what the exact height of the reflecting layer, if there is one that works under those circumstances at 5 meters. A reflector for the purpose is still waiting at 9EHT until we can try the thing fully, which must of necessity be delayed until early September, since Douglas is at present engaged in some ¾-meter work at General Electric's research laboratory.

WHAT IS LEFT?

WE HAVE, then, a number of interesting possibilities to back up our interesting actualities. One who has been at this 5-meter affair for quite a considerable while assures you that the working out of these possibilities is an enchanting game, made doubly so by the fact that everyone else has not done the same thing 10,000 times. Suppose then that a few of us try this Telefunken-Douglas near-vertical or wholly vertical beam while a few of the rest of us build decent double-detection receivers and listen for them. There is room also for some "straight" receivers and transmitters such as have been suggested. Certainly there are too many one-way 5-meter contacts in existence to let the two-way possibilities go on in their present state.

I am willing to help as I may, which is to say I'm perfectly willing to answer letters if their writers will but recall that stamped envelopes with a return address greatly encourage a reply!

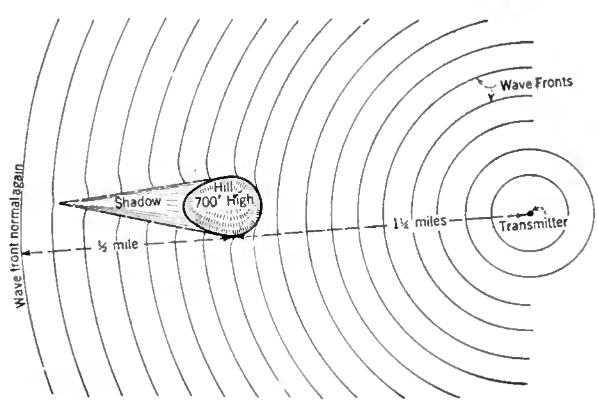


FIG. 5

AS THE BROADCASTER SEES IT

BY CARL DREHER

Broadcast Transmitters

IN THE May, 1928, issue of the *Proceedings of the Institute of Radio Engineers* Mr. I. F. Byrnes presents a paper on "Recent Developments in Low Power and Broadcasting Transmitters." Mr. Byrnes is a member of the staff of the General Electric Company, and his paper is a résumé of the recent work of the G. E. transmitter experts in this field. The latter portion is of particular interest to broadcasters.

The design requirements in modern broadcast transmitter construction are summarized by Byrnes as follows:

1. The carrier wave must be readily maintained within 500 cycles of the assigned frequency, and its frequency must not fluctuate with modulation.

2. The electro-acoustic characteristics of the equipment must be such that the output of the set is as faithful a copy as possible of the input. (The frequency transmission characteristic from microphone to antenna must be sensibly horizontal within the principal portion of the audio band.)

3. The circuits and tubes must be engineered so that the equipment will have ample overload capacity and modulation peaks will not cause distortion through "overshooting" at any point.

Illustrations of a 1 k.w. broadcast transmitter (ET-3633) are given in the paper. Normally this transmitter is built for operation on a frequency between 666 and 1200 kilocycles, although it may readily be modified for the other frequencies within the broadcast band. A condenser transmitter is supplied in the studio. The case of the condenser transmitter contains the first audio tube, which is of the UX-201A type. There follow in the audio chain one other UX-201A amplifier, a UX-210 amplifier, two UV-211 amplifiers and four UV-851 modulators. In the radio chain the tubes comprise a UV-211 as the master oscillator, two UV-211's as intermediate radio amplifiers, and one UV-851 in the output stage. A UV-211 is also supplied as an oscilloscope rectifier to indicate the percentage of modulation. The ratio of modulators to radio amplifiers (4:1) will not be a surprise to those readers who recollect the article on "Modulation" in this department for July, 1926, and the reference to Kellogg's "Design of Non-Distorting Power Amplifiers" in the May, 1925, issue of the *Journal of the A. I. E. E.* For any sort of deep modulation it is necessary to supply about as much plate power to the modulators as to the oscillators or power amplifiers in the modulation stage, and as a modulator normally takes about a quarter of the power drawn by the same type of tube delivering radio-frequency energy, the answer is obvious. In the 1 k.w. transmitter the design of which is being outlined the provision of four modulators in parallel results in a very low-impedance bank which, in combination with a good-sized speech reactor, retains the low audio frequencies and keeps the characteristic flat at the lower end.

The first three stages of audio amplification in the transmitter proper (following the UX-201A associated directly with the microphone and housed in the "bullet," as the cylindrical case of the earlier designs was called by the poets of the General Electric Company) are resistance-coupled. The condenser tube, however, delivers its output through a step-down transformer, so that the lead between the "bullet" and the set, being a connection between low impedance circuits, may be made reasonably long (a few hundred feet). The last 211 stage is reactance-coupled to the modulators. The third and fifth audio stages have volume control potentiometers on the inputs. When the input from a line is used to modulate the set the first audio tube is dropped out by means of a switch. The line, in other words, is expected to provide as much energy as the condenser mike plus two 201A tubes.

The radio-frequency chain of this transmitter starts with a master oscillator. Shielding is employed to stabilize the frequency, and the coupling of the successive radio-frequency circuits reduces harmonic radiation. There is no crystal control in this transmitter, however.

Power is supplied to the plates from a motor generator set comprising three units: the motor, excitor, and a two-commutator high-voltage generator. A separate two-unit motor generator supplies d.c. filament energy. The audio filaments are heated from a storage battery. These measures, with the addition of suitable filters, guard against noise.

The oscilloscope is similar to the oscillographs found in physical laboratories, except that it contains only one vibrator and the light source is an incandescent lamp instead of an arc. It is consequently unsuited for the taking of photographs. The operator, looking at the revolving mirror, sees a wiggling line the amplitude of which shows to what degree the carrier is being modulated. The rectified carrier supplies a reference amplitude, while the wiggling line is the audio component, likewise rectified. A loud speaker is also connected in this circuit, so that it provides both visual and audio monitoring of the radiated energy. Fig. 1 shows the connections schematically.

Sets of the ET-3633 type are in use at CYJ in Mexico City, and at Cornell and St. Lawrence Universities.

Design and Operation of Broadcasting Stations

21. WATER-COOLED VACUUM TUBES (*Part 2*)

IN GENERAL a broadcast transmitter has an efficiency of about 20 per cent. in terms of average carrier power in the antenna over power drawn from the a.c. mains. A transmitter rated at 50 kw. in the antenna, for instance, will take around 250 kw. from the power company. Most of this energy has to be carried off in the form of heat by the vacuum tube cooling system.

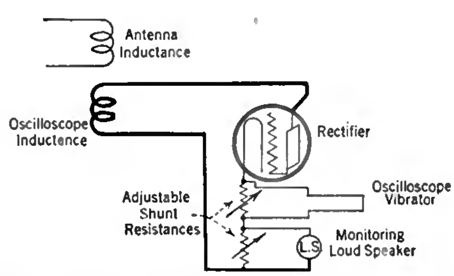


FIG. 1

The power so lost is naturally great in the case of the larger stations. The cooling systems of such installations are built to get rid of around 200 kw.—more or less of this capacity being used according to the power at which the transmitter is run. The total dissipation may be calculated in two ways, the results of which should agree. One method requires a knowledge of the total flow of water and the rise in its temperature owing to its contact with the anodes. In a specific example, let us assume a water flow of 150 gallons a minute and a rise in temperature of 5 degrees Centigrade, corresponding to 9 degrees Fahrenheit. A U. S. standard gallon weighs 8.33 pounds at 72 degrees Fahrenheit. For the accuracy of our calculation no correction need be made for another temperature. The water circulation is therefore 1249.5—let us say 1250 pounds per minute. Now, a B.T.U. (British thermal unit) is the heat required to raise the temperature of one pound of pure water one degree at 62 degrees Fahrenheit. In the case of this water system, therefore, we are carrying off, each minute, 1250 times 9, or 11,250 B.T.U. But from other relations we know that 1 kilowatt-hour equals 3415 B.T.U. One kilowatt-minute, therefore, would correspond to about 56.9 B.T.U. Dividing this figure into the value of 11,250 B.T.U. per minute secured above, we get 197.7 kilowatts as the total heat loss in the tubes. The same total should result if the individual losses of the various units are estimated electrically and added up. Roughly, the anode efficiency of an oscillator or radio frequency amplifier in a broadcast transmitter may be reckoned as 65 per cent. The anode efficiency of a modulator may be more like 30 per cent. Taking, for example, a tube with a nominal oscillator rating of 20 kilowatts, we may find it drawing a plate current of 2.0 amperes at 15,000 volts. Of this 30 kw. input to the plate only about two thirds will be converted into oscillating energy; about 10 kw. is heat loss. To this should be added the I^2R of the filament, which in the case of such a tube will correspond roughly to 1 kw. (about 50 amperes at 20 volts). The total heat loss of the tube may be taken as 11 kw., therefore. As a modulator, suppose that the tube draws a plate current of 0.5 ampere at 15,000 volts, the grid being biassed negatively about 500 volts. Of these 7.5 kilowatts, only 1.5 kw. may be transmitted as voice or tone energy, leaving 6.0 kw. as heat loss from the electrical input to the plate, to which must be added the former figure of 1 kw. for the filament, or 7.0 kw. in all. Similar calculations for the various tubes in the transmitter should result in a total equal to the loss indicated by the temperature rise of the cooling water.

The nominal rating of any vacuum tube, and the actual output which it is prudent to try to get from it, are two different things, and never more so than in the case of water-cooled tubes. It pays to underload them. This is not to say that the nominal rating is altogether a fiction. One balances output against reliability and life. A so-called 20 kw. tube, like the one the losses of which were discussed above, may deliver 20 kw. reliably enough for radio telegraph service, but in broadcasting, where extreme reliability is required, no one would think of taking more than 8–10 kw. out of it, as an oscillator or radio am-

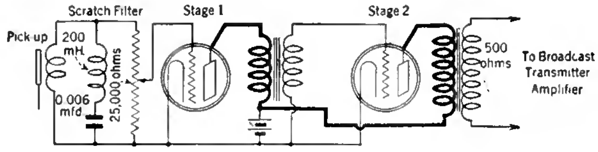


FIG. 2

plifier, or 1.0–1.5 kw. as a modulator. Even if an anode voltage of 15,000 is allowed in the instructions, it is likely to be found running at 10,000, with a plate current of less than one ampere; as a modulator it will be taking a plate current of a half or third ampere at the same lower voltage. Under those conditions it is likely to run eight or ten hours at a stretch, if the cooling suits it, without knocking out the breakers and leaving the listeners in silence, and to do this day after day. It may, in fact, do it for years; the skeletons of water-cooled tubes with 3,000–4,000 hours of useful service may be seen in museums. Some, again, are buried after 40 minutes. They all look the same when they are taken out of the crates.

The life of vacuum tubes may be prolonged if they are carefully handled. Of course, continuous water supply is a primary requisite and pressure- or flow-actuated relays are used to shut off the filament supply as soon as the water fails. When set adjustments have been changed, it is wise to resume operation at some low plate voltage corresponding to reduced power, so that undue stresses will not be set up in the tubes. Excessive vibration or rough handling of any kind should be avoided. Dropping tubes into water jackets for an inch or so, knocking off grid seals with wrenches, and similar accidents, should be as rare as announcers who shrink from publicity. Starting resistances for the filaments should be used to limit the first surge of current. The filament connections, carrying about 50 amperes, must be tight and clean, or heating at these points may cause burning and destruction of the leads. The grid and filament leads should not be so tight that any force is exerted on the walls of the tube, nor so loose that they may lie along the glass; the first condition may result in mechanical breakage; the second in puncturing following corona. Other such precautions in handling are more or less obvious. If they are not followed a water-cooled radio station can break a millionaire faster than the Street. Even if they are followed such outfits are not for the poor.

22. PHONOGRAPH PICK-UPS

ASIDE from the modulation of a broadcast station from a phonograph for program purposes, as commonly used in the smaller studios, this is about the only convenient method of running prolonged transmitter tests where music is required. Phonograph transmission by radio is, of course, nothing new. In 1917 I recollect seeing and hearing the radio telephone transmitter with which Dr. Alfred N. Goldsmith communicated from New York City with Dr. A. H. Taylor at the University of North Dakota so controlled, and probably this was not the first instance of such use of the electromagnetic pick-up. Of late years the development of the electric phonograph has made it possible to impress on a suitable radio transmitter quite decent acoustic material from wax records, a frequency range of from 100 to 4,000 cycles being covered without serious distortion. The film phonographs which, aside from their use in sound-motion picture work, are not yet commercially available, can probably do better; but this article, being of the same practical nature as the others in the series, is concerned only with reproduction from the common flat disc records.

A short bibliography of the subject, for those who wish to do a little reading in this field of electro-acoustics, is as follows:

Maxfield and Harrison: "Methods of High Quality Recording and Reproducing of Music and Speech Based on Telephone Research." *Journal of the A. I. E. E.* March, 1926.

Kellogg: "Electrical Reproduction from Phonograph Records." *Journal of the A. I. E. E.* October, 1927.

Millen: "The Electrical Phonograph." *Radio Broadcast.* May, 1927.

Millen: "Building an Electrical Phonograph." *Radio Broadcast.* June, 1927.

Wilson: "A Phonograph Amplifier." *General Radio Experimenter.* April, 1928.

Almost all the devices commonly used for transforming sound into electrical energy, such as the condenser and carbon telephone transmitters, may be used as phonograph reproducers, the actuating force being derived from the revolving record instead of from a wave in air. The most convenient commercial form has been found to be the magnetic type, which is substantially a small alternating current generator driven by the record. The operating principle is the same as that of the electromagnetic telephone transmitter, which does not happen to be common in American broadcasting. Many variations in construction are possible; Fig. 3 shows one in general use, so that it will be unnecessary for readers to take their own electric phonographs apart. The magnetic field is provided by a permanent magnet. An armature is free to move within a small amplitude in the air-gap. The movement of the needle as it is carried along the record groove causes the armature to wiggle about its pivot. The system is so designed that the motion of the armature is proportional to that of the needle. A coil of fine insulated wire surrounds the armature. The magnetic flux through this coil varies slightly as the armature vibrates. We might say that a small electromagnetic ripple is superimposed on the constant magnetic field supplied by the permanent magnet, like the commutator ripple of a d.c. generator. The result is, of course, that a corresponding e. m. f. is generated in the coil. This may be applied to the grid of a vacuum tube and amplified.

The type of reproducer thus sketchily described works with records having laterally cut grooves, as distinguished from grooves of varying depth. If suitably supported it would, of course, give some sort of reproduction with the latter style of record also. A telephone receiver with a needle soldered to the diaphragm will reproduce sound from a phonograph record, but the reproduction will not be faithful. In other words, the principle of the device is simple, but high quality output requires much finesse in design, as is shown in Kellogg's paper.

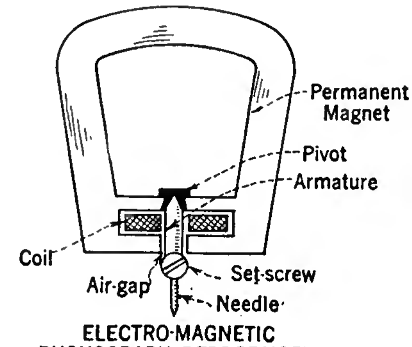


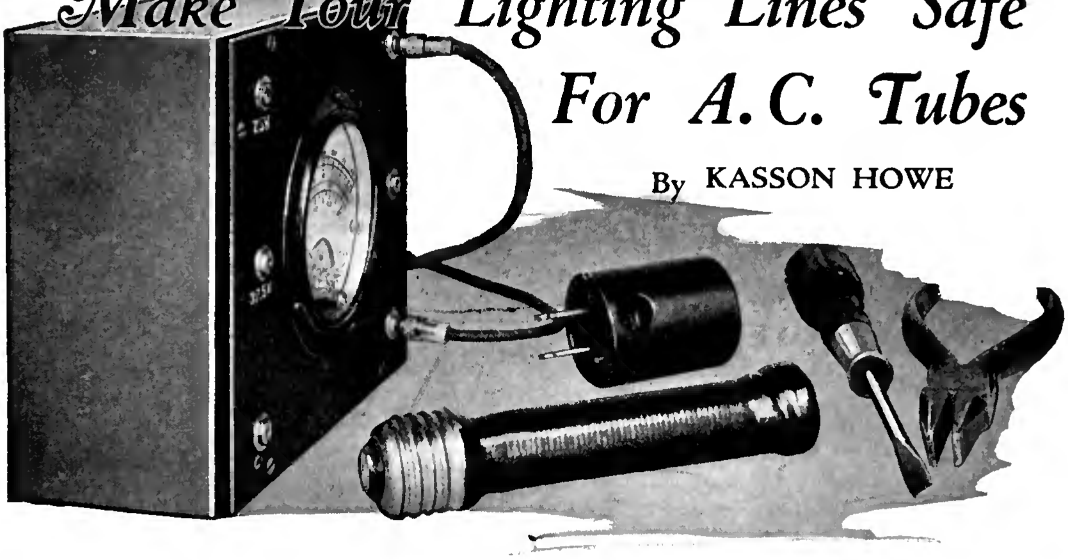
FIG. 3

The output of magnetic phonograph reproducers varies, naturally, with the make, type of record, etc., but in general it is at such a level that two stages of amplification will bring it up to loud speaker volume. Assuming this to require a level of plus 12 TU at the speaker terminals, and calling the amplification 28 TU, we find a reproducer output of minus 16 TU. Probably a level between minus 10 and minus 20 TU will include the makes and conditions usually encountered in practice. In other words, the phonograph reproducer is good for an output level considerably greater than that of a high quality carbon transmitter, but not as high as that of a commercial telephone transmitter (zero level) in which, however, quality is sacrificed to sensitivity.

Fig. 2 shows schematically a suitable amplifier circuit. The output of the generator is such that it will not overload a tube of the 199 size, so that this may be used for the first stage, if desired. The second tube should be of the 171 or 210 size. In a broadcast station it is often considered better practice not to use smaller tubes than the 5-watt (oscillator rating) size, so that an amplifier of the 17-B type, using two 5-watt tubes, may be associated with the phonograph reproducer. In Fig. 2 the volume control is a 25,000-ohm potentiometer. These instruments are now made very cheaply and conveniently by the use of transverse wires imbedded in a carbon composition ring. A scratch filter is also shown. It happens that the noise made by the needle as it rides along the surface of the record has some of its more annoying components in the neighborhood of 4,500 cycles, so that a series circuit tuned to about this frequency will by-pass a good part of the surface noise—and also any frequencies above 4,000 cycles which may be present in the output of the reproducer. But usually it is better to sacrifice this section of the band in order to get rid of the background noise.

Inasmuch as input to the preliminary amplifier of a radio transmitter, from the wire line connecting the transmitter with the studio, is commonly at a level of about minus 10 TU, a magnetic phonograph pick-up of the type described, with a two-stage amplifier including a gain control, may readily be substituted for the line when local test modulation is desired. Likewise at the studio the same combination may be used in place of microphone pick-up, both the gain of the studio amplifier and the amplifier associated with the pick-up being kept low. With a medium gain setting the phonograph amplifier will deliver energy at a suitable level to the line, if that is desired.

Of course the 25,000-ohm volume control across the input of the phonograph amplifier is not the only type which may be used. A standard high resistance (about 400,000 ohm) interstage gain control is just as suitable. But if a line (500: 500 ohm) amplifier with such a gain control is connected to the phonograph pick-up care should be taken to omit the input transformer, so that the pick-up goes directly to the grid of the first tube. Five hundred ohms is too low for connection across a device with the impedance of most magnetic pick-ups.



Make Your Lighting Lines Safe For A.C. Tubes

By KASSON HOWE

The use of a fixed resistor to prevent a.c. filament overload from high line voltage is valuable when the line voltage is uniformly too high. This method does not give real regulation, inasmuch as it cannot be varied to meet irregular line voltage variations, but it does provide insurance, when the proper value of resistance is selected, against maximum line voltage overloads. It has the advantages of inexpensiveness, ease of installation, and the fact that once installed the resistor needs no further adjustment. Where the line voltage is variable, more accurate adjustment is required, and here a power rheostat may be used. This article gives the necessary data for determining line voltage variations, choosing the correct value of resistors or rheostats, and making the installation.

—THE EDITOR.

A MAN who lives in New York City paid over five hundred dollars for an a.c. radio set. It was one of the best known makes, and he looked forward with more than a little anticipation to the pleasure and entertainment it would give him. He bought a high priced set because he wanted real tone and power, single dial control, a.c. operation, and most important of all, freedom from those minor troubles sometimes associated with radio. The set had that perfection of construction and attention to detail which gave every assurance of long and uninterrupted service.

Imagine his amazement and disappointment when two sets of a.c. tubes blew out during the first month of operation. It seemed incredible. Like many other a.c. set owners, he denounced the new type of tube as a costly failure, and criticised the manufacturer and dealer from whom he had purchased the set in no gentle terms.

To some degree he was justified, for certainly the user cannot be blamed for tube failure, no matter what the cause, unless he has actually tampered with the receiver. Probably the dealer who sold the set had to stand most of the gaff; it would, therefore, seem advisable for dealers to become familiar with the method described in this article of compensating excessive line voltage, and seriously consider the installation of such devices when the receiver is first placed in operation at the customer's home. This entails some additional expense, but will probably result in fewer calls for service and fewer dissatisfied customers. One can't, unfortunately, bring dead a.c. tubes back to life, but there are means of preventing trouble from short tube life before it ever starts. The work involved is simple, and can be done by anyone.

Consider that a.c. tubes cost anywhere from $3.00 to $6.00 apiece, depending upon the type, and it will be seen that one set of tubes blown out or with life shortened means considerable expense. And what is more to the point, it is needless expense. When an initial check on incoming line voltage shows a figure above that specified by the manufacturer as the safe maximum limit for the operation of the set, it is little short of sheer extravagance to neglect the fact and place the receiver in operation without doing something to reduce the line voltage.

An accurate a.c. voltmeter, with range from 0 to 150 volts, is the only apparatus needed to make the initial test. For practically all factory-built a.c. sets sold to-day, any figure above 115 volts should be considered excessive unless otherwise stated by the manufacturer. If the reading is above 115 on the a.c. voltmeter, it will certainly be cheap insurance for the a.c. tubes in the set to compensate excessive line voltage. A 10 per cent. increase in filament voltage may cause as much as a 50 per cent. decrease in tube life. This means, obviously, that the tube budget over the course of a year may be double what it would be if proper precautions were taken.

The extra 5-volt range from 115 to 120 volts should be regarded as dangerous and worthy of attention from the a.c. set owner. Probably a majority of a.c. sets in New York City operate at a figure somewhere within these limits. The trouble that has been experienced with short a.c. tube life is proof enough in itself that any reading of line voltage above 115 calls for attention if one wants to be absolutely safe.

Where line voltage on accurate measurement is over 120 volts there can be absolutely no question of the need for the correct value of resistor to compensate the extra voltage, which is dangerous beyond a shadow of doubt.

HOW TO GO ABOUT THE JOB

THE measurement of line voltage, as mentioned above, should be done with a high grade a.c. voltmeter. The other bit of needed information is the primary current rating of the receiver in amperes, which will in practically all cases be found upon the name plate inside the cabinet, on the power unit, or on the name plate of the power supply transformer which supplies A, B, and C voltages to the receiver. If you fail to find this after careful inspection, write to the manufacturer of the set, asking him for the primary current rating of the particular model in question.

Having the accurate line voltage figure and the current rating of the receiver, it is now an easy matter to select the correct value of resistor to reduce line voltage. Table 1 lists the current in amperes drawn by various kinds of re-

TABLE 1

FIXED RESISTORS FOR LINE VOLTAGE CONTROL

Current in Amperes Drawn by Receiver	*These Resistors Will Reduce the Voltage Across the Receiver from the Voltages Shown to 110 Volts*										
	2.5 Ohms	3.5 Ohms	5 Ohms	7 Ohms	10 Ohms	12.5 Ohms	15 Ohms	22 Ohms	31 Ohms	45 Ohms	62 Ohms
	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage	line voltage
0.25						112.5	113.0	114.3	116.3	119.2	122.7
0.50				112.7	114.0	115.1	116.1	119.0	122.7	128.7	136.0
0.75			113.0	114.2	116.1	117.5	119.2	123.6	129.4	138.1	
1.00		112.7	114.0	115.6	118.2	120.2	122.2	128.2	136.0		
1.25	112.5	113.5	115.0	117.1	120.2	122.7	125.2	133.1			
1.50	113.0	114.1	116.1	118.5	122.2	125.5	128.7				
1.75	113.5	114.8	117.1	120.0	124.3	128.2	131.9				
2.00	114.0	115.6	118.2	121.5	126.5	130.8					
2.25	114.5	116.5	119.1	123.0	128.7						
2.50	115.1	117.1	120.2	124.3	130.9						

TABLE 2
CURRENT DRAINS FOR TUBE COMBINATIONS

Combination of Tubes	*Primary Current Rating (amperes)*
2, 3 or 4 226 type tubes 1 227 type tube 1 171 type tube 280 or Raytheon Rectifier	0.25
3 or 4 226 type tubes 1 227 type tube 2 171 type tubes (push-pull) 280 or Raytheon rectifier	0.45
3 or 4 226 type tubes 1 227 type tube 1 210 type tube 281 rectifier	0.50
3 or 4 226 type tubes 1 227 type tube 2 210 type tubes (push-pull) 2 281 rectifiers	0.75
2, 3 or 4 226 type tubes 1 227 type tube 1 250 type tube 2 281 rectifiers	1.00
2, 3 or 4 226 type tubes 1 227 type tube 2 250 type tubes (push-pull) 2 281 rectifiers	1.25

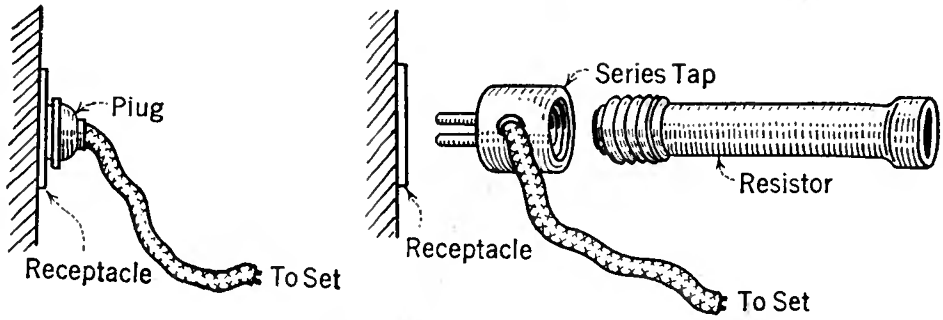


FIG. 1

At the left is an ordinary plug-in connection to an a.c. line: At the right is the method of installing a power resistor of the Edison base type in series with the receiver supply transformer, by means of a series tap. An ordinary power resistor of the correct value may be used, but does not make as neat a job as that made with an Edison base type of resistor

ceivers, a number of line voltages above 110, and the value of resistors needed to reduce excess incoming voltage to 110 volts—a safe figure for use with any commercial a.c. set.

Take the case of a receiver with a primary current rating of 0.50 amperes and a known line voltage of 119 volts. Checking on the table we find that a resistor of 22 ohms will reduce the excessive line voltage to a safe figure.

Another common current drain, usual with modern receivers using 210 or 250 type power tubes, is 1.25 amperes. Suppose the line voltage reads 120.2. Checking on the tabulation in Table 1 it is readily seen that a 10-ohm resistor will do the work of stepping the excess voltage down to 110, the safe figure.

If the set is designed for a normal line voltage of 115 volts, instead of 110, subtract five volts from the actual measured line voltage, and use the result as the line voltage in using the table.

Power resistors with Edison bases suitable for screwing into ordinary light sockets and floor receptacles are now on the market, and are particularly handy for this work. Type EB Ward-Leonard Vitrohm resistors and type 997 Aerovox Pyrohm resistors are of this type, and may be obtained in a wide range of resistances.

Having selected a resistor of the correct rating by reference to Table 1, the work of utilizing it is a matter of ten or fifteen minutes at the most. Fig. 1 at the left shows the connection to the receiver from the wall outlet before the installation of the resistor. At the right are the revised connections, using a resistor of the Edison base type. A series tap, such as the Hubbell No. 7029, provides a convenient means of mounting the resistor, and has an opening at the side for the cord running to the radio receiver.

First remove the leads from the plug. Connect the leads to the series tap. Screw the resistor into the series tap.

CURRENT DRAIN OF KIT SETS

WHERE the receiver is built at home from a kit of parts, there is no quick way of getting the primary current rating as in the case of the manufactured set. Table 2 gives the current values computed for tube combinations used in most kit sets, and will prove of value in helping to determine the correct value of resistor for use with sets built at home. The combination of tubes is indicated at the left and the primary current rating at the right.

Knowing the primary current rating of the home built set and the value of line voltage, it is an easy matter to select the correct value resistor from Table 1 and apply it as described before.

REGULATION WITH POWER RHEOSTATS

THE information given above takes care of those cases in which the line voltage is excessive but *constant*. But what about those cases in which the line voltage is sometimes normal and at other times excessive? In such instances we cannot use a fixed resistor to take up the excessive voltage, but must use a variable resistor with a maximum value of resistance equal to or somewhat more than the resistance required to reduce the line voltage to 110 volts from the maximum value of line voltage encountered during the day. For example, suppose that with the a.c. voltmeter we measure the line voltage at various times during the day and find that it reaches its highest value at 11:00 P.M., at which time it is 125 volts. We must then use a variable resistor with a maximum value that will reduce the voltage for the set to 110 volts when the line voltage is 125 volts. If the receiver draws 1.0 ampere from the line, then, from Table 1, the required resistance is 22 ohms. Companies that manufacture power rheostats that can be used are mentioned in Table 3. [There are other methods of line voltage control, but they require more elaborate and expensive apparatus. These appliances do not fall within the scope of this article, but will be treated in a later one. In "Strays from the Laboratory," on page 259, will be found some information in regard to them.—*The Editor*.]

Fig. 2 shows how to connect the rheostat to provide adjustment of incoming line voltage. First determine the primary current rating of the receiver and choose the power rheostat most nearly suited to your requirements from the data in Tables 1 and 3.

Mount the rheostat at a convenient point, away from combustible material. Break one lead of the parallel cord running from the plug to the set, and attach the rheostat in the lead as shown in Figure 2.

Finally, adjust the rheostat until the voltage across the tube filaments is the minimum satisfactory voltage for tube operation.

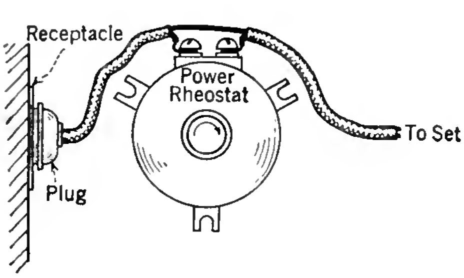


FIG. 2

The power rheostat is connected in series with the receiver power transformer by tapping one of the supply leads. The rheostat may be mounted in any convenient place, provided it is not near any combustible material, as the rheostat is required to dissipate considerable heat

TABLE 3
POWER RHEOSTATS FOR LINE VOLTAGE CONTROL

Name of Manufacturer	*Catalog Number of Rheostat*	*Remarks*
Ward-Leonard Electric Company	Vitrohm Rheostat No. 507-63 No. 507-59 No. 507-83	0-50 ohms for currents up to 0.9 amperes 0-20 ohms for currents from 1.0 to 1.75 amperes 0-12.5 ohms for currents from 2.0 to 2.5 amperes
Central Radio Laboratories	Centralab Power Rheostat	Available in suitable sizes to cover all cases.
Clarostat Manufacturing Co.	Power Clarostat	Available in three sizes: 0 to 10 ohms, 25 to 500 ohms and 200 to 100,000 ohms. The first two sizes are most useful for line voltage regulation.
Carter Radio Company	Hi-Watt Rheostat Type SW	Available in 19 different sizes from 1 ohm up to 500 ohms
Herbert H. Frost, Inc.	De Luxe Rheostat Series, 1800	Available in sizes suitable for line voltage control, from 2 ohms to 20 ohms

"Our Readers Suggest—"

A Simple Short-Wave Plug-in Coil

An old tube base makes an excellent winding form for short-wave coils. A set of coils, covering the entire frequency gamut between 15 and 200 meters, is easily made, and may be plugged into the standard UX socket. Small holes are drilled into the sides of the tube base (after removing glass and cement) to permit the passage of the wires, which are soldered to the socket prongs. The wire may then be wound tightly in the conventional solenoid form or, if the tube base is grooved on a screw cutting lathe, a space wound coil may be made.

If the threading tool is ground to a blunt point twice the diameter of the wire (generally No. 26 or 28), three wires can be wound in the same slot, as suggested in Fig. 1, with only a small increase in the distributed capacity of the coil. This is the familiar single bank winding.

Everett Freeland, Dowagiac, Mich.

STAFF COMMENT

A third or tickler coil can be wound, tied together with thread, dropped within the tube base, and secured with a bit of wax. All terminals can be brought out to the four prongs, in accordance with the circuit of Fig. 2—a parallel feed tickler feedback arrangement. The following table gives the correct number of turns of wire for satisfactory tuning in the short-wave bands with a 0.00014-mfd. condenser:

	No. of Turns		
Wave Band	*Primary*	*Secondary*	*Tickler*
20 meters	2	4	5
40 meters	2	6	10
75 meters	4	15	15

"Our Readers Suggest" is a clearing house for short radio articles. There are many interesting ideas germane to the science of radio transmission and reception that can be made clear in a concise exposition, and it is to these abbreviated notes that this department is dedicated. While many of these contributions are from the pens of professional writers and engineers, we particularly solicit short manuscripts from the average reader describing the various "kinks," radio short cuts, and economies that he necessarily runs across from time to time. A glance over this "Our Readers Suggest" will indicate the material that is acceptable.

Possible ways of improving commercial apparatus is of interest to all readers. The addition of an extra stage of power amplification, is a good example of this sort of article. Economy "kinks," such as the home-made power unit, are most acceptable. And the Editor will always be glad to receive material designed to interest the experimental fan.

Photographs are especially desirable and will be paid for. Material accepted will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—The Editor.

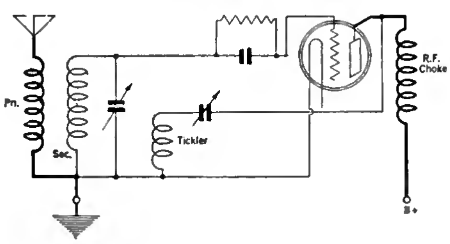


FIG. 2

A High-Resistance Voltmeter

A high-resistance voltmeter is essential for reading voltages across the output of a power supply unit. These instruments are generally rather expensive. The experimenter can occasionally save himself some money by converting a burned out thermo-galvanometer or ammeter into a high-resistance voltmeter. It is very unusual for the coil in a thermometer, such as the Weston No. 425, to burn out. Generally, it is the thermo-couple that is fused, rendering the instrument useless as far as its original purpose is concerned.

However, by removing the burned out couple, and placing a high resistance in series with the coil, an excellent high-resistance voltmeter will be had. It is necessary, of course, to recalibrate the scale to read in the correct number of volts.

A resistance of 100,000 ohms connected in series with the coil of a Weston type 425 instrument is about correct for full scale deflection at three hundred volts.

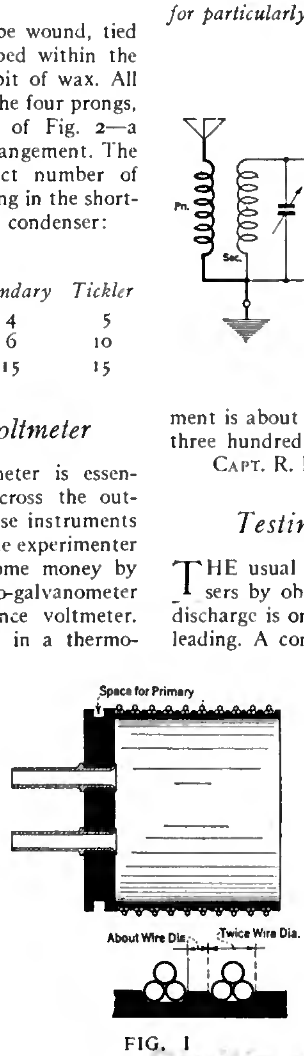


FIG. 1

Capt. R. B. Moran, Fort Monmouth, N. J.

Testing Filter Condensers

The usual method of testing filter condensers by observing the size of the spark on discharge is only approximate and is often misleading. A condenser that is in poor condition and which leaks badly will usually give a spark on discharge, leading one to believe that the condenser is in good shape. Anyone having a high-resistance voltmeter may use the following method with reliable results. The condenser to be tested is charged from a d.c. source, either 90 volts of B battery or the 90-volt tap on a power unit. After waiting an arbitrary length of time—one minute, for instance—the condenser is discharged across the voltmeter terminals and the "kick" of the needle noted. It may be necessary to repeat this test, the first operation giving the approximate scale reading; then, focusing the eye on this portion of the scale, the second reading may be obtained accurately. This will allow comparison between different condensers and will show up a poor one. Where a number of condensers are to be tested a clip connection will be found convenient. Care should be taken in handling the connecting wires to prevent the charge from leaking off through the resistance of the body before it is discharged across the voltmeter. When using a 90 volt charging source and a Weston voltmeter, 0–150 volts scale, having a resistance of 13,500 ohms, it was found that high-grade condensers in good condition gave a needle swing on discharge of about 5 volts for each microfarad of rated capacity.

D. C. Redgrave, Norfolk, Va.

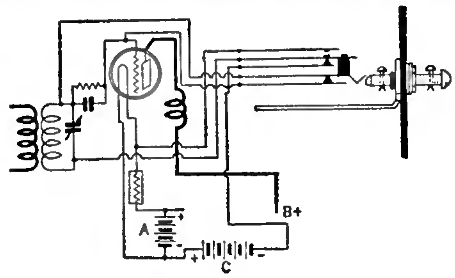


FIG. 3

A Grid-Plate Detection Switching Arrangement

Radio Broadcast has devoted considerable attention to the possibilities of plate or bias rectification in the detector circuit, stressing its advantages and disadvantages in comparison with the more conventional grid-condenser system. While the plate system reduces overloading on local stations, its lack of sensitivity does not recommend it for dx reception. A switching arrangement, permitting instantaneous change from one method of rectification to the other is obviously the ideal arrangement.

The writer has evolved the simple circuit shown in Fig. 3. A double circuit jack is employed to effect the change. The jack is mounted on the operating panel close to the detector tube, and functions in a push-pull fashion by means of bakelite rod ¼" in diameter, fitting the jack like a phone plug. Two small cotter pins limit the motion of the pin. (A Yaxley type VM switch may be substituted for the improvised jack idea.) The insulation on the jack should be of the best, and no paste or acid flux should be employed in making the soldered lead connections.

There is no difference in the tuning dial readings with either system of rectification. Any type of detector tube can be used, the bias battery varying between 1.5 and 6 volts, depending

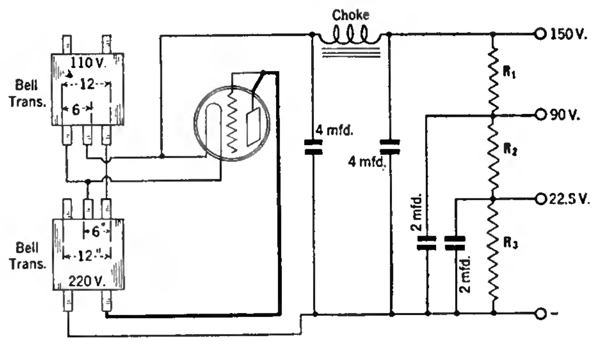


FIG. 4

upon the tube and the plate potential. These voltages should be varied until best results are obtained. Using a 201A tube, with 45 volts on the plate, a 4.5 volts C-bias will be correct.

JOSEPH A. GARDNER, Los Angeles, Cal.

A Cheap B Battery Substitute

THERE remain many receivers operated from B batteries due to the relatively high cost of power supply devices. A cheap but quite satisfactory socket power device can be built up in accordance with the diagram of Fig. 4, using two bell-ringing transformers having 6 and 12-volt secondaries.

The 6-volt winding of one transformer is used to light the filament of the rectifying tube (a 201A with the grid and plate strapped) while the 12-volt secondary is connected to the 6-volt winding of the second transformer, which will then output 220 volts from the primary, acting as a step-up transformer.

If the drain to the receiver is comparatively low, not exceeding twenty milliamperes, the primary of an audio-frequency amplifying transformer can be used as a choke coil.

The values of the condensers are indicated on the diagram. Resistors R_1 and R_2 are conveniently combined in a Duplex Clarostat, while R_3 is a fixed 5000-ohm resistor.

C. H. MEISSNER, Woodcliff, N. J.

Noisy Reception and Soldering Flux

THE soldering flux that is used in the construction of radio apparatus is generally considered a relatively inconsequential item in the building of a receiver, regardless of the fact that the use of rosin is recommended in the majority of constructional descriptions. As a service man whose endeavors are divided between the ailments of home-made and commercially built receivers, I do not think this consideration has been adequately emphasized. Too much publicity cannot be given to the detrimental effects of the average soldering flux.

Unnecessary radio noises form fifty per cent. of radio troubles, and in my own experience no less than nine out of every ten cases of noise can be traced directly to the use of an acid flux or paste. Static, poor connections, run down batteries, and antique grid leaks do not produce more than ten per cent. of the noise difficulties encountered in home-made receivers.

Nothing but rosin should be used to facilitate soldering. While the use of rosin necessitates careful scraping of joints, a very clean and hot iron, the extra trouble is more than compensated by permanently quiet reception.

Once noise has developed in a receiver an attempt, occasionally successful, can be made to clean the suspected parts, such as socket and transformer terminals and especially cracks adjacent to soldered connections. The terminals and surrounding territory should first be cleansed with an alkali, such as household ammonia. This in turn is washed away with water. A generous application of wood alcohol completes the ablutions.

This sometimes works—not always. As usual an ounce of prevention, in the way of rosin-core solder, is worth a pound of cure.

A. G. WOODWARD, New York City

A New Use for Burned Out Tubes

A BURNED out tube may be used as a neutralizing condenser in many r.f. circuits where the neutralizing capacity must be approximately the same as the grid-plate capacity of the r.f. tube. No connection is made to the filament. The difference in capacity between tube in the lighted and unlighted condition is so small as to be of no importance when used as a neutralizing capacity. A great advantage of this stunt is that no adjustment is required. Of course, the neutralizing tube will have to be of the same type as the r.f. tubes.

R. WM. TANNER,
Berkeley, Cal.

Mounting Single Hole Condensers With Special Dials

I ENCOUNTERED difficulty in mounting a single hole type of condenser with a Marco dial so that the rotor would turn without binding. This particular make of condenser would not fit the mountings that came with the dial. By adding an extra bracket to the frame, I was able to mount the condenser in a manner altogether satisfactory.

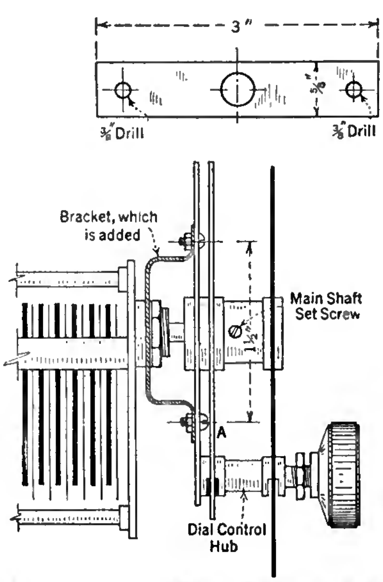


FIG. 5

This bracket is made of $\frac{1}{16}''$ brass strip $\frac{5}{8}''$ wide and 3" long. Two holes are drilled near each end with a $\frac{3}{8}''$ drill. The size of the center hole varies with the make of condenser. A $\frac{3}{8}'$ hole is drilled in the frame of the dial at *A*. A slotted hole comes drilled in the frame of the dial on the other side of the shaft.

The condenser is mounted on the bracket and the shaft inserted in the condenser hub as is made clear in Fig. 5. The bracket is then adjusted to fit and is bolted to the frame with two small bolts. The rotor is positioned so as to give the correct reading on the scale and the set screw is then tightened. The condenser is then ready for mounting on the panel of the receiver.

STUART E. MOODY, Rochester, N. Y.

Two Receivers From One Antenna

TWO radio receivers may be efficiently operated from one antenna if connected as shown at A in the diagram, Fig. 6. The size of the radio-frequency choke is not critical but it should have low distributed capacity. The one I am using is one inch in diameter wound for four inches with number 26 d. c. c. wire. Both sets must be of the non-oscillating type. Either common or separate ground connections may be used.

C. H. CAMPBELL, Bridgeport, Conn.

STAFF COMMENT

THERE are several other simple ways of operating two or more receivers from a single antenna. Different systems work better with different receiver combinations. Two additional systems are shown in B and C of Fig. 6, B being the better of the two methods.

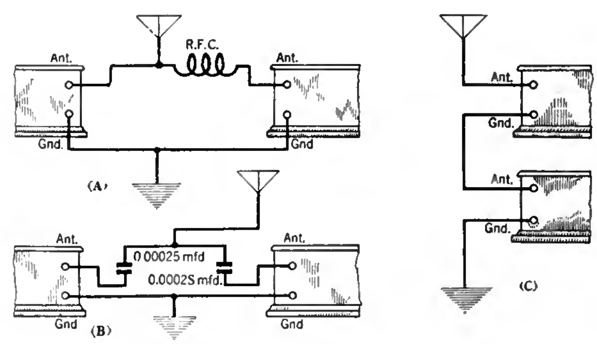


FIG. 6

An Extra Power Stage of Resistance-Coupled Amplification

AN ADDITIONAL stage of power amplification can be added to practically any receiver without touching the wiring of the set itself. A resistance-coupled power stage is assembled exterior to the receiver and is merely plugged into the output jack of the set (or wired to the output binding-posts, as the case may be). Additional connections are, of course, made to the A, B, and C batteries, while the loud speaker is plugged into the output of the power amplifier.

The power tube may be left in the receiver, or a lower power tube substituted for it, and the bias changed accordingly. The usual power tube arrangement prevails in the added stage.

ARCHIE H. KLINGBEIL, Ashtubula, O.

STAFF COMMENT

THIS additional stage of power amplification is not limited to resistance coupling, but may be employed with single transformer, impedance and push-pull circuits. In cases where the receiver is equipped with a choke coil output device, the coupling condenser and the resistor can be dispensed with, only the grid lead to the extra tube being necessary.

An external stage of amplification is not practicable on receivers already employing three steps of audio, or with sets provided with output transformers.

A Compact and Inexpensive "Trouble Shooter"

By EMIL REISMAN

SINCE the beginning of the radio art, trouble-shooting has been one of the bugbears of the engineer, experimenter, and novice. Modern broadcast receiving sets often break down when least expected, and many times at points which the designing engineer had considered invulnerable to anything short of earthquakes, lightning, or dynamite.

Most readers of this magazine have spent an evening attempting to locate the source of trouble in a balky or inoperative set. After prying out coils, transformers, condensers, and other apparatus; after testing them, and finally after several hours work, it may have been discovered that the trouble was due to a weak tube or poor connection. In itself the defect could probably have been remedied in a few minutes; but hours were spent in locating it. A tester to help in locating defective apparatus would be of great convenience.

The instrument described here is dedicated to the purpose of saving time and patience. The "trouble shooter" is used to test each tube in the set while the set is in operation. Defective apparatus connected in the tube circuits will usually change the readings of the meters in the tester. Defective tubes or improper A, B, or C voltages can also be determined. The tester will not point an "accusing finger" at any certain piece of apparatus, but will aid in localizing any trouble in the set, thus saving much time.

The tester makes use of a tube base which is inserted in the socket of that part of the set where trouble is suspected. A four-wire cable from the tube base is connected through meters to a socket in the tester. An ammeter is in series with the filament circuit, and another is connected in the plate circuit. The tube is inserted in the socket of the tester, and the set turned on. The filament and plate current drawn by the tube are indicated by the meters. The meter readings will usually give a clue as to where the trouble is located.

WHAT PARTS ARE NEEDED

A LIST of parts for the "trouble shooter" is as follows:

A_1—1 Milliammeter, 0–10 mA (Weston model 506 or Jewell model 135), or 1 milliammeter, 0–25 mA (Weston model 506, or Jewell model 135)
A_2—1 Milliammeter, 0–500 mA (Weston model 506 or Jewell model 135)
R—1 10,000-ohm resistor, current carrying capacity 25 mA. (for 0–25 milliammeter) or 1 20,000-ohm resistor, current carrying capacity 10 mA (for 0–10 milliammeter)
S_1—1 Small d.p.d.t. switch
S_2—1 Push-pull, or toggle switch
2 Binding posts
1 UX socket
1 UX tube base
1 Panel, 8" x $3\frac{1}{2}$", or other convenient size
1 Small cabinet to fit panel

The 0–10 or 0–25 milliammeter, A_1, is used to measure the plate current drawn by the tube. If it is expected to test sets using the 171 or 210 type of tubes, the 0–25 milliammeter should be used. For sets using a 112 type power tube or no power tubes the range of the 0–10 milliammeter

THE "trouble shooter" described in this article has the virtues of simplicity in construction and operation, and low cost. It does not have the universal range of the tester described by Mr. Messenger in the July number of RADIO BROADCAST; *it is designed to measure the filament currents, plate currents and plate voltages of d.c. tubes while the set in which they are used is in operation. However, as the author points out, in most cases of receiver trouble the information given by these measurements will localize the defective parts of the circuit and make a blind search unnecessary. The compactness and portability of the "trouble shooter," together with its inexpensiveness and simplicity, should make it a very valuable instrument to the service man.*
—THE EDITOR.

will be sufficient. When the higher reading meter is used, a reading of one or two milliamperes will scarcely be visible on the scale; therefore if possible, use the 0–10 milliammeter. [It is a simple matter to use a low reading milliammeter, 0–10 mA, for example, and to place across it a shunt when higher currents are to be read. Such a shunt may be constructed of part of a rheostat and connected to a switch which is installed on the panel. The rheostat could be mounted inside the cabinet, of course.—THE EDITOR.]

The 10,000- or 20,000-ohm resistor, R, used with the plate current meter permits the meter to be used to measure B-battery voltage when the voltage is impressed across the two binding posts. If the 0–25 meter is used in the tester, the 10,000-ohm resistance should be used, and the reading in milliamperes multiplied by ten to give the reading in volts. The full scale voltage reading will be 250 volts. When the 0–10 milliammeter is used, the resistance should be 20,000 ohms; and the reading in mils multiplied by 20 to give volts. In this case the full scale reading will be 200 volts. Only an accurate high grade resistance should be used in order to insure correct voltage readings. Good resistors are usually guaranteed to be within five per cent. of their marked value; therefore quite accurate voltage readings may be depended on.

The principle by means of which an ammeter may be converted into a voltmeter as described in the preceding paragraph is simplicity itself. A known resistance when connected across a source of potential will allow a certain current to flow. If an ammeter is inserted in series with the resistor to measure the magnitude of the current, the voltage applied may be calculated by a simple application of Ohms law: $E = IR$. If R is made a constant value, E is directly proportional to I at all times. Therefore the voltage being measured is proportional to the deflection of the needle on the ammeter scale. Suppose a 0–10 milliammeter is to be used to measure voltages up to 200 volts. In order to determine the proper value of resistance to be used with the meter, Ohms law is again applied: $R = E/I$. Two hundred volts divided by 0.01 ampere gives us 20,000 ohms resistance. The multiplication factor is gotten by dividing the maximum voltage to be measured by the maximum reading on the meter. In this case 200 volts divided by 10 gives a factor of 20. This means that the reading in milliamperes multiplied by 20 will give the voltage.

CONSTRUCTION OF THE TESTER

THE tube base is taken off a discarded tube, and should be of the UX type. Break away as much of the glass as possible, and then scrape out the cement. When the base is thoroughly cleaned out, solder a flexible lead about two feet long to each of the contact pins inside the base. It is advisable to use leads of a different color for each of the four wires to prevent confusion when the unit is completed. The handle for the tube base may be made from a piece of broom stick. Saw a piece about three inches long from the top of the broom—making sure, of course, that your wife is not in the vicinity. Bore a hole lengthwise through the center large enough to accommodate the four flexible leads which you have soldered to the base. Now, whittle down the end of the handle until it fits snugly within the base. Pass the four leads through the hole; coat the end of the handle with glue, and force it into the base. The four leads should be tied or taped together in several places in order to make one compact cable. The free end of the cable connects to the

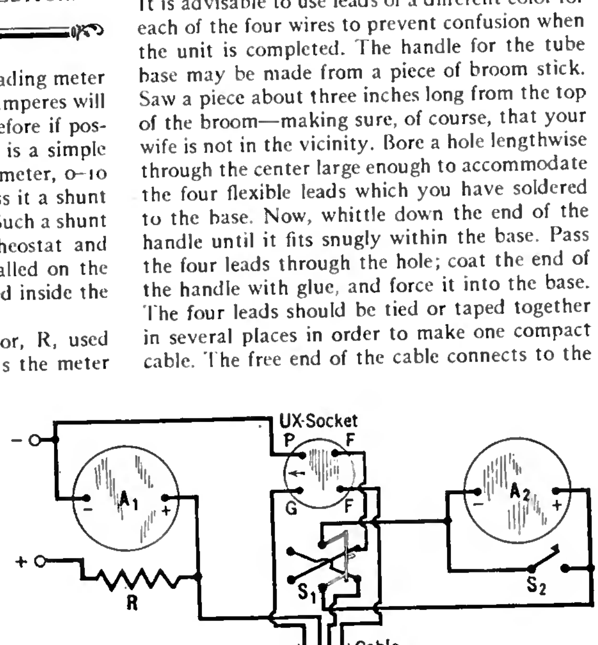


FIG. 1

NORMAL PLATE AND FILAMENT CURRENT FOR VARIOUS TUBES

Type	*Filament Current (mA)*	*Plate Current (mA)*						*Grid volts*					
		45 V.	67 V.	90 V.	135 V.	157 V.	180 V.	45 V.	67 V.	90 V.	135 V.	157 V.	180 V.
200A	250	1.0											
201A	250		1.7	2.0	2.5				-3.0	-4.5	-9.0		
112	500			4.0	5.8	7.9				-4.5	-9.0	-10.5	
112A	250			Same as 112						Same as 112			
171	500			11.0	16.0	18.0	20.0			-16.5	-27.0	-33.0	-40.5
171A	250			Same as 171						Same as 171			
199	60	1.0	1.7	2.5				-1.5	-3.0	-4.5			
120	125			3.2	7.0					-16.5	-22.5		
12	250		1.8	2.6					-3.0	-4.5			
226	1050 a.c.			3.7	6.0		3.8			-6.0	-9.0		-16.5
227	1750 a.c.			3.0	5.0		6.0			-6.0	-9.0		-13.5
					250 V.	350 V.	425 V.				250 V.	350 V.	425 V.
210	1250				12.0	16.0	18.5				-18.0	-27.0	-35.0

The operating currents and voltages of the standard tubes are given in the table above as helpful data for use with the trouble shooter. The table may be clipped and pasted on one of the panels of the instrument, thus making it handy for use in checking up on tubes.

tester through a hole in the back of the cabinet.

A d.p.d.t. switch, S_1, is used to reverse, when necessary, the direction of current flow through the filament milliammeter, A_2. The filaments of various sets are not always wired alike as to polarity; hence, when some sets are tested you will find it necessary to have the switch to the right in order to have the filament meter read; with other sets the switch will have to be thrown to the left.

A small short-circuiting switch, S_2, is connected across the filament milliammeter, A_2, for protective purposes. The meter should be short-circuited when tubes with a filament consumption of more than 500 milliamperes, or tubes using A. C. on the filament, are tested.

The placement of the parts is shown in the photograph, and Fig. 1 gives the wiring of the instrument, which is quite simple.

TROUBLE SHOOTING

TO TEST a set thoroughly with the "trouble shooter," take out the first radio-frequency tube and insert in its place the tube base of the tester. Place the tube in the tester socket, turn the set on, and note the readings of filament and plate current. If possible, adjust the filament current to its normal value. If the plate current is not near normal, replace the tube with one which is known to be good, and again note the plate current reading. If the reading is the same as the previous one, the defect probably lies in that part of the set which is connected to the tube circuit; or perhaps the B or C battery voltage is not of the proper value. Each tube socket in turn should be tested until the trouble is localized. It should not take more than a few minutes to test the entire set.

Below is given a list of symptoms and a guide to where the trouble can probably be found. After becoming accustomed to using the tester you will find that with very little trouble you can completely analyze a set.

1. *Filament current—no reading*
   - (a) filament circuit open
   - (b) defective rheostat or ballast resistance
   - (c) A-battery dead
   - (d) defective tube
2. *Filament current—below normal*
   - (a) too much rheostat resistance in the circuit
   - (b) poor contacts in filament circuit
   - (c) A-battery voltage low
3. *Filament current—above normal*
   - (a) insufficient rheostat resistance in the circuit
   - (b) A-battery voltage high
4. *Plate current—no reading*
   - (a) plate circuit open
   - (b) transformer primary open
   - (c) B-battery dead
   - (d) B-battery polarity reversed
   - (e) defective tube
5. *Plate current—below normal*
   - (a) C-battery voltage high
   - (b) B-battery voltage low
   - (c) tube defective or needs reactivation
6. *Plate current—above normal*
   - (a) grid circuit open
   - (b) transformer secondary open
   - (c) C-battery voltage low
   - (d) C-battery polarity reversed
   - (e) B-battery voltage high
   - (f) defective tube

The table on this page, giving the normal plate and filament currents and grid biases, for the standard vacuum tubes, will also prove helpful in trouble-shooting.

When testing B-batteries, be sure that the tester is not connected to the set. The terminals of the B-battery are connected to the proper binding posts, and the milliampere reading noted. The reading multiplied by the factor gives the voltage. It is wise to scratch the multiplication factor on the panel. Also mark the positive binding post, so that the battery may be connected with the correct polarity each time.

The "trouble shooter" is not guaranteed to be a cure-all, but when used intelligently it will save the user much time, trouble, and possibly expense. For the laboratory, and for service and repair men, this instrument will be found invaluable.

Book Review

WHAT USE BROADCASTING? By William G. Shepherd, included in "Mirrors of the Year." Frederick A. Stokes Co., New York, 1928. Price $4.00

IT IS fitting that the current "Mirrors of the Year," among articles on aviation, the state of the nation, Messrs. Sacco and Vanzetti, feminism (U. S.), the fevers of journalism, the progress of science, art, literature and the movies in the United States, should include a treatise on broadcasting. Mr. Shepherd's discussion is reprinted from *Collier's*. It is not a depressingly serious effort, and will be remembered no longer than the paper on the theatre which precedes it or the article on the girls' clothes which follows, but it fits neatly into the jazzy although quite informative pages of the Messrs. Frederick A. Stokes Company's compendium.

Mr. Shepherd's principal interest is in the political and sociological aspects of broadcasting, and he begins with a story about the Republican Convention at Cleveland, in June, 1924. He says he saw there a "puzzled looking young man fooling around with various gadgets," in a glass booth. The young man turned out to be Graham McNamee, then just beginning his career as perhaps the premier political reporter of the air, although already famous as a radio announcer in other fields. Mr. Shepherd may be romancing a little, because I do not believe that anybody ever saw McNamee puzzled, and the operators would kill him if he touched the gadgets—unless, of course, he first gave them a drink or other good and valuable consideration.

Mr. Shepherd goes on to tell how, in contrast to the unknown functions and future of broadcasting in 1924 politics, in 1927 President Coolidge waited ten minutes before starting his speech at a United Press banquet, because the stations of the broadcast chain were not ready to go on when he was. In a considerable number of years of active broadcasting I never saw that happen, but probably the President would wait in such a contingency, because he knows that the audience along the network far exceeds that visibly present. The same thought, no doubt, emboldens the broadcast technicians to erect a rampart of microphones before the Executive so high and wide that most of the people in the hall where he is speaking can't see his face.

"What Use Broadcasting" continues with some consideration of the delicate problem of free speech on the air. "There is more freedom of the air in 1928," says Mr. Shepherd, "than there was early in the broadcasting era." This is true, and I believe, as apparently Mr. Shepherd does, that it is due to the influence of a highly intelligent and tolerant conservative, Mr. M. H. Aylesworth. I am myself in the liberal and sometimes in the radical camp, and so I may be allowed to say without suspicion of bias that, in situations where amicable adjustment is possible, I would far rather deal with a sincere and fair-minded Tory than with the average jumpy and querulous liberal. For an illustration on a large scale, just look at Dwight Morrow and Mexico. In broadcasting, Mr. Shepherd cites the case of Mr. Norman Thomas speaking over WJZ without any censorship, and without pulling down the pillars of society. Since then, as a matter of fact, not only a few socialists, but even several communists, have agitated the 50-kilowatt transmitters, and what happened was precisely what my kind customers may recollect I have been predicting in our "As the Broadcaster Sees It" department for the last three years—nothing. The listeners were all tuned to the other channel, enjoying a jazz band. Of course the defenders of the downtrodden do not get a fifty-fifty break on the air, or anything like it. They have no more chance of that than Mr. Hughes would have of presenting the capitalist case in Russia. But in this country they are certainly getting a better break in broadcasting than in the domestic movies, for example. Can you imagine one of the news reels portraying the handsome countenances of Messrs. Foster and Gitlow, even once? The present regime of intelligent and unfrightened conservatism in the high seats of broadcasting is about all that can be expected while the stone angel on top of the Cathedral of Saint John the Divine stands mute with his trumpet raised to his lips, not yet ready to announce the Resurrection.

—CARL DREHER.

An Adapter for *Long-Wave* Reception

By W. H. WENSTROM
Lieut., Signal Corps, U. S. A.

ROCKY POINT

THE long-wave adapter described here was designed in conjunction with the short-wave adapter described in the July number of Radio Broadcast, *to extend the receiving range of the R. B. Lab receiver, so as to include all the wave-bands between 20 and 2500 meters. However, the unit may be used with any receiver that embodies one or more stages of audio. By substituting a 0.0005-mfd. tuning condenser for the 0.00035-mfd. condenser illustrated the tuning range may be extended so as to receive NAA, at 2677 meters, and other stations above 2500 meters. Also a plain dial may be substituted for the more expensive vernier dial mentioned in the list of parts, since long-wave stations will remain tuned-in over several dial degrees.*
—The Editor.

MANY listeners are turning away from the narrow confines of the broadcast band, in which too often musical excellence and technical perfection are stifled under the never-ending flood of politics and sectionalism. Naturally enough, the recent trend has been toward the short waves. It would be useless to claim that there are more interesting things above the broadcast band than below it, but much of the real pleasure of radio lies in a broad interest rather than a narrow one, in standing aloof from the fads, in being somewhat original. And an exploration of the waves between 550 and 2500 meters will not prove entirely what Carl Dreher calls "chocolate-and-pineapple" originality.

In the July issue of Radio Broadcast a short-wave adapter for the R. B. Lab. receiver was described. This article continues the completion of the Lab. receiver, but the adapter here described may be used with practically any set having one or more stages of audio-frequency amplification. As the adapter contains a detector circuit, only the audio circuits of the receiver are used. The adapter's phone broadcast reception possibilities, in America at least, are slight. Most of the signals within its range are in code. But the adapter makes a good code practice set for those who wish to broaden their radio knowledge in this direction.

GENERAL DESIGN

The adapter, whose circuit is shown in Fig. 1, consists essentially of a tuned detector circuit which can be made to regenerate or oscillate. For economy and compactness the regeneration condenser is quite small. The antenna coupling is inductive and variable. The detector output terminates in a tube base which plugs into the detector socket of a standard broadcast set. The adapter detector (with its high tuning range) in this way temporarily replaces the set detector. Two Silver-Marshall plug-in coils L_1, L_2, and L_3—the 111-D and the 111-E—are used. With the 0.00035-mfd. tuning condenser, C_1, the respective tuning ranges of these coils are 600-1400 meters and 1100-2500 meters. The calibration chart in Fig. 2 will probably hold quite approximately for any adapter, as on long waves circuit changes do not have a very great effect. A 0.0005-mfd. tuning condenser would extend the tuning ranges slightly, and would be desirable for those who wish to copy the NAA time, weather, and press broadcasts on 2677 meters.

For effective reception at higher wavelengths the antenna should be rather long. It is true that many stations can be heard on the usual 100-foot broadcast antenna, but signals are louder with a longer one. The writer used a 250-foot single wire in tests, and 750 to 1000 feet would not be too long. Even on short waves a long, low single wire seems to improve the signal-noise ratio upon which satisfactory reception depends. Where the lighting wires are overhead rather than underground, a light socket antenna plug offers possibilities.

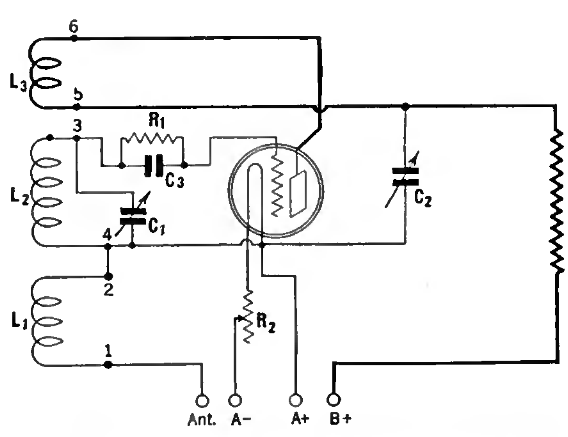


FIG. 1. THE CIRCUIT DIAGRAM

CONSTRUCTIONAL DETAILS

THE construction is plainly apparent from the diagrams and photographs. The unit is so simple that none should have trouble with it. The arrangement of parts and wiring can, of course, be varied to suit individual requirements. The wiring is done with solid Acme Celatsite. As explained in the short-wave adapter article, the a.c. tube is not a good oscillating detector. For this reason a d.c. tube is always used in the adapter; it may be almost anything from a UX-112A to a UX-199. The UX-112A, UX-200A and Ceco H are more sensitive than others. If a UX-199 is used with a 6-volt battery the rheostat, R_2, should be 50 ohms.

The plug connections are clearly shown in Fig. 4. If the receiver power is direct current, the adapter requires no additional battery. If the receiver power is alternating current, the adapter requires an A-battery. For intermittent use with a storage battery tube four or eight dry cells should do; a UX-199 tube will run even on a 4½-volt C-battery. A list of the parts used in this particular set is given below.

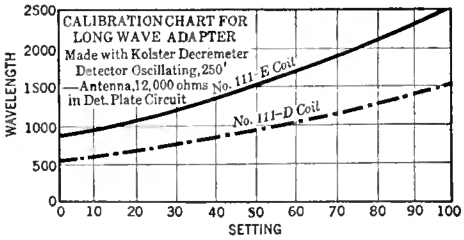


FIG. 2

THE PARTS USED

HOME constructed coils for this adapter can be made in this manner: For a coil with a wavelength range corresponding to curve 111-D, Fig. 2, wind on a 2" cylinder a bank wound coil consisting of 13 piles of 20 turns each for the secondary. The winding at one end of the coil, L_1, should contain 100 turns and the rotor winding, L_3, should contain about 60 turns. For a coil to tune as indicated by curve 111-E wind 9 piles of 44 turns each on a 2" form, the other two windings being the same as above. Use about No. 28 s.s.c. wire for all the windings.

The other parts specified for this adapter have no special electrical characteristics and parts electrically equivalent to those mentioned in the list may, of course, be used.

C_1—Hammarlund type M L-17 variable condenser, 0.00035 mfd. (A 0.0005-mfd. variable condenser may be used, as explained in the text)
C_2—Hammarlund variable condenser, 0.0001 mfd.
C_3—Sangamo fixed condenser, 0.00025 mfd., with grid leak clips.
L_1, L_2, L_3—Silver-Marshall coils, No. 111-D and No. 111-E
R_1—Tobe Tipon grid leak, 6 megohms
R_2—Yaxley switching rheostat, 30 ohms (50 ohms for UX-199 tube)
R_3—Durham resistor, 10,000 ohms
1 Karas 4" vernier dial
1 Benjamin cushion UX socket
1 Silver-Marshall coil socket, type 515
4 Eby binding posts, small
1 Bakelite panel, $\frac{3}{16}$" x 7" x 9"
1 Bakelite binding post strip, $\frac{3}{16}$" x $\frac{3}{4}$" x $4\frac{3}{4}$"
1 Plywood baseboard, 1" x 8" x $8\frac{1}{2}$"
Celatsite wire

WHAT THERE IS

THERE are plenty of signals above the broadcast band. Some valuable information is contained in the chart on page 169 of the July issue of RADIO BROADCAST, and in the table on page 52 of the May issue. All these frequencies are assigned by international conferences in which every important nation is represented. Six hundred meters is the calling wave for ships of all nations on the seven seas. When contact has been established with another ship or the shore, messages are usually handled between 600 and 1000 meters, though the 600-meter wave may be used for messages where calling is not interfered with. This wave is also used for marine distress calls, which are fortunately rare. When the broadcasting stations shut down for an SOS, one can often hear spark signals from the disabled ship itself.

Marine direction finding occupies 800 meters. A ship in doubt of its position calls a control station on shore. Then two or more widely separated stations on shore take radio bearings on the ship's transmitter. When these bearings are plotted on a chart their intersection gives the ship's position, which is promptly radioed to it by the control station on shore.

When the coastal weather is at all foggy one can hear the radio beacons sending out their distinctive signals. They are small tube transmitters, usually aboard lightships, and their note is c.w. modulated at about 1000 cycles. Their signals may be found on the Department of Commerce navigation charts. A few in the New York area actually checked by the writer are: Nantucket Shoals Lightship—4 dashes; Fire Island—2 dashes; Ambrose Channel—single dashes; Seagirt Lighthouse—3 dashes. By listening to these beacons start up, one after another, it is possible to trace roughly the progress of thick weather along the coast. People who live far inland will miss a great deal of this marine radio, unless they are near the Great Lakes.

Long-wave broadcasting has never taken hold in America, but it is important in Europe. Theoretically, the range of a 1400-meter station should be over three times that of a 400 meter station of the same power, but for some reason the long-wave European broadcasters do not seem to get out very well. Perhaps the average receiving antenna is too small for effective long-wave work. Some long-wave European broadcasters using over 10 kw. are: LP, Berlin, 1300 meters, 12 kw.; projected station at Moratala, Sweden, 1304 meters, 40 kw.; projected station at Moscow, 1450 meters, 40 kw.; 5XX, Daventry, England, 1600 meters, 16 kw. (from *Citizens Radio Call Book*). Trying for these stations should prove interesting during the winter months.

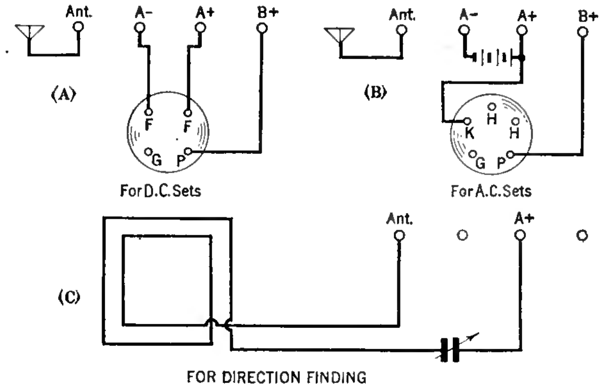


FIG. 4

Large ships use bands between 2000 and 3000 meters for through traffic, and often attain surprising ranges. Two or three years ago the transport *Chateau Thierry* worked New York with its 5-kw. arc from a position near San Francisco.

Some applications of this long-wave adapter make it useful on small yachts or other ships equipped only with conventional broadcast receivers. By listening on 600 meters in fog or storm, the navigator can get some idea of the number of ships near him, as well as bits of information about the weather and sea from the messages these ships exchange. The Navy weather and press broadcasts may also come in very handy at times. By listening to the radio beacons on 1000 meters the yachtsman can get a rough idea of his distance from them. It would even be possible to rig up a loop on deck—say about 30 turns on a frame two feet square, connected in series with a large variable condenser and the adapter primary Fig. 4 shows the connections. Signal changes are noted on rotating the loop; the minimum signal means that the beacon is in a direction perpendicular to the plane of the loop. This arrangement should work up to five or ten miles.

Though these higher waves are almost unknown to most radio listeners, they play a great and increasing part in the business of the world. The man who is bored with broadcast reception, who wishes to broaden his interest and extend his knowledge, will find a new field in exploring the possibilities of the radio spectrum. above the broadcast bands.

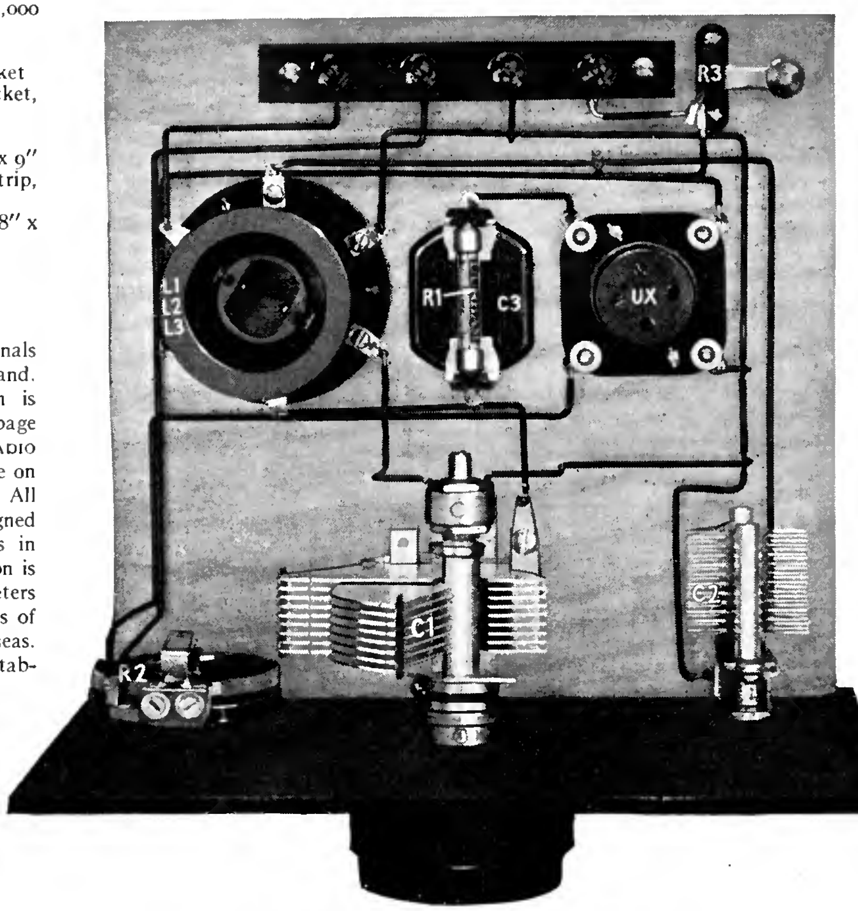


FIG. 3. THE PLACEMENT OF THE INSTRUMENTS

No. 7. September, 1928.
RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

Stromberg-Carlson Receivers Nos. 635 and 636

MODEL 635

THE Stromberg-Carlson receivers Nos. 635 and 636 are self-contained, completely light-socket-operated radio receivers, the receiving apparatus and the complete power supply being mounted on one metal base and contained in a single cabinet. The No. 635 receiver is housed in a table mounting cabinet; No. 636 is a console model. The same apparatus and circuit is employed in both. Type 227 tubes are used throughout the receiver with the exception of the audio output tube, which is a type 171 tube, and the rectifier which is a full-wave type 280. The tuning system uses four stages, consisting of the tuned antenna stage followed by three stages of tuned and neutralized radio-frequency amplification. The coils are enclosed in aluminum shields and the variable condensers are all ganged to the single tuning control. The detector is the C-battery type, and the audio amplifier is a two-stage transformer coupled affair. The volume control consists of two variable resistors mounted on the same shaft and operated from a common control, one of the resistors controlling the amount of signal energy entering the r.f. amplifier and the other controlling the amount of energy admitted to the detector.

The Nos. 635-A and 636-A receivers are designed to operate efficiently on 105-125 volts, 50-60 cycle a.c.; the Nos. 635-B and 636-B receivers on 105-125 volts, 25-40 cycle a.c.; and the Nos. 635-C and 636-C receivers on 210-250 volts, 40-60 cycle a.c.

The receiver is equipped with a switch to compensate low and high line voltages. With voltages lower than those recommended for efficient operation of the receiver, the receiver may operate satisfactorily, but the amplification will be decreased and the tone quality impaired; and with voltages greater than those recommended, the life of the tubes will be somewhat shortened.

TECHNICAL DISCUSSION

1. The Tuning System.

The antenna stage of the receiver is tuned, which makes the set more sensitive than receivers of the same type employing an untuned antenna system. One control operates all of the tuning condensers, C, simultaneously, accurate electrical alignment of the various stages being obtained by the use of small midget condensers, C_1, in each stage connecting across the main tuning condensers; these latter condensers are adjusted at the factory.

2. Detector and Audio System.

Plate rectification or "grid bias" method of detection is used, followed by two stages of high-quality transformer coupled audio amplification, the ratio of the first transformer being 4:1, and that of the second being 2.8:1. The secondary of each audio transformer is shunted with a 1.0 megohm resistor to obtain the desirable audio-frequency characteristic. The output of the audio system is coupled to the loud speaker by means of a 60-henry choke and a 2.0-mfd. condenser. A correctly designed "high-frequency cut-off" audio filter is included in the audio output system. A phonograph pick-up jack is provided in the front panel of the receiver, which, upon insertion of the phonograph pick-up plug, connects the output of the pick-up to the audio system in place of the detector output of the receiver.

3. Volume Control.

The volume control consists of two separate units operated simultaneously by the same control knob. The primary of the antenna coil has a 10,000-ohm potentiometer, R_1, shunted across it, with the variable contact grounded. This controls the amount of signal admitted to the radio-frequency amplifiers. The second unit is a 10,000-ohm variable resistor, R_2, shunted across the primary of the third radio-frequency transformer. This controls the amount of signal admitted to the detector.

4. Filament Circuits.

The heaters of the three radio-frequency and first audio tubes are connected in parallel, but with separate twisted pair connections to each tube from the power transformer secondary, which supplies approximately 2.3 volts to each of these tubes. The power transformer secondary which supplies these tubes is provided with a grounded center tap for hum balance. A separate secondary of the power transformer supplies approximately 2.3 volts to the detector tube heater; this results in a better condition for suppressing hum. A 10-ohm potentiometer, R_3, with its variable contact grounded for hum balance, is shunted across the current supply to this tube. The filaments of the audio output tube and the dial light are connected in parallel and are supplied with approximately 4.5 volts from the power transformer. A 20-ohm potentiometer, R_4, with its variable contact grounded for hum balance, is shunted across this current supply.

5. Plate Circuits.

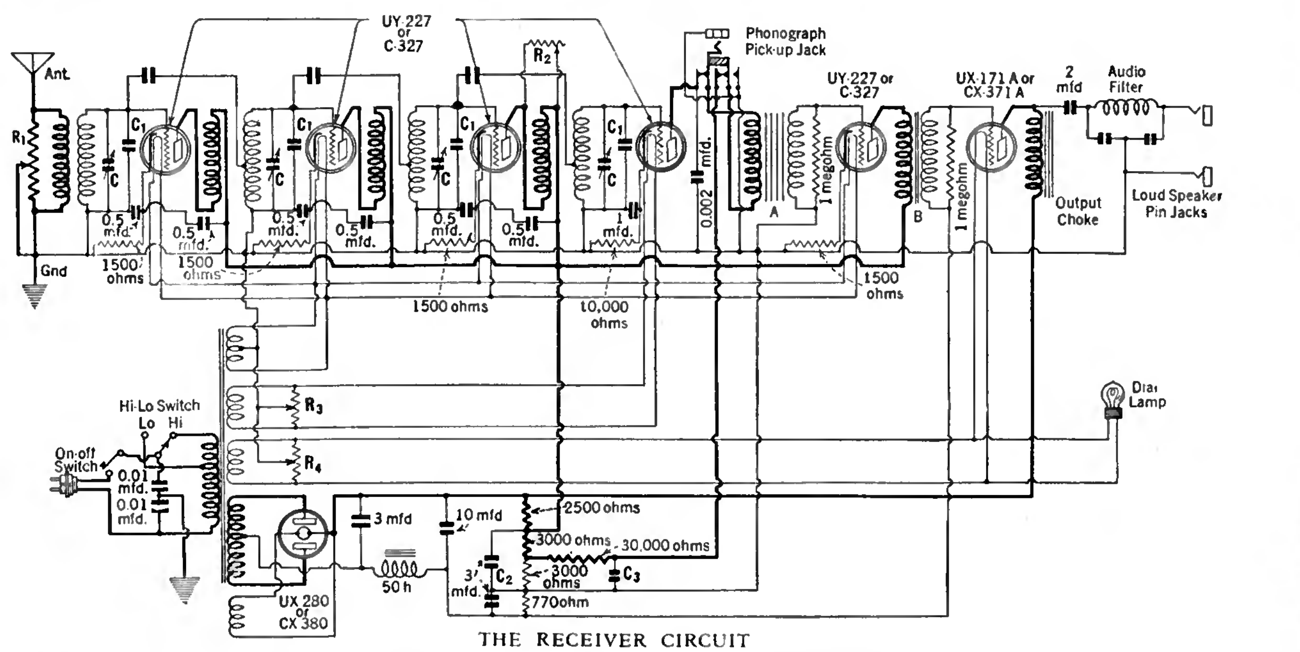
The plates of the radio-frequency and first audio tubes are supplied with approximately 110 volts d.c. from the power equipment. The detector plate is supplied with approximately 36 volts d. c. and the audio output tube is supplied with approximately 180 volts d. c. from the power equipment. The radio-frequency and first audio plate supply is "bypassed" to ground by a 3-mfd. condenser, C_2, which is contained in the power equipment, and the plate supply to the radio-frequency tubes is "bypassed" to the cathode at each radio-frequency tube by a 0.5-mfd. capacitor. The detector plate supply is "bypassed" to ground by a 3-mfd. capacitor, C_3, which is contained in the power equipment.

6. Grid Circuits

The grids of the radio-frequency and first audio tubes are biased negatively approximately 5 volts with respect to the cathodes, by means of a 1500-ohm resistor connected between each cathode and ground. The detector grid is biased negatively approximately 3.5 volts with respect to the cathode, by means of a 10,000-ohm resistor connected between the cathode and ground. These biasing resistors are "bypassed" by 0.5-mfd. capacitors in the radio-frequency stages, and by a 1-mfd. capacitor in the detector stage. This prevents the resistors from having any effect on the radio frequency current and insures stability. The power equipment supplies approximately 40.5 volts negative bias to the grid of the audio output tube.

7. The Power Supply

The power transformer consists of a primary winding and secondary windings which supply the radio-frequency and first audio tube heaters, the detector tube heater, the audio output tube and dial light filaments, the rectifier tube filament, and the high voltage which is rectified and filtered to supply the plate voltage for the receiving tubes. The grid bias voltage for the audio output tube is also supplied from this source. The primary circuit of the power transformer is provided with a "Hi-Lo" switch, which compensates for high or low line voltages. Full-wave rectification is accomplished by one UX-280 Radiotron or CX-380 Cunningham rectifier tube, and the filter system consists of a 50-henry choke, a 3-mfd. condenser and a 10-mfd. condenser. A voltage divider connected across the output of the rectifier and filter system supplies the correct voltages to the radio-frequency, detector, and audio tube plates and to the grid of the audio output tube.



THE RECEIVER CIRCUIT

No. 8. **September, 1928.**

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

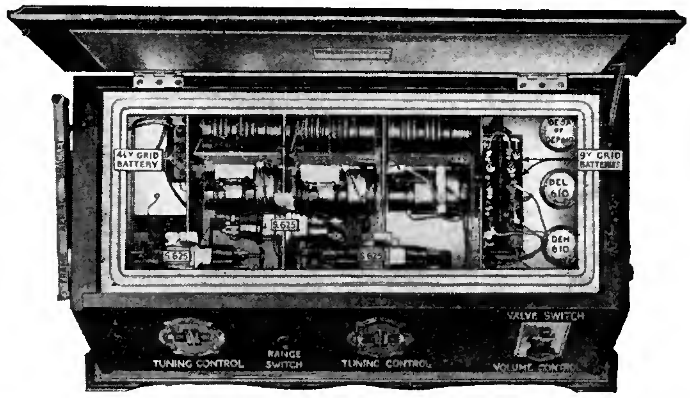
The Marconiphone Model 61 Receiver

THIS Service Data Sheet is devoted to a description of one of the leading receivers now being manufactured and sold in England. The design of this receiver affords some interesting comparisons with American receivers of similar design, which should prove interesting to many of our readers. Screen-grid tubes were available and in use in England for several years before the advent of the type 222 tubes in America, and the double-ended construction adapted by our British friends has some advantages in simplifying receiver design, which are pointed out below.

THE most interesting receiver in the British radio field at the present moment is undoubtedly the Marconiphone Model 61. This six-tube set has three screen-grid tubes, a C-battery type detector and two resistance-capacity-coupled audio-frequency stages. The latter are normal in construction, but the radio-frequency end of the instrument is decidedly unique and gives many valuable lessons to the experimenter.

The tubes employed are of the double ended type due to Captain Round, the famous Marconi engineer. Their construction is shown in the photographs below. It will be seen that a "V" filament and standard grid are mounted on one glass foot, and the plate with the screen grid on a second, the electrodes then being assembled in a glass bulb and the tube finished off with two caps.

The anode and screening grid are flat, the latter having a "skirt" approximately ¼" wide brought as closely as possible to the glass to prevent edge effects. The great practical advantage of this construction is shown in the top view of the receiver, where it will be seen that the tubes are mounted horizontally with their screening grids in the planes of the inter-stage partitions, which are cut away just sufficiently to allow for the diameter of the glass. The whole of each stage is entirely enclosed by the screening when the cover is closed. Furthermore, by an ingenious process the magnesium "getter" used to remove the last traces of gas from the tube is limited to the plate end of the bulb and cannot therefore form a conducting path past the screening grid.



THE GENERAL LAYOUT OF PARTS

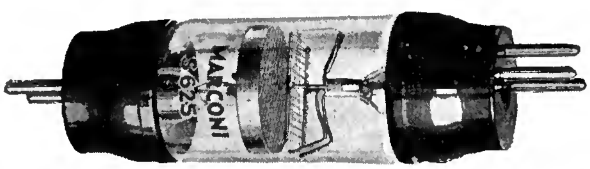
A 6-volt, 0.25-ampere filament is used, and at the standard operating voltages of 120 on the plate, 80 on the screening grid and minus 1½ on the control grid, the amplification factor is 110 and the plate impedance 175,000 ohms.

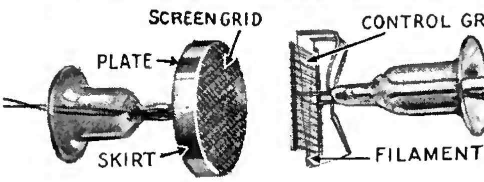
Full advantage of this high mu value cannot be taken when three stages are in use, as instability is inevitable. A step-up of 30-35 per stage is actually achieved in Model 61. Incoming signals are therefore amplified 30,000 times before reaching the detector. Multiply this by a conservative 25 as being the step-up of the detector and two audio-frequency tubes and we theoretically obtain a total magnification of nearly three quarters of a million times between aerial and output! With this stupendous increase it is clearly essential not only to adopt the most perfect screening but also to take precautions against coupling through the common wiring and batteries, in order to obtain stable operation.

The system of screening is shown in the top view. Front, back, baseboards and sides of the cabinet are copper lined and there is a partition between each r.f. stage. A broad lip is formed round the upper edge of the screen and in this is laid a length of cable covered with braided copper and bonded to the metal at several points. To the underside of the cabinet top is secured a copper plate of sufficient size to complete the screening. When it is closed this plate is pressed into firm contact with the braided cable throughout its length, thus insuring a perfect electrical joint.

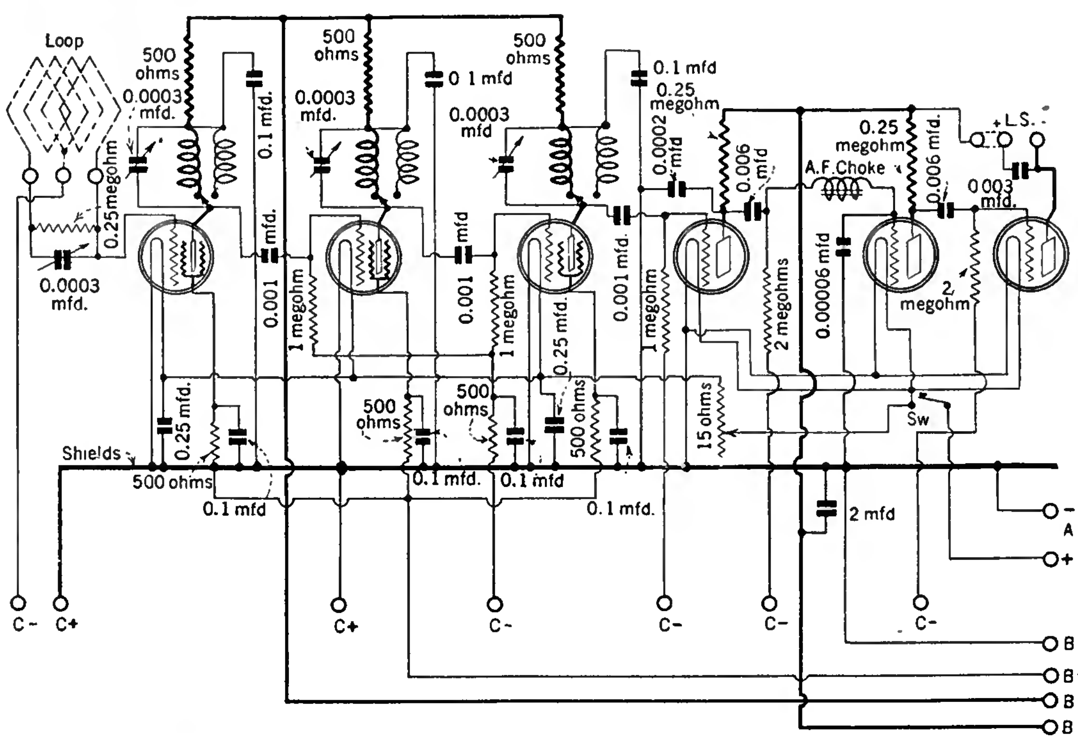
The four circuits—loop and three tuned circuit—are tuned by separate condensers arranged in pairs with edge control dials so placed as to be easily controlled with two fingers. As the circuits are accurately matched and not too sharply tuned (the selectivity of this receiver is probably insufficient for use in the United States—*Editor*) it is a simple matter to find a station by synchronizing at approximately the correct wavelength and operating all simultaneously. The dials are calibrated in meters.

There are two sets of astatic tuning coils covering 250-550 and 1000-2000 meters, the change-over being effected by multiple switches controlled by the "Range Switch" on the front panel.





THE ENGLISH SCREEN-GRID TUBE



THE CIRCUIT OF THE MARCONIPHONE MODEL 61

A Simple Unit for Measuring Impedances

By F. J. FOX and R. F. SHEA

MR. FOX and Mr. Shea have described in this article a very excellent use for vacuum tube voltmeters in the measurement of coils, condensers, and resistors that are ordinarily used in the audio-frequency and power circuits of modern radio receiving equipment. The circuit arrangement used is such that the unknown impedance is compared to a known resistance and at the balance point the unknown impedance is equal to the known resistance, whence we may easily calculate the inductance or capacity by the formulas given in the text. The comparative simplicity of the device is commendable, and since the device may be readily constructed for use in the home laboratory we feel that the article will appeal to our many friends who have shown such great interest in the descriptions of home laboratory equipment that have appeared in RADIO BROADCAST.

—THE EDITOR.

THE COMPLETED UNIT

All the instruments used in making the measurement are housed in this box, with the exception of the decade resistance box, which is connected in the circuit by means of terminals behind the rear tube. The C batteries are also housed in the box.

IN THE design of radio equipment there are many instances when it is desirable or necessary to know the impedance of large inductances or capacities which are used in the building of a piece of apparatus—for example, a B-power unit. Large inductances and capacities may, of course, be measured on a bridge (an expensive piece of apparatus) but in many cases, especially where the necessary standards of inductance and capacity are not at hand, the method to be described will be found useful, accurate, and inexpensive.

Most methods of measuring large impedances require the use of expensive apparatus and delicate instruments. The authors have aimed, in the method described here, to provide a simple, accurate and inexpensive method of measurement.

The apparatus utilizes vacuum tube voltmeters and provides a quick and accurate means of measuring impedance. The accuracy of the method is limited only by the precision of the meters used and the care used in making the instruments. With inexpensive instruments this device will give results to three figures and therefore is accurate enough for practical radio design work.

HOW THE UNIT WORKS

IT IS possible to measure high impedances by the use of a vacuum tube voltmeter in a circuit as indicated in Fig. 1. With this arrangement the vacuum tube voltmeter is used to read the voltage across the unknown impedance, and the current through the impedance is read by the milliammeter. The impedance is then equal to the voltage divided by the current. From the standpoint of simplicity this method has two disadvantages: it is necessary that the vacuum tube voltmeter be calibrated to read voltages, and an a.c. milliammeter—an expensive and delicate instrument—is necessary. To eliminate these disadvantages the circuit shown in Fig. 2 has been devised. In this case two vacuum tube voltmeters are used, one across a variable resistance, R, and another across the unknown impedance, Z, connected in the circuit at X. To calibrate this set-up a known value of resistance is first connected at X. The resistance box, R, is then set exactly equal to the known resistance so that the voltages across the two voltmeter circuits will be exactly equal to each other. A.C. voltage from the transformer, T, is then applied and the readings of the vacuum tube voltmeters as indicated by the meters, M_1 and M_2, are carefully taken.

The tubes for the set-up should preferably be very nearly matched so that when calibrating, the meter readings are very nearly alike for voltages of the order of those being used. That is, with the two equal resistances in place, the input voltage should be varied by means of the variable resistance in the primary of the supply transformer, T, and the meter readings noted. Tubes should be selected which give meter readings that correspond very closely over the entire range of voltages. From this calibration we know the corresponding readings of the two meters at any points on their scales under the condition that the voltage impressed across the input of each vacuum tube voltmeter is the same. The calibration is complete and we can now use the circuit to measure unknown impedances.

The unknown impedance to be measured is connected at X in place of the known resistance and the resistance of R is varied until the readings of the two meters correspond. We know from our calibration that when the readings correspond the voltages across the two vacuum tube circuits are the same. It therefore follows that under the condition that the readings of the two meters correspond, the voltages across resistance R and the unknown impedance are the same. Since the current through R and through the unknown impedance at X is the same it follows that

$$IR = IZ$$

where

I is the current

R is the value of resistance at which the readings of the meters corresponded

Z is the value of the unknown impedance

Therefore the impedance Z is equal to the resistance R.

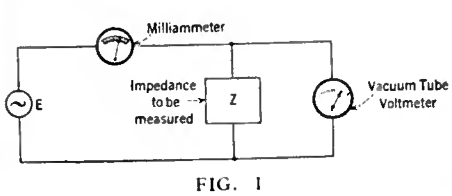


FIG. 1

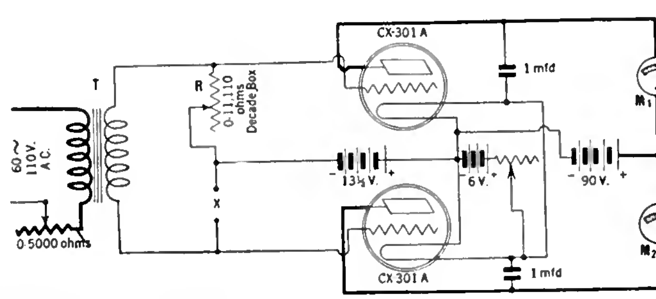


FIG. 2

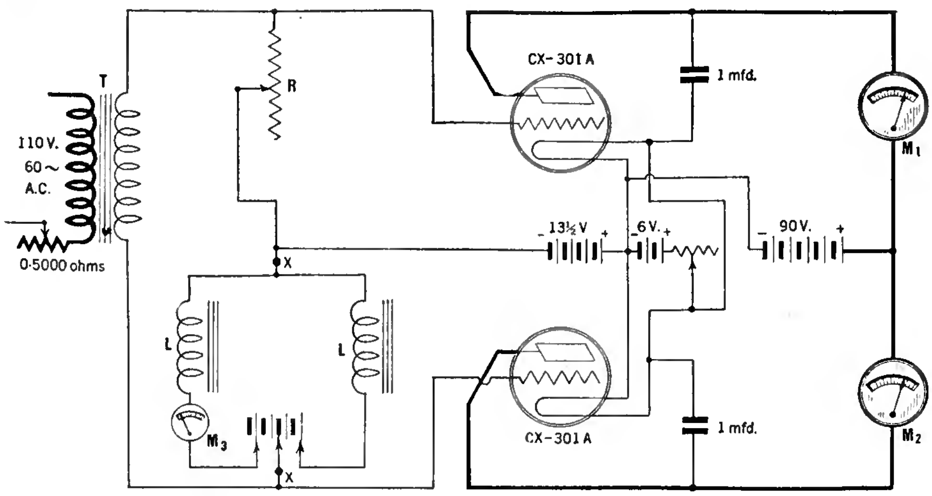


FIG. 3

Thus we obtain directly a value for Z in ohms. If then the d.c. resistance is obtained on a Wheatstone bridge the inductance is easily obtained from well known laws. In the case of large condensers the resistance may be safely neglected.

For inductances:

$$Z = \sqrt{\omega^2 L^2 + R^2}$$

$$\text{or } L = \sqrt{\frac{Z^2 - R^2}{2\pi f}}$$

$$\text{At 60 cycles } L = \sqrt{\frac{Z^2 - R^2}{377}}$$

where

z = impedance in ohms
ω = 2πf = 6.28 times the frequency in c.p.s.
L = inductance in henries
R = resistance of the coil in ohms

In the case of a condenser the following holds true:

$$\text{At 60 cycles} \quad z = \frac{10^6}{\omega c} = \frac{10^6}{2\pi f c} \qquad c = \frac{10^6}{377z}$$

Where

z = impedance in ohms
c = capacity in microfarads

THE CONSTRUCTION OF THE UNIT

WE SHALL now describe this set-up, Fig. 2, in greater detail. Resistance R is a variable decade resistance box (such as those made by General Radio Company). This box has steps of units, tens, hundreds and thousands. The tubes used in the vacuum tube voltmeter are of the CX-301A type and should preferably be matched to give identical readings on the calibrating set-up so as to facilitate measurements. A 90-volt B battery is used in conjunction with 13½ volts of negative C bias. This bias drives the operating point well down to the lower knee of the plate-current-grid-voltage characteristic of the tube so that a small applied voltage gives a relatively large change of plate current. The meters, M_1, and M_2, are of Weston or Jewell 0–1.5 d.c. milliampere type. If the a.c. voltage from the transformer is about 12 volts the plate current of each tube will be about 1 milliampere and this is a convenient value to use. The transformer T which furnishes the measuring voltage should deliver about 12 to 14 volts, and a 5000-ohm heavy duty Bradleyohm or similar variable resistance is inserted in its primary.

The photograph at the beginning of this article shows a typical layout of the testing apparatus described above. The vacuum tubes, meters M_1 and M_2, exciting transformer, T, by-pass condensers and C batteries are housed in the box. The box should be so arranged that the C batteries may be easily replaced when necessary. The knob of the 5000-ohm variable resistance which is used to control the exciting voltage is placed in a convenient position outside of the box between the two tubes. The cable at the left goes to the 110 volt a.c. source, and the cable at the left to the batteries. The impedance to be measured is connected in the circuit by means of the two binding posts on the front. Two similar terminals in the back are used for connecting in the decade resistance box.

The resistance used at X for calibration should be about 1000 ohms and unless it is a standard resistance it will have to be measured carefully on a good bridge and labeled.

If greater accuracy is required higher grade meters than the ones described will have to be used; however, the small meters are accurate enough for all practical purposes.

WHEN BIASING CURRENT IS PRESENT

IT HAS been pointed out that it is frequently necessary to find the impedance or inductance of a filter choke coil, an impedance coil, or the primary of an audio-frequency transformer when certain values of direct current are flowing through the windings. Or it may be necessary to study the effect of various values of direct current on the inductance of a coil when the turns are varied or the air gap changed. A circuit which is used for this purpose is shown in Fig. 3. In this case a network consisting of two identical coils, L and L (under test), a milliameter, M_3, and a storage B battery is connected at X–X. The terminals of the B battery should be accessible so that various voltages may be tapped off. It should also be in good condition and all cells should show the same terminal voltage. As may be seen from the diagram the battery produces a circulating current around through the two coils, but since terminals X–X are connected to the midpoint of the battery and of the choke coils no potential exists between these points. When changing the amount of circulating current it is very important that this condition be maintained, otherwise the grid bias on the vacuum tube voltmeter, M_2, will be changed and a serious error will result. In case there is any doubt it is well to check the voltages on each side of the midpoint with a high grade voltmeter. Another way to check this is to take a reading of the vacuum tube voltmeter, M_2, when no a.c. is impressed and when no biasing current is flowing (battery cut out of circuit). Another reading is then taken with no impressed a.c. but with battery voltage of the desired amount in the circuit. If the vacuum tube voltmeter reading, M_2, does not change then the battery is not affecting the voltage balance, and the test may proceed.

Storage B batteries will deliver up to about 150 milliamperes. If more current is desired through the coils under test it will be necessary to use regular storage batteries.

Impedances measured in the manner indicated in Fig. 3 will be equal to one half the impedance of a single choke coil. Multiply the measured value by two and proceed to compute the inductance as outlined in the equations above.

Book Review

EXPERIMENTAL ELECTRICAL ENGINEERING AND MANUAL FOR ELECTRICAL TESTING. By V. Karapetoff. Third Edition, Revised and Enlarged, in Two Volumes. Vol. I, xxxii and 795 pages, 6 by 9, 391 figures, $6.00. Vol. II, xxxii and 618 pages, 280 figures, $5.00. John Wiley & Sons, New York.

IN ISSUING the third edition of Karapetoff's famous work on "Experimental Electrical Engineering" in a revised and reset printing John Wiley & Sons are performing about the same service for the electrical engineering profession at large as when they made Morecroft available in a second edition to radio engineers.

About the book little remains to be said. The author has been Professor of Electrical Engineering at Cornell University since 1904. He is one of the group of American electrical engineers, like Steinmetz, Pupin, Pender, Ryan and others, who have advanced the profession by their work both in the universities and outside, and who have in several cases combined notable literary and artistic talents with engineering ability. The two volumes of "Experimental Electrical Engineering" contain about all that the engineer wants to know about electrical testing and the practical behavior of electrical machinery. If he is interested in the process of getting the magnetization curve of an iron sample by the bismuth spiral method he will find it, in the same chapter with the Thompson permeameter, the Du Bois balance, the Koepsel permeameter, and the Ewing Permeability Bridge, in the first volume. If he happens to have gone into the talking movie field to find, perhaps to his surprise, that oscillograph galvanometers are used in some of the sound-movie recorders, he can read up on the applications and physical behavior of such devices in the second volume, where the electromagnetic oscillograph, its galvanometer, optical system, recording apparatus, electrical circuits, transient visualizer, and possible accessory apparatus, such as vacuum tube amplifiers, are quite completely described. The radio engineer will find a chapter on high-frequency measurements. Everybody in the profession will find something, and usually a lot, about what he wants to know. The treatment is packed with valuable references and numerical data. On assuming a new job recently, one of the first things I did was to order copies of both volumes. I knew perfectly well that before long one of the engineers would refer to it and find out in short order something worth a great deal more to the company than the price of the books—and the 1413 pages would remain for more use of the same kind indefinitely, unless somebody who is not as honest as he is wise steals them for his private library. —CARL DREHER.

A Six-Tube Screen-Grid Receiver

By McMURDO SILVER

Silver-Marshall, Inc.

THE receiver described here is one of the new models in the line of kits to be marketed this season by Silver-Marshall. It is an excellent and attractive receiver and the essentials are priced to make the eyes of the home constructor and professional set builder open wide. The complete receiver was tested in the Laboratory and it performed very well indeed "in all departments," as the sporting writers say. The "gain" of this set is high, which is advantageous when the user wants distance. It should be remembered, however, that no high-gain receiver can successfully be operated where there is much man-made or other interference. It is simple enough in conditions like that to cut down the gain and to tune to stations where signal level is above that of the noise. Additional constructional data is available from the manufacturers or from RADIO BROADCAST.

—THE EDITOR.

THE new Screen-Grid Six receiver is a highly perfected development of the receiver known to readers of RADIO BROADCAST for three years as the Silver Six, Shielded Six, and Shielded-Grid Six. The new Screen-Grid Six takes full advantage of all meritorious features of its predecessors, and, like the latest of them, it employs three stages of high-gain r.f. amplification with screen-grid tubes.

In performance, the receiver will give 10 to 15 kc. selectivity, in almost any location, and will bring in from forty to one hundred stations in a single average evening's tuning. Such are the results that have been had with numerous models built to the new design operated in many different locations in and about Chicago during the early months of 1928. And yet it can be built at home for less than seventy-three dollars!

As an example, the log on this page was obtained in two hours' time in a typical residential location within a few miles of Chicago's twenty-odd local stations. All the stations listed were received on the loud speaker with practically "local" volume, using only a 35′ antenna.

Since the Screen-Grid Six design would seem to represent not only a new high level of radio receiver performance, but also a new low level in cost, almost regardless of performance, it is felt that a description of the engineering features of the design, together with other points of interest, will not be unwelcome to RADIO BROADCAST readers.

From an examination of the photographs and drawings it is seen that the Screen-Grid Six is a six tube t.r.f. receiver consisting of a three-stage radio-frequency amplifier using screen-grid tubes, followed by a detector and two-stage audio amplifier. In this respect it is not at all unusual (though at this writing there are known no ready-made sets incorporating the full advantages of screen-grid r.f. amplification.) If there is anything at all unusual about the set, it is the fact that the three r.f. tubes have been made to average about two hundred and fifty times the amplification obtained from this same number of 201A tubes in some receivers using an r.f. choke in the input. In addition, the audio gain is greater than that of the ordinary audio system of the same number of stages, due to the employment of the Clough audio system.

How this is done is easily seen by taking as a typical example a representative ready-made six-tube set costing about one hundred and fifty dollars. In this common type of set the first r.f. tube has its grid circuit connected across a small r.f. choke directly in the antenna circuit, across which is developed the signal voltage. This type of coupling gives no voltage step-up between antenna and first r.f. tube, and does not contribute in any way to selectivity. The first tube with the t.r.f. transformer that follows it shows an average amplification of less than 10 times between 200 and 550 meters (this figure is quite generous). The two additional r.f. tubes, with two more t.r.f. transformers, each give a gain of 10 per stage. Thus, 10 x 10 x 10 = 1000 shows the amplification between antenna and detector grid circuit.

LOG OF SCREEN-GRID SIX

Station	Location	Right Dial*	Kc.
WNBA	Forest Park, Ill.	1	1440
KSTP	St. Paul, Minn.	4	1360
WJKS	Gary, Ind.	6	1290
WGES	Chicago.	8	1240
WOK	Chicago.	12	1190
WJAZ	Chicago.	19	1140
WTAS	Elgin, Ill.	18.5	1090
WENR	Chicago.	23	1040
WTMJ	Milwaukee	24	1020
KMOX	St. Louis, Mo.	26	1000
WHT	Chicago.	28.5	980
KDKA	Pittsburgh	31.5	950
KFAB	Lincoln, Nebr.	32.5	940
KOA	Denver, Colo.	34.5	920
KFQB	Ft. Worth, Texas	36	900
WSM	Nashville, Tenn.	37	890
WLS	Chicago.	42	870
WEBH	Chicago.	47	820
WDAF	Kansas City	47.5	810
WOC	Davenport	50	800
WGY	Schenectady	51	790
WBBM	Chicago.	54	770
KWKH	Shreveport, La.	55	760
WTAM	Cleveland	57	750
WCCO	Minneapolis	59.5	740
WGN	Chicago.	62	720
WOR	Newark, N. J.	63.5	710
WLW	Cincinnati	65	700
WQJ	Chicago.	71	670
WJZ	New York	73	660
KRLD	Dallas, Texas	75	650
KFI	Los Angeles	77	640
WSB	Atlanta, Ga.	79	630
WCFL	Chicago.	82	620
WEAF	New York	84.5	610
KTHS	Hot Springs	86.5	600
WOW	Omaha, Nebr.	89	590
WFLA	Clearwater, Fla.	92	580
KYW	Chicago.	95	570
WHO	Des Moines	98	560
KSD	St. Louis, Mo.	100	550

* *Reading of left dial is not given, since it varies a few degrees for different antenna lengths. Both dials "track" very closely.*

For the Screen-Grid Six a tuned antenna input circuit was designed having the very best possible characteristics which could be attained in practice. This circuit consisted in its final form of a very low resistance coil consisting of 89 turns of No. 20 enameled wire upon a threaded bakelite form $3\frac{1}{4}''$ long and $2\frac{1}{2}''$ in diameter. A tap on this coil about 40 turns from the filament end is used when the set is to operate with a small antenna; when a long antenna is used or greater selectivity is required the antenna is connected to this tap through a 75-mmfd. midget condenser. Any student familiar with average coil resistance will realize that the values of 3.3 ohms at 550 meters and 11.5 ohms at 200 meters obtained with the coil, tuned by a 0.00035-mfd. condenser, represent an unusually good circuit (the coil itself has a "figure of merit" practically double that of the best coils on the open market). This input coil, L_1 in Fig. 7, is tuned by a single condenser, C_1, actuated by the left-hand drum, D_1.

In a test made to determine the characteristics of the antenna circuit, a representative antenna of 400 mmfd. capacity, 25 ohms resistance and 28 microhenries inductance was coupled to the input coil first through a small primary coil of 20 turns, and then through a large primary of 35 turns in series with a 75-mmfd. midget condenser; which was employed to regulate selectivity. Curve A of Fig. 1 shows that the voltage step-up provided by this tuned antenna input circuit varies from 64 at 200 meters (1500 kc.) to 28 at the middle of the broadcast band and rises to 100 at 550 meters (545 kc.)! And 545 kc. is the point at which the greatest step-up is always needed, for the amplification of any practical r.f. amplifier always falls off at long waves, as will be shown. The shape of this curve is not wholly ideal, but there is certainly no comparison between the voltage amplification that can be had from this circuit, with its one additional tuning dial, as compared to curve B of Fig 1. (Curve B represents the voltage amplification of a good untuned antenna coupling choke, and is hardly distinguishable from the base line of the curve of Fig. 1.) The dip in the center of curve A shifts with different size antennas and may further be shifted by adjustments of the midget antenna coupling condenser, C_6, so that it is seldom necessary to operate the receiver with as low a voltage step-up in the antenna coupler as is shown by the lower bend of curve A.

THE R.F. AMPLIFIER

THE antenna input circuit is followed by three identical tuned circuits, each housed in individual copper shielding cans, SH_1, SH_2, SH_3. These circuits employ small plug-in inductances, L_2, L_3, L_4, the secondaries of which consist of $98\frac{1}{2}$ turns of No. 29 enameled wire wound upon a threaded moulded bakelite form $1\frac{1}{2}''$ in diameter

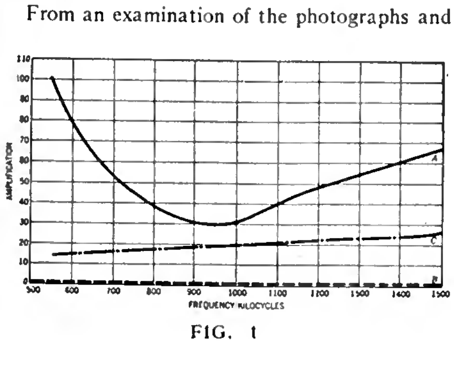


FIG. 1

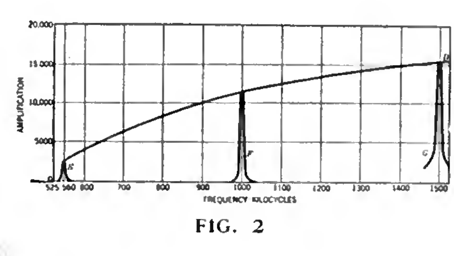


FIG. 2

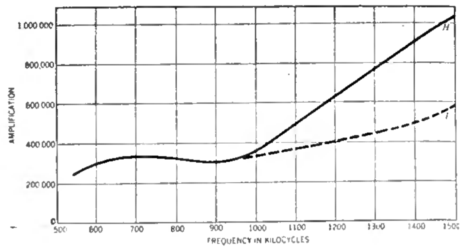


FIG. 3

and $1\frac{1}{2}''$ long. The primaries of the r.f. transformers consist of 50 turns of No. 38 enamelled wire on a piece of $1\frac{1}{4}''$ diameter tubing slipped inside of the secondary form. Two of these tuned circuits feed the two remaining screen-grid amplifier tubes, S_5 and S_6, while the third circuit feeds the detector tube, S_9. The actual measured voltage amplification of one individual stage is shown in curve C, Fig. 1, and is seen to vary from 14 per stage at 550 meters (545 kc.) to 25 at 200 meters (1500 kc.). While this amplification may seem very low for a screen-grid r.f. amplifier stage, it must be borne in mind that the high amplification factor of screen-grid tubes has no direct bearing upon the actual amplification that may be obtained from them in practice; that the maximum voltage gain which can be had from these tubes in the broadcast band with practical circuits will vary between 30 and 65 per stage, but that in order to obtain such amplification selectivity must be thrown to the winds. In the Screen-Grid Six, this has purposely not been done and the effective amplification of the three shielded r.f. amplifier stages has been purposely held at a low value in order that maximum possible selectivity could be obtained in these circuits. The overall voltage amplification of the three screen-grid stages, neglecting the antenna coupler, is shown by curve D of Fig. 2, and will be seen to vary from 2500 times at 550 meters to 15,500 times at 200 meters (curve D is simply the cube of curve C of Fig. 1).

An important thing to note at this point is the relative selectivity of the three-stage r.f. amplifier unaided by the antenna circuit (which contributes a very high degree of selectivity in itself). The selectivity curves in Fig. 2 do not show that the receiver is, like all t.r.f. sets, inherently non-selective at the lower frequencies. In curve H, Fig. 3, is shown the calculated r.f. amplification from antenna to detector grid for the Screen-Grid Six. (This amplification was calculated because of the practically impossible task of measuring the overall gain of such a sensitive receiver.) The curve is based upon the actual measured amplification for individual amplifier stages, and corresponds to curve D multiplied by curve A. Inasmuch as regeneration is not seriously present on the longer wavelengths (low frequencies) there is every reason to believe that the curve represents the actual performance of the receiver above 300 meters (1000 kc.). The rapid rise in amplification of the calculated curve below 300 meters is offset by the fact that on these lower waves there is a tendency for the receiver to oscillate, which is in turn offset by reducing the potential on the screen grids of the r.f. amplifier tubes by adjusting the potentiometer, R_1. The effect of this reduction is to increase the plate impedance of the r.f. tubes, which, in turn, decreases the effective amplification and increases the effective selectivity. The net result is a flattening off of the overall amplification curve much as shown by the dotted lines of Curve I, Fig 3, (curve I represents the actual performance of the receiver). It is seen to be quite flat, though the individual curves composing it were anything but flat to start with.

Before passing on from the r.f. amplifier, it is well to mention that every precaution has been taken to render the performance of this portion of the receiver as stable and dependable as possible. This can easily be realized from an examination of the illustrations and diagrams, which reveal individual copper stage shielding for the tuned r.f. amplifier circuits, individual bypassing of all B-supply leads by condensers directly in the stage shields, and the isolation of all r.f. currents from any common paths which might cause coupling and instability. The antenna input circuit is thoroughly shielded from the three remaining r. f. circuits, and when the receiver cabinet is in place, it is thoroughly shielded from extraneous interference. In order to allow for compensation of varying antenna characteristics, the option of two methods of antenna coupling is provided. One method employs a variable selectivity control in the form of a 75-mmfd. antenna series condenser, C_6. In the other method the condenser is omitted, and the antenna taps the primary coil, L_1, directly. The single tuning condenser, C_1, tunes the antenna circuit, and the triple gang condenser, C_2, C_3, and C_4, tunes the three remaining r.f. circuits housed in shields SH_1, SH_2, SH_3. Three compensators on the condenser frame allow compensation, once the set is assembled, for variations in tube and circuit capacities. Oscillation over the lower portion of the broadcast band, and volume over the entire band, is controlled by the potentiometer, R_1, which varies the potential on the screen grids of the r.f. amplifier tubes, S_4, S_5, S_6. The detector, S_9, presents no unusual features, being the conventional grid-condenser, C_{13}, and leak, R_7, type with negative filament return, since this was found to give best results in the Screen-Grid Six.

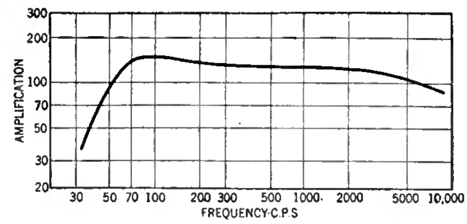


FIG. 4

THE AUDIO CHANNEL

THE transformers employed in the a.f. amplifier, T_1 and T_2, will be seen to consist of auto-transformers, resonating condensers, and plate resistors, all sealed in individual cans. These transformers have an effective transformation ratio of about 4.3 for T_1, and 3.5 for T_2, and through a unique phenomena of resonance obtained from proper proportioning of the auto-transformer windings, the condenser and the resistance, together with the plate resistance of the tubes used, a rising low-frequency characteristic is obtained which provides a hump in the amplification curve just below 100 cycles. (Fig. 4) A description of the audio amplifier system will be found in an article by Kendall Clough in the July issue of RADIO BROADCAST (pp. 133–4)

The effective voltage amplification of transformers T_1 and T_2 with a CX-301A or CX-112A first stage tube and CX-112A or CX-310 output tube would be approximately 960, a value much higher than is obtained from an ordinary transformer amplifier employing 3:1 transformers which would give a voltage gain of only 575 times as well as a bad fall-off in low-frequency amplification. (For the benefit of the dyed-in-the-wool fan who may think to improve ordinary transformers by either choke or resistance parallel feed, let it be stated that this cannot be done by rule of thumb methods—the Clough system has to be carefully proportioned mathematically to attain the results shown in Fig. 4.)

The photographs, drawings, and parts list are clearly marked and keyed and require practically no explanation. Mechanically, the receiver consists of a pierced metal chassis $21\frac{7}{16}''$ long, $9\frac{15}{16}''$ wide, and $\frac{5}{8}''$ deep. On top of the chassis are fastened, at the left end, the antenna coil, L_1, the antenna tuning condenser, C_1, as well as antenna and ground binding posts BP_1, BP_2,

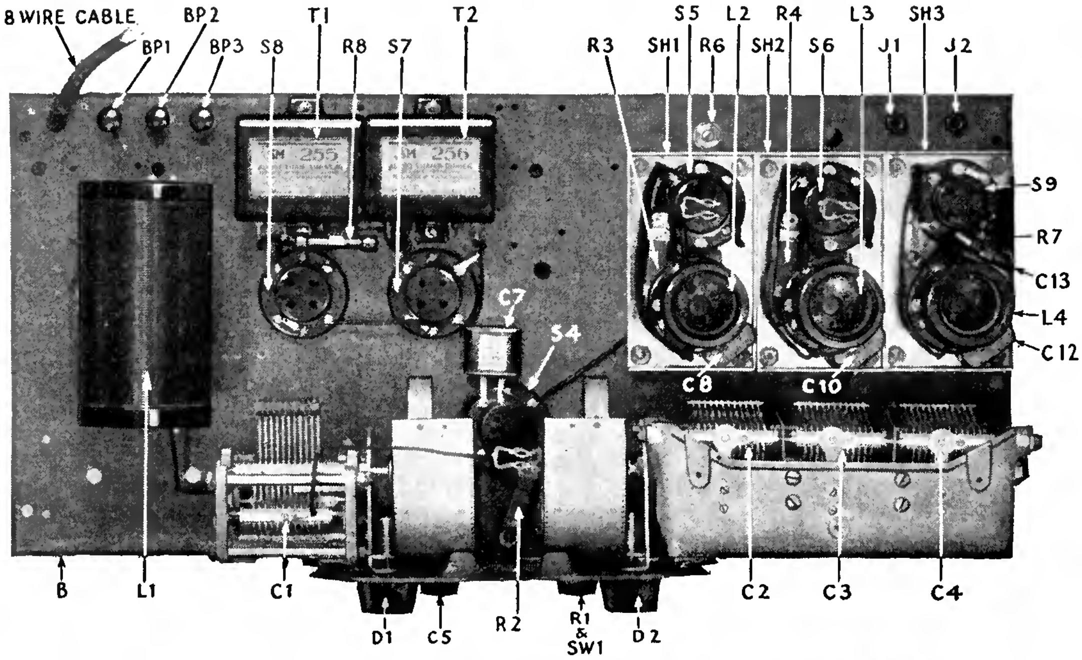


FIG. 5. ARRANGEMENT OF PARTS ABOVE SUB-PANEL

BP_3, and the hole for the battery cable. To the center rear of the chassis is the audio amplifier consisting of two transformers, T_1, and T_2, and two tubes, S_7 and S_8, with space left either for two large type transformers, or an output transformer in addition to the small types specified. To the right front is the three gang die-cast condenser, C_2, C_3, and C_4, tuning the three shielded r.f. circuits housed in the copper shields, SH_1, SH_2, SH_3, just behind this condenser. The two condenser assemblies are tuned by the drum dials, D_1, and D_2, visible through the windows of the front control escutcheon. Below the vernier knobs of the dials are, to the right, the volume control potentiometer, R_1, to which is attached the on-off switch, SW, and to the left is the selectivity condenser, C_5, in series with the antenna. The positions and uses of the various bypass condensers and resistors are evident from a study of Fig. 7. Just behind one of the copper stage shields is located a rheostat, R_6, used to compensate variations in A-battery voltage. It is intended to be adjusted by a screw-driver.

The receiver requires for operation three CX-322 tubes, one CX-301A (or preferably CX-112A) detector tube and one CX-301A (or preferably CX-112-A) first a f. amplifier tube. Any power output tube such as CX-112A, CX-371A, CX-310, or CX-350 may be used, provided suitable A and B supply is available. In the circuit shown, a CX-112A or CX-371A output tube may be used at will, though with the latter the addition of an output transformer is desirable to protect speaker windings. Either batteries or standard light socket power units may be used to operate the receiver. The plate current consumption is about 30 mA with 112A output tube, or 40 mA with 371 output tube. Hence a B-power device should prove more economical for operating the receiver, especially if a 371 tube is used.

Some may want to operate the set from the light socket through the use of a.c. tubes. In such cases heater type a.c. screen-grid tubes should be used in the r.f. stages and ordinary three electrode heater type 227 tubes in the detector and first audio stages. The output tube may be any type, with its filament operated from a.c. Complete circuit diagrams for a.c. operation can be obtained though RADIO BROADCAST or directly from the manufacturer. For a.c. operation some changes in the circuit and parts required for the construction of the receiver will be necessary.

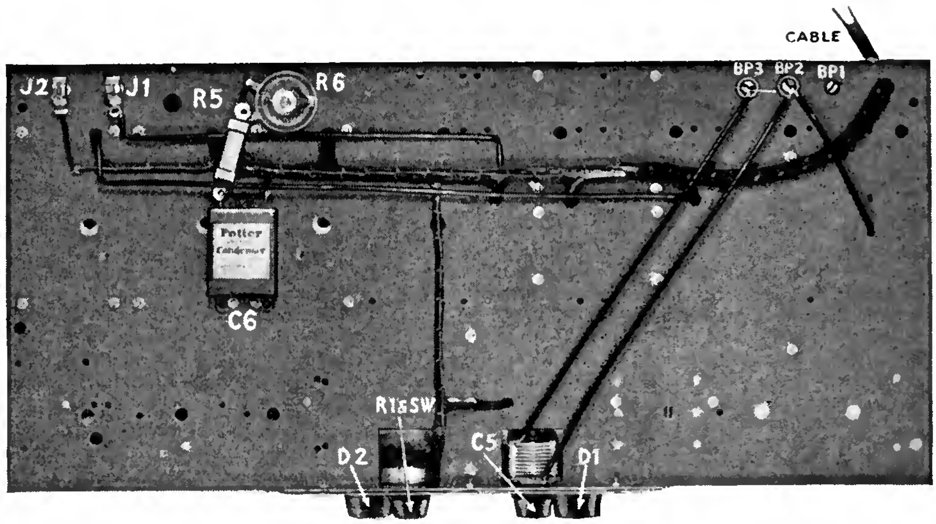
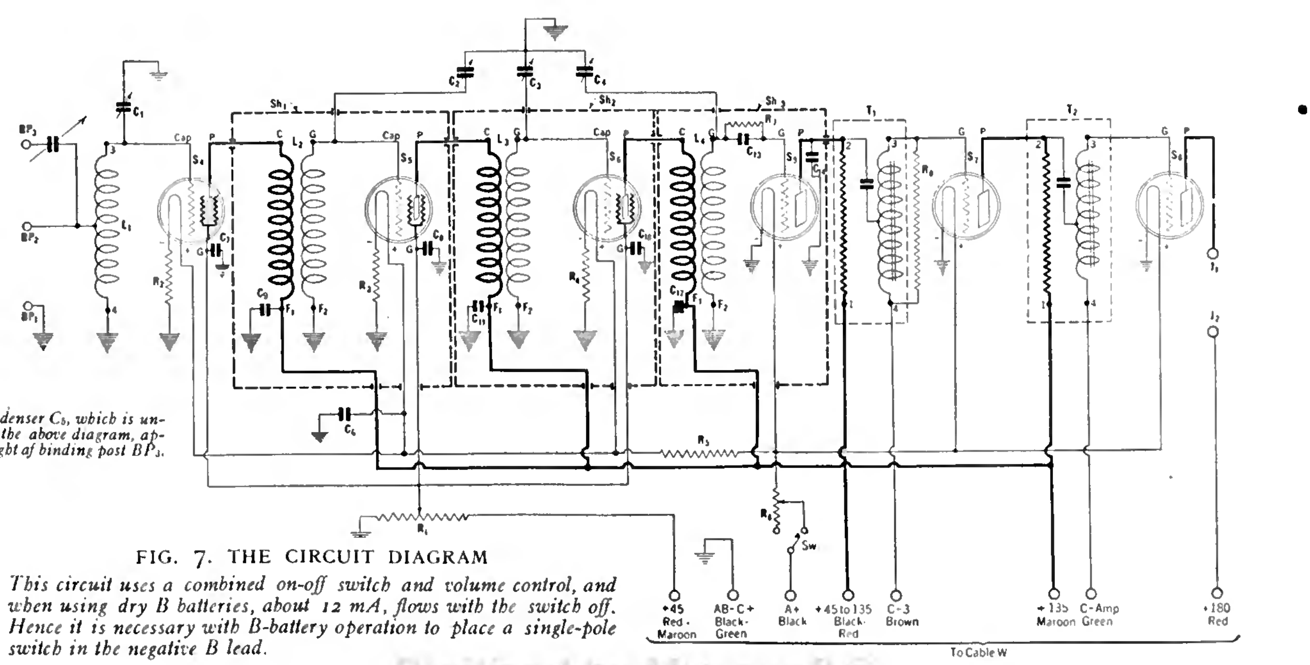


FIG. 6. UNDER THE SUB-PANEL

LIST OF PARTS

THE complete kit for this receiver may be obtained from Silver-Marshall, Inc., including a drilled chassis and all the necessary hardware. The special parts used in the circuit are the antenna coil, L_1, the r.f. transformers, L_2, L_3, and L_4, and the audio transformers, T_1 and T_2. The specifications of the antenna and r.f. coils are given in the article, and may be made at home. It is not advisable to substitute for the audio transformers, since the advantages of the Clough system of audio amplification, as described in the article, will be lost. The remainder of the parts in the list below are of standard design, and other parts electrically and mechanically equivalent may be substituted.

B—1 S-M Universal pierced base chassis, No. 701
E—1 S-M dual control escutcheon, No. 809
D_1—1 S-M vernier drum dial (left), No. 806L
D_2—1 S-M vernier drum dial (right), No. 806R
C_1—1 S-M 0.00035-mfd. Universal condenser, No. 320R
C_2, C_3, C_4—1 S-M 0.00035-mfd. 3-gang condenser, No. 323
C_5—1 S-M 0.000075-mfd. midget condenser, No. 342B
R_1—1 Yaxley 3,000-ohm midget potentiometer, type 53000
SW—1 Yaxley switch attachment, type 500
J_1, J_2,—2 Yaxley insulated tip jacks, type 420
R_1, R_2, R_3—3 Carter 10-ohm resistors type RU10
R_5—1 Carter $1\frac{1}{2}$-ohm resistor, type H$1\frac{1}{2}$
R_6—1 Carter 6-ohm sub-base rheostat, type A6
C_6—1 Potter 1-mfd. bypass condenser, No. 104
C_7, C_8, C_9, C_{10}, C_{11}, C_{12}—6 $\frac{1}{4}$-mfd. midget bypass condensers
C_{13}—1 0.00015-mfd. grid condenser with clips
C_{14}—1 0.0002-mfd. bypass condenser
R_7—1 2-megohm grid leak
R_8—1 Durham 0.15-megohm resistor with leads
SH_1, SH_2, SH_3—3 S-M copper stage shields, No. 638
L_1—1 S-M antenna coil, No. 140.
L_2, L_3, L_4—3 S-M plug-in r.f. transformers, No. 132A
S_1, S_2, S_3,—3 S-M 5-prong tube sockets, No. 512
S_4, S_5, S_6, S_7, S_8—5 S-M tube sockets, No. 511
S_9—1 Naald cushioned tube socket, type 481XS
T_1—1 S-M first stage a.f. transformer, No. 255
T_2—1 S-M second stage a.f. transformer, No. 256
BP_1, BP_2, BP_3—3 Moulded binding posts consisting of $\frac{8}{32}$ screw, nut, and moulded top.
1 S-M 708 8-lead, 5-foot connection cable
1—S-M 818 hook-up wire (25 ft. to carton)
1 Set hardware (obtainable from Silver-Marshall)



Note: Condenser C_5, which is unlettered in the above diagram, appears to right of binding post BP_3.

FIG. 7. THE CIRCUIT DIAGRAM

This circuit uses a combined on-off switch and volume control, and when using dry B batteries, about 12 mA, flows with the switch off. Hence it is necessary with B-battery operation to place a single-pole switch in the negative B lead.

New Apparatus

PRODUCTS of radio manufacturers whether new or old are always interesting to our readers. These pages, a feature of Radio Broadcast, *explain and illustrate products which have been selected for publication because of their special interest to our readers. This information is prepared by the Technical Staff and is in a form which we believe will be most useful. We have, wherever possible, suggested special uses for the device mentioned. It is of course not possible to include all the information about each device which is available. Each description bears a serial number and if you desire additional information direct from the manufacturer concerned, please address a letter to the Service Department,* Radio Broadcast, *Garden City, New York, referring to the serial numbers of the devices which interest you, and we shall see that your request is promptly handled*—The Editor.

Power Apparatus for the 250 Type Tube

X52

Device: Power Supply Apparatus for use with the type 250 tube. In constructing a power unit to use the type 250 tube it is essential that apparatus be used that will be capable of supplying to the tube sufficient current and voltage. There is given below a *résumé* of power apparatus, old and new, made by several manufacturers which may be used satisfactorily to operate a power amplifier using a type 250 tube.

Amertran Power Transformer, Type PF 250. *Price:* $30.00. Gives a d.c. output of 400 to 450 volts, 200 mA., with two type 281 rectifying tubes, full-wave; either one or two power tubes, type 250, single or push-pull, can be used. Filter Choke Coil, type 709. *Price:* $6.00 each. Inductance: 50 henries at 120 milliamperes.

Dongan Power Transformer, Type 7568. *Price:* $13.00. Designed for full-wave rectification using two type 281 rectifiers. Double Filter Choke Coil, type 5554. *Price:* $11.00.

National Power Transformer, type R. *Price:* $14.50. Designed for full-wave rectification using type 281 rectifiers. Filter Choke Coil, type 80. *Price:* $10.00.

Samson Power Transformer, type 162. *Price:* $18.00. Designed for half-wave rectification using type 281 rectifier. Filter Choke Coil, type 312, 30 henries, 120 mA. *Price:* $12.00.

Silver-Marshall Power Transformer, type 328. *Price:* $18.00. Designed for full-wave rectification using type 281 rectifiers. Type 327 (*Price:* $12.00) may be used in half-wave circuits. Filter Choke Coil, type 331. 27 henries, 120 mA. *Price:* $8.00.

Thordarson Power Transformer, type T 2900. *Price:* $20.00. For full-wave circuit using two type 281 tubes. Double Filter Choke Coil, type T-20-99. *Price:* $14.00.

Application: The above apparatus is for use in constructing power amplifiers using the type 250 tube. The General Radio Company also manufacture apparatus for this purpose and their units were described in this section in the June issue. Further information including circuit diagrams, can be obtained from the above manufacturers through Radio Broadcast.

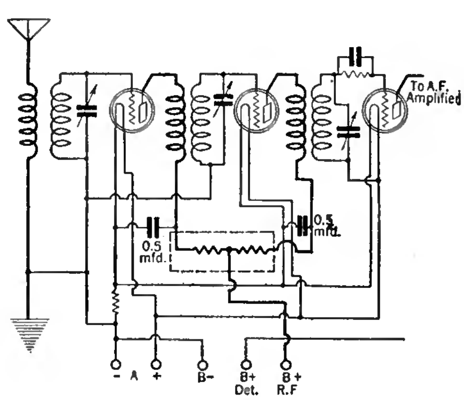


FIG. 1

One use of the Duplex Clarostat is, as shown in this diagram, to control the plate voltage applied to either tube of a two stage radio frequency amplifier

THE DUPLEX CLAROSTAT

A Dual Resistance with Many Uses

X53

Device: Duplex Clarostat Resistance. A novel form of resistance consisting essentially of two Clarostat resistances in a single metal case. Each section can be independently adjusted to any value of resistance within the range of the Clarostat, which is from a low resistance to a high resistance of about five million ohms. Resistance is varied by tuning a slotted screw with an ordinary screw driver. May be mounted on panel, sub-panel or baseboard. Furnished with mounting bracket. *Manufacturer:* Clarostat Manufacturing Company. *Price:* $2.25.

Application: The instruction sheet supplied with each Duplex Clarostat points out many uses for the device. These include its use in resistance-coupled amplifiers, in push-pull amplifiers, as a plate voltage control, as a center-tap resistance, etc. In Fig. 1 and 3, which illustrate two of these uses, the Duplex Clarostats have been enclosed in dotted lines.

Aluminum Shields

X54

Device: Aluminum Box Shields. Designed for use in constructing shielded receivers. Two sizes are available; the Junior size measuring 4½ x 4½ x 5 inches high and the large size measuring 5 x 9 x 6 inches high. The Junior shield has room for a coil and a tube; this shield is for use with a metal sub-panel and is not supplied with a bottom the large shield can be used to house the coil, tube, and tuning condenser. The shields are made of 0.08- inch thick aluminum, and they consist of four sides, top, bottom, and two slotted corner posts into which the sides are fitted. *Manufacturer:* Aluminum Company of America. *Price:* $8.00 for set of four Junior shields, $3.50 each for large shields.

Application: Shielding is of importance to radio amateurs who wish to improve their present outfits or who have decided to incorporate shielding in new equipment of their own design.

Reviewing the circuits generally used, a single-tube receiver with regenerative detector usually is not improved by shielding, unless it happens to be located very close to a broadcasting station. In this case the entire detector circuit, including the coil, the tube socket, and the tuning condenser, may be mounted advantageously inside a standard aluminum box shield.

In a receiver employing one stage of radio-frequency amplification and a regenerative detector, the detector circuit may be shielded completely. If this is done there is little additional advantage in shielding the radio-frequency stage.

A circuit using two stages of radio-frequency amplification may be improved slightly by using shields of the partition type. Where selectivity and stabilization are especially necessary, the coils, tube sockets, and condensers may be mounted in shields. The apparatus of one stage only should be placed inside a single box, separate boxes being used for additional stages. An alternative is to place the coils and tube sockets of each stage in Junior Shields with the tuning condensers outside of the shields.

For circuits employing three stages of radio-frequency amplification, it is recommended that each stage, including the condensers, be housed in a standard box shield, or the Junior size shields may be used for covering the coils and tube sockets only.

For super-heterodyne circuits, in which the maximum of selectivity is desired, it is advisable to shield the entire first detector circuit in a box-type shield and the entire oscillator circuit in a similar unit.

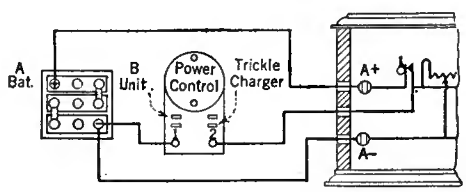


FIG. 2

Automatic Control for A and B Power

X55

Device: Multiple Type 445 Automatic Power Control. Designed especially for use with radio receivers drawing a filament current of less than about 0.36 amperes (corresponding to the current required for six 199 type tubes). The Yaxley type 444 control should be used if the receiver has a total current drain of more than 0.36 amperes. This type 445 control automatically turns off the trickle charger and turns on the B-power unit when the filament switch on the

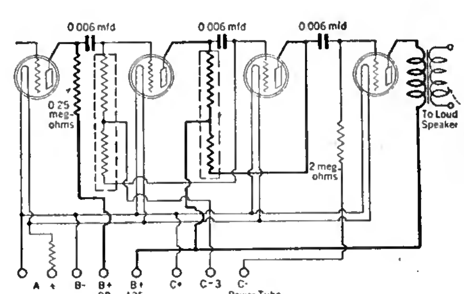


FIG. 3

A second use for the double resistance described above in X53 lies in controlling the plate voltage to two tubes in a two or three stage audio amplifier. Another Duplex Clarostat may be used to control the grid leak resistance of the two tubes

THE MAGNAVOX SPEAKER, TYPE D-80

receiver is turned on. When the set is turned off, the power control turns off the B-power unit and turns on the trickle charger. The connection of this control to a radio receiver is shown in Fig. 2. *Manufacturer:* Yaxley Manufacturing Company, *Price:* $6.00.

Application: As mentioned above, the power control is designed especially for use with radio receivers using six 199 type tubes or less. By its use the charging of the battery is automatically taken care of while the radio receiver is not in use and there is no possibility that the B-power unit will be left turned on while the set is not in use.

Dynamic Speakers for A.C. and D.C. Operation

X56

Device: Magnavox Dynamic Loud Speakers. The following types are available:

Type R-4. The field winding of this model requires 0.65 ampere at 6 volts. This energy may be supplied from a storage battery or any other source of 6 volts d.c.

Type D-8. This model requires 6 to 12 volts d.c. for field excitation. The field current at 6 volts is 1.1 amperes and at 12 volts 2.2 amperes.

Type D-80. The field circuit of this model is supplied through a transformer and rectifier from the 110-volt a.c. light socket. The hum due to the use of rectified a.c. is prevented by means of a neutralizing coil as explained below.

All of the above models are identical in practically every way with the exception of changes associated with the particular method of field excitation which is used. In the case of the type 80 unit utilizing rectified a.c. for field excitation, an additional coil is wound on the moving element and the current through this extra coil neutralizes the effect of the pulsating current in the field winding. The resultant effect upon the cone is zero and therefore no hum is produced.

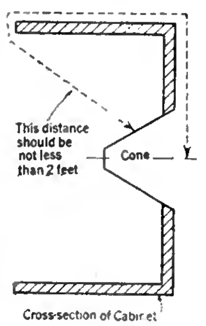


FIG. 4

All of the models include an output transformer designed to adapt the impedance of the moving coil to that of the power tube. If it is desired to use one of these loud speakers in special circuits such as push-pull or a parallel arrangement of power tubes, special transformers are required. These transformers can be obtained from any of the well known manufacturers of audio frequency apparatus.

It is essential that a baffle be used with these loud speakers. Two waves are generated by the movement of a free edge cone, into which class fall speakers of this type. When the cone moves forward it compresses the air in front of it and at the same time decompresses or rarifies the air at the back of the cone and unless a partition is erected to keep these two effects separate they will tend to neutralize each other and lower the efficiency of the speaker. The baffle is especially necessary to obtain satisfactory reproduction of the low frequencies, for at high frequencies the cone itself acts as an effective baffle. The baffle may take the form of a cabinet or of a large flat surface. In either case the baffle itself should be so constructed that it will not readily vibrate. Otherwise it will produce exaggerated response at those frequencies at which the baffle resonates. In the Laboratory a large flat piece of wood measuring about four feet by four feet, and an inch thick, is used with excellent results. If a cabinet is used for the baffle the distance from the center of the front of the cone around the edge of the cabinet to the rear of the cone should be at least two feet. This distance is indicated in Fig. 4. The baffle should be left open at the back and in order to prevent undesirable resonance in the cabinet itself, it may be necessary that a few small holes be placed in the side and bottom.

Manufacturer: The Magnavox Company. *Prices:* Type R-4, $35.00; type 8, $35.00; type 80, $50.00 without cabinet.

Application: Present day dynamic speakers represent one of the most important developments in radio. Theoretically the dynamic speaker is capable of giving practically uniform response over the entire range of audio frequencies, and such uniform response is realized to a considerable extent in practice under good operating conditions. A dynamic speaker is now used in the Laboratory as a standard of comparison for it is capable of giving much better quality than other types of loud speakers available at present. Many will prefer to purchase only the unit and install it in a baffle consisting of a large flat board about one inch thick and preferably three or more feet square.

For Push-Pull Amplification

X57

Device: Push-Pull Audio Transformer, Type H. These transformers are for use with either 171 or 210 type tubes in push-pull amplifiers. The turns ratio of the input transformer is 1.75 to 1; the turns ratio of the output transformer is 1 to 1. *Manufacturer:* Dongan Electric Manufacturing Company. *Price:* $4.50 for the input transformer; $4.50 for the output transformer.

Application: The circuit diagram of a single stage push-pull amplifier using these transformers is given in Fig. 5. The tubes may be either 171's or 210's. The resistance, R, supplies C bias to the tubes; for 210's its value should be 750 ohms, for 171's its value should be 1000 ohms.

DONGAN PUSH-PULL TRANSFORMER

Fixed Resistances

X58

Device: Davohm, and Super-Davohm Wire-Wound Fixed Resistances. Davohm resistances are made in the following sizes; 7.5 watts (500 to 15,000 ohms), 15 watts (500 to 15,000 ohms), 1 watt (100 to 5000 ohms), 2 watts (100 to 7500 ohms). Super-Davohms have a rating of 1 watt and are available in sizes ranging from 10,000 ohms to 5 megohms. Manufactured by the Daven Radio Corporation. *Prices,* vary with rating of resistor.

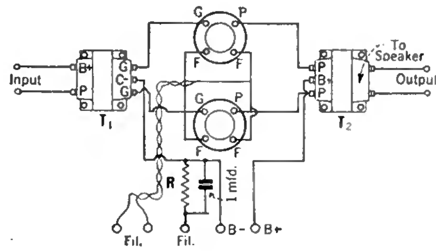


FIG. 5

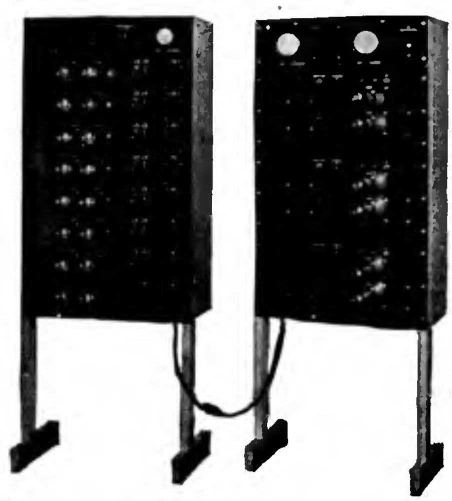
Application: May be used in any device where there is need for a good resistance. The Davohm resistances are excellent for use in all types of power units. Super-Davohms are useful as laboratory standards, multipliers for voltmeters, plate resistances in a. f. amplifiers, grid suppressors in r. f. amplifiers, etc.

A. C. Power Amplifier for Many Loud Speakers

X59

Device: Distributing Power Amplifier for apartment house use. The amplifier illustrated consists of eight 210 push-pull stages each operating ten loud speakers, with approximately 500 milliwatts per outlet. The eight amplifiers with their input panel are powered by three rectifier panels employing 281 type tubes, each of which delivers approximately 132 mils. at 450 volts, each rectifier operating three amplifiers. The complete installation is light-socket operated, and comes in a varying number of racks to take care of varying numbers of outlets. These racks need merely be interconnected by the plugs provided, the output of the radio receiver connected to the amplifier, and the power plug inserted in an a. c. light socket, and the installation is ready for operation. Manufactured by Silver-Marshall, Inc. *Price:* $300.00, approximately, for an amplifier suited to the operation of from four to ten loud speakers.

Application: This amplifier rack represents a development in equipment suited to public address or apartment house installation and the accompanying photograph shows a typical distributing amplifier—a good subject for a conversation with your landlord.



SILVER-MARSHALL DISTRIBUTING AMPLIFIER

A Non-Radiating Short-Wave Tuner

By JAMES MILLEN

RADIO BROADCAST has described in past months a number of interesting short-wave receiver units of various designs. The unit described here, a product of the National Company, contains no audio system—which makes it applicable to any audio system whether a part of a standard receiver or not. The set is non-radiating, and due to the isolation of the radio-frequency stage from the detector circuits, the tuning points as noted on the dial do not vary with antennas of varying lengths. The antenna circuit is choke-coupled to the screen-grid tube. A "picture diagram" of the set and most of the constructional data have not been included in this article because a blueprint of the hook-up and layout and constructional data are available through RADIO BROADCAST *or direct from the National Company.* —THE EDITOR.

SYMMETRY AND SIMPLICITY IN THE FRONT PANEL

NOW that short-wave broadcasting has passed through its early experimental stages and reached the state where reliable reception of good quality programs is readily obtained by means of easily constructed and inexpensive receivers, a great many readers who in the past have confined their efforts to the construction of radio receivers for use on the regular broadcast band, desire to build a good short-wave receiver.

Aside from the mere fun of building a "different" type of radio set, there is that thrill of receiving understandable programs from distant and foreign stations. With a short-wave receiver, distance takes on an entirely new meaning.

It is not uncommon to receive broadcasting from ANE at Java, 3LO at Melbourne, Australia, 5SW at London, PCJJ in Holland, and many others; and static and fading are frequently entirely absent when reception on the regular broadcast band is exceedingly poor.

THE DESIGN OF THE RECEIVER

THE National Screen-Grid Short-Wave receiver comprises several interesting features. One is the single tuning control. Another is the foundation unit design which permits an efficient layout of parts, with but a few connections to be made by the assembler. As a result of the 222 type tube in the first stage, the sensitivity of the receiver in general is materially better than that of the plain regenerative detector type formerly so much in use. Furthermore, the use of the 222 tube ahead of the essential regenerative detector prevents radiation—a problem which would soon become quite serious if all the short-wave receivers were of the radiating variety. Still another important advantage secured by the use of the 222 tube as in this receiver is the elimination of tuning "holes," or dead spots commonly encountered with plain regenerative receivers. Although heretofore rather carefully placed shielding has been considered essential to a receiver using the 222 tube, the use of the untuned antenna circuit employed in this screen-grid short-wave receiver makes shielding unnecessary. The elimination of the shielding not only reduces the cost of parts and simplifies the work of construction, but also makes it a simple matter to change coils when going from one band to another. To cover the band of from 15 to 115 meters (20 to 2.65 megacycles) four interchangeable transformers are used. These transformers differ in a number of respects from the conventional "short-wave coils" with which everyone is familiar.

In the past it has been the general practice to employ coils of fairly large diameter—usually about 3 inches or so. As a result, all but perhaps the 100-meter coil would have a diameter much greater than its length. It is a well known fact that the most efficient coil is one having what is known technically as "unity form factor," or in other words a length of winding equal to the diameter. By using a coil diameter smaller than customary and at the same time varying the spacing between turns and size of wire, a coil of high efficiency for each band has been developed. In addition, in order to secure a high mutual inductance between the primary and secondary of the r.f. transformer without unnecessarily high capacity coupling, the primary or plate coil is wound of very fine wire located between the turns of the secondary or grid coil. The tickler winding in each instance is located in a slot at the low potential end of the transformer.

One of the most essential and most neglected features of a good short-wave inductance is rigidity. Without rigidity any slight vibration or jar in the room where the receiver is being operated will result in unsteady signals. Also, such coils will not stand up under continual handling, with the result that stations are seldom received from time to time at the same dial setting. In the case of these coils, such difficulties are entirely overcome by winding the transformers on threaded micarta tubing, and soldering the ends of each coil directly to the special one-piece contacts located around the bottom of the tube.

While some readers may think that the use of such a micarta tube would increase the losses in the coils by a noticeable amount, such has been found not to be the case, as the dielectric is located in the weakest part of the magnetic field of the coil.

Another interesting feature is the special tuning condenser employed. This condenser, while resembling in general appearance the standard National Girder Frame condenser, is one designed especially for use in short-wave receivers. In the first place, it has a straight frequency line characteristic, so as to make tuning equally easy at both ends of the dial. A further arrangement for facilitating tuning is the 270 degree rotation, which spreads the stations over 50 per cent. greater dial range than if the standard 180-degree rotation had been employed. The double plate spacing that will be noted from the illustrations, is employed to "smooth out" any slight irregularities in the characteristic curve of the condenser, which, while not ordinarily detectable at broadcast frequencies with

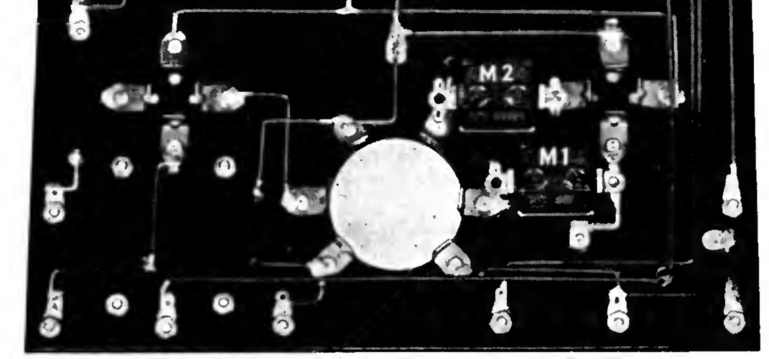


FIG. 1. UNDERNEATH THE SUB-PANEL

standard condensers, is quite noticeable at the short wavelengths.

A final innovation in the condenser design is a constant impedance pig-tail which eliminates variations in dial settings due to pig-tail inductance variations when the old style of "clock spring" contact is used.

The r.f. choke coil, G_1 in Fig. 2, used in the detector plate lead, is of the multi-section slot-wound variety having very low distributed capacity over a wide band of frequencies. The other r.f. choke, or grid circuit impedance, G_2, is one especially designed for the purpose and has an inductance of approximately 2 millihenries.

Perhaps it would be well to caution at this time against the use of the wrong size filament resistor, R_3, for the UX-222 tube. This resistor should be of the 15-ohm size and not 22 ohms. Due to the type number of the tube, UX-222, and the practice of some resistor manufacturers of marking their 22-ohm units as type 22, many experimenters have assumed that a "type 22" resistor is the proper one to use with a UX-222 tube under any conditions.

COIL DATA

THE four coils used in this set have wavelength ranges as follows:

Type A—15.5 to 26.5 meters. Secondary, 4 turns of No. 14 enameled wire; tickler, 2 turns of No. 30 d.s.c. wire; primary, 3 turns of No. 28 enameled wire.

Type B—23.5 to 41 meters. Secondary, 7 turns of No. 14 enameled wire; tickler, 2 turns of No. 30 d.s.c. wire; primary, 6 turns of No. 28 enameled wire.

Type C—37.5 to 65 meters. Secondary, 14 turns of No. 14 enameled wire; tickler, 3 turns No. 30 d.s.c. wire; primary, 14 turns No. 28 enameled wire.

Type D—64 to 115 meters. Secondary, 25 turns of No. 18 enameled wire; tickler, 4 turns No. 30 d.s.c. wire; primary, 25 turns No. 28 enameled wire.

All of the coils are wound on 2 inch tubing. The secondaries of the first three types are spaced 8 turns to the inch; the secondary of D coil is spaced 14 turns to the inch. The tickler is wound in a slot $\frac{3}{8}''$ below the filament end of the secondary and the primary is wound in the spaces between the secondary turns.

CONSTRUCTIONAL NOTES

BY CAREFULLY studying the illustrations, one will readily see how to mount all of the parts on the foundation unit. All holes are drilled and the work is very easy. As soon as the assembly is completed the wiring may be done. If the wiring diagram is carefully followed it is quite simple for anyone to obtain a very neat job. Needless to say, all connections should be carefully soldered. The two moulded mica condensers located under the sub-panel, are fastened in place by soldering their terminals directly to the socket and coil clips between which they are connected.

In order to make contact to the cap or control grid of the 222 tube, use a short length of small, flexible, rubber-covered wire, or very fine single silk-covered wire, running in a piece of small spaghetti and ending in a fuse clip or similar home-made clip, to snap on at the top of the cap.

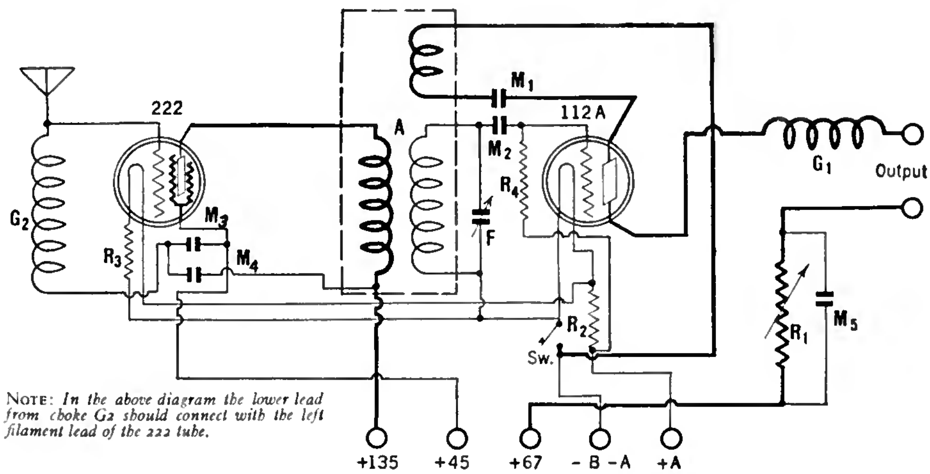


FIG. 2. THE CIRCUIT DIAGRAM

AUDIO AMPLIFIERS

FOR headphone reception, it is recommended that a single stage of transformer-coupled audio amplification be added to the output of the receiver as just described. While such an additional amplifier is not at all necessary, it will be found of considerable aid in receiving distant and weak signals.

When loud speaker operation from such short-wave broadcasting stations as KDKA, WABC, etc., is desired, then the use is recommended of a high grade two-stage transformer-coupled audio amplifier of either the straight or push-pull variety.

LIST OF PARTS

THE complete parts, together with the foundation unit, may be obtained in kit form. However, all the parts, with the exception of the coils, are of standard des gn, and other equivalent parts may be substituted. The coil data is given in the text.

A—4 National short-wave transformer coils covering the range of 15 to 115 meters
E—1 National dial, type E, with type 28 illuminator
F—1 National condenser, short-wave type, 125 mmfd.
G_1—1 National r.f. choke, No. 90
G_2—1 National h.f. impedance, No. 10
M_1—1 Aerovox molded mica condenser, 0.001 mfd.
M_2—1 Aerovox molded mica condenser, 0.00025 mfd.
M_3, M_4—2 Aerovox bypass condensers, 0.5 mfd.
M_5—1 Aerovox bypass condenser, 1.0 mfd.
R_1—1 Electrad Royalty resistor, type L, 0–500,-000 ohms
R_2—1 Filament resistor, 2 ohms
R_3—1 Filament resistor, 15 ohms
R_4—1 grid leak, 6 megohms
S—1 Yaxley filament switch
8 Eby binding posts
1 Foundation Unit, including Westinghouse Micarta panels, sockets, gridleak and r.f. choke mounts, completely drilled, ready to assemble
UX-222 and UX-201A tubes

OPERATION OF THE RECEIVER

AT THIS time, the writer feels that socket-power units are not suitable for use with a short-wave receiver. It is necessary for satisfactory results, therefore, to employ 135 volts of dry or storage B battery, in addition to the usual 6-volt storage A battery. If an audio amplifier of some kind is not to be employed, then a pair of phones should be connected to the "output" posts on the right-hand side of the sub-panel.

A good ground may be connected to minus A. In some instances, however, better results are obtained without the use of a ground.

For an antenna it is recommended to use a single wire of from 35 to 100 feet in length and as high and free from surrounding objects as possible.

By means of the variable resistance regeneration control (right-hand knob) the detector tube may be made to oscillate, and then the carrier of the station received. A slight readjustment of both controls should then bring in the station. The tuning of a short-wave receiver is a much more critical process than that of a standard broadcast receiver, and unless care is used, the novice is likely to pass right by a station.

Station 5SW at Chelmsford, England, can generally be heard between 5 and 6 P.M. in Boston when using transformer B and with the dial set at about 31.

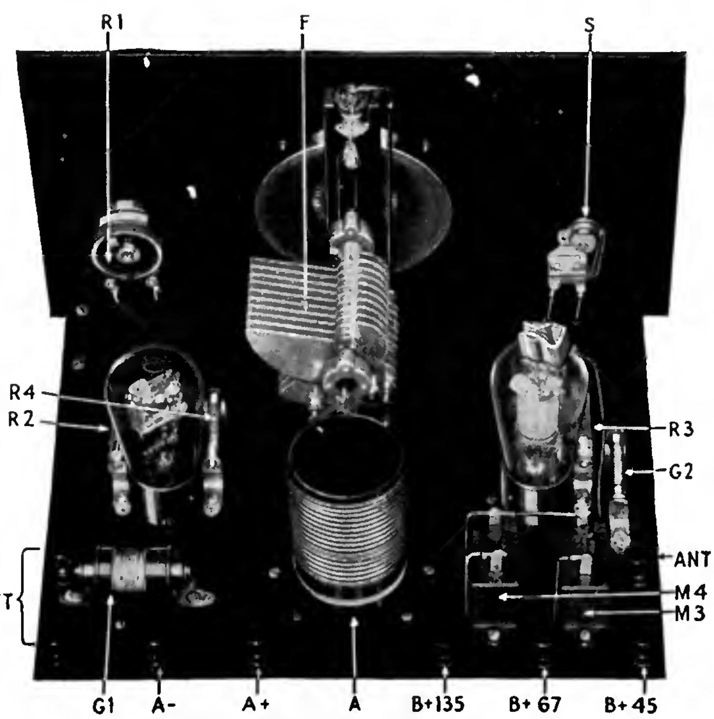


FIG. 3. ABOVE THE SUB-PANEL

What RADIO Has Done *for* AVIATION

By AN ENGLISH RADIO ENGINEER

An English answer to the charges made by "Anonymous" in the November number of this magazine, that aviation has not made the proper use of radio, points out the fact that in the "air-minded" countries of the Old World radio is playing its part in the safety of air navigation. The implication is that as America develops its commercial air lines to the point at which they are now developed in Europe, radio will be recognized as an essential part of airplane equipment.

—The Editor

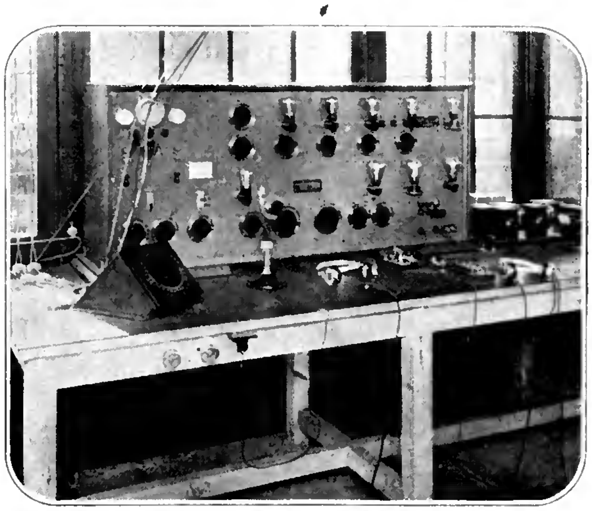
MUCH has been said in the past about the failure of aviation to make the proper use of radio, particularly on such hazardous ventures as transoceanic flights. An unusually stimulating article on this subject by "Anonymous," entitled "What's the Trouble with Aircraft Radio?" appeared in the November, 1927, number of Radio Broadcast. As its title suggests, "Anonymous" is looking rather for what radio has not done for aircraft than what it has done. We may fairly claim that the latter is even more striking than the former.

No radio engineer who has had experience in aircraft radio would attempt to minimize the difficulties to be encountered in adapting radio to aircraft use, but that these difficulties are not insuperable has been proved time and time again since the institution in England, by the Marconi Company, of what I believe were the earliest experiments in this direction at that famous nursery of European aviation, the Hendon Airdrome near London. Incidentally, these "laboratories" were in the Graham White sheds at Hendon, so it cannot be said that the radio engineers were out of touch with the flying men. To-day the Marconi Company is working in close collaboration with the Air Ministry and aircraft operating and constructing companies, and has recently completed the construction of an entirely new installation at the London Air Port at Croydon, with four transmitters working on different wavelengths, which is claimed to be the most up-to-date airdrome radio installation in the world.

During the war the evolution of the radio telephone set for airplanes was pushed forward, and in the summer of 1915 the first spoken message from an airplane to the ground, in England, was obtained by Major Prince in collaboration with Captain H. J. Round—then members of the experimental section of the Royal Flying Corps at the Brooklands Wireless School—by means of a continuous wave tube transmitter. Continuous inter-machine working was not an accomplished fact until 1917, but it was used for formation control in the latter stages of the war.

In the last few years the development of radio for fighting planes has proceeded to a stage far in advance of that reached by November, 1918, with the result that the wonderful squadron "air drill" that may be seen in the world's leading air forces has become a practicable and safe proposition instead of—as it would be without radio—a hazardous adventure. For purposes of this "air drill" in close formation the Marconi Company has now developed a small, light set using an aerial system attached to the wings.

It is, however, to the enormous possibilities of civil aviation that the world is turning its eyes to-day; and no thoughtful person will quarrel with "Anonymous" when he says: "Before passengers are permitted to risk their lives, regulations regarding suitable radio equipment and personnel to operate it should be laid down." This state of affairs has already been reached in all the principal countries in Europe. But, before we examine more closely the working of this commercial aviation policy in Europe, let us look at some of the more spectacular achievements of radio—because "Anonymous" has selected some spectacular non-achievements.



IN THE CROYDON RADIO CONTROL TOWER

The four transmitters at Mitcham, 4½ miles from the Croydon Air Port, are controlled from this room. At the left is the direction finding unit; next to it is the 9-tube multiwave receiver amplifier. Transmission takes place on telephony and telegraphy.

WHERE RADIO HELPED THE FLYER

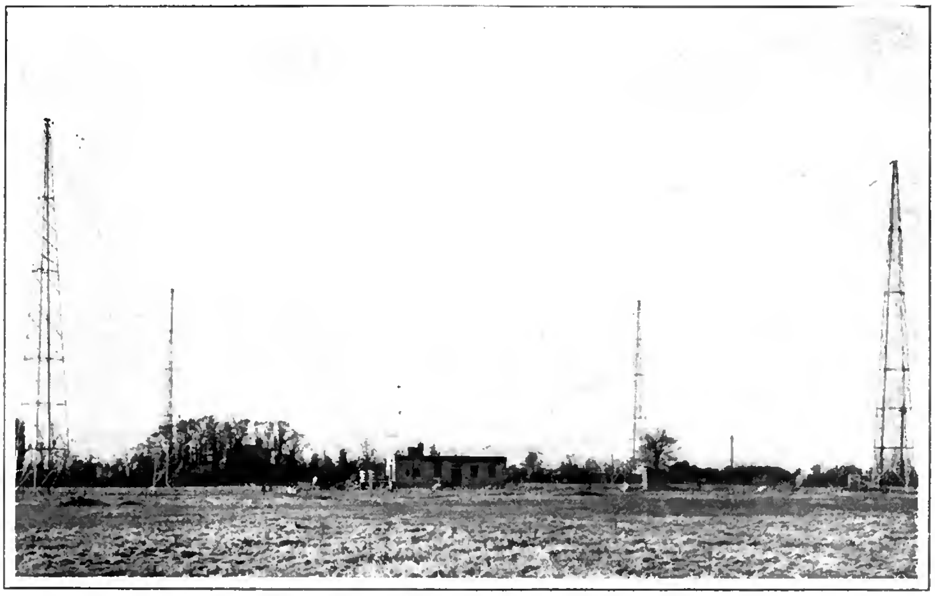
WHEN the British Airship R34 flew across the Atlantic in July, 1919, radio was used in a very practical manner by its navigators for direction finding and position finding. In addition the airship was in touch with the Air Ministry in London practically throughout its voyage, and during the whole time that it was over the Atlantic was never out of touch with land on one side or the other. Just what this would mean to a commercial air line of the future need not be emphasized. And there is another achievement in connection with radio on airships of which the radio engineer can justly be proud. In a heavy gale in April, 1925, the British military airship R33 broke away from its mooring mast at Pulham and floated off over the North Sea, driven by a furious wind. Thanks to the work of its radio operator, however, the airship was able to keep in touch with its base throughout the time of its involuntary flight. Officials there and at the Air Ministry knew all the time exactly what the position of the airship was and how it was faring. The information that they were able to give to Flight Lieutenant Booth, who was the chief officer in the airship at the time of the breakaway, as to his position and the extent of his drift from hour to hour was undoubtedly one of the leading factors in assisting the gallant crew to pilot the damaged airship safely back to land.

The *Norge* also found radio of the greatest value for communication and direction finding on its polar flight. Commander Gottwaldt, who was in charge of the radio and meteorological services on board, reported that communication with the outside world was maintained practically throughout the flight until, by an unfortunate mishap that could not have been foreseen, the 300 foot trailing aerial, covered with ice, was broken during the last stages of the voyage through the vessel having to fly extremely low. Even after this the *Norge* was able to locate her position by means of the radio direction finder, for which a separate aerial, bound to the fabric of the airship, was used.

Among Atlantic flyers with heavier-than-air machines, Commander Franco, who flew from Spain to South America in the spring of 1926, used a direction finder as well as an ordinary transmitter and receiver, to good effect. At the conclusion of that flight, Commander Franco and his navigator, Captain Ruiz de Alda, said: "We give full credit to the Marconi direction finder for route finding throughout the voyage."

Commander Byrd, after his flight, said: "Radio will play a great part in the future transatlantic navigation of the air. Science has not yet developed any instrument that will enable the air navigator to locate himself in a fog except by radio bearings. It seems that undoubtedly transatlantic landing fields of the future will have in the vicinity several radio direction finding stations, so that if the airplane arrives in foggy weather it will be able to locate itself by these radio bearings."

Perhaps, however, the most striking instance of the value of radio was its achievement during the wonderful flight of Captain Kingsfort-Smith and his companions in one of the greatest air adventures ever undertaken, the flight of the *Southern Cross* from California to Honolulu, from Honolulu to Suva, Fiji, and then to Australia. During their adventurous journey radio rendered great assistance to the navigators, and kept the world informed of every incident of the flight throughout the whole journey.



THE AIR PORT TRANSMITTERS

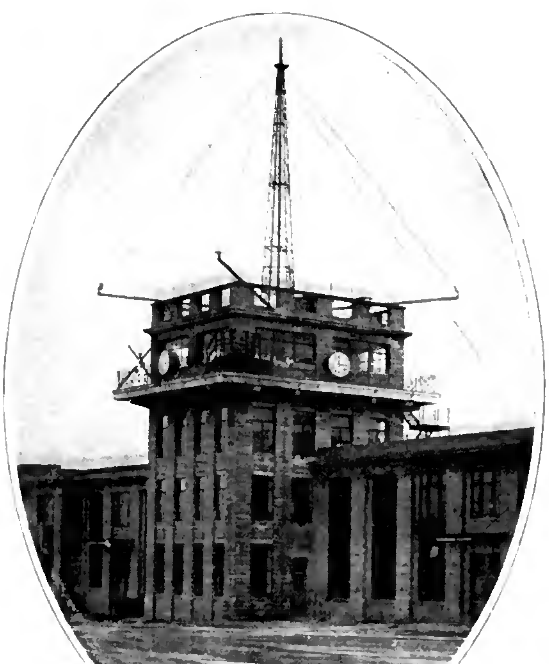
The four transmitters and antenna system are located 4½ miles from the flying field, leaving the field itself clear for taking off and landing. The antenna masts, placed at the corners of a 250-foot square, are 100 feet in height, and support four cage aerials of the inverted "L" type

RADIO IN THE FLYING ROUTINE

PERHAPS even more important, however, than these big examples of what radio has done for flying, is the day-to-day routine radio work carried out on the European air lines. Marconi AD6 equipment—a 150-watt telephone-telegraph set with a trailing aerial—is standard equipment on all Imperial Airways machines and on the machines of many other European air lines.

Every commercial airdome of importance in Europe is equipped with radio apparatus for communication and direction finding. At the London Air Port at Croydon the new radio station that has just been built replaces the one that has done duty there for the last seven years. The new station consists of a group of four 3-kw. transmitters, capable of telephonic and continuous wave and interrupted continuous wave telegraphic transmission, operated in conjunction with a radio direction finding receiver. This receiver has been specially designed for its work by the research department of the Marconi Company, and in addition to its remarkable selective characteristics it is arranged so that if required two or more circuits can be operated on different wavelengths for the reception of telephony and telegraphy on the same aerials.

Constant use is made of radio facilities by the pilots on the European air lines, and some of the leaders among them have said more than once that they would hesitate to fly an air liner not equipped with radio. On two or three occasions flights have been made between London and the Continent on foggy days when the pilots have not seen the ground from the time they took off to the time they landed. For instance, in November last Captain A. S. Wilcockson, an Imperial Airways pilot, flew a Handley-Page Rolls Royce



THE CONTROL TOWER

The radio control room is located on the top floor of the tower of the Terminal Building at the Croydon Air Port. On the top of the tower are the directional antennas and a 100-foot horizontal antenna.

plane from Paris to Croydon above a fog bank which obscured the ground practically the whole of the way. In spite of the denseness of the fog Captain Wilcockson completed his journey in 2 hours and 26 minutes, which was a good average time for the trip from Paris to London. When he started from Le Bourget at 8 A.M. visibility was about 1000 yards, and the weather report gave fog over most of the route except for patches of clear weather near the French coast. Five minutes after leaving Paris Captain Wilcockson found himself in dense fog and had to rise 2,000 feet to get above it. At this height the plane was flying in bright sunshine and continued to do so for the greater part of the journey. It was, however, necessary to fly entirely by compass bearing. The pilot asked for several bearings and positions from Croydon during the journey and these brought him in on a direct line to the Croydon Airdrome. There was one break in the fog, about 10 miles from Croydon, which enabled the pilot to recognize the ground and corroborate the fact that he was on the right bearing. The fog then closed in again and in his own words he "dropped right on to the airdrome."

Captain Wilcockson said this was one of the worst fogs he had ever experienced but he had no doubt during the whole journey that he would get through in comfort, as his past experience with his radio apparatus had given him confidence that he could navigate on bearings through the fog, however dense it might be. "I had no difficulty at all in keeping in communication with Croydon at any time, whether I was in the fog, above it, or when coming down to the airdrome; but it would have been impossible to have made the journey without wireless," Captain Wilcockson said.

There were five passengers on the machine. They had a very happy and comfortable journey and were quite thrilled with their novel experience.

These are just a few of the things that radio has done and is still doing for flying.

Checking Up on Audio Distortion

By G. F. LAMPKIN

FREQUENCY distortion in audio amplifiers is primarily a question of poor design, and is somewhat beyond the province of the set builder. Amplitude distortion, on the other hand, is usually the result of improper operation; its detection, as Mr. Lampkin explains, may be accomplished by the use of a milliammeter, and its correction by the proper adjustment of the operating voltages of the amplifier. Any radio fan possessing a milliammeter can make the measurements described in this article, and in this way not only get better results from his amplifier, but also learn a great deal about audio amplification in general. —THE EDITOR.

OF THE two kinds of distortion that may occur in an audio-frequency amplifier, the one that usually receives the lesser attention is the one easier to correct. If an amplifier does not produce an output that is an exact, enlarged reproduction of the input—*i.e.*, if the output signals are not proportional in strength to the input signals at the broadcasting microphone, no matter how weak or strong those signals may be—obviously, distortion is taking place. Such action is designated as amplitude distortion; and the intelligent use of nothing more than a milliammeter will show the causes of this kind of distortion, when appropriate remedies may be applied.

The correction of the other kind of distortion—frequency distortion—necessitates the use of more extensive equipment. This type of distortion is characterized by unequal amplification in different parts of the frequency spectrum. It is the type that has received somewhat greater attention in the design of audio transformers, coupling impedances, etc., with good characteristics. Suffice it to say that, in the analysis of a receiver for frequency distortion, the frequency characteristic of a single coupling unit may mean little or nothing. The frequency characteristic of the loud speaker may mean much more than the characteristic of a single audio transformer, for example. Only the overall frequency characteristic of the receiver, from the antenna to the loud speaker, should be relied on as a figure of merit. It is impossible to make each unit of the receiver perfect; but, fortunately, it is not impossible to make the composite performance of all the receiver units approach perfection. Making one unit imperfect in the opposite sense to another will cause the defects to cancel, and so leave the near perfect characteristic. In any case, successful correction of frequency distortion requires the use of more than a milliammeter.

THE CAUSE OF AMPLITUDE DISTORTION

AMPLITUDE distortion is the result of amplifier overloading. A given tube is constructed to handle a certain amount of audio-frequency power without overloading. When this power limit is passed, overloading and amplitude distortion occur, so that the two go hand in hand. The more or less familiar curve that shows the relation between the plate current and the grid voltage of a vacuum tube can be used as a basis for showing how amplitude distortion takes place, and how it may be eliminated. Typical characteristic curves for one of the so-called power tubes are given in Fig. 1. They show how the plate current of the tube would vary when the grid voltage is swung through various values, for any particular B voltage. With a 135-volt B battery, if the C voltage is minus 30 volts, the plate current is 13 milliamperes; if minus 10 volts, 36 milliamperes, and so on. [Mr. Lampkin's curves are theoretical and must not be assumed to be those of a 112 or 171 type tube, whose characteristics might seem similar. They are the so-called "static" curves, and really for purposes of this argument should be "dynamic" instead. However, since the plate currents for these curves are so low, and because dynamic curves would differ for each load in the plate circuit—each transmitted audio frequency, for example, if the tube were working into a loud speaker—it has been thought much simpler to use static curves as shown. The argument would be the same in any case; overloading distortion could be predicted from inspection of dynamic curves, due to the fact that these curves are not exactly linear, although they are much straighter than the static curves shown.—THE EDITOR.] Suppose this tube were placed in an amplifier, with 90 volts on the plate and a C battery of 22 volts. The steady plate current would be 6.3 milliamperes, as indicated on the curve by the point "A."

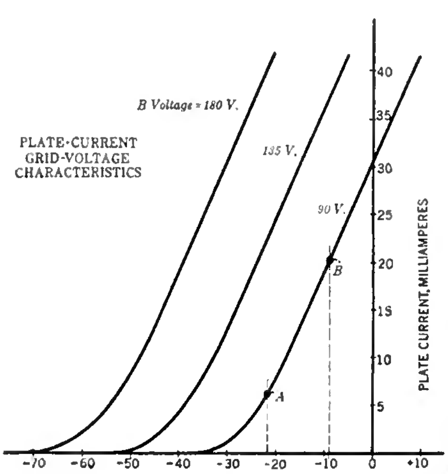


FIG. 1

The audio-frequency signal voltages, when impressed on the grid of the tube, would alternately add to and subtract from the bias voltage. In Fig. 2 the curve is redrawn for 90 volts B battery, and the point "A" is indicated. About this bias of 22 volts swings the audio voltage, alternately positive and negative, or to right and left, as shown along the extended vertical line. For each value of the resultant voltage on the grid, that is, the steady bias voltage plus or minus the instantaneous a.c. voltage, there is a corresponding instantaneous value of plate current. The curve drawn through the latter points, along the extended horizontal axis, is the form of the output current. So long as the signal voltages are comparatively low, say plus or minus four volts, the reading on the plate milliammeter will remain invariant. Although the plate current alternately increases and decreases, it must be remembered that the alternations take place one hundred or more times per second, and are much too fast for the ordinary milliammeter needle to follow. If the grid voltage does not swing beyond this plus or minus four volts the plate current on one half the cycle increases as much as it decreases on the next half cycle, so that the average force on the meter needle does not change and the reading stays constant. If a very low audio frequency were impressed on the grid of this tube, for example, a 10 cycle note, the milliammeter needle would actually wobble up and down from its average value, indicating that the instantaneous plate current varied in accordance with the incoming signals.

However, when a stronger signal comes through and forces the grid voltage to swing to wider limits, the reading on the milliammeter will change. This greater input voltage may swing from plus 16 volts to minus 16 volts, and would have a graphical representation as in Fig. 3. In this case, when the total grid voltage reaches minus 35 volts (that is, minus 22 due the C battery plus minus 13 due the signal), the plate current becomes zero, and remains zero as long as the voltage is more negative than this value. The curve of output current shows clearly the portion of the cycle during which the current is cut off. Such an output, for a strong signal, is decidedly not an exact, enlarged reproduction of the input. The graph of plate current shows that the positive halves of the wave are larger than the negative halves, for the latter have their tops chopped off. On the curve, the horizontal line at 6.3 milliamperes represents the plate-meter reading when no signal is impressed. On the strong signal the average value of the plate current jumps to 9.6 milliamperes, and this deflection is taken up by the meter. Thus the fluctuation of reading on the plate-current meter is coincidental with amplitude distortion, and may be used as an indication of the latter.

The remedy for distortion of this sort, where the meter deflects up on strong signals, is to decrease the C-battery voltage. The chopping off of the negative loops of plate current is due to the lower bend in the characteristic curve. Decreasing the C bias moves the working point away from this bend, that is, up the curve, so that the negative grid voltage swings cannot

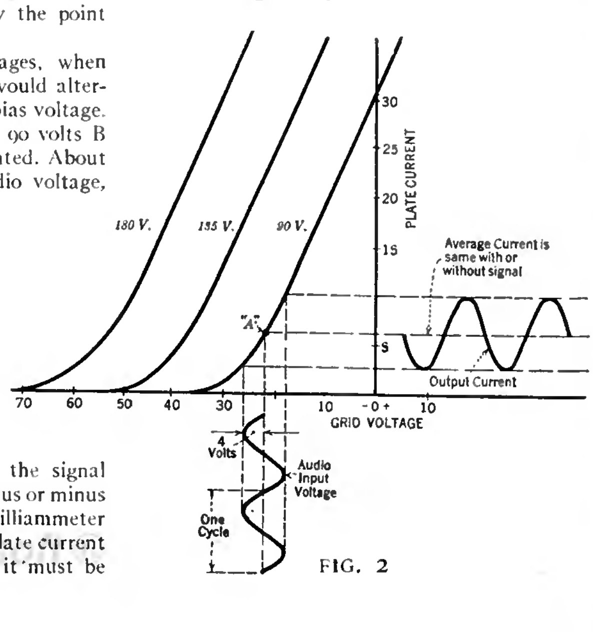


FIG. 2

reach it. This, of course, increases the steady plate current. Another remedy, and in this particular case a better one, is to increase the plate voltage to 135 or higher; it may be seen that this accomplishes the same purpose as above, by shifting the operating point to one of the higher curves and automatically increasing the distance to the lower bend of the curve.

DISTORTION FROM A POSITIVE GRID

AMPLITUDE distortion caused by cutting off of the positive peaks of signal voltage may be had at another portion of the curve—in particular, where the grid voltage crosses the zero line and goes positive with respect to the filament. To find out why this causes distortion requires that a start be made at the plate circuit of the preceding tube. The connections are those of Fig. 4A, which shows two tubes with resistance coupling. The coupling resistance, the coupling condenser, and the grid leak may be replaced by a single impedance, Z, equivalent in value; and the equivalent circuit is redrawn in Fig. 4B. The first tube has an alternating voltage generated in its plate circuit, due to the signal voltage at its grid. The generated voltage acts upon the internal plate resistance of the tube, R_p, and the coupling impedance in series, causing an alternating current to flow through them. Each element then has a voltage drop across it, the sum of the drops being equal and opposite to the impressed voltage. The proportion of voltage that exists across Z may be expressed very nearly by $\frac{Z}{Z+R} \times$ total voltage.

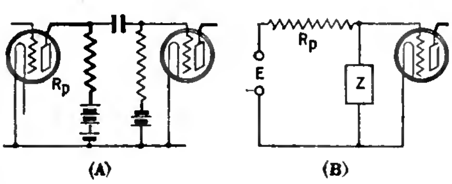


FIG. 4

That is, the larger the value of Z, the higher the voltage existing across it, and vice versa.

In the amplifier circuit, suppose the B voltage on the last tube to again be 90, but suppose the C bias has been dropped to only 9 volts, so that the operating point becomes "B" of Fig. 1. As long as the signal voltage swings within limits around "B"—namely, plus or minus 9 volts, there is no distortion. But if the signal amplitude runs higher, a direct current flows from filament to grid each time a signal peak makes the grid positive with respect to filament—exactly as a current flows to the plate when it has a positive voltage on it. When the grid is negative, no current flows to it, when positive, more or less current flows, depending on how far positive the voltage goes. This can only mean that the resistance from grid to filament has been decreased enough to permit current to flow; in fact, compared to the resistance when no current flows, the grid-filament resistance goes down tremendously when grid current flows. But the grid-filament path is in parallel with the coupling impedance; and when paths are in parallel, the equivalent impedance of the combination is always lower than that of the smallest element. Therefore, when the grid-filament path drops from a very high to a low value of resistance, it drags down the equivalent value of the coupling impedance, which in turn means that the a. c. voltage across the coupler decreases. It must be remembered that the grid-filament resistance is lowered only on the positive peaks, so it is at these points that the voltage is lost, and the tops of the input signal are cut off. Losing the tops of the wave means that the negative loops become relatively larger, so that the average of the plate current goes down. When amplitude distortion takes place because of the grid swinging positive, the reading on the plate milliammeter decreases. The remedy in this case is to increase the C-battery bias, moving the operating point away from the zero line so that the voltage swings cannot reach it.

THE PROPER REMEDY

IT MAY be seen, therefore, that there is an optimum value of C bias for each value of plate voltage. It is somewhat less than half of the bias necessary to give zero plate current, by inspection of the characteristic curves. The object is to the confine the grid voltage swings between the point of zero voltage and the lower point where the curve begins to bend—in other words, to the part of the characteristic where the "curve" is a straight line. If, after attaining the optimum bias, amplitude distortion still occurs, the remaining remedy is to increase the plate voltage; incidentally, this necessitates a new bias. The latter remedy is limited, of course, by the permissible plate voltage that may be applied to the tube. Above this power level, a new tube of higher power rating must be used; or, with the same tube, the condition simply means that the volume control on the receiver must be lowered, if amplitude distortion is to be done away with.

In the case where the grid voltage goes positive a meter may be placed in the grid circuit and used to show the grid current that flows. If the amplifier is resistance coupled to the previous tube, the flow of current will be so small as to be indistinguishable on a one-milliampere meter. The reason is that only a slight value of current flowing through the high-resistance grid leak provides a negative drop that compensates for the positive peak of signal, and the grid cannot go far enough past the deadline to give an appreciable current. Amplitude distortion is present, nevertheless, just as much as with any other coupling system.

Nothing has been said heretofore concerning filament saturation, but assumption has been tacitly made that in all cases the filament was capable of supplying all the electrons needed. If not, the characteristic curves shown in Fig. 1 would, at a given plate current, bend sharply to the right and continue horizontally. Such a curve would obviously cause serious amplitude distortion if the grid voltage variation came into the saturation region. The distortion would be analagous to that caused by grid current flow. Such distortion is often caused by an exhausted tube or a low voltage storage battery. Assurance must be had, then, that the filament of the tube is turned up to rated voltage, or that it has not lost its emission. A very approximate way of obtaining the optimum C bias is to short the grid to the filament of the amplifier tube, and read the plate current. Then remove the shorting wire and adjust the bias till the plate current is slightly more than half the former value. All makers of power tubes indicate the proper B and C voltage which should be used.

The effect of amplitude distortion is to introduce in the output frequencies that are not present in the input voltage. A pure, smooth input voltage, such as those of Fig. 2, impressed on an amplifier in which amplitude distortion occurs, would come out with one or both the peaks flat-topped, as has been seen. This sort of a wave is composed of more than is apparent from a casual inspection. It really has the original pure wave combined with a family of harmonics—waves

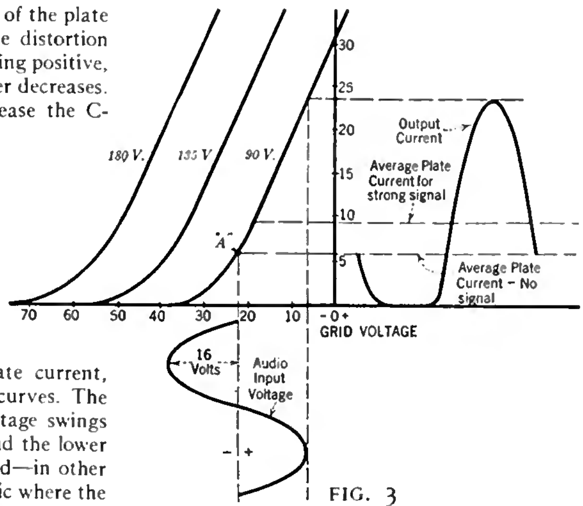


FIG. 3

with frequencies that are 2, 3, 4, 5, and so on, times the original frequency. For sake of illustration, suppose the signal has its positive peak cut off and that it is cut straight across. Such a wave is shown by the heavy curve of Fig. 5. The finer-lined curves show the components that are actually present, and which in the composite form the output wave. With this sort of action accompanying amplitude distortion, there is no wonder at the weird jumble issuing from some loud speakers when trying to reproduce musical selections, where each note proceeds from the loud speaker accompanied by its own little family of harmonics. A bit of experimenting with a milliammeter while listening to the reproduction will enable one to connect the results of amplitude distortion with the cause.

There is an interesting connection between frequency distortion and amplitude distortion. With transformers in the amplifier which will not pass the low notes, the set will handle a given power level without distortion. If, in an attempt to better the fidelity of reproduction, transformers be installed which will pass the low notes, the effective maximum power capacity of the amplifier will be lowered because, as is more or less well known, the lower notes contain more energy or have a greater amplitude. The better class of broadcasters have the low-frequency, large-amplitude voltages present in their output. Where the original amplifier would not pass these notes, the better transformers enable it to do so; and although the higher frequencies still come through with the same amplitude, the newly introduced low frequencies overload the amplifier. It is well to make sure that the loud speaker can reproduce the lower frequencies before installing transformers to pass them. Otherwise the only attainment would be to reduce the power capacity of the amplifier, for even though the speaker cannot respond to the new low notes, it will respond to their distortion products.

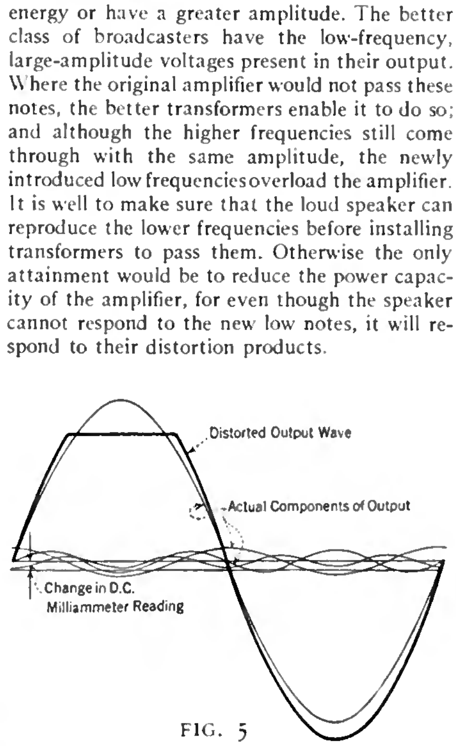


FIG. 5

Manufacturers' Booklets

A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

READERS may obtain any of the booklets listed below by using the coupon printed on this page. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. 1928 revised booklet, with circuit diagrams of popular kits. RADIALL COMPANY.

2. HARD RUBBER PANELS—Characteristics and properties of hard rubber as used in radio, with suggestions on how to "work" it. B. F. GOODRICH RUBBER COMPANY.

5. CARBORUNDUM IN RADIO—A book giving pertinent data on the crystal as used for detection, with hook-ups, and a section giving information on the use of resistors. THE CARBORUNDUM COMPANY.

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10. VARIABLE RESISTANCE—As used in various circuits. CENTRAL RADIO LABORATORIES.

12. DISTORTION AND WHAT CAUSES IT—Hook-ups of resistance-coupled amplifiers with standard circuits. ALLEN-BRADLEY COMPANY.

15. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using Raytheon tube. GENERAL RADIO COMPANY.

15a. B-ELIMINATOR AND POWER AMPLIFIER—Instructions for assembly and operation using an R. C. A. rectifier. GENERAL RADIO COMPANY.

17. BAKELITE—A description of various uses of bakelite in radio, its manufacture, and its properties. BAKELITE CORPORATION

22. A PRIMER OF ELECTRICITY—Fundamentals of electricity with special reference to the application of dry cells to radio and other uses. Constructional data on buzzers, automatic switches, alarms, etc. NATIONAL CARBON COMPANY.

23. AUTOMATIC RELAY CONNECTIONS—A data sheet showing how a relay may be used to control A and B circuits. YAXLEY MANUFACTURING COMPANY.

26. DRY CELLS FOR TRANSMITTERS—Actual tests given, well illustrated with curves showing exactly what may be expected of this type of B power. BURGESS BATTERY COMPANY.

30. TUBE CHARACTERISTICS—A data sheet giving constants of tubes. C. E. MANUFACTURING COMPANY.

32. METERS FOR RADIO—A catalogue of meters used in radio, with diagrams. BURTON-ROGERS COMPANY.

33. SWITCHBOARD AND PORTABLE METERS—A booklet giving dimensions, specifications, and shunts used with various meters. BURTON-ROGERS COMPANY.

36. CHARGING A AND B BATTERIES—Various ways of connecting up batteries for charging purposes. WESTINGHOUSE UNION BATTERY COMPANY.

37. WHY RADIO IS BETTER WITH BATTERY POWER—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON COMPANY.

46. AUDIO-FREQUENCY CHOKES—A pamphlet showing positions in the circuit where audio-frequency chokes may be used. SAMSON ELECTRIC COMPANY.

47. RADIO-FREQUENCY CHOKES—Circuit diagrams illustrating the use of chokes to keep out radio-frequency currents from definite points. SAMSON ELECTRIC COMPANY.

48. TRANSFORMER AND IMPEDANCE DATA—Tables giving the mechanical and electrical characteristics of transformers and impedances, together with a short description of their use in the circuit. SAMSON ELECTRIC COMPANY.

49. BYPASS CONDENSERS—A description of the manufacture of bypass and filter condensers. LESLIE F. MUTER COMPANY.

50. AUDIO MANUAL—Fifty questions which are often asked regarding audio amplification, and their answers. AMERTRAN SALES COMPANY, INCORPORATED.

52. AUDIO QUALITY—A booklet dealing with audio-frequency amplification of various kinds and the application to well-known circuits. SILVER-MARSHALL, INCORPORATED.

53. TUBE REACTIVATOR—Information on the care of vacuum tubes, with notes on how and when they should be reactivated. THE STERLING MANUFACTURING COMPANY.

56. VARIABLE CONDENSERS—A bulletin giving an analysis of various condensers together with their characteristics. GENERAL RADIO COMPANY.

57. FILTER DATA—Facts about the filtering of direct current supplied by means of motor-generator outfits used with transmitters. ELECTRIC SPECIALTY COMPANY.

58. HOW TO SELECT A RECEIVER—A common-sense booklet describing what a radio set is, and what you should expect from it, in language that anyone can understand. DAY-FAN ELECTRIC COMPANY.

67. WEATHER FOR RADIO—A very interesting booklet on the relationship between weather and radio reception, with maps and data on forecasting the probable results. TAYLOR INSTRUMENT COMPANIES.

69. VACUUM TUBES—A booklet giving the characteristics of the various tube types with a short description of where they may be used in the circuit. RADIO CORPORATION OF AMERICA.

70. IMPROVING THE AUDIO AMPLIFIER—Data on the characteristics of audio transformers, with a circuit diagram showing where chokes, resistors, and condensers can be used. AMERICAN TRANSFORMER COMPANY.

72. PLATE SUPPLY SYSTEM—A wiring diagram and layout plan for a plate supply system to be used with a power amplifier. Complete directions for wiring are given. AMERTRAN SALES COMPANY.

73. RADIO SIMPLIFIED—A non-technical booklet giving pertinent data on various radio subjects. Of especial interest to the beginner and set owner. CROSLEY RADIO CORPORATION.

76. RADIO INSTRUMENTS—A description of various meters used in radio and electrical circuits together with a short discussion of their uses. JEWELL ELECTRICAL INSTRUMENT COMPANY.

78. ELECTRICAL TROUBLES—A pamphlet describing the use of electrical testing instruments in automotive work combined with a description of the cadmium test for storage batteries. Of interest to the owner of storage batteries. BURTON ROGERS COMPANY.

81. BETTER TUNING—A booklet giving much general information on the subject of radio reception with specific illustrations. Primarily for the non-technical home constructor. BREMER-TULLY MANUFACTURING COMPANY.

83. SOCKET POWER DEVICE—A list of parts, diagrams, and templates for the construction and assembly of socket power devices. JEFFERSON ELECTRIC MANUFACTURING COMPANY.

84. FIVE-TUBE EQUAMATIC—Panel layout, circuit diagrams, and instructions for building a five-tube receiver, together with data on the operation of tuned radio-frequency transformers of special design. KARAS ELECTRIC COMPANY.

85. FILTER—Data on a high-capacity electrolytic condenser used in filter circuits in connection with A socket power supply units, are given in a pamphlet. THE ABOX COMPANY.

87. TUBE TESTER—A complete description of how to build and how to operate a tube tester. BURTON-ROGERS COMPANY.

88. SUPER-HETERODYNE CONSTRUCTION—A booklet giving full instructions, together with a blue print and necessary data, for building an eight-tube receiver. THE GEORGE W. WALKER COMPANY.

89. SHORT-WAVE TRANSMITTER—Data and blue prints are given on the construction of a short-wave transmitter, together with operating instructions, methods of keying, and other pertinent data. RADIO ENGINEERING LABORATORIES.

90. IMPEDANCE AMPLIFICATION—The theory and practice of a special type of dual-impedance audio amplification are given. ALDEN MANUFACTURING COMPANY.

92. RESISTORS FOR A. C. OPERATED RECEIVERS—A booklet giving circuit suggestions for building a.c. operated receivers, together with a diagram of the circuit used with the new 400-milliampere rectifier tube. CARTER RADIO COMPANY.

93. B-SOCKET POWER—A booklet giving constructional details of a socket-power device using either the BH or 313 type rectifier. NATIONAL COMPANY, INCORPORATED.

95. Resistance Data—Successive bulletins regarding the use of resistors in various parts of the radio circuit. INTERNATIONAL RESISTANCE COMPANY.

96. VACUUM TUBE TESTING—A booklet giving pertinent data on how to test vacuum tubes with special reference to a tube testing unit. JEWELL ELECTRICAL INSTRUMENT COMPANY.

98. COPPER SHIELDING—A booklet giving information on the use of shielding in radio receivers, with notes and diagrams showing how it may be applied practically. Of special interest to the home constructor. THE COPPER AND BRASS RESEARCH ASSOCIATION.

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103. A. C. TUBES—The design and operating characteristics of a new a.c. tube. Five circuit diagrams show how to convert well-known circuits. SOVEREIGN ELECTRIC & MANUFACTURING COMPANY.

104. OSCILLATION CONTROL WITH THE "PHASATROL"—Circuit diagrams, details for connection in circuit, and specific operating suggestions for using the "Phasatrol" as a balancing device to control oscillation. ELECTRAD, INCORPORATED.

105. COILS—Excellent data on a radio-frequency coil with constructional information on six broadcast receivers, two short-wave receivers, and several transmitting circuits. AERO PRODUCTS COMPANY.

106. AUDIO TRANSFORMER—Data on a high-quality audio transformer with circuits for use. Also useful data on detector and amplifier tubes. SANGAMO ELECTRIC COMPANY.

108. VACUUM TUBES—Operating characteristics of an a.c. tube with curves and circuit diagram for connection in converting various receivers to a.c. operation with a four-prong a.c. tube. ARCTURUS RADIO COMPANY.

110. RECEIVER CONSTRUCTION—Circuit diagram and constructional information for building a five-tube set using restricted field coils. BODINE ELECTRIC COMPANY.

111. STORAGE BATTERY CARE—Booklet describing the care and operation of the storage battery in the home. MARKO STORAGE BATTERY COMPANY.

112. HEAVY-DUTY RESISTORS—Circuit calculations and data on receiving and transmitting resistances for a variety of uses, diagrams for popular power supply circuits, d.c. resistors for battery charging use. WARD LEONARD ELECTRIC COMPANY.

113. CONE LOUD SPEAKERS—Technical and practical information on electro-dynamic and permanent magnet type cone loud speakers. THE MAGNAVOX COMPANY.

114. TUBE ADAPTERS—Concise information concerning simplified methods of including various power tubes in existing receivers. ALDEN MANUFACTURING COMPANY.

115. WHAT SET SHALL I BUILD?—Descriptive matter, with illustrations, of fourteen popular receivers for the home constructor. HERBERT H. FROST, INCORPORATED.

116. USING A B POWER UNIT—A comprehensive booklet detailing the use of a B power unit. Tables of voltages—both B and C—are shown. There is a chapter on trouble-shooting. MODERN ELECTRIC MFG. CO.

118. RADIO INSTRUMENTS, CIRCULAR "J"—A descriptive manual on the use of measuring instruments for every radio circuit requirement. A complete listing of models for transmitters, receivers, set servicing, and power unit control. WESTON ELECTRICAL INSTRUMENT CORPORATION.

120. THE RESEARCH WORKER—A monthly bulletin of interest to the home constructor. A typical feature article describes the construction of a special audio amplifier—AEROVOX WIRELESS CORPORATION.

121. FILTER CONDENSERS—Some practical points on the manufacture and use of filter condensers. The difference between inductive and non-inductive condensers. POLYMET MFG. CORP.

122. RADIO TUBES—Specifications and operating characteristics of vacuum tubes. Twenty-four pages. E. T. CUNNINGHAM, INC.

123. B SUPPLY DEVICES—Circuit diagrams, characteristics, and list of parts for nationally known power supply units. ELECTRAD, INC.

124. POWER AMPLIFIER AND B SUPPLY—A booklet giving several circuit arrangements and constructional information and a combined B supply and push-pull audio amplifier, the latter using 210 type tubes. THORDARSON ELECTRIC MFG. CO.

125. A. C. TUBE OPERATION—A small but complete booklet describing a method of filament supply for a.c. tubes THORDARSON ELECTRIC MFG. CO.

126. MICROMETRIC RESISTANCE—How to use resistances for: Sensitivity control; oscillation control; volume control; regeneration control; tone control; detector plate voltage control: resistance and impedance coupling: loud speaker control, etc. CLAROSTAT MFG. CO.

127. VITROHM NEWS—A monthly bulletin dealing with the resistance problems of the home constructor and experimenter. WARD LEONARD ELECTRIC CO.

128. SANGAMO CONDENSERS—A helpful table for converting capacities from microfarads to micromicrofarads. SANGAMO ELECTRIC CO.

129. TONE—Some model audio hook-ups, with an explanation of the proper use of transformers and chokes. SANGAMO ELECTRIC CO.

130. SCREEN-GRID AUDIO AMPLIFICATION—Diagrams and constructional details for remodeling old audio amplifiers for operation with screen-grid tubes. THORDARSON ELECTRIC MFG. CO.

131. THE MERSHON CONDENSER—Two illustrated booklets giving the theory and uses of the electrolytic condenser. AMRAD CORPORATION.

132. THE NATIONAL SCREEN GRID SHORT-WAVE RECEIVER—Constructional and operating data, with diagrams and photographs. JAMES MILLEN.

133. THE NATIONAL SHIELD-GRID FIVE—A circuit diagram with constructional and operating notes on this receiver. JAMES MILLEN

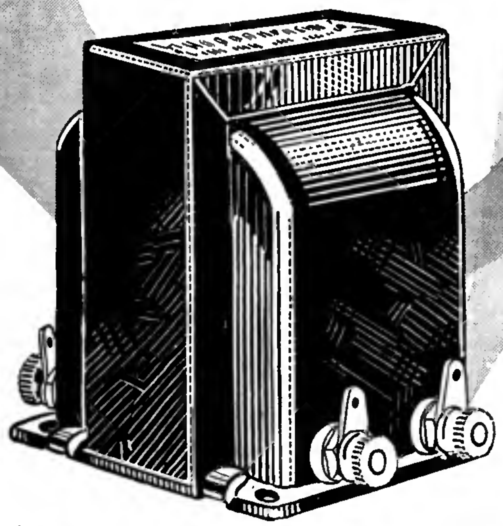
134. REMLER SERVICE BULLETINS—A regular service for the professional set builder, giving constructional data, blueprints, and hints on marketing. GRAY & DANIELSON MFG. CO.

135. THE RADIOBUILDER—A periodic bulletin giving advance information, constructional and operating data on S-M products. SILVER-MARSHALL, INC.

136. SILVER MARSHALL DATA SHEETS—These data sheets cover all problems of construction and operation on Silver-Marshall products. SILVER-MARSHALL, Inc.

139. POWER UNIT DESIGN—Periodical data sheets on power unit problems, design, and construction. RAYTHEON MFG. CO.

A NEW NOTE IN AUDIO AMPLIFICATION



THORDARSON R-300 AUDIO TRANSFORMER

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

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

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

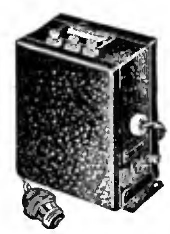
Power Supply Transformers

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

Double Choke Units

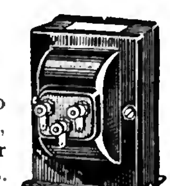
Consist of two 30 henry chokes in one case. T-2099 for use with power supply transformer T-2098, $14; T-3099 for use with transformer T-2900, $16; T-3100 for use with transformer T-2950, $18.

Power Compacts



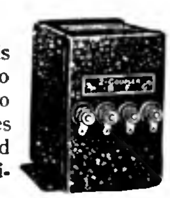
A very efficient and compact form of power supply unit. Power transformer and filter chokes all in one case. Type R-171 for Raytheon rectifier and 171 type power tube, $15.00; Type R-210 for UX-281 rectifier and 210 power tube, $20.00; Type R-280 for UX-280 rectifier and 171 power tube, $17.00.

Speaker Coupling Transformers



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

Screen Grid Audio Coupler



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

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

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

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

Name..

Street and No...

Town.................................... *State*..................

The *Radio Broadcast* LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4" x 6" filing cards, or in a notebook. The cards should be arranged in numerical order. In July, 1927, an index to all sheets appearing up to that time was printed. In the May, 1928, issue we printed an index covering the sheets published from August, 1927, to May, 1928, inclusive.

All of the 1926 issues of RADIO BROADCAST are out of print. A complete set of sheets, Nos. 1 to 88, can be secured from the Circulation Department, Doubleday, Doran & Company, Inc., Garden City, New York, for $1.00. Orders for the next set following can also be sent. Some readers have asked what provision is made to rectify possible errors in these sheets. In the unfortunate event that any serious errors do occur, a new Laboratory Sheet with the old number will appear.

—THE EDITOR.

No. 217 RADIO BROADCAST Laboratory Information Sheet **September, 1928**

Using a Milliammeter as a Voltmeter

WHAT RESISTANCES MUST BE USED

BY CONNECTING accurate fixed resistances in series with milliammeters it is possible to make very useful voltmeters that may be used to read filament voltages, plate voltages, C voltages, the output voltage of B-power units, etc. The accuracy of such a home-made voltmeter depends upon the accuracy of the milliammeter and the fixed resistance. Resistors accurate to within a few per cent. can be obtained by purchasing them directly from any reputahle manufacturer.

The table on this sheet gives the values of resistances required with different milliammeters to read voltages from 1 volt up to 1000 volts. For example, if a 5-mA meter is to be used to read voltages up to 50 volts then a 10,000-ohm resistor is necessary. A 1.0-mA meter may be used to read voltages up to 1000 volts if a resistor with a value of 1,000,000 ohms (1 megohm) is placed in series with it. The values of resistance required to read voltages not given in the table, or for use with meters with higher ranges may be determined by dividing the voltage to be measured by the maximum current in amperes of the meter. Suppose that a 50-mA meter is to be used to read voltages up to 300 volts. Three hundred volts divided by 0.050 amperes (50 mA) gives 6000 ohms as the required value of the resistance.

Resistors with a wattage rating of 1.0 watt will be satisfactory for all those values given in the table, but it is advisable to use resistors with a rating of about 5.0 watts so that there will be little possibility of the value of the resistance changing due to heating. Also resistors with a rating of 5 watts, operating at considerably below their rated dissipation, will be likely to hold their calibration a much longer time than resistors of lower wattage.

VOLTAGE MULTIPLIER FOR MILLIAMMETERS

Milli-Amperes	1,000 Ohms	10,000 Ohms	100,000 Ohms	1,000,000 Ohms
1.	1. volt	10 volts	100 volts	1000 volts
1.5	1.5 "	15 "	150 "	
2.	2. "	20 "	200 "	
3.	3. "	30 "	300 "	
5.	5. "	50 "		
8.	8. "			
10.	10. "			

No. 218 RADIO BROADCAST Laboratory Information Sheet **September, 1928**

Servicing Radio Receivers

HOW FAULTS SHOULD BE LOCATED

THE tracing of faults in a radio receiver is not always an easy matter. There is a tendency to delve at random into the vitals of the receiver rather than to follow a systematic procedure by which the fault may generally be more quickly and easily located. In locating and remedying faults the systematic testing of the circuit and the apparatus in the receiver is essential.

Measuring instruments are frequently helpful in making these tests but a great deal may be done with a simple and inexpensive device. In the testing of the component parts in a receiver a pair of telephones connected in series with a small battery is useful in determining where the fault exists. The windings of a transformer may be readily tested by means of this simple circuit. When the two terminals are connected across the transformer winding a click will be heard if the circuit is continuous. Fixed condensers may also be tested, and here a click should be heard when the leads are placed across the terminals of the condenser, but no click will be heard when the terminals are removed unless the condenser is defective. If the insulation in the condenser is poor, however, or the condenser is definitely short-circuited, a click will be heard both when the circuit is closed and when it is opened.

Ordinary radio-frequency transformers and superheterodyne intermediate-frequency transformers, audio-frequency or radio-frequency choke coils, etc. may also be tested for continuity by connecting the test terminals across the terminal of the device under test. If the device being tested has a high resistance the click will be of less intensity than that obtained when testing a low resistance device. In any case, no click at all will indicate an open circuit.

When a radio receiver fails to operate, such tests as we have outlined here can be applied to the various components of the receiver to determine whether or not a piece of apparatus is at fault.

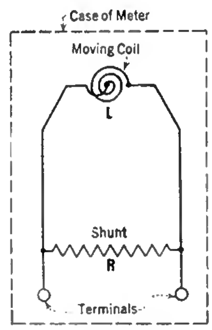
No. 222 RADIO BROADCAST Laboratory Information Sheet September, 1928

Measuring Instruments

THE AMMETER

LABORATORY Sheet No. 214 in the August issue explained the operation of a simple measuring instrument. An instrument of the type illustrated in that sheet can only be constructed to handle small currents, for to handle large currents the moving coil, L, and the leads to it would have to be made of very heavy wire. Since the coil, L, is part of the moving element, it must be kept light in weight; it is possible, therefore, to use only a fine wire on the coil. For larger currents the arrangement indicated in the sketch on this sheet is used. R is a resistor called a "shunt" consisting of one or more strips of a special alloy. The current in the circuit divides, most of it going through the shunt because its resistance is small in comparison with that of the moving coil of the meter. The current through the coil, however, is a certain definite fraction of the total current and therefore if we know the current flowing through the coil we can readily determine what the total current in the circuit is.

As an example, if the resistance of the shunt, R, is 0.01 ohms and that of the moving coil of the meter 0.99 ohms then the current divides in the same ratio. Out of every unit of current flowing through the circuit into which the meter is connected 99 parts flow through the shunt and one part flows through the meter. The current in the meter is therefore an accurate measure of the total current in the circuit and therefore for any one shunt the scale on the meter is calibrated to read directly the total current.



Meters with current ranges up to 50 or 75 amperes may be obtained with the shunt built inside of the case. For higher ratings the shunt forms an extra piece of apparatus and the meter is connected across it by means of a pair of wires.

No. 223 RADIO BROADCAST Laboratory Information Sheet September, 1928

Radio Transmission

HOW DISTANCE AFFECTS THE SIGNAL

PROBLEM: A receiver is tuned to a broadcast station located a certain distance away and signals from it produce sufficient power in the loud speaker circuit to make reception satisfactory. By what percentage will the power in the loud speaker be reduced if the receiver is removed to a point twice as far away from the transmitter, assuming, of course, that the sensitivity of the receiver remains unchanged.

Solution: To solve this problem we must know how the output power of a receiver varies with the r.f. input at the antenna and we must know how the received energy varies with the distance between the receiver and the transmitter.

(a) The power in the plate circuit of the power tube (and therefore the power supplied to the loud-speaker) varies as the square of the signal voltage on the grid of the power tube.

(b) The voltage output of a detector tube varies as the square of the voltage on its grid.

(c) Therefore, the power into the loudspeaker varies as the fourth power of the voltage impressed on the grid of the detector tube.

(d) The voltage impressed on the detector tube is proportional to the voltage at the antenna. Therefore the power into the loud speaker varies as the fourth power of the voltage impressed in the antenna.

(e) The voltage at the antenna varies as the field strength.

(f) Therefore, the power into the loud speaker varies as the fourth power of the field strength.

Statement (f) tells us how the power into the loud speaker varies with field strength. But the field strength surrounding an antenna varies inversely as the square of the distance between the transmitter and the receiver. Therefore, the power into the loud speaker varies inversely as the eighth power of the distance between the transmitter and the receiver.

The problem states that the distance between the receiver and the transmitter has been doubled, i.e. the distance has been multiplied by 2. The eighth power of 2 is 256; therefore by doubling the distance between the receiver and the transmitter we have cut down the power in the loud speaker to 1/256 of what it had been.

No. 224 RADIO BROADCAST Laboratory Information Sheet September, 1928

Text Books on Radio

THERE are certain books and radio magazines that the serious radio experimenter should not be without and in this sheet we give a list of some of what we consider the more important of the publications. The short descriptive sentence following each title will help to classify the book in our readers' mind.

Radio Instruments and Measurements. A 345-page book, presenting information regarding the more important instruments and measurements actually used in radio work. The contents is of interest to all radio engineers. The book is published by the Department of Commerce and is known as Circular No. 74. Obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., for sixty cents.

Principles Underlying Radio Communication. Another government publication to be recommended. This book is quite an excellent elementary text book of radio and general electricity and may be easily understood by anyone with a fair knowledge of algebra. Everyone should have it. It is known as Radio Communication Pamphlet No. 40, and the Superintendent of Documents, Government Printing Office, sells it for $1.00.

Principles of Radio Communication, by J. H. Morecroft. This is probably the most complete book on radio engineering. The text deals with all phases of the art of radio communication and the treatment is very complete, the book containing about 1000 pages. Published by John Wiley and Sons, Inc., New York City. Price: $7.50.

Thermionic Vacuum Tube, by H. F. Van Der Bijl. An excellent book setting forth the principles of operation of vacuum tubes. It is a very useful book for any radio engineer. Published by the McGraw-Hill Book Co., Inc., New York City. Price: $3.00.

Radio Engineering Principles, by Lauer and Brown. A book less extensive than Morecroft's but excellent for those whose requirements are satisfied with a shorter and less expensive text. It is a very scholarly presentation. Published by McGraw-Hill Book Co., Inc., New York City. Price: $3.50.

Radio Frequency Measurements, by E. B. Moullin. A book dealing with the theory and practice of radio measurements. A handbook for the laboratory and a text book for advanced students. Many of the measurements are made with the aid of the vacuum tube voltmeter. Published in England but it can be obtained from the J. B. Lippincott Co., in Philadelphia.

Practical Radio Construction and Repairing, by Moyer and Wostrel. This book aims to be of service to the amateur constructor and radio service man. It is essentially practical in its treatment. Published by McGraw-Hill Book Co., Inc., New York City. Price: $1.75.

Take the Advice of Leading Radio Service Organizations

...*Play Safe with*

PARVOLTS!

IF you want the real truth about condensers go to an organization that builds, services and repairs every type of radio receiver and power supply unit.

Such an organization is Rossiter, Tyler & McDonell. These engineers have had actual experience in every branch of radio. Mr. Frank McDonell says:

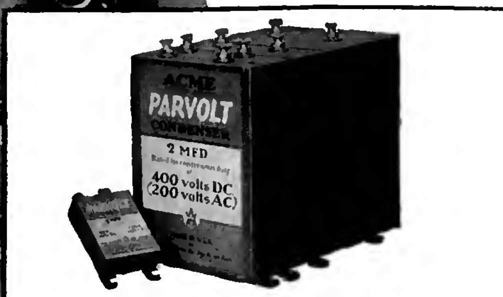
"*We think so well of* ACME PARVOLT *Condensers that we have samples constantly on display for all clients to see. Those of our customers who know radio also know that* PARVOLTS *are thoroughly reliable. We like our clients to realize that we use the best in radio.*"

Mr. McDonell says that his firm has used many ACME PARVOLTS in both experimental and practical work and has never known one to break down under proper load. Absolute safety is vital with a firm doing a large volume of service work.

Should a condenser blow out, many dollars would be lost in ruined tubes, transformers, chokes and other parts. The experience of the nationally known house of Rossiter, Tyler & McDonell should be a good guide for other builders and service men to follow. Don't take chances with condenser break down. Play safe with ACME PARVOLTS.

Made by THE ACME WIRE CO., New Haven, Conn., manufacturers of magnet and enameled wire, varnished insulations, coil windings, insulated tubing and radio cables.

Mr. McDonell says: "Our PARVOLT *display board is very useful, for we frequently have occasion to show our clients how these condensers are made."*



ACME PARVOLT FILTER CONDENSERS—*Supplied in all standard mfd. capacities for 200, 400, 600, 800, 1000, and 1500 Volt D. C. requirements. Uniform height and width for easy stacking. Supplied singly or in complete housed blocks for the important power supply units such as Thordarson, Samson, and others.*

ACME PARVOLT BY-PASS CONDENSERS *are supplied in all standard mfd. capacities and for all required working voltages.*

ACME PARVOLT CONDENSERS

Made by the Manufacturers of

ACME CELATSITE HOOK-UP WIRE

ENAMELED AERIAL WIRE
Enameled copper wire in both stranded and solid types. Also Acme Lead-ins, Battery Cables, Indoor and Loop Aerial Wire.

CELATSITE FLEXIBLE and SOLID
For all types of radio wiring. High insulation value; non-inflammable. 10 colors.

ACME SPAGHETTI
A superior cambric tubing for all practical radio and other electrical requirements. Supplied in 10 colors.

No. 219 Radio Broadcast Laboratory Information Sheet September, 1928

Sizes of Tap and Clearance Drills

TABLE OF SIZES

THE table on this sheet will be found useful in constructing radio receivers and power units, when it is necessary to tap or drill holes to take a certain size machine screw. The first and second columns, headed "Screw Number" and "Threads per Inch" in each section of the table, identify the machine screw, and the third column headed "For Tap" gives the drill size if the hole is to be tapped so that the screw will thread into the hole. If the hole is to be drilled so that the machine screw passes through the hole, then the "Clearance" size drill should be used.

SCREW NUMBER	THREADS PER INCH	DRILL NUMBER		SCREW NUMBER	THREADS PER INCH	DRILL NUMBER	
		For Tap	Clearance			For Tap	Clearance
3	48	45	38	7	30	31	21
3	56	44	38	7	32	30	21
4	32	43	31	8	24, 30	30	17
4	36	42	31	8	32	29	17
4	40	41	31	9	24	29	13
5	30, 32	40	29	9	28	28	13
5	36	38	29	9	30	27	13
5	40	37	29	9	32	25	13
6	30, 32	35	26	10	24	25	8
6	36	33	26	10	30	22	8
6	40	32	26	10	32	21	8

No. 220 Radio Broadcast Laboratory Information Sheet September, 1928

The Roberts Four-Tube A. C. Receiver

PARTS REQUIRED

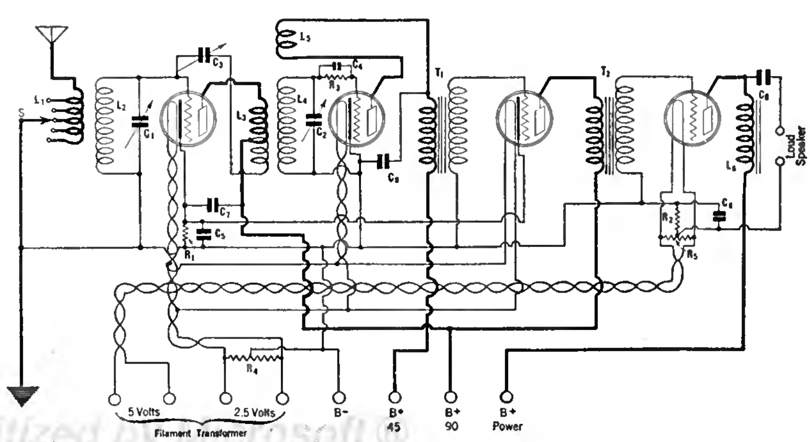
ON LABORATORY SHEET NO. 221 is published a circuit diagram that has been requested by many readers in their letters to the Technical Information Service. It is the circuit diagram of a 4-tube Roberts receiver for a.c. operation using three 227 type a.c. tubes and one 171A type tube.

The following parts are required for the construction of the receiver:

C_1, C_2—2 Tuning condensers of a size such as to cover the broadcast band with the coils used. Homemade coils made according to the specifications given below require 0.0005-mfd. condensers
C_2—Neutralizing condenser, 0.00002 mfd. maximum capacity.
C_4—Grid condenser, 0.00025 mfd.
C_5, C_6, C_7—3 Bypass condensers, 1.0 mfd.
C_8—Output condenser, 2 to 4 mfd.
C_9—Bypass condenser 0.0002 mfd.
L_1, L_2—2 Thirteen point spider-web coils. L_1 consists of 35 turns of No. 22 d.c.c. wire tapped at every five turns. L_2 consists of 44 turns of the same size wire.
L_3, L_4, L_5—3 Thirteen point spider-web coils. L_3 is a double wound primary consisting of two parallel windings of 18 turns of No. 26 d.c.c. L_4 is the same as L_2. L_5 consists of 12 turns of No. 22 d.c.c. mounted on a form so that its coupling to L_4 may be varied.
L_6—Output choke coil, 30 henries.
R_1—C bias resistor, 500 ohms.
R_2—C bias resistor, 2000 ohms.
R_3—Grid leak, 2 megohms.
R_4, R_5—2 filament resistors, 20 ohms, center-tapped.
S—Antenna tap switch.
T_1, T_2—2 audio transformers.
3 five-prong sockets.
1 four-prong socket.
Filament transformer supplying 2.5 and 5.0 volts.

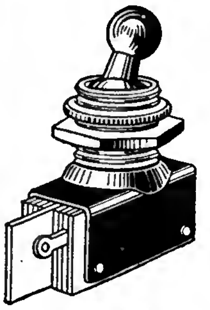
No. 221 Radio Broadcast Laboratory Information Sheet September, 1928

Circuit of the Roberts Four-Tube A.C. Receiver



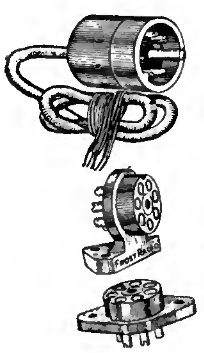
ANNOUNCING
A FULL AND COMPLETE LINE OF
FROST-RADIO

To Better Serve Your Parts Requirements



NEW FROST-RADIO A. C. SNAP SWITCH

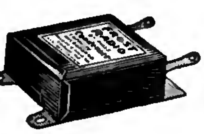
Inspected and passed by Underwriters' Laboratories. Entire switch is enclosed in finely made metallic housing. Has positive contacts. Carries 3 amps. at 250 volts. Extended soldering lugs make installation extremely simple. Terminals perfectly insulated from each other. Single hole mounting. Price: 75c.



NEW FROST-RADIO, CABLE PLUG

Moulded throughout of Bakelite. Terminals are moulded right into Bakelite, and can never come loose. Color markings also moulded in, doing away with paper chart or other makeshifts. Cable is best grade colored rubber covered wire, 5 feet long. Design of springs insures permanent tension. Complete plug, with cable, $2.25. Baseboard Socket: 75c. Panel Socket: 75c.

NEW FROST-RADIO BY-PASS CONDENSERS



Designed to give many years of trouble-free service. Linen and flax paper stock and highest grade foil are used in building these condensers. Conservatively rated. Vacuum impregnated and enclosed in hermetically sealed metal cases. Five capacities. Prices: 80c to $2.00.

YOU long have known Frost-Radio as the leading line of radio parts for the set-builder. NOW it is possible for you to practically build your entire set with these parts, due to the addition of many new items to the Frost-Radio line. See your dealer to-day for your parts requirements. He has everything you need, all of the sterling quality which has made Frost Parts famous. The complete line includes the following:

- Variable High Resistances
- Variable High Resistances with D. C. Switch
- Variable High Resistances with A. C. Snap Switch
- Gem Variable High Resistances
- Approved A. C. Snap Switch
- Air Cooled De Luxe Bakelite Rheostats
- Gem Rheostats
- Gem Hum Balancers
- Fixed Resistances
- Center Tapped Resistances
- UX Base Bakelite Sockets
- Panel Brackets
- Hook-Up Wire
- Universal Resistance Kits
- Frost Fones
- Bakelite Adapters
- Gem Jacks
- Pan-Tab Jacks
- Loop Plug and Jacks
- Microphones
- Plugs
- Battery Switches
- Ground Clamps
- Extension Cords
- Jack Switches
- Jack-Boxes
- By-Pass Condensers
- Medium Duty Filter Condensers
- Heavy Duty Filter Condensers
- "B" Blocks
- Moulded Mica Condensers
- Cable Plugs
- Convenience Outlets

NEW FROST-RADIO MOULDED MICA CONDENSER

Easily mounted anywhere because equipped with well designed terminal lugs and integrally moulded Bakelite flanges (for subpanel mounting.) Being small in size they have low dielectric losses. Seven capacities, from .0001 to .006. Prices: 45c to 90c.

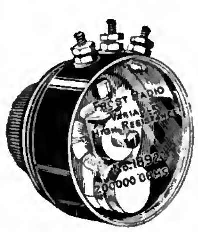
NEW FROST-RADIO UNIVERSAL "B" BLOCKS

Conservative voltage ratings and remarkably fine construction unite to make these "B" locks stand up longer, give greater satisfaction. Enclosed in hermetically sealed metal cases. Fitted with tinned soldering lugs. Consists of 3 sections of 2 mfd. each, 1 section of 1,000 working volts; other two sections of 600 working volts; 1 section of 4 mfds., 400 working volts and 1 section 1 mfd., 400 working volts. Price: $18.00.

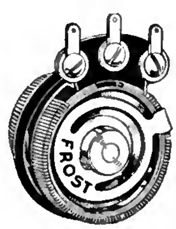
NEW FROST-RADIO HEAVY DUTY FILTER CONDENSERS

Designed especially for use in "B" Eliminators, power amplifiers and other power devices; also for use in transmitting circuits and with other spark discharge apparatus. Conservatively rated. Capacities: .5 to 2 mfds. Prices: $2.00 to $7.00.

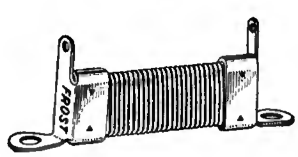
THOUSANDS OF SET BUILDERS KNOW AND USE THESE OLD FRIENDS



FROST-RADIO VARIABLE HIGH RESISTANCES

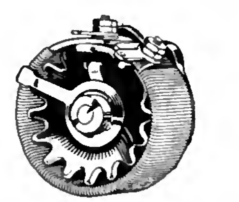


FROST-RADIO GEM RHEOSTATS
"A Good Little Rheostat"



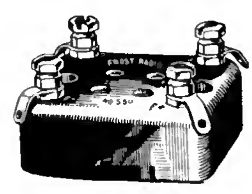
FROST-RADIO FIXED RESISTANCES

Ample current carrying capacity. Wound on flexible Bakelite strip with die cut threads. Terminals admit of mounting either under subpanel or on terminals of sockets. .4 to 50 ohms: 15c. 100 to 1000 ohms: 25c.



FROST-RADIO AIR COOLED BAKELITE RHEOSTATS

Winding strip is die-cut threaded Bakelite of highest quality. German silver contact arm exerts precisely correct pressure to insure proper contact and eliminate wear. All metal parts nickel-plated and buffed. Hundreds of thousands of these sturdy rheostats are in daily use. Plain type: $1.00. With Switch: $1.35.



FROST-RADIO UX BASE BAKELITE SOCKET

This is the famous Frost Socket that holds all UX and CX base tubes in bull-dog grip, because contact springs grip the tube prongs for almost their entire length. Price: 40c.

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"Radio Broadcast's" Directory of Vacuum Tubes

THE table below is as complete as is possible to make it and should be a constantly useful reference for all radio workers. The data on some Western Electric tubes are included because some of our readers live in Canada and in other countries where tubes of this manufacture are available. We have followed the RCA-Cunningham tube terminology; other manufacturers make types of tube similar in each class, although each manufacturer has his own terminology. The reader who desires to use a CeCo tube for example, need only ask his dealer or the manufacturer for a CeCo of the 201-A type, etc. The same follows naturally for any of the vacuum tubes in the classifications below made by Arcturus, Sovereign, Sylvania, Marathon, Gold Seal, Sonatron, Kellogg, Magnetron, Speed, and others.

AVERAGE CHARACTERISTICS OF RADIO VACUUM TUBES

	GENERAL							DETECTION				AMPLIFICATION						
	MODEL	USE	CIRCUIT REQUIREMENTS	INTER-ELECTRODE CAPACITIES IN MMFD. FILAMENT COLD	"A" SUPPLY	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT (AMPERES)	DETECTOR GRID RETURN LEAD TO	GRID LEAK MEGOHMS	DETECTOR "B" BATTERY VOLTAGE	DETECTOR PLATE CURR'T (MILLIAMPERES)	AMPLIFIER "B" BATTERY VOLTAGE	AMPLIFIER "C" BATTERY VOLTAGE	AMPLIFIER PLATE CURRENT (MILLIAMPERES)	A.C. PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
Detectors and Amplifiers	C-11 WD-11					Same as below, except for base, which is old UV type												
	CX-12 WX-12	Detector or Amplifier	Transformer Coupling	G-F 6, G-P 5.5, P-F 7.5	Dry Cell 1½ V. Storage 2 V.	1.1	.25	+F	3 to 5	22½ to 45	1.5	90 135	4½ 10½	2.5 3.5	15,500 15,000	425 440	6.6 6.6	7 35
	CX-112 A UX-112 A	Detector or ↓ Amplifier	Transformer Coupling	G-F 9; G-P 11; P-F 7.5	Storage 6 V.	5.0	.25	+F	3 to 5	45	1.5	90 135	4½ 9	5.5 7	5,300 5,000	1,500 1,600	8 8	30 120
	C-299 UV-199					Same as below, except for base, which is old UV type												
	CX-299 UX-199	Detector or Amplifier	Transformer Coupling	G-F 3.6, G-P 3.5; P-F 4.5	Dry Cell 4½ V. Storage 4 V.	3.0 3.3	.060 .063	+F	2 to 9	45	1	90	4½	2.5	15,500	425	6.6	7
	CX-300 A UX-200 A	Detector	Transf. or Resis. Coupling	G-F 3.4, G-P 8.8; P-F 1.5	Storage 6 V.	5.0	.25	−F	2 to 3	45	1.5	Following UX-200 A characteristics apply only for Detector connection			30,000	666	20	—
	CX-301 A UX-201 A	Detector or Amplifier	Transformer Coupling	G-F 5.8; G-P 10.1; P-F 6.1	Storage 6 V.	5.0	.25	+F	2 to 9	45	1.5	90 135	4½ 9	2.5 3	11,000 10,000	725 800	8 8	15 55
	CX-322 UX-222	Radio Freq. ↓ Amplifier	Special Shielding	G-P 0.025	Dry Cell 4½ V. Storage 4-6 V.	3.3	.132	—	—	—	—	135	1½ *	1.5	850,000	350	300 M	—
	CX-322 UX-222	Audio Freq. ↑ Amplifier	Resistance Coupling	—	Dry Cell 4½ V. Storage 4-6 V.	3.3	.132	—	—	—	—	180 §	1½ □	.3	150,000	400	60	—
	UX-226 CX-326	Amplifier A.C. Filament Type	Transformer Coupling	G-F 3.65, G-P 8.2; P-F 2.1	Transformer 1.5 V.	1.5	1.05	—	—	—	—	90 135 180	6 9 13½	3.5 6 7.5	9,400 7,400 7,000	875 1,100 1,170	8.2 8.2 8.2	20 70 160
	C-327 UY-227	Detector A.C. Heater Type	Transformer Coupling	G-F 3.6; G-P 3.7; P-F 2.75	Transformer 2.5 V.	2.5 H	1.75	K	2-9 ¼-1	45 90	2 7	Following UY-227 characteristics apply only for Detector connection			10,000 8,000	800 1,000	8 8	—
	CX-340 UX-240	Detector or Amplifier	Resistance Coupling	G-F 3.4; G-P 8.8; P-F 1.5	Storage 6 V.	5.0	.25	+F	2 to 5	135 § 180 §	0.3 0.4	135 § 180 §	1½ 3	.2 .2	150,000 150,000	200 200	30 30	—
Power Amplifiers	CX-112 A UX-112 A	↑ Power Amplifier	No L.S.C. Required	G-F 9; G-P 11; P-F 7.5	Storage 6 V. Transformer 5 V.	5.0	.25	—	—	—	—	135 157½	9 10½	7 9.5	5,000 4,700	1,600 1,700	8 8	120 195
	CX-220 UX-120	Power Amplifier	No L.S.C. Required	G-F 4.5; G-P 5.4; P-F 4.4	Dry Cell 4½ V. Storage 4 V.	3.0 3.3	.125 .132	—	—	—	—	135	22½	6.5	6,300	525	3.3	110
	CX-371 A UX-171 A	Power Amplifier	L.S.C. except at 90 V.	G-F 6.8; G-P 9.5; P-F 6.5	Storage 6 V. Transformer 5 V.	5.0	.25	—	—	—	—	90 135 180	16½ 27 40½	10 16 20	2,500 2,200 2,000	1,200 1,360 1,500	3.0 3.0 3.0	130 330 700
	CX-310 UX-210	Power Amplifier	L.S.C.	G-F 7; G-P 8; P-F 7	Transformer 7.5 V.	7.5	1.25	—	—	—	—	250 300 350 400 425	18 22½ 27 31½ 35	10 13 16 18 18	6,000 5,600 5,150 5,000 5,000	1,330 1,450 1,550 1,600 1,600	8 8 8 8 8	340 600 925 1,325 1,540
	CX-350 UX-250	Power Amplifier	L.S.C.	G-P 8.7	Transformer 7.5 V.	7.5	1.25	—	—	—	—	250 300 350 400 450	45 54 63 70 84	28 35 45 55 55	2,100 2,000 1,900 1,800 1,800	1,800 1,900 2,000 2,100 2,100	3.8 3.8 3.8 3.8 3.8	900 1,500 2,350 3,250 4,650

AVERAGE CHARACTERISTICS OF WESTERN ELECTRIC TUBES

MODEL	USE	CIRCUIT REQUIREMENTS	INTER-ELECTRODE CAPACITIES IN MMFD. FILAMENT COLD	"A" SUPPLY	FILAMENT TERMINAL VOLTAGE	FILAMENT CURRENT (AMPERES)	DETECTOR GRID RETURN LEAD TO	GRID LEAK MEGOHMS	DETECTOR "B" BATTERY VOLTAGE	DETECTOR PLATE CURR'T (MILLIAMPERES)	AMPLIFIER "B" BATTERY VOLTAGE	AMPLIFIER "C" BATTERY VOLTAGE	AMPLIFIER PLATE CURRENT (MILLIAMPERES)	A.C. PLATE RESISTANCE (OHMS)	MUTUAL CONDUCTANCE MICROMHOS	VOLTAGE AMPLIFICATION FACTOR	MAXIMUM UNDISTORTED OUTPUT (MILLIWATTS)
"N" 215-A	Detector or Amplifier	Transformer Coupling	G-F 4.4, G-P 6; P-F 3.8	—	1.0	0.25	+F	2-9	45	1.0	67	6.0	1.0	20,000	300	6	8
"V" 102 D	Amplifier	Resis. or Impedance Coupling	—	—	2.0	0.97	—	—	—	—	130	1.5	0.75	60,000	500	30	4.2
"L" 216 A	Amplifier	Transformer Coupling	—	—	5-6	1.0	—	—	—	—	130	9.0	8.0	6,000	980	5.9	60
"O" 104 D	Power Amplifier	Transformer or Imped. Coupling	G-F 8.2; G-P 5.46, P-F 8.0	—	4-5	1.0	—	—	—	—	130	22.5	20.0	2,200	1,100	2.4	145
"E" 205 D	Power Amplifier	Transformer or Imped. Coupling	—	—	4.5	1.6	—	—	—	—	350	22.5	33	3,500	2,000	7	890

SPECIAL PURPOSE TUBES

MODEL	USE	CIRCUIT REQUIREMENTS	BASE	MAXIMUM OVERALL HEIGHT	MAXIMUM OVERALL DIAMETER	PURPOSE	CHARACTERISTICS	
CX-380 UX-280	Full-Wave Rectifier	Full-Wave Circuit	Large Standard UX Base	5 5/8"	2 3/16"	Rectification in Eliminators	Filament Terminal Voltage..5 Volts Filament Current..........2 Amperes A.C. Plate Voltage..........300 Volts (Max. per Plate) R.M.S.	Max D.C. Output Current (both Plates)..........125 Milliamperes D.C. Output Voltage at Max. Current as applied to filter of typical rectifier circuit..........260 Volts
CX-381 UX-281	Half-Wave Rectifier	Half or Full Wave Circuit	Large Standard UX Base	6 1/4"	2 7/16"	Rectification in Eliminators	Filament Terminal Voltage..7.5 Volts Filament Current......1.25 Amperes A.C. Plate Voltage..........750 Volts (Maximum) R.M.S.	Recommended / Maximum A.C. Plate Voltage..........650..750 Volts D.C. Output Current..........65..110 Milliamperes D.C. Output Voltage as applied to filter of typical rectifier circuit..620..620 Volts
CX-374 UX-874	Voltage Regulator	Series Resistance	Large Standard UX Base	5 5/8"	2 3/16"	Constant Voltage Device	Designed to keep output voltage of B Power Units constant when different values of "B" current are supplied	Operating Voltage.......90 Volts D.C. Starting Voltage........125 Volts D.C. Operating Current.....10-50 Milliamperes
C-376 UX-876	Current Regulator (Ballast Tube)	Transformer Primary of 65 Volts for use on 115 Volt Line	Standard Mogul Type Screw Base	8"	2 1/16"	Constant Current Device	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage	Operating Current........1.7 Amperes Mean Voltage Drop.......50 Volts Permissible Variation....±10 Volts
C-386 UX-886	Current Regulator (Ballast Tube)	Transformer Primary of 65 Volts for use on 115 Volt Line	Standard Mogul Type Screw Base	8"	2 1/16"	Constant Current Device	Designed to insure constant input to power operated radio receivers despite fluctuations in line voltage	Operating Current.......2.05 Amperes Mean Voltage Drop.......50 Volts Permissible Variation.....±10 Volts
C-377	Protective Tube	—	Double Contact Bayonet Auto. Type △	1 7/16"	2 1/2"	Current Limiting Device	Used in "B" Battery circuits to prevent excessive current resulting from short-circuit which might damage tubes or wiring	Voltage Drop Across: Half Filament / Entire Filament 2.5 / 5 At 20 Milliamperes D.C. 45 / 90 At 90 Milliamperes D.C.

↑ (↓) Note other use of this Radiotron above (below)
* Inner Grid −1½ Volts; Outer Grid +45 Volts, 0.15 Milliamperes
□ Outer Grid −1½ Volts; Inner Grid +22½ Volts, 6 Milliamperes
§ Applied thru plate coupling resistance of 250,000 Ohms
△ Connection to shell of base for third terminal which is the lead to mid-point of filament

Note: All grid voltages are given with respect to cathode or negative filament terminal

Maximum values not to be exceeded

Except for half ampere filament, UX-112 and UX-171 characteristics are identical respectively to UX-112-A and UX-171-A.
K.....Cathode
H.....Heater Voltage
L.S.C...Loud Speaker Coupling, consisting of either Choke Coil and By-Pass Condenser or Output Transformer of 1:1 or step down ratio, recommended wherever plate current (D.C.) exceeds 10 milliamperes.
M.....With a screen-grid tube, on account of circuit limitations, the actual voltage amplification obtainable does not bear as high a relation to the voltage amplification factor as in the case of three element tubes.

Notes on the "Cornet" Receiver

By W. H. WENSTROM

Lieut. Signal Corps, U. S. A.

THE article on the "Cornet" multiwave receiver, which appeared in the June number of RADIO BROADCAST (pp. 77–79) has evoked a number of inquiries as to the operation and use of the set, especially in regard to the possibility of its employment as a portable receiver. The following notes have been prepared to answer these inquiries, and to give additional data to those who have built the set and wish to increase its flexibility and range as much as possible.

Portable use: This circuit is admirably adapted to portable use. While not as sensitive as some multitube arrangements, it is far simpler and more dependable. Dry cell tubes are recommended, and the construction should be made more compact and mechanically stronger. It is advisable to mount all parts on a heavy bakelite panel. A single wire antenna about 50 feet long, and made fast at the free end fairly high up on some convenient object, is probably best. Unless a good ground is available a counterpoise, or insulated wire laid along the ground under the antenna, should be used. Other things, such as the frame of an auto, may be used as a counterpoise.

Use of dry cell tubes: Down to and including the 40-meter band UV-199 or UX-199 tubes can be used without any circuit changes whatsoever. In the 20-meter band the 199 tube begins to be rather cranky as an oscillator. Some lines of attack on its unwillingness to oscillate are:

1. Adjust potentiometer
2. Pick best oscillator out of several tubes
3. Connect a small condenser of "neutro" type between plate and grid.
4. Increase tickler turns.

In general, the 199 tubes will be quite satisfactory, used with either adapters or 199 sockets. The overall gain is something like half that of storage battery tubes. Several 199's must be picked over to find a really good detector which, when found, will fall considerably below a Ceco H or UX-200A in sensitivity. A possible combination would be a Ceco H as detector and a 199 as audio amplifier.

Coil for 200–550 meter band: A standard Silver-Marshall type No. 111-A coil may be used. With this coil the circuit as shown in the diagram on page 78 of the June issue tunes up to about 400 meters. To cover the remainder of the band, a Sangamo 0.00015-mfd. fixed condenser is connected in parallel with the condenser marked C_1.

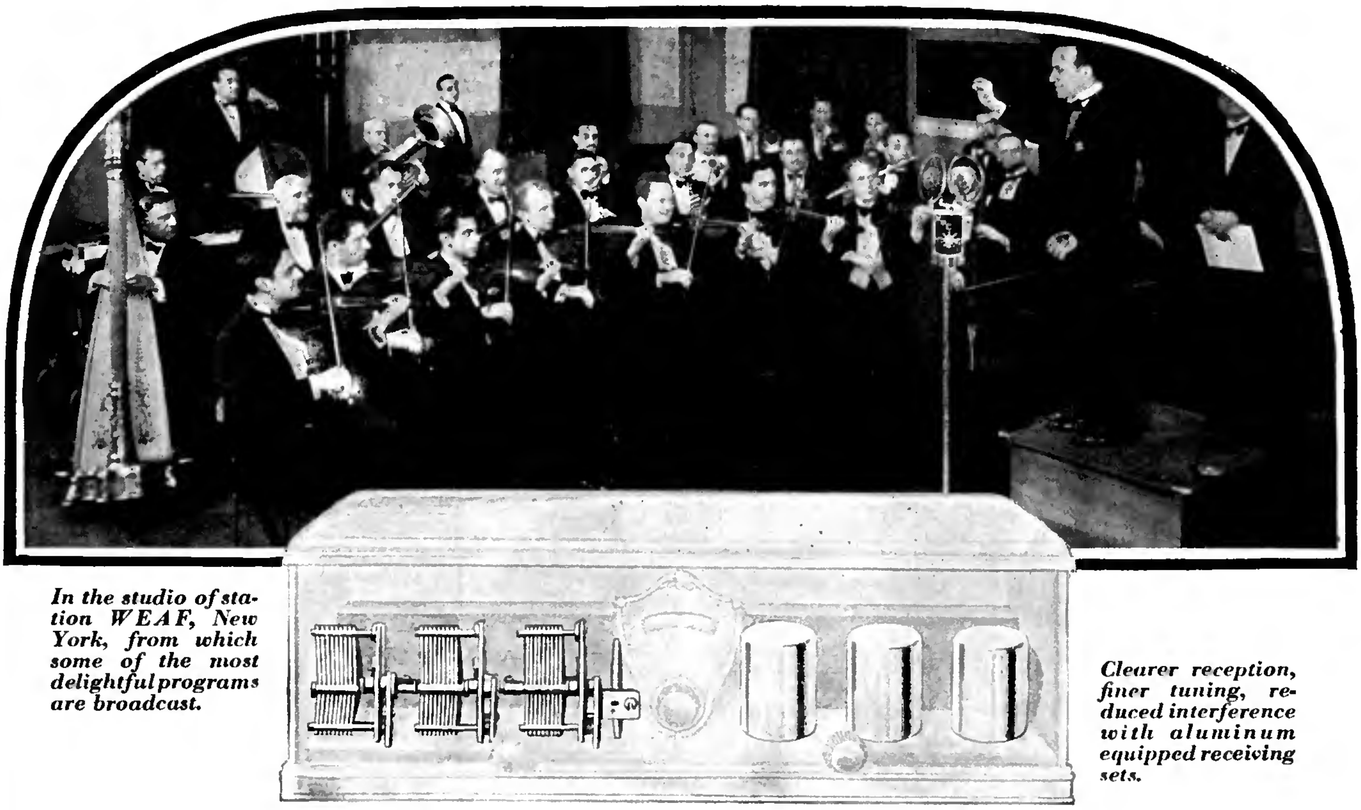
Book Reviews

DRAKE'S RADIO CYCLOPEDIA. By Harold P. Manly. Frederick J. Drake & Co., Chicago. Second Edition, 1928. Price: $6.00

IN THE field of radio reception this should be a useful book, but the title is misleading, for in spite of its 920 pages, 1000 illustrations, and 1500 subjects, it is not a radio encyclopedia. Such a work, in any complete and satisfactory form, still remains to be written.

"Drake's Radio Cyclopedia" is printed without page numbers, making it easy for the publishers to insert new material as it appears, somewhat at the expense of the reader who dislikes to turn pages unnecessarily. The material is arranged alphabetically; if, for example, you want to read up on "Leakage Flux," you go through the L's until you reach the desired

(*Continued on page 304*)



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Book Reviews

(*Continued from page 302*)

phrase, whereupon you are referred to "Flux, Leakage," and have to repeat the same procedure in the F's before you get what you are after.

The book is intended to bridge the gap between the engineer and the "radio worker"—presumably someone who must utilize the knowledge of the engineer and must do it without the engineer's training and characteristic lingo. In the receiver field it accomplishes this feat as successfully as it can be done. Diagrams are used liberally. Although some of them are very elementary, their inclusion is justified, since the volume is intended to help people who need it precisely because their technical training is meagre. One diagram shows, in illustration of "Ampere-Turn" and "Ampere-Hour," an ammeter with the pointer indicating 1 on the scale, a clock with the sector between 1 and 2 shaded, and a coil connected in series with the ammeter with one turn and three turns to indicate one and three ampere-turns, respectively. In another place, radio tools, including scissors, round nose pliers, diagonal cutters, a panel hole cutter, and a counter-sink, are shown. While such radio tabloid stuff will not result in a tremendous demand for the book at M. I. T., it may help some of the lads struggling with definitions which seem obvious to a lot of people who once had to learn them just as painfully.

Although the subject matter is not confined to radio receivers, everything is considered from the standpoint of a radio worker whose experience has been confined to reception. The treatment of television is sketchy and inferior to what can be learned from some of the newspaper supplements nowadays. There is nothing of practical value to the radio telephone transmitter specialist, and very little of anything in that line. Under "Microphone" there are five lines of formal definition, with no description of different types or modes of operation. Four lines are devoted to "Radio Telephony." But in this edition 56 new pages have been added on the screen-grid tube and the practice of socket power receiver operation. This is a typical placing of emphasis in this volume.

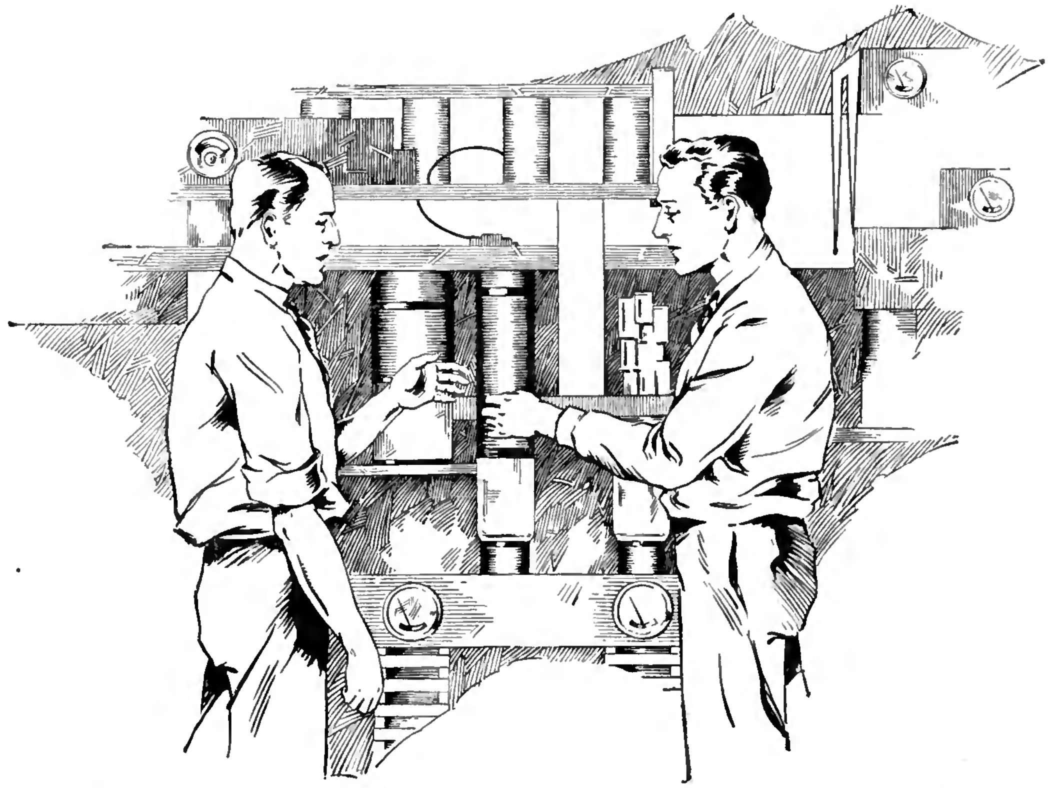
The treatment is non-mathematical, as would be expected, and where algebraic formulas are used symbols are avoided, the words being written out.

In its class "Drake's Radio Cyclopedia" is a worthy job, except for the title. Either a few hundred pages on radio transmitter technique should be included in the next edition, or it should be called "Drake's Radio Receiving Encyclopedia."

BIBLE DRAMAS. By William Ford Manley. Fleming H. Revell Company, 1928.

THIS book presents in printed form the series of biblical dramas broadcast on Sunday nights through the N. B. C. system. The stories of James of Galilee, David and Goliath, Judith, and other notables of Scripture are told in the form of radio plays suitable for church and social gatherings. A few pages of "Production Suggestions" precede the actual stories. I was not particularly impressed by the literary form of those of the plays I heard on the air, but they read quite well and the style partakes somewhat of the majesty of the Biblical narratives which, whatever you may think of the content, are not bad epics. The book will naturally interest the older citizens in the villages more than the metropolitan flappers who are dutifully following the prediction of the Epistle of Jude, 18, "In the last time there shall be mockers, walking after their own ungodly lusts," but even this is not certain, with the "King of Kings," at this writing, showing once more on Broadway.

(*Continued on page 306*)



In the Modern Broadcasting Station

And in quality radio receivers for home use, Faradon Capacitors play a very definite part in maintaining satisfactory service, meriting its widespread utilization.

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Electrostatic Condensers for All Purposes

Book Reviews

(*Continued from page 304*)

The Elements of Radio-Communication. By O. F. Brown, with a Foreword by Admiral of the Fleet Sir Henry B. Jackson. Oxford University Press. New York, 1927. 216 pages. $3.50

IN HIS foreword Admiral Jackson recommends this text on radio communication to those who, like himself, have no mathematical abilities. It is not intended for radio specialists as much as for those outside the profession who wish to gain some knowledge of radio operations through the study of a moderately technical work. The danger in all such efforts is that the results will seem slight to the serious radio engineer, even when the text used may present grave difficulties to many of its students. Sir Henry thinks that Mr. Brown's book should appeal "to the public generally who wish to know how broadcasting works without having to study mathematical formulae." It seems to the reviewer that the book is too technical for this audience. Sir Henry's thirty-odd years in radio work lead him to minimize many difficulties which exist for people without his background.

Chapter 1 contains some historical treatment of the subject which, to critical American readers, will appear somewhat over-simplified, insular, and not inclined to give full credit to the work of German and American pioneers. The following chapters discuss such subjects as high-frequency alternating currents, transmission of damped and continuous waves, thermionic valves, radio telephony, and directional reception, with considerable clarity and about the same degree of detail with which a college text on physics tackles the problems of mechanics and optics. This entails some faults of omission, as in Chapter 8, where the author, after itemizing the defects of commercial carbon microphones, turns abruptly to condenser transmitters, apparently ignoring the existence of high quality carbon microphones.

In his chapter on "Short-Wave Transmission and Reception" Mr. Brown includes a graceful compliment to the amateurs, whose work he calls "extremely brilliant," and he goes on to say: "There is little doubt that the remarkable results of these men had in no small measure the effect of causing other experts to investigate and consider seriously the possibilities of short waves."

The last chapter, on the "Nature and Origin of Atmospherics," contains an interesting account of the research work of Watson Watt and E. V. Appleton and should be read by engineers interested in this special branch.

—Carl Dreher.

Something to Omit

IF I were a Radio Commissioner, which God forbid, the first stations which I should banish from the air are those which announce grandly at the beginning and end of each transmission period that they maintain their assigned frequency with a quartz crystal standard. That is as if you went to some Vice President and asked him to give you a job because you clean your teeth every morning with dental floss and come to the office without poisoning policemen's horses or assaulting shop girls. A radio station is bound by law to stay on its assigned frequency. How it does it is surely none of the public's concern. It can do it, for all the listeners care, by hanging a piano on the aerial or uttering prayers. The act requires no more mention than any other act of public decency. The listeners want entertainment; the correct functioning of the transmitter may be taken for granted. To argue otherwise indicates a strange misunderstanding of the normal proprieties.

—Carl Dreher.

Letters from Readers

Our Latest Departures

SEVERAL recent additions to the editorial contents of RADIO BROADCAST have brought forth comment from many sources. We are happy to feel that our innovations are worthy of response, and want to get as much of it as we can—both favorable and adverse. Here's some from Mr. Lewis S. Maxfield, of Brooklyn, N. Y.

To the Editor:

Allow me to express my appreciation for the series of articles entitled "Home Study Sheets" beginning on page 135 of the July issue. This is something that has been long wanted and I am pleased to see that my favorite magazine is to publish same.

Let us have more of the science and physics side of radio and less knocking of programs, which after all are free and if you don't like them don't listen.

Mr. Maxfield is an engineer and physicist. Here's what an amateur thinks—Sherwood J. Beutler, of Buffalo, N. Y. (8-HT)

To the Editor:

I wish to commend you upon the interesting technical articles you are publishing in RADIO BROADCAST, particularly your introduction of the "Home Study Sheets"; also the addition of Mr. Robert S. Kruse to your engineering staff.

I have been active in the amateur and laboratory development of radio for the past ten years, during which time I have reviewed many radio magazines, but for clear, reliable technical data I believe RADIO BROADCAST rates the highest of them all.

Unfortunately, we can't exactly claim Mr. Kruse as a member of our engineering staff, but there are a great many more articles that he is cooking up for future issues. Incidentally, some of the answers to the problems in the "Home Study Sheets" are making the Laboratory Staff sit up and take notice in regard to such details as neatness, clarity, and general excellence of arrangement.

Our Mistake

GLARING mistakes have occurred in every form of printed matter known, from the famous "Wicked Bible" to the modern tabloids. Here is one from the July issue of RADIO BROADCAST, in Mr. Messenger's article on the universal set tester. Among others, W. D. Wollaver, Watertown, N. Y. has written to us about it.

To the Editor:

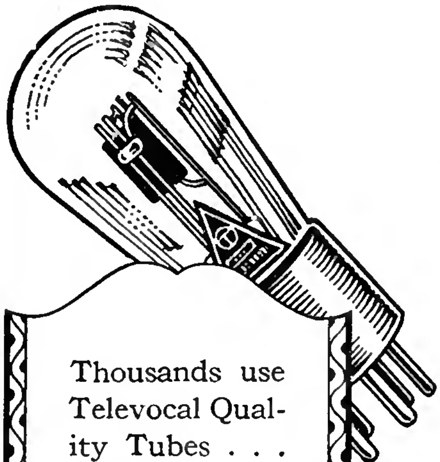
In your July issue [Page 149] you had an article on a three meter tester and gave a diagram of the same. I have started building the tester, but have run up against something which seems incorrect. The minus terminal of the socket has no connection in the diagram.

I have not tried to work the circuit on my own hook, as I thought there should be a connection on the terminal. I would greatly appreciate your help on this.

Mr. Messenger himself caught the error and telegraphed that the connection should go from the minus terminal on the tube socket to the minus lead from the plug on the cable.

The *American Mercury* recently offered a salary of a million dollars a year to an infallible proof reader. All the applicants for the job were refused, because in the very paragraph in which the offer was made there was a typographical error which none of the applicants caught. And it wasn't a trick! We are in the same boat with the *Mercury*. After checking, rechecking, and

(Continued on page 310)



Thousands use Televocal Quality Tubes . . . there must be a difference! All standard types. Ask for them at dealers.

Televocal Corporation
Televocal Building
Dept. B-2, 588 12th Street
West New York, N. J.

Televocal
Quality Tubes

RADIO DEALERS

Send for our catalog illustrating the products of over 100 radio manufacturers.

WHOLESALE ONLY!

F. D. PITTS COMPANY
219-223 Columbus Ave.
BOSTON, MASS., U. S. A.
Established 1919

Increased Amplification Improved Quality with this new valve

Full size illustration of the DA2 amplifying valve. Price $3.00 each.

Harold P. Donle's Latest Achievement

The inventor of the famous Sodion Detector valve brings out this DA2 6-volt amplifying valve which can be used in any type D. C. set with no changes.

Amplification for both audio and radio frequency are greatly increased, and the quality of your set vastly improved.

Those that have tried these valves are enthusiastic about them.

Here is what some of them say:

"We seem to obtain far greater volume and clarity."

"Really, it is the most marvelous valve I have ever come in contact with."

"I have tried two of these tubes in my regular tuned radio frequency broadcast receiver, and I am delighted with the increase in volume and distance obtained."

"Received the four tubes ordered, to-day. Must say that they even exceed all my expectations."

"It is a pleasure to report that the three tubes I received from you Saturday have increased the sensitivity of my Hammarlund-Roberts Hi-Q to a considerable degree. I also tried one in the R. F. stage of a Browning-Drake and there too, the gain was considerable."

"Excellent for low wave sets"

If your dealer has not yet received his stock, mail orders will be promptly filled upon receipt of check.

The Donle Electrical Products Corporation
MERIDEN, CONNECTICUT

Letters from Readers

(*Continued from page 308*)

re-rechecking diagrams and copy, we can only make a prayer to the gods of radio and wait for the letters to come in.

As a Listener See It

THE editorial department, "The March of Radio," has never been guilty of "kid-glove" tactics in dealing with the politico-radio situation in these parts. Although this policy may have added a few sore heads to our list of readers, we feel that the vast majority agree with us that adverse criticisms in this department are made for the benefit of the broadcast listener. It is, therefore, particularly pleasing to quote a comment from a Southern reader on an editorial attack on a Southern broadcast station. The editorial deplored the fact that the only Southern station to ask for increased power was KWKH, which had in the past consistently ignored the orders of the Federal Commission and employed its facilities for the vilification of that body.

To the Editor:

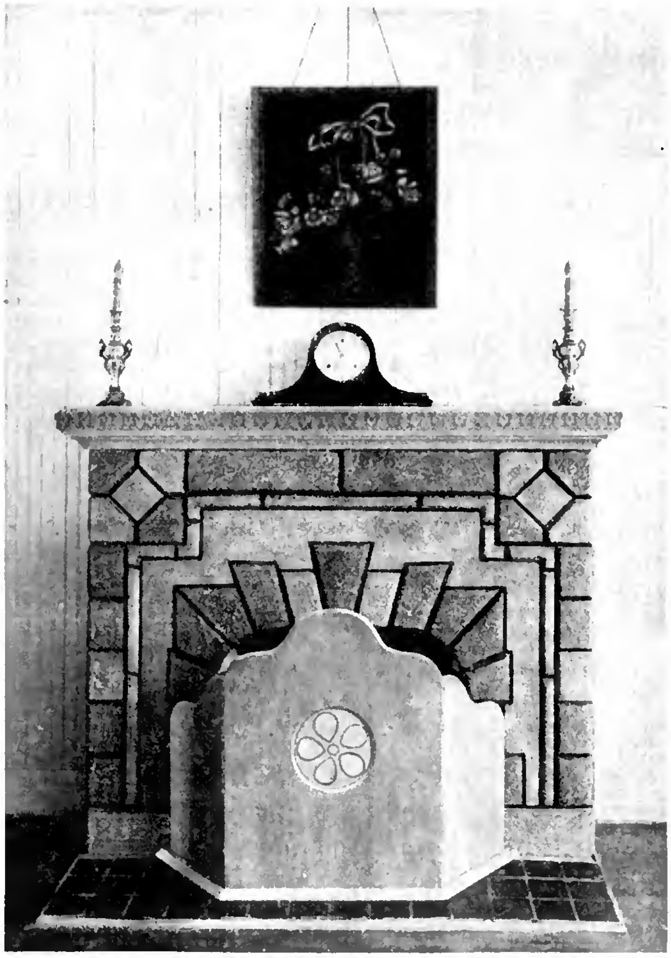
I have had occasion heretofore to express my appreciation of your editorial policy and am writing again for that purpose.

Your comment in the June issue [Page 69] relative to conditions in the South and particularly your reference to station KWKH, Shreveport, has our hearty approval. In the July issue your frankness and fearlessness in stating the case against the Radio Commission deserve our best thanks.

These things, in a periodical of such high standing, and so completely expressive of radio listener sentiment, are bound to have their effect eventually.

E. W. MATTHEWS,
Augusta, Ga.

Decorative *and* Efficient Dynamics



Advance Fireplace Co., Detroit

Showing the fireplace and wall picture speakers.

HERE'S the newest thing in dynamic speakers—an attractive fireplace screen or handsome picture speaker — that you can easily build yourself. Either will be a worthwhile addition to your home, and you have a thoroughly dependable dynamic unit, the latest thing in radio, as well.

The fireplace baffle board comes in gum wood, walnut or mahogany, or unfinished for you to do in any color to match any decorative plan. It is sent knocked down and is easily assembled. When assembled it is 30 inches high and 36 inches wide.

The picture speaker comes in several beautifully oil painted designs on velvet or will be painted to your own design at no extra cost. Including frame the size is 24 x 34 inches. A six-inch magnetic speaking unit of standard make is used.

Enjoy your radio to the fullest this winter with these splendid and decorative speakers. We furnish everything. Write to-day for our remarkably low prices.

Color! Tone!

Everyone is using color in their homes now. With either our fireplace or picture speakers you can have color that will harmonize with your home color scheme.

And our speaking units will give you a richness, a clarity of tone you usually associate with speakers much higher in price. Get our prices today.

BRYDEN PRODUCTS, Inc.

2559 Bellevue Ave. Detroit, Mich.