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Sensitivity and Fidelity of Grid Leak-Condenser Detection Measurements on Moving Coil Loud Speakers

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UBLEDAY, DORAN & CO., INC. GARDEN CITY, NEW YORK
During the past several years, we have made exhaustive surveys of our readers to make certain that we were providing the kind of radio magazine that would be most beneficial to you and to the industry. You have written us, praising our efforts; have supported us with your yearly subscriptions, or your regular newsstand purchases; and, cooperating with our Research Division, have told us who you are and what you are doing. In turn we wish to tell you what our surveys revealed:

84% of Radio Broadcast readers are professionally connected with the industry. It is regularly read and used by important executives of radio manufacturing companies, by chief engineers in charge of design and production of radio apparatus with a retail value of $500,000,000 annually. By chief engineers of radio broadcasting stations, by communications engineers who control the far-flung radio links which join nation to nation. By thousands of radio dealers—servicemen who contribute their expert knowledge to sell millions of radio sets, to keep them in working condition, and who use their contact with the consumer to introduce ever better machines and equipment to supplant old sets. By the great numbers of technical men who share the direction of radio retail organizations—those whose expert knowledge directs radio service work on the one hand, and on the other enables them to choose technically the best in radio merchandise to offer the buying public. By thousands of servicemen who are expanding the uses of radio in new ways, installing receivers and public address systems in schools and elsewhere, etc. By countless engineers and technicians in that newest of the new fields borrowing experience and personnel from radio—the sound motion picture industry.

The remaining 16% of Radio Broadcast readers are a vast group of experimenters—those who explore the mysteries of short waves, build all kinds of test apparatus, etc. Among you are countless college students and those who study radio at home, independently, or in organized courses by mail—the coming leaders of the industry.

To all our readers—to the 16% and the 84%—we pledge Radio Broadcast in coming months will be better than ever.

Editorially, the services and features which have caused the majority of progressive radio dealers, engineers, executives, servicemen, sales managers and technical leaders of radio to read Radio Broadcast—will continue to be offered for your interest. Radio Broadcast will continue ever abreast or a step ahead of the fastest-growing, most fascinating industry in the world—ever alive, interesting, accurate, and above all, useful.

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Total - - - - - 84%

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"I Found the Short Cut to Success in Radio through this amazing home laboratory method!"

By Frank Halloran

I got hungry to get into Radio when I learned about the big money it was bringing my next door neighbor. He was only twenty-eight years old, but his income was over four times as much as I was getting. He owned a fine car, dressed in expensive clothes, took week-ends off to go hunting and fishing, and was one of the most popular fellows in town.

"Charlie," I asked him one day, "how did you become a radio expert?"

"A cinch," he smiled. "I took it up in my spare time at home."

"What?" I asked in surprise, "you actually took a radio course by mail?"

"No," he shot back. "Not just a mail order course, but the only technical home-laboratory training conducted under the auspices of the Radio Corporation of America! Believe me, this 'big-league' organization not only knows what's what in radio, but it knows how to teach it!"

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Taking Charlie's advice was the luckiest thing I've ever done. It's bringing me more money in a week than I've often earned in a month!

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The Radiobuilder, a monthly publication telling the very latest developments of the S-M Laboratories, is too valuable for any set builder to be without. No. 9 (Jan. 1929) gave full particulars about the new apparatus described above, long before it was available in any other form. Send the coupon for free sample copy, or to enter your subscription if you want it regularly.

If you build professionally, but do not have as yet the S-M Authorized Service Station appointment, ask about it.

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... among other things

The issue before you might be called a special tube number. In addition to the series of charts and explanatory curves which accompany them, we present the article by K. S. Weaver of the Westinghouse Lamp Company on the characteristics of the 250-type tube, some data in "Strays from the Laboratory" on new English tubes of interest, and a useful article by G. F. Lampkin on the use of a vacuum tube circuit to control the output of radio transmitting apparatus.

We call especial attention to the new section of Radio Broadcast, "In the Radio Marketplace." This new news section of the magazine will, as our plans develop, become increasingly useful to every reader who is in the radio industry. A new feature, prepared with much the same purpose as our famous "Laboratory Data Sheets," appears in the "Marketplace" this month. It is the "Radio Dealers' Notebook" containing complete information every month on one subject of interest to those who serve the public, radio-wise. We welcome suggestions as to how this feature can be broadened to be of increased value. The article by Charles Williamson on page 299 describing an automatic volume control system will be of interest to experimenters and to advanced servicemen who may find it possible to install the device on receivers owned by their clients who are interested in owning the latest improvements.

The April Radio Broadcast will contain among many other things, an interesting article by Roger Wise on "Characteristics of Filament Type Rectifiers," illustrated with many tables and curves; the second article by Prof. Terman on "Detection" will appear, this one being devoted to "power detection"; and, a story by K. W. Jarvis on "Selectivity"—a subject on which much should be said because increased attention is being devoted to it.

Many radio companies are sending printed matter by mail to radio dealers and radio service organizations, particularly the former. Much of what they send is of prime interest to servicemen and the technical head of the business, who, parenthetically, is often one and the same person. It is an unfortunate fact that as things are, much of this information which servicemen really could use never reaches them. The answer? Well, we would rather the mail be addressed to the serviceman or technician than change the habits of the dealer who offends.

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THE Master Hi-Q 29 is the only circuit permitting the use of shield-grid tubes at their maximum amplifying ability.

So remarkable has been the performance of this receiver that not only are professional men everywhere building it, but the engineers of nearly a score of the foremost radio companies have purchased it either for personal use or for laboratory experiment.

Due to the characteristics of loosely tuned circuits, each of the doubly tuned radio-frequency transformers used in the Hi-Q '29 actually constitutes a "band-pass filter", the effect of which is shown in the graph below. Space does not permit full description of the many advantages thus gained but the informed radioman should quickly grasp the results shown in the exclusive Hi-Q "flat-top" response curve.

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ADDRESS.
DE LUXE RADIO SERVICE AVAILABLE IN UP-TO-DATE HOSPITAL

A centralized two-channel radio program distribution system has been installed in the Knickerbocker Hospital, New York City, by the Radio Corporation of America. Loud-speaker and headphone outlets are located in each of the various wards as well as the rooms occupied by the hospital staff. At any of the outlets the listener has a choice of tuning-in either one of the two programs which are being distributed. This picture shows an operator adjusting the control-panel dials of the new installation.
THE nondescript tangle of antennas on the roofs of most large apartment houses is a familiar sight and a frequent source of comment. The opinion most often expressed is that human ingenuity should be able to find a more systematic method of providing the tenants with reception facilities. Nevertheless, no such method previously has made its appearance, the problem being left almost entirely to the devices of the individual tenants.

The result is a maze of wires on the roof which is anything but artistic. It is the "roof jungle" of the modern city. A typical "jungle," which is a sample of what is seen for mile after mile from an elevated train in New York, is shown in Fig. 1.

The "jungle" is not only an eyesore for the landlord, but it results in a great deal of building defacement as well. Nails are driven, holes are bored, and grooves are cut. The ideas as to how it should be done are different with each succeeding tenant. Fig. 2 illustrates the careless way in which many antennas are installed by apartment-house tenants.

In a few instances, this system, or lack of system, has been replaced by a more orderly arrangement supervised or constructed by the building owner. This is usually an improvement from an artistic standpoint, but the radio reception provided is seldom satisfactory for several reasons. The antennas are usually only a few feet above the roof of the buildings and, as practically all modern buildings are of steel framework, which is an excellent ground, the effective height of the antennas is very low. The long-lead-in wires, which are usually necessary, have a large capacity to ground which has the effect of partially bypassing what little signal is introduced into the antenna. Although these long-lead-in wires do more harm than good in picking up signals, they are very effective in picking up the noise from the various kinds of electrical machinery distributed about the building. Also the close proximity of all these antennas causes a number of undesired effects. If receivers are used that employ tuned input circuits, it will be found that when one receiver is turned on, a change in tuning becomes necessary in the other sets in the building. If some tenants have receivers capable of oscillation, the reception of the others is often interfered with. In addition, each antenna tends to shield the others from the signals.

The result of all this is that an overwhelming demand exists for a satisfactory system of distributing radio signals to tenants. The situation is so acute that builders have expressed a willingness to delay their building program if such apparatus would be available at an early date. Many owners report tenants changing apartments in trying to find a location having good reception facilities.

A New System

THE following describes a system which solves the problem in a manner thoroughly satisfactory to both tenant and owner. The "roof jungle" of antenna wires are replaced by a single antenna of attractive appearance and efficient design. The signals from the common antenna are distributed at radio frequency to each apartment in the building, over conductors which are enclosed in metallic conduit.

Each apartment is equipped with a radio-outlet plate containing antenna and ground terminals. When a radio receiver is connected to these terminals, it will perform in the same manner as though it were connected to a very good isolated antenna. Fig. 3 shows a schematic diagram of an installation.

The received signal causes a radio-frequency voltage drop across $R_1$ and this voltage is fed to the grid of the amplifier tubes in the antenna-coupling units. There may be any number of antenna-coupling units up to about ten, used on one antenna. These are located on the roof in the pent house. The radio-frequency transformer, $T_2$, in the plate circuit of each of these tubes feeds a transmission line, or distribution riser which leads to several apartments. The coupling tube or "extension unit" in an individual apartment passes the signal on to the individual receiving set through another radio-frequency transformer $T_3$.

The unique virtues of this system are:

1. The high signal intensity obtained.
2. The total absence of interference between receivers.
3. The elimination of the pick-up of interfering electrical noise on the distribution system.
4. The efficient transmission of signals at all frequencies in the broadest range at the same time.
5. The economy of initial cost and maintenance.
6. Ease of installation.
7. Businesslike arrangement and attractive appearance of the whole system.

A high signal intensity is obtained by the use of a single really good antenna and an efficient distribution system. Interaction between receivers is eliminated by placing a coupling tube in each apartment. Thus a change in the tuning of any receiver does not affect the impedance of the distribution riser in the least. Furthermore, if a receiver oscillates, the generated high-frequency energy does not get past the coupling tube and, hence, does not interfere with the reception of others, except insofar as radiation takes place directly from the coils of one receiver to those of another. This interference due to the neighbor's birds is reduced greatly.

The interference caused by the operation of the various types of electrical machinery about the building is minimized. Of course, that portion of the radiated noise which reaches the antenna high above the roof, will come through. However, the strong electrical fields close to this machinery will not be picked up by the distribution risers. Any voltage induced in the transmission line wire is induced in the enclosing conduit as well and there is no effective input voltage between grid and filament of the coupling tubes from this source. This will of ten mean the difference between good reception and poor reception in buildings where noisy electrical machinery is in use.

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**Fig. 1—View of the "roof jungle" of radio antennas in a New York City apartment-house district. The r.f. distribution system described in this article would correct this condition**

March, 1929
Principle of System

EFFICIENT transmission of signals at all frequencies of the broadcast band simultaneously, is obtained by the use of the principle of the loaded transmission line. The grounded neutral circuit (similar to that of a push-pull amplifier) is necessary to eliminate ground current in the conduit which would prevent proper loading of a single sided line. The radio-frequency transformators are used in the plate circuits of the coupling tube to match properly the tube impedance to the load.

A feature which is essential to the practicability of the system is the centralization of the B supply for the coupling tube, since the cost of supplying a separate B-power unit for each tube would be prohibitive. One B supply is used for each antenna-coupling unit and all the extension units tapped off the associated distribution riser. This is better than a single large B supply for the entire system because it makes a more flexible arrangement, better adapted to fitting a wide variety of building sizes.

The arrangement for using the r.f. distribution wires for carrying minus B, and the grounded conduit for carrying plus B, is rather unique and effects a distinct saving in apparatus required. As may be seen in Fig. 5, the grid of the coupling tube is connected directly to the line. The signals are prevented from flowing to the filament by the r.f. choke. The d.c. plate current flowing in the resistor R supplies bias voltage for the grid. The condenser Cg keeps the filament at ground potential to the signal voltage. The pipe and box are connected to the positive B that is used as the source of B voltage for the plate. The power transformer lights the filament of the tube. If the negative side were grounded and the positive side on the line, as would be more conventional, it would be necessary to add a grid leak and two condensers to each coupling-tube box to obtain equivalent operation.

The economies effected by this method of centralization of B supply, make the cost per apartment of the installation only about the same as the cost of a real good antenna for each apartment.

The entire system is as easily installed and as "fool-proof" as the wiring for the electric lighting circuits. The distribution risers are run in standard half-inch steel conduit (with no appreciable increase in attenuation—to the surprise of many). Where possible, these risers are run vertically from the roof to the ground floor. Any number of coupling tube boxes from one to five may be tapped off on each floor. However, the usual number will be one or two coupling tube boxes in multi-storied buildings, since ten coupling tubes is the practical maximum set for one riser. A set of loading coils is inserted in the line on every other floor.

Coupling Boxes Described

THE coupling-tube boxes of both the central and apartment types are sunk into the walls and covered with flush cover plates. Fig. 6 provides an interior view of a coupling-tube box showing the location of the filament transformer, the tube, and the radio-frequency transformer.

The coils seen just above the filament transformer constitute a set of loading coils for the line. If the coupling-tube box is not in a position where the loading coils are needed, they are omitted. If a set of loading coils is required at a point remote from any coupling-tube box, another type of box is used to mount them separately.

The electrical portion of the coupling-tube box is held in place by two screws. This unit is not inserted in the box until the rest of the installation is complete, thus minimizing the number of damaged units. This assembly is shown in Fig. 4a.

The unit going in the antenna-coupling-tube box is the same except that a slightly different r.f. transformer is used. This is shown in Fig. 4c. The r.f. unit is seen in the top of the box. The bottom of the box contains the B-power unit for one transmission line.

A special outlet plate is installed in each apartment. Antenna and ground pin jacks are provided and also a socket for plugging in a socket-powered receiver. The switch turns off the power on the receiver and on the filament of the coupling tube for that apartment.

The theory of the design and operation of the distribution system is somewhat involved but an attempt will be made to give it in sketchy form. The design is based on the principle of the low-pass filter or loaded transmission line shown in Fig. 3a. The formulas applying to this circuit are:

$$f_c = \frac{\pi V}{L}$$

where $f_c$ is the cut-off frequency. As shown in the operation curve, higher frequencies than $f_c$ are attenuated to a degree which increases rapidly as the frequency is increased. Lower frequencies are transmitted with practically no loss. If $E$ volts is applied at a frequency lower than $f_c$ in series with the first resistor, $R_i$ (commonly called the generator resistance) then $E/2$ volts will appear across the terminal resistor $R_i$, providing the circuit is so balanced that the two equations are fulfilled.

Fig. 3—These circuit diagrams and formulas explain the operation of the apartment-house r.f. distribution system described by the writer.

Solving the Formulas

THERE is then a pair of simultaneous equations with four unknowns. Clearly any two of the variables may be fixed at any desired values and the corresponding values of the other two variables are then determined by the two equations.

The easiest value to fix is $f_c$. A convenient value for $E$ is 1,570,000. A convenient value for $L$ is 10 ohms.

If a convenient value is assigned to $L$, $C$, or $R$, the other two values will then be fixed by the two equations. It is most convenient to have the loading coils a distance apart equal to a multiple of the distance between floors in a building since the coils may then be placed in the coupling-tube boxes. Special boxes need not be provided and mounted. A handy distance is every two floors, as will be seen. This length (20 or 22 ft.) of No. 18 telephone twisted pair has a capacity of a little

---

**Fig. 2**—Each tenant develops a different way to erect an antenna. The above picture shows the careless construction of a typical apartment-house antenna.
about 2.25. It is designed to match an impedance of about 2000 ohms which seems to be a good average value for the input impedance of the various types of receivers. To make the impedance of the transformer more nearly like that of an antenna, a small series condenser was added.

If a one-volt r.f. potential is applied on the grid of the antenna-coupling tube, and the amplification factor of the tube is nine, we have \[1 \times 9 \times \frac{1}{10} \times \frac{1}{2} = \frac{1}{2}\] volt applied to the grids of the apartment-coupling tubes assuming no attenuation. The ratio of the apartment-coupling tube transformer is 2.25.

over 300 mmfd. Allowing about 50 mmfd. apiece for an average number of coupling tubes (two) gives a line capacity of 400 mmfd. Solving for \(L\): (See Fig. 3a):

\[L = \frac{100 \text{ Microhenries}}{500 \text{ ohms}}\]

A hundred feet of line having these characteristics is found to transmit signals over the entire broadcast band with a negligible amount of attenuation. The length of each section of the line is not very critical. It may be varied 25 per cent. with no bad effects.

Designing the Transformer

REFERING to Fig. 3c, a further feature to consider is the design of a suitable transformer to match the plate impedance of the tube (10,000 ohms) to the 500-ohm load. This requires a step-down ratio of the square root of 20, or about 1.3 to 1. Since it is impractical to build a 100 per cent. coupled transformer, the leakage reactance must be used as the loading inductance of the first section of the line. The inductance of the primary must be great enough to make an effective transformation at the lowest frequency of the band.

Two millihenries is found sufficient for the primary. That portion of the secondary which may be considered 100 per cent. coupled to the primary must have an inductance of 0.002 divided by 20 = 100 microhenries. Adding to this the leakage reactance of 100 microhenries gives a transformer with a 2000-microhenry primary a 200-microhenry secondary, a mutual inductance of 450 microhenries and an effective ratio of transformation of 4.5.

It should be noted that the tube's plate-filament capacity (10 mmfd.) multiplied by the square of the transformation ratio (i.e., 20) supplies the correct terminal capacity for the low-pass filter (i.e., 200 mmfd.).

The design of the output transformer of the apartment-coupling tube is obtained by following a similar line of reasoning. Its ratio is

Fig. 4—Pictures of the apparatus used in an apartment-house r. f. distribution system. A shows the electrical portion of the coupling-tube box, B is an interior view of the coupling-tube box, and C is a view of the antenna-coupling box.

Fig. 5—Schematic wiring diagram of a typical r. f. distribution system of the type designed for apartment house use.
BEFORE we delve into the large subject of methods whereby reclai-ant
radio receivers may be induced to play a new and more useful part, we shall take into consideration the following articles, we might profit by a dis-
cussion of the elements of knowledge which the serviceman needs to have if he is to be a really capable technician. To enumerate such a stock of "expert," There are two definite forms of knowledge the gaining of which the serviceman may pursue, and a definition of what each is, plus what each will do, will give us some basis for deciding their relative importance.

Service-Manual Knowledge

LET us first consider the man whose radio
knowledge is limited to a thorough acqu-
quaintance with the kind of service data prev-
dented in manufacturers' service manuals. He knows the physical layout of a number of make-type models of receivers. In a particular model, he knows the name of each part and it's exact placement, the number of each tube socket and the types of tubes which correspond to the socket numbers. He knows to which socket prong or to what terminal of which cans up something-or-other "unit" each wire from each numbered terminal lug goes. He knows, by the way that this is the fact that, testing with a C battery in series with a high-resistance meter, the proper effect from lug number 2 on the left-hand terminal strip to prong 3 in socket 7 is a full reading of the bat-
tery potential on his voltmeter, and that if he does not get such a reading there it will then be necessary to replace the coupling, audio, or power assembly which is catalogue number 3452. He knows in detail exactly what shields, controls, and screws to remove and which wires to unsolder in order to remove that particular part, and even, without any exacting, the quickest and easiest way to install the new part.

The man who has that sort of knowledge, all of which can be memorized, like dates in history, from the service manuals put out for dealers and distributors by all reputable manufacturers, can run a number of things with it. Servicing a given model and its asso-
ciated apparatus, with which he has be-
bcome familiar by studying the manual and by actual practice on that model, he can find and cure all of the ordinary run of troubles in nearly the minimum of time required. He can also find and cure, from instructions given in the manual, the most mysterious and most funda-
mental system troubles. If the customer is present, he will give the impression, by the ease and rapidity with which he works, that he is a man of the amount of the serv-
ciceman. Those things are assets which are unquestionably of great value to every serviceman and every service organization.

But, suppose that this man is called upon to service a receiver, of even the same general type as some of those with which he is im-
timately familiar, and serve an outside manual which he has been unable to obtain, or having obtained one has not even looked at it. (Servicemen have been known to neglect those things, alas!) So far as is known, the chief engineer employed by the maker of this set has unique (and always superior) ideas of the proper placement of sockets, terminal

strips, wires, and other parts. The service-
man with only the kind of radio knowledge we have described would be completely at sea, and, on that particular job, he would be a total loss to both himself and his organiza-
tion.

Even taking for granted that a serviceman knows fundamental, technical, and service manuals, and all the models of receivers put on the market by the large number of reputable manufacturers, it is by no means safe to assume that he would be willing to memorize to the extent necessary if he is to depend upon them as his only source of service information. Neither is it safe to assume that he will never be called upon to service a circuit which he can't be taken apart, reassembled, and turned on to work. The man who can, for instance, take apart a deForest, or any one of the four million sets "designed" and built by an "expert radio engineer" who is always a "personal friend" of the afflicted but in-
ocently enthusiastic customer. The manu-
factured sets in daily use, the manufacturers of which are no longer exact and for which no service manuals were ever printed, as well as those sets built by individuals, still com-
prise a very large proportion of the total number of broadcast receivers which are en-
tertaining or annoying—depending largely upon one's degree of musical education—the American nation, and which, therefore, be ignored by servicemen.

Basic Knowledge

LET us now consider the man who has a broad knowledge of the fundamental theories of tube and circuit operation and thorough understanding from experience of how those theories work out in the few basic kinds of circuits which are in general use, but who has never seen a manufacturer's service manual. Such a man knows appro-
imately how to expect from any receiver, because he is familiar with the general results to be expected of that particular type or combination of types of circuit. He knows approximately what voltages and currents to expect at various points. He knows the order of values of resist-
ances and capacitances, and some broad idea of the degree of overall gain to be expected. He is capable of servicing any make or model of receiver and of solving any particular type or combination of types of circuit. He knows how to apply and test the service manual for that particular model of receiver. Because of his general education, he can trace out of operation of circuits he
can determine definitely whether each part is functioning properly. If any part is failing to do its job, he does not need service data sheets to tell him how to determine why, or what to do about it.

The man who has that sort of radio training demurs from his service manuals. He is, by virtue of his ability to apply technical knowledge and logical thought to the solution of his service problems, which can never be realized by the man who exercises only his memory of picture diagrams of sockets, termi-
nal lugs, and canned units.

Looked at from the standpoint of service efficiency, however, there is one question of which we have just described may not be ideal. Service, to be efficient, must be done thoroughly and it must cope adequately with every problem that arises, no matter how complex, but it must also be done in the shortest possible time. The man who can find and cure any trouble which exists in any radio receiver by reason of his broad technical knowledge, but who is not also familiar with the physical layout of parts and terminals, color codes, and most of the specific data of that nature given in service manuals, is laboring under a serious disadvantage. While he is capable of discovering whatever of those details he may require in order to service properly a partic-
ular model, it will take him far more time to do so on each job than would be required if he had studied the manual. And time, in the radio service business, represents money just as fully as it does in most other lines of en-
deavor. While most of us are repairing radio receivers rather than selling bonds, neckties, or what-have-you because we happen to like it better, there are a few of us who are not also under the necessity of deriving from it our daily bread and frequent larger sizes of small

Ideal Knowledge

LET us, then, consider the merits of the man who has the kind of memorized knowledge which may be obtained from manuals and service manuals. We have also has a broad background of knowledge of the theories underlying the operation of radio receivers in general coupled with ex-
tensive practical knowledge of how those theories perform in the types of circuits which are in use.

Such a serviceman can complete the ordinary service job even faster than the man who has only service-manual knowledge, for his additional technical training and experience very often enables him to make a more rapid diagnosis of the trouble, elim-
inating some of the steps required by the narrowly trained man. He is not stuck by troubles that are unusual, but confidently attacks each job with the unfurled assurance that no matter what the trouble may be, he can discover it, determine its cause, and ef-
ciently cure it. Whether he is curing a trouble as simple as the need for replacement of a thoriated-flament tube whose emission has become too low, or a trouble as complex as a recalcitrant piece of electrical equipment due to imperfect contact, caused by oxidation, between an r.f. stage shield and its base, he makes a very favorable impression on the

If the customer is present the serviceman will give the impression that he is thoroughly competent.

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www.americanradiohistory.com
A serviceman may be called upon to repair any one of the four million sets "designed" and built by an "expert radio engineer." He must have a strong desire to acquire it in order that we may have the greatest satisfaction of knowing that our work is really well done and in order that we may have confidence in the work we have chosen to do. Obviously the man who relies solely upon the practical experience he can get from actually servicing radio receivers and does not supplement that with study, will never be a good serviceman. Neither will study alone make a good serviceman. Practice and study must go hand in hand, each supplementing and guiding the other, and proficiency cannot be attained in a few months, but only be acquired by years of study and effort.

The best source of detailed knowledge of particular models of receiving sets is the manufacturer's service manual or service-data book. However, servicemen have discovered the hopelessness of the task of instilling into the average dealer the fact that it would pay him to give the necessary service to his customers, something which was discovered by a good many service organizations a number of years ago. Some few of the more progressive manufacturers have awakened to the fact that, because of the attitude of the average dealer toward service, most of the service on their sets is performed by service organizations after the end of the period during which the dealer gives free service. Wanting those service organizations to perform the work and knowing that it will not be more than he can do to help by furnishing service data on all models upon receipt of requests written on the business letterheads of such concerns, he is having the manufacturers furnishing data, starting with the June, 1928, issue, circuit diagrams of manufacturable receivers together with charts giving pertinent data such as circuit diagrams, voltage and current capacities, and voltage values, which are of considerable aid in the absence of the more complete data usually furnished by manufacturers. On each of the models.

For the more interesting, and far more important study of the basic principles, there is no single source which is more complete and readable than Moore's book, Principles of Radio Communication. It is published in New York by John Wiley and Sons, Inc., and can be obtained at a cost of $7.50. The price may seem high, but as an investment in the acquisition of knowledge it is well worth the money. It should be in every serviceman's library, and is invaluable to every radio manufacturer, and is certain to be the first in the list of books which will be purchased by any serviceman who has a definite idea of what he wants to learn about radio.

In radio work the contents of interest to all radio engineers. The book is published by the Department of Commerce and is kept in every public library. It is entitled Principles of Radio Communication, written by Dr. J. H. Dellinguer of the Bureau of Standards, with the assistance of six other professional physicists and radio engineers and one well-known professor of mathematics. It may be obtained, at the ridiculously low cost of one dollar, from the Superintendent of Documents, Government Printing Office, Washington, D. C.

The author of this article strongly recommends that all who have not read it read it. If you have not read it, send it to Washington for the latter, and when you have assimilated all of it, then tackle the Morecroft's radio. One other publication which is an invaluable addition to any radio library is in the Bureau of Standards Circular No. 74, Radio Instruments and Measurements. It may be obtained for 50 cents, also from the Superintendent of Documents. Modern radio mathematics has become rusty, or if you did not have enough of it in high school, there is a textbook by George Howe, Mathematics for the Practical Man, which assumes only a knowledge of elementary arithmetic and gives you in a very easily understood form exactly what you need for a thorough understanding of Morecroft's. It is published by D. Van Nostrand Co., New York, and costs $1.50.

While there are a few radio texts which contain articles of value, it is the opinion of the author that it is a mistake to attempt to read all of them, and that one good radio text must assume the place of one's study of books. It is also his opinion that Radio Broadcast contains a greater amount of material which is of importance to the serviceman than does any other periodical. The "Home Study Sheets," "Laboratory Information Sheets," and "Strays from the Laboratory," which appear monthly, are minis of clearly presented useful information. There also have been, and will continue to be, various technical articles on timely subjects which are essential, but which cannot be written in the usual short, easy to read articles, although a few algebraic expressions are employed where they are essential. Oxford University Press, New York, 1927. Price: $1.00.

Principles of Modern Radio Receiver, by L. Grant Hubbard, is a new book that is longer but more readable than any other similar book. The author is well known as a manufacturer of high-priced receivers, and his book is a result of experiments in the design, construction, and testing of the various types of receivers he has built. This book is published by Wiley and Sons, Inc., New York City. Price: $7.50.


Radio Engineering Principles, by Lauer and Brown. A book less extensive than Morecroft's but excellent for the beginner. It is a simple book, free from technical jargon, and is very useful for the beginner who is interested in radio but who is not interested in technical jargon. It is a valuable text for the student of radio engineering. Wiley and Sons, Inc., New York City. Price: $4.00.

Radio Telegraphy in Measurements, by E. B. Moultif. A book dealing with the theory and practice of radio measurements. A handbook for the laboratory and a service manual for the radio man. All measurements are made with the aid of the vacuum tube volt-meter and the receiver in the hands of the operator. From the J. L. Lippincott Co., Philadelphia, $10.00.


A Laboratory Treatise on Batteries Eliminator Design and Operation, by John W. Rider. This book is a work of reference, while additional to a library of elementary radio texts. It is intended for the use of radio operators and the operators of special-ity units and is of value to servicemen and manufacturers. Radio Operators Association Co., New York City. Price: $1.00.

No. 305-A Radio Instrument Data Sheets. This book consists of 190 short articles giving concise and accurate information in the field of radio and closely allied sciences. The book is published by the University of Chicago Press, etc.

How Radio Receivers Work, by Walter Van B. Roberts. This is a book on radio engineering designed to be both instructive and descriptive, but definite ideas that will enable the reader to understand the operation of the radio receiver, the circuitry, and to read with benefit the more complete treatments of the subject. Radio Broadcast, Garden City, N. Y. Price: $1.00.

If he helps to increase the number of steady customers of the organization it follows that his pay will increase steadily and that he will be given larger responsibility.
The MARCH OF RADIO

A Study of Program Possibilities May Open New Radio Markets

The radio industry is engaged in selling devices for reproducing broadcast programs in the home. Only to the degree that radio entertainment is acceptable to the listening public does its market expand. This season’s enormous sales are due as much to general program popularity and the availability of receiver operation and maintenance. Stabilization in receiver design precludes the likelihood of revolutionary sales stimulation because of the appearance of entirely new types of receivers, except through the solution of the many problems retarding the commercialization of visual reception.

For the moment, we dismiss the possibility of television because it is predicated upon considerable technical development and upon the establishment of an entirely new broadcasting structure. We are not in possession of sufficient proof of its reasonably early development as a commercial product to predict whether it will be a vital sales factor within one year, five years, or twenty. The commercial history of the motor car, the airplane, and radio broadcasting itself is illustrative of the long period which may elapse between elementary discovery and general commercial development. As early as 1899, substantial stock flotations were launched successfully by companies proposing to exploit the radio telephone and old timers in radio recall entertainment. First was heard with crystal sets broadcast as early as 1910, 1912, and 1913. Yet we waited until 1923 before there was a substantial market for home reception.

Assuming that broadcasting, purely for commercial reasons, will develop in the immediate future, we might conclude that we have before us only an era of ordinary, though presumably prosperous, competitive competition, with radio reception as stabilized as the motor car, the typewriter, and the electrical refrigerator. Under those conditions, merchandising skill, service support, and advertising ideas will account for the commercial successes of the future. Indeed, this year's outstanding radio surprise is directly a product of merchandising aggressiveness and a successful appeal to dealer cooperation. Considering that we are far from radio's saturation point and over half the receivers in use are already obsolete, this prospective era of intense commercial competition is one which cannot be missed.

The 1928 sales record will probably stand no longer than the end of 1929. There is ample reason to believe that the future receiver will insure a huge sales volume for many years to come.

The basic commodity of the radio industry, radio programs themselves, however, offer new avenues of public appeal which may uncover unexpectedly large sales fields. Our competent contemporary Radio Retailing, recently suggested the idea of a radio set for every office. The present-day program offerings, however, have little more appeal to the average business institution than a kitchen cabinet or a phonograph. A fundamental change in the character of daytime programs is necessary to develop a market for radio reception in the business world. It is one, however, presenting great possibilities if the broadcasting interests possess sufficient initiative to depart from present trends. These possibilities are worthy of the utmost consideration by broadcasting management because the establishment of specialized audiences at hours now of small commercial value means proportionately increased revenue possibilities.

Certain stations have established daytime audiences of considerable value. While the average standard of programs addressed to the householdwife are hopelessly mediocre and fall far short of their mark, nevertheless they have demonstrated the great possibilities of daylight broadcasting. During the day, the major part of these programs is direct advertising of the most flagrant character, restricting response to an undiscriminating though nevertheless large audience. Daytime farm programs have also reached many listeners and great political addresses delivered in daylight hours have been rewarded with adequate response.

EXAMPLE OF BUSINESS APPEAL

There has not, however, been any conclusive test of appeal to the business man. One requirement which must be met is that he be served with precisely the information he needs in a few regularly scheduled minutes of each day. An illuminating instance occurred recently in New York demonstrating the worth of the business man. WMCA has been broadcasting a brief news summary and stock market report immediately after 5 p.m. during the last two hours of every business day. They have been received by an increasing number of the city's administration at the close of the business day.

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for universal appeal has discouraged program pioneering in spite of the fact that radio has scored a much higher percentage of successes with the continuity than its nearest counter-
part, the phonograph. The continuity has the very important advantage to the com-
mercial broadcaster that it holds its audience's attention for so much longer than any
almost unknown background of musical entertainment. We regret that, although the continuity has won a permanent place for itself, the recordists have not copied the few outstanding successes, despite the infinite variety of original characterization open to writers of continuity scripts.

**Dramatic Programs**

In the field of radio story telling and en-
actment, a distinctly different field of con-
tinuity, the True Story hours are the represen-
tative successes in the field. A higher plane of
story structure is conceivable, but, for vivid-
ness of presentation and broadness of appeal, they are superior to later imitations.

"Great Events in History," remain the unques-
tioned leaders in serious dramatic pre-
sentation of the full-time continuity type. But, for pure acoustic artistry, they have been ex-
celled by the "Air Circus" and "I'll Be Back" from "Parker Sketches" and "Interborough Sketches." Their author has caught radio's most illusive quality, vivid-
ess on the air, and has shown that short dramatic novelties are an important trend because they have a substantial appeal to a distinctive strata of the radio audience, some of which may be hostile to the stereotyped program trend.

Finally, the Damrosch symphonic educa-
tion for the holiday audience in New York, which means that radio tubes will be functioning at hours when they have been accustomed to rest. That is the real test of an expanding radio audience - that it appeals to new listeners and increases listening hours. We are not attempting to review program progress from the standpoint of higher general standards, but from that of broadened appeal. We expect radio programs to improve because steady progress is necessary to main-
tain its position in competition with its real competitors, the phonograph, the motion picture, and the motor car. Expansion of radio's market requires more than holding its own against com-
peting forms of entertainment. It must swing into the fold entirely new listening groups. As the program listening hours of its estab-
lished followers. Creators of new program services make liberal contributions to radio's potential market. The association of pro-
gram development with the pros-
perity of manufacturer, jobber, deal-
er, and radio servicemen is an intimate yet generally unreal-
ized interdependence.

**A New Radio Service to Aviation**

PEAKING at the autumn meeting of the National Academy of Sciences, Dr. E. F. W. Alexander described a potential market which he has been pursuing, looking toward the development of a means of communication by radio of the sight of an airplane above ground. The altimeter, which is conven-
tionally employed, measures barometric pressure, but, according to Mr. Alexander, gives no indication of height above ground unless aviator happens to know its exact alti-
tude. Furthermore, the changes in barometric pressure, accompanying changed weather con-
ditions, must be compensated.

The principle of the Alexanderson device is simple. A high-frequency continuous wave is radiated from the plane in flight and the component reflected from the ground is used to determine the frequency received at the transmitter. When the plane is at a height above ground which is an exact multiple of the transmitted wavelength employed, the reflected signal balances out the radiated signal and the minimum signal is received. As the plane rises through the distance of a wavelength, the signal goes through a com-
plete cyclic change. A graphic record, made on experimental flights, shows that altitudes up to 1000 feet have been determined quite accurately by this method, following exactly simultaneously, recorded readings made with an altimeter. The wavelength used was 95 meters and each cycle of the record represents an altitude change of 155 feet.

**A Possible Development**

Dr. Alexander has made several suggestions as to possible lines of development. He pro-
poses the use of two antennas with no oscilla-
tor in each, one having a wavelength of ten meters and the other of eleven. The best fre-
quency of the two oscillations is then detected and observed. The frequency will be of the order of 3,000,000 cycles but the signal inten-
sity will change cyclically as the plane changes in altitude. It will pass through maxima when the echo wave tends to decrease the frequency of the eleven-meter oscillator at the same time that it increases the frequency of the ten-meter oscillator, producing maxima at heights of 25, 75 and 125 meters, corresponding to 290, 240 and 400 feet.

The experience with the new system is naturally limited and, considering the peculiar-
ities of short wave radiations, it is quite possible that ground conditions will cause sufficient variations in the character of the reflected wave to create practical difficulties. It requires a fair amount of equipment aboard the plane and skillful manipulation and, while the duties of the pilot are so manifold, concerned not only with actual piloting but watching of motor indicators, radio com-
munication, and navigation, it is unlikely that so complex a system will have much prac-
tical application until it is further simplified. But Dr. Alexander has pointed the way to

A reconstructed picture of the half circle of 170-foot masts erected at Poldhu in 1901. This antenna, which consisted actually of 100 separate "Cliffords" across the Atlantic and was used successfully in Marconi's early transatlantic experiments. The transmitter was located in the building in the center of the masts

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**High-Frequency Allocations**

The Federal Radio Commission has allocated 551 of the 639 channels between 1500 and 6000 kilocycles, by assigning 308 channels to fixed stations, 118 to mobiles, and 95 to government stations. Of the fixed stations, the greatest surprise is offered in the allotment of the Universal Wireless Communications Company of 40 channels, which has now been turned over to the Radio Corporation of America or the Mackay interests. In view of the fact that the Universal Company is an entirely different type of agency, able to use direct with wire telegraph circuits, this allotment is causing considerable amazement in communication circles. The commission is capitalized at $25,000,000, recruited prin-
cipally from Buffalo business men. In its direction personnel, as announced, appear no names of executives known to be experienced in traffic management or radio-telegraph technique, although, no doubt, the Com-
mssion has been advised by adequate evidence of sufficient available capital, personnel and technical knowledge or it would certainly not have made such a liberal allotment of radio frequencies. This assignment is a distinct departure of the Commission's announced policy of confining high-frequency channel assignment to services which cannot be conducted through non-radio circuits.

Twenty channels are assigned to the press, 73 to marine service, 64 aviation, 5 railroad, 6 portable, including geophysical and police, 138 amateur, 100 visual, 4 experimental, and 70 point to point. Some private companies and services allotted channels are Ford Motor, Com-
monwealth Edison, Tropical Radio,

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**In the World of Broadcasting**

Merlin Ayles, president of the National Broad-
casting Company, in an end-of-
the-year statement broadcast through the work, announced that the expenditures made through his company for talent in 1926 were $8,000,000.
and for wire network service, $2,000,000. If American listeners had paid for their broadcasting service through direct taxation, as do British listeners at their rate of $250,000 per station per year, American listeners would have paid $192,000,000 per year or from $15 to $25 per set for the main-
tenance of the 700 stations serving them. The cost of broadcasting is met largely by adver-
sisers who distribute the expense among all classes of listeners and non-listeners. Mr. Aylesworth attempted to show that commercial broadcasting is in no way competitive with newspapers.

APPEALS from decisions of the Federal Radio Commission's decisions have been brought before the Court of Appeals of the District of Columbia by WNYC, WNBC, and WABC, the latter's challenge to the or-
gans of portable stations WANG, WIND, and WING. The outcome of these cases will determine, in a large measure, whether the Commission has sufficient power to exercise control over the broadcasting situation. Louis G. Caldwell, the Commission's indefatigable chief attorney, has agreed to continue his services through the month of February. If these cases are decided adversely to the Commission, we will enter a new phase in broadcast regulation. Fundis will then have to be appropriated sooner or later, for the confiscation of broad-
casting stations so that their number may be reduced to the point that the broadcasting hand is no longer overloaded. It will require a long time, however, to put over such a step because neither the broadcasting stations or a majority of the Commission are prepared to face the facts in the matter. Many, like Commis-
sioner Robinson, still favor low-powered broadcasting and heavily overloaded channels thus evading the necessity of reducing the number of stations on the air. Optimists hope for solution of the congestion problem by development of synchronizing methods, which would eventually enable network programs to be radiated on the same frequency. If com-
mmercial broadcasting continues to grow, con-
scious war against broadcasting during the night hours would make it possible to main-
tain synchronized programs with the network stations assigned to regional channels and preserving clear channels for network key stations and worthy independents. But until both continuous network broadcasting and practical synchronizing are accomplished facts, this solution is still in the future.

WNYC has appealed to the courts the decision of the Commission affirming the time sharing order with WWSB. In its brief, filed in answer to the appeal of the District of Columbia, the city makes much of the point that WNYC is called upon to share time with a commercial station and that the rights of municipal stations are superior to those of commercial stations. Considering that there is no possibility of sharing with any but a commercial station in the metropolitan area and that advertising merchandise is no less useful than advertising the deeds of political incumments and the gossip of municipal bureaus, this idea is based upon apparently unsound foundations. Any superior right which may be established by stations of a political origin over stations operated purely to appeal to the public through its educational and entertainment value would be unfortunate. It is to be hoped that all stations will be compelled to stand upon their service to the public and that no privileged classifications will ever appear in our highly unsynchronized broadcasting channels. The most important contribution of WNYC is its "University of the Air," and its potential service in cooperating in health department propaganda and maintaining law and order. It has been demonstrated that more than half time is required for these very worthy purposes.

The Federal Radio Commission announced that after January 1st no visual trans-
missions of any kind would be permitted in the broadcast band, but it reversed its position regarding the first few orders for maintaining such transmissions between 1 and 6 A.M. It has, however, dallied so long with this problem that many have become dis-
trustful of the commission's future development of visual broadcasting by experi-
menter participation has been rendered abortive. Many pioneers have suffered heavy financial losses, and it has not been sufficiently acknowledged that something was done through a temporary arrangement which has been somewhat mitigated by early consideration of the problem. The experimenters, having served his purpose of starting the whole broadcasting structure is thus rudely cast out from a field of activity which showed great promise of a revival of ingenuity and skill in radio reception.

Representative Wallace White of Maine has introduced a resolution to extend temporarily the authority of the Federal Radio Commission. If this year to year extensions become habitual, it is quite probable that Congress will ultimately form a communications commis-
nion, which will have in addition to the duties of the present Federal Radio Commission, complete regulation over telephone and tele-
graph systems. Because of its quasi-public nature, the communications business is com-
mon with railroads, suffers from excessive political regulation with the inevitable result that costs of operation are increased propor-
tionately to the political meddling tolerated. Excessive profit in the communications busi-
ness, and in fact any quasi-public function which is necessarily monopolistic in character, should certainly be regulated so that only a reasonable return is made on the capital in-
vested. As soon, however, as regulation broadens its scope into details of management, it generally works against the public interest. If politicians attempt to rule experts, the results are disastrous and, if experts are sub-
stituted for politicians, the method is wasteful. Had the present commission tackled its problems with greater aggressiveness and expediency, it would now be an appellate body meeting only on appeal. All that would be as a proper federal authority. If the communications business is to be regulated, a bureau of the Department of Commerce, exactly as it was prior to the chaotic conditions brought about in 1920. Congressional meddling that led by the protraction of the Commission's problems.

IN THE first week in January, the Columbia Broadcasting System has augmented its network from 21 stations confined to the northeastern part of the United States, to 47 transmitters reaching from coast to coast. As early as July 10th, Columbia will have 13 chain's contract expires, of which carry the programs and the balance are monitoring and emergency circuits, are used. Fifty repeater points are involved and the total general broadcasting two-handed tele-
phone engineers were employed in maintaining wire service.

WABC is now under the management of the United Independent Broadcasters, operators of the Columbia Chain. As soon as the chain's contract with won expires in September, WABC will be the source of all Columbia programs. Alterations in the time-sharing order are contemplated, and removal to a less-populous area has already taken place. Won plans no changes. With the exception of a few stations still, therefore, become the leading independent station of the metropolitan area, continuing its policy of originating its own features.

Schedule of the Best Short-Wave Programs

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*--During 9:00 to 10:30 P.M. period the N.B.C. Red network program comes through all 4 waves. Other periods have separate programs. At 12:00 P.M. you can watch by "Big Ben" from London, England.

* march, 1929 * * page 298 *
Operating Data on a NEW AUTOMATIC VOLUME CONTROL SYSTEM

By CHARLES WILLIAMSON

Department of Physics, Carnegie Institute of Technology

ALL of us have been annoyed at some time or other by a terrific burst of sound from the loud speaker when, in attempting to clean a vacuum cleaner, we have happened to come across a powerful local station. Sudden loud speaker overloading may also occur with certain types of broadcasting, such as organ music, which exhibits an unusually wide range of volume. In many cases, the voice of the announcer is received at a much higher volume level than that of the music. But the worst case of unexpected sound peaks arises when listening to a distant station that is fading badly. When it comes back, it usually does so with a roar; and static crashes are at their loudest because the sensitivity control has been advanced fully in order to make the program audible when the station fades.

An Automatic Control

LAST August the writer designed a simple and inexpensive device to cure such troubles. It has been tested on several receivers and in each case the difficulty was corrected almost perfectly.

The addition of the writer's device to any d.c.-operated receiver does not require that the circuit of the set be altered in any way. (When using this device in connection with an a.c.-tubed receiver the results may not be entirely satisfactory as an increase in hum may result; and particularly when the set uses 226-type tubes—Editor.) The device is connected across the loud speaker terminals and is operated by the a.c. voltages appearing across the loud speaker. In fact, by red. But the plate voltage on the r.f. tubes automatically as the volume from the loud speaker rises.

Since the device described in this article functions due to the changes in voltage across the loud speaker, it will have the effect of contracting the volume range—in other words diminishing automatically at the receiving end what the monitoring operator does (or should do) at the broadcasting end. Serious distortion of the signal currents will occur only if the device operates with a time lag so short as to be comparable with one fourth of a cycle at the lowest frequency likely to be handled by the audio system. An examination of the circuit (Fig. 1 diagram A) will show that the time constants of the choke-condenser and resistance-condenser combinations are of the order of 0.1 second or greater.

Dr. Charles Heinroth, the eminent organist, assures me that he would not regard a systematic contraction of the dynamic range as undesirable distortion of his programs. In fact, he thinks it would be better than the hit-or-miss monitoring sometimes met with! Hence I think we can regard this type of automatic volume control as distorting only in a formal sense. Not even a musician can detect it in the receiver's output unless he has an unmonitored output with which to compare.

Manual adjustment of the plate voltage of an r.f. tube will show that large changes may be had over a certain region without noticeably affecting loud speaker volume. If, as is often the case, the amplification of the r.f. stage under control is partly regenerative, it will fall off rapidly at first, as oscillation is left behind. After this there will be less change, since to a.a. plate voltage connected to the output transformer, the change in voltage of the tube will change slow by diminishing plate voltage over a certain region. Later, however, they both begin to change faster, and the amplification of the r.f. circuit is reduced rapidly. Thus, in a receiver of this type, this automatic volume control has the advantage that a loud signal throws the receiver out of oscillation instead of into oscillation.

The parts required for the construction of the volume control described by the writer follow:

| B1 | One high-resistance unit (See Table I for proper value) |
| B2 | Two rheostats or filament-ballast units |
| C1 | One fixed condenser, 200-volt, 1-mfd ; |
| L1 | One choke coil, 30-henry ; |
| R1 | One tube socket, 3.0-ohms |
| R2 | One power tube, 171-A type. |

The circuit diagram of the automatic volume control device is shown in diagram A of Fig. 1. This circuit also shows the method of connecting the volume control to a receiver, having an output transformer. Diagram B shows the input of the device connected to a receiver having a choke-condenser output circuit. It will be noted that in each of these cases the load speaker return must be made to the negative 45-volt C-bias terminal rather than to the negative rail as usual. Diagram C shows the device connected to a receiver using a push-pull output circuit. Two condensers, C2 and C3, are required, as shown.

In all of the above cases, the control tube may be operated from the same A, B, and C supply as the rest of the receiver, and its filament may be heated by an a.c. If desired. Also, with all types of receivers the r.f. tubes obtain their plate potential from the "B+R.F." terminal of the volume control unit.

The high-resistance unit, B1, should have a variable of 0 to 9,000 volts if a plate potential of 180 volts is available, and if there is a negative bias of 4½ volts on the grid of the first r.f. tube. For lower values, either of B or grid bias potentials, the following table shows the proper size resistor to use:

<table>
<thead>
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<tr>
<td>R.F. Grid</td>
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<tr>
<td>Bias (Volts)</td>
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The values of the resistors B1 are not especially critical; they are determined by the restriction that the first r.f. tube should not receive more than 90 volts of plate potential. If the r.f. B-plus lead supplies two tubes, the resistances in the above table should be divided by two.

If a variable-resistance unit is used in place of the fixed resistor, it may be set to the best value by placing a high-resistance voltmeter (1000 ohms per volt) across the plate and filament terminals of the first r.f. tube, and adjusting the knob of the variable resistor until the meter reads 90 volts (or whatever other voltage is normally placed on the r.f. tubes). This must be done with the receiver fully turned on, but not tuned into any station.

The choke coil, L1, used in this device, if not bought as a unit, may be made up of almost anything at hand, since, if only one r.f. tube is controlled, it need not handle more than 5 milliamperes at 90 volts. If a speaker filter is available, it can be used in place of C1 and L1.

With the receiver in operation, there is nothing to suggest the presence of the automatic volume control. The tone of the receiver remains constant, and there is no hint of speaker overloading. The original volume control on the set, whatever its type, is indifferent with it. Where it might be supposed that the volume range of the music would be brought to a dead level; such is not the case, however, the range is merely reduced to an extent that the audio system can handle without noticeable distortion. If desired, the amount of such compensation can be regulated by turning down the filament of the control tube; and, of course, the device can be cut out entirely by turning it off. As to the sensitivity of the set, this is in no way impaired; for the full 90-volt potential is available for the r.f. tubes until a signal begins to come in; and it is not materially reduced until the signal becomes loud.

Both calculations and trial indicate that a 112- or 120-type tube may be used for the control circuit instead of a 171-A type tube with some loss of efficiency. In these cases the negative grid bias of the control tube should be 9 and 223, volts, respectively. Of course, the r.f. tube or tubes under control may be any type of whatever except the type 226, which hums badly if its plate voltage is changed.

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Fig. 1—Diagram A shows the automatic volume control connected to the output transformer of a standard receiver. Diagrams B and C show the input of the device connected with other types of receivers.

• march, 1929 • page 299 •
IF THE a.c. screen-grid tube is made available before next year’s receivers are designed, it is our bet that many of them will find their way into 1939’s receivers, just as they have found their way into the best English sets. Over there 39 per cent. of all the types of sets manufactured during 1928 were three-tube sets—and 30 per cent. of the types used r.f. amplification. So screen-grid tubes were used on 80 per cent. of the sets with r.f. amplifiers.

Data on English receivers: The above figures are but a part of an interesting analysis which was published in Wireless World, November 14, 1928, on the receiver situation in England. The other data show that the filter-tube receiver, probably the most popular number of tubes in this country, constituted only 14 per cent. of the several types of receivers made in England during 1928. Seven per cent. of the receiver types employed no r.f. amplification at all. 39 per cent. used a grid leak and condenser type of detector, 70 per cent. used transformer coupling in the a.f. amplifiers, and 79 per cent. connected the loud speaker directly into the plate circuit of the last tube.

What will be used in next year’s receiver? We have read recently several excellent articles on the use of a screen-grid tube as a detector. These articles described the research of J. H. Nelson, of the Cunningham laboratory, and were published in Radio Engineering, October, 1928: Proceedings, I.R.E., June, 1928; and Lefax 35, December, 1928.

The great advantage of the C-bias, screen-grid detector lies in its ability to handle a relatively large input r.f. voltage without overloadung, and its relatively high output. According to Mr. Nelson, the first stage of audio can be done away with provided we use a screen-grid tube as a detector, and provided the r.f. amplifier supplies from 2.1 to 18.6 times as much amplification as when an ordinary general-purpose tube is used as detector with a two-stage transformer-coupled a.f. amplifier. Now when the 322 detector tube is compared to a 357 tube connected as a grid leak and condenser detector, the amplification of the r.f. end of the receiver must be 18.6 times as much. Of course, a C-bias is used with the 322 detector tube. Compared to the use of a 201A as a C-bias detector, the 322 and one stage of audio amplification requires 3.17 times as much amplification as when an ordinary general-purpose tube is used as detector.

If, then, we use screen-grid r.f. amplifiers, say two stages of them, the gain per stage must lie between 1.78 and 4.32 times as much as with present circuits, and if three of them are used, the increased gain per stage must lie between 1.47 and 2.65 for the two cases.

Now it does not seem difficult to design an r.f. amplifier, using screen-grid tubes, that could produce 18.6 times as much amplification as present-day sets, which used with a screen-grid detector, will work directly into a power tube thereby eliminating one tube. This means an additional voltage gain of about 35 on to our present-day r.f. amplifiers. We do not consider this impossible—nor are we convinced that it is desirable to substitute r.f. gain for a.f. gain.

One point of importance regarding the use of the screen-grid tube as a detector has not been discussed—what kind of a frequency characteristic can be obtained with it?

Selectivity versus sensitivity: The problem is not to get more amplification into our r.f. amplifiers. We have plenty now. The problem is to increase their selectivity without damaging their fidelity of response. It is our bet that the only reason why people tolerate present-day receivers—and their loud speakers—which bring out the low notes—is because of the lack of competition from, and comparison with a really high-quality receiver. One only has to look at the selectivity curves, published in Dr. Hull's article, "Measurements on Broadcast Receivers," in February Radio Broadcast, or Mr. Jarvis’ article in January Radio Broadcast, to see how few notes above 3000 cycles we are getting, and anyone has to listen but once on any good night in practically any home in the Middle West to long for a more selective receiver.

The only answer is the solution that engineers have suggested time and again, and which the Members of Congress who meddle with radio affairs, do not seem to understand. This answer is to eliminate about half of the present broadcasting stations. The myth of having 30 cleared channels is amusing indeed to anyone who listens under average conditions. This does not mean listening in New York City, or near any great center of broadcasting, but say in Ohio. We had the dubious pleasure of listening to there during the Christmas week. The receiver was undeniably less selective than many of the two-, three-, and four-stage r.f. amplifiers now on the market, sold as having perfect tone quality.

An hour before sunset in Ohio, we heard stations as far away as Winnpeg, C.B., on a four-tube set, and W.B.H. Circuitry which has been described many times in this magazine. We could tell at once that the practice of putting two large stations, KDKA and WJZ, for example, on adjacent channels is bad. If you live near KDKA it works out fairly well because you can’t hear WJZ on the adjacent channel, but if you live equidistant from the two, you can’t listen to either of them.

The following are among the subjects discussed in “Strays” this month:

1. New Trends in Radio Design
2. Two New A.C. Tubes on Way
3. Accuracy of Variable Condensers
4. New Radio Tubes in England
5. Importance of Reducing A.C. Hum
6. Receiving on 600 Meters
7. Selectivity of Browning Drake

Two New A.C. IF THERE is anything more interesting than radio gossip, it is speculation on how much of what we hear is true. We are glad to chronicle the gossip regarding two new tubes which do—so they say—are soon to appear on the American market.

One is an a.c. screen-grid tube of somewhat better characteristics than our present d.c. tube with its fragile and microphonic filament. The tube has a typical heater filament, 2.5 volts and 1.5 amperes. At 180 volts on the plate, a screen-grid potential of 75 volts, and a control-grid bias of minus 15 volts, the plate resistance is about 400,000 ohms, its amplification factor about 400, and its mutual conductance about 150 micromhos. This is considerably better than the d.c. tube with a mutual conductance—which is about all that matters in a tube of this kind—of not much more than 300 micromhos. The grid-plate voltage is in the order of 0.01 m.m.f., its input capacity about 5 m.mfd., and its output capacity about 13 m.mfd. The plate current is about 0.4 ma. and the screen-grid current under normal conditions about 0.3 ma.

The other new tube is a cross between a 17A and a 250, i.e., a tube with about double the power output of the 17A at a maximum plate potential of 250 volts. Many thousands of listeners who overload a single 171 on loud, note overload are forced to overload the house or the neighborhood with the racket from a 250-type tube with 450 volts on the plate, will be pleased with this new tube. Its filament consumes 1.5 amperes at a filament potential of 2.5 volts, and is not of the heater type. Its normal grid bias will be about 50 volts. Plate current about 32 m.a., amplification factor about 3.5, and power output of 1500 milliwatts.

We have not been able to confirm the rumors that such tubes are going to be announced—but rumors mean that such tubes are in the process of development and that is the

Fig. 1—The diagram of the Lab. Circuit receiver with fixed condensers which increase wave-length range to 1500 meters.
portant thing. Sooner or later they will appear whether their constants resemble those give above or not.

Accuracy of Variable Condensers

LAST month we spoke of the effect on the tuning of a radio receiver of using several ganged condensers, and stated that a number of experimenters were using them to obtain an equivalent of tuning one of the condensers by one dial degree, and that such a detuning would cause a reduction in signal strength of about 5 per cent.

Another prominent engineer remarks that the figure of one quarter of one per cent is too high, and that many experimenters will not accept the question of cost enters here—and that the rest of a radio receiver at the present time cannot be built with such a high degree of accuracy.

New Radio Tubes in England

TABLE I gives some data on new Marconi tubes which are available in England, the land of many tubes. Unfortunately all of the data on these tubes is not available, but it is certain that this country will be directed toward the low filament consumption of some of these samples of foreign economical tubes.

WE HAVE spoken about the loudspeaker several times. Here is a explanation of its value.

Let us suppose the power tube delivers 1000 milliwatts to the loud speaker at the lowest signal to be received, and that this power tube will be 40 below this value. This is the normal range of broadcasting, 40 db, corresponding to a power ratio of 10,000 times. Now suppose that at the town hall to be received from the loud speaker is not to objectionable. This means that it ought to be about 20 below the signal output. This makes the hum power output 60 db below 1000 milliwatts, or one microvolt.

If the resistance of the loud speaker to the hum producing voltage is 4000 ohms, the voltage across it is 0.063 volts. Suppose the amplifier is a conventional two-stage transformer-coupled amplifier using transformers with turns ratios of 1:1. Let us suppose the voltage gain of such an amplifier, from resistance output to the primary of the first audio transformer is 40 db, then across this primary is 0.063 + 150 or about 0.00402 volts or 0.42 millivolts.

All of this indicates that the maximum hum across the first audio transformer must be no greater than 0.42 millivolts—and yet we remember reading somewhere that the hum voltage in the plate circuit of a heater-type detector tube is of the order of several millivolts.

Let us look at the plate-supply device. If the total output potential is about 200 volts, the hum output will be about 50 millivolts. Across the 45-volt tap will be roughly one, quarter of this hum voltage or 12.5 millivolts. For the sake of argument, let us assume that 95 per cent of this voltage, which is impressed across the plate filament circuit of the detector finds its way across the primary of the transformer. This means that due to the plate-supply device alone 10.8 millivolts of hum appears across the inputs of the receiver. This 10.8 volts measured by 150 ohms comes 1.62 volts across the loud speaker. Let us suppose there is already this much there from the use of a c.a. tube detector. The same thing will happen to the 10.8 millivolts, or only 26 db below the maximum output of the amplifier! An assumed figure of 100 millivolts across the primary of 45-volt tap is high because the filter condensers across it, and those across the 90-volt tap, get rid of much of the a.c. voltage creating the hum. It is certain, however, that a similar amount of hum would be present across the 90- and 45-volt taps. This analysis may account for the fact that many experimenters who have built amplifiers direct down under-cycles prefer to use a d.c. tube for a detector and obtain its plate voltage from a 45-volt B battery. And it is surprising how much the low frequencies come up in apparent volume when the a.c. hum is cleaned out of one's receiver, amplifier, power supply, and loud speaker, it is true that as the receiver ensemble hum signal frequencies lower in pitch than this hum can be heard, and that few signals of the same frequency as the hum can be heard. They sound much louder than the hum—all of which points out some interesting psychological facts. A quiet receiver will always seem to have a much better low-frequency response than one which has a lot of hum in its output.

Receiving on 600 Meters With Lab. Set

DURING the Vodris disaster we listened to the traffic to and from ships in the vicinity of the wreck, and discovered many interesting things about the chaotic condition of the ether during such periods. We used our Lab. Circuit receiver with the addition of two fixed condensers which would give an increase in the tuned circuits.

These fixed condensers brought the maximum wavelength that could be received up to nearly 800 meters, and thereby permitted the reception of all of the ship-to-shore traffic on the several channels between 600 and 800 meters. The circuit diagram is given in Fig. 1. The Yagi switch is a simple double-pole double-throw unit and the condensers had a capacity of 250 mfd.

Selectivity in the Browning-Drake Set

IN SEPTEMBER the Emergency Broadcasting, Glenn Browning described some of the experiments which he and Mr. Browning-Drake receiver. This receiver uses somewhat closer coupling between primary and secondary of the interstage r.f. transformer than has been attained heretofore, with the result, according to Mr. Browning, that better selectivity is secured. This statement "closer coupling, better selectivity" bothers many readers, and so we have asked Mr. Browning to explain it. We reproduce some of the mathematics below.

A brief statement of what happens is as follows: for a fixed amount of amplification in a tuned radio-frequency transformer working in conjunction with a given amplifier, the selectivity may be increased as the coefficient of coupling and at the same time decreasing the number of turns on the primary so that the amplification remain the same. This is due to the fact that as the number of turns is decreased and the coupling increased the resistance reflected into the secondary circuit from the primary decreases. The selectivity of the secondary circuit approaches more nearly its selectivity when standing alone and not connected to the plate resistance.

Let \( r_p \) and \( r_s \) be the ratio of resistance to primary and secondary circuits and \( \psi \) be the ratio of resistance to reactance of secondary. Then the primary is present. Let \( R_p \) be the apparent resistance of secondary when primary is present.

\[
R_p = R_s \psi^2 \]

\[
T_p = R_p + \frac{1}{\omega^2 L_p^2} \]

\[
\omega = \frac{1}{\sqrt{L_p C_p}} \]

Where \( R_s \) = Secondary resistance

\( R_p \) = Plate resistance of tube

\( T_p \) = Apparent resistance of secondary

\( \psi \) = Ratio of resistance to reactance of the secondary

\( K = \frac{1}{\omega^2 L_p C_p} \)

and as \( \psi \) is increased the selectivity factor of the secondary increases. It is worth noting that if unity coupling prevails and if the number of turns of the tube is used for maximum amplification, then the selectivity of the tuned circuit is halved, as all mathematics and experience dictates.

Removing Noise in Shielded Receiver

THE following letter from a reader in Farmington, Michigan, may help others who have shielded receivers.

"I would like to pass along a discovery I made regarding the Sargent-Raymont Seven. I had considerable difficulty at first owing to instability in the r.f. amplifier. At last, I found it would work perfectly and the next day it would fly into oscillation for no reason at all. I finally found this to be due to poor electrical contact between the parts of the electrical removable cover. I procured a piece of aluminum 8 inches wide and long enough to cover the r.f. stages and found that it securely to the partitions. This cured my trouble."

Many experimenters find their receivers do not work after shielding has been added. The idea of r.f. not getting out of the coils but in the fact that the whole arrangement has not been properly designed. A change in the design of the shielding is not only lose inductance at an alarming rate but have an astonishing increase in resistance as well.

The League of Nations intends to resume the short-wave broadcast trials which took place in Geneva in May and June last year. The special purpose of this second series will be to examine the possibility of transmitting speeches in English, French, Spanish on March 13, 19, and 25 at 8:30 p.m. on a wavelength of 18.4 meters. The entire program will be connected by ordinary telephone cable with the Dutch station of Kootwijk (call letters PAC) kind permission of the League by the Dutch Post Office authorities.

Sixty-minute speeches will be broadcast at 15.00 hours (E.S.T.) on 18.5 meters in English, French, Spanish on March 12, 19, and 26. Thirty-six minute speeches will be broadcast in Japanese on March 13, 20 and 27 at 8:10 p.m. on a wavelength of 18.4 meters. The entire program will be connected by ordinary telephone cable with the Dutch station of Kootwijk (call letters PAC) kind permission of the League by the Dutch Post Office authorities.

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KEITH HENNEY

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TABLE I

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www.americanradiohistory.com
A

BOUT seven years ago there was formed in the town of Hoxton, N. J., the Radio Frequency Laboratories, Inc., an organization devoted to research—a task that has long been a proudly accepted function of the university.

The first members of the staff were men known to have a permanent interest in the questions "why?" and "how?" Their orders were to gather together the necessary apparatus and attack the important problems in radio. I remember clearly the glee with which that prospect was greeted.

That laboratory, with the same frame of mind, is the present Research Division of R. F. L. As its contributions have reached commerical form they have been put into the hands of licensed manufacturers whose output is a large share of all that comes to market. Perhaps this is because the contacts have been mainly with the engineers of these organizations, for which H. F. L. is a centralized bureau of research, although working on its original problems as well.

Accomplishments

BECAUSE of the highly interlocking nature of the research and engineering problems I find it difficult to delineate the work done by these laboratories. However, in the course of various friendly visits made without any such story as this in mind, there has stuck in my recollection some matters that are mentioned in the following paragraphs—the list admittedly being neither complete nor frightfully accurate.

The laboratories devoted considerable effort to the first neutralized radio receivers, and, incidentally, this was also one of the first single-control sets to be produced.

Methods were developed for determining the sensitivity, selectivity, and fidelity of a radio receiver and these methods have been adopted by the Institute of Radio Engineers as the American Standard Methods for measuring a radio receiver's performance.

In collaboration with General Radio, there was developed (and placed on the market by G. R. E.) a standard signal generator for use in measuring radio receivers.

The Laboratories developed a technique of making sound measurements which made it possible to measure the overall receiver performance from the antenna to the sound wave produced by the loud speaker.

A study of detection was made particularly at high signal levels, and detectors were developed which do not produce distortion and which are not subject to overload.

These studies applied particularly to 100 per cent. modulated r.f. signals. The use of these was particularly attractive, for the modulation is increasing—or perhaps we had better say that there is increasing interest in the invariance—of transmitting stations to attempt such modulation.

Some elements were designed, constructed, and used in the development of receivers pending the availability of such tubes on the market.

The active research problems are quite beyond such a brief account as this: the designs for the next year's broadcast sets of the licensees are still confidential—though I yearn to write about two features thereof. However, R. F. L. is engaged in another task which may be described. In the commercial progress of aircraft, there has developed a need for a reliable means of guiding an airship—a method that will prove equally reliable during day and night and in all sorts of weather. For this purpose radio beacons have been used, but there has existed no receiver for airplane use that would provide the necessary sensitivity and at the same time be able to function without a trailing antenna. The Radio Frequency Laboratories were asked to cooperate with the Department of Commerce in developing a receiver that would do these things.

The Airplane Receiver

AT THE opening of the Aircraft Radio Laboratory on January 9, demonstration flights were made with a new beacon receiver. This receiver uses five tubes of which the last two are resistance-coupled audio and the first two are of the screen-grid type. It is rather startling to have such a receiver, working with a seven-foot rod antenna, produce a beam signal which, at 30 miles from Hadley Field's beacon station, is far beyond the scale of any ordinary audio amplifier and weeks headsets in short order. With voice modulation at the beacon station, the Wright J-5 motor's roar weekly retreated behind the signal. In L. E. language, the set has a sensitivity of 5 microvolts on a 30 per cent. modulated signal. The sets may be used either on the "A & N" beacon system or with the vibrating-reed system. Of these two systems, we will speak but briefly. In both cases there are sent out two beams, diverging slightly and the course lies down the center of the angle.

With the "A & N" system the letter A (—) is being sent on one beam and the letter N (—) on the other. It is sent on both beams equally such that if the two beams are being received equally well the two letters interlock to make a steady signal. In the vibrating-reed system the two beams are modulated at radio frequency, one at 65 cycles and the other at 85 cycles per second. At the receiving end, therefore, the output from the two demodulators is equal if one is on the course. If the plane falls off course the 65-cycle modulation may be picked up less and the 85-cycle one more. The receiver therefore will be able to find the plane and the rod spreads out more while the other narrows down, thus advising the pilot as to the direction in which he is off. With the receiver mentioned here the range of the beacon is variable up to 150 miles, with a normal 2 kw. beacon station and a seven-foot rod antenna on the plane.

Airplane Height Indicator

THERE is at present being developed by the Aircraft Radio Division of the R. F. L. a height indicator. In its present stage of development this device is used to give a series of two or three separate indications (such as the lighting of different colored lamps) each of which corresponds to a definite height above the earth or water over which the plane is being flown. It must be clearly understood that the device is not an altimeter, the device at present used in airplanes and which tells the pilot the height of his plane above sea level. The R. F. L. height indicator will have no reference to sea level but uses the surface under the plane as the datum point—it is of small interest to a pilot how high he is above sea level when he is flying above a mountain and the tree tops are only 50 feet below.

This new apparatus was first installed in a D. H. plane and successfully operated over land, fresh water, and ocean. The installation has been made in a radio test plane of the laboratory. The apparatus is in the forward cockpit of the ship and is housed in an aluminum box, the whole weighing about 7 pounds. The antenna is a doublet stretched between wingtips, and lying beneath the wings.

In its present form the device is useful for landing in ground fog, and for landing on smooth water in clear weather. When flying over trees the indicator flickers continually. Of course, it is felt that aviation radio will become of steadily increasing importance. The Laboratories have acquired an airport. For the hangar we can say that it has better than average accommodations, including garages, living quarters, a shop, an office, and an 80 x 100-foot space for planes, which enter through doors with 18-foot headroom. Amazingly enough the place is heated well. It does not stick in my recollection that I have ever been in an airplane hangar that was not three degrees colder than outdoors.

In another corner of the field is a laboratory concerned with various measurements, kitchen, lounge and library, bridge measurement room, and laboratory. The transmitting and receiving laboratories, private laboratories, director's conference room, and the finely equipped shop.
GRID-LEAK GRID-CONDENSER DETECTION

By FREDERICK EMMONS TERMAN
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DETECTION is a subject upon which little real information is available to the radio experimenter. While amplifier circuits are designed with full knowledge of the results that will be obtained under different conditions, the detector is left to chance. Recent investigations have shown that the detection of weak or moderate-strength signals is determined by the behavior of the detector, and that the exact behavior of the detector cannot be obtained simply by using this new constant. The sensitivity and distortion resulting with grid-leak detectors when strong signals are being received can also be readily analyzed, and it will be shown that a properly operated grid-leak “power” detector is superior to the grid shunt because it gives less distortion than the usual plate-rectification detector.

A careful study of articles which have considered this subject are as follows:


Process of Detection

DETECTION is the name given to the rectification of high-frequency alternating-current voltages in radio receivers. In the grid-leak method of detection, the circuit for which is shown in Fig. 2, the rectification takes place in the grid circuit by making use of the curve of the grid-current grid-voltage characteristic.

The case of weak signals will be considered first. The grid-leak “power” detector acts very differently, and will be taken up in another article.

The relation between grid voltage and grid current in a typical vacuum tube is given in Fig. 1. It will be noted that there is a small grid current even when the grid is negative with respect to the negative side of the filament. This is the result of the velocity which the electrons have as they leave the filament.

In the absence of a radio signal voltage, the grid assumes a voltage which is the potential of the grid return lead (the lead which completes the circuit from the grid back to the filament) minus the voltage drop due to the grid current flowing through the grid leak. This can be readily seen by examining Fig. 2. This actual grid voltage is the operating grid potential, and gives the point on the grid-voltage grid-current characteristic of Fig. 1 at which the detector operates. The operating grid potential is usually within a fraction of a volt of the negative filament voltage when the grid return lead is connected to the positive side of the filament. A higher resistance grid leak makes the operating grid potential more negative (or less positive), but the grid voltage changes only a volt or so when the grid-leak resistance is varied from 1 to 10 megohms. The principal function of the grid leak is to fix the operating grid potential at a point on the grid voltage-current characteristic suitable for rectification in the grid circuit.

When a radio-frequency signal, such as developed by the tuned circuit LC of Fig. 2, is applied to the detector grid, this voltage is superimposed on the operating grid potential, making the actual grid voltage alternately more and less than the operating grid potential. This is illustrated in Fig. 1. In which E0 is the operating grid potential, E1 is the amplitude of signal voltage, and E2 is the variation in actual grid potential when the signal voltage is present.

Principle of Detection

THE signal makes the instantaneous grid voltage swing alternately from E0 + E1 to E0 - E1, as indicated in Fig. 1. This fluctuation in grid voltage causes the grid current to vary, but, due to the high-frequency characteristic, the grid current increases more during the half cycles when the signal voltage is positive than it decreases during the half cycles when the signal voltage is negative. The net result is a rectified current flowing in the grid circuit produced by the application of the radio-frequency signal voltage to the grid.

Reference to Fig. 1 will make clear how the rectification is accomplished. When the signal is present the instantaneous grid potential varies as indicated by the sine wave SSS. This variation in grid potential causes the grid current, Ig,s, to vary according to the curve to the right in Fig. 1. The middle dot-dash horizontal line shows the grid current that flows when the grid potential is E0 (no signal present). The average grid current that flows when the signal is present is indicated by the light dash line. The difference between these two horizontal lines represents the rectified current flowing in the grid circuit as a result of the application of the signal voltage to the grid.

The amplitude of the rectified grid current depends upon the amplitude of the signal voltage. When the signal is a modulated alternating-current voltage, the rectified grid current varies in amplitude at the frequency of modulation. Thus, when the signal is unmodulated at 1000 cycles, the rectified grid current pulsates in amplitude at a 1000-cycle rate. In Fig. 3 there is shown the rectified grid current resulting when an unmodulated, a simply modulated, and a complexly modulated wave is rectified in the grid circuit of a detector.

The rectified grid current produced in the manner that has been described by the application of a signal voltage must flow through the impedance offered by the grid-leak grid-condenser combination, and will produce a voltage drop in this impedance. This drop causes the grid potential to become more negative by the amount of the drop, and the change of grid potential thus produced affects the plate circuit by ordinary amplifier action. It is the change of grid potential caused by the rectified grid current flowing through the grid-leak grid-condenser impedance that gives the rectified signal.

The explanation that has been given of grid-leak detection with weak signals differs considerably from the familiar one in which the function of the grid leak is to let the grid-condenser charge leak off and return to the filament.

What goes on in a detector circuit is not the easiest thing in the world to understand, but we believe Professor Terman has made the operation of grid-leak grid-condenser detectors as clear as possible. In this article he points out that there are two detector constants that tell the whole story about what a tube will do as a detector, and advocates that tube manufacturers publish the values of these constants on tube cartons. We agree. Several other articles on the long-neglected subject of detection are awaiting publication. Some are from Professor Terman and others are from Roger Wize and his former associates at the Cunningham laboratory.

THE EDITOR.

* * *
Features of Practical Detection

It will be observed that the grid-leak detector combines two distinct functions. First, it is the rectification of the signal voltage, and the utilization of the rectified current to produce a change of grid potential, and second is the amplification of this change of grid potential in the plate circuit. This latter process is purely a matter of audio-frequency amplification, and is quite generally understood. The real problem of grid-leak detection is therefore centered around the determination of the change of potential produced by the rectifying process, and the rest of this article will be devoted to a discussion of the factors controlling the rectified grid current, and the grid resistance which produces it.

In the analysis of practical detection it is necessary to consider only the audio-frequency components of the rectified grid current. The direct component is lost in the loudspeaker, and so is unimportant.

The sensitivity of the detector (i.e., the change of grid potential produced by a given input signal voltage) is obviously determined by the effectiveness with which the signal voltage excites the grid-leak condenser combination to offer resistance to the audio-frequency components of the rectified current. The impedance which the grid leak-condenser combination offers to the rectified grid current depends greatly upon the frequency of this current. At low frequencies, such as 50 cycles, this impedance is very high because the low-frequency current has difficulty in getting through the grid condenser and is accordingly forced through the high resistance of the grid leak. On the other hand, at high audio frequencies, such as 5000 cycles, the grid condenser offers an easy path for this direct current, practically short-circuiting the grid leak.

The result is that the rectified grid current tends to produce less change of grid potential on grids adjacent to lower audio notes. This reduction of sensitivity at the higher audio frequencies can be quite serious, and unless the detector is adjusted properly will lead to very bad quality. Satisfactory reproduction of the high notes requires that the smallest possible grid condenser capacity be used in order to minimize the short-circuiting effect of the grid leak on the potential of the grid. If the grid condenser is made too small, however, an appreciable part of the audio-frequency voltage developed by the tuned circuit would appear across the grid condenser, and the signal voltage, $E_0$, actually applied to the grid would be seriously reduced (see Fig. 2). The best value of grid condenser for all standard type tubes is from 0.0001 to 0.00025 mfd. Larger capacities should never be used.

The Equivalent Circuit

From the discussion of what has been given it is seen that the two important features of the grid-leak detector are the amount of rectified grid current produced by a given signal, and the amount of voltage drop which this rectified current produces in flowing through the grid leak-condenser combination. Recent investigations, both theoretical and experimental, have shown that this rectified grid current is produced by the application of a small radio-frequency signal voltage to the detector grid acts exactly as though it were produced by a suitable series of low-frequency generators acting between the grid and filament in series with the grid-filament resistance of the tube.

There is one such generator for each component of the rectified grid current. The most important of these equivalent generators is the one of modulation frequency.

The action that takes place in the grid circuit of a grid-leak detector can be conveniently described in terms of the equivalent grid circuit shown in Fig. 4. Here the rectifying effect of the grid-leak condenser is replaced by the equivalent generators, $E_0$, which are considered as producing the rectified grid current in place of the radio signal in the rectified grid circuit. The equivalent generators act in a circuit consisting of the grid leak-condenser combination, $R_C$, in series with the grid-filament tube resistance, $R_g$. This grid resistance, $R_g$, is analogous in all respects to the plate resistance, $R_p$, and is the reciprocal of the slope of the grid voltage-current characteristic shown in Fig. 1. While the grid resistance in general depends upon the grid potential, in the infinite case this is not the case with grid-leak detectors because the detector works with a small but definite grid current. The grid resistance, $R_g$, depends upon the grid plate, and filament voltage and is therefore centered around the grid resistance of the tube, which is made more negative. High grid-resistance rectifiers accordingly give a high grid resistance because such leaks give a more negative voltage drop in the grid-filament resistance so that low resistance leaks will fix the operating grid potential where the grid resistance is low.

Tube Capacity

The capacity $C'$ indicated in Fig. 4 is the input grid-filament tube capacity to be considered. It is larger than the interelectrode capacity by an amount depending upon the plate circuit impedance which is placed in the ordinary 200-mu, 226, 227, 112A, and 201A tubes when there is a transformer in the plate circuit. The capacity $C'$ is in parallel with the grid-filament resistance $R$ of the tube, and the low resistance of the grid condenser capacity is the actual capacity plus $C$.

The generators that can be assumed acting between the filament and grid in series with the dynamic resistance to produce the rectified grid current have no actual existence. It is merely that the effect of applying a signal voltage to the grid, though it can be analyzed into fictitious generators acting between the grid and filament, is that the fictitious generators are present, and as through they and not the signal voltage were the forces really producing the rectified grid current. The voltage developed by this series of fictitious generators can conveniently be called the rectified grid voltage, $E_g$, and will be represented by the symbol $E_g$.

One of the fundamental features of the law of detectors is that the size of the equivalent rectified grid voltage, $E_g$, which can be considered as acting to produce the rectified grid current, depends only upon the strength and type of signal and upon the tube characteristics at the operating grid potential. The size of grid condenser grid leak has no effect on the amplitude of the rectified grid voltage, $E_g$, except in so far as the grid-leak resistance affects the operating grid potential.

Part of the rectified voltage, $E_g$, in the equivalent circuit of the grid-leak detector is present.

Detector Voltage Constant

The size of rectified grid voltage, $E_g$, used in the equivalent detector circuit of Fig. 4 depends upon the tube characteristics at the operating grid potential and upon the signal voltage. The action of the tube in rectifying the radio-frequency signal voltage developed by the detector grid can be completely taken into account by a single tube constant called the voltage constant of the tube and represented by the symbol $V_g$. The voltage constant, $V_g$, is measured in terms of volts and varies between 0.2 and 0.5 volts for nearly all properly adjusted detectors. The voltage constant of the grid-leak condenser depends upon the slope of the grid voltage-current characteristic at the operating point, and upon the way in which this slope varies with grid voltage. Mathematically it is defined by

$$V_g = \frac{V_m}{E_g}$$

This can be measured by determining the grid resistance at the operating grid voltage, and at grid voltages slightly more and less than the operating voltage. As has been pointed out, the modulation-frequency component of the rectified grid voltage is the important part. The crest or peak value of this component of $E_g$ is equal to $mE/V_g$ where $m$ is the degree of modulation, which must lie between 1.00 and zero, and will only reach 1.00 when the music or speech is very loud, and $E$ is the peak amplitude of the signal carrier wave. The crest amplitude is 1.414 times the effective (or r.m.s.) amplitude. It is to be remembered that field strengths, etc., are ordinarily expressed in effective values, while amplifier inputs must be expressed in crest amplitudes because it is the crest amplitude of the sine wave that overloads the amplifier.

Practical Example

As a simple example, consider the case of a signal modulated 20 per cent, or 0.20 at 1000 cycles, with a carrier crest amplitude of 0.05 volts being applied to a detector grid operated where the voltage constant is 0.25 volts. The crest value of the 1000-cycle component of rectified grid voltage is therefore $(0.05)^2/(0.25) = 0.002$ volts crest value. The amount of 1000-cycle rectified grid current existing in the grid circuit of the actual detector is equal to the product of the voltage constant and this 0.002 volts of 1000 cycles will produce acting in the equivalent grid circuit of Fig. 4. The 1000-cycle voltage drop produced in
across the grid leak-condenser combination in the equivalent circuit by the action of the
-0.002 volts is the amount of 1000-cycle voltage drop in grid potential existing in the
actual detector, and is the amount of 1000-
cycle voltage which is applied to the input of the audio amplifying system. (This does not
mean the voltage applied to the primary of the
first audio transformer, for example, but the audio-frequency voltage impressed on the
grid of the detector, which the au-
thor considers as the beginning of the audio
system. If the mu of the detector tube is 8,
the maximum voltage across the primary
under these conditions would be 8 x 0.002
or 0.016 volts—(Editor.) The negative sign of
the rectified grid voltage is caused by the fact that the voltage constant of the grid is
negative, and this merely means that the
voltage acts in a direction opposite to that
indicated by the arrow in Fig. 4.
It is apparent from a study of Fig. 4 that
the fraction of the rectified grid voltage which
is usefully used to produce change of grid
potential is determined by the ratio of im-
pedance to the rectified grid voltage, which
the grid leak-condenser combination offers
to the grid-resistance, Rg. The higher this
ratio, the more sensitive will be the detector
but in no case will the change of grid potential
ever exceed the rectified grid voltage.
In order that the detector may reproduce
the high notes, it is necessary that the impedance of the grid
leak-condenser combination at the highest
note required be sufficiently great relative to
the grid resistance, Rg, as to cause most of
the rectified grid voltage of this high fre-
quency to be used up as voltage drop across
the grid leak and condenser. Then the high
notes will be reproduced with full sensitivity
and, as the low notes are already as loud as
possible, the detector will give good quality
output covering the entire audio-frequency
range.

The quality of the detector output will be
worst for operating points which give a high
grid resistance, Rg, than for conditions which
give a low grid resistance. Thus, high-resis-
tance grid leaks give poorer quality than low-
resistance ones. With a given size grid con-
denser, however, the quality is not improved
appropriately after the grid resistance gets less
than a critical value to be discussed later. The
maximum allowable grid resistance, Rg, is
determined by the highest audio frequency
to be reproduced at full sensitivity, and by the
limit of the cut-off frequency. Of these, the
grid resistance has little effect on the quality at
the high notes except as a means of controlling
the operating grid potential, and hence of controlling the detector output. Rg, however,
becomes important when the rectified grid currents of high audio
frequency very largely go through the grid
condenser shunting the grid leak.

Detection Data

The most satisfactory way to represent
detector characteristics is to plot grid
voltage constant, Vg, as a function of grid
resistance, Rg, at the operating point. Since
the sensitivity of the detector is proportional
to the rectified voltage and this in turn
is determined by Vg, while the possible qual-
ity is dependent upon Rg, such a curve can be
considered as showing the relation between
sensitivity and quality.

A typical relation between the grid voltage
constant, Vg, and grid resistance, Rg, is
shown in Fig. 5. This figure also shows the
operating grid potential required to give
different values of grid resistance. In ex-
amining the Vg-Rg characteristic it is to be
remembered that, since the rectified grid
voltage is inversely proportional to Vg, the
sensitivity is greatest when the grid voltage
constant, Vg, is smallest. In Fig. 5 it is accor-
dingly seen that the operating grid potential
gets more negative, and the grid resistance,
Rg, increases, the sensitivity rapidly in-
creases until Rg equals about 150,000 to
200,000 ohms. For all grid resistances higher
than approximately 150,000 ohms the sensi-
tivity as indicated by the Vg curve is substan-
tially the same, and is the maximum sensitivity
which is obtainable from this particular tube.
While Fig. 5 gives the Vg-Rg characteristic
of a particular tube at particular values of
and rated filament conditions, but would
be substantially unchanged if measured at other
plate and filament voltages. The important
differences between the various tube types are
(a) the value of voltage constant on the flat
plate, which is inversely proportional to the value
of Vg at the low flat part of the curve begin-
s. These characteristics are tabu-
lated in Table I. The values in the third
column give the effective sensitivity, which
different types of tubes differ, i.e., the point at
which the flat part of the curve begins, hus
and is important, in determining the effective-
siveness with which the high notes may be
reproduced. The lower the value of grid re-
stance at which the low flat part of the Vg-
Rg curve begins, the better the detector.

Practical Detection

The principles and data of the preceding
paragraphs will now be applied to the
problems involved in selecting detector tubes
and adjusting their circuits. It is necessary to remember that
the sensitivity depends upon, first, the maxi-
mum change of grid potential obtainable,
which, as the rectified voltage, is dependent
upon the value of Vg over the low flat part as tabulated in Table I, and second, the amplification
produced in the tube of this change of grid
potential. While both the 20A and the 199
have substantially the same Vg, the 20A
tube is a better amplifier because of its higher
plate and lower Rg, and therefore, superior. The 227 tube is a more sensitive detector than the 226 tube because, although
they are equally good amplifiers, the 227 tube has a different characteristic curve which
is determined by the rectified grid voltage to amplify. On this basis the 227 hester-type tube is the most
sensitive detector, closely followed by the 226 and the 1124 types. Other tubes, such as the 201A, 199, 171A, 120, and 12 varieties are distinctly
less sensitive, either because of high grid
directional constant or because of low audio-
frequency amplification per stage. The 20A
gas tube and the 240 high-mu tube are no
tube rectifiers than the 201A tube, but as
both have a high m, they are more sensitive
than other detector tubes in resistance-
coupled circuits.

Securing Sensitivity

In order to realize the full sensitivity of
the detector tube the operating grid po-
tential must be such as to give a grid
resistance that is on the low flat part of the Vg-
Rg characteristic. No detector tube should be operated at a point lower than the value
given in the fourth column of Table I. If this rule is violated great loss in
sensitivity will result.

Since Rg is not the same as the grid-leak resistance the next step is the selection of a
value for the latter that will give the best
operating grid potential. In general, the most

Fig. 6—Grid current as a function
of grid resistance and Vg

Plate and filament voltages, an investigation in
which over 1000 measurements of Vg were
made showed that every tube tested had a
Vg-Rg characteristic similar in shape to Fig. 5. In every case there was the same rapid
decrease in Vg at increasing values of grid
resistance and this was followed by the low
flat part of the curve at all grid resistances
above a critical value. Not only does every tube have the same
value of Vg-Rg characteristic, but every tube of the same type was found to have substantially
the same characteristic for plate and filament voltages (provided there was sufficient electron emission from the filament). Furthermore, if the tube, or even rejuvenating it (in the
case of thoriated filaments) had no effect on the Vg-Rg relation as long as the filament was well illuminated, the grid constant, which tubes of the same type differ is in the
grid voltage required to give a particular value of grid resistance. At high plate and
low filament potentials the operating grid voltage must be slightly more positive to ob-
tain a given grid resistance than at low plate and high filament potentials. As the grid
resistance and plate potentials conditions different tubes of the same type will sometimes require operating grid voltages differing in extreme cases by as much as 0.5 volts to give the same
Vg.

Characteristic Curves

The Vg-Rg characteristics for standard
types of tubes are given in Figs. 8 and 9. These curves are all for a plate voltage of 42

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Fig. 7—Detection characteristics of
two-detector tubes
favorable operating point is the one that gives the lowest permissible grid resistance, as indicated in the fourth column of Table I; except to operate with \( R_g \) less than 100,000 to 75,000 ohms in ordinary cases because of losses in the grid circuit. The value of grid-leak resistance controls the operating point, as has been explained. The greater the leak resistance, the more will be the voltage drop in the leak, the more negative will this make the actual operating grid potential, and the larger \( R_g \) will be.

The value of grid-leak resistance giving a desired operating grid resistance can be determined exactly by certain obvious measurements, which, however, require apparatus frequently not available, or they can be determined approximately with the aid of Fig. 6, which shows the grid current that will flow when the operating point is on the low part of the \( V_g-R_g \) characteristic, and when the tube's \( V_g \) is on the flat part, and the desired \( R_g \) is known. To select the grid leak in this approximate way one first determines the grid current that will flow at the desired operating grid resistance, using Fig. 6, and then computes the resistance this current would have to flow through to produce a voltage drop equal to the voltage drop in the filament. The resistance thus obtained when used for the grid leak will give the desired grid resistance usually without more than 20 per cent. error for all plate voltages within the usual operating range, and for all tubes of that type. Thus, if the desirable \( R_g \) for 20A tube is to be operated at \( R_g = 150,000 \) ohms, the grid current as determined from Fig. 6 (\( V_g = -0.17 \)) is approximately what the grid-leak resistance for rated filament potential of 5.0 volts would be 5.157 = 3.2 megohms. The grid return lead would then be brought back to the resistive connection.

This approximate method can be satisfactorily applied to all tubes except the 200A and the 227. With 227 tubes satisfactory results will be obtained when the grid leak is such as to give a drop of 0.9 volts when the grid current at the desired operating grid resistance is flowing through the leak.

**Grid-Condenser Determination**

After selecting the tube, the proper operating grid resistance, and the grid leak that will give the operating \( R_g \) desired, there remains the determination of the grid condenser. The grid condenser capacity is determined by the highest audio frequency that is to be satisfactorily reproduced, and by the operating grid resistance. The rule is that the resistance of the effective grid condenser capacity (which is the actual grid condenser capacity plus the input grid-filament tube capacity to audio frequencies) at the highest note to be reproduced at least 70 per cent. as well as the low notes must be equal to the grid resistance. Therefore, if \( f \) is this highest frequency and \( C_{eff} \) is the capacity, then

\[
C_{eff} = \frac{1}{2 \pi f R_g}
\]

The actual grid condenser size is \( C_{eff} \) minus the tube input capacity—about 70 mmfd. for tubes with \( mu = 9 \) and for the other tubes it is 90 mmfd. or 240 mmfd. respectively.

In the case of the 201A tube considered, if the highest note is to be 5000 cycles, then

\[
C_{eff} = \frac{1}{2 \pi \times 5000 \times 150000} = 0.000212 \text{ mmfd.}
\]

As the tube input capacity is about 70 mmfd. a grid condenser capacity of 0.000242 mmfd. will be required. With this capacity, the grid current will be reproduced half as well as the low notes.

In Table I there is tabulated the value of grid-leak resistance which will put the operating grid resistance at approximately the value corresponding to the lowest permissible figure as given in the fourth column of the table.

**Comparison of Detector Tubes**

The indications are that the merit of a detector tube as a rectifier depends not only on the characteristics of the filament, or the electron emitting cathode, and only secondarily, if at all, upon other features such as the \( mu \), electrode voltages, number of elements, power capacity, and the like. The oxide-coated filament is definitely superior to the thoriated-tungsten filament, which, in turn, is better than straight tungsten. At the same time there is some difference between different types of tubes with the same kind of filament material.

In selecting a detector tube the choice depends upon several conditions. If the audio system to be designed includes tubes with 227, 220A and 200A tubes are best. When the detector is transformer coupled and is operated by storage battery, the 112A is best, being definitely superior both in amplification and rectification to the 201A which consumes the same filament power. Of the dry-cell filament tubes the obsolescent cx-12 is much more sensitive than the 199. Of the a.c. tubes, the 227 type is the best detector, being better than any of the d.c. or other a.c. tubes.

It is interesting to note that the gas-filled 200A "super-sensitive" detector is no more sensitive than would be a 201A tube built with the same high \( mu \). The gas apparently contributes substantially nothing to the 201A tube but an objectionable hiss!

In conclusion it is worth pointing out that the value of the grid-voltage constant, \( V_g \), over the low flat part of the curve and the value of grid resistance, \( R_g \), at which the flat part begins, are tube constants which should be published by tube manufacturers. Both of these quantities are as truly characteristic of a given make and type of tube as the \( mu \) and plate resistance. Both detection constants are substantially independent of age, filament, and plate voltages within the operating range of values.
ALL experimenters should be able to draw graphs, or plots, and to interpret what these pictures mean. Also they should be able to interpret what the curves drawn by other experimenters mean, because these curves are a form of concentrated information of infinitesimal variety. In few cases it may contain a summary of a month's work in a laboratory, or of many month's work in the solution of complex mathematical formulas. It is always a visual picture or representation of some physical, electrical, or mechanical phenomenon.

This "Home-Study Sheet" is written in the hope that some of the apparent facts about curves presented in this book to familiarize the student and encourage more experimenters to keep their data in this convenient form.

To state that a graph is a visual representation of a mathematical expression may not convey much to the average experimenter, but such is a fact nevertheless. Every graph or plot or curve is a representation in graphic form of a mathematical equation. Some curves, however, are so complex that the expression would be very difficult to figure out. Conversely, every mathematical expression may be plotted in the form of a graph. A graph is a visual statement that two factors are related to each other in some fashion, either simple or complex. Thus, one factor may increase when the other increases, directly or according to a square or a more complicated law, or it may decrease as the other increases.

A form of graph with which everyone is familiar is a map. We say that a certain town, "A," is so many miles north and so many miles west of Chicago. Anyone with a map could put his finger on such a place at a moment's notice. A map has the essentials of every graph, namely, two coordinates (axes) at right angles, north and east-west, or an origin, in this case Chicago, and a point which we wish to locate with respect to this origin. Fig. 1 shows how we would locate the town of "A." Some maps have the coordinates marked off as shown on the top and down the left side of Fig. 1 and so "A" on such a map would be defined as existing at (B). In this case the origin is at the top left hand corner of the graph.

Problem 1. Mark on the map a town, "B," which is at (F, 6).

Such a means of locating a point on a map is everyday knowledge.

The next problem is a bit more complex. How would you state that a railroad runs north and south and at a distance of 50 miles from Chicago? Here we must locate not a point on a map but a straight line perpendicular to one axis (coordinate) and parallel to another. A simple expression for such a line, representing a railroad, would be (west 50 miles) signifying that the road runs north and south and was 50 miles west of Chicago at its nearest point.

Problem 2. A road runs south of Chicago through (D, 6) and straight east and west. Mark it on the map.

The next problem would be to describe a road that runs at a right angle and up and down to within 50 miles to Chicago. We could state that it ran through two towns, then give their locations on the map just as we located the point (B, 3) above.

Problem 3. A road runs through (B, 2) and (F, 6). Draw a line that runs north and south through Chicago is the nearest approach.

Lines with angles at the intersection of two lines; a line is defined when two points through which it passes are located. The points are always given coordinates away from vertical and horizontal axes or coordinates.

### Other Types of Graphs

A graph is no different from a map, even though the axes or coordinates may be called X and Y instead of north and east-west. Also such high-sounding words as "ordinates" and "abscissas," etc., may be used to express the distance up or down, and right or left, from some point chosen as the origin. In a graph the units of measurements, instead of being miles or feet, may be amperes, degrees, centigrade, or volts.

Generally the origin is at the lower left-hand corner of the paper. The reason why it cannot be somewhere else: for example in plotting the plate current of a vacuum tube against the grid voltage, the vertical axis (representing plate current) is usually near the center of the graph instead of at one corner, so that both positive and negative values of grid voltage may be plotted. Wherever the origin is, to plot the position of a point with respect to the origin, we must locate the point first on the axes and then extend in the right (or left) and erect a perpendicular line; then this line represents all points that have the same location with respect to the origin.

For example, on Fig. 2 is plotted the point (X=5, Y=3), or the position of this point. We locate the point (X=5, Y=3) on the axes, then extend in the right and erect a perpendicular line which contains all points that have the same location with respect to the origin.

### Equation of a Straight Line

A point is represented as follows, (X = 5, Y = 2).

A straight line is a bit more complex because it goes through two points whose location must be given. We can plot any complexity by using two such points through which we draw the straight line going upwards or downwards and then extend, or directions, so that the equation of a straight line may be represented at the point where it crosses the X and Y axis. Thus the line crosses the Y axis at Y = 2X - 5 (slope of line is 2).

A line parallel to the Y axis is expressed as (X = 5, Y = constant), because it represents all points 5 units to the right of Y. Similarly a line parallel to the X axis and so many units above it is represented as (X = constant, Y = 6). For example, a line parallel to the Y axis and 5 units above it is represented as (X = 5, Y = 6).

A line going through the origin, such as OA of Fig. 3, is represented by the equation Y = 0 which means that the vertical (Y) contains all points (X = 0).

A line which goes through the origin and is perpendicular to the Y axis (Y = constant) is represented by the equation Y = constant, which means the horizontal (X) contains all points (Y = 0).

### Plotting Curves—Part I

**Problem 4. Assume the resistance of a circuit is 1 ohm. The voltage is 240 volts. What is the current?**

Volts/ohms = amperes

Current = 240/1 = 240 amperes

**Problem 5. Assume several values of E in the above case and plot the current on a cross-section paper.**

We may change the current by changing the voltage, since the current in equation form is: 1 = E/R and the line crosses the vertical or current axis at 1 = 4. When E = 1 volt, I = 4/2 = 2 amperes. And so on.

**Problem 7. Assume several values for E in the above case and plot the current on a cross-section paper.**

We may change the current by changing the voltage, since the current in equation form is: 1 = E/R and the line crosses the vertical or current axis at 1 = 4. When E = 1 volt, I = 4/2 = 2 amperes. And so on.

**Units**

The appearance of a curve may be changed somewhat by changing the units into which the vertical and horizontal axes are divided. As an example, plot the following data which give the d.c. output voltage of a dc-300 rectifier tube as the load current is changed, and as various a.c. voltages are put on the plate of the tube. There will be three curves for the three plate voltages applied to the tube. First make the vertical divisions, 100, 150, 200, 250 volts, etc. then make the same divisions on the cross-section paper. Then note how much flatter the curves seem. The slope of these curves is an indication of the "regulation" of the rectifier, that is, how many volts drop is caused by increasing the output current.

**Problem 8. The ratio between the voltage and the current at any point on these curves gives the d.c. resistance of the rectifier.**

The slope of the line, that is the change in voltage divided by the change in current is the d.c. resistance of the rectifier. Calculate the d.c. resistance at each of these points and plot against current.

**Data for Example**

<table>
<thead>
<tr>
<th>Current output</th>
<th>0</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>450</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
<th>900</th>
<th>1000</th>
<th>1100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Watts (Volts)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>20</td>
<td>307</td>
<td>303</td>
<td>300</td>
<td>297</td>
<td>293</td>
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<td>283</td>
<td>280</td>
<td>276</td>
<td>272</td>
<td>268</td>
</tr>
<tr>
<td>30</td>
<td>297</td>
<td>293</td>
<td>289</td>
<td>286</td>
<td>283</td>
<td>280</td>
<td>276</td>
<td>272</td>
<td>268</td>
<td>264</td>
<td>260</td>
<td>256</td>
</tr>
<tr>
<td>40</td>
<td>286</td>
<td>283</td>
<td>280</td>
<td>276</td>
<td>272</td>
<td>268</td>
<td>264</td>
<td>260</td>
<td>256</td>
<td>252</td>
<td>248</td>
<td>244</td>
</tr>
<tr>
<td>50</td>
<td>276</td>
<td>272</td>
<td>268</td>
<td>264</td>
<td>260</td>
<td>256</td>
<td>252</td>
<td>248</td>
<td>244</td>
<td>240</td>
<td>236</td>
<td>232</td>
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<tr>
<td>60</td>
<td>266</td>
<td>262</td>
<td>258</td>
<td>254</td>
<td>250</td>
<td>246</td>
<td>242</td>
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<td>230</td>
<td>226</td>
<td>222</td>
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<tr>
<td>70</td>
<td>256</td>
<td>252</td>
<td>248</td>
<td>244</td>
<td>240</td>
<td>236</td>
<td>232</td>
<td>228</td>
<td>224</td>
<td>220</td>
<td>216</td>
<td>212</td>
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<td>80</td>
<td>246</td>
<td>242</td>
<td>238</td>
<td>234</td>
<td>230</td>
<td>226</td>
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<td>192</td>
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<tr>
<td>100</td>
<td>226</td>
<td>222</td>
<td>218</td>
<td>214</td>
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<td>202</td>
<td>198</td>
<td>194</td>
<td>190</td>
<td>186</td>
<td>182</td>
</tr>
</tbody>
</table>

**March, 1929**

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PLOTTING CURVES—PART II

Radio Broadcast's Home-Study Sheets
March, 1929

CURVES may be plotted either from a mathematical formula or equation or from a set of data obtained in a laboratory or from some source. If accurate, the results have already done the laboratory work. To plot these curves properly, one needs a good pen and a ruler, or a French curve, and some cross-section paper. The latter may be bought from Keuffel and Esser, Department, Codex, and other manufacturers, and is obtainable in many colors, many sizes, and shapes, some of which are punched for loose-leaf note books.

Keuffel and Esser paper No. 359-6 and 355-21R are both convenient and are ruled 10 x 10 to the inch and are punched for standard size note books. Another good paper is Keuffel and Esser No. 359-11 which is ruled 20 x 20 to the inch. Diagram Nos. 310-10 to 10 x 10 and 10 is punched. Codex 2 and 3 cycle logarithmic paper, No. 3135 and 3112, and Keuffel and Esser double logarithmic three cycles, No. 359-12, are useful in plotting frequency characteristics of audio transformers, amplifiers, loud speakers, etc.

Vacuum-Tube Characteristics

The characteristics of a vacuum tube are usually represented on a sheet of graph paper and are called the characteristic curves. Because there are three variable factors involved, plate current, grid voltage, and plate voltage, a complete picture of the tube and its action in a circuit cannot be represented on a single sheet of paper, (which has only two dimensions), but two curves are needed, or better still a three dimension model made of plaster of Paris or wax. Some very beautiful and often sophisticated art works are used in the course on vacuum tubes given at Craft Laboratory, Harvard University. These are part of the equipment of any good radio engineering course. We can get a good idea of what a set of curves do by making two curves called the Eg-Ip and the Ej-Ip curves. These show what the plate current is at various grid voltages and plate voltages. The slopes of these curves are important tube factors.

Problem 1: Plot the data in Table 1, making the vertical axis, the current axis (in mA), and the horizontal axis, the reciprocal of the plate resistance of the tube. The slope of the curve must be divided by 1.0 to get the resistance. Calculate the plate resistance at several grid points on the curve. Plot the mutual conductance and the plate resistance against grid voltages, plate volts, and plate current. In each case assume one of the variables as fixed, e.g., when calculating and plotting the plate resistance assume the grid voltage is some constant value for one set of values, and then assume another value for another set of data.

Table 1

<table>
<thead>
<tr>
<th>Grid volts</th>
<th>Plate volts</th>
<th>Plate resistance (ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>60</td>
<td>135</td>
</tr>
<tr>
<td>0</td>
<td>80</td>
<td>135</td>
</tr>
<tr>
<td>0</td>
<td>100</td>
<td>135</td>
</tr>
<tr>
<td>0</td>
<td>120</td>
<td>135</td>
</tr>
</tbody>
</table>

Correcting Errors of Measurement

A curve which is a visual picture of a given laboratory experiment may be very useful in detecting or correcting errors in measurement. For example, if we know that the relation between two factors is a straight line, and when we plot the curve, several points seem to be off this line, these points indicate errors in measurement. In calibrating a wave-meter, according to "Home-Study Sheet No. 13," errors may occur, and the only way to tell them is by plotting the curve of wavelength squared against capacity, or wavelength against condenser degrees. The first of these curves will be a straight line, and the latter will be a smooth curve. Points off the curve should be considered wrong and must be re-plotted or disregarded.

Problem 2: Plot the data in Table 2, first showing the relation between wavelength squared and condenser capacity, and, secondly, the variation of wavelength with condenser degrees. Determine which points are wrong, and indicate what the wavelength should be instead of the values given. If the slope of the straight line, i.e., (wavelength)^2 against capacity is divided by 3.54, the inductance of the circuit will result. Determine the inductance.

Table 2

<table>
<thead>
<tr>
<th>Wavelength (MHz)</th>
<th>Condenser capacity (milfd)</th>
<th>Condenser capacity (mfd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>175</td>
<td>15</td>
<td>0.01</td>
</tr>
<tr>
<td>255</td>
<td>35</td>
<td>0.10</td>
</tr>
<tr>
<td>300</td>
<td>55</td>
<td>0.20</td>
</tr>
</tbody>
</table>

Fig. 1—Frequency characteristics of transformer plotted on cross-section paper

Amplification-Frequency Characteristics

The frequency characteristics of amplifiers and audio transformers may be plotted directly against frequency. It has now become standard practice to plot amplification against frequency arranged in octaves, so that each change in frequency gets equal attention. For example, the curve of Fig. 1 represents a transformer of the olden days when low-frequency amplification was unthought of. Note what a long flat portion the curve has. Then look at the curve of Fig. 2 in which the same data is represented on logarithmic paper. Here the low frequencies, i.e., from 100 to 1000 cycles are not crammed into a very small part of the whole horizontal scale but get the same horizontal space as does the range from 1000 to 10,000 cycles—and both of these spaces represent a 10 to 1 change in frequency.

The ear hears according to a logarithmic scale, and so amplifier characteristics are usually plotted against transmission units (m) of low gain with some given frequency as standard. That is, the response at all frequencies is plotted with respect to the response of some intermediate frequency as standard. For example, we may use the 1000 cycle power output of an amplifier obtained at 1000 cycles and then compare the power output of other frequencies to the value at 1000 cycles. Or we may simply plot the power output at all frequencies without regard to any given frequency as standard. Use curve given the characteristics of the other tells us the power output. The characteristic may be obtained from the power output curve by noting from it how much more power is obtained at one frequency than another.

Characteristics of amplifiers should always be plotted with a logarithmic horizontal frequency scale and preferably with a vertical scale either in milliwatts or in units of transmission gain. Problem 3. Transfer the data given in the curve of Fig. 3 to paper, first calculating the power output as an up or down from 1000 cycles, where the voltage amplification is 850 and secondly plotting the number of dB corresponding to the voltage amplification, e.g., 2000 gain of 100 correspond to a line of 40 dB. Remembering that the ear can hear with some difficulty changes in power output of 3 m and cannot hear smaller changes than this, plot the data in Table 3 and determine if the amplifier is a good one. Plot in on using the power output at 1000 cycles as standard. Will the line be in response at 100 and 500 cycles be noticeable to the ear?

Table 3

<table>
<thead>
<tr>
<th>Frequency cycles</th>
<th>Power output (mW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>60</td>
<td>175</td>
</tr>
<tr>
<td>100</td>
<td>350</td>
</tr>
<tr>
<td>200</td>
<td>700</td>
</tr>
<tr>
<td>400</td>
<td>2000</td>
</tr>
<tr>
<td>800</td>
<td>8000</td>
</tr>
<tr>
<td>1000</td>
<td>105</td>
</tr>
</tbody>
</table>

Summary

A graph is a visual representation of some physical or mathematical law. To plot the curve when the law or equation is known, it is only necessary to assign various values for one of the related factors and to calculate what the other values are. Thus we can use Ohm’s Law to determine some voltage and calculating what the current will be at a known resistance. Then voltage and current values are plotted to each other. Most amplifier relations between two factors give curves which are not straight lines and the mathematical equation or formula is seldom known.
time avoiding an excessive amount of de-
tuning of the autodyne detector in process of
transferring the signal into the i.f. system.
This contrary pair of considerations may re-
quire a word of explanation. If audio quality
were the only consideration we would choose
an intermediate frequency in the vicinity of
perhaps, 1000 kc., thus securing a noiseless
amplifier and complete certainty that the har-
monics of the oscillating detector would do
no damage. This plan was followed in the
February article with a separate oscillator
(heterodyne). But with an autodyne (com-
bined oscillator and first detector) we cannot
use as high an intermediate frequency for we
would then be compelled at all times to tune
1000 kc. off the desired signal so as to transfer
it to the 1000 kc. amplifier. Such mistuning
would, of course, weaken the signal materially
whereas the detuning necessary to produce a
100 kc. beat is not fatal. Fortunately this—
like the other difficulties—turns out to be
an academic, and not a practical, difficulty.

The i.f. system used consists of a pair of
Rusco 95 kc. air-core transformers and a
Rusco band-pass filter working at 95 kc.

The tuner with which the device has been
associated in the writer's experiments is made
by the National Company and has a wave-
length range of 14.5 to 115 meters. At the
115-meter end of the range a 95 kc. beatnote
requires nearly 4 per cent. mistuning, which
seems rather bad to one accustomed to broad-
cast work. At the 14.5-meter end the mistun-
ing is about \( \frac{1}{2} \) per cent. Fortunately one is
saved by the very thing that suggested the
band-pass, namely, the comparative lack of
selectivity of a lonesome tuned circuit. In
practice the signal obtained is not materially
weaker than that obtained with a heterodyne,
the rest of the equipment remaining the same.
This is, to a considerable degree, accounted for
by the fact that the strength of the oscillation
was adjusted in all cases to a favorable value
by use of the normal controls of the tuner,
operating in the normal manner.

Radiation from the autodyne's first de-
tector is prevented by the 222-type tube in
the first socket of the receiver.

The circuits, which are shown in Figs. 1, 2,
and 3, do not seem to require much explana-
tion. However, some readers may be confused
by the band-pass filter, but its purpose may be
explained by the simple statement that its
business is to pass only the band of frequen-
cies lying between 90 kc. and 100 kc., while
stopping lower and higher frequencies. It
follows that the only signals to get through
the system are those which the autodyne sys-
tem has transferred into the "pass-band.
" The purpose of this device is, therefore, to
provide the selectivity of the system and to
suppress noise as well. Since the Rusco band-
pass filter consists of four shunt sections
(and the corresponding series parts), it is
sufficiently complex to give a good flat top
and sharp cut-off, unlike the usual arrays of
tuned circuits.

Adjustment of Filter

One difficulty may arise which has caused
several filters to be denounced as "no
good." A filter, unless terminating in the
proper sort of a load, will produce all sorts of

Sensitivity of System

When the question of sensitivity arises
one must confess that a definite loss has
taken place by reason of the choice of 95
kc. as an intermediate frequency. However,
this loss is not serious as the presence of a pair
of screen-grid tubes in the complete system
produces an overall gain that is materially
above that of the system described last
month, and is, in fact, above normal require-
ments. The chief weakness of an intermediate
frequency is due to the desire to avoid any
damage to audio quality, while at the same

There are two ways of making a
short-wave super-heterodyne, as Mr.
Kruse pointed out in February Radio
Broadcast. One involves turning a
short-wave tuner into the frequency
changer and one's broadcast receiver
into an intermediate-frequency ampli-
fier. In this article he tells how to
make a receiver that starts with the
antenna and ends with the audio
output—and it is a double-detection
set of considerable amplification and
selectivity. It does not involve playing
tricks on one's short- or broadcast-
wave receiver.

—The Editor
weird response effects with humps of signal coming through where there should be none. If your band-pass filter does not perform properly it is suggested that you shut a 500,000-ohm Frost resistor across the output, and, by pure cut and try, adjust the terminal conditions so that the desired action is obtained. When the action is correct the signal "snaps" in, stays for a while as the tuning dial of the receiver is turned, and then "snaps" out.

Observe that the output circuit of the National tuner has been altered a bit. This is to permit the 95 kc. output to enter the i.f. system, at the same time permitting the regeneration control to function. The numberings shows what has been done, as do the diagrams of Figs. 1 and 2. The r.f. choke has been eliminated, C has been moved, and the wiring has been changed slightly. These changes also improve the control when using the smallest tuner-coll.

Rather than draw the complete schematic diagram it has been considered best to mark various parts of the adapter (Fig. 3), such as "A," as often as necessary, even though only a single terminal is required in the receiver. Therefore, it should be understood that all binding posts with the same markings on either the set or the adapter are to be connected together.

In the second i.f. stage a 222-type tube is shown. The gain obtained in this way is more than required, but if anyone desires more gain he is welcome to use a 222-type tube in the first i.f. socket as well—providing he can invent a way to match the high plate impedance to the lower impedance of the band-pass filter. This is strictly necessary to secure decent filter action, not to speak of decent gain. On the other hand, it is perfectly practical to use 201A-type tubes in both of the i.f. positions. In this plot the band-pass circuits will tend to oscillate and stabilization of some sort must be provided. The simplest thing is the old standby: return the grids to a potentialmeter across the A supply and turn the knob to suit. The potentiometer may conveniently have a resistance of 400 ohms and the grid returns should be bypassed directly to their own filament with 0.1 mfd.

If anyone has available other i.f. transformers they may be used, provided the first contains a primary by-pass condenser. Usually it is of the "tuned" variety and has such a condenser. Frequencies materially above 100 kc. are not to be recommended because of the detuning required, while very low frequencies tend to cause difficulties from noise and damaged quality.

**Concerning A.C. Operation**

A RECEIVER akin to the one here described has been operated for some weeks with various portions of the circuit modified to permit the use of a.c. tubes. On the whole the performance has been satisfactory but previous experience with such matters teaches the writer to believe nothing about an a.c. job until it has been thoroughly time-tried.

We must not stop without mention of television reception. If the transmission is being made with a 21-hole disc at 15 pictures per second, or a 48-hole disc at 21 pictures a second, we have a "basic" frequency of modulation amounting to 360 cycles and a tolerably probable impulse frequency running up toward 9000 cycles. This means that the carrier plus both sidebands will be about 18,000 cycles wide, which is about twice as wide as the "pass" band of the Rusco filter. The set is, therefore, not good for the purpose unless a filter with a wider pass band is used, and even then it does not have much to recommend it since there are easier ways to attack the problem. For this sort of work it is recommended that an entirely different amplifier of the usual "television type" be used which can be done with the greatest ease as the tuner has not been incorpated in any way. It should be noted that the tuner controls are at all times operated in the same manner whether it be used with the "television" amplifier, the band-pass amplifier or the usual audio amplifier alone.

Since mention has been made of satisfactory gain through the system it may be of interest to run hurriedly through the circuit with this in mind. The first 222-type tube, which is used as a "coupling tube," produces a gain of about 2, the autodyne detector produces a gain that is varied with adjustment, and signal strength, the first i.f. tube (201A) produces a gain that is not up to the usual at such frequencies because of its peculiar plate load. The 222-type tube which follows the filter operates with a moderately good plate load and provides most of the gain in the i.f. system which may be further improved by using a "tuned" impedance at this point, making sure that the condenser between this circuit and the next grid is of very high leakage resistance. The following 201A-type tube, acting as second detector, produces the slight gain which is normal in that position and this is generally sufficient to cause the signal to overload either this tube or the 112A-type audio tube, although the latter is working under proper conditions. To take care of this condition a Frost high resistance rheostat has been mounted on the hitherto blank panel of the adapter and has been connected across the secondary of the first 95 kc. transformer. By a minor operation it has been modified so as to open at one end of the scale, thus permitting the removal of the shunt when it is not desired. If no very strong signals are encountered it is better to connect this control across the secondary of the second 95 kc. transformer since then it will have no effect on the detector regeneration.

Another feature of the receiver described by the writer is that the use of the National steel cases and the various part shields results in a complete freedom from the bothersome hand capacity common to short-wave receivers. To complete this effect the panel of the right-hand (i.f. and a.f.) case was backed by a sheet of aluminum.

**List of Apparatus**

The parts required for the construction of the double-detection short-wave receiver described in this article follow:

One National screen-grid short-wave tuner;
One blank panel; aluminum;
One bakelite top panel, 9 x 11;";
One Rusco band-pass filter, 95-ke.;
Two Rusco i.f. transformers, 95-ke.;
Four tube sockets, v.c.c.-type, tinplated construction;
Three Carter resistors, 1-ohm, 2-ohm, and 4-ohm;
Two Sangamo mica condensers, 0.001-mfd. and 0.005-mfd.;
One Durham grid resistor, 11-megohm;
One Twin-Coupler 222-type shield;
Clips for grid leak, brass angle for connecting panel and base, machine screws, wire, binding posts, etc.

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*American Radio History*
CONSIDERABLE work is being done in determining the behavior of microphones under various conditions of studio pick-up. While the results will probably not be reported for months or years, the literature already contains some material of practical value for those who are interested in securing the best possible quality of reproduction as well as for laboratory technicians who use microphones in sound-measurement determinations.

B. F. Miessner's article in the September, 1926, RADIO BROADCAST, on "The Importance of Acoustics in Broadcasting" is worth reading in this connection. Miessner was concerned in this paper with possible distortion in radio reproduction caused by the directional characteristics of microphones and loud speakers. He concluded that these devices usually vary in directional characteristics with frequency. For horn speakers and flat diaphragms enclosed on one side he secured a polar diagram, reproduced herewith as Fig. 1, which shows a regular falling off in intensity from front to rear at low frequencies, the presence of a minimum at 90-120 degrees at higher frequencies, and a marked beam effect at still higher frequencies. This beam effect was also very noticeable with cone- and halfboard-type loud speakers, as well as the dynamic units.

Miessner argued that such an effect as that of Fig. 1, secured by measurements on a horn or diaphragm of about 12" diameter, would also be noted in pick-up work with the same device, the action being a reversible one. "It is plainly evident," he wrote, "that if a musical instrument, say a 'cello with low-pitched fundamental and high-pitched overtones, is placed at an angle of 45 degrees to the face, as it well might in a studio, the fundamental would be received about 75 per cent. as loud as if it were in front of the microphone, while overtones of the order of 5000 cycles would be reduced to less than 10 per cent." He went on to raise the point that a square-law effect might be involved when the directional distortion of the microphone is repeated by the loud speaker. While this is true, quantitatively Miessner's illustration of the 'cello is somewhat misleading under practical conditions, as he himself recognizes, for toward the end of the article he modifies his conclusions as applied to the then standard broadcasting microphone of the Western Electric 372-w double-button carbon type, now superseded by the 387-w. Although this microphone has a closed back, it responds to sounds from the rear because of diffraction around the housing. The facility with which the sound wave bends around the obstruction depends on the wavelength compared to the size of the obstacle. If the microphone housing is small compared to the wavelength, diffraction takes place with little loss in intensity. For higher frequencies, on the other hand, the diaphragm may be in a region of pronounced acoustic shadow, resulting in discrimination against high notes. With an actual microphone diaphragm and housing the ratio of dimensions to wavelength is not, as unfavorable as Miessner's curves of Fig. 1 would indicate, and he gives another set of polar diagrams, (Fig. 7 in the original article) here reproduced as Fig. 2, which approximate actual broadcast pick-up conditions. In the latter, it will be noted, the discrimination at 45 degrees against a 1000-cycle tone, compared to the 100-cycle fundamental, is not of the order of 7.5, but only about 2.3.

A simple expedient used by broadcast engineers in order to reduce loss of the high frequencies in picking up music over a wide front, as in the case of an orchestra of good size, is to employ two microphones facing outwards at right angles (Fig. 5) mounted on a single stand a few inches apart. This doubles the angle in which pick-up occurs without serious directional distortion. If this angle is 90 degrees for each transmitter, the two will cover a total of 180 degrees, or all of the space in front of the microphone stand. The outputs of the two microphones are mixed in the usual way (Fig. 4) where the repeating coils have 200-omh windings to match the impedance of the microphones, and the potentiometers are about 400 ohms each, the combination working into the 200-omh input of the amplifier. An additional advantage of such a combination lies in the fact that pick-up is not confined to one point in the room and there is less chance of running into any serious acoustic anomalies arising from interference of reflected waves or other effects of the room characteristics. However, a right-angle microphone combination of this type presents no advantage in picking up announcements or other close-talking material.

THE BEAM EFFECT

The beam effect of projection of high frequencies is well recognized now in human articulation, the output of many musical instruments, and in loud speaker design. Pick-up of ordinary speech with present-day equipment is generally defective when the speaker is not talking directly into the microphone because the high frequencies, which are so important in the interpretation of speech, issue in a beam in the direction in which the
suspended the acoustic modeling to every consideration sound comes through the inter-vening corridor, but intelligibility is poor because the high frequencies, probably deficient to begin with, do not bend around corners and survive the larger waves. Transmission of high frequencies is always a delicate job, and constant precautions are necessary to retain them. A cone loud speaker designed with a certain kind of paper, for example, loses the high frequencies first of all when a thicker grade of paper is substituted. The high notes are lost before the low ones in transmission along the telephone line. Directionally, likewise, discrimination is usually against the upper frequency range.

MICROPHONES IN LAB. WORK

Microphones, useful to the broadcast engineer as a means of sound pick-up, also serve as measuring instruments in the laboratory. The condenser transmitter is the form most used for this purpose, its construction and mode of operation being favorable to constancy of characteristics over long periods, while a carbon microphone, obviously, cannot be depended upon to the same extent. Stuart Bloch, in an article reprinted in part in his work on "The Effect of Reflection by the Microphone in Sound Measurements, in the Bell System Technical Journal," the article, which appears in slightly abridged form in the same month's issue of the I.R.E. Proceedings, is of more interest to laboratory technicians than to the operating engineers, but should not be entirely ignored by those of the latter who want to be known as up-to-date workers.

The condenser transmitter is used in acoustic work to measure sounds which, after it picks them up and converts the energy into corresponding electrical variations, are amplified and operate a recording system, such as a vacuum-tube voltmeter and galvanometer. Figure 5, for example, shows the use of such a system in measuring loud-speaker characteristics.

The only trouble with this scheme is that the condenser transmitter is so large that it tends to distort the sound field which it is supposed to measure. It is as if, in measuring the flow of a stream, we introduced an object so large that it changed the velocity and direction of the current. Here is one method of acoustic measurement which does not suffer from this defect, or does so, at least, to a lesser degree. This is the Rayleigh disc, which is affected by the velocity of sound only in the sound waves, while the condenser microphone is a pressure-operated device. The usual form of the disc is a thin, light, elliptical piece of mica, suspended at the end of a long axis by a fine fibre, and silvered on one side to reflect a beam of light. Under the impact of a sound wave the disc, which is only about half an inch long, is deflected. The angle of deflection is measured by means of the light lever and gives an indication of the acoustic forces at work. A condenser transmitter, being a relatively cumbersome implement, requires some correction for its own effect on the forces it measures, and what Ballantine has set out to do is to find a way to make the correction required at different frequencies.

If the waves are long they bend around the microphone (diffraction) with little influence by this means the waves are reflected with a consequent increase in the apparent value of the pressure before the diaphragm. A tightly stretched diaphragm of infinite extent would receive the whole pressure perfectly and the indicated pressure would be double the pressure which would prevail were the microphone not there. The microphone is large enough to act as such an obstruction for short sound waves. The problem then is to evaluate the extent to which the microphone suppresses the instantaneous sound pressure at various frequencies.

Ballantine goes about this with a simple but ingenious procedure. He mounts his condenser transmitter with its first stage of amplification in a spherical "bullet," with the diaphragm sensibly in the surface of the sphere. The diffraction of sound by a spherical obstacle is a classical problem, soluble by intricate but known methods. Ballantine has performed the calculations and drawn his results in the form of a curve showing the ratio of the indicated pressure to the pressure in the undisturbed field (microphone removed) at various frequencies. With a sphere six inches in diameter, he finds that this ratio is unity (100 cycles, no correction needed), about 1.25 at 500 cycles, 1.56 at 1000 cycles, 1.71 at 2000 cycles, up to nearly 2.0 at 10,000 cycles. He has also determined the curve for a 12-inch spherical mounting. The results may be applied experimentally to the more usual forms of microphone mountings, which are not amenable to calculation. Ballantine has this work under way. When the correction curves for practical mountings are published, more accurate determinations of sound pressures by the use of ordinary condenser microphones will be possible.

Correction After a Decade

MY OPINION of engineers, I believe one of them, is that they are valuable members of society. But I must admit that sometimes they are all wrong.

In the summary of the paper by Bailey, Dean, and Wintringham on "The Receiving System for Long-Wave Transatlantic Radio by the operation on the same band by several transatlantic Radio Engineers, I find a calculation of the effect of a receiving location in Maine (for reception of British transatlantic telephone signals) by a simple antenna. "If the receiving were to be accomplished near New York using a loop antenna," it reads, "we would have to increase the power of the British transmitting station 20,000 times to obtain the same signal-to-noise ratio."

Ten years ago I was working on static elimination in company with a first-rate radio engineer. His record since then has borne out that classification. What I recall distinctly is that as we were walking home one day he said, "After all, the way to lick static is to use more power at the transmitter." Two million kilowatts, say?

Safety for the Broadcasters

COMMENTING on an article in Radio Broadcast about the electrical safety of one of the engineers at Daven-try, Mr. Saul Bloch offers the following idea as a means of preventing such fatalities in broadcast stations:

"In setting up a transmitter why not build the following type of moving platform next to those parts of the apparatus which carry high tension currents?"

1. The platform should be located in such a manner that when anybody wishes to approach the high tension wires he will have to stand on the platform in order to be within reach of the wires.

2. The platform should be set on some sort of device which would permit it to lift slightly below its normal level when the man steps on it.

3. The platform should be connected in the circuit that it when moves down with the whole high voltage circuit the high tension circuit would be automatically broken.

"To an engineer," adds Mr. Bloch, "this may not be possible, but it can be considered as an invention of Ruhe Goldberg's, but it is being offered in all sincerity."

While I do not consider this idea practicable I certainly feel that it deserves discussion if only to keep the subject before the men who take the risks. My opinion remains as I have frequently stated it before—that there is no mechanical substitute, in working with high tension currents, for unremitting awareness of danger on the part of the operators and the caution that should result therefrom. A disconnect scheme like that proposed by Mr. Bloch could not be depended on to function infallibly. Automatic shut-down devices actuated by push-buttons and operating through relays sometimes fail to act. An open-circuiting platform would entail the same jeopardy. There are times, also, when the operator wants to get close to the station in operation, in order to observe a tube or some other part of the equipment. If he knows that the 10,000 volts are ready to jump on him he is as safe a foot from the conductors as ten feet away. The stuff will not leap at him; he has to get within an eighth of an inch before anything can happen. In the vast majority of cases where men have been killed or injured it has been because they forget that the current was on.
Duplex Set Improves Fidelity

A CUBAN SHORT-WAVE RECEIVER

By FRANK H. JONES

The unique short-wave receiving circuit described on this page will be of interest to radio experimenters living in the tropics where static on broadcast wavelengths is severe during most of the year. Mr. Jones points out that the same high-quality programs may be received with fidelity on short wavelengths. On these waves static is not noticeable and fading may be overcome by mixing the signals of two stations which transmit the same program. A table on page 298 of this issue gives the operating hours and wavelengths of seven high-powered short-wave broadcasters which transmit chain programs. The hours during which two or more stations broadcast the same program are also indicated.

—The Editor

RETURNING to the diagram of the detector circuits it will be noticed that the two detectors, X and Y, are isolated from each other and from the audio unit by r.f. clake coils and aluminum shielding. The next most interesting feature is the cam switch which governs the negative bias to the detector. The detectors are connected with the double primary input transformer (Samson type Y interstage push-pull) of the amplifier. The switch in the X position, only the X detector feeds its half of the primary of the transformer, with the switch in the Y position, the Y detector is connected with the other half of the primary of the transformer, and with the switch in the mid position both detector circuits feed into the double primary simultaneously.

The use of a double primary transformer is not absolutely essential to the success of the writer's system, but it provides most satisfactory results. In place of the double-primary transformer, it is possible to use an ordinary interstage transformer (not push-pull) by connecting the plate terminals of the two detector tubes to the "P" terminal of the transformer, and the positive B supply to the "B+" terminal of the transformer.

An interstage push-pull transformer with three primary terminals instead of four (Samson make them) may also be used; in this case the plate of one detector is connected with one "P" terminal of the transformer, the plate terminal of the second detector is connected with the other "P" terminal, and the positive of the B supply is fed to the "B+" terminal of transformer. However, the circuit shown seems to be less susceptible to low-frequency noises such as 60-cycle hum.

It is not necessary to give specific information regarding the other details of the receivers as this is given in the standard. The two detector circuits are identical, and may be similar to those used in your pet short-wave set. Following the above, the audio amplifier is standard. The writer built the best possible amplifier as he wished the system described fidelity and this proved very much worth while.

Programs Available

THE writer, who is located in Tainuru, Cuba, has been able to receive with satisfactory volume the signals of seven short-wave stations which transmit high-quality broadcast programs. These stations are: w2XAF, Schenectady, N. Y., on 31.41 meters; w2XAB, Schenectady, N. Y., on 19.56 meters; w2XW, Chelmford, England, on 25.53 meters; w2XK, Pittsburgh, Pa., on 25.4 or 63.5 meters; cjrX, Winnipeg, Canada, on 25.6 meters; pcfX, Eindhoven, Holland, on 31.2 meters; and Columbia's new station, w2XE, Richmond Hill, N. Y., on 58.5 meters. Of the above listed stations w2XW, w2XAB, and w2XAF usually transmit the program of WEAF, the NBC's Red and Blue network programs, while stations w2XAF, Columbia, and several others transmit the programs of the Columbia chain. So, if one can receive these stations well, he is listening to the real pick of radio programs. A table giving the operating schedule of these stations will be found on page 298 of this issue. In his endeavor to receive short-wave programs, Mr. Jones encountered the problem of fading, and the periods of fading were much more frequent than on the long wavelengths. Also, it was discovered, that fading periods differ on different wave bands. This fact prompted the design of the receiver described in this article; it was thought that if the same program could be received on two different wavelengths with two different detectors, and the outputs of the two detectors feeding into the same audio amplifier, the fading periods differ on different wave bands. This fact prompted the design of the receiver described in this article; it was thought that if the same program could be received on two different wavelengths with two different detectors, and the outputs of the two detectors feeding into the same audio amplifier,
**The Projection of Motion Pictures**

The sound motion picture industry is moving with such rapidity that even those in that field—as is Mr. Dreher, who writes regularly on the subject for Radio Broadcast—have trouble in keeping abreast of developments. It is the purpose of these regular contributions to survey some of the highlights in the technical branches of sound picture work with the purpose of providing accurate technical information for those working in the field, for practising broadcasters whose daily work is perilously close to sound movies, and for all others who are interested.  

—The Editor

The heat of the light source in a theatre is regulated to some extent that if the film stops moving it will catch fire. The operator may extinguish his arc in time to avoid this, but to prevent reliance being placed on the heat of the centrifugally operated shutter is placed ahead of the film. At normal speeds this is kept open by the action of a governor, but as soon as the speed drops to a point where there is danger of ignition the shutter drops. The speed at which the shutter operates may be around 40 feet per minute, the normal silent projection speed being from 60 to 120 feet per minute while sound pictures run at 90 feet per minute.

The film itself passes through the projector with the pictures upside down and the emulsion side of the film. In the standard size it is 1⅞ wide and 5⅞ thick. Both margins are perforated so that the film may be dragged along with means of toothed wheels called sprockets. There are 16 perforations per foot, or four to a picture on either side, 16 pictures to the foot being standard.

The object of the film projection is to produce in a mixture of nitric and sulphuric acids to render it soluble, forming pyroxyline or nitro-cellulose. This is dissolved in a mixture of caustic, alcohol, and other materials forming a viscous "dose," which is spread and dried on large drums with much complicated processing and finally cut up into strips of celluloid on one side with the light-sensitive emulsion of silver bromide in gelatine. The emulsion of negative stock, used in cameras, is more sensitive and less contrasty than that of positive stock, from which prints are made. Sound records, incidentally, are better made on positive stock.

The mechanism for taking the film through the projector will be considered in more detail later.

The light which passes through the film is汇集ed on a screen. The light from the screen is then focused by a converging lens, where the rays cross so that the image is seen on the screen right side up. The projection lens generally consists of a system of focusing lenses.  

The object of the film is to produce an illusion of motion in the eyes of the audience. This is accomplished by providing a mechanism to move the film at regular intervals. In a typical projector, the film is fed into the projector through a slot, and as the film moves, the image on the screen is updated due to the movement of the film. The movement of the film is controlled by a mechanism that ensures the correct amount of film is moved each time a new image is required on the screen.

**Fig. 1—Schematic diagram of mechanism in a standard motion-picture projector with sound adjacent**

- **Upper Magazine**
- **Upper Loop**
- **Fire Trap**
- **Gate Idler**
- **Guide Roller**
- **Tension Pad**
- **Photo Cell**
- **Upper Sprocket**
- **Lower Loop**
- **Gate Shoes**
- **Pad Rollers**
- **Idler**
- **Sound Head**
- **Lower Magazine**
- **Lower Sprocket**

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successive pictures are being jerked into place. This periodic light interrupter has an auxiliary function, which is, by means of an added blade or two, to break up the stationary periods of projection and thus to eliminate flicker. These functions will be considered quantitatively later.

The throw or projection distance is measured, as shown in Fig. 3, from the objective lens to the screen, along the axis of projection which is a straight line passing through the center of the photograph, the center of the screen image, and approximately through the center of the source of light. All the elements of the optical train, when in proper adjustment, are centered on the axis of projection.

MECHANICAL DESIGN

Fig. 1 gives a view of the projector mechanism from behind. The parts were all adjusted and assembled, and where the projectionist stands during operation. The film to be projected is placed in a length of 1000 or 2000 feet on a reel in the upper magazine, the beginning being on the outside of the roll, with several feet of leader before the action of the subject begins. The film is then passed through a take-up magazine and coiled into the lower magazine, the lower magazine being on the right side of the machine and the upper magazine on the left side. The take-up mechanism is a self-tensioning type.

The film is clamped between the roller guides, and the wiper bar may be adjusted to any height desired. The sprocket and film are under full tension, being wound around the sprocket through the roller guides.

The film is led through the intermittent shutter, which is a revolving blade type. The intermittent must be adjusted to the correct tension to prevent slack or breakage of the film.

The shutter is a revolving blade type. The intermittent is adjusted to the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film.

The intermittent shutter controls the motion of the film just below the gate. The film is passed through the intermittent shutter, which is a revolving blade type. The intermittent is adjusted to the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film.

The intermittent, which is a revolving blade type, adjusts the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film.

OPERATION OF SHUTTER

Now that the action of the intermittent has been described, the intermittent shutter may be analyzed in greater detail. Fig. 2 presents a view of a segmental disc type of revolving shutter, viewed from a point in front of the projector. The shutter in this case has two blades. One of these, usually slightly the broader, is known as the working, cutting, obscuring, main, or master, or travel blade, which has the function of intercepting the light during the movement of the film across the picture aperture. The fourth blade, known as the intercepting or flier blade, interrupts the light during the rest or projection period and thus reduces or eliminates flicker by increasing the number of pictures per second thrown on the screen. Flicker is the visible alternation of light and darkness. It is, however, it is not sufficiently rapid.

Sixteen pictures per second is enough to produce an illusion of motion, but not enough to overcome consciousness of the alternation of light and darkness. The addition of a second blade to the shutter increases the alternations to 32 per second, making the flicker less annoying. High projection speed obviously tends to decrease flicker by increasing the number of pictures per second and the periodicity of the light fluctuation. The frequency required for comfortable vision depends on the brightness of the screen, which is dependent on the intensity of the light source and the type of reflecting surface used in the screen.

The film is led through the intermittent shutter, which is a revolving blade type. The intermittent is adjusted to the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film. The shutter is adjusted to the correct tension to prevent slack or breakage of the film.

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Cabinet Resonance Explained

MEASUREMENTS ON DYNAMIC SPEAKERS

By FRANK C. JONES

At the present time a good moving-coil loud speaker in a three-foot-square baffieboard operated from a good amplifier provides fidelity par excellence. Mr. Jones, an independent investigator living in California, gives us some actual data on well-known speakers in this article, data which should appeal to anyone interested in "quality." The effect of cabinet resonance, the directional effects of dynamic speakers, and the use of filters are discussed and illustrated graphically. Incidentally, an article on the electrostatic loud speaker is being prepared for an early issue.

—THE EDITOR.

The Magnetic Field

There are two general types of loud speakers in use at present for radio reproduction. These are the electromagnetic drive and electrodynamic drive cone loud speakers. The latter is the most recent and will be described in the following discussion because it gives a much wider frequency response than do other types.

The usual dynamic loud speaker consists of a moving-coil system and some form of magnetic field. The moving coil is attached to a small cone which acts as a diaphragm to set the surrounding air into motion. This coil moves back and forth in the magnetic field and the amplitude and frequency of motion depends upon the audio signal currents through the coil. The cone usually has two supports, one near the moving coil in the form of a fibre or aluminum spider frame, and the other at the front edge of the cone in the form of a thin leather ring. These two supports allow the cone to vibrate freely in a plunger motion back and forth.

The magnetic field generally consists of a field winding, an iron core, and a shell-return magnetic path. The power used by the field varies from 2.5 up to 20 watts for different types. Most of the magnetic field flux is used up in the air gap across the moving coil since this gap is fairly large. At least 0.010 inch clearance is allowed on each side of the coil and the coil itself is from \( \frac{1}{2} \) to \( \frac{3}{8} \) inch thick.

The Dynamic Unit

The dynamic loud speaker is really a very complex machine when an attempt is made to analyze it electrically. At first sight, it appears that it functions in a simple fashion, i.e., the diaphragm is actuated by the moving coil which in turn moves in accordance with the audio-frequency currents flowing through it. This is true within certain limits but the question arises as to how much distortion is introduced for currents of different frequencies.

It is assumed ordinarily that a dynamic loud speaker is inertia controlled, that is, its diaphragm acts as a plunger. Then, for simple harmonic motion where the driving force alternates between +F and -F dynes, the amplitude can be expressed as:

\[ x = \frac{F}{k} \]

In the case of a small diaphragm

\[ x = \frac{P}{2\pi V} \]

where:

- \( P \) = power in ergs
- \( V \) = velocity of sound
- \( x \) = amplitude of motion
- \( \beta \) = sound attenuation
- \( S \) = diaphragm area
- \( \rho \) = density of air
- \( f \) = frequency in cycles

By large and small diaphragms are meant those whose outside diameters are larger and smaller, respectively, than the wavelengths of sound expressed in physical measure. These two equations show, therefore, that for a small diaphragm, the amplitude must vary inversely as the square of the frequency for constant sound output. For a large diaphragm the amplitude must vary inversely as the frequency.

For high audio frequencies, the wavelength becomes small enough to have the equation for the large diaphragm hold true, i.e., the amplitude varies inversely as the first power of the frequency. This means that the power output in sound will be so small at the high frequencies that the lower frequencies will be overemphasized. This occurs in some models of dynamic loud speakers, and may be made worse by cabinet resonance.

Operation at High Frequencies

The two formulas are true for inertia-controlled diaphragms in which the whole diaphragm moves as a unit. This actually holds true for low frequencies with a small cone such as is used in a dynamic loud speaker. The cone shape gives the diaphragm very good rigidity. However, for higher frequencies, this does not hold true since the apex vibrates separately and flexural waves are radiated out to the edge of the cone. This is liable to cause standing waves along the diaphragm for the higher frequencies due to reflected waves from the edge of the cone. This occurs at certain frequencies and is quite apparent in the response curves for some loud speakers.

Because at high frequencies the loud speaker cannot be considered as inertia controlled there usually results a large increase of sound output for the higher frequencies. The combination of the two effects, inertia control and wave-motion control, generally causes a peak at about 3000 cycles per second for most commercial forms of these loud speakers. Beyond that point the plunger action or inertia control output drops off so rapidly that it is negligible and practically all of the sound output comes from the wave-motion action.

The motional resistance and impedance curves of the action of the moving coil and diaphragm also show that the output would be very small for the higher frequencies if it were not for this wave-motion action. Fig. 3 shows some impedance curves of two varieties of dynamic loud speakers. In both cases the moving coil has an appreciable inductance so its reactance increases rapidly for the higher frequencies. This reactive component is of very little use and serves to give a poor impedance match to the power tube. An example of the impedance of a magnetic type of loud speaker is shown in Fig. 1.

Motional Resistance Measurements

The moving coil should consist theoretically only of a pure resistance, and the motional resistance portion of this would represent the useful part towards work done. This motional resistance is due to the acoustical load on the diaphragm and is so related to the useful sound output. It is possible to measure the motional resistance for all frequencies by means of an impedance bridge. First a resistance curve is taken with the cone free to vibrate and moving with an amplitude about equal to that obtained for normal sound output. Then the cone must be blocked securely, and a second resistance curve made. The difference of values of these two curves gives a third curve of the motional resistance. These curves are interesting because they indicate the load.

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Fig. 1—Impedance curve of a standard magnetic-type loud speaker.

Fig. 2—Two types of filter circuits (equalizers) used in connection with dynamic loud speakers to produce a cut-off above 5000 cycles.
impedance which is offered to the power tube. Some dynamic loud speakers have a large motion caused by the resonant frequency of the moving coil and cone system. Usually this occurs at a low frequency, from 20 to 70 cycles, per second, that is not noticeable on radio reproduction.

**Filter Systems**

**Present-Day** models of dynamic loud speakers usually have some form of filter or equalizer as an integral part of them. The impedance of the moving coil is quite low, from 4 to 12 ohms for low frequencies, so a step-down transformer is used to obtain better undistorted power output from the power tube. In all cases the filter is connected across the primary or high-tension winding of the transformer. These filters or equalizers cut off above certain frequencies or cause a power loss at some frequencies.

The most general type of filter consists of a simple "PI" section filter consisting of two 0.01- to 0.02-mfd condensers and a 100- to 200-millihiere inductor as shown in Fig. 2A. This form of filter cuts off the frequencies above its natural resonant frequency and has practically no effect on the lower frequencies. It is called a low-pass filter because it cuts off above about 4000 cycles per second. Contrary to manufacturers' statements, these do not cut off at about 5000 cycles, but all makes tested began to cut off at about 3500 cycles. A 4000-cycle cut-off is very difficult to notice as far as speech is concerned, but some of the brilliance is lost, especially for music.

Another form of filter or equalizer (diagram b of Fig. 2) consists of a resistance, inductance and capacitance in series connected across the primary of the step-down transformer. At the resonant frequency of this circuit the attenuation is greatest. By proportioning the values in this equalizer the "PI" may be turned on or off the bass or shallow to remove a resonant peak in the loud speaker output. This form of equalizer may be used to remove the peak mentioned before where the wave motion and pleuner motion combine to cause an increased sound output. This peak and its removal by the equalized method is shown in response curve A of Fig. 5.

The series-resonant filter is used in the Jensen dynamic loud speaker, where the "PI" filter is used generally in the Magnavox, Rola, and other popular makes of dynamic loud speakers.

Properly designing the shape and weight of the moving system it should be possible to eliminate equalizers and filters. A shallow cone, with an opening greater than 90°, will cause the wave motion to become effective at a lower frequency unless the stiffness and weight of the system are changed. Heavier paper cone causes energy loss due to the added weight. It also affects the higher frequency due to decrease of stiffness. The size of the cone also affects the frequency response due to the acoustic impedance which the air offers. Another effect is the directional properties at high frequencies due to the megaphone effect of the cone. The cone shaped diahragn is not ideal but its advantages overshadow its shortcomings in present-day design.

That it is possible to overcome the usual peak at about 3000 to 4000 cycles by proper design was shown in a test on a new model Jensen speaker. This curve is shown and as can be seen the shift from plunger action to wave motion is gradual enough so that the response is nearly uniform. This was done by using a larger cone diaphragm which changes the weight and stiffness. Using a larger diaphragm means a good low-frequency response since for the same latitude of motion there is of course a much greater amount of air set in motion. Conversely, for the same sound output the larger diaphragm does not have to move as far which simplifies construction somewhat.

For low frequencies, 30 to 100 cycles per second, the amplitude of motion for good sound output is quite great. A motion of 1/8 to 1/4 inch is not uncommon. Such great motion causes crystallization of the rear speaker support with breakage of the baffle in time. With the larger diaphragm the motion is much less so the tendency to break is greatly lessened.

**Baffles for the Dynamic**

The subject of baffles is difficult to handle since it must consider the effect of cabinet resonances, circulating air currents, standing-wave effects, and acoustics of rooms.

A source of sound emits waves of a spherical or hemispherical shape and these vibrations of air travel out to all parts of the room. Reflection and resonant effects take place, although generally the reflection properties are of minor importance and standing waves are reflected more or less from anything which they strike. If the walls and floor have drapes and rugs, the amount of absorption is, of course, much greater than in a bare room. Therefore, the reverberation is less, that is, the reverberation time is less and the note of any frequency dies out more rapidly. The definition of music is also much clearer in such a room, and within certain limits, much more pleasant.

Another effect of excessive reverberation is the creation of standing waves of sound. In this case the reflected waves are of sufficient amplitude, and of proper phase for some frequencies, to cause points of maximum and minimum sound. This is easily noticed on organ music which is generally sustained long enough to allow a person to move a few inches or a few feet during some particular note. The presence of maximum and minimum areas of sound for frequencies is quite pronounced in many rooms.

**Reasons for Baffle**

A DYNAMIC loud speaker with its small diaphragm will not produce tones of low frequencies unless a baffle sort is provided. The baffle should provide a path through the air such that the shortest distance from one side of the cone to the other is at least one quarter wavelength of the lowest frequency desired. This does not prevent interference of the two sources of sound waves at the edges and near the baffle but it does stop the air circulation sufficiently to allow the loud speaker to reproduce the low tones. Considering the velocity of sound in air to be about 1100 feet per second, a baffle for tones as low as 75 cycles per second can be calculated easily.\[1 \times \frac{1100}{75} = 33 \text{ feet} = \text{diameter of baffle}\]

This, of course, can be in the form of a square 33 feet on a side. Thus to reproduce actually a tone of 30 cycles a baffle 9 feet square would be necessary. The wall or ceiling of the room may be used for the purpose when such a baffle is desired.

If frequencies below the "cut-off" of the baffle are impressed on the loud speaker, the resulting tone is made up mostly of higher harmonics. Tests by ear apparently show quite a bit of the fundamental tone but this is nearly all due to the modulating property of the human ear, since it combines the harmonics in a manner similar to the first detector or "mixer" tube in a super-heterodyne receiver. For example, if the ear hears two tones one of 120 and one of 100 cycles, there is apparently a strong 60-cycle tone present, which, of course, is not apparent to electrical recording systems. Fortunately very little music is transmitted below 80 to 100 cycles per second so a baffle of 3 feet effective length is sufficient for present-day needs.

When a flat baffle is used there are no

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**Fig. 4—The circuit used by the writer for measuring the characteristics of dynamic-type loud speakers.**

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resonant effects but as soon as the sides are bent around, as in a cabinet, bad resonance occurs. Part of this resonance is due to the sides vibrating and part due to the natural period of the cavity. Making the cabinet of heavy wood helps reduce the resonating effect due to the sides vibrating. That this effect of cabinet resonance is very bad can be shown experimentally. The effect on music and speech is to change the quality greatly. It becomes booming in nature because the resonance is generally at low frequencies, and, in addition, the air chamber attenuates the high frequencies.

Response Measurements

MEASUREMENTS were made by means of a W. E. 387w transmitter and calibrated amplifiers over the audio-frequency band in an effort to learn something about cabinet resonance. The circuit arrangement used is shown in Fig. 4 in which a special beat-frequency audio oscillator was used as a source of sound. This audio oscillator had a range of from less than 30 cycles up to about 15,000 cycles and was, of course, continuously variable. Particular care was taken to minimize standing waves of sound in the room. The most practical method is to have the "mike" less than a foot from the loud speaker so that the direct sound wave is much stronger than the reflected waves.

Numerous response curves were run with the "mike" in different locations. Some trouble was had from room resonance and reflecting surfaces since either the loud speaker or the "mike" had to be moved for the different runs. Even with these effects it is quite evident that cabinet resonance is pronounced as shown in curve n of Fig. 5. A larger cabinet generally has a lower resonant period, but because of audio amplifier deficiencies, it may not be very noticeable.

Padding the inside of the cabinet with felt does not help much since felt is not an efficient absorbing material for low frequencies. Therefore, felt padding may attenuate the high frequencies more and tend to make the quality even more drummy in character. Felt padding helps occasionally in damping the sides to prevent vibration. Lining the cabinets with acousticCelotex or some such material should help greatly. Mounting the entire loud speaker unit in thick felt seems to remove the cabinet resonance but this cuts down the sound output nearly half. Only the front can emit sound in this case so a larger power tube is necessary to prevent overloading in the audio amplifier for the same sound output.

Effect of Small Cabinets

THE harmful effect of small cabinets on the higher frequencies is shown vividly in the curves of Fig. 5. The solid curve was taken with the microphone about 15 centimeters in front of the loud speaker, the dotted curve was taken with the microphone at the same distance to the rear and the dot-dash curve was made with the microphone on one side. The dot-dash curve shows the effect of cabinet resonance since the "mike" was near one of the vibrating surfaces. The sudden drop at low frequencies is probably due to interference of sound waves emitted from the back and front of the loud speaker.

The dotted curve of Fig. 5 shows the effects of cabinet resonance and the attenuation of the high frequencies. Evidently the cabinet cavity acts like a condenser in absorbing more energy on the higher frequencies. It is like a horn loud speaker in which there is a large air cavity between the diaphragm and the throat of the horn. It is quite a well-known fact that such a cavity attenuates the high frequencies greatly. If the air chamber or cavity is large enough with respect to the diaphragm, such as with a console cabinet, this attenuation of the high frequencies is of much less importance. If a small cabinet must be used, drilling a few large holes in the sides should help reduce both cabinet resonance and high-frequency attenuation. These holes would prevent the small cabinet from acting as a horn, but the effective baffle size would be diminished somewhat so the very low notes would be down a little in level.

Large cabinets such as those used to completely house the radio receiver may reduce the resonance to a minimum by using a screen back for the cabinet and by not having any shelves inside of the cabinet. The use of a couple of strips of acoustic material, such as type DB Celotex, fastened to the sides or top inside of the cabinet should make this form of cabinet practically as good as a flat baffle.

Fig. 5—Response curves of several dynamic-type loud speakers measured under different conditions. Curve A, Jensen loud speaker; curve B, Jensen loud speaker with different baffles (measured five feet in front of loud speaker); curves C, dynamic loud speaker in a small cabinet; curve D, small-cabinet-type dynamic loud speaker; curve E, Magnavox dynamic loud speaker; curve F, Jensen loud speaker with large cone and no filter or equalizer.
RADIO Interference from House Plumbing: Two extraordinary but similar cases of radio interference have come to my attention. Although both conditions arose in the operation of short-wave receivers, the trouble may be affecting ordinary receivers, and telling of the experiences here may enable others to clear up an obscure source of trouble. In the first instance, a microphonie trouble developed in the receiver. The noise was terrible. The effect was suggestive of a loose connection. Sometimes a violent rapping on the side of the receiver, while placing an object on a distant table produced an explosion. Every connection from an antenna to ground on a cold-water pipe was thoroughly overhauled. The trouble would reappear after each discovery and removal of its supposed cause. Matters reached a desperate state. As a last test, the set was put in operation and a 40-foot extension cord attached to the head set. The set was in the dining room and the floors of the dining room and kitchen were explored by rapping on the electric circuits from point to point, like a blind man and the resultant static was carefully studied. A lone point on the floor, remote from the set, was found to be the most "sensitive." The extension was then carried through the floor to the cellar and the exploring transferred to the pipes hung from the floor overhead. Some were quite sensitive but they were not coupled with the ground connection.

The trouble was quite by chance traced to the metal stopper of a laundry tub. This stopper fitted loosely in the drain outlet and was attached by a brass chain to the cold water faucet. This proved to be a most sensitive microphone affected by vibrations conveyed to it from pipes hung overhead. It acted as a variable length circuit in the pipe grounding system, changing the electrical constants of the system. Pulling out the plug and hanging it over the side entirely cleared this vexing interference.

Later an annoying but less overwhelming noise was traced to a variable contact between two pipes in the cellar that crossed each other. A little wedge of wood placed between them remedied this trouble. Probably many similar cases of interference exist which have not been traced down. This is particularly likely to be true of those who are now acquiring short-wave receivers. If trouble from loose connections cannot be found in wires in the attic, it is time to be suspicious of pipes in the cellar!

C. A. BRIGGS, Washington, D. C.

A simple method of determining if a noisy receiver is suffering from the trouble described by Mr. Briggs is to run fifty feet of wire almost anywhere, and use this as a counterpoise in place of the ground. Also, a simple cure might be a permanent counterpoise or six feet of iron pipe driven into the earth.

THE SERVICEMAN'S CORNER

With this issue of Radio Broadcast, "The Serviceman's Corner" stretches into its natural stride. The purpose of this department is to publish everything and anything of genuine interest to the radio serviceman that can be briefly and thoroughly covered. Subjects justifying longer treatment will be covered in complete articles elsewhere in Radio Broadcast. Contributions, payable at our usual rate, will be welcome from engineers, manufacturers, servicemen, and dealers who have been intimately associated with any of these problems.

It is requested that the contributor write us on his professional stationery, enclosing with his letter copies of his business cards and business literature if any.

—THE EDITOR.

Servicing Magnavox Receivers: William K. Augenbaugh, of Altoona, Pa., has run across several Magnavox receivers that would not function when the original tubes were replaced with R. C. A. or Cunningham tubes. The difficulty, he points out, can be remedied by short circuiting the coil of wire that will be found under the cardboard at the bottom of the set—near the front panel. Also the pin on the volume-control rheostat should be removed or bent so that the rheostat can be adjusted to the full "on" position if necessary.

Finding tube-locations: I was recently called on to install a new a.c. set. Not finding any installation instructions or data on proper location of tubes, I hit upon a useful method of locating the proper socket for the proper tube.

No mistake can be made about the 280 or the v-227, especially since the latter has five prongs. The set in question required four 226's, one 227, two 171's and one 280. Putting a 226 in a 171 socket won't do the 226 any good. I took a 171 and put it into the first socket next to the 227. I was sure about the location of the 227. Not seeing the filament light, I assumed it to be a 226 socket. In this way, by trying all the other sockets, I found which were the 226 sockets and which the 171.

FRED BERKLEY, Astoria, Long Island.

Polarity Incorrectly Stamped: I just serviced a Radiola No. 20. The owner of this set was using a 22.5-volt B battery as a C battery, connected correctly. I tested the set as usual. It would receive only locals, and these not at all well. Closer inspection, with a voltmeter, showed that the C battery was incorrectly stamped, the stamping being reversed for positive and negative. This is the second time in my eight years of servicing sets that this same thing has come to my attention.

GEORGE A. HARTMANN, Howell, Indiana.

Terminal reversal has also happened within the experience of the editor. A check of the socket and tube connections with the usual plug-in testing outfit would show this up as a very high plate current through the tube having the reversed grid bias.

Servicing Cheap Receivers: L. R. Arnold, of the Richards Radio Company, Providence, R. I., comments on the difficulties of servicing inexpensive receivers. These are often characterized by fairly good reception on local stations, but are insensitive to distant stations and stations covered by the upper section of the tuning dial.

These receivers can often be improved, as far as sensitivity is concerned, by running all r.f. tubes, with the exception of the first, from 135 volts through a bypassed variable resistor, using the additional knob as a sensitivity and volume control.

A Portable Receiver To Check General Conditions: The Klotser Radio Company provides its dealers with a portable demonstration set possessing several points of interest that recommend similar outfits for the serviceman. The complete apparatus is pictured in Fig. 1, and consists of two carrying cases, one holding the receiver, tubes and power supply, and the other the loud speaker. A portable receiver of somewhat similar design is of inestimable value to the serviceman in solving the more general problems of poor reception. The inability of a receiver being serviced to receive certain stations can be checked against a standard receiver, the characteristics of which are well known to the serviceman, to determine whether it is the location or the receiver that is at fault.

Fig. 1—Portable radio receiving apparatus that suggests a useful adjunct to the serviceman's equipment for determining general receiving conditions
An Outfit of This Sort proved itself worth while to the department editor in the case of a broadcast I heard recently on the West Coast. The transmitter was in New York City. Noise reception in this particular apartment removed radio from the entertainment class. However, by using a pair of receiver coils untuned and working exclusively from independent battery sources, it was easily ascertained that the pickup was conductive through the lines. The receiver was rewired for better reception (a desperate remedy) and has been giving satisfactory service ever since.

An Unusual Problem: The following incident came to my attention while servicing an Atwater-Kent battery receiver equipped with an A-power unit, and perhaps a little information about the apparatus might be of interest.

The set was playing along nicely when I arrived, but a moment later the thing stopped dead. After about 30 seconds the set gradually began and set itself to its volume. As nothing like this had happened before installing the power unit, of course, this was blamed. A careful check of both the A- and B-power unit circuits failed to reveal anything. A wire from the power rheostat in the A-power circuit seemed to be a little loose, but installing a new power rheostat didn't remedy the trouble.

By carefully questioning the owner of the set I discovered that some time before a very similar trouble had developed in the set when it was used from batteries. The music had died down but hadn't stopped entirely and by working the filament switch the full volume was restored. Enough back and forth to the inspection of the filament switch. Sure enough there was the trouble. This is how I doped it out. The filament switch with a short or jar or other disturbance would cause a poor connection in the filament circuit. This, in turn, would cause the voltage in the A-power unit to rise due to the reduced load. The choke in the B-power unit (in accord with an electrolytic condenser and Tunzor full-wave rectifier) would blow as soon as 8 volts or more was pushed into it. It took the condenser perhaps three seconds to heal and the remainder of the thirty seconds to charge up again. After repairing the set this trouble never recurred.

Alton R. Bowe, Pleasantville, N. J.

All in a Day's Work: Here are two difficult problems, each one more or less unique. The trouble was similar in each case and may aid in solving related troubles found by brother servicemen.

The D. C. Problem: Supplementing your editor's remarks about the portable receiver which was recently laboratory-tested, Arthur R. Gerling of Kellogg and Bertine, New York, writes:

During my eight years of selling and servicing receivers in the wealthiest d.c. district in the United States, I have acquired a knowledge of what the élite want in the way of radio entertainment and reception, and also

The C. Problem: Now is a good time to have the radio licensed, tested, and put into first-class condition.

A radio receiver is a very delicate piece of apparatus and no matter how well constructed should have attention from time to time to maintain it in order for best results. Often a little work of this kind will make a marked improvement in quality of reception.

Batteries, Eliminators, Tubes, Aerial should all be in proper order.

We are technically trained for this work, have the most modern tools, testing equipment, and apparatus for performing this work in a workmanlike manner at reasonable prices. A postcard or telephone call will receive prompt attention.

Endorsed by

National Radio Institute
Washington, D.C.

WILLIAM V. LOWE
Box No. 387
Tel. 3527-M
Fitchburg, Mass.

The bug-a-boos that sometimes prevent us from giving them just what they want.

These folks whom I have chosen to call the élite would be quite satisfied—for the most part—with just the same kind of reception that the average cut-out man gets in the Bronx (where a.c. current is supplied). In many cases even this is denied them—why? First, because they are burdened with d.c. current with its many disadvantages known to all servicemen. Second, the management of the apartment houses in which they dwell often have stringent rules regarding the use of a.c. power, and usually forbid them entirely—quite a reasonable attitude. Third, the numerous d.c. motors always found in large apartment houses, which change points when installing the present-day d.c. set, plus the natural loosening of the “madame” to have wires stretched here and yon about her drawing room. boudoir—or what have you.

The several sets now being put out by leading manufacturers are successful in only a comparatively small percentage of cases, and these very often because of the industry of the serviceman making the installation as regards filtering motors—known to interfere—putting filters in the d.c. line—experimenting with antennas, etc.

Is the manufacturer really interested in helping to solve this d.c. problem by putting out a set that will work perfectly well within a minimum, or must the serviceman continue to rub along as best he can under the circumstances?

My answer to the d.e. question is: A superheterodyne using a loop—disappearing when not in use—20a-type tubes—d.e. operated—cone cabinet with a self-contained dynamic loud speaker. Price: $200 to $500.00.

What is your answer? Solve it and the residents along Park Avenue will forever be in your debt.

[By the way, the portable used by the editor was exactly this].

Neat Connections with Bell Wire: It is possible to use ordinary bell or annunciator wire for hook-up and for external wiring purposes without having the work marred, as far as possible, by crossing and tangled final links. If first the outer cover is unwound as far back as desired, then the inner covering, which is wound in the opposite direction, is unwound to the proper distance and clipped short, there will never be any ragged ends hanging loose.

J. H. Bond, Dallas, Texas.

Testing Audio-Frequency Transformers: When doing service jobs I always carry a carbon microphone so that I can be connected across the primary of the first audio transformer in series with a six-volt battery. If, on speaking into it, the voice comes through the transformer the channel can be eliminated as the source of trouble.

BERNARD J. CANNON, Pittsburgh, Pa.

[Another simple way of accomplishing the same test is to connect a loud speaker across the grid leak of the detector tube, and speak against the diaphragm. The unit from an old long-distance line must be used, however, as it is conveniently in the service kit for this purpose. It is, as Mr. Cannon suggests, the simplest test for the audio channel—Editor].

Defective Transformers: The usual tests for an open primary will not locate a microphonic transformer. The method described may be an inexpensive and convenient check on the transformer receiver across the secondary. A defective primary will generally show up, as a loud scratching, after a few seconds. The effect of course may be very much enhanced by connecting to the line an oscillator.

C. WASHBURN, JR. Jacksonville, Fla.

Noise in the volume control: Here is a suggestion for remedying a difficulty which has turned up in some instances. If a set had not been used for some time and the weather has been damp, slight moisture may form at the point of the volume-control contacts. A condition of this kind will cause some noise when the volume control is adjusted. Fada Sales points out that although such a condition may not always be apparent, it is easily fixed by moving the contact arm back and forth until the slight oxide coating has worn away.

Watch for bad contacts: Two simple sources of improper contact which may cause trouble are worth mentioning. Receiver or amplifier microphone antennas connecting to the receiver through a plug and jack arrangement may develop noise due to dirty contacts. The trouble is usually corrected by replacing the plug with a bit of fine sandpaper. Contact prongs in the house-lighting plug circuit connecting the receiver to the convenience outlet may form a connection in the outlet is not tight. Noise resulting from
The Case of the Broken Vase: "A telephoned service call" writes D. F. Greer, Coatesville, Pennsylvania, "informed me that while the set tuned properly, it lacked volume. I assumed that it was probably a case of poor tubes, open transformer, or similar ailment. On testing the set, and checking the ground wires o.k. and routine tests showed no opens, no shorts, tubes good, plate and filament voltages correct, proper C. voltages, and still the set did not deliver a "kick." A new speaker was substituted with no change. I was on the point of removing the set to my shop for a bench test when I accidentally discovered the difficulty. In testing the B power unit, I had clipped the negative lead of the meter on the negative post and the positive lead at the time lay in my left hand. I gazed disgustedly at the set and toyed abstractedly with the extension cord of the loud speaker. There was a deflection in the voltmeter (the cord had been tested for continuity), and at the same time a tingling sensation in my hand. Then the truth dawned. The loud speaker was being shunted by moisture in the cord. I could not understand what caused the dampness until one of the maids confessed she had knocked over a vase containing cut flowers and the water had seeped deeply into the cord. This experience illustrated to me the value of a high-resistance voltmeter.

Antenna-Ground, connections: While there are several devices made for the purpose of bringing the antenna and ground wires into the house, the use of an ordinary convenience receptacle makes a neat job and one which is uniform with other receptacles and wiring in the house. I have found that the owners of higher-priced sets prefer this manner of entrance rather than the use of window strips and manufactured receptacles. A porcelain tube is used through the brickwork to insulate the antenna lead-in. The wires are then pulled through the knock-out in the rear of the receptacle and the ends clamped under the screws inside the box. A length of double-conductor and receptacle plug then connects the set to the outlet. Be sure to cut the hole in the basement to fit the box and not the outlet plate. Fig. 4 shows this method.

—D. L. Love, Greensboro, N. C.

Contributions on the routine of servicing, the general equipment, and tools employed are piling in on the service desk in response to our recent request for such material. Just what we are going to do with this—outside of the fact that it will be used—we don't know. It is possible that the material will prove of sufficient interest and length to justify a separate article—or perhaps we shall make a symposium of the various contributions—or, again perhaps, we shall pick the best points of all contributions and give them to you as a direct.

At any rate we are still open for suggestions on the routine of servicing and the simplest, yet complete, equipment with which to do it.

Francis H. Engel, Radiotron Engineer r, with the R. C. A., sends along the following suggestions relative to the rectifier tubes, and power tubes suspected of suffering from old age:

1. The loss of emission in a rectifier tube (which is the usual cause of failure) is quite often accompanied by an increase in alternating-current hum. The most practical and simplest method of determining whether or not the rectifier tube is defective is to remove the tube in question and substitute it in its place a new tube of known good quality.

2. The average life of the 281-type rectifier is greatly in excess of 1000 hours when operated under maximum rated conditions. Individual tubes may fall short of this figure but the large majority of them will exceed it.

3. Regarding a test for defective output tubes the same scheme as outlined above for the rectifier tube would seem best.

Many servicemen have written us asking for suggestions as to the best book available on the general theory of radio technology. We don't know any such book because each inquirer wants a book with some special emphasis to suit his particular needs. Most of our correspondents want a book that suits itself for daily dealing with receiving circuits, which does not devote major attention to the general theory of electrical circuits. There is such a book, indeed there are several. How Radio Receivers Work, by Walter Van B. Roberts, and published by Radio Broadcast, Garden City, N. Y., is $1 net contains precisely the simple analysis that is so welcome when it is found. Other useful books are listed on page 295 of this issue.

4. Another test which a serviceman should make when looking for trouble in the rectifier unit of a receiving set is to test for d.c. voltage across the output terminals of the filter and voltage divider. Knowing, from experience, the normal value he can readily tell by his meter reading whether or not the rectifier tube is operating satisfactorily.

Literature That Sells Service: The radio service business, for the greater part, concerns a commodity that sells itself. When a radio set actually goes wrong, the average person turns to the serviceman and it requires no salesmanism to convince him that his set needs repair. However, sales literature—circulars and cards describing the advantages of some particular serviceman or company—can go a long way toward building up a profitable service business.

Such literature acts in several ways. It reminds the radio owner that it is foolish to wait until his set actually goes bad—until he misses entertaining programs—before calling in the serviceman. It also impresses on his mind the name and address of a reliable serviceman. To many, such facts may call his attention to subtle difficulties existing in his set of which he was only vaguely aware.

Fig. 2 shows a card circulated by William V. Lowe, Certified Radiotistician, of Fitchburg, Mass., that gives a good idea of what can be done in the way of progressive servicing.

The possibilities of drumming up trade in this manner are enormous. Special circulars could be prepared, prior to important broadcasts, suggesting the inspection services of an expert at a special price. The average set owner should be educated into having his equipment examined at regular intervals—in the same way that the intelligent man goes to his dentist. Stock circulars can be prepared for distribution in the late summer suggesting that now is the time to have receivers gone over thoroughly in preparation for the coming radio season.

Good radio service sales literature might turn the summertime into a profitable radio season.

"The Serviceman's Corner" is particularly interested in circulars, letterhead and cards of this nature, and will pay a special price for those reproduced.

Arthur Rogers, New York City serviceman, has been building up sales on electric phonograph pick-ups by following up his old customers. He circularizes the owners of receivers he made several years back, adding to this list all recent service jobs on old equipment. He suggests modernizing these receivers by the installation of power amplifier apparatus and new speakers. The phonograph pickup naturally follows.

"The Serviceman's Corner" pays for live sales tips.

What should the serviceman charge? What is an equitable price for an inspection—for an hour's work? How should the serviceman figure his charges? Should the profit on parts lessen his charges for time? The "Serviceman's Corner" will welcome an exchange of ideas on this subject.

An antenna clamp which makes installation quick, and much neater than is often possible has been brought out by the F. G. Manufacturing Company, 1117 People's Bank Building, Indianapolis, Indiana. This clamp requires no nails or braces to affix it to the roof or chimney. A sample has been examined in the Laboratory and found very satisfactory. The picture, Fig. 3, shows how the device looks.
Explaining the Whole "Business"

IMPORTANCE OF IMPEDANCE RELATION

By C. T. BURKE
Engineering Department, General Radio Company

Conditions in Tube Circuits

IN COMMUNICATION circuits, the impedance of the circuit elements is often necessarily high, so that the current flow even under short circuit will not cause damage. Under these circumstances, with vacuum tubes it is possible to realize the theoretical maximum output of the device, obtained when the load impedance equals the generator impedance, and the so-called "matching" of impedances becomes important. That is, in connecting two circuits or devices together, it becomes important to have the impedance of the source circuit (the "primary") equal to the impedance of the load (or "sink"). For a concrete example, a power tube of 5000 ohms impedance will deliver maximum power to a load of 5000 ohms impedance.

The importance of exact matching of impedances is undoubtedly over-emphasized. In the power curve of Fig. 3 it will be noted that, while the maximum power to the load occurs with a load resistance of 5000 ohms, the load resistance can vary from 2500 to 10,000 ohms, a range of about 4 to 1, with only ten per cent. reduction in load power. Owing to a peculiarity in the behavior of vacuum tubes, the maximum unadjusted output will be delivered to a load of twice the impedance of the tube, i.e., 10,000 ohms for a 5000-ohm tube, and in designing a circuit this relation is usually aimed at.

The impedance of a device is determined generally by certain considerations in its design which cannot be altered conveniently to obtain the optimum impedance relation when the device is worked out of a source of a certain impedance. The remedy for this situation is fortunately quite simple, involving only the use of the so-called impedance adjusting transformer. The remainder of this article is devoted to a discussion of this important device.

Impedance Adjustment

IT WILL be remembered that impedance was defined as the opposition which a circuit offered to the flow of current, in other words the factor which determines the flow of current from a source of definite voltage and internal impedance. If, then, a load impedance may be so affected as to cause the same current to flow into the source as would another impedance, it is, so far as the source is concerned, equivalent to the latter impedance. If the load impedance is less than the source impedance that is, two methods of increasing it, by means of a series impedance, and by means of a transformer. The series impedance method does not generally accomplish the desired result. Under the conditions in which we are principally interested, i.e., a vacuum tube feeding a loud speaker, the series impedance is not effective. While the "matching" of impedance accomplished does increase the power output of the tube, it does not increase the input to the load, since the added power is dissipated in the extra series resistance. Similar reasoning will dispose of the suggestion of the use of a parallel impedance to reduce the load impedance. There is left as a possible means of impedance adjustment, the transformer.

The action of a transformer is to step-up or -down an alternating current or voltage. Since the transformer is not a source of power, the power must be the same on both sides except for the losses in the instrument. Power being proportional to the product of current and voltage, this product must be the same on both sides of the transformer, i.e., the current is stepped-up in the same ratio as the voltage is stepped-down, and vice versa. This ratio of transformation is the ratio of turns in the two windings (approximately).

Consider the loaded transformer of Fig. 1.

The definition of impedance may be stated algebraically as:

\[ Z = \frac{E}{I} \]

impedance = voltage \/

current

Then if \( Z_{eq} \) is the equivalent impedance of the transformer and load (the impedance which would permit the same current to flow as flows with the loaded transformer):

\[ Z_{eq} = \frac{E_1}{I_1} \]

\[ \frac{E_1}{I_1} = \frac{E_2}{I_2} \]

\[ Z_{eq} = \frac{E_1}{I_1} = \frac{E_2}{I_2} \]

where

\[ Z_{eq} \] - equivalent impedance of load from primary of transformer

\[ E_1 \] - voltage across primary

\[ I_1 \] - primary current

\[ E_2 \] - secondary voltage

\[ I_2 \] - secondary current

That is, the equivalent impedance of a transformer of a turns ratio of \( N \), loaded with...
The impedance \( Z_L \) is a squared time constant \( Z_L \), or the effect of the transformer is to multiply the load impedance by the square of the turn ratio which may be a fraction or an integer depending upon whether the high or the low side of the transformer is loaded.

In the foregoing discussion, the turns ratio of the transformer is assumed to be the only transformer characteristic entering the relation. This ideal condition does not actually exist and, in designing or selecting an impedance adjustment transformer, other factors must be considered. There are, of course, the power losses which invariably accompany the passage of power through a conversation. These, however, are small in a well-designed transformer. Most important, however, is the impedance of the transformer itself.

In discussions of impedance-adjusting transformers, the statement is often made that the primary impedance of the transformer should equal the impedance of the source, and its secondary impedance equal to the load, but this is a careless statement. The effective impedance of the loaded transformer is determined by the transformer.

Table of Wavelength Allocations

The following table gives the wavelength allocations which were adopted by the International Radiotelegraph Conference at Washington, D.C. The data show the type of service permitted in wavelength bands between 3 and 30,000 meters (60,000 and 10 kilocycles per second). This radio allocation plan, of course, is used in all civilized countries of the world, as it was adopted at an international conference.

<table>
<thead>
<tr>
<th>Frequencies in kilocycles per second (kc/s)</th>
<th>Approximate wavelengths in meters</th>
<th>Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-100</td>
<td>30,000-3,000</td>
<td>Fixed services, Mobile services and mobile services.</td>
</tr>
<tr>
<td>110-125</td>
<td>5,000-1,250</td>
<td>Mobile services, Maritime mobile services open to public correspondence exclusively.</td>
</tr>
<tr>
<td>125-150</td>
<td>2,500-1,875</td>
<td>Mobile services. (a) Broadcasting. (b) Fixed services. (c) Mobile services. The conditions for use of this band are subject to the following regional arrangements: All regions where broadcasting stations are not operating on frequencies below 3,000 kc. (above 1,000mks), (d) Broadcasting within the band 194-235 kc (1550-1400m), (e) Broadcasting within the band 194-235 kc (1550-1400m), (f) Mobile services except commercial ship stations, (g) Fixed air services exclusively. (h) Mobile services not open to public correspondence, (i) Mobile services not open to public correspondence.</td>
</tr>
<tr>
<td>150-160</td>
<td>1,875-1,550</td>
<td>Mobile services. (a) Broadcasting. (b) Fixed services. (c) Mobile services. The conditions for use of this band are subject to the following regional arrangements: All regions where broadcasting stations are not operating on frequencies below 3,000 kc. (above 1,000mks), (d) Broadcasting within the band 194-235 kc (1550-1400m), (e) Broadcasting within the band 194-235 kc (1550-1400m), (f) Mobile services except commercial ship stations, (g) Fixed air services exclusively. (h) Mobile services not open to public correspondence, (i) Mobile services not open to public correspondence.</td>
</tr>
<tr>
<td>160-194</td>
<td>1,875-1,550</td>
<td>Mobile services. (a) Broadcasting. (b) Fixed services. (c) Mobile services. The conditions for use of this band are subject to the following regional arrangements: All regions where broadcasting stations are not operating on frequencies below 3,000 kc. (above 1,000mks), (d) Broadcasting within the band 194-235 kc (1550-1400m), (e) Broadcasting within the band 194-235 kc (1550-1400m), (f) Mobile services except commercial ship stations, (g) Fixed air services exclusively. (h) Mobile services not open to public correspondence, (i) Mobile services not open to public correspondence.</td>
</tr>
<tr>
<td>194-285</td>
<td>1,550-1,050</td>
<td>Mobile services. (a) Broadcasting. (b) Fixed services. (c) Mobile services. The conditions for use of this band are subject to the following regional arrangements: All regions where broadcasting stations are not operating on frequencies below 3,000 kc. (above 1,000mks), (d) Broadcasting within the band 194-235 kc (1550-1400m), (e) Broadcasting within the band 194-235 kc (1550-1400m), (f) Mobile services except commercial ship stations, (g) Fixed air services exclusively. (h) Mobile services not open to public correspondence, (i) Mobile services not open to public correspondence.</td>
</tr>
</tbody>
</table>

1Mobile services may use the band 550 to 1,300 kc (545-230m) on condition that this will not cause interference with the services of a country which uses this band exclusively for broadcasting.

Note: It is recognized that short waves (frequencies from 6,000 to 23,000 kc approximately)—waves from 50 to 13m approximately—are very efficient for long-distance communications. It is recommended that the frequency limit for the 50 to 13m band be recommended as the band of waves reserved for this purpose, in services between fixed points.
our readers suggest...

Reducing Static

A SIMPLE and effective way to reduce heavy static crashes and other interference such as howls from radiating receivers to the signal level has been tried out by the writer on a number of receivers with gratifying results.

A neon glow lamp, such as is sold by electrical-supply houses for use as pilot lights on 110-volt lines, is the “magic lamp” which effectively reduces static to inaudible “plunks,” and cuts the ear-splitting howl of radiating receivers to a less offensive squall that does not rise in volume above that of the incoming signal.

The neon glow lamp, known as T14 and rated at 1/2 watt, costs 60 cents. It has a screw base, containing a resistance compound which prevents excessive current flow when used on standard light circuits. Carefully cut this screw base off with tin snips and remove the resistance compound, being cautious not to break the delicate bulb or the fine lead-in wire. Solder No. 30 copper wires to the leads. Bend a piece of light metal around the glass bulb so as to form a mold for a base. Drop in hot sealing wax or resin. This will harden into a base which will protect the tube and the delicate terminals.

The “static-spiller” is now ready to be connected in shunt with the loud speaker as suggested in Fig. 1.

The signal volume should be adjusted to suit the average requirements. At this volume setting the neon tube will not light at all, or only at rare intervals. When static is received if the surge is equal or smaller in amplitude than the incoming signals it will pass through unaffected by the neon tube, but it will be fairly innocuous. The crashing static that makes radio reception impossible is greater in volume than the received signal and therefore “spills over” through the shunting neon tube. When bad static is being received the crashes are visible each time they occur, the tube flashing brightly.

When the squall of a bloop comes through the tube lights, holding the squall down to the level of the received signal.


STAFF COMMENT

Mr. Starzl’s idea should be reasonably effective in many cases. It is not a static eliminator. It is merely a device that has a limiting effect on volume. If the device is set to operate above a certain arbitrary signal level, the effect of any disturbance above this limit will be reduced.

It will be desirable to adjust the neon-lamp circuit so that it spalls over at the correct intensity. If it spills over at too low a volume a variable resistor, such as a universal range Clarostat, should be placed in series with it.

A Good Coil Cement

AN EXCELLENT dope for coating solenoid coils, and for giving the necessary rigidity to spiderwebs and other self-supporting coils, may be made by dissolving one ounce of paraffin in one pint of high-test gasoline. This solution may also be used as a substitute for boiling in paraffin in almost any radio impregnation job.

S. W. OLDESHAW, Waterbury, Conn.

Ghostly At Least

I HAVE found that my radio set can be enjoyed by everyone in the house by means of a very simple device. I attached a long cord to my loud speaker, and passed it through the same hole that I use to bring my battery wires up from the cellar. Then I place my loud speaker directly in front of the opening where cold air is taken into the hot-air furnace. When I turn on my radio set, the pipes from the furnace serve as carriers, transmitting the music into all rooms of the house. Oftentimes a guest is quite mystified to hear this perfectly transmitted music coming out of the register.

JACQUE LONGAKER, Buffalo, N. Y.

STAFF COMMENT

The idea is novel—useful to an extent, and replete with humorous possibilities. But we should hesitate to second our contributor’s characterization of the reproduction as “perfectly transmitted.” Hot-air heating pipes hardly have the acoustic properties of an ideal loud speaker.

An Economical Voltage Divider

THE 2 candle-power 110-volt carbon lamps, purchasable at almost any five and ten cent store for ten cents, make excellent resistor units for radio purposes. Each lamp has a resistance of about 2000 ohms.

I have found them particularly applicable to the requirements of a voltage divider in power-supply units. A power source having a maximum potential of 180 volts will require from six to eight lamps for a “bleeder” arrangement. These may be mounted easily by placing them in holes, one inch in diameter, drilled in thin wood or a bakelite strip. After the lamps have been mounted they are connected in series by soldering directly to the screw bases. Employing eight lamps, any voltages between 0 and 180 may be had in 22.5 volt steps. A typical arrangement is suggested in Fig. 3. As usual, each voltage tap should be bypassed to B negative.

C. H. GALEBRAITH, Boston, Mass.

****

This department of Radio Broadcast is utilized each month for the presentation of miscellaneous short radio articles which are received from readers. These abbreviated manuscripts describe “kinks,” radio short cuts, and economies that the experimenter runs across from time to time and that can be made clear in a concise exposition. Although some of these notes have been submitted by engineers and professional writers, the editors particularly solicit contributions from the average reader. All material accepted, including photographs, will be paid for on publication at our usual rates with extra consideration for particularly meritorious ideas.

—THE EDITOR.

**Fig. 1.—A neon tube connected as shown above in an effective static reduce.**

**Fig. 2.—The vacuum-tube circuit shown above is an excellent variable-range high resistor.**

**Fig. 3.—A simple inexpensive voltage divider for a B power-supply unit.**
Data on Design and Operation

A HOME-MADE THERMIONIC MILLIAMMETER

By G. F. LAMPKIN

The characteristic of the current of the filament, however, is not necessarily the same as the average value of the filament current, for the filament current is determined by the change in the d.c. plate current. By suitable calibrations, and may be seen that a given change in r.m.s. filament current at a low initial current, say 38 mA, will produce only a fraction of the plate-current change that would be caused at a higher initial current 60 mA, for example. The resistance in the circuit diagram of Fig. 1 through which bucking-out current is fed to the plate meter is varied. The only control is the 0.4-milliamperes resistor.

The procedure in using the meter is to close the battery switch and adjust the filament rheostat until the plate meter reads zero. This will happen when the emission current equals the bucking-out current supplied through the 4-Volt battery and fixed rheostat.

Thus the size of the fixed resistor automatically determines what initial emission current must flow and accurately what part of the filament-plate current characteristic is to be used. If the value of the fixed resistor is low, the bucking-out current will be large. To produce an equally large emission current a higher initial filament current will be necessary, and the resultant sensitivity of the meter to a.c. will be good. However, extreme values of initial filament and emission current are detrimental to the tube's life and the accuracy of calibration and so should be avoided.

The calibration curves of Fig. 3 were made by measuring the superimposed 60-cycle current on the tube's filament, and taking the corresponding readings. With a 2500-ohm resistor in the bucking-out circuit, the initial plate current, which was required to equal the bucket-out current, was 1.6 milliamperes; and the superimposed a.c., which gave a one-milliamperc plate current range, was 3 to 18 milliamperes. Greater sensitivities can be had by working higher on the emission curve, i.e., with smaller values of bucking-out resistance, but such is not advisable. A 10,000-ohm resistor and an initial plate current of 0.4 milliamperes gave a range of 6 to 23 milliamperes a.c. (curve 2 of Fig. 3). With the bucking-out circuit opened, and the plate current adjusted to an initial current of 0.02 milliamperes, the a.c. maximum was 35 milliamperes (curve 1.). The calibration on the latter range departs much farther from the linear than does the one for 6-23 milliamperes.

The lower range calibration works over a more restricted and a straighter part of the emission characteristic, so that it does not show the sharp bend present in the 15-35 milliamperes curve.

It is important to note that there must not exist a d.c. path in the circuit which carries the to-be-measured a.c. A d.c. path would draw current from the filament battery of the tube and disarrange the zero setting. In

Parts required for construction of a 33-m. A thermionic milliammeter

The author of this article, who is no stranger to the readers of Radio Broadcast, has used the meter described in this article to determine the frequency characteristics of receivers, the currents into loud speakers, the a.c. power-supply chokes whose inductance was being measured, and, as he says, never yet met a user that will measure accurately small values of a.c. many other uses will be found for it. It is much less expensive than a combination thermo-couple and microammeter—and repairs are less costly, too.

The Editor

View of the author's thermionic milliammeter set-up

marc, 1929 . . . page 325
ampere curve
emission
to calibrate
approximately
of
condenser
such cases it would be necessary to insert a condenser in the a.c. leads to the tube. The size of the condenser is determined by the impedance which it is permissible to insert in the circuit carrying the a.c. The resistance of the thermionic meter alone to the a.c. is approximately 50 ohms.

**Calibration by Calculation**

The check between calculated and calibrated points agrees within 3 per cent. and this shows that it is not necessary to have 20- or 40-milliampere a.c. meters at hand to calibrate the thermionic meter. From the known data as to initial filament-current and emission characteristic it is perfectly feasible to get good calibrations by computation. The procedure followed for the 6-33 milliampere curve (curve 2 Fig. 3) was first to measure the bucking-out current through the 10,000-ohm resistor. This was 0.4 milliamperes. From the emission curve of Fig. 2, 0.4 milliamperes corresponds to 46 milliamperes, the initial filament current. This is \( I_{ac} \) in the formula above. Then values of superimposed \( I_{ac} \) were assumed—say 7, 10, 11, etc. milliamperes—and the resulting r.m.s. values figured. For instance, for 10 milliamperes of assumed a.c.,

\[
I_{rms} = (10)^2 + (10)^2 = 2116 + 100 = 61.4 \text{ mA}
\]

Going back to the emission curve, 47.1 milliamperes in the filament gives 0.52 milliamperes plate current. Although 0.4 milliamperes already flow in the plate circuit, the meter reads only 0.12 mA, because of the bucking-out current. Thus the meter reading of 0.12 milliamperes corresponds to 10 milliamperes of superimposed a.c. In the case of the 15-35 milliamperes curve (curve 1 Fig. 3) there was no bucking-out current. The initial plate current of 0.02 milliamperes meant a filament current of 35 milliamperes. The combination with an assumed value of 35 milliamperes a.c. gives:

\[
I_{rms} = (35)^2 + (35)^2 = 1225 + 1225 = 48.8 \text{ mA}
\]

The plate current for 48.8 milliamperes filament current is 0.75 milliamperes. Thus the plate meter reads 0.75 mA. 33 mA, a.c., flows through the filament.

Both the filament battery and the bucking-out battery circuits on the meter set-up can be opened, and a.c. alone used to heat the filament—when case currents from 35 milliamperes up can be measured. If lower current ranges are not necessary, the thermionic meter becomes simpler by itself. The raw materials required are only the tube, the one-milliampere meter, and a 225-volt B battery. There are no restrictions as to d.c. path in the circuit in which current is measured. The wave shape of the current is immaterial—on any sort of wave the meter reads the r.m.s. value. Shunts may be used to extend the range indefinitely upward. The fact that a filament-current change of only 35 to 50 milliamperes gives full-scale change on the plate meter is both an advantage and a disadvantage. The limited a.c. range allows an open and easily read scale so that currents can be determined accurately. It also means, however, that an inconvenient number of points must be used to get overlapping ranges.

A possible alternative is to connect the grid and the plate to one side of the filament. By doing this the rate of increase of plate current with filament current is cut down, and a range of approximately 35 to 60 milliamperes results. In other words, the minimum readable current is 58 per cent. of full-scale value as compared with 70 per cent. when the grid is tied to plate. However, this alternative method makes the plate current dependent in a greater measure on the plate voltage, so that changes in plate voltage damage the accuracy more than in the case of grid-plate connection.

In Fig. 4 are given sample calibrations for the tube (grid connected to plate) when carrying a.c. alone, with and without shunts. These calibrations may be made with either d.c. or a.c. and then be used to measure any sort of a current.

(Editors Note: Mr. Lampkin has indicated briefly the uses to which such an instrument as he describes can be put. Anyone who has worked in the laboratory where small a.c. potentials must be measured, either at low or high frequencies, will appreciate the advantages of this combination of tube and d.c. meter.

As an example, let us try to measure the impedance offered to a 60-cycle current by a 300-ohm choke and requires methods, all of which are more or less complex. This impedance, however, is largely inductive reactance, and, if we knew the current through the coil at a given a.c. potential across it, this reactance could be calculated. From this would come the value of inductance and impedance in which we are interested. At 30 henries and with a c.a. potential of 110 volts, the current through the coil will be about 10 milliamperes. Now a thermocouple that will measure currents of this value costs about $25 and requires a sensitive d.c. microameter in order to read the rectified current. This meter will cost not less than $35 and probably amount to $100. Therefore, in order to measure this small current of 5 to 10 milliamperes, equipment worth over $100 is required.

The device described by Mr. Lampkin will measure this current easily and at much less cost than by the use of a thermo-couple and indicating meter. It is only necessary to put an initial current through the filament of the tube and then to add the current going through the choke. The differential of filament current will correspond to currents of filament current that have been calculated, the meter is immediately useful. The change in plate current caused by the change in filament current can be obtained from a curve similar to those given on this page.

Other uses for the device have been indicated in the box on the preceding page.

In all of the cases where a.c. and d.c. both flow through the device under measurement, care must be taken to prevent the d.c. current from flowing into the tube filament. This may be done by the expedient of using a large fixed condenser through which the a.c. will pass but which offers a very high opposition to the flow of d.c.

This milliammeter is one that can be built and operated by any home experimenter or any laboratory worker. The requirements are simple, a d.c. meter reading about one milliampere, a 60-milliampere filament tube, and a little patience at calculating what plate current will be read when a given a.c. current is added to the filament current. As the author points out the resistance of the voltmeter to the a.c. currents which it is designed to measure is of the order of 50 ohms. The effect of the resistance of the circuit in which this a.c. currents flow must be taken into account, but in general such an addition will not upset the circuit condition.
THE MAJESTIC MODEL 70-B RECEIVER

This seven-tube Majestic receiver consists of a three-stage tuned radio-frequency amplifier, a detector and a two-stage transformer-coupled audio-frequency amplifier, the output circuit of which is push-pull using two 171-A-type tubes. The power unit supplies A, B, and C potentials to the set and also provides field current for a Majestic model G-2 dynamic loud speaker.

THE FEDERAL TYPE D (60 CYCLE) RECEIVER

This interesting receiver manufactured by the Federal Radio Corporation uses four 201-A- and one 171-A-type tubes in a series filament circuit, the necessary current being furnished by a Raytheon A-type rectifier. It should be noted that the filament circuits of the r.f. amplifier tubes contain r.f. choke coils to prevent common-coupling in the filament supply.

The data which was given in the description of the receiver in previous "Set Data Sheets" has been lettered on the above diagram.
THE CROSLEY MODEL 704-B RECEIVER

This popular model in the Crosley line is a complete a.c. set. The Hazelfoe neutrodyne circuit is used in the r.f. amplifiers to prevent oscillation. The circuit of the power supply is designed to furnish the current to a Crosley Dynacone loud speaker although any type of loud speaker may be used with the set. The output circuit is push-pull.

THE CROSLEY MODEL 705 RECEIVER

This light-socket-operated receiver is designed for use in districts where the only power supply available is 110 volts d.c. The set uses five 201A- and three 171A-type tubes in a series-filament circuit. The two push-pull 171A-type tubes in the output are supplied with about 90 volts so the available a.f. output is 100 milliwatts per tube giving a total of 300 milliwatts.

The data which was given in the description of the receiver in previous "Set Data Sheets" has been lettered on the above diagrams.
THE 250-type power tube was developed to fill a definite place in the field of radio reception, that of a tube which would deliver a large output to a loud speaker without appreciable distortion and with a grid swing or input signal strength readily obtainable with available apparatus.

The tube as finally developed has been found to meet this requirement well. A filament of the coated type is used which insures an ample electron emission with a moderate filament power consumption. The plate resistance is inherently low, a plate voltage of only 450 being required for full power output.

The general characteristics of the tube were determined according to its intended use as a power amplifier. Consequently it is not well adapted for use as an oscillator or voltage amplifier. The use of a coated filament together with the low amplification factor, which were found to be very desirable features, are not ideal from the standpoint of oscillator tube design, although the tube can be used as an oscillator in certain cases.

Before going into the details of the development of the 250 it may be of interest to consider some of the factors which have made the production of tubes of high power output desirable.

A very few years ago about the only kind of loud speaker in general use was of the horn type operated by a vibrating metallic diaphragm. The characteristics of this type of loud speaker were such as to accentuate greatly the higher frequencies and to suppress the lower frequencies. Recent developments, however, have made it possible to reproduce frequencies well below 100 cycles with practically normal relative intensity.

A general idea of the relatively large amount of power that the output tube must handle in order to reproduce the lower frequencies adequately may be secured by examination of a curve in the paper "An Analysis of the Voice-Frequency Range" by I. B. Crandall and B. MacKenzie, Bell System Technical Journal, July, 1922. This curve shows in a striking way that in normal speech the power associated with the low frequencies is enormously greater than that associated with high frequencies.

The same general relation may be observed readily by the use of an oscillograph or a milliammeter inserted in the output circuit of a receiving set. Low notes at intensities which are not particularly striking to the ear are seen to have amplitudes many times greater than those of the higher notes. This effect is evident with speech, with music, or in instrumental music is being studied.

A little thought will show that the use of tubes designed low power output in sets equipped with transformers which pass the low notes will, unless the output of the set be very much reduced, result not only in bad distortion of the low notes, but also in many cases the complete obliteration of the high notes.

Table I shows the power output, grid swing and other characteristics of the tubes which have been developed from time to time in order to meet the growing demand for a larger power output.

Analysis of Various Types

OF THE tubes listed the 199- and 201a-types are general purpose tubes, the others were designed primarily as output tubes. The 112a, however, while distinctly an output tube, has a high amplification factor which makes it useful as a voltage amplifier and detector as well. The 210 also has a fairly high amplification constant which facilitates its operation as an oscillator; but as a power output tube, although the plate voltage is high, the grid swing is only 35 volts and the power output low compared with that of the 250.

The power output of the 250 is about ninety times as great as the output of the 201a which originally was used as the output tube of most storage-battery-operated sets at the time when the horn-type loud speaker was common.

Most people readily appreciate the advantages of increased volume when it has been demonstrated that this can be obtained without distortion.

With the relatively poor fidelity of reception that was formerly obtained, people having a well-developed sense of musical harmony, generally preferred to use low volume due to their unconscious objection to the distortion at full volume. In many cases it was contended that the music was too loud although it was the distortion accompanying high volume which was the real source of the objection. With the best equipment now available most people, after becoming accustomed to the fact that good volume may be obtained without distortion, prefer to have their sets adjusted for a more normal volume.

Development of the 250

A THE time work was started on the development of this tube it was decided to limit the plate potential to 450 volts; and in order to keep the physical dimensions within limits that would permit the use of the standard chassis base the plate was limited to a size which was estimated to be able to dissipate 25 watts without an unduly high temperature rise; the blackening of the plate makes a larger heat dissipation possible, due to the resulting increase in thermal emissivity. It was further estimated that with one stage of audio-frequency voltage amplification, using equipment now available, a grid swing of 80 volts peak could be obtained.

With these factors fixed at a starting point, several tubes were made up having amplification constants ranging from 2.5 to 8.3.

A set of static characteristic curves was then taken for each tube and these was calculated the maximum undistorted power output that could be obtained, using in each case the optimum value of load impedance and grid bias. The plate current in all cases was limited to 55 milliamperes, the value corresponding to a heat dissipation of 25 watts.

The maximum second-harmonic distortion permitted in these calculations was five per cent., a value which has been assumed generally to be inappreciable in effect on reproduction.

The methods of calculating the maximum power output from a set of static characteristic curves have been described in detail by others ("Design of Non-Distorting Power Amplifiers" by E. W. Kellogg, Proceedings A.I.E.E., Feb., 1925, and "Output Characteristics of Amplifier Tubes" by J. C. Warner and A. V. Loughren, Proceedings I.R.E., Dec., 1926); a brief outline of the procedure will be sufficient here.

For a moderate plate voltage at which the heat loss at the plate is below the maximum allowable, the best load impedance is equal to twice the tube impedance. That this is true has been shown theoretically by W. J. Brown ("Symposium on Loud Speakers," Proceedings of London Physical Society, 36, Part III, April, 1924) and was verified experimentally by Hanna, Sutherland, and Upp preceding their development of the 250.

An actual determination of the proper load impedance and grid bias for maximum power...
output at a given plate voltage involves a considerable amount of cutting and trying, due in part to the fact that the tube resistance varies with plate current. The most straightforward procedure is probably that of taking points on the plate-current curves, at the desired plate voltage, corresponding to several values of plate current and determining for each the load impedance that will give the maximum power output without excessive distortion. Fig. 6.

The power output in watts for any dynamic curve is given by:

\[ W = \frac{1}{8} (1 \text{ max} - 1 \text{ min}) (E_{\text{p max}} - E_{\text{p min}}) \]

The minimum plate current is that where the negative grid swing is equal to the fixed grid bias.

When this has been done it will be found that the ratio of the load resistance to the plate resistance, \( R_L/R_0 \), becomes less as the plate current is increased or the grid bias is decreased; and that the maximum power output is obtained at a point where the ratio is equal to approximately two.

If, however, the plate current at this point is greater than the maximum allowable, the output corresponding to the maximum plate current on the power curve must be used, the load impedance being in this case greater than twice the tube impedance.

Fig. 3 illustrates one step in the procedure, the second-harmonic distortion due to the curvature of the dynamic characteristic. The formula used is:

\[ \frac{1}{\text{max}} - I_{\text{min}} \]

and gives the amplitude of the second harmonic component as a decimal of the amplitude of the fundamental.

Fig. 1 shows the relation between the power output obtainable at various plate voltages and the load impedance. The curve marked \( V_{\text{p max}} = 25 \) shows the limiting values as determined by a plate dissipation of 25 watts. This curve also shows that when the plate current becomes the limiting factor, a load resistance greater than twice the tube impedance should be used. For example, at \( E_{\text{p max}} = 500 \), the load resistance should be 2.8.

In Fig. 4 are summarized the results of the work done on the tubes of different amplification constants. Curve 1 shows how the maximum undistorted power output varies with amplification constant, the dotted portion indicating how the output would increase if the plate dissipation were not a limiting condition. Curve 2 shows the corresponding grid swing required in peak volts.

It will be seen that the grid swing required to operate the tube at full output becomes rapidly greater as the amplification constant decreases. Also it will be noted that the power output reaches a maximum and then decreases. Both of these conditions are due to the fact that at low values of amplification constant the grid becomes less effective in controlling the electron flow to the plate. This results in an excessive curve of the plate-characteristic constant which gives a correspondingly limited working range when the maximum distortion permitted is fixed at a low value.

Fig. 5 shows the relation between maximum undistorted power output and plate voltage. Over a limited range the power output may be taken as proportional to the square of the plate voltage.

Figs. 2 and 7 show the static characteristic curves.

The dotted curves of Fig. 7 correspond to a filament voltage of 7. The maximum undistorted power output is in this case 4.27 watts, a grid swing of 78 volts being required. It will be seen that there is little loss in maximum power output or in sensitivity when the tube is operated, and it is, in fact, frequently preferable to operate the tube slightly below normal filament voltage in order to protect it from over voltage due to line fluctuations when, as is usually the case, it is operated on alternating current. Careful control of filament voltage will help materially in securing satisfactory operation and long life.

The inter-electrode capacities are from grid-to-plate 9 muf., from grid-to-filament 7 muf., and from filament-to-plate 5 muf.

**Table I—Power Output of Various Tubes**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>( E_{\text{p max}} )</th>
<th>( E_{\text{p min}} )</th>
<th>( E_{\text{p max}} )</th>
<th>( E_{\text{p min}} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>199</td>
<td>90</td>
<td>4</td>
<td>6.6</td>
<td>15,500</td>
</tr>
<tr>
<td>125</td>
<td>135</td>
<td>22.5</td>
<td>3.3</td>
<td>6600</td>
</tr>
<tr>
<td>201A</td>
<td>135</td>
<td>9</td>
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*To negative end of filament.

**Operation of the 250**

The 250, requiring for full power output a grid swing of 80 volts, has been designed to be operated from a detector followed by one stage of audio-frequency amplification.

By the use of a high plate voltage on the detector, and the plate-current method of detection the intermediate stage of audio-frequency amplification may be omitted. This will tend to improve the quality, due to the elimination of any audio transformer, as well as to the improved detector action when plate-current detection is used. This, of course, will require rather high radio-frequency amplification preceding the detector. The power supply for use with an amplifier employing a 250-type output tube should use too 281-type half-wave rectifier tubes in a full-wave circuit.
IN THE RADIO MARKETPLACE

News, Useful Data, and Information on the Offerings of the Manufacturer

Two New Tubes

A LEAST two new tubes will be released during 1929; one is a new power tube which will (according to information given by Philco operators) have been made by the National Carbon Company, makers of batteries and receiving sets. A survey made under their direction developed the fact that there are more than 10,000,000 homes in the United States that are not wired for electricity and cannot use a.c. sets. Of this astounding number, very few are not potential customers for radio sets.

Many dealers have allowed this large market to escape their notice because of the justified popularity of the a.c. set. The National Carbon Company have formulated a plan to help dealers sell this large market. The principal points in their plan are:

1. The dealer is asked to ascertain from his local chamber of commerce, bank, or other authority, the approximate limits of his trading area.
2. He is asked next to consult either the United States census or county maps for the approximate population of his trading area.
3. Dealer then divides this total population by 4.3, which will give him the approximate number of families. This will be the total potential market for both a.c. and battery-operated sets.
4. Following that, he ascertains from his electric light and power company how many of these homes are wired. (This is the number of residential meters in his area.)
5. Dealer subtracts the number of wired homes from the total number of families and he has the approximate number of homes which cannot use a.c. radio sets. This represents his market for the modern battery-operated set.

It is suggested that dealers order their stock of a.c. and battery-operated sets accordingly.

Some interesting information turned up as a result of the survey. Washington, D. C., is regarded as one of the most urban communities in the country. A large part of the District of Columbia is unlighted; it is estimated that there are no fewer than 28,000 homes in the District unwired for electricity and potential markets for battery sets. Ohio has 915,000 unwired homes; Kentucky, 418,700; Pennsylvania, 852,500; North Carolina, 514,900. The total for the entire United States is 10,539,510. In many states it is estimated that the battery market is 70 per cent. of the total.

Freshman Price Reduction

ON JANUARY 17, the Chas. Freshman Company announced a price reduction on all cabinet models of the Freshman line. The new list prices of the various models are as follows: Q-16, $99; OD-16, $129; N-12, $189; N-17 $195. These prices do not include tubes.

How to Sell Battery Sets

SALES suggestions of wide use to those interested in the market for battery-operated receivers have been made by the National Carbon Company, makers of batteries and receiving sets. A survey made under their direction developed the fact that there are more than 10,000,000 homes in the United States that are not wired for electricity and cannot use a.c. sets. Of this astounding number, very few are not potential customers for radio sets.

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Roger Wise With Majestic

ROGER M. WISE, for many years chief engineer of E. T. Cunningham, Inc., has left that organization and joined the Grigsby-Grunow Company of Chicago, manufacturers of Majestic radio sets and loud speakers. A tube manufacturing division, it is said, will be added to the other manufacturing activities of Grigsby-Grunow.

New Receivers Announced by Fada

RECENTLY Fada announced several new receivers containing such features as push-pull amplification and dynamic loud speakers in the console model. This new Fada is an eight-tube set using five 227-type tubes, two 171A-type tubes, and a 280-type rectifier tube. The circuit consists of three stages of tuned r.f., detector and two-stage audio amplifier, the last stage being push-pull. Fada 32 uses the same circuit and tubes as the 16, but operates in the tuning range from 1210 to 1410 kilocycles in a console with a built-in dynamic loud speaker. The Fada 18 is a d.c.-operated set designed to fulfill the needs of those living in districts supplied with direct current, and will be released in a console with a built-in dynamic loud speaker. The Fada 18 uses five 112A tubes and two 171A tubes in a circuit similar to the model 16. Other items in the Fada line are the model 72 radio-phonograph combination, the model 14 magnetic speaker, the models 14 and 15 dynamic loud speakers.

Federal Series-Filament Sets

THE models F-10 and F-11 Federal Orthodonic receivers are designed for either a.c. or d.c. operation and they use ordinary 1-ampere tubes in a series-filament circuit, all the necessary A, B, and C potentials being supplied by a Raytheon 3A-type rectifier. The four r.f. stages and the first audio stage employ 101A-type tubes. The detector is a 112A tube and the output stage uses a 171A-type tube. The order of the tubes in the series-filament arrangement is first r.f., second r.f., third r.f., fourth r.f., detector, and finally second a.f. The set is completely shielded and carefully neutralized. If the set is to be supplied from d.c., i.e., a storage battery and a B-power unit, it is simply necessary that the tube filaments be connected in parallel instead of in series.

New Philco Console Receiver

THE New Philco line for 1929 features a 10-console set selling at the low price of $157. The set is entirely a.c. operated and contains eight tubes including a rectifier. Into the console is built a dynamic-type loud speaker. There are two other models in this line, the Highway selling for $275, without tubes, and the Lowboy selling for $215. All of these sets use the same circuit, consisting of a neutralized tuned r.f. amplifier followed by a two-stage audio amplifier with push-pull in the output. The Philco Company feel that these sets will require a minimum of servicing but have nevertheless arranged the design of the set so that all connections may be reached easily so that any servicing which may be necessary can be done quickly and efficiently.

Polynet to Make Coils

THE Polynet Manufacturing Company of New York has announced the purchase of the Colton Electric Manufacturing Company of Easton, Pa. Polynet is now in a position to supply filter blocks, condensers and resistances, and, with these added facilities, coils for power transformer, audio transformers, moving-coil loud speakers, power packs, etc., being manufactured.

Jensen Auditorium Loud Speaker

A N auditortium-type dynamic loud speaker is being manufactured by the Jensen Radio Manufacturing Company. This loud speaker will have a field coil of 2250 ohms and it will consume a current of 90 mA at a potential of approximately
The Radio Dealer’s Note Book—No. 1 Interference Filters

The electrical noises from oil burners, battery chargers, heating pads, spark igniters, vacuum cleaners, dental motors, electric thermostats, sparking brushes on motors, etc., can be amplified and detected by a modern sensitive radio receiver almost as well as it can amplify and detect the signals from broadcasting stations. The latter is a desirable program, the former is certainly undesirable. As receivers have become more sensitive the problem of eliminating interference due to electrical appliances has become a pressing question of constantly increasing importance.

If general electrical interference cannot be eliminated by attaching some gadget to the receiver—the interference must be eliminated at the source. Fortunately, however, there are now available a large variety of devices designed for use at the source of interference and their installation is a simple problem.

We have listed in the table all the interference devices on which we have data available at this time. From the table some idea of the wide variety of devices available can be obtained but it is not possible here to point out the many uses to which they can be put, or the manner in which some of the manufacturers have arranged the devices so that they can be installed easily and quickly.

The problem of installing interference preventers is the job of the dealer and serviceman and data on these devices should be in the hands of all those who do servicing. As a service to readers, the Editors have arranged that servicemen may receive complete information on all the devices listed in the table by simply writing to the Service Department of RADIO BROADCAST and requesting the data on interference devices. We would suggest that in all cases a card or letterhead be enclosed with the request to identify the writer as a serviceman or dealer.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Type No.</th>
<th>Price</th>
<th>Line Voltage</th>
<th>Wattage Rating</th>
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<td>3.00</td>
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Note: Line voltages are a.c. unless otherwise specified.

200 volts; the field current will be supplied by a full-wave rectifier system using the 280-type rectifier tube. The 220 c.c. model has the same field as the a.c. model but it is intended that the field will be supplied from 220-volt d.c. service mains—in this model a transformer and rectifier are of course unnecessary. The type 110 c.c. model is to be supplied from 110-volt d.c. mains. The field resistance is about 600 ohms and the field current, therefore, is about 180 mA. It should be noted that the power consumed by the field in each case is about 20 watts. The cone has a diameter of 12 inches.

A Super-heterodyne Kit Set—The Tyman “80”

A LL radio receivers in use today fall into one of two broad classes, that group in which the signal is amplified at the frequency at which it is received and a second group in which the signal is amplified at some frequency other than that at which it is received. In the first class are the tuned r.f. sets and in the second class fall all the superheterodyne sets. Past receivers have been attached to individual makers of receivers in both classes, but in principle and general design they remain essentially the same.

The new Majestic model 21 is completely shielded seven-tube receiver. The cabinet is of ‘post-colonial’ design and the built-in loud speaker is a dynamic type.

The Tyman Imperial “80” employs a first detector, oscillator, and three stages of intermediate-frequency amplification using a.c. screen-grid tubes and operating at a frequency of 480 kc. The i.f. amplifier is followed by the second detector and a two-stage transformer-coupled a.f. amplifier. The power tube is a manufacture supply. Interchangeable coils are provided so that the set may be used for both broadcast and short-wave reception.

In the design of the i.f. amplifier a very complete set-up of laboratory instruments and equipment was necessary to measure accurately the efficiency of the a.c. screen-grid tubes at frequencies of about 500 kilocycles. The efficiency of the screen-grid tube operating as an impedance-coupled amplifier was the most critical step to gain per stage while the characteristics of a band-pass filter was the goal for selectivity.

The actual gain of an impedance-coupled screen-grid tube is of no importance as a satisfactory figure—but the width of the bottom of the curve is too broad for good selectivity.

In order to obtain the maximum efficiency from a screen-grid tube it was found necessary to tune the plate circuit with a low-loss coil and condenser combination. An interesting thing was noticed with regard to the relative amplification obtainable from a screen-grid tube with various LC ratios. A one-inch diameter coil form was used with a variable condenser. The first measurements were made with approximately 0.005 in. of capacity tuning the one-inch diameter coil. Only enough turns of wire were used to have sufficient inductance to tune to 500 kilocycles.

With a coil of 140 turns of No. 30 enamelled wire on a one-inch diameter form tuned with a one-turn moving capacity, a gain of 16 db was obtained. The greatest gain, 21 db, was obtained by fifteen turns. A coil of 325 turns of No. 34 enamelled wire was tuned with a few micromicrofarads to the same frequency and a gain of 31 db was obtained. This data was the basis of all further work on Tyman intermediates.

Finally experimental work was begun upon tuned primary and secondary circuits, the first results were discouraging because of the general characteristics of coupled tuned circuits which produce double-peaked curves. This led to the measurement of loosely coupled tuned circuits. It was found that by just barely coupling the two circuits a result as shown in the curve insert (a) of Fig. 1, could be obtained. Then by carefully decreasing the LC ratio of both the primary and secondary circuits an actual amplification in the order of twenty-five to thirty per stage was possible.

To improve the selectivity of the first-detector circuit regeneration was employed. Some of the r.f. current in the plate circuit of the first detector were fed back to the lower end of the antenna coil by a small semi-fixed condenser C1, which is adjustable from the top of the set by a screw driver. Once set it should not be necessary to readjust it unless antenna or tubes are changed.

**Biasing Resistor**

In designing the rest of the circuit, provision was made for obtaining grid-bias voltage for.
The use of heater-type tubes permitted the employment of individual grid-bias resistors which were connected between the cathodes and ground.

The volume control had to be independent of frequency and should not detune the set or spoil fidelity. The best place for such a control is before the second detector and by experiment it was decided the best method was to increase the grid bias on two of the screen-grid tubes by varying the biasing resistor, \( R_c \), connected between the cathode and ground. This resistor had to be so designed as to be able to give a small amount of bias at its minimum-resistance position and the value of resistance had to increase at a uniform rate until maximum resistance was attained in order to get sufficient grid bias at minimum-volume position or maximum-resistance position. It was found that when the grid bias upon a 222-type or screen-grid tube was 0.005 volts the amplification was greatest, and, as the grid bias was further increased or decreased, the amplification began to decrease. The volume control was, therefore, designed to have a value of minimum resistance which kept the grid bias on the two intermediate-frequency screen-grid tubes at about 0.05 volts—the best value.

The Audio System

The audio of the Tyrman "80" was designed especially for the 222-type tube and the frequency characteristic of the audio amplifier is sufficiently wide to give the utmost in fidelity. Bypass condensers of 250 mfd. are essential with the 250 power amplifier and a good loud speaker.

Bypass condensers are an essential part of the Tyrman "80." It was found necessary to bypass individually each of the bias resistors. This tended to eliminate the possibility of coupling through a common grid circuit. A filter block consisting of six 1-mfd. condensers is provided for bypassing the 150- and 50-volt B-supplies and for bypassing the audio circuit.

It was found necessary to incorporate a special filter, consisting of a resistance and a capacity, in the first audio circuit. Without this filter it was found that at times instantaneous hums imposed upon the power pack by the 250 tube (due to overloading) caused plate modulation of the detector circuit and resulted in "motorboating."

Power Pack

The power pack for the Tyrman "80" was designed with three ideas in mind, first, low burn, secondly, plenty of available output, and thirdly, reliability. The power pack has a transformer which can be overloaded one-hundred per cent. without causing serious trouble. Normally, it operates at a temperature far below the normal temperature at which the transformers of this type are usually operated. The voltages delivered by the secondaries are such that line voltage can vary from 100 to 130 without causing trouble with the set or the tube. The filament or heater potential is set at 2.1 volts and, although the tubes will operate at 1.9 volts and also at 2.3 volts, this point was found to be the most desirable for average conditions.

In order to obtain the amount of current necessary for good regulation and for operating the dynamic-speaker field directly from the power pack, it was necessary to use two 281-type rectifying tubes but this was more than compensated in the increased reliability of the power pack. The Tyrman "80" power pack can be used to energize any 100-volt dynamic-speaker field which does not require more than 45 milliamperes.

The mechanical or chassis design of the Tyrman "80" makes it a pleasure to wire the set because no wiring is necessary above the subpanel. The fact that all of the grid circuits are returned directly to ground eliminates a great number of wires in the set and also prevents the possibility of interstage feed-back due to parallel wiring.

The parts for this receiver are sold only in kit form by the Tyrman Electric Company. The total cost of a complete set of parts for the receiver and power supply is $199.50.

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Fig. 1—Complete schematic diagram of the Tyrman Imperial "80" super-heterodyne receiver. Insert A: frequency characteristic of i.f. amplifier stage.
A Varied List of Books Pertaining to Radio and Allied Subjects Obtainable Free With the Accompanying Coupon

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3. Distortion and What Causes It—Hook-up of loud speakers and pertinent data on distortion. ALLEN-BRADDLEY COMPANY.
4. The construction of various types of bakelite in radio, its manufacture, and its properties: HARDCASTLE & BLACK COMPANY.
5. A Primer of Electricity—Fundamentals of electricity with reference to the application of dry cells to various radio uses. Describes the construction of switches, alarms, etc. National Carbon Company.

6. A tube data sheet showing how a relay may be used to control A audio tubes. YALE & TOWNE MANUFACTURERS CO.
7. Tube Characteristics—A data sheet giving dimensions, specifications, and prices used with various tubes. BERTON ROGERS CO.
8. Way Radio Is Better With Battery Power—What dry-cell battery to use; their application to radio, wiring diagrams, and prices. WESTERN TELEGRAPH CO.
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10. Radio-Frequency Chokes—Circuit diagrams illustrating the characteristics of a.c. chokes, f.c. chokes, and data on choke characteristics. SAMSON ELECTRIC COMPANY.
11. Radio-Frequency Data Sheets giving the mechanical and electrical characteristics of tubes, together with a short description of their use. SAMSON ELECTRIC COMPANY.
12. Tube Reactivator—Information on the care of tubes and tubes used to build receiving sets. THE STEELING MANUFACTURING CO.
13. Electronic Troubles—A book of meters used in radio, with diagrams. BERTON ROGERS CO.
14. Construction of Radio Meters shows how to build long-wire meters, with illustrations. BERTON ROGERS CO.
15. How to Select a Receiver—A common sense look at the receiver, and what to look for in a receiver. Twenty pages of constructional data on receivers. DAY-FAN ELECTRIC COMPANY.
16. A very interesting booklet on the relationship between weather and radio reception, with maps and data on predicting the probable results. TAYLOR INSTRUMENT COMPANY.
17. Vacuum Tube Characteristics of the various tube types with a short description of where they may be used in the circuits; list of American Material in the Vacuum Tube Corporation of America.
19. Radio Supplies—A non-technical booklet giving pertinent data on various radio supplies of special interest to the beginner and set builder. CROSLEY II RADIO CORP.
20. Electronic Troubles—A pamphlet describing the use of electrical testing instruments in automotive work. Contains information about the characteristics of the cadmium battery for storage batteries. Instructions to the owner of storage batteries. DUNTON ELECTRIC CO.
21. Better Tuning—A booklet giving much general information on radio reception with specific data on the tubes used. FREDERICK & THURLOW MANUFACTURING Co.
23. Radio Supplies—A non-technical booklet giving pertinent data on various radio supplies of special interest to the beginner and set builder. CROSLEY II RADIO CORP.

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106. Vacuum Tubes—Operating characteristics of an a.c. tube with curves and circuit diagram for conversion of various receivers to d.c. operation with a four-stage push-pull amplifier. THORDARSON ELECTRIC COMPANY.
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R. B. 3-25
WHAT IS A GOOD TUBE

THREE years ago a series of articles was published in Radio Broadcast as a result of a serious investigation of the characteristics of the radio vacuum tubes then on the market. A group of reputable manufacturers sent samples of their products to the Laboratory to be tested. Many of these manufacturers have since demonstrated their faith in the facts by updating the data that were presented then—but their names are forgotten. At that time, radio listeners and dealers did not have the means of finding out the characteristics of the tubes, and probably knew little about what the characteristics meant if they had been able to obtain them. No one knew how long a tube was supposed to last, least of all the ultimate user. Then the market for radio receivers was rising rapidly, but was still small. And so the data collected in the Laboratory and published in this magazine not only gave the public an idea of how to choose a good tube, but how to use them intelligently, and—if they desired—simple methods of measuring their characteristics as well.

To-day the picture is different. There are perhaps a dozen reputable manufacturers of tubes for receivers and power apparatus—and yet the market for tubes has increased to a degree never dreamed of by the forfathers of radio. The tubes made by these manufacturers are far more reliable and act much more like their brothers from other factories. The tube business is "shaking down;" it is becoming more a matter of engineering and less of cut-and-try. The names of these manufacturers we still see on tube cartons are the names of people who have learned by experience how to make a good tube.

Now the question is, "What is a good tube?" To-day the answer presented in the following pages is an attempt to answer that question. It is presented for the benefit of radio dealers and servicemen whose responsibility to the users of tubes is great. These men are in intimate contact with radio listeners and must daily answer the question, "What tube do you recommend?" The data should be interesting to the ultimate user of the tube too, for he ought to know what to expect and when his expectations have or have not been realized. The over-enthusiastic manufacturer knows about the tubes he sells, the better he can satisfy the demands of the user who wants long life more than he wants a cheap price.

The data are in a form so that they can be clipped from the magazine and filed in a notebook. We suggest each sheet be mounted on a heavier sheet in the notebook. This information represents the latest obtainable data on the best-known tube manufacturers and until something startling occurs in the tube business, something entirely unforeseen, the data will remain the best indication of what these better-known manufacturers are building into their tubes.

Answering the question "What is a good tube?" involves two factors, the electrical characteristics of the tube and the factor of economy. How long will the tube last?

The characteristics of general- and special-purpose tubes have undergone no radical changes in a year or more. Whether or not a tube is fortunate, we are not prepared to state. It is true that every reputable manufacturer who is interested in his future is doing his best to build good tubes, tubes whose characteristics are good when the user purchases them, and good for a long time afterward. The uniformity in the characteristics, as shown by comparing the data in the following pages, was not true three years ago. Then there was a great disparity between the characteristics of one tube as compared with a similar type made in another plant. Now a 201A-type tube is a 201A-type tube no matter who makes it.

Standard Tube Types are Similar

DIFFERENCES among the products of the tube manufacturers are differences of construction, differences of material. More emphasis must be placed upon the latter, because the inherent characteristics are much the same no matter what the name of the tube. But the differences in mechanical construction, in pumping, and in the choice of materials used are the differences that determine life and the characteristics one may expect a good tube.

The first factor, the electrical characteristics of tubes, involves the manufacturer alone. The second involves both the manufacturer and the user. But it was the short time that was made available to the receiver crossed, or if a screw driver in the experimenter's or engineer's laboratory or in the serviceman's shop falls into the power supply by accident. The best tube will have short life if its filament or plate voltage limits are exceeded. The electrons which make the radio wheels go round are tireless workers, but their supply is limited. The best tube will suffer with fatigue if it is forced to work under conditions for which it was not designed.

Generally speaking, tubes from one of the manufacturers represented in the following pages should last as long as from any other, and, although there may have been a time when manufacturers neglected the fact that their tubes lasted too long, it is true now that every manufacturer must make his tubes as good as is possible. Competition takes care of that.

And yet all the responsibility for long tube life does not rest with the manufacturer. The serviceman who recommends the tube, the dealer who sells it, and the user who employs it must share this responsibility. The dealer-serviceman's share is particularly great for it is he who knows whether or not the set-owner is operating the tubes of his set at voltages recommended by the manufacturer. The user must not fail to tell the user not to raise the plate or filament and plate voltages until the last "ounce" of signal strength or "DX" is extracted from his radio.

Importance of Correct Voltage

A TUBE manufacturer is much more familiar with his product than anyone else can be, and when the tube manufacturer sets the voltage limits which his tubes can stand, the user has no right to assume a new set rulings for himself and to expect the manufacturer to replace tubes which seem to have premature failure of emission. In other words, if the correct filament or heater voltage of a certain tube is 2.5 volts, the experimenter should not use 3.0 volts nor should he use 2.0 volts and expect long healthy tubes.

Let us consider the case of a power tube, a full-wave filament rectifier, for example. It seems natural to suppose that it will last much longer if one doesn't overheat the filament and such is true. But let us reduce the voltage across the filament, burn it at a lower temperature, and see what happens. All tubes lose emission as they get old. Rectifier tubes have a certain lower emission limit beyond which they cannot hope to keep up with the demand of electrons imposed upon them by the receiver, but by the filter and voltage divider as well. Once the tube emission falls below this figure, the voltages supplied to a receiver begin to fall, a.c. hum begins to come up—because the wave-form of the rectified output is no longer 'half sine waves, but has a flat-topped form, hard to filter—and the regulation goes bad because of the increase in effective resistance of the rectifier and hence of the plate-voltage supply system.

When such a tube is operated below its rated temperature the supply of electrons is not as great as when the temperature is raised. This means that the useful life of the tube is decreased, because the lower limit of emission is reached sooner. The tube is still good, and probably would continue to supply plenty of voltage if its temperature were increased—but the only safe and economical method is to supply the heating voltage that the tube needs throughout its life. Let us consider the use of neon thermometers which are used to control all but a few tubes when their name is known to him. It is safe to state that a purchaser of tubes gets exactly what he pays for, and if he wants freedom from replacement worries, he should purchase a tube whose name is one he is sure of, one that is nationally advertised and sold, and backed by a manufacturer who has a reputation for making good products out of glass, nickel and electrons.

The user cannot tell by looking at a tube if it is good or not. He must rely either on the tube maker's reputation or upon the advice of his dealer or serviceman. It is certain that the latter must not trick the former into buying "just as good" products on the supposition that they can get away with it. A dealer who has a monopoly on the radio sales in his community might sell the tubes that cost the least and have the shortest life, but he could be sure that some-one would soon furnish his customers with better tubes at a very

First, from the user's standpoint, there are three rules. 1. Buy a well-known tube, 2. Buy it from a well-known dealer, 3. Operate the tube at correct voltages.

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**RADIO BROADCAST'S TUBE DATA CHARTS — I**  E. T. CUNNINGHAM, INC.

THE complete chart of average characteristics of Cunningham Radio tubes shown below has been arranged for convenient reference. In the section under the heading "Amplification" is a tabulation of the resistor values required to furnish the C voltage, or grid bias, when this voltage is obtained from the plate voltage source. The resistor value required when the filament is operated from d.c. differs from those required when the resistor is connected in the mid-tap of the filament winding or power transformer used with a.c. operation, being higher in the latter case. When the plate current of one tube is greater than that of any other tube, that is the current for that tube alone through the resistor.

The difference in grid bias required for d.c. and a.c. operation arises from the fact that with battery operation the plus C is referred to minus A, whereas with a.c. operation the plus C is returned to the filament mid-tap, so that the actual voltage on the grid is reduced to the extent of one-half of the drop across the filament (plate) circuit, voltage. In the case of type CX-371A this amounts to 2.5 volts, so that while the bias required for battery operation at 180 volts plate is 40.5 volts, with a.c. operation this becomes 43 volts.

**Curves showing amplification factor (Mu), plate resistance (rp), and mutual conductance (Gm) are shown for types CX-301A, CX-327, and CX-371A.**

In these illustrations the horizontal axis is not plate voltage, but plate current, and in order to show the values at low plate currents, graphs with a logarithmic scale have been used. Assuming that the filament is in good condition (as may be determined by an emission test), it is probable that the amplification factor is slightly above or below the value indicated on the graph for the average value. This small variation will not affect the operation of the tube, but will result in the plate current being slightly below average if mu is above average, and vice versa. If the plate current is too high under operating conditions, and the plate voltage of resistance is found from the curve, this value will be found to be quite close to the value obtained on the bridge measurement. This is particularly true of Cunningham tubes because the passing limits for each type are so close that all erratic tubes are rejected.

With batteries, all voltages are fixed and do not vary with plate current, while with a.c. operation the plate voltage bulbs vary with plate current. It is, therefore, more convenient to measure only the plate current to determine the operating point, rather than to attempt the measurement of H and C voltages. The readings of the latter are apt to be affected by the current taken by the voltmeter, even while the high-resistance types are used.

Attention should be called to the filament voltage for lower characteristics, and in view of the high voltages and the large currents involved, operation of such types at voltages under their rated values is not advisable. In the case of tube CX-371A a filament of 25.2 volts at 2.6 amperes, and a power consumption of 65 watts at 200 volts, may be used without danger. The rated values are given to point out the importance of care in avoidance of temperature rise, and to that end should be used as a guide to the maximum value for each particular type, a greater safety being permissible.

In operating type CX-327 as a detector, an average value of 2.25 volts will be used with the tube performance. When this tube is used as an amplifier it should be operated by a high-sensitivity detector tube of the range of 2.25 to 2.6 volts is recommended.

The rating of the 200 volt cathode-type tube will be of particular interest to experimenters who prefer full-wave rectification, as it is important that the rating from 300 volts per anode to 350 volts per anode will permit sufficient voltage to operate the CX-350 at a plate voltage of 250 to 300 volts.

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<table>
<thead>
<tr>
<th>TYPE USE</th>
<th>FILAMENT SUPPLY</th>
<th>RATING (V)</th>
<th>OPERATING VOLTAGE</th>
<th>POWER CONSUMPTION</th>
<th>TUBULARITY (V)</th>
<th>OVERALL LEAK (MA)</th>
<th>CURRENT OVERALL LEAK (MA)</th>
<th>VOLTAGE OVERALL LEAK (MA)</th>
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<tbody>
<tr>
<td>C-340A</td>
<td>200 volts</td>
<td>100</td>
<td>150</td>
<td>300</td>
<td>40</td>
<td>500</td>
<td>600</td>
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<th>POWER CONSUMPTION</th>
<th>TUBULARITY (V)</th>
<th>OVERALL LEAK (MA)</th>
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<td>100</td>
<td>150</td>
<td>300</td>
<td>40</td>
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<td>600</td>
<td>700</td>
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<th>TUBULARITY (V)</th>
<th>OVERALL LEAK (MA)</th>
<th>CURRENT OVERALL LEAK (MA)</th>
<th>VOLTAGE OVERALL LEAK (MA)</th>
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<td>200 volts</td>
<td>100</td>
<td>150</td>
<td>300</td>
<td>40</td>
<td>500</td>
<td>600</td>
<td>700</td>
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<th>RATING (V)</th>
<th>OPERATING VOLTAGE</th>
<th>POWER CONSUMPTION</th>
<th>TUBULARITY (V)</th>
<th>OVERALL LEAK (MA)</th>
<th>CURRENT OVERALL LEAK (MA)</th>
<th>VOLTAGE OVERALL LEAK (MA)</th>
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<td>150</td>
<td>300</td>
<td>40</td>
<td>500</td>
<td>600</td>
<td>700</td>
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<th>TYPE USE</th>
<th>FILAMENT SUPPLY</th>
<th>RATING (V)</th>
<th>OPERATING VOLTAGE</th>
<th>POWER CONSUMPTION</th>
<th>TUBULARITY (V)</th>
<th>OVERALL LEAK (MA)</th>
<th>CURRENT OVERALL LEAK (MA)</th>
<th>VOLTAGE OVERALL LEAK (MA)</th>
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<tr>
<td>C-390A</td>
<td>200 volts</td>
<td>100</td>
<td>150</td>
<td>300</td>
<td>40</td>
<td>500</td>
<td>600</td>
<td>700</td>
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</tbody>
</table>
What greater Endorsement than Public Approval
Since 1915

Don't use Old Tubes with New Ones
use New Cunningham tubes throughout
THE uses of vacuum tubes have a right to expect a two things from the manufacturer of the tubes: first, the proper characteristics at the start of their life, and secondly a long life. Life tests were made in Radio Broadcast's Laboratory on several makes of tubes. The life tests consisted of running the filaments of the tubes from a.c. and putting 100 volts d.c. from a generator on the plate with the grid left free. At the end of each hundred hours each tube was taken off test and its plate resistance and amplification factor measured on a tube bridge. The amplification-factor measurement gave an indication of any change in the internal arrangement of the tube elements, the test of the plate resistance indicated whether or not the emission of the filament was falling off.

It is a fact that Sylvania tubes not only had the correct characteristics at the start of such a life test and held them throughout, but the majority of the tubes tested actually decreased slightly in plate resistance, and thereby had a somewhat higher mutual conductance at the end of 1000 hours than they did at the start of the test. In other words, the tubes improved. The curve in Fig. 3 shows the average tube of the lot. Its starting resistance was 12,700 ohms, and at the end of 1500 hours, when the test was discontinued the resistance had decreased to 12,000 ohms or about 6 per cent.

The Sylvania Company makes 19 types of tubes, including two special detectors, the SX-200 A and the SX-200 B. The latter is an eighth-ampere special detector tube. Both are vacuum vapor tubes, and get special care in manufacture and test. With each special detector tube is packed a certificate which guarantees "greater distance receiving range and more volume in the reception of weak signals than any other tubes."

Characteristic curves made in the Laboratory on the Sylvania eighth-ampere general-purpose tubes, the SX-201 B tubes, prove them to have as good or better characteristics than the average quarter-ampere tube of the 291 A type.

Some characteristic curves of Sylvania a.c. tubes of the heater and filament types are shown in Figs. 1 and 2. These data are plotted against heater volts, *Eh*, for the SX-227 tube and filament volts, *Ej*, for the SX-220 tube. They show the utility of running these tubes at voltages beyond their normal rating, and prove that voltages slightly under rated values will produce practically identical characteristics. For example, the plate resistance (Fig. 1) of the SY-227 at a plate potential of 90 volts with a zero grid bias is approximately 10,000 ohms when using a heater potential of 2.55 volts; with the same grid and plate voltages the plate resistance is about 8500 ohms at normal heater temperature.

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### Average Characteristics of Sylvania Radio Tubes

<table>
<thead>
<tr>
<th>Type</th>
<th>Use</th>
<th>Base</th>
<th>Height (Max)</th>
<th>DIAM. (Max)</th>
<th>Supply Source</th>
<th>Plate Volts</th>
<th>Plate m.A.</th>
<th>Grid Volts</th>
<th>Plate Resistance (Ohms)</th>
<th>Amplification Factor</th>
<th>Initial Conductance Microhms</th>
</tr>
</thead>
<tbody>
<tr>
<td>SX-201 A</td>
<td>Detector Amplifier</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V.</td>
<td>5.0</td>
<td>0.25</td>
<td>20-45</td>
<td>45-135</td>
<td>1.0 to 3.0</td>
<td>0 to 9.0</td>
</tr>
<tr>
<td>SX-201 B</td>
<td>Detector Amplifier</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V.</td>
<td>5.0</td>
<td>0.125</td>
<td>20-45</td>
<td>45-135</td>
<td>1.0 to 3.0</td>
<td>0 to 9.0</td>
</tr>
<tr>
<td>SX-200 A</td>
<td>Detector</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V.</td>
<td>5.0</td>
<td>0.25</td>
<td>20-45</td>
<td>45-135</td>
<td>1.0 to 3.0</td>
<td>0 to 9.0</td>
</tr>
<tr>
<td>SX-200 B</td>
<td>Detector</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V.</td>
<td>5.0</td>
<td>0.125</td>
<td>20-45</td>
<td>45-135</td>
<td>1.0 to 3.0</td>
<td>0 to 9.0</td>
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<tr>
<td>SX-112 A</td>
<td>Semi-Power Amplifier</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V, A.C. 5 V.</td>
<td>5.0</td>
<td>0.25</td>
<td>90-180</td>
<td>10.0 to 16.5</td>
<td>4.5 to 10.5</td>
<td>2,200</td>
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<tr>
<td>SX-171</td>
<td>Power Amplifier</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V, A.C. 5 V.</td>
<td>5.0</td>
<td>0.50</td>
<td>90-180</td>
<td>10.0 to 16.5</td>
<td>4.5 to 10.5</td>
<td>2,200</td>
</tr>
<tr>
<td>SX-171 A</td>
<td>Power Amplifier</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V, A.C. 5 V.</td>
<td>5.0</td>
<td>0.50</td>
<td>90-180</td>
<td>10.0 to 16.5</td>
<td>4.5 to 10.5</td>
<td>2,200</td>
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<tr>
<td>SX-240</td>
<td>Det Amp. Res Coupling</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Storage 6 V.</td>
<td>5.0</td>
<td>0.25</td>
<td>135-180</td>
<td>135-180</td>
<td>1.0 to 3.4</td>
<td>4.5 to 15</td>
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<tr>
<td>SX-199</td>
<td>Detector Amplifier</td>
<td>X</td>
<td>4 1/4&quot;</td>
<td>1 3/16&quot;</td>
<td>Dry Cells 4.5 V. Storage 4 V.</td>
<td>3.3</td>
<td>0.06</td>
<td>20-45</td>
<td>45-135</td>
<td>1.0 to 3.2</td>
<td>0 to 10.0</td>
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<tr>
<td>SX-199</td>
<td>Detector Amplifier</td>
<td>V</td>
<td>3 5/8&quot;</td>
<td>1 3/16&quot;</td>
<td>Dry Cells 4.5 V. Storage 4 V.</td>
<td>3.3</td>
<td>0.06</td>
<td>20-45</td>
<td>45-135</td>
<td>1.0 to 3.2</td>
<td>0 to 10.0</td>
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<tr>
<td>SX-120</td>
<td>Power Amplifier</td>
<td>X</td>
<td>4 1/4&quot;</td>
<td>1 3/16&quot;</td>
<td>Dry Cells 4.5 V. Storage 4 V.</td>
<td>3.3</td>
<td>0.125</td>
<td>135</td>
<td>6.5</td>
<td>22.5</td>
<td>6,300</td>
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<tr>
<td>SX-226</td>
<td>Amplifier</td>
<td>X</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>A.C. 1.5 V.</td>
<td>1.5</td>
<td>1.05</td>
<td>90-180</td>
<td>3.5 to 7.5</td>
<td>4.5 to 15</td>
<td>7,400</td>
</tr>
<tr>
<td>SX-227</td>
<td>Detector</td>
<td>Y</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>A.C. 2.5 V.</td>
<td>2.5</td>
<td>1.75</td>
<td>90-180</td>
<td>3.0 to 7.5</td>
<td>6.0 to 13.5</td>
<td>10,000</td>
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<tr>
<td>SX-222</td>
<td>Amplifier</td>
<td>Y</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>Dry Cells 4.5 V. Storage 4.6 V.</td>
<td>3.3</td>
<td>0.132</td>
<td>135-180</td>
<td>1.5</td>
<td>1.5</td>
<td>850,400</td>
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<tr>
<td>SY-222 A.C.</td>
<td>Amplifier</td>
<td>Y</td>
<td>4 11/16&quot;</td>
<td>1 3/16&quot;</td>
<td>A.C. 2.5 V.</td>
<td>2.5</td>
<td>1.75</td>
<td>135-180</td>
<td>5.0</td>
<td>1.5</td>
<td>200,000</td>
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<tr>
<td>SX-210</td>
<td>Power Osc. Amplifier</td>
<td>X</td>
<td>5 6/8&quot;</td>
<td>2 7/16&quot;</td>
<td>A.C. 7.5 V.</td>
<td>7.5</td>
<td>1.25</td>
<td>250-425</td>
<td>10 to 18</td>
<td>18-35</td>
<td>5,000</td>
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<tr>
<td>SX-250</td>
<td>Power Osc. Amplifier</td>
<td>X</td>
<td>6 1/8&quot;</td>
<td>2 7/16&quot;</td>
<td>A.C. 7.5 V.</td>
<td>7.5</td>
<td>1.25</td>
<td>250-450</td>
<td>28-55</td>
<td>45-84</td>
<td>1,800</td>
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</table>

**Notes:**
- Where only one set of characteristics is given these are applied to the mean or most used values of plate and grid voltages.
- Bases will be designated by the following letters, according to their styles:
  - X = Standard Push Type
  - Four Long Prods. = V = Old Navy Type
  - Four Short Prods. = Y = Push Type, Five Long Prods.
A few of the many popular types included in the CECO line.

AC-22
N-27 (227)
J-71-A (171-A)
L-50 (250)
M-26 (226)
AX (201-A)

CECO Tubes are recommended for their exquisite tone quality and long life.
Improving the Radio Dealer's Service to the Public

BY MAKING available for public use (usually in advance of other tube manufacturers) each new development in the tube industry, CeCo has won the hearty endorsement of thousands of radio pioneers. This carries with it a great responsibility.

For this reason—the public looks for more than the usual from CeCo. A superior performance is expected—demanded. Accordingly, each CeCo tube MUST be as painstakingly fashioned, tested and re-tested as though it were the sole output of the factory.

We pledge our continued support to this policy, as well as to the policy of experimentation and research to improve constantly the performance of radio tubes.

Write today for the interesting CeCo story:

Don't miss the CeCo Couriers entertaining program every Monday evening at 8:30 Eastern time (7:30 Central time) over the Columbia Broadcasting System.

CeCo Manufacturing Co., Inc.
Providence Rhode Island

CeCo Radio Tubes are used by millions.
Why Raytheon Tubes are "HEALTHY"

The performance and life of a radio tube are largely governed by the maintenance of the pre-determined fixed position of the elements to each other. When the elements (filament, grid and plate) are shifted—due to weak mechanical construction or vibration in shipment—the life of the tube is frequently shortened by as much as 75%.

Unlike any and all other radio tubes, the relative positions of all the elements are permanently maintained in Raytheon tubes and the fragility has been conquered and eliminated. Raytheon tubes cost you no more and by longer life, they should reduce your maintenance cost by one-half. And—most important of all—their performance never varies.

Raytheon MANUFACTURING COMPANY, Cambridge, Mass.
RADIO BROADCAST'S TUBE DATA CHARTS — III RAYTHEON MANUFACTURING COMPANY

IN THE opinion of the Laboratory, one of the most important steps toward bringing radio reception to its present point of near perfection is to be credited to the Raytheon Company's gaseous rectifier tube which was the first really satisfactory tube after supplying d.c. voltages from a.c. sources—and which is to be found to-day in thousands of plate voltage supply units, as well as in equipment supplying A, B, and C voltages.

The "Raytheon tube," by which everyone means the 125-milliamperes rectifier tube, came at an opportune time. The tubes used ranged from an overworkeds201A-type tube with its grid and plate connected together, to some few special two-element filament-type tubes, none of which was able to supply up to the load demand for electrons in plate voltage supply devices. The Raytheon tube stood up—only "B" eliminating became successful adjuncts to modern radio receivers.

When television began to interest development engineers, there was an immediate demand for photo-electric cells. These are glass balls, not unlike radio receiver tubes, into which a light can be directed. When this light falls upon the sensitive electrode, it liberates electrons which are attracted toward a positive plate, and so a light beam can cause an electronic current from a local B battery. The strength of this current should be proportional to the light falling upon the sensitive plate, the tube should not be microphonic, should have an amplification factor, should have a high order of sensitivity—that is, the current released from the local battery must be as high as possible with a given amount of incident light—and must be stable in operation.

The experience accumulated in the Raytheon Laboratories since 1929 in the purification and study of rare gases made possible the development of such photo-electric cells. A graph gives the characteristics of the type 5CF Foto-Cell.

There is also a demand for a tube which has opposite characteristics from the Foto-Cell, that is, a tube which will give off light when excited by an electrical input. This light should vary in direct proportion to the strength of the incoming signal. The tube must be uniform in illumination, low in power consumption, and as brilliant as possible. Such a cell is the Raytheon Kino-Lamp. Under full-voltage conditions it supplies 15 candlepower of illumination which can be easily and positively controlled by television signals.

For years the "S" tube was the stand-by of the amateur. The passing of the "S" tube was a regrettable incident—but now the Raytheon Company has a new rectifier that has characteristics as shown on this page. This looks like an ideal tube for the amateur and anyone who wants a source of high voltage d.c. secured from the a.c. lamp socket. The experience obtained with the internal resistance which indicates that very little power will be lost in the tube. Low internal losses, good regulation characteristics, and high amplification are the advantages of this new Raytheon product known as the Ray-S tube. It can be used wherever high current at high voltage is desired. For example, at an input r.m.s. potential of 2500 volts, a current of 230 milliamperes can be supplied at a d.c. voltage of 2660, which represents a power of 570 watts.

Receiving Tubes

The Raytheon Company has recently begun the manufacture of receiving tubes of the types indi-

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<th>AVERAGE CHARACTERISTICS OF RAYTHEON TUBES</th>
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<td>3 LS</td>
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<td>3 GL</td>
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Unquestionably the Most Complete Radio Testing Apparatus Ever Devised

The SUPREME is sweeping the country by storm. Radio technicans and engineers everywhere are amazed at its performance, and its already long list of users are enthusiastically proclaiming its superiority. Truly an amazing instrument; it makes every test that can be made by all other testing devices combined and many that heretofore have not been available in any service instrument.

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The case containing the instrument was designed after careful study by practical radio technicians of many years' experience in radio service. Its arrangement is most complete and convenient—a proper place for every tool, accessory, part, and material that a service man might need; even a swinging tube shelf that affords absolute protection to tubes. A complete set of tools, from electric soldering iron to screwdriver, is furnished, and of course, all necessary adapters and accessories. Everything the service man requires—all in one case. And still, due to ingenious design, this case is only 18 x 10 x 7 in., and weighs complete only 23 lbs.

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Greenwood, Miss.

6 Day Trial

Please ship me one Model 500A SUPREME.

Upon delivery of the instrument, I will deposit with the express agent either the cash price of $150 or $30.50 cash and 10 trade acceptances (installment notes) for a balance, at my option, subject to the following conditions:

It is agreed that the deposit made with the express agent shall be retained by him for six days. If within that time, after testing the instrument I am not entirely satisfied, I have the privilege of returning the instrument to the express agent in good condition, with the seal unbroken (see note below) and all tools and parts intact. Upon such return and upon the prepayment of return express charges, the deposit will be promptly returned to me.

Signed

Firm Name

Address

City State

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NOTE: The seal on the panel of the instrument covers the master screw in the assembly. It is never necessary to disturb this, and it does not in any way prevent or restrict the use of the instrument. Factory guarantee ceases with disturbance of seal.

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1. Voltmeter, three scales of 0/180/1000/0000, 1000 ohms per volt.

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 conceivable

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You have waited long and patiently for an instrument such as the SUPREME. It is now here—at your command for greater accuracy and thoroughness, bigger profits and satisfied customers.

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The only self-rectifying oscillation tester in existence.

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The SUPREME will give direct reading of amplifying power of tubes and will show actual working condition of all tubes.

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It will give plate and filament voltage readings with or without load; will test voltage and current of all radios, including those using tubes such as 80 and 806. It will give grid circuit readings up to 110 volts; plate voltage readings up to 600 volts; test output of trickle chargers; or any output up to 35 amps.

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RADIO BROADCAST'S TUBE DATA CHARTS — IV CeCo MANUFACTURING COMPANY

The chart on this page gives the characteristics of the entire CeCo line of tubes. A plane will show that the line is complete, and that the constants are such as experience and engineering have dictated to be the best for the tubes serving the purposes for which they were made. In addition to tubes whose names and uses everyone knows, there are several others on this list that will need some explanation. For example, type G is a high-mu tube useful for resistance- and impedance-coupled amplifiers. Owing to its other low plate resistance, 25,000 ohms at a plate potential of 50 volts, and 0.25 grid bias, the tube will make a good detector. In addition to this tube, CeCo manufactures a special detector, type H, useful as an indicator and with lower plate resistance than type G. Both of these tubes have a fairly high mutual conductance.

Type K is a special radio-frequency amplifier tube, with an amplification factor of 12.5 and a plate resistance of 11,000 ohms. Under normal operating conditions, 90 volts on the plate and a negative bias of about one volt, the mutual conductance is equal or better than the average general-purpose tube, and naturally enough, a somewhat greater amplification at high frequencies results.

Type L 15 is a new power tube, as is Type L45. At the time of compiling these data, only experimental tubes were available, and it is not thought wise to include data on these tubes. Suffice to say, the CeCo organization is awake to the necessity of power tubes fitting into the picture somewhere between the present 121 and the much more powerful tube, the 259 type.

Despite the interest in the screen-grid tube, little has been done with it in commercial receivers, chiefly because it required a source of d.c. current for its filament. The chart below shows the characteristics of the CeCo a.c. screen-grid tube, the A.C. 22. It is a standard heater-type tube, namely, one requiring 2.5 volts and 1.75 amperes, and because of this construction it does not suffer from many of the faults of the d.c. screen-grid tube. It is not microphonic, its filament (cathode) is sturdy and it has continuous emission of electrons. Its plate resistance is 450,000 ohms and its mutual conductance over 700 micromhos under normal operating conditions, i.e., 135 volts on the plate, 67.5 volts on the grid, and a negative grid bias of 1.5 volts on the control grid.

Fig. A gives the essential characteristics of the tube plotted with reference to the control grid bias. To see what the tube would do in a radio-frequency amplifier, the data in Fig. B and Fig. C were taken in the Laboratory. The circuit diagram is given on Fig. B, and shows a resistance input of 3.5 ohms, a transformer coupling the A.C. 22 to a standard heater-type transformer as a Cahill or plate-rectifier detector, and a microammeter in the plate circuit of the detector which acts as a vacuum-tube voltmeter.

The voltage ratio, Eo/Ei, varies from about 40 at low broadcast frequencies to about 70 at 1,500 kc. This means that an input voltage of 0.1 volt, after passing through the screen-grid tube and its coupling transformer, becomes 4.0 volts on the input to the detector at 50 kc. and 7.0 volts at 1,500 kc. Fig. C gives an idea of the selectivity of a single stage as illustrated in Fig. B. The primary of the transformer had an inductance of 350 microhens, the secondary an inductance of 2.5 microhens and the mutual inductance between them was about 100 microhens, giving a coefficient of coupling of about 0.55. The secondary had a diameter of about 2 inches and was space wound so that its resistance was quite low. The input resistance of the detector was high since it was an overbiased tube. As Fig. C shows, the selectivity of such a single stage varies at the two frequencies used. At 1590 kc. the selectivity is such that a 500-cycle note would suffer a loss of about 3.5 db while at 735 kc. the loss would be 4.4 db.

**Table: Test Characteristics of CeCo Tubes**

<table>
<thead>
<tr>
<th>MODEL NO</th>
<th>CORE-SPARKLING TYPE</th>
<th>USE</th>
<th>BATTERY VOLTS</th>
<th>FILAMENT VOLTS</th>
<th>FILAMENT AMPS</th>
<th>DETECTOR PLATE VOLTS</th>
<th>AMP. MAX. PLATE VOLTS</th>
<th>GRID BIAS</th>
<th>PLATE VOLTS</th>
<th>GRID CURR. (mA.)</th>
<th>PLATE RESISTANCE (OM.)</th>
<th>MUTUAL ODOMAX. ANGLE (MO.)</th>
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# The Radio Broadcast Laboratory Information Sheets

The aim of the Radio Broadcast Laboratory Information Sheets is to present, in a convenient form, concise and accurate information in the field of radio and closely allied sciences. It is not the purpose of the Sheets to include only new information, but to present practical data, whether new or old, that may be of value to the experimenter, engineer or serviceman. In order to make the Sheets easier to refer to, they are arranged so that they may be cut from the magazine and preserved, either in a blank book or on 4" x 6" filing cards. The cards should be arranged in numerical order.

Since they began, in June, 1926, the popularity of the Information Sheets has increased so greatly that it has been decided to reprint the first one hundred and ninety of them (June, 1926-May, 1928) in a single substantially bound volume. This volume, "Radio Broadcast's Data Sheets," may now be bought on the newstand, or from the Circulation Department, Doubleday, Duran & Company, Inc., Garden City, New York, for $1.00. Inside each volume is a credit coupon which is worth $1.00 toward the subscription price of this magazine. In other words, a year's subscription to Radio Broadcast, accompanied by this $1.00 credit coupon, gives you Radio Broadcast for one year for $3.00, instead of the usual subscription price of $4.00.

—The Editor.

## No. 265

**Radio Broadcast Laboratory Information Sheet**

**March, 1929**

Electrifying Battery-Operated Sets

The circuit of a typical A-power unit is given on this sheet. The transformer, T, supplies a.c. voltage to the rectifier, R, which feeds pulsating d.c. to the filter system where the ripple is removed so that the current leaving the output terminals of the filter system is practically pure d.c.

The arrangement of the chokes and condensers in the filter system varies in different units. In some cases both the chokes are placed in the same side of the line and three condensers are frequently used instead of two.

The transformer, T, is generally provided with taps on the secondary, as we have indicated, so that the output of the system may be corrected for different current drain. The greater the output current required from the unit, the higher must be the voltage impressed across the rectifier.

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## No. 266

**Radio Broadcast Laboratory Information Sheet**

**March, 1929**

Effect of Room Acoustics

Mr. Irving Wolff, of the Technical and Test Department of R. C. A., remarks in an article on loudspeaker measurements (Proc. I. R. E., December, 1928) that:

"We are sometimes amazed after having conducted listening tests on a loud speaker, and having reached the conclusion that it is pretty good, to find it unsatisfactory when moved to a different room or even a different position in the same room. It is, therefore, very important when taking loudspeaker curves to consider the question of room acoustics and loud-speaker position."

"Some of the factors which may be expected to have a pretty big effect are:"

- Room absorption characteristics
- Room resonances
- Position of loud speaker in room
- Position of listener with respect to loud speaker
- High frequencies radiated in a beam. If high response is wanted the speaker should, therefore, be pointed and placed so as to cover as large a portion of the audience as possible. Placing the loud speaker in a corner or in any kind of a cavity will usually have a big effect on the response. The space between the back of the loud speaker and wall or other obstruction will act as a resonant chamber whose vibrations will be excited by the vibrations of the rear side of the loud speaker diaphragm. It is impossible to say whether this effect will be pleasing or otherwise. It will depend on the unadulterated response characteristic and whether the resonance is of such frequency as to supply a region which is lacking.

"Under present broadcasting conditions where the range of frequencies transmitted is cut off pretty sharply at 5000 cycles or below, tube overloading on a loud speaker which reproduces real high frequencies shows up as a roughness, rasp, and very often as a sound which resembles a paper rattle. This is caused by the generation of harmonics and combination tones. These added notes show up particularly badly when they are produced at the higher frequencies, as there is no true transmission of sound of the same frequency to act as a mask."
PLUG in a Falck Claroceptor between wall socket and radio set and eliminate “static” from motors, street cars, telephones and electrical appliances. This new improvement by a pioneer radio parts manufacturer grounds and thus blocks out line interference noise and radio frequency disturbances. Also improves selectivity and distance. Requires no changes in set. Measures just 3 1/2 x 5 1/2 x 2 1/2 inches. Thousands now all over America use the Claroceptor for clearer A. C. reception. Get one right away—at radio parts dealers. Write for descriptive folder.

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Perform that “adenoid operation” on your set

TAKE out the “adenoids”, those inferior transformers which make your set sound as if it were afflicted with a bad case of adenoids... Then put in their place, the standard of excellence in Audio Transformers—AmerTran DeLuxe.

Ever hear a child talk before and after an adenoid operation? Well, if you have, you will appreciate the difference AmerTran transformers will make in any set.

AmerTran products are built exclusively for the purpose of achieving realism in tone. It cannot be done cheaply, or haphazardly. AmerTran’s 30 odd radio products all play their definite part in producing the finest tone known to radio.

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THE 3-B Mixing Panel is designed to accommodate almost any combination of pickup circuits up to a total of six. Any three of these may be made to pass through the three Compound Mixing Controls at the same time, and instantaneous switching is available for the remaining circuits.

The incoming circuits may consist of condenser transformers, carbon microphones, telephone lines or low impedance phonograph pickup devices in practically any combination. When a single input circuit of extremely low level is encountered, the positions set in one may be cut entirely out of the system, thus causing no loss whatever to the weak incoming signal.

The panel is 5/16 black sanded Bakelite, 19 in. wide and 12 in. high. Detailed information and circuit is shown in bulletin No. 7, which we will be glad to mail to you. The price in the U. S. A. and Canada is $275.00, F. O. B. Chicago.

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Send for our bulletins on Broadcasting Equipment.
A BROADCASTING station is assigned to a definite frequency by the Federal Radio Commission. In the operation of the station it is essential that the major part of the radiation take place within 500 cycles of this assigned frequency. Even however, for reasons of economy, the oscillators at the transmitter are generally modulated rather than underloaded, it is always found that they generate, beside the fundamental frequency, a considerable amount of energy at harmonic frequencies. A transmitter operating on a frequency of 600 kilocycles will generate energy at 1800 kilocycles, so that the program could be heard on both of the channels—albeit, of course, it is probable that the 1000-kilocycle wave would produce interference with a station assigned to that frequency. Some method must, therefore, be used to suppress the harmonics since, if they are permitted to get into the antenna, they will cause interference in other broadcasting channels. The greatest interference is caused in the channel corresponding to a frequency twice that on which the station is authorized to operate. In the August, 1928, Bell Laboratories Record the following interesting remarks were published relative to the suppression of harmonics from one of the experimental stations operated by the Bell Telephone Laboratories:

"In this respect, as in many others, 3XN, the latest broadcasting development of our Laboratories, marks a new level of attainment. The transmitter has a power input into the antenna system of 20 kilowatts, the power carrier wave alone, and the instantaneous peak power during the broadcasting of a program may reach 200 kilowatts. And yet, with all that power in the carrier wave, the amount of the second harmonic allowed to escape would not light the ten thousand incandescent lamps. To be exact, it is less than 0.005 watt and represents about one cubic foot of the carrier wave.

Ordinarily, a purity (lack of harmonic) of 80 to 95 per cent, can be readily and cheaply attained. To carry this to 99.9 per cent, is considerably more and to carry it to 99.9 per cent, many times as much. The extent to which the purification is carried out is now largely to the designs of the radio transmitter, and they look upon it as an economic balance between the job that they would like to do and the cost of the equipment that can be justified. The more powerful the broadcasting transmitter, the more important becomes the problem of attaining its harmonics, and the greater the care which must be bestowed upon its harmonic filters."

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**No. 267**

RADIO BROADCAST Laboratory Information Sheet

March, 1929

Power in Broadcast Harmonics

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**No. 268**

RADIO BROADCAST Laboratory Information Sheet

March, 1929

Mathematics of the Tuned Circuit

---

**No. 269**

RADIO BROADCAST Laboratory Information Sheet

March, 1929

Importance of Bass Notes

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**WESTON ELECTRICAL INSTRUMENT CORP.**

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CROSLEY announces:

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Mandarin Red
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Attach to antenna and add tubes

The AC Electric Gemchest $99.

To radio's great value Crosley now adds STYLE. To perfection of radio reception Crosley introduces FASHION. Chinese Chippendale is the motif. Three popular, smart, stylish colors afford your trade a splendid choice. Mandarin Red, Nanking Green and Manchu Black. All sold complete.

The gem of this fine AC Electric Gem amongst radio's smartest, smartest. Not too big. Just enough color to command the furnishing of any room.

In it is built the famous Crosley AC Electric GEMBOX and the Crosley dynamic type power speaker DYNACONE.

The same cabinet with the Crosley 8 tube SHOWBOX built in sells for $115. Prices quoted do not include tubes.

Radio excellence! Decorative smartness! Color harmony! See other side of this announcement for complete line.
Price Correction
After the black printing on this sheet, analysis of manufacturing costs made it possible to reduce prices on the Crosley Gemchest and Showchest described on the reverse side of this sheet. The price on each model has been reduced $5.00.

NEW PRICES
GEMCHEST $94
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The New
8 tube JEWELBOX $105

Power detector, tuned antenna circuit, UY-227 tubes in all sockets except output and rectifying.

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Power detector makes use of plate rectification instead of grid rectification as commonly used in radio. Result: over-loading prevented and tone improved.
Tuned antenna circuit creates selectivity and sensitivity to a degree of quality never before attained.
By use of UY-227 type tubes, except in output, filtering of circuits is improved.

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8 Tube
SHOWBOX
$80

This famous, finely balanced neutrodyne receiver—sensitive and selective to a marked degree is also available in a new black wrinkle finish brushed with white gold as well as the popular brown and gold finish.
Features of the SHOWBOX are FULL VOLTAGE on audio plates—perfected MERSHON Electrolytic condenser in power pack which will not break down—push-pull amplification — modern illuminated dial and many others found in sets at twice its price.
Crosley dynamic type power
DYNACONE $25

CROSLEY
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Lowest priced FIRST CLASS AC electric radio on the market—The GEMBOX at $65. Unusually sensitive and selective. Genuine neutrodyne and operates power speaker.
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Prices quoted are without tubes.

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Helzle and Kaufman, the builders of the Byrd and Wilkins' radio equipment, as well as that for the record-breaking aeroplane "Southern Cross", selected Hammarlund condensers "on account of their ruggedness and simplicity"—crashproof qualities—not easily made inoperative in case of accident.

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2 Tubes in Parallel

In last audio socket. This reduces the impedance in the power stage, resulting in much better reproduction of the ordinarily "hard-to-get" low notes.

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Filament Equalizers. Used in filament circuits to keep the filaments at their best operating points.

It will pay to send for 40-Page Free Booklet, "Resistance, The 'Control Value' of Radio."

---

**No. 270**

**Radio Broadcast Laboratory Information Sheet**

March, 1929

Formulas for Power Output

The undistorted power output of a tube is defined as the maximum power which can be supplied to a load without introducing more than five per cent. distortion due to the curvature of the tube's characteristic. It has been determined that the maximum amount of undistorted power is obtained from any given tube when the load resistance equals twice the plate resistance of the tube. The power output can be computed from the formulas:

\[ P = \frac{2}{9} \left( \frac{E\text{.c}}{R\text{.p}} \right)^2 \]

where

\[ P = \text{power in milliwatts} \]

\[ E\text{.c} = \text{amplification constant} \]

\[ R\text{.p} = \frac{1}{2} \text{plate resistance} \]

If peak values of a.c. voltage on the grid are used instead of r.m.s., then the formula is:

\[ P = \left( \frac{E\text{.c}}{R\text{.p}} \right)^2 \]

---

**No. 271**

**Radio Broadcast Laboratory Information Sheet**

March, 1929

Test for a Faulty Push-Pull Amplifier

SEVERAL letters have been received recently by the Laboratory relative to the operation of push-pull amplifiers. Evidently some servicemen, quite capable of servicing any ordinary type of amplifier, are frequently unable to repair the push-pull amplifier that does not give good quality but which is wired correctly, uses good apparatus, and employs tubes that take normal plate current. The trouble is generally due to oscillations in the push-pull amplifier but to detect these oscillations it is necessary to apply to the push-pull amplifier a signal which can be readily detected.

The test which is necessary to detect the oscillations consists of placing a meter in the C minus lead to the push-pull stages to determine if there is any grid current. The location of the meter is shown in sketch A. Under normal conditions there will be zero current in the grid circuit but if the circuit is oscillating several milliamperes may flow in the grid circuit. If such a test indicates that an amplifier is oscillating, then one or both of the following remedies must be applied.

The first thing to do is to connect a 50,000-ohm resistor in the common C minus lead at the point indicated by "C". This resistor should not be bypassed with a condenser. The fidelity of the set, in fact, will it show satisfactory operation over a wide range of voltages. This recommendation has also been extended to include tubes used for detector service. A choke coil must be used here instead of a resistance because of the loss in plate voltage which would be produced by a resistance.

---

**No. 272**

**Radio Broadcast Laboratory Information Sheet**

March, 1929

Importance of Correct Filament Voltages

This Laboratory Sheet supplies additional information on the subject covered in Sheet No. 254 published in the January issue. The latter sheet suggested the use of somewhat lower than rated voltage on the filaments of 226- and 227-type a.c. tubes. The information which follows from R. M. Wise, Chief Engineer of R. F. Cunningham, Inc. points out that the use of lower than rated voltage may be recommended generally.

"In using new tubes, and particularly with certain tube types, very satisfactory operation will be obtained at considerably reduced voltages. However, we find that reduction of the voltage below a certain point has little beneficial effect on tube life and in some cases may shorten it due to the fact that the coated filament at times loses its activity when operated at low temperatures. As an example, we find that average new c-327 tubes made excellent performance below 2.4 volts, yet the emission life of the cathode at this temperature is not as satisfactory as is the case when it is operated at, or near, rated voltage. The c-327 having voltage rating has been chosen with all of these factors in view, and, while for detector service we find it advisable for a time to reduced 2.55 volts, this recommendation has never been extended to the operation of the tube as an amplifier. As an amplifier we consider the preferred operating range to be from 2.4 to 2.6 volts, while as a master it will show satisfactory operation over a wide range of voltages. This recommendation has also been extended to include tubes used for detector service. A choke coil must be used here instead of a resistance because of the loss in plate voltage which would be produced by a resistance.

"It is particularly important to operate power and rectifier tubes within a range of + or - 5 per cent. from the rated value. Several instances of unsatisfactory operation of type cv-350 have been traced to operation at 6 volts. In each case satisfactory operation was obtained soon as the filament potential was raised to 7.5 volts. It is true that there is not much change in character when the tubes are operated somewhat below rated voltage. This holds for new tubes, but the question of melting occurs through the life of the tube is an important factor and, as previously stated, is best realized by operating the tube close to rated voltages. There is a considerable difference in life when operated a moderate change in emission will not affect operation, due to operation on or below the knee of the saturation curve, while if operated at reduced voltages a similar change in emission will result in impaired performance."
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• march, 1929 • page 353 •
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BOOK REVIEWS


This book, one of the earliest texts on television, is a volume of some importance, although, judging by the price in comparison with the number of pages, the publishers do not anticipate any considerable circulation.

In his Foreword Mr. Baird asks, "Where better can we seek for truth than in scientific research? Sport, business, and politics have all the other avenues into which man directs his energies, are tainted with commercialism, self-interest, passion, and emotion." It is painful, but much more important to be forced to quote the irresponsible ballyhoo of Captain Charles E. Stratton, Managing Director of Baird's International Television Ltd., Ltd., "The next step in the development of the television will be the perfection of the single tube system, which will be capable of being used for broadcast purposes and will be".

Nearly every examination. For example, the author's introduction to the subject of television is as follows: "The television is an instrument for rapidly advancing the arts of the world. It is a means of communication, a means of entertainment, a means of education, a means of art, a means of science, a means of economics, a means of politics, and above all, a means of religion."

The volume is a valuable contribution to the study of television and should be read by all interested in the subject.

Reviewed by A. E. H. DREWELL.

Letters from Readers

Service Men Disagree

During the last few months considerable space has been devoted in the pages of Radio Broadcast to articles of interest to service men. The series of experiences in radio servicing which were recounted by Mr. Alcorn, a practicing serviceman, considerably interested in material of this nature has been manifest in recent letters which have been received from readers. Although much of the correspondence has been favorable, there are a few letters which contain constructive criticism which is also appreciated.

In the following paragraphs are excerpts from a letter written by an editor of TV Radio Service, Inc., one of the oldest and largest service organizations in New York City. Although the views expressed in this letter do not coincide with those of Mr. Alcorn, the arguments are very interesting.

To the Editor:

We are roused from our literary lethargy by a driving desire to comment on the service article by Mr. Alcorn, appearing in November radio. It is with considerable satisfaction that we are in agreement with the author's opinion that the support of manufactured set manufacturers is prohibited. We believe that, if a service organization were to support the activities of its servicemen in the field must be equipped (Continued on page 356)
For the New Tubes!

POLYMET

Single-Dial Tuning-Unit
No. 222-A
for A.C. Sets

For the new R. C. A.—A. C. Shield-Grid Tube

This improved NATIONAL Tuning Unit embodies matched condensers for better single control, and coils designed for use with this wonderful new A. C. Tube.

For the new R. C. A. Power Tube

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Type 575 for use with 210 type tubes and 281 rectifier tubes.
Type 1152 for use with 210 and 250 type tubes and 281 rectifier tubes.
Type 1128 for use with 250 type rectifier tubes or the Elkon E-100 metallic rectifier.

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ROBERT S. KRUSE
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BROADCASTING FROM THE INSIDE

Every month in RADIO BROADCAST appears the department called "As the Broadcaster Sees It," written by Carl Derber, one of the best known broadcast engineers in the country. Along with humor, news, and searching comment, Mr. Derber's writings have become one of the most popular features of the publication. Are you reading it? Subscribe by the year and make sure that you receive a single issue. Send your check for $4.00 to Subscription Department, Double-day, Doran & Co., Inc., Garden City, N. Y.

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Letters from Readers

(Continued from page 354)

with the most complete time-conserving testing apparatus obtainable, within the limits of practical portability. We believe that a good set analyzer, or diode—in as we prefer to call them—when carried by an intelligent, experienced radio serviceman who is thoroughly familiar with the uses to which such a device may be put, will pay for itself within six months, by reason of increased efficiency in locating trouble exactly, in saving of time, and also in the very beneficial psychological effect on the customer.

As one concrete example of the value of a good-diode, in rebuttal of Mr. Alcorn's statement to the contrary, a really well-designed one will accurately show an open r.f. grid suppressor, as well as other open circuits in the r.f. portion of a receiver.

John S. Dunham, New York City.

Accept of these words, Mr. Alcorn's letter was forwarded to Mr. Alcorn, and the following reply has been received to the opinion expressed above:

To the Editor:

I have read with interest the comment received from Mr. Dunham on my November article. I disagree with your correspondent, because the costly elaborate test equipment is prohibitive to the small radio dealer who has only two or three servicemen. Of course, if an organization is as large as your correspondent's seems to be, judging from his letter, the cost of testing equipment is not as important, especially if servicing constitutes the main activity of the business. On the other hand, the small dealer finds that an outfit of about seventy-five dollars for the portable test equipment of each serviceman is considerable, unless his financial condition is much better than the average.

B. B. ALCORN, Kew Gardens, N. Y.

No. 32 Tinned Hair Wire

Since the publication of the article "From Milliammeter to Multimeter" in June Radio Broadcast a number of readers have asked where the wire specified for the shunts may be obtained. The author of the article has come to our aid in answering this question.

To the Editor:

The No. 32 tinned wire, specified in the article "From Milliammeter to Multimeter," consists of an annealed strand on which a thin coating of tin has been applied. It should be obtainable at any good hardware store. The Pickering Hardware Company, 5th and Main streets, Cincinnati, Ohio, can furnish the wire on five-cent spools. One spool is more than sufficient to make the shunts described.

G. F. Lampkin, Cincinnati, Ohio.

Our Policy Appreciated

A QUESTION always open to debate is whether a radio publication is justified in mentioning in its column the trade names of manufactured parts. It is our opinion that readers derive the greatest benefit from articles when complete information is given; but all magazines do not agree.

A letter from South Africa shows the foreign reader's reaction to our policy.

To the Editor:

I wish to express my appreciation of the fact that you always mention the name of the manufacturer when describing a circuit in your magazine. This is particularly desirable from the viewpoint of readers in foreign lands. As you may easily understand, it often takes months to secure apparatus from the United States, and when trade names are not included in an article the time required to secure

(Continued on page 358)
MUTUAL CONDUCTANCE METER

Tubes are the heart of radio. Engineers, Service Men, Laboratory Workers must know how good their tubes are. Tube measuring equipment for either the determination of a single tube constant, mutual conductance, or for the most extensive examination of tube characteristics has been designed by the General Radio Company.

To test a number of tubes of the same type, the Mutual Conductance Meter—Type 443 is sufficient to call the bad tubes from the good. This Bridge has a single dial calibrated directly in Microhoms with an accuracy of adjustment that is greater than the average uniformity of production tubes. This margin of accuracy is the user's guarantee that after the Mutual Conductance bridge has discovered the secret of the tube, the story is told. This bridge is now used for production tests in tube plants, by dealers who want to protect themselves and insure their customers will get wide awake tubes, and by service men—everywhere, in fact, where a quick tube test is desired.

Type 443 Mutual Conductance Meter . . . Price $55.00.

The Mutual Conductance Meter is but one item in an extensive line of laboratory apparatus, including decade resistance boxes, wave and frequency meters, crystal control apparatus, inductance, resistance and capacity standards, attenuation networks, and high quality audio frequency amplifying and power equipment.

GENERAL RADIO COMPANY
30 State Street
274 Brannan Street
Cambridge, Massachusetts
San Francisco, California

CHECK . . .
CHECK . . .
CHECK .

through a barrage of inspections

Examined at every step . . . checked at every operation and tested at frequent intervals . . . that is the lot of each and every ARCTURUS A-C Tube . . . terminably "on trial."

Not a tube escapes. It must measure up to the most rigid standards set by our engineers. Standards that have spelled success for ARCTURUS A-C users . . . that have made ARCTURUS Tubes the basis by which other tubes are judged.

The engineering attainments in ARCTURUS A-C Tubes are sound reasons why critical engineers and manufacturers demand these Long-Life blue tubes.
Letters from Readers
(Continued from page 356)

apparatus is doubled, due to the necessity of first writing the publication for the trade names of the parts required.
"B. STRUTT MAJOR, Johannesburg, South Africa.

Short Wave Stations

MANY radio listeners equipped with short-wave receivers are anxious to pick up the signals of experimental telephone stations operating on frequencies within the range of their set. In this connection Radio Broad-cast has endeavored to prepare a schedule of short-wave transmissions, but it has been found that the hours of operation of these stations is varied from day to day. The list which is printed below contains much accurate data as it is possible to publish at the present time. The principal stations of the world, which may be heard regularly in this country with a simple short-wave receiver, are listed in the order of their assigned wavelengths.

<table>
<thead>
<tr>
<th>Call Letters</th>
<th>Location</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>PCE</td>
<td>Kootwijk, Holland</td>
<td>19.56</td>
</tr>
<tr>
<td>w2XAD</td>
<td>Schinnen, Holland</td>
<td>19.56</td>
</tr>
<tr>
<td>WWG</td>
<td>Fort Wayne</td>
<td>22.8</td>
</tr>
<tr>
<td>WWK</td>
<td>Pittsburgh</td>
<td>25.4</td>
</tr>
<tr>
<td>WSW</td>
<td>Chelmsford, England</td>
<td>25.5</td>
</tr>
<tr>
<td>CBC</td>
<td>Winnipeg, Canada</td>
<td>25.6</td>
</tr>
<tr>
<td>3WE</td>
<td>Sydney, Australia</td>
<td>28.5</td>
</tr>
<tr>
<td>W2XAB</td>
<td>New York</td>
<td>30.9</td>
</tr>
<tr>
<td>WCJ</td>
<td>Eindhoven, Holland</td>
<td>31.2</td>
</tr>
<tr>
<td>2WBN</td>
<td>Schenenberg, Holland</td>
<td>31.4</td>
</tr>
<tr>
<td>6JE</td>
<td>Johannesburg, S. Africa</td>
<td>32.0</td>
</tr>
<tr>
<td>2XW</td>
<td>Melbourne, Australia</td>
<td>32.0</td>
</tr>
<tr>
<td>W2XAM</td>
<td>Newark</td>
<td>34.0</td>
</tr>
<tr>
<td>WGR</td>
<td>Springfield</td>
<td>34.0</td>
</tr>
<tr>
<td>WWF</td>
<td>Mt. Vernon, Va.</td>
<td>56.0</td>
</tr>
<tr>
<td>W3X</td>
<td>New York</td>
<td>56.7</td>
</tr>
<tr>
<td>W2XE</td>
<td>Richmond Hill</td>
<td>58.5</td>
</tr>
<tr>
<td>2Y</td>
<td>Paris, France</td>
<td>60.0</td>
</tr>
<tr>
<td>2XL</td>
<td>London Bridge</td>
<td>60.0</td>
</tr>
<tr>
<td>W2XG</td>
<td>Council Bluffs</td>
<td>61.0</td>
</tr>
<tr>
<td>K6DA</td>
<td>Pittsburgh</td>
<td>63.5</td>
</tr>
<tr>
<td>6WTA</td>
<td>San Francisco</td>
<td>65.0</td>
</tr>
<tr>
<td>W2XBA</td>
<td>Newark</td>
<td>65.18</td>
</tr>
<tr>
<td>WBE</td>
<td>Springfield</td>
<td>70.0</td>
</tr>
</tbody>
</table>

Mexican Short-Wave Stations

The following is a new list of radio-telephone stations in Mexico which has just been received from Mr. L. Lujan, Consul of Mexico.

<table>
<thead>
<tr>
<th>Call Letters</th>
<th>Location</th>
<th>Power Watts</th>
</tr>
</thead>
</table>
| Radio Broadcast Stations in Mexico

<table>
<thead>
<tr>
<th>Owner</th>
<th>Call Letters</th>
<th>Power Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raul Acuña</td>
<td>CRL</td>
<td>500</td>
</tr>
<tr>
<td>El Buen Tiempo</td>
<td>CRL</td>
<td>500</td>
</tr>
<tr>
<td>M. A.</td>
<td>CRL</td>
<td>500</td>
</tr>
<tr>
<td>Roberto Reyes</td>
<td>CRL</td>
<td>100</td>
</tr>
<tr>
<td>F. Zorrilla</td>
<td>CRL</td>
<td>100</td>
</tr>
<tr>
<td>Florida Socialista del Sureste</td>
<td>CRL</td>
<td>100</td>
</tr>
<tr>
<td>H. H. Gonzalez</td>
<td>CRL</td>
<td>100</td>
</tr>
<tr>
<td>Miguel A. Garcia</td>
<td>CRL</td>
<td>100</td>
</tr>
<tr>
<td>Martinez y Zuniga, Mexico</td>
<td>CRL</td>
<td>100</td>
</tr>
</tbody>
</table>

*All stations are licensed to operate on wavelengths between 350 and 550 meters.

EXPERIMENTAL MEXICAN RADIO STATIONS

<table>
<thead>
<tr>
<th>Owner</th>
<th>Call Letters</th>
<th>Power Watts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constantino Tarnava</td>
<td>MON</td>
<td>24 A</td>
</tr>
<tr>
<td>Rafael R. Grasse</td>
<td>TAN</td>
<td>20</td>
</tr>
<tr>
<td>Luis Fuentes</td>
<td>TAN</td>
<td>20</td>
</tr>
<tr>
<td>Licio Fuentes</td>
<td>CSH</td>
<td>100</td>
</tr>
</tbody>
</table>

*Experimental stations are licensed to operate on wavelengths between 100 and 250 meters.

Jensen in 1929

Every radio authority knows what Peter L. Jensen did in 1927 and 1928. His perfection of the dynamic speaker assured the qualities in a radio reproducer which the perfection in audio circuits demanded. His reproducers served as the pattern for the entire radio industry.

And now watch Jensen in 1929!

The new Jensen Auditorium Speaker has already been announced. It is designed to operate with all types of amplifiers from the smallest with one tube to the largest with push-pull stages employing type 250 tubes.

And in sensitivity, brilliance and separation of tones, in its ability to reproduce tremendous volume, this speaker is unmatched by any other reproducer ever made.

Write today for literature and technical data.

JENSEN RADIO MFG. COMPANY
338 N. Kedzie Ave., Chicago, Ill.
212 Ninth St., Oakland, Calif.

JENSEN PATENTS ALLOWED AND PENDING
Also Licensed under Telephone and Magnatone Patents

NEW LOW JENSEN PRICES

| Transmitter | Jensen Standard Dynamic | Jensen Armstrong \n---------|------------------------|-------------------|
| 8-10 volt D.C. | $35.00 | $45.00 |
| 12 volt D.C. | $40.00 | $55.00 |
| 16 volt D.C. | $50.00 | $70.00 |

| Jensen Audiovisor Speaker | Jensen Armstrong Speaker \n---------|------------------------|-------------------|
| 12 volt D.C. | $55.00 | $65.00 |
| 16 volt D.C. | $65.00 | $75.00 |

Prices subject to change or wiring required. All sets and many foreign countries are made to order. Any model may be fitted with any cabinet in stock. A. C. and D. C. sets.

"NEW!" AERO-CALL SHORTWAVE CONVERTER

Shielded Filtered

Factory-Built, Ready to Plug Into Your Present Radio Set

The AERO-CALL Set is a compact factory-built short-wave adapter equipped with special short-wave coils. It is designed for both A. C. and D. C. sets. Operates perfectly on A. C. or D. C. sets without motorizing. By an auxiliary filter system circuit, it can be plugged into any regular radio set. This amazing radio instrument now makes it possible for you to reach ‘round the world—England, Germany, Holland, Australia, Panama, Java and many foreign countries are just a step away from your short-wave radio. Many have caught the excitement of many others from coast-to-coast that your regular receiver cannot pick up. What a thrill it is to plug this into your set and instantly get in another world. No change or wiring required. All complete, ready to operate, and will include everything necessary to install. Just order this, and your set will be ready to work 12-9 and 12-11 in.

The only converter we know of that really works on all sets. Two models—A. C. and D. C. Write for Catalogue and the conversion. We will refund 100% if not satisfied. 100% guarantee. No. 1, with D. C. tube, for D. C. sets | $25

At leading dealers and jobbers

S A V E

$2.00

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Gentlemen: Please enter my subscription to RADIO BROADCAST for two full years at the special rate of $6.00—saving me $2.00 on the regular subscription price.

Address—

Name—

Address can be accepted unless the classification is not correct.

Mail today!