RADIO BROADCAST

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GARDEN CITY NEW YORK

DOUBLEDAY, DORAN & COMPANY, INC.

1929

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(*Illustrated Articles. Editorials in Italics)

AUTHORS

PORTRAITS

(*Portraits in "The March of Radio")

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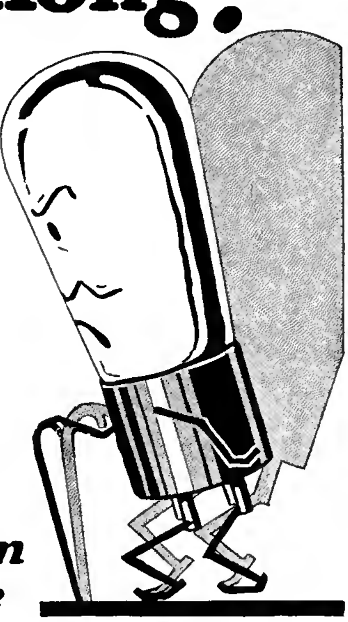

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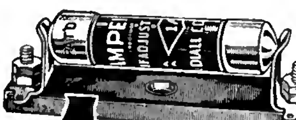

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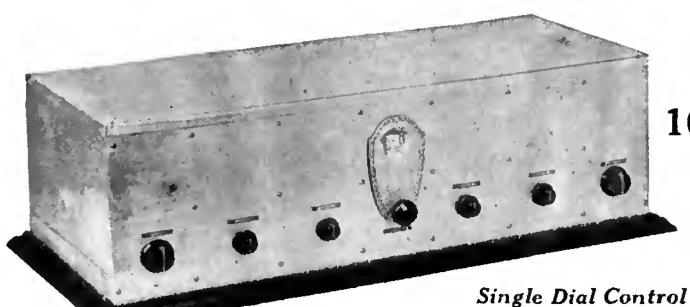

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RADIO BROADCAST

NOVEMBER, 1928

WILLIS KINGSLEY WING, Editor

KEITH HENNEY, Director of the Laboratory | EDGAR H. FELIX, Contributing Editor

Vol. ~~IX~~ 14. No. 1

CONTENTS

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

AMONG OTHER THINGS. . .

A FUNDAMENTAL part of the policy of this magazine is the careful scrutiny of everything appearing in its pages, from the smallest advertisement to the most intricate of technical articles. We have always felt that our first duty to the reader was to protect him from misleading statements and inaccuracies of whatever sort. This magazine is not, however, the expression of one man's opinion, nor even of the group responsible for editing and publishing it. We have frequently given space to articles on technical subjects in which the authors came to conclusions at variance with our own opinions. Almost invariably after the appearance of the magazine we would be deluged with letters and telephone calls demanding to know why we "said" this or that. The editorial expressions of this magazine, whether general or technical are always definitely identified. Articles from other sources are also indentified, and for the opinions expressed, the author is alone responsible. We welcome the opportunity of printing controversial articles.

TO JUDGE from reports which reach us, the motion-picture industry is in nearly as complete a turmoil as that in which radio found itself some years ago. The cause of the trouble is, of course, the application of synchronized and non-synchronized sound accompaniment to the "feature picture." This development is bringing into play practically all of the experience that broadcasters have so laboriously accumulated in the past few years, and is drawing into the movie field many broadcasters and other engineers who have developed apparatus and its uses for this work. In this connection, the pages of Carl Dreher's department, "As the Broadcaster Sees It," are well worth watching, for Mr. Dreher is including much first-hand and practical information on sound motion picture work. Much of this work is being done by expert radio service men.

A NEW ZEALAND radio distributor writes us he is interested in communicating with American radio manufacturers who wish New Zealand distribution for kits or complete sets, either a.c. or d.c. operated. Manufacturers who are interested may communicate with the editor.

FOR those to whom the news has not yet traveled, we repeat the announcement made in this column last month: the bound volume of RADIO BROADCAST Laboratory Information Sheets Nos. 1–190 is now available at $1. Order from your newsdealer or directly from the Circulation Department of Doubleday, Doran.

TO JUDGE from the comments in many letters, the Home Study Sheets are increasing in popularity. It may have escaped the attention of many who are following these Sheets that we are quite willing to examine the answers to the problems in each Study Sheet. These answers will be promptly examined and returned with our comments.

THE December issue will contain an interesting article on band-pass filters, an interesting and practical article on television, more good data for the service man and professional set builder, instructions on how to grind quartz crystals, a number of important constructional articles—and our regular departments.

—WILLIS KINGSLEY WING.

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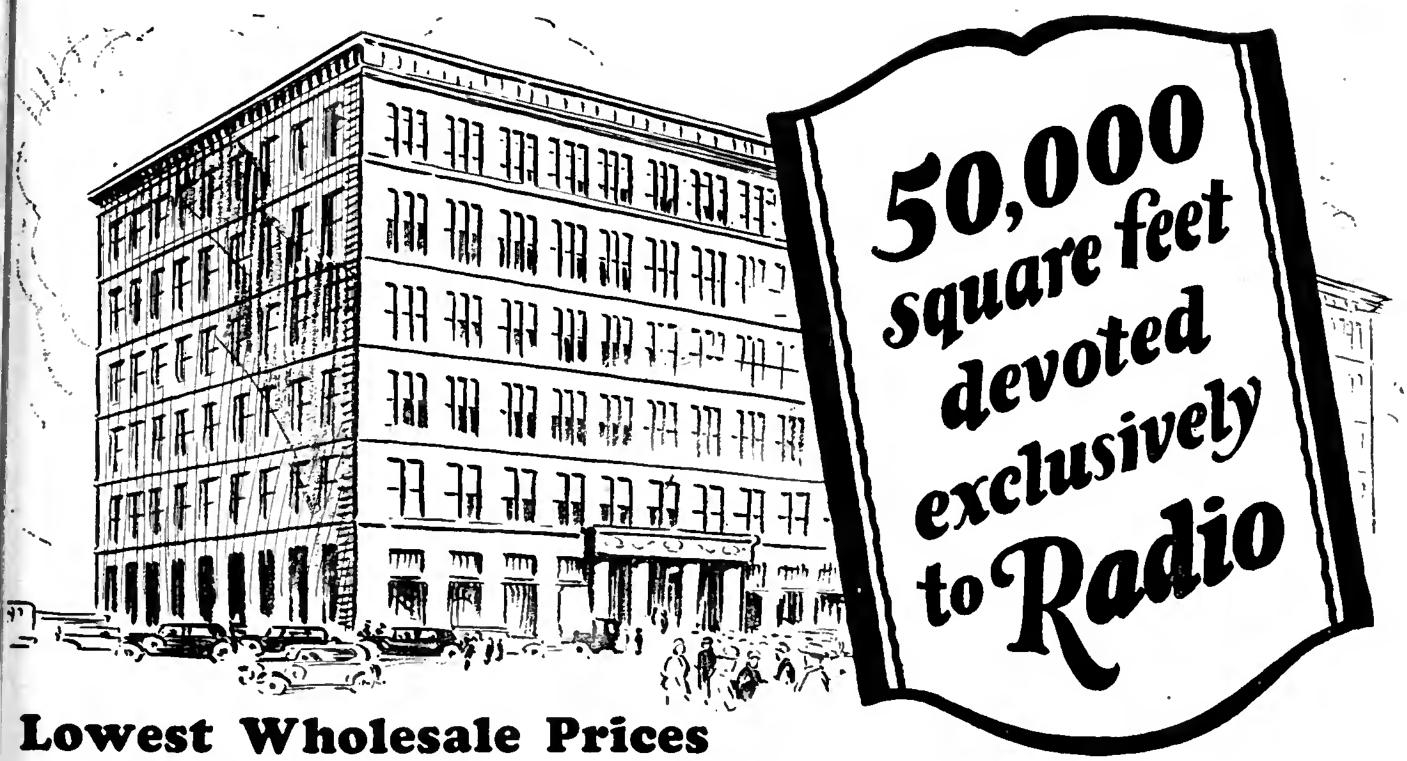

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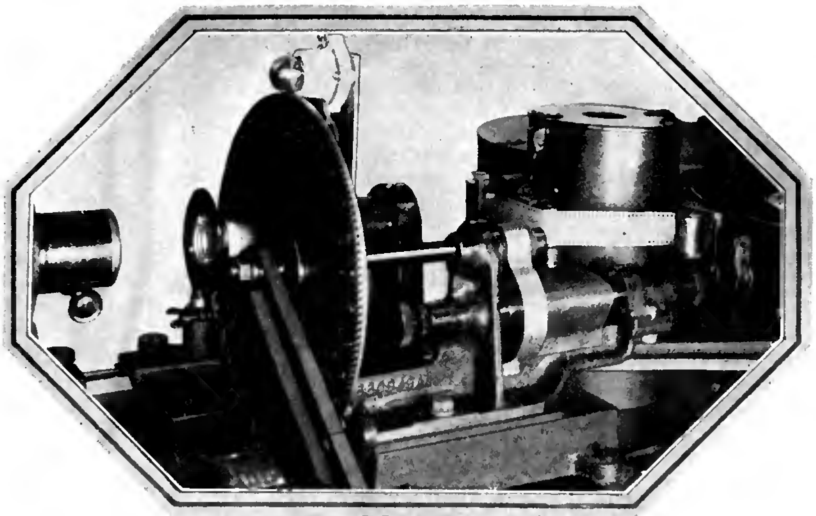


NEW DEVICE PUTS MOVIES ON THE AIR
This apparatus is the heart of the television motion picture transmitter developed by Westinghouse. It is used at KDKA *for the broadcasting of radio motion-picture programs*

What Prospects of Television Abroad?

By LAWRENCE W. CORBETT

IN DISCUSSING the progress of television the technical press of the United States and Great Britain appears to take turn in deploring the lack of initiative of its own countrymen and in praising that of its rivals across the Atlantic. Yet, if we take the opinion of no less an authority than Sir Oliver Lodge, we must admit that the leading exponents of the art in both countries are equally up against a stone wall and that the limitation of the apparatus they are using at present will not permit further improvement.

But Sir Oliver Lodge, and other equally famous scientists whose opinions incline in his direction, are by no means pessimistic of the ultimate success of television. His criticism applies only to that apparatus now commonly used by many of those who claim recognition in the art. Mechanical contrivances, Sir Oliver believes, are limited by certain physical restrictions which it will be inordinately impossible to surmount. To use his own words:

> Cathode rays or moving electrons are the only things likely to be sufficiently docile and controllable to be used as the agents for television. No material things are likely to be able to move quickly enough, but electrons respond so instantaneously that, if devices can be invented for utilizing them, the theoretical difficulties with the required rapidity of motion would begin to disappear both from the sender and the receiver, especially as photoelectric response is almost infinitely rapid.

A. Campbell Swinton, whose early apparatus was described in an article on television which appeared in RADIO BROADCAST for July, 1928, by R. P. Clarkson, appears to have realized the limitations that mechanical equipment would impose upon television, as far back as thirty years ago, and to have recommended the utilization of cathode rays. As stated in the July article, the proposed equipment originally devised by Mr. Swinton offered possibilities which many of our so-called "advanced" present-day systems do not.

At the time of writing this article (early in August and in London) much is being said about Baird's statement that he will market in September a home television receiver which will cost $125.00 The inventor has told the writer that he is already well in production with these receivers and that there will be no shortage when the instruments are released. In fact, the writer has already seen a finished model in the Baird laboratories. The cabinet houses both the television receiver and a electrodynamic loud speaker of American pattern. An eight-inch diameter circular glass screen is to the left of the cabinet, and through this screen, but on a smaller-sized square, is seen the actual imagine.

When questioned as the availability of service to purchasers of these sets (bearing in mind that the B. B. C. has refused to coöperate with Baird at the present time) the inventor informed the writer that he will transmit pictures from a 4-kw. (input) transmitter on the roof of his laboratories in the heart of London. These transmissions, it is planned at the time of writing, will take place on 200 meters (1500 kc.) Mr. Baird has no license for this transmitter, since, says he, one is not required for television transmissions.

Here is raised an interesting point. An English editor of a group of radio publications who has studied the British Telegraphy Act very thoroughly tells the writer that by no possible inter-

The British Situation

BY NORMAN EDWARDS

Managing Editor, Popular Wireless and Modern Wireless

FOR months past the question of television has been agitating the minds of the British public, and day by day the Press in all parts of Great Britain has been persisting in dinning into the public ear that "television is here."

The Baird International Television Development Co., backed by British capital, invested for the development of television in England, now definitely has promised a television service by the end of the current year, despite the fact that the British Broadcasting Corporation, which has a monopoly on broadcasting in England, has refused to coöperate with Baird and his associates because, in the opinion of the Chief Engineer of the B. B. C., and his advisers, the Baird system is not developed sufficiently to warrant it being utilized as a public service: and the Chief Engineer and his associates in the British Post Office having investigated the Baird system believe it to be in a state of experimental infancy and unfitted for offering a means of service to the public.

Furthermore, the Wireless Telegraphy Act, which governs the use of radio in England, legally has been interpreted to cover television, and as the British Post Office refused to licence the Baird system as a public utility service, the question now arises in the public mind as to what Baird will do.

The Baird people definitely seem to believe that they can find a legal flaw in the Act of Parliament which governs the use of radio in Great Britain, and propose to start a service, without receiving the permission of the British Post Office. But it is believed that the Post Office will take steps to prevent Baird giving an unauthorized service. The position at the moment is complicated.

The reason why the British Post Office and the B. B. C. will not coöperate with Baird is not due to any prejudice but simply to the technical fact that the experts concerned do not consider Baird's system likely to be successful in satisfying the public demand for a television service. Baird still adheres to the mechanical system which experts have pointed out repeatedly—experts which include Sir Oliver Lodge; Dr. Lee de Forest; Captain Eckersley, the Chief Engineer of the B. B. C., and A. A. Campbell Swinton, F. R. S.—shows no likelihood of being developed in such a way as to provide a commercially possible television service, and in fact, not even a service which would warrant the authorities in England granting the Baird Company facilities for exploiting it to the public.

I can say in conclusion that Mr. Corbett's article sums up both technically and legally, with excellent succinctness, the television situation in Great Britain.

pretation of the law may Baird "televise," which in itself constitutes transmission of intelligence, unless he obtains a license. And he has been refused the necessary license! It has been prophesied that Baird will be enjoined by law from transmitting as soon as he commences to do so! Surely this attitude on the part of the authorities can be due to nothing more or less than lack of faith by the British Post Office engineers (under whose scrutiny radio is microscopically preserved) in Baird's present methods. Baird, it must be admitted, has made remarkable strides in the advancement of the art but now, it is felt, he has come to the end of his tether, and is being criticized severely for placing on the market apparatus representing a germ of an idea still in an embryonic stage of undevelopment.

It is argued that Marconi had no more to offer the public in those early days when he first fought to establish his ideas about wireless, but then, he appealed to a far more critical public (and then only to highly-trained engineers) than Baird is doing. Moreover, Baird, aided by colorful and exaggerated reports in a general press that knows nothing more about his invention than the fans who will be expected to invest in his televisors, is meeting with considerably less opposition than did Marconi.

COLOR TELEVISION

COLOR TELEVISION, the latest development of Baird, was described in the London daily papers in glowing terms. The writer was given a personal demonstration of this new child of television, by Baird, and was impressed only to the extent that is due to a radical development yet in its cradle days. A man's head, covered alternately with a blue or red cloth, afforded the subject to be transmitted in the demonstration. It was possible to see when the subject opened or closed his mouth, put out his tongue, and possibly when he rolled his eyes, and to see the different colors of the head coverings, but to say that the features were recognizable would highly exaggerate the matter. Monochrome (black and white) television, however, affords several times as much detail as color television.

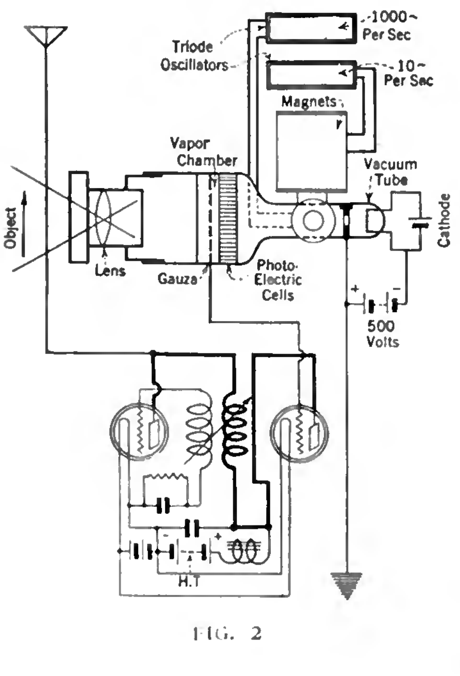


FIG. 2

The following explanation of the principles of color television was dictated by Mr. Baird especially for RADIO BROADCAST. Except for the changes outlined below, the equipment is similar to that used by Baird in his monochrome experiments and already described in this magazine on several occasions:

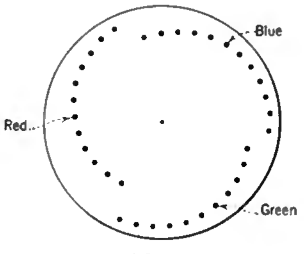


FIG. 1

BAIRD'S EXPLANATION

THE transmitting machine consists of a disc perforated with three sets of holes arranged in spirals and set round the periphery of the disc. See Fig. 1.

One spiral is covered with red filters, the second spiral is covered with green filters, and the third spiral with blue filters, so that each spiral lets through only light of one color. As the disc revolves, a spot of red light first traverses the object being transmitted, this red light being thrown back from the object and effecting a photo-electric cell. The red light, having completed this traversal of the object, the green spiral next comes into operation and traverses the object with a spot of green light. This is then followed by the traversal of the object with a spot of blue light from the spiral covered with blue filters. Thus, the object is traversed first by green, then by red, and then by blue illumination and three images are sent out to the receiver, the first image showing only the red parts of the object, the second image showing only the green parts, and the third image showing only the blue parts.

At the receiving station a similar disc to that of the transmitter revolves exactly in step with the transmitting disc, and behind this disc in line with the eye of the observer are two glow discharge lamps—a neon lamp, and a lamp filled with helium and mercury vapor. The neon lamp supplies the red constituents of the light and the helium and mercury vapor the blue and green. The eye of the observer sees first a red image, then a blue image, and then a green image, the images being presented so rapidly that persistence of vision causes them to blend and the observer to see a composite image made up of these three colors.

Now red, green, and blue constitute the three primary colors from which all other colors are made up: for example, purple is a combination of red and blue, yellow is a combination of green and red, and in the same way all other colors are made up of various proportions of these three primaries, red, green, and blue. The process used in color television is exactly similar to the three-color process used in color cinematography.

The application of color television will naturally be considerable, but it is not proposed by the Baird Television Company to put color machines on the market for some time, as this apparatus is still in the experimental stage. The first television machines to be marketed will be simply monochrome, showing one color, and these machines were exhibited at the Radio Exhibition held at Olympia, on September 22nd last, and will be placed on the market at a price of £25.

The image appears on a glass screen approximately eight inches in diameter and the televisor includes a loud speaker of the electrodynamic type. A special receiving device has been designed which enables both vision and speech to be received from the same aerial and at the same time.

As three separate images must be sent in color television the speed of transmission should be increased three times. In practice, however, it is found that this increase of speed is unnecessary as each of the three images contains in itself quite a large proportion of the visual image received and it is not necessary to transmit at more than twice the speed of normal television to obtain a satisfactory blend of the images and colors.

CAMPBELL SWINTON'S EXPERIMENTS

THE favorable opinion tendered toward the suggestion of Oliver Lodge and others who suggest the utilization of electrons as a basis for experiment in the development of television leads one to expect that newer experimenters in the field will turn their attention to such systems as that avocated by Campbell Swinton. His experiments have been carried to a much farther stage than Mr. Clarkson explained in RADIO BROADCAST recently.

It was only shortly after Braun, in 1897, introduced the cathode-ray oscillograph that it occurred to Swinton to work on the cathode-ray principle in an endeavor to make practical some system of television. He found in experiments that the cathode-ray beam could be deflected both magnetically and electrostatically with remarkable precision. With two similar cathode-ray beams simultaneously controlled and deflected by electric or magnetic forces due to identical currents Swinton expected to obtain absolute synchronism in the motions of the beams with maximum accuracy, irrespective of the speed. He planned to use one of Braun's oscillographs at the transmitting end and another one at the receiving end, the beams to be synchronously and simultaneously deflected by the varying fields of two electromagnets placed at right angles to each other, and energized by the same two a. c. currents of widely different frequencies. In this manner the moving extremities of the two beams would sweep over the surfaces at the transmitting and receiving ends with remarkable rapidity and synchronism, so rapidly, in fact, as to take advantage of the well-known phenomenon of persistence of vision.

To produce the required picture at the receiving end it was only necessary that the rapidly scanning extremity of the cathode-ray beam be impinged on a sensitive fluorescent screen. The beam, of course, would be caused to vary in intensity by the varying signals from the transmitter, thus producing the necessary graduations of light and shade to produce a picture. Swinton's real difficulty lay in devising a system which would efficiently accomplish the variations in

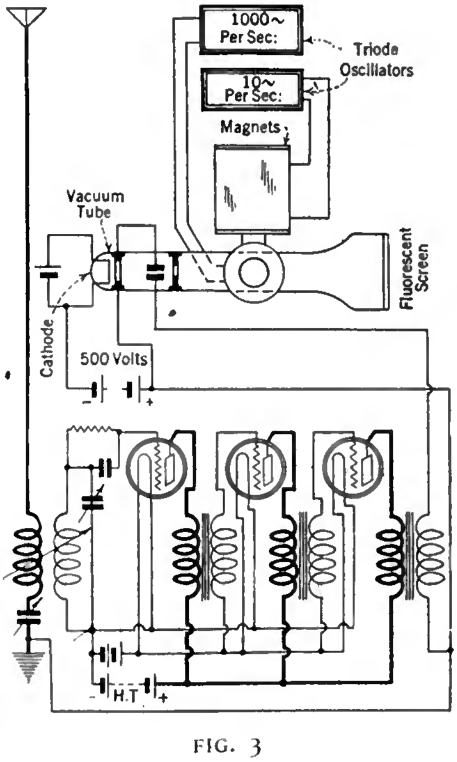


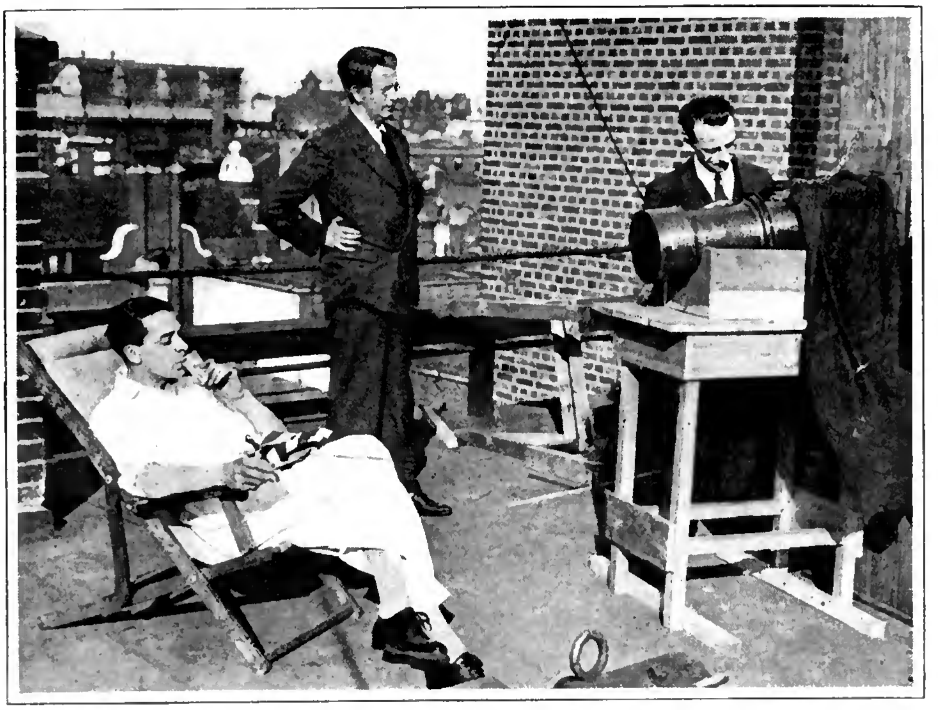
FIG. 3

the transmitted current, which, in turn, depended for its variations on the variations of the scanning cathode-ray beam at the transmitter. In these early experiments the use of a selenium cell was depended upon as the link responsible for the actual variations in transmitted current.

In 1911 Swinton first suggested the use of photo-electric cells as the basis for the transmitting screen—not a single cell, but a fine mosaic of them—and this idea survives in his latest equipment.

Some inventors use the combination of a mechanical arrangement at the transmitting end and the cathode-ray beam at the receiver. Naturally, then, the final result is governed by the speed of the mechanical parts, and the speeding up made possible by the use of electrons throughout is not possible.

As a further development, Swinton suggests the use of electrons by means of suitable three-electrode tubes to supply, from batteries or from the mains, the two a. c. currents of largely different frequencies required to actuate the deflecting magnetic or electrostatic systems at the receiving and transmitting ends, used for the purpose of causing the synchronous, combined oscillating and traversing movements of the beams. The exact synchronization of these latter could be maintained by special radio signals on a wavelength separate from that used for the transmission. Figs. 2 and 3 show the latest Swinton transmitter and receiver circuits, respectively. In these circuits it will be seen that all mechanical motion has been done away with, resulting in circuits hardly more complicated than those used at the present time for broadcasting reception.



BAIRD DEMONSTRATES DAYLIGHT TELEVISION

In this picture Jack Buchanan, the popular musical comedy star, is shown sitting in front of the new Baird daylight television camera Mr. Baird is standing in the center, and his assistant is adjusting the lense of the television camera

In describing the operation of his apparatus, Swinton writes as follows:

At both ends the two cathode-ray beams impinge on screens, which they are caused by the defecting systems to sweep rhythmically and in complete synchronization in parallel lines backwards and forwards from end to end. In the transmitter the screen is composed of a very large number of minute photo-electric cells each of which are activated more or less by the amount of illumination it receives from the image thrown upon the whole screen by the lens. The end of the transmitting cathode beam explores each of these cells in turn, and as to whether it finds it illuminated and thus activated or not, an electrical impulse of varying intensity, proportional to the amount of local illumination, is transmitted to the neighboring gauze grid. The varying electric current thus originated after amplification and conversion into wireless waves is transmitted to the receiver, where, after further amplification and detection, it varies the strength of the receiver cathode-ray beam, which, in turn affects the brightness of that particular portion of the fluorescent screen on which the end of the cathode beam is at that instant impinging. Thus, on the receiving fluorescent screen a replica of the picture thrown by the lens on the transmitting screen is reproduced.

Very probably with modern knowledge and arrangements the transmitting method in which selenium is used might be got to work, though perhaps it would be too sluggish for showing rapid movements in the picture transmitted.

A CRITICISM OF MODERN METHODS

COMMENTING in a paper on the advances made in television, whose mechanical devices formed the nucleus of the apparatus, Mr. Swinton has said:—

What has been effected mechanically, more especially in America, shows what can be done by vast expenditure, labor, and elaboration. As experimental shows they were no doubt magnificent, but having regard to the apparent impossibility of either improving or amplifying to any sufficient extent, one doubts whether they can lead to anything really worth having along their own lines. Surely it would be better policy if those who can afford the time and money would abandon mechanical devices and expend their labors on what appear likely to prove the ultimately more promising methods in which the only moving parts are imponderable electrons.

In a letter which appeared in the *London Times* Mr. Swinton expressed other views on television. Excerpts from the letter follow:

To the Editor of the Times:—

The telegram on the progress of television in your July 14 issue leads me to think some comment should be made on the many very absurd prognostications that have appeared on this important subject.

It is well known that all methods of television are based on the same principle as is the reproduction of pictures in the Press, wherein the picture in each case is composed of a mosaic of minute dots so small and so closely packed together that the individual dots are not recognizable as such by the unaided human eye. Let us take as an illustration a well-reproduced newspaper half-tone 10 x 16 inches in size. This contains more than 250,000 dots.

Now on the same principle that requires that cinematograph film pictures have to succeed one another at the rate of 16 a second, so as to give the illusion of continuous motion, for the purpose of successful television each of the thousands of dots has to be registered in its proper place and with its proper strength no fewer than 16 times a second. Thus to transmit the picture referred to would require registering the dots at a rate of 4,000,000 a second.

Such achievements are obviously entirely beyond the possible capacity of any mechanism with material moving parts and this view, which I have personally been inculcating in scientific circles for many years, has recently been thoroughly endorsed by no less an authority than Sir Oliver Lodge, himself a notable pioneer inventor in wireless telegraphy, who has recently written two articles on the subject. In these he entirely agrees with my view that nothing of this order can ever be hoped for from material mechanism, and that the only way in which it can ever be accomplished is by doing away entirely with material moving parts and utilizing the vastly superior agency of electrons, those infinitesimal and imponderable unit particles of negative electricity which are the most mobile things known to science.

A. A. CAMPBELL SWINTON.

OTHER EUROPEAN INVENTORS

NOT a great deal is heard of the effort of European inventors on the Continent, although from time to time small items of intelligence do come through. In France, M. Bélin, in conjunction with M. Holweck, has succeeded in transmitting shadows. The apparatus of M. Bélin is unique in that the transmitter makes use of two mirrors vibrating at right angles to one another, the combined action of which enables the subject transmitted to be explored by a potassium photo-electric cell. At the receiving end there is a fluorescent screen traversed by a cathode ray. Thus we get a combination of the use of the mechanical and the electron!

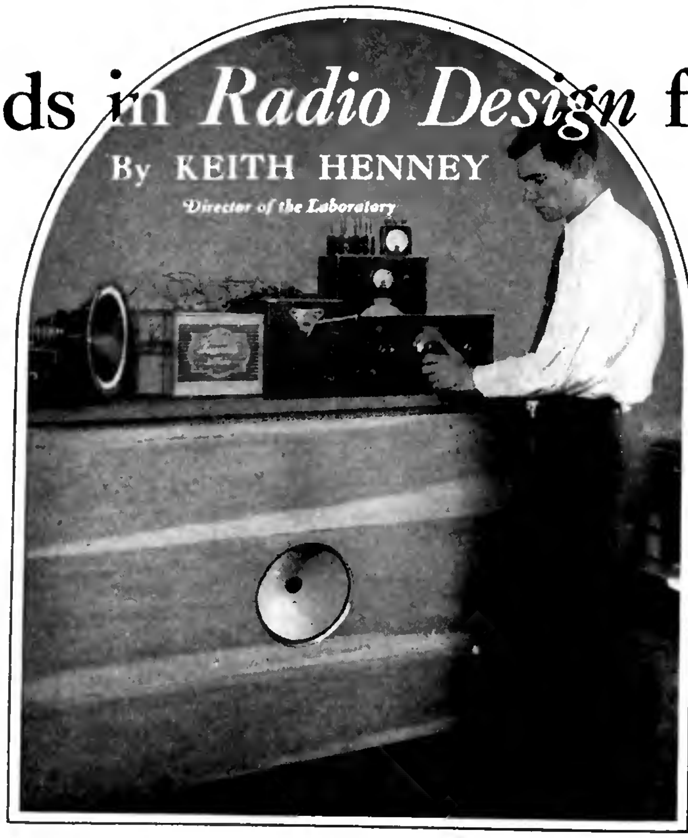
Another Frenchman, M. Dauvillier, has also succeeded in transmitting shadows, but admits that an increase of one thousandfold in sensitivity will be necessary before his apparatus is perfect.

Other scientists who are bending their efforts in an endeavor to be first in the race are Mihàly, Korn, Nesper, and Muller. The latter has been experimenting for some time in an endeavor to produce metal foils of extreme thinness, and has produced some of gold a hundred times thinner than heretofore, so thin, in fact, that printed letters can be read through six layers. Varying intensities of light passing through these layers of foil have been found to alter a current of electricity passing through. The use of this discovery may lead to the production of a very cheap television equipment, it is hoped.

New Trends in *Radio Design* for 1929-30

By KEITH HENNEY

Director of the Laboratory



AT THE present writing (September) several distinct trends in the progress of radio may be observed by any one who gets about even a little bit. These trends are often first evidenced in home-made receivers and in the kit sets put out by wide-awake manufacturers and are later seen in the sets built by the large complete-set people. Sometimes, of course, the set manufacturer is in advance of the others, but in general the tendency has been for this branch of the industry to follow the leader. Whether this is due to lack of engineering initiative, or to hesitancy to adopt something new, or to patent arrangements, is difficult to say. It is true, however, that among the licensees of the R.C.A. there have been few major new ideas that have seen the light of the dealers' shelves. These people are still making t.r.f. sets or neutrodynes. Small improvements have been made, but they are in the nature of refinements of existing circuits and apparatus.

What are these new trends, and what do they mean to the future of the radio business—say the 1929–30 season?

THE DYNAMIC SPEAKER

WE HAVE already discussed in this magazine the moving-coil or dynamic speaker. After considerable effort to find an unbiased source of loud speaker information, we discovered Joseph Morgan of the International Resistance Company, who wrote the article "All About Loud Speakers" in the August RADIO BROADCAST.

There is no doubt that the present season is going to be a dynamic speaker season. Nearly every set manufacturer of note will have a model or two equipped with this newest milestone on the way toward more perfect reproduction. There are many such speakers now on the market; some of them are the Magnavox, Jensen, Peerless, Rola, Newcombe-Hawley, Marco, Radiola 105, Farrand, etc.

Why is the moving coil speaker superior to our present cone and horn types? Briefly, because it presents to the final power tube a nearly pure resistance rather than a complicated combination of inductance, capacity, and resistance whose frequency characteristic is anything but a straight line. The dynamic speaker has a moving system that can move through large distances, up to a quarter inch, which means that plenty of low-frequency power can be put into it with the certainty that sound energy will come out, and that there will be no clatter of armature against pole pieces. No other type of speaker has been tested in the Laboratory which reproduced fundamental tones below 100 cycles. They emit sound, to be sure, but it is not like the original.

Will 1929 See These New Developments in Everyday Use?

1. THE DYNAMIC SPEAKER
2. THE BAND SELECTOR
3. THE ONE-STAGE AUDIO
4. THE FIVE-ELEMENT TUBE

The dynamic speaker, then, is here, and in 1929 will take its place in the best commercial sets and in the homes of the most critical home set builders and engineers. It entails several hardships on the constructor. The filter in his power supply must be better than is necesaary with other speakers that do not reproduce tones below 100 cycles. He must put the speaker in the middle of a rather large and awkward and solid board not less than three feet square for best results. His amplifier, to utilize the advantages of this kind of speaker, must be very good. Because the speaker is more efficient —at least some of them are—he can get along with less power, but at present it is not safe to economize at this point. The constructor had better plan to use 171's or better in his final stage. The day of the 199 tube loud speaker is not yet here. On the other hand, we do not believe it necessary for the home listener to go to 250-type power output tubes, although the reserve power possible with such an amplifier as was described in the July RADIO BROADCAST (page 141), is something to strive for as the ultimate.

In the laboratory of Dr. John P. Minton, the well-known acoustical engineer, we heard a 10-inch Peerless dynamic speaker which was mounted in a three-foot baffle of not too solid construction. The speaker was operated from an amplifier employing a single 171-type tube in the output stage, and the results were very satisfactory. The signals were made louder than could be tolerated comfortably in a small apartment, and they were considerably "up" from the output of a W.E. 560 AW. Persons who invariably talk louder than the radio when the latter is turned on would have considerable trouble in preventing one enjoying a symphony concert from a local station with such a speaker connected in the output circuit.

At the present time the Laboratory staff is busy measuring the characteristics of a number of the newer speakers of this type and when the datum is available in its final form it will be published in RADIO BROADCAST.

THE BAND-PASS R.F.

ANOTHER very distinct trend is the band selector business. In December, 1927, Dr. F. K. Vreeland read a paper before the I. R. E. on his ideas of what a good radio-frequency amplifier should be. He had two suggestions. One was to stagger the three tuning condensers of a t.r.f. set slightly, that is, tune two of the condensers slightly above and below the exact resonance point. This, according to Dr. Vreeland, would tend to broaden the top of the response curve and to steepen its sides. This would make it possible to receive the high audio frequencies that are

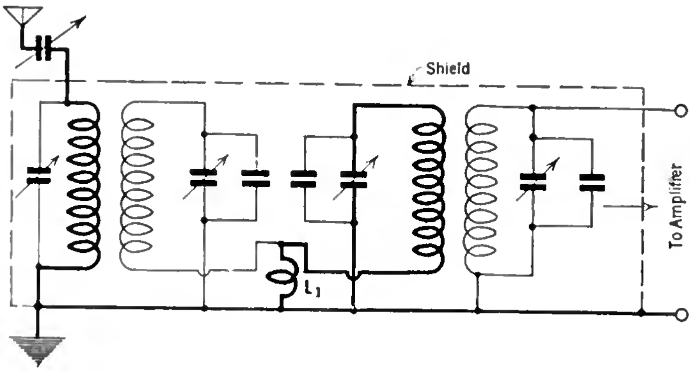


FIG. 1

There are no tubes in the Jones band selector which is shown in schematic form here. All the selecting is done by one set of apparatus, the amplifying by another. The tuned circuits are coupled together by the small inductance, L_1

so badly clipped at present, and yet to prevent cross-talk from adjacent radio channels.

Dr. Vreeland's other suggestion has occasioned a lot of discussion. It consists in using in the receiver a band selector composed of—this is our interpretation, not Dr. Vreeland's—two tuned circuits coupled closely enough so that the resonance curve of such a system has a flat top, a top with a dip in it, or a sharply peaked top depending upon the constants of the circuit. According to the discussion, this is not a new idea—we do not know that Dr. Vreeland said it was—but the fact is that in the old spark days, the bane of radio inspectors was the closely coupled antenna-transmitter system which emitted a broad wave.

The effects of staggering are two: (1) to broaden the top of the response curve and thereby to improve fidelity; and (2) to reduce the r.f. gain somewhat. With deliberate staggering it should be possible to use very highly selective circuits—"low loss," if you will. Then the gain per stage ought to be somewhat greater. The gain in fidelity, however, will not be noticeable on the average amplifier and loud speaker. On the other hand, with a flat audio amplifier, a good transmitting station, and a dynamic speaker, the higher frequencies as heard should be materially improved.

We must now record a visit to the Technidyne Laboratory, where we again had the pleasure of chatting with Mr. Joseph Jones who is business manager of this organization, of which Mr. Lester Jones is the engineer. This was not our first meeting or conversation, and only convinced us the more that this is an organization which will be heard from more and more in the next few years.

The Technidyne group has a band selector, too, but it differs in several respects. The Jones group has in addition a self-shielded coil, a loop of similar characteristics, and an untuned r.f. amplifier of considerable gain. How these work into a modern receiver will be indicated below. The coil has two windings, one inside the other. The high potential ends of the coil are inside, so that one can grasp hold of the coil, or wrap a short-circuited turn of heavy copper wire about it, without destroying signals or even detuning the set. In our opinion this is an extremely useful invention and has resulted in a very valuable patent. So long as coils are used in receivers, there must be means of keeping their respective fields from getting out of bounds. One method is to encase the coil in a metallic can—shielding it—and another is to use a self-shielded coil.

The Jones band selector will probably be used in several receivers, notably the Sparton. It works out as follows. A band selector is made up of several coils and condensers and encased in a container. This has but one wire coming from it, the connection to the following unit, the r.f. amplifier, which connects to the detector and the audio system. This amplifier is untuned, has five stages in it, with the gain varying from 3000 to 15,000 from the short to the long waves to offset the lack of coupling on these waves between set and antenna. When an antenna is attached to the amplifier input, the mix-up of signals is worse than anything the Radio Commission ever imagined.

This circuit has several obvious advantages. In manufacture there are three belts on which the selector, the r. f. amplifier, and the a.f. amplifier are placed for inspection. This is to be contrasted to factories in which the completed receiver is placed upon a single belt. If anything goes wrong with a selector unit, it is removed; the same thing happens with an r.f. or a.f. amplifier. When any good selector is attached to any good r.f. and a.f. amplifier units a good receiver results.

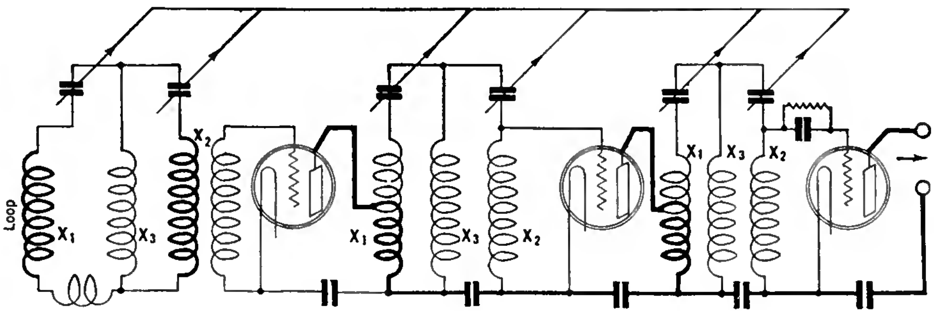


FIG. 2

The circuit diagram of the Vreeland band selector: note the inductance, X_3, which couples together the two tuned circuits composed of X_1 and X_2 and their associated tuning condensers

In service a similar occurrence takes place. The service man takes with him an extra selector and an r.f. amplifier. If the customer's selector is out of order, a new unit is slipped into place—the entire set is not placed out of commission.

The Hammarlund-Roberts engineers have incorporated the band selector idea in their 1929 Master receiver already described in this magazine (October, page 341). In this receiver both the primaries and the secondaries of the r.f. transformers are tuned, the two circuits being coupled together by the mutual inductance existing between the two coils. This is very loose mechanical coupling. The Vreeland and the Jones system use other types of coupling, it being possible, of course, to couple two tuned circuits together with mutual or self-inductance, or with capacity or resistance or combinations of all of these.

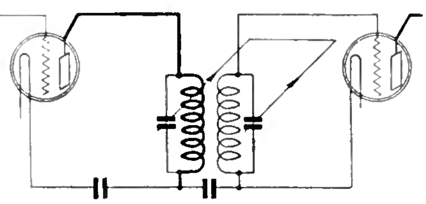


FIG 3

The band selector used in the Hammarlund-Roberts "Hi-Q 29" receiver. In this case the tuned circuits are coupled together by the mutual inductance existing between primary and secondary

Here, then, is the second trend toward band selectors, electrical contrivances which cut out of the broadcast spectrum a swath of the desired width. Such circuits have been suggested as a relief in the present overcrowded ether conditions. We believe, however, that another year will see the band selector the rage in set construction. The Jones system is a preselector, that is, the signals are first selected and then amplified. In the Vreeland and the Master Hi-Q circuits amplification and selection go on at the same time.

THE ABBREVIATED AUDIO

THE third noticeable trend is toward the elimination of the first stage of audio, and working the power amplifier by the detector. Let us see what this means. First of all it means that the detector must supply a much higher output a.f. voltage and therefore must be supplied with a higher input modulated r.f. voltage. The Jones system does not use the usual first stage of audio. The detector is a C-bias affair with input r f. voltages of the order of 10 to 15 volts. A new R. C.A. super has also been put on the market which uses a.c. tubes and has only one audio stage.

The elimination of the first stage of a.f. reduces cost, makes a set simpler to construct and should reduce not only tube noises and the tendency toward severe microphonics, but eliminate considerable a.c. hum, which is a great advantage when the dynamic speaker is used with a good amplifier.

One well-known physicist-radio engineer states that in his opinion the proper place for the loud speaker is in the detector circuit. Whether the set of the future will have no audio amplification at all cannot be debated at present.

A NEW TUBE IN THE OFFING

IN ENGLAND there is considerable talk of the new special-purpose tube with five elements, the Pentode. This is a power valve built along lines similar to our present screen-grid tube. The idea is to get much greater output power with given input voltages. It is a tube with a large amplification factor and a high plate impedance; with our present low-impedance speakers it may require new coupling devices. A number of articles have appeared in *Wireless World* (England) recently on this tube, which lead us to believe that the Pentode will do much toward making unnecessary all the r.f. amplification that eliminating one audio stage demands at present.

WHAT ARE WE COMING TO?

HERE, then, are the trends in sight. The first, the dynamic speaker, is here now. It is one more step toward better reproduction, greater fidelity of voice and music. The second, the band selector, is another step toward fidelity, with the possibility of an increase in selectivity. In the hands of Lester Jones the problem of selectivity has been separated from that of amplification—a feat we predicted months ago. The super-heterodyne is such a circuit, although not to the degree the Jones system is. The third trend is the elimination of the first stage audio. In the Jones system this is done by using greater r.f. amplification and detectors more heavily biased than those of the present. In the super-heterodyne the amplification is at intermediate frequencies. The Pentode tube may make it possible to eliminate some of the additional r.f. gain now necessary, with an obvious advantage from the standpoint of cost and simplicity.

It looks as though it is never safe to predict that the time has come when there is nothing new under the radio sun. The home constructor, however, need not feel it unwise to construct a set at present on the suspicion that next year's circuits will make obsolete his present gear. Receivers built to-day according to recognized engineering principles and equipped with good amplifiers and speakers will be standards of comparison for some time to come.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

New Allocation Repairs the Broadcast Structure

THE Federal Radio Commission has, at last, bestirred itself. It has formulated an orderly plan of allocation, based upon conservative engineering estimates of the capacity of the broadcasting band. When the plan is in smooth operation, it will increase the program service obtainable with any radio receiver capable of reaching out beyond neighborhood locals.

We hesitate to praise any constructive step announced by the Commission because, up to this time, it has always reversed itself before promised reforms have been put into operation. It proposed to eliminate all stations persistently wandering from their channels, but backwatered before the echo of its brave statements had died out. It called a host of stations before it to prove they were operating in the public interest, necessity and convenience, with a grand fanfare to the effect that many would thus be weeded out, but the actual result of the hearings was negligible. From past experience, we cannot avoid fearing a complete reversal of form and a repudiation of the meritorious broadcast allocation plan. We hope that public approval of the announced plans will be so forcibly expressed that, this time, there will be no turning back.

The plan itself is a normal and sensible classification of channels into local, regional, and national groupings. Forty channels, eight per zone, are nationally cleared for exclusive service by stations of 5000 watts or more. Only one station is in operation on each channel at a time, although time division may be employed in the case of stations not prepared to operate on a full-time basis, or to permit division of channel facilities among the states according to population, as required by the Davis Amendment. This exclusive service band lies between 1190 and 640 kilocycles.

Four channels, 1460 to 1490 inclusive, are devoted to stations of a maximum power of 5000 watts, to be shared by two zones, presumably on opposite coasts of the country, thus providing good regional service.

Thirty-five channels, ranging throughout the dials from 1430 to 580 kilocycles, are assigned to stations having a maximum power of 1000 watts. These channels will be used in not less than two nor more than three zones simultaneously for night broadcasting, although in isolated instances, the maximum will, for the time being, be exceeded when no serious interference is caused. These are the so-called "regional channels."

Five additional channels, ranging throughout the band, for stations up to 1000 watts, will be duplicated in every zone, thus providing medium power, local, and limited regional service.

Finally, six channels at the lower end of the dials, will be thickly populated with 100-watt broadcasters, accommodating a great number of stations providing strictly local service.

This, in brief, is the skeleton of the allocation plan, as it was first announced by the Commission. Undoubtedly, it will be modified. Such dubious features as limiting the maximum power of permanently licensed stations to 25,000 watts, on the exclusive channels, is a useless curtailment of the service of these channels. Did it serve to increase the number of stations which might be assigned to a channel, it could be justified on that ground. It amounts only to an order compelling stations to render less than their best possible service. Apparently, it is a concession to Judge Robinson, who wanted to put a 5000-watt power limit on broadcasting, thereby reducing the total area of the United States served by high-grade broadcasting to considerably less than ten per cent.

EFFECT OF THE DAVIS AMENDMENT

THE Davis Amendment requires equal distribution of channels among the zones, and their distribution within zones according to population. As a consequence of the varying areas of the zones, more than half of the desirable regional and national channels necessarily are assigned to the Northeastern quarter of the country, comprising the first, second and part of the fourth zones. The Western half of the country, the fifth zone, has only one-fifth of the total number of cleared channels. The Southern zone, comprising an area of about a fourth of the country, is given only one third the number of preferred channels assigned the Northeastern quarter of the country.

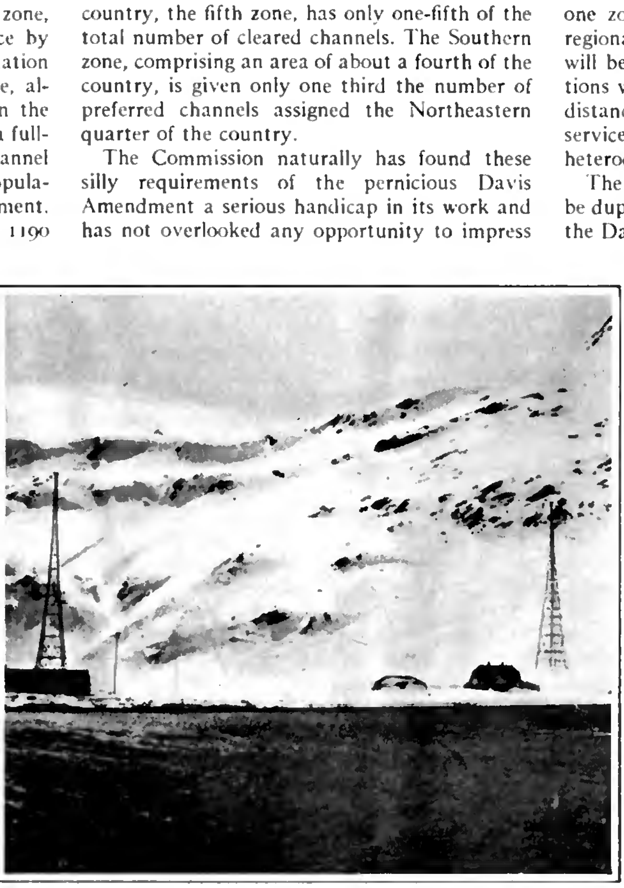
The Commission naturally has found these silly requirements of the pernicious Davis Amendment a serious handicap in its work and has not overlooked any opportunity to impress the public with the effect of the provisions of the Amendment in unnecessarily depriving the South and West of broadcasting stations. However, had the Commission acted promptly upon the various allocation plans offered it from the very day of its organization (of which one, submitted by a member of the staff of RADIO BROADCAST, provided almost precisely the structure at last agreed upon), the Amendment never would have been passed. The year and a half of dilly dallying which preceded the adoption of the present plan has inflicted a more or less permanent handicap upon the broadcast structure in the form of the Davis Amendment.

To the broadcast listener, the faithful adoption of the present plan means clear reception on most of the positions of the dial. Forty channels are completely cleared, providing for eight stations in simultaneous operation per zone. Thirty-four channels are partly cleared for regional service, offering a standard of reception about equal to that heretofore found on the so-called cleared channels. The number of stations reasonably clear of heterodynes, is vastly increased and chain programs will no longer crowd the few choice dial positions.

By taking into consideration the channels which will be used simultaneously by more than one zone, the total number of stations in the regional class, operating simultaneously at night, will be 125, or 25 per zone. These regional stations will give satisfactory service for moderate distances beyond the so-called "high-grade service range" and should be entirely free of heterodynes within the high-grade service area.

The six channels devoted to local service may be duplicated at fairly short distances, but again the Davis Amendment acts to curtail the potential service of these channels. The number of stations per zone upon these channels must be equalized although, for example, there could otherwise be about twenty times as many local communities using these channels in the fifth zone as in the first, without having any greater congestion than is found in the first, so marked are the differences in the areas of these zones.

Another curious consequence of the Davis Amendment is the somewhat diverse effect it has upon the two centers of broadcast congestion, New York and Chicago. Because New York has such a predominant proportion of the population of its zone, it suffers a somewhat smaller curtailment of assignments than Chicago. Casual observation of the Chicago situation shows a heavy mortality in time on the air of its all-too-numerous 5000-watt stations, but the actual effect will not be nearly as drastic as it appears. Many of Chicago's 5000 watters have been operating on extensive time division in the past and others are merely call letters rather than actual stations. Practically no licenses will be cancelled any-



MARCONI'S NEW 6-KW, 2000-METER TRANSMITTER

This wireless telegraph station at Grytviken, South Georgia, maintains a daily telegraph service with the Falkland Islands which in turn communicate with Montevideo where and, by liberal use of time division and limited application of power cuts, the new structure will work a minimum hardship upon station owners.

In spite of the dire predictions of opponents to a plan based upon engineering considerations, the plan supports the contention of engineers that allocation, based upon sound technical evaluation of the capacity of the broadcast band, does not require heavy mortality of stations.

PLAN BETTER THAN HOPED

FOR two years, we have urged in these columns that the number of stations on the air simultaneously be reduced to 200 or 225; the plan exceeds our fondest hopes because it places only 165 stations in simultaneous operation on 74 channels. The balance of the band is reserved for strictly local services. Receivers in good locations will bring in a parade of unheterodyned stations and good programs will again have almost nationwide audiences. The wall of local stations, in congested centers, will be partly levelled. Every section will profit by lessened heterodyning. The South and West are seriously restricted by enforced disuse of available channels. In the South, this is no immediate hardship, as there are fewer stations in operation but, on the Pacific Coast, a great many needless holes in the ether can be credited to the Davis Amendment.

We predict one unexpected result of the new broadcasting structure: the restoration of popularity of long-distance listening. Radio reception has arrived at a respectable degree of quality of reproduction. Cleared channels will bring back a limited amount of dial twisting and, within a year or two, long distance will again be a desired quality in a radio receiver. Long distance is the magic of radio, just as speed is the zest of motoring. Beauty in appearance and tone will always predominate as a sales appeal, but the flash of distance will rise again as improved conditions make its enjoyment possible. This repeats in radio the cycle of automobile sales appeal: first, speed, then an era of emphasis on comfort and beauty and, finally, these characteristics combined, as they are in the products of to-day.

What Is Public Interest?

LOUIS G. CALDWELL, as attorney for the Commission, on August 25, issued a detailed interpretation of the so-called public-interest, convenience and necessity provisions of the Radio Act. Inasmuch as the Commission must, sooner or later, prove in the courts that the new allocation plan is justified by these considerations, that interpretation is virtually the Commission's plan of defense. The statement points out particularly that the Davis Amendment, although calling for equalization of powers and stations in each district, does not set aside the public interest, convenience, and necessity clause and that, therefore, all new stations, authorized in under-quota districts, must pass qualification standards imposed by these four, all-important words. It further points out that renewal of existing licenses is not incumbent upon the Federal Radio Commission, unless it finds that public interest, convenience, and necessity are served; that the issuance of a license is not to be regarded as a finding beyond the duration of the period covered by said license; relicensing in the past, indicating that the station has met the test of public convenience, does not, however, bind the Commission to continue past mistakes, should any have been made inadvertently; that public interest, convenience, and necessity cannot possibly be defined and must be judged by individual situations and conditions; that there is demand for a variety of services, including high-power service, covering large territories, and low-power service for local interest; that the broadcasting of phonograph records as a considerable part of a station's service is not a public service unless special records are developed for broadcasting only; that advertising should be incidental to a real service rendered by a program; that stations of 500 watts power or more should not be located in thickly inhabited communities; that very low-power stations should not be permitted in very large cities; such channels being more usefully employed in smaller towns; that the character and financial responsibility of applicants for licenses are important considerations; that broadcasting time should not be used to air discussions of a private nature; that stations, not operating on a regular schedule, do not serve the public; that a broadcaster, who is not sufficiently concerned with public interest to equip his transmitter with adequate frequency control or check thereon, is not entitled to a broadcasting license. These considerations were the basis upon which the practical application of the broadcast allocation plan were founded when the Commissioners made their individual station assignments to national, regional, and local channels.

THE STAGE OF A TELEVISION DRAMA

This picture shows how WGY broadcast the first television drama, "The Queen's Messenger." Three television cameras were used—one for each of the two players and the third for the "props"—and by a twist of the knob the director could bring the desired camera into the circuit. Also, a television receiver was installed in the studio to enable the director to check the image

The Race for Television Publicity

THE race for television publicity continues. The latest to score is the Westinghouse Company, which demonstrated a sixty-line television scanner and reproducer. This is ten lines better than the television elephant which the Bell Laboratories built some years ago. Instead of scanning a living subject, light was passed to the photo-electric cell through a motion-picture film. This was proclaimed in the newspapers as a radical invention, although the first broadcasting of radio movies, as we recall it, was demonstrated to members of Harding's cabinet seven years ago, by C. Francis Jenkins. With amazing ingenuousness, the Westinghouse publicity stated that Mr. Conrad began his television researches only three months ago.

The uselessness of the device from a practical viewpoint could be gleaned from a single statement in the publicity to the effect that the frequencies used to transmit the sixty-line picture lay between 500 and 60,000 cycles, so that a total of 150,000 cycles of ether space would be required to radiate the signal by the conventional, double-side-band method. An extra 5000-cycle wave was used for synchronizing purposes.

The usual statement was made that the device would be marketed by the Radio Corporation of America when ready for public consumption. Mr. H. P. Davis, Vice-President of the Westinghouse Company, also stated to the press that the device would soon be ready for the home user. So are steam yachts!

WRNY Television Transmissions

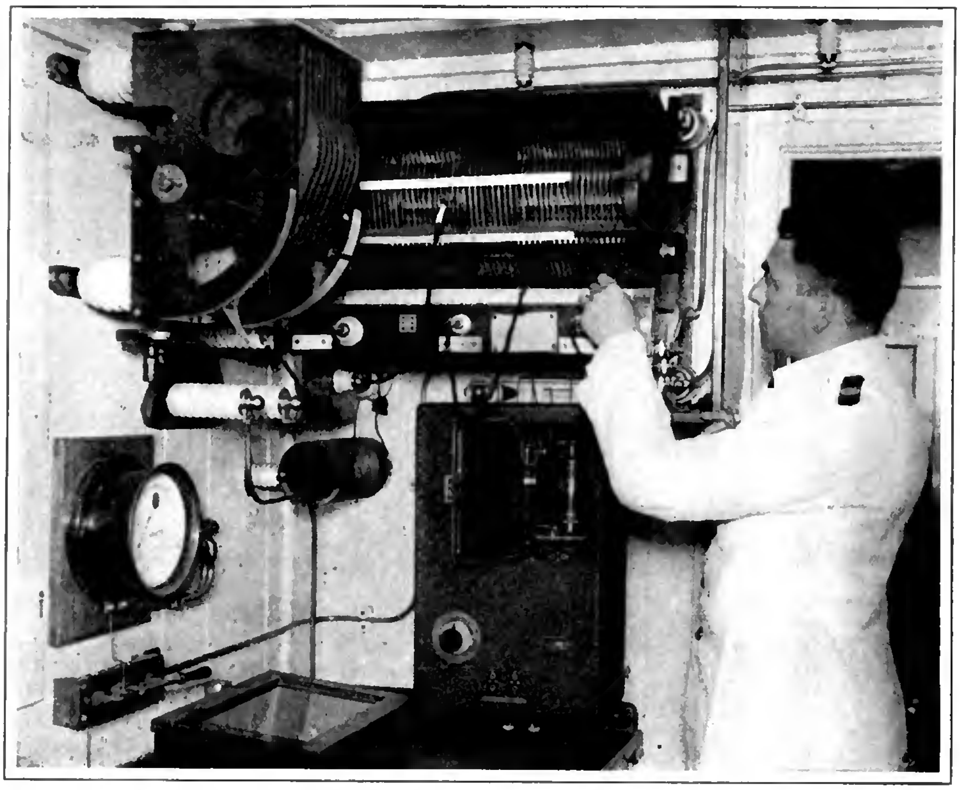
STATION WRNY began its transmissions on August 21. Its television signal is now heard from the fifth to the tenth minute of each hour that the station is on the air. A 48-line picture is transmitted on the broadcast band, but its channel width is restricted by sending only 7.5 pictures a second instead of sixteen. This does not improve the quality of the transmission.

A Milestone in Television

THE first time that remote-control television broadcasting has ever been undertaken was the occasion of Governor Smith's acceptance speech on August 27. On this occasion, WGY installed its portable television transmitter, which makes a 24-line picture, at the State House in Albany. The television signal was transmitted through eighteen miles of wire and then radiated by WGY, the General Electric station at Schenectady.

The television pick-up equipment, erected near the microphone, consisted of three units, two tripod-mounted, photo-electric cells in boxes, a light source, and a scanning device. The cells were placed at the left of the Governor, within three feet of his face, and the light source between the cells. A 1000-watt lamp was used to play on the Governor's face, the intensity of the light being broken up by a scanning disc.

The General Electric people did not issue any applesauce publicity about milestones in history at the time. When they issue a statement that home television is practical, we will believe it.



A MODERN RADIO INSTALLATION ABOARD AN ITALIAN LINER

New Nationwide Picture Transmission Service

A HEADLINE in the New York *Times*, announcing a nationwide television service, proved upon analysis to be the announcement of a proposed extension of commercial still-picture transmission by the R. C. A. A 5000-cycle signal, transmitted over a special carrier, is used for synchronization. The image is thrown upon a ground-glass screen and there photographed. The device was produced in the laboratories of the Westinghouse Company and may be used by the R. C. A. in competition with the A. T. & T. system. This is neither television nor broadcasting. Otherwise, the headline was correct.

Need for Defining Television Practices

SINCE many broadcasting stations appear to be groping toward television, it is desirable to reduce to a minimum the number of scanning disc apertures and their different combinations, and to agree upon the direction of disc spiral and disc speeds to be used. These factors are being determined in a very unscientific and haphazard fashion. Each individual television transmitter, being put into operation, seems to work according to the whim of its builder, with the result that any television receiver now built is capable of receiving from only a single transmitter, although it may be within range of two or three signal sources.

The variables are not confined merely to the number of holes in the disc. Some transmitters scan their subjects in such a manner that the first sweep of the disc makes the top line of the picture; others start at the bottom. Some require the receiving disc to run clockwise; others counter-clockwise. Still others, intending that universal or direct-current motors be used for driving receiving discs, are not operating at closely regulated speeds so that standard synchronous motors may also be used for reception.

It is too early to propose standards for these factors because standards imply agreement upon practical constants. Television is altogether too crude to be standardized. It would have been no more ridiculous, in 1904, to standardized upon 28 x 3 inch automobile tires, than to decide today upon 24 or 48 line scanning discs for television. But it is worth agreeing upon temporary standards of (1) disc speed, (2) direction of spirals, (3) common multiple for number of holes, and (4) direction of disc rotation.

Newspaper Has Radio Picture Transmitter

THE Edinburgh *Scotsman*, a leading newspaper, claims the distinction of being the first newspaper in the world to own and operate its own photo-telegraphic service for the regular transmission of news pictures. The time of sending pictures from London to Edinburgh has been cut from eight hours to eight minutes. The costliness of the several systems in use for commercial picture transmission in the United States have precluded their routine use by newspapers. The A. T. & T. system is well organized, but newspapers complain that they have to wait so long between the filing of pictures and the time they are actually sent that airplane delivery is more rapid and desirable. The R. C. A. transoceanic service is useful only in the case of pictures of extraordinary interest because transatlantic transmission of pictures is difficult.

Commercial Broadcasting Increases

A VERY healthy trend in the strengthening of the economic foundation of broadcasting is indicated by the growing percentage of national advertisers using commercial, goodwill broadcasting, as reported by the Association of National Advertisers. The figures represent investigation of the activities of 352 leading advertisers. For that number, the percentage using radio grew from 11.6 per cent. in 1927 to 14.5 per cent. in 1928 and the actual number from 41 to 51. Broadcasting is the only one of the eight classifications, into which national advertising falls, that has shown a marked increase in the number of users. The greater the number of national advertisers, seeking to please the public by goodwill programs, the greater the competition for public attention, and consequently the higher the program standards. Better commercial programs also mean further improvement in standards of non-commercial programs and a very happy outlook for the radio listener. Another field which is developing is broadcast advertising by local stations. The peak of direct advertising by the local broadcaster is passing and more intelligent and serviceable use of the radio announcement is being made by the smaller stations.

Here and There

A NEW chain is again announced on the Pacific Coast, comprising KJR, Seattle; KEX, Portland, KGA, Spokane; KYA, San Francisco; and KMTR, Los Angeles. Rival chains to the N. B. C. Pacific Coast network which did not materialize have been announced before. Perhaps this new one will.

MR. OSWALD SCHUETTE, professional radio agitator, employed by the Radio Protective Association, offered a petition to the Commission that the licenses of WEAF, WJZ, WGY, WRC, KOA, KGO, KDKA, KYW, KFKX, WBZ and WBZA be revoked on the grounds that the companies operating these stations constitute a radio monopoly. Louis G. Caldwell, counsel for the Commission, pointed out that, until the companies called are found guilty of monopoly in the courts, licenses cannot be revoked on that ground; that there being no point-to-point communication, and therefore no competition between cable, wire, telegraph or telephone systems involved, the Commission is powerless, under Sections XIII or XV, to take the silly action proposed by Mr. Schuette and his excited associates. This proposal is even more drastic than Judge Robinson's suggestion that the power of these stations be cut to 5000 watts. It might prove a healthy lesson to carry out such a threat, just to witness the storm of listener protest against the disruption of broadcasting service from favorite stations.

AS EVERYONE perforce knows, radio has come to its own as a political medium. The Democrats are spending about half a million for radio, using six half-hour periods a week, including a liberal appeal to the women's audience. They are also spending $100,000 for individual programs over independent stations. Entertainment is being broadcast in connection with political features. The Republicans are using the network three times a week, the entire country being covered once a week by the inclusion of the Pacific network. Also, 43 half-hour programs are being sent over the Columbia network, thus insuring the listener of no rest from political blasting.

Aircraft Radio

CAPTAIN S. C. HOOPER pointed out the importance of using the 500-kilocycle distress frequency on aircraft making over-water flights. This enables flyers to establish communication with ships at sea and shore stations, while utilizing the high frequencies, permitting long-distance transmission, often precludes nearby reception. For example, the *Greater Rockford*, which made an amazing landing somewhere between Newfoundland and Greenland, was heard successfully in Wisconsin. But none of the shore stations in Canada or Greenland could hear its signals because of skip-distance effect. Had it been possible to take compass readings in Greenland or Canada, the whereabouts of the place would have been much better known and the rescue would have been accomplished very much sooner.

NEW YORK STATE plans an aviation weather service and is establishing twenty weather bureau stations which will make reports to Gustav Lundgren, meteorologist, at Albany. The data will be compiled and telegraphed to every airport in the state, as well as broadcast twice daily through N. B. C. stations.

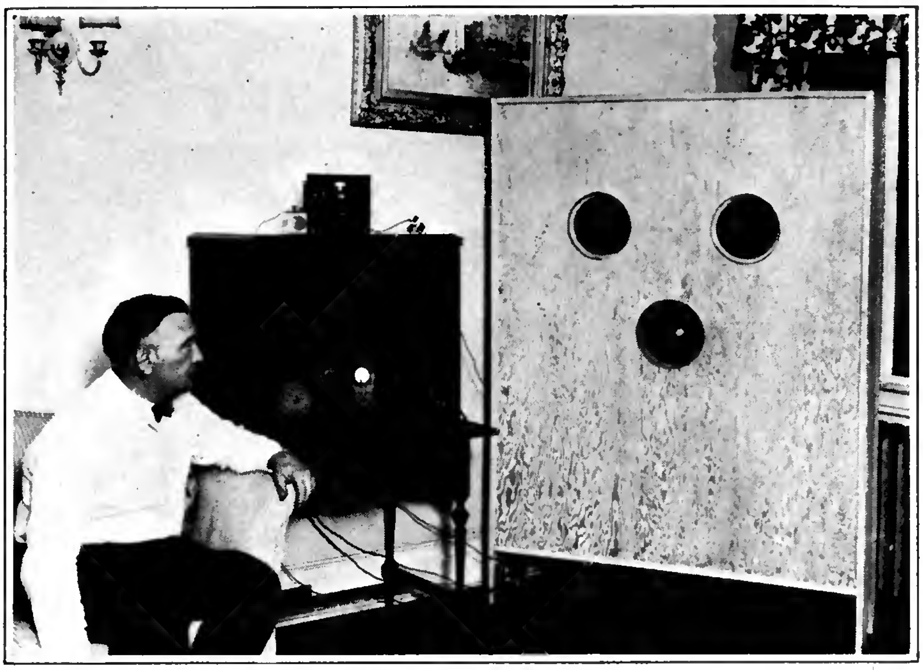
A DIRECT, high-power service between San Francisco and Tokio, the first occident to orient service to be directly connected by modern, high-speed telegraphy, was announced by the R. C. A. Messages to Japan heretofore have been relayed through Hawaii.

THE Federal Radio Commission authorized the R. C. A. to establish direct communication with Liberia, although a channel for that purpose already has been allocated the Firestone Company which, by the way, did not oppose the R. C. A.'s application. If the Commission is holding to its promulgated principle, a single radio link is not sufficient to handle all the traffic between Liberia and the United States and the duplicate services are warranted by the amount of message traffic to be handled.

ANOTHER pair of licenses granted for services of doubtful value are the permits issued to the Universal Wireless Communication Company for two 10,000-watt stations, one for New York and one for Chicago, to operate an overland radio-telegraph service. Filling channels with unnecessary services means later denials to essential services.

THE International Telephone and Telegraph Company has made an agreement with the Spanish and General Corporation to build a radiotelegraph station in the Azores for transatlantic communication. This will distribute North- and South-American traffic to European countries where the Mackay Companies have no direct communication through their agreement with Eastern Cables, Ltd.

REAR VIEW OF GIANT SPEAKER



AN ELECTRODYNAMIC SPEAKER OF DE LUXE DESIGN

Three dynamic units are used in the loud speaker shown above. The baffle on which the units are mounted is of box construction and measures $4\frac{1}{2}$ by $5\frac{1}{2}$ feet. The designer of the speaker, Mr. Mampe, of Palisade, N. J., is shown in the picture

THE call letters of the ship and planes of the Byrd Expedition are WFBT, WFA, WFD, WFE, KIK and, for the planes, WFC, WFB and WFF. The wavelengths in meters of the channels to be used will be 91.3, 68.1, 53.1, 45.6, 34.06, 26.5, 22.8, 17.95, and 13.72. Eavesdropping upon the affairs of the expedition will be possible all over the United States. The expedition will carry 20 transmitters and 26 receiving sets and a most comprehensive line of accessories and parts to keep the installations in operation for two years.

Radio in Foreign Countries

AT THE Berlin Radio Show, there were 350 exhibitors, including the Army and Navy, Lufthansa and the German Postal Administration. The most interesting television device demonstrated was the invention of one Mihaly, which gave the shadowy outline of the person spoken to on the telephone.

THE Department of Commerce report for June shows a marked increase in United States exports of radio equipment. The greatest growth was in transmitting sets and parts, which, compared with June, 1927, exports of $5,806, rose to just short of $50,000. Receiving sets rose from $174,433 to $228,983. Radio imports were more than $5000.

THE Radio Corporation has made an agreement for interchange of patent rights and for the sale of radio equipment with the State Electrical Trust of Leningrad.

A PUBLICITY statement from Russia reports that there are 67 broadcasting stations now in operation in that country, serving 250,000 listeners. Because of the great area involved, Russia will naturally require many broadcasting stations, although the number of receivers in use is still discouragingly small. Increasing public interest promises considerable growth in the future.

THE British Radio Union, a £30,000,000 concern, will acquire all the ordinary shares of the Eastern, Eastern Extension, and Western Telegraph Companies and all the ordinary and preference shares and debentures, if any, of the Marconi Wireless Telegraph Company. This is the practical consummation of the British cable merger plan.

THE British Board of Trade has passed a law, compelling Class 2 ships, freighters with more than fifty in the crew, to carry automatic distress-signal alarms. Class 3 ships, with less than fifty in the crew, are unaffected, while Class 1 ships, passenger liners and other vessels with more than 200 persons on board are permitted to displace one wireless operator with the automatic alarm.

DR. McINTYRE of the Ministry of Health of the British Board of Trade and Drs. H. C. Case and Philip Morton are experimenting, aboard the S. S. *Mauritania*, to develop an international medical chest, making possible a code, directing medical treatment at sea, which will be understandable in any language. This promises to be an aid to smaller ships which have no physician aboard.

THE National Electrical Manufacturers' Association estimates that, by cutting the total number of its meetings in half and holding the annual meeting in the fall instead of in the spring, it will save its members, through reduced time, traveling and other expenses, approximately $300,000. Attendance at some trade association meetings of the radio industry really makes it doubtful whether such expenses should be charged to personal amusements or as a legitimate business expense. The radio industry might employ an accountant to determine the financial loss it suffers by supporting two trade organizations and then follow the wise example of NEMA and reduce the number to one.

—E. H. F.

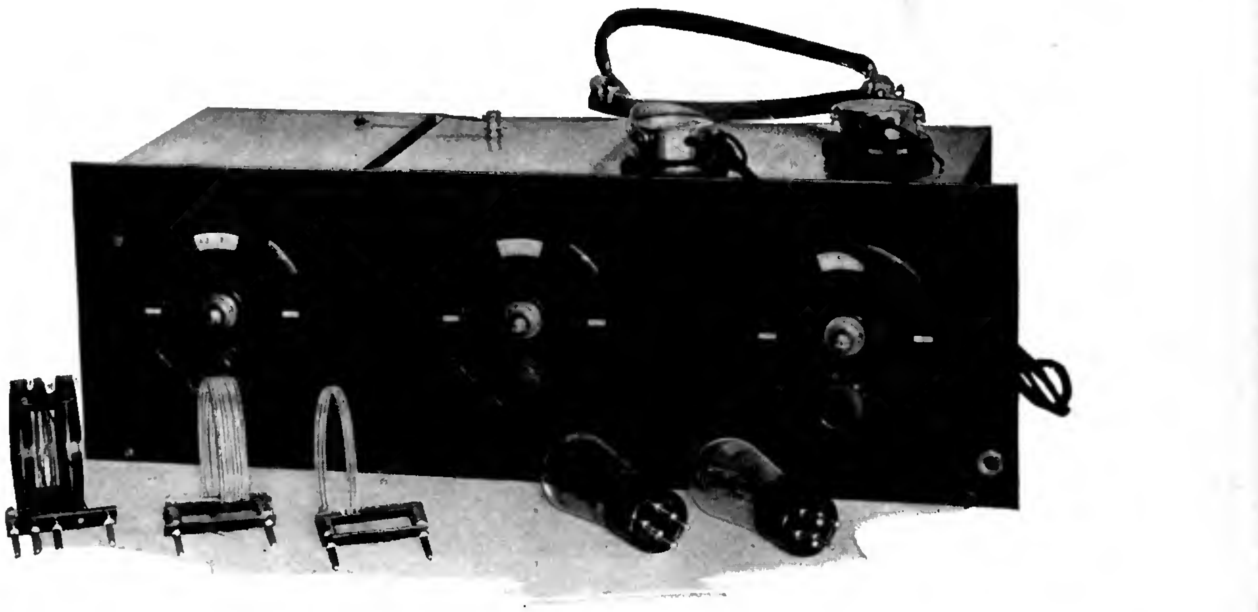


FIG. 5. FRONT VIEW OF RECEIVER

A Two-Tube T.R.F. Short-wave Receiver

By WILLIAM BOSTWICK and W. T. THOMAS

A RECEIVER to operate satisfactorily on short waves must fulfill several important requirements, and in explaining the design of the short-wave receiver described in this article, it will be well to consider these one by one, so that the reader may have a clear idea of the various phases of the problem at hand.

In the first place the receiver must be completely free from body capacity, and arranged so that its coils pick up no energy themselves. This means complete housing in good metallic shields.

The receiver should be equipped with a regenerative detector the control of which must be smooth and easy. Capacity control of regeneration has been selected as best meeting these conditions.

Any receiver placed before the public for construction, should, in the opinion of the authors, be a non-radiating device.

The receiver must be selective yet must not cut side bands, and it must cover the required wavelength range.

Lastly mentioned but far from last in order of importance, the set must have high overall voltage amplification, yet keep the amplification of noise at a minimum.

THE DESIGN OF THE UNIT

THE above résumé of what a short-wave set should be, is, of course, general, and outlines the things to be expected from the correct receiver for this job. The set that we propose to develop in this paper is one that fully meets this rigid set of requirements, and at a figure that will not strain the average pocketbook.

The set, as seen in the photographs and diagrams, is composed almost entirely of standard commercial parts. The tuning range of the receiver is from 15 to 140 meters, effected by means of three sets of easily interchangeable coils. This range covers to-day's domestic and foreign short-wave broadcasting, and the more important amateur bands. No audio amplifier is included in the set, which should preferably be used in conjunction with two stages of high-grade audio, or better still, with a power amplifier using a push-pull circuit. The set requires the use of a 6-volt storage battery or an "A" power unit, and three different B potentials, namely, the plate voltage for the screen-grid tube, the screen-grid voltage, and the detector plate voltage. The writers have found that 180, 60, and 45 volts, respectively, work out very well.

Impedance coupling is employed in the r.f. stage, as this is the only practical method of matching the plate impedance of the r. f. tube at short wavelengths. A screen-grid tube is employed on account of its high voltage amplification, and also because it is the only tube that can supply stability to a short-wave r. f. amplifier. A 200A detector tube should be used.

Perhaps a word as to results would not be out of place at this point. During the short time that this set has been in operation in our laboratory it has completely and easily covered the world. Phone reception has been effected with points ranging from Alaska to New Zealand and from England to Russia and Java, not to mention many other foreign stations at lesser distances, a low gain two-stage audio amplifier being used on the output of the set. Quite often signals from 5sw, the short-wave broadcasting station of the British Broadcasting Co., in Chelmsford, England, are strong enough to give loud speaker operation directly off the detector output. For those interested in amateur c.w. reception it will suffice to say that Australian amateurs have been heard in Ithaca, N. Y., at 3 P.M. with the phones on the table, and this also right off the detector, using no audio.

FOR the first time we are glad to be able to present a short-wave receiver using a screen-grid amplifier which is tuned. Up to the present time, designers of such receivers have been content to use the screen-grid tube as a sort of blocking tube which prevents oscillations from the detector getting into the antenna, and which gives a certain amount of amplification, it is true, but not an amount comparable to what is possible when the amplifier input is tuned.

In the Laboratory the receiver worked beautifully without any a.f. amplifier, the signals from the detector being as loud as those from an ordinary short-wave receiver using one stage of audio. It is true that such a receiver as this has an additional tuning control, and that for maximum signal strength and selectivity, both the amplifier and the detector circuits must be tuned, but it is believed that it is worth it.

The writer recommends that 180 volts be used on the screen-grid plate and 60 volts on the screening grid of this tube. In the Laboratory the receiver worked properly with only 135 and 45 volts, respectively, on the plate and grid.—THE EDITOR.

CONSTRUCTION

IT WILL be noticed that in the design of this receiver one of the shield cans called for is of rather large dimensions, necessitated by the placing of both the r. f. and detector tubes in the same compartment, the overall width parallel with the panel being 13". In some localities difficulty may be experienced in obtaining a shield of this size ready made, and for this reason it was thought advisable to include a description of the shields, for the benefit of those who wish to make their own. Let it be said, however, that unless one has had some experience in work of this nature, he had better take the drawings to a good tinsmith and have him make them, in which case it will be well to impress upon him the importance of having a close fit around the base; when the two halves are put together, the gap should not exceed 1/32" at any point if a really good job is done.

The material may be either half hard brass or copper and should be slightly less than 1/32". Half hard brass 0.0225" was used by the writers.

Aluminum may be used equally well but should be roughly three times the thickness mentioned.

Upon referring to drawings in Fig. 2 it will be noted that the developments and bending lines are given, the lettering corresponding with the assembly sketches, all dimensions being given in inches and all bends are at right angles and should be quite sharp. A wooden block roughly 6″x 4″x 7½″ was carefully squared up and was found very useful as were also a pair of large wood clamps and a mallet.

It is advisable to commence with piece B in Fig. 2, being careful to bend exactly on the lines. Next the side pieces, G_1 and G_2, are cut out and bent along the dotted lines, these forming the sides of the cover can, being soldered along the two diagonal edges and also soldered inside the top piece, B. The rectangular slot shown in the cover cans are best cut after the soldering is completed.

Next piece A is cut out and bent along the dotted lines, care being taken that the lips on the portion fitting against the panel are bent so as to just allow room to slide the top piece in from above.

The large can is made in precisely the same manner except that the two rectangular slots are provided in the cover can to accommodate the two condensers. After the shields are completed, three small V-shaped notches are cut in both upper and lower portions in order to allow certain wires to go to the terminal strip and the jack, as can be seen from the pictures.

The next step is the mounting of the shields and the panel on the baseboard. The lower portions of the shields are screwed to the base using round-headed screws, being sure to place the small shield at the extreme left of the board, and the large one about ¼″ from the right-hand extremity of the smaller, as shown in the pictures. The panel mounts directly to the baseboard with four 1″ wood screws. The drilling of the panel is very simple and for that reason no layout is shown. A ⅜″ hole is drilled ⅝″ from the right-hand end of the panel to accommodate the filament-control jack.

The three variable condensers, C_1 C_2 C_3 in Fig. 1, are mounted symmetrically on the panel as shown in Fig. 5, holes being drilled through both the panel and the upright shield fronts; the templates furnished with the condensers giving the exact hole positions and sizes. The holes for the shafts of the two end condensers are 3⅝″ from the respective panel edges, and 3¼″ down from the top of the panel. The third and larger condenser, C_3, used for regeneration control, is mounted exactly between the other two and at the same distance from the top edge of the panel.

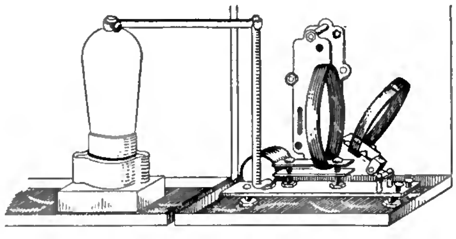


FIG. 3. DETAIL OF COIL ASSEMBLY

THE COILS USED

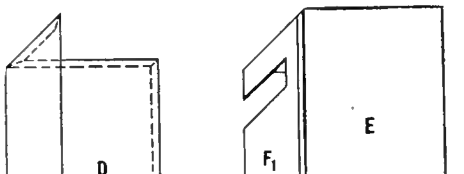
THE next job is the making of the coils for the various wavelength ranges of the r.f. tuner, together with their mounts. All coils are 3″ in diameter and are of the so-called air wound type. The size of the wire is No. 16 and the winding is spaced the diameter of the wire. Windings of this type can be purchased by the inch from most radio stores. There are three of these coils to be made to cover the 15–140 meter range, having three, eight, and fifteen turns respectively. The general form of these may be seen in the photographs. The first step in construction is to cut three strips of 1/16″ bakelite, 2½″ by ¼″. Drill through all three of these strips two holes exactly 2″ apart and on the center line of the strips, and of a diameter suitable to take the male portion of the General Radio coil mount plugs. The placing of the strips and the method of holding the coil may be seen from the Fig. 3. This procedure is followed in making the other two coils.

The next thing to be done is to remove the primary coil and its supports from the mounting base of the Aero coil set. A piece of Bakelite 5¼″ x 1¼″ has this primary mounted on it at a point ½″ from an end in exactly the same manner as it was originally mounted on the Aero base. Drill two holes in the new base exactly 2″ apart and symmetrically placed with respect to the base. These are to take the female portion of the General Radio plugs. Having completed this piece, mount it in the first shield as shown in the Fig. 4, taking care to raise it enough so that the plugs extending through it do not touch the metal shield. To this base is now attached, as the constructor sees fit, a rigid vertical rod of copper or brass extending to a height of 6½″ above the shield base. This is the "signal artery" to the set, and is shown in the photographs and the diagram in Fig. 3. A connection is made at the base between this and the nearest female General Radio mount in any convenient manner. Care must be taken not to permit this upright rod to extend through the mounting far enough to come in contact with the shield base. Now placing the small 1½-volt biasing battery as shown in Fig. 4, and wiring according to Fig. 2, we are finished with the first can. It might be well to mention at this point that both shield bases are connected together by soldering a short "jumper" wire to each and that the ground, A minus, B minus leads are common and connect directly to base shields.

The base for the Aero coils can now be mounted in the large shield base by means of wood screws and the feet supplied for the purpose. Care must again be taken to prevent the coil plugs from touching the shield base when the plugs are fully inserted. The location of this mounting is very important. Its center is placed 6¼″ from the right-hand edge of the large shield base and 3″ from the back edge of the same.

The set of Aero coils that are to be used in the detector circuit, with the mount just mentioned, have to undergo a little treatment before they can be put into service. Due to the addition of the r. f. tube to these coils, the wavelength range is raised and we are forced to remove some wire. From the smallest coil one half turn is to be removed from the grid end (end farthest from the tickler coil). To do this unsolder the wire from the lug, slip the wire through the guide bars until you reach a point directly above the base, then run the wire directly down diametrically across the coil to the lug where it was at first, cut off the excess and solder. In the same manner one and one half turns must be removed from the medium coil and three turns from the larger.

The detector socket may now be mounted in the rear right-hand corner of the large base shield, so that the tube pin points toward the panel. Fig. 4 shows how much clearance should be left for the sides of the shield cover. The r. f. socket is also mounted in this base and is located in the rear left-hand corner, placed so that the pin is parallel to the panel and pointing toward the first shield. This socket is raised up on a small wooden block until the control grid cap of the tube is exactly 6½″ above the shield base. The mounting positions of the two condensers, C_5 and C_6, and the two r. f. chokes, L_3 and L_5, are also shown. The 20-ohm rheostat, R_1, on the screen-grid tube should have one lug soldered directly to the plus filament lug on the r.f. tube



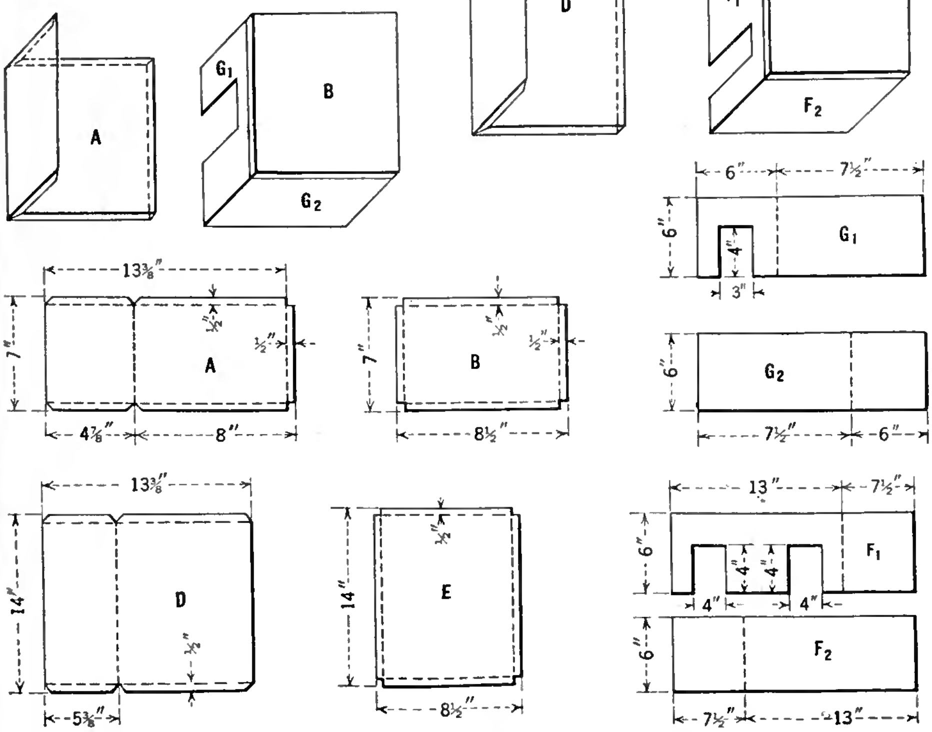


FIG. 2. DETAIL OF SHIELD COMPARTMENTS

socket, and the 10-ohm rheostat, R_3, is likewise fastened to the lug on the detector tube socket. The location of the two fixed condensers, C_4, C_7, and C_8, is also shown.

This places all the apparatus except the grid leak and condenser, whose locations are readily observable. The only point to be noted is the raising of the grid-leak mount from the base shield by the thickness of a ½" wooden block; these parts should be placed as near the detector tube as possible. The terminal strip at the back of the set and the filament-control jack are next mounted as shown.

The rheostats are adjusted once, to give the correct tube voltages, and thereafter are left alone. Using a 6-volt storage A battery, the respective settings were found to be as follows: The r.f. rheostat, R_1, was turned on one third from the full off position and the detector rheostat, R_3, was set one half from the full off position.

Should the constructor prefer fixed filament resistors may be used for R_1 and R_3, the size required for the screen-grid tube being the same as for the UX-120 power tube; the detector takes the usual ¼-ampere (four ohm) type.

In making the wiring to the terminal strip care should be taken to make sure that the notches provided to allow these wires to pass through the shields have their sides well rounded with a file so that they will not cut through the insulation on the wires.

Having finished the preceding operations, there are only two or three things more to be done before putting the set on the air. When the small shield cover is slipped in place it will be found that the vertical rod will hit the top of the cover and accordingly a ½" hole must be drilled in the cover to accommodate this rod. It will be found best to drill a smaller hole first to serve as a guide as to the position of the rod. Similarly a ¾" hole must be made in the larger shield to allow the cap of the screen-grid tube to protrude. Great care must be taken to prevent either of these coming in contact with the shield covers and a small wrapping of insulating tape or a small piece of rubber tubing is necessary to insulate these points. A removable connection must now be provided to join the top of the rod and the cap of the screen-grid tube when the shields are in place. This can be made out of bus wire as shown in the photographs, care being taken that a snug connection is made when it is sprung into place.

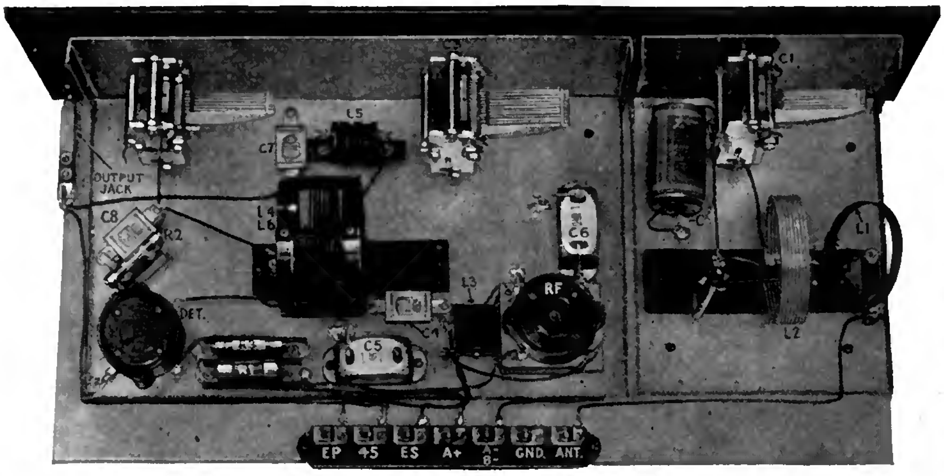


FIG. 4. LAYOUT OF PARTS ON BASEBOARD

OPERATING DATA

To PLACE the set in operation it is but necessary to connect it to antenna and ground, as well as the required d.c. potentials, and feed the output into a two-stage audio amplifier, to give the necessary volume for consistent loud-speaker operation. It will be found that in all probability the dials on the tuned stages will not agree particularly well, as it is almost impossible to match coils and condensers at the frequencies with which we are dealing. The small coils will be found to cover 14–38.5 meters; the intermediate, 35–81 meters; and the large coils 80–140 meters. These are of necessity approximate values. It is understood that corresponding pairs of coils are to be used simultaneously in the coil mounts; the home-built coils in the r.f. stage and the commercial coils in the detector stage. In changing coils care must be taken to handle them only by their bases as the fragile windings and frames are easily injured.

After adjusting the filament rheostats and applying the necessary voltages, we are ready to commence operations. The set is operated just like any tuned r.f. set using detector regeneration, except that the tuning is extremely sharp.

The right-hand dial is the station selector, and the left tunes the r.f. stage (which must be kept in resonance with the detector circuit, for maximum energy transfer to the detector), and the center dial controls regeneration. It will be well to permit the detector to oscillate until a station carrier-wave is heard, then bring the r.f. stage into resonance with the detector. This may de-tune the detector slightly, but a simple readjustment will care for this. The regeneration control may now be backed off and the detector should slide smoothly out of oscillation; if it does not, a reduction in detector plate voltage is advisable. The broadcaster's modulation should now come through satisfactorily.

And now a word as to the antennae for use on short waves. The difference between high or low, short or long is not very marked. In general a single wire about 60 feet long placed as high as possible will answer well.

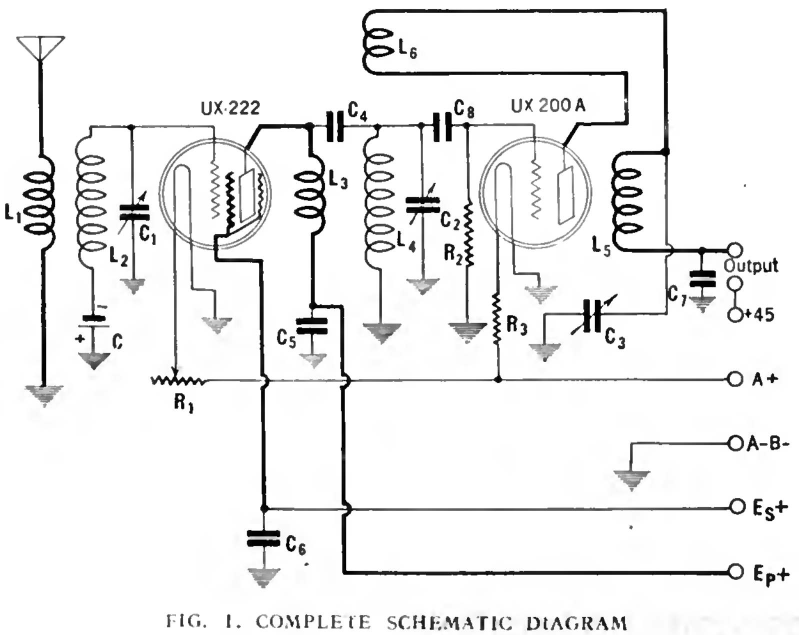


FIG. 1. COMPLETE SCHEMATIC DIAGRAM

LIST OF PARTS

THE parts used in the writer's receiver follow. Parts of equal electrical and mechanical characteristics may be used in place of those mentioned in the list, of course.

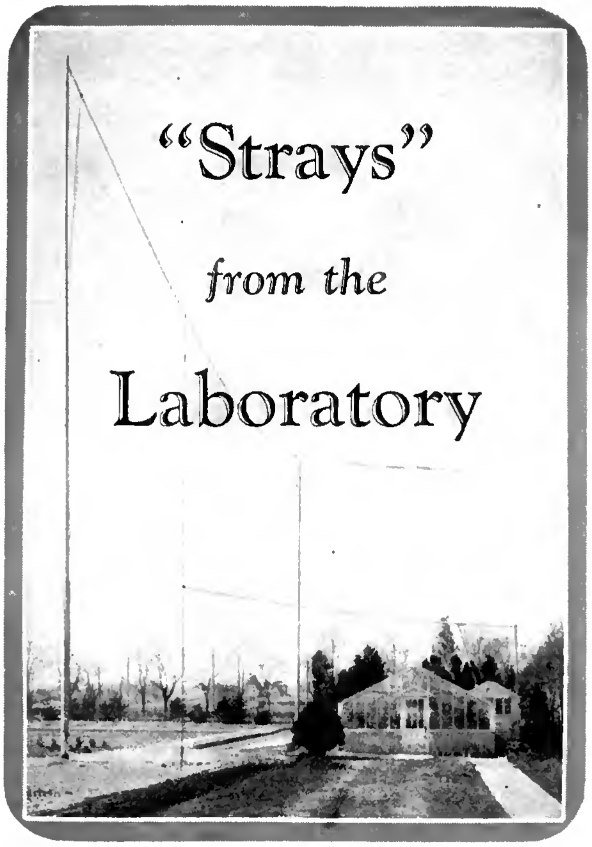
- C_1, C_2—2 Amsco S.L.F. variable condensers, Type 1213
- C_3—1 Amsco S.L.F. variable condenser, type 1223
- C_4, C_7—2 Tobe fixed condensers, 0.001 mfd.
- C_5, C_6—2 Tobe by-pass condensers, 1.0 mfd.
- C_8—1 Tobe fixed condenser, 0.0001 mfd.
- L_1, L_2, L_4—1 Set Aero short-wave coils and mount
- L_3, L_6—2 Short-wave r.f. chokes
- R_1—1 rheostat or fixed resistor, 20 ohms
- R_2—1 Tobe grid leak, and mount, 10 megohms
- R_3—1 rheostat, 10 ohms, or fixed resistor, ohms
- 1 1½-volt C battery (flashlight type)
- 2 Amsco full-floating tube sockets
- 1 Two-circuit filament-control jack
- 1 7-contact terminal strip
- 6 General Radio plugs
- 2 General Radio receptacles
- 1 Bakelite Panel, 7" x 21"
- 1 Soft wood baseboard, 9" x 20" x ½"
- 2 Shield cans as shown or stock for same
- 3 Marco vernier dials
- Miscellaneous wood and machine screws, wire, etc., piece of scrap bakelite 1½" x 5½" and 9 pieces ¼" x 2½" x $\frac{1}{16}$".

The last two items are for coil mounts and base.

To put the receiver into operation the following are needed.

- 1 Screen-grid tube
- 1 Detector tube (200A type)
- 6-volt storage battery or A supply
- Source of B power (see text)
- 2-stage audio amplifier

"Strays" *from the* Laboratory



Dynamic vs. Magnetic Speakers

WE ARE being asked our opinion of the "dynamic" speaker at least once a day, and our present ideas are as follows. In the first place, all loud speakers are dynamic, in the sense that some of their parts move. This includes the old horn type, the newer cone type, and the newest type in which the coil moves with respect to the field. So the reader had best look carefully into the claims of speaker advertising, or the claims of over-the-counter salesmen to make certain that the speaker he is buying is the type he wants.

Considering the question of fidelity of response only, not the question of efficiency, the moving-coil speaker compared to a good cone will "prove in" only on frequencies below 100 cycles. Compared to the old stand-by, the W. E. 540-AW, a good dynamic speaker unit on a baffle 3′ x 5′ and one inch thick (a baffle 3′ square would be equally effective) reproduced notes below 100 cycles while the cone reproduced nothing below that frequency. It is true that tones come out of the cone when 100-cycle and lower notes are put on it, but these are not true tones, but complicated harmonics of the fundamental tones generated in the speaker itself. So when one listens to a good orchestra with a good amplifier and good cone from a good station, the viola he hears is a synthetic viola made up of harmonics generated partially in the speaker and partially in the ear.

On frequencies above 100 cycles the cone as tested in the Laboratory was about as good as the best of the dynamics. Of course, measurements show that the cone was "down" at frequencies as low as 200 cycles compared to the moving-coil speaker, but the ear is deceived and satisfied easily and reception coming from the 540-AW is, in our opinion, good enough for the average household. The Balsa-wood speaker, already described in this magazine, is somewhat better than the cones, but suffers from mechanical troubles.

The moving-coil speaker, then, is better than the good cones only on frequencies below 100 cycles. It must be mounted in a rather large and solid board, not in a small and beautiful cabinet. In the latter housing the lower tones will be lost, and certain frequencies will be badly reinforced due to cabinet resonance; these tones will "boom."

Because frequencies below 100 cycles are reproduced—some moving-coil speakers go down to 50 cycles easily—the filter of one's power-supply unit must be such that no 120-cycle or 60-cycle hum gets through. This means that a. c. tubes are almost out of the question—and our experience has been that when one places a socket-operated moving-coil speaker in the middle of a large baffle board, the hum is pretty bad. If the speaker is a d. c. unit, it does not produce a hum of its own, but if it has a small built-in rectifier the user may expect some hum—if a large baffle is used.

For one who wants the best, the moving-coil speaker in a baffle about three feet square—larger if possible—will give it. But with this combination one must have an almost perfect amplifier, one which is flat from 50 to 5000 cycles—there are very few of them—and a perfectly quiet power-supply unit, and there are very few of them, especially if a. c. tubes are used. And there are few stations transmitting programs that will cause one to note the difference between an excellent moving-coil speaker and a good cone. Even the few stations that transmit down to 100 cycles do not have many programs which make one wish for a better amplifier and loud speaker. A recent release from the Freshman Company states there is little music below 120 cycles. We venture to say that the majority of home-made receivers using good parts is ahead of the majority of broadcasting stations when one considers fidelity.

Regarding Series-Filament Operation

SEVERAL of the readers of Radio Broadcast have written for information on the problem of series-filament operation. Are there other readers who would like to have an article on this subject? Some data was published in Radio Broadcast in the June, 1927, issue and an article appeared in *Radio Engineering* in the June, 1928, issue.

The advantage is as follows:

It is possible to build a quieter receiver for a.c. operation than by the use of a.c. tubes. With excellent amplifiers and dynamic speakers on large baffle boards this is important. With the ordinary amplifier and loud speaker it is not important as the average a.c.-operated set is quiet enough.

The disadvantage of series-filament operation is that small tubes, such as the 199, must be used. This fact makes it somewhat more tricky to design the circuit as when one tube goes bad the others may follow unless precautions are taken to prevent such difficulty. Also, under some conditions there may be a greater tendency for the receiver to motor-boat.

Until the UX-201B tubes, which require only one-eighth ampere for the filament and which are now sold in Canada, are released, the 199-type tubes must be employed. These tubes have a rather low gain, and are quite microphonic. Some other tube manufacturers, Sonatron, for example, make an eighth-ampere tube but these have not been submitted to our Laboratory for test and we can therefore neither recommend nor discourage their use at the present time.

Who wants technical data on series-filament operation?

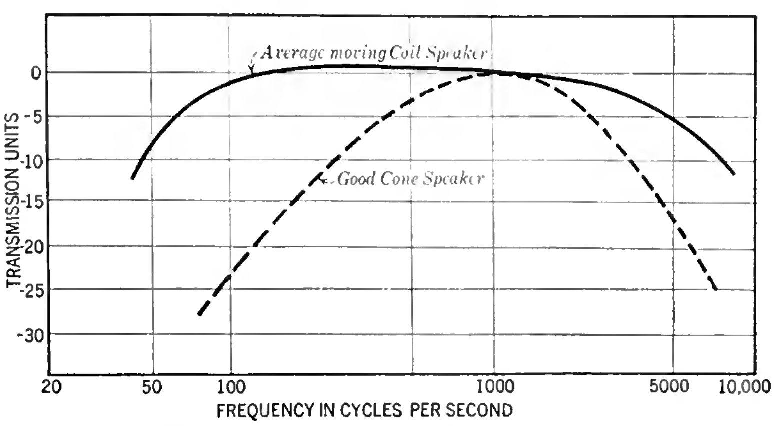
Present Designs Do Not Consider Economy

ECONOMY in radio receiver operation has been out of the question for several years. In the early days tubes were expensive, they required high filament currents, and anyway who would think of investing a hundred dollars in a radio and spending twenty dollars a year on upkeep? Nowadays the criterion seems to be how expensive a radio can I build or buy? Multi-tube sets, sets that take power—some of them take lots of it—from the lamp socket, sets in which tubes don't seem to last as long as in the old days are the rule to-day.

There is one notable exception to this seeming connivance between radio apparatus manufacturers and the power companies. This is the Eveready set which requires a plate current of only 8 milliamperes. This receiver is very clearly within the pocketbook requirements of the rural listener, or the listener who desires not to awe his neighbors by relating the tales of his 100-watt receiver. This Eveready product uses high-mu tubes, and, of course, the output will not be called a public nuisance. It is a receiver we are glad to see designed and sold.

How many readers of Radio Broadcast would like to build such a set?

And while we are asking for readers' opinions, how many would like to see the contents of the magazine marked with the Dewey decimal system for article classification? A reader brings up the point that it is difficult to index and to file the contents of the magazine at present, and that each month he must mark the articles he wants to file according to this



AVERAGE CHARACTERISTIC CURVES OF DYNAMIC AND ELECTROMAGNETIC SPEAKERS well-known system. Such a marking might take place in the editorial office before the magazine is put on the presses—but it takes work and time, and it is our present opinion that there are other things which the readers would sooner see in these pages than a classification of material.

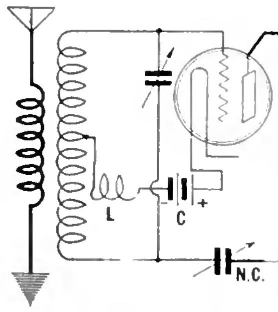


FIG. 1

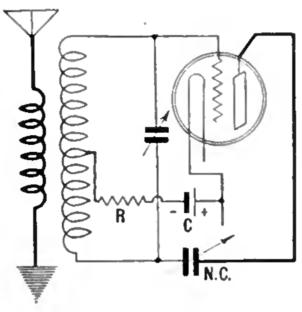


FIG. 2

Kinks on stabilizing a Rice circuit

How to Stabilize Rice Amplifiers

THERE are several methods of keeping a Rice neutralized amplifier from breaking into oscillations at a very high frequency determined by the leakage inductance of the input coil and the tube capacity in parallel with the neutralizing capacity. One method is to insert a choke coil in the center-tap connection of the amplifier input coil as shown in Fig. 1. This method is used in the R. B. Lab. Circuit. The choke may be replaced by a resistance as Mr. Knowles pointed out in his June, 1928, article. This method is illustrated in Fig. 2.

Another, and less expensive, method is to wind a turn or two of wire about the two ends of a solenoid coil in such a direction that no loss is introduced at broadcast frequencies but a large loss at the frequency at which the circuit tends to oscillate. The direction of winding is opposite to the direction in which the tuning inductance is wound.

If a few ohms of resistance is inserted in this winding either by using a concentrated resistor, or by using resistance wire—iron picture wire purchased in hardware stores will do—the parasitic oscillations will not be produced and everything will be lovely. This system is shown in Fig. 3.

New Radio Tubes Needed

THERE are three Radiotrons we should like to see released in the United States. One is the much heralded eighth-ampere general-purpose tube similar in its characteristics to our 201A. It is known as the UX-201B.

Another is a power tube, called the UX-121B, which is designed for use in the last stage. It consumes a filament current of one-eighth ampere, uses a C bias of 16.5 volts with a plate potential of 135 volts and can deliver 125 milliwatts of undistorted audio-frequency power, an increase of almost three times the power handling ability of the 201A-type tube. The third tube is the WX-25 which is a better ¼-ampere tube than the 201A but not as good as our 112-type tube.

The electrical characteristics of the three tubes described above will be found in a table on this page.

The "gyps" are still at it

PEOPLE who do business with "gyps" must expect to be "gypped." Not long ago we disclosed an interesting output device which cost but a dollar or two and which was worth nothing at all. Another example of the way some people acquire experience was brought to our attention recently.

In a certain store on "Radio Row," New York City, a transformer was being sold for $1.00 to which could be added a dry rectifier unit, like the Elkon, and a condenser. This equipment, it was said, would provide the purchaser with an excellent A-power unit at small cost. The idea is perfectly good, the transformer is good, the Elkon rectifier units and condensers were good. Where was the catch?

The transformer delivered only 7 volts, and after passing through the rectifier and filter the potential was reduced to 3.8 volts at the output. The combination was absolutely worthless unless one were going to use it on a dry-battery tube set—but nothing was said about the voltage obtainable when the purchaser paid out his money.

New Precision in Quortz Plates

WE HAVE a letter from Carl Zeiss, Inc.—whose name is known to every user of photographic, microscopic, or telescopic equipment throughout the world—stating the firm is now building glass discs for measuring purposes with an accuracy of $\frac{8}{100{,}000}$ of an inch and asking if there is need for quartz plates of this accuracy. At the present time quartz plates for frequency measurement and control are sold by but few companies. We should say that Carl Zeiss, Inc. might sell a number of quartz plates accurately ground.

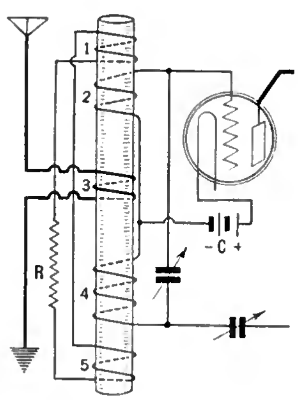


FIG. 3

Extra coil and resistor improves Rice Set

Seven New Radio Booklets

THE following booklets are more than worthy of mention—they should be read by all readers who like to "keep up."

Through Electrical Eyes, by John Mills. A reprint of an address given at Atlantic City Nov. 26, 1927, on the physics and chemistry involved in television. Mr. Mills is Director of Publications of the Bell Telephone Laboratories.

The Electrad Truvolt Divider Manual, Electrad, Inc.

The Amperite Blue Book, Radiall Company.

The Polymet Manual of Engineering Data, Polymet Mfg. Corp.

The Gateway to Better Radio, Clarostat Mfg. Co.

The Boston Post Book on Television by Henry M. Lane.

Radio Facts and Principles. The testimony of John V. L. Hogan before *Federal Radio Commission*, July 23, 1928. This booklet, which may be obtained from the Superintendent of Documents for five cents, contains in few words a most readable summary of the entire problem of the transmission and reception of radio broadcasting.

Portable Radio Sets

A RECENT copy of the *Wireless Trader* (England) devoted sixteen full pages to describing 66 models of portable sets manufactured in that country by no less than 61 manufacturers. Only the most rudimentary arithmetic is necessary to count the number of portable sets made in this country; in spite of the fact that there seems to be a rather consistent demand for them, to judge by the letters that come to the Editors.

Underground Aerials

WE ARE finding it difficult to know what stand to take on the underground antenna business. At present the vote among readers of these pages seems about half and half; some do and others don't like them. A reader in Ontario writes: "have been using ground antenna for the past five years with excellent results. It consists of 50 feet of well-insulated cable attached to an old galvanized water tank three feet in earth. Am able to get British Honduras, Jamaica, and others on home-made three-tube regenerative set."

Another in Texas writes: "My experience with underground antennas is that they are not worth planting, and we don't have rocky ground, nothing but plain silt soil."

The following letter is from a reader in Bangor, Maine:

> While I can't give you any signal-static ratio, measurements, comparing using an underground antenna with the usual types, I have formed my own opinion along these lines. I installed a much-advertised device, according to directions, and operated it with a Tyrman "70" screen-grid super-heterodyne, and I want to say that, as an eliminator of static and power-line disturbances, it proved to be a dismal failure. As an antenna it was very efficient, but it didn't even begin to live up to the claims made for it.

After reading the letters we are inclined to believe that the underground antennas are fine for those who like them and fierce for those who don't.

The trouble lies, not with the antennas, but with the advertising. If such advertising states that signals will be as loud as signals obtained with high clear antennas of the conventional sort but devoid of static, the copy should not be trusted too implicitly. On the other hand, if the advertisement states that the static will be reduced and that reception in geneal will be clearer it seems a fair gamble.

The underground antenna is not new. It is very old. It never gave as strong signals as a free wire high above earth, but under certain conditions it may give reception freer of static than the elevated wire. We often disconnect the antenna from our own receiver during bad weather in order to receive local stations with a minimum of static. This makes it necessary to make the set somewhat more sensitive, more sharply tuned, and more critical of adjustment.—KEITH HENNEY.

Designation	If	amp. voltage	C bias	Ip	Rp	μ	Gm	P
UX-201B	.125 amps.	90	4.5	2.5	11000	8	725	15
		135	9	3.0	10000	8	800	55
121B	.125 "	135	16.5	6.0	5000	5	1000	125
WX-25	.25 "	90	4.5	3.5	8000	7.9	1000	130

If = Filament current
Ip = Plate current in mils
Rp = Internal resistance of tube
μ = Amplification factor
Gm = Mutual conductance
P = Output power in milliwatts

When the Set Stops Working

A Service Man's Experience

By B. B. ALCORN

FROM the standpoint of the radio dealer or service man, the problems arising from the service and repairing of radio sets are most complex, as each new advance in radio design creates new problems in repair, and almost daily some new radio ailment presents itself for correction. To cover all the problems of radio servicing is beyond the scope of this article, but there is room for considerable discussion of the ordinary service methods from the point of view of the man in the field who is meeting and solving these problems daily.

The troubles encountered in radio servicing may be divided into about ten major divisions, as follows:

1. Defective tubes
2. Defective batteries
3. Open circuits
4. Defective parts
5. Defective antennas
6. Defective grounds
7. Use of harmful gadgets
8. Misconnections
9. Short-circuits
10. Defective arresters

Under each of these major divisions are numerous subdivisions. It is the purpose of this article to cover the first three of these divisions, particularly the third, giving actual cases which have come before the writer. Subsequently articles will deal with service problems under the remainder of these divisions. Many of the cases cited are of an unusual nature, such as are not encountered in the ordinary day's work, but it is such peculiar problems which illustrate the repair man's technique better than the rank and file of radio ailments.

TUBES AND BATTERIES

THE location and treatment of troubles under major divisions 1 and 2 require little explanation. In the case of batteries a good voltmeter is all that is necessary for locating the trouble; for testing tubes, a tube tester or a set of tubes known to be good may be used. Defective tubes or batteries should, of course, be replaced with good ones. At this point, however, it is suggested that a very simple and accurate method of determining which tube or tubes are weak is to insert a 0–50 milliammeter in series with the minus B lead. First take the total reading, then remove the tubes one at a time and note the current drop at each removal. The tube (not counting the detector) whose removal gives the smallest drop in current is the weak tube—assuming, of course, that all the tubes are supplied with the same B and C voltages. A recheck on this method can be made by replacing the tubes one by one and noting the gain per tube.

OPEN CIRCUITS

UNDER the heading of open circuits the service problems are very numerous, and may apply to any part of the receiver or accessory apparatus. The methods of locating these troubles are as numerous as the troubles themselves; the best method, perhaps, is the use of a set checking device, of which a large number of types are available. While the manufactured set checkers are all good, their cost in most cases is prohibitive, especially when a dealer or service shop has a number of service men to provide with outfits. The writer has designed a set

A RADIO SERVICE MAN AT WORK

checker which is not too costly and which is built around the meters which every service man who takes his job seriously should already possess. This checker will show short circuits, open circuits, and the approximate condition of tubes. Since, however, this article aims only to tell of some of the cases encountered in radio servicing, the construction of this tester will be given in a future issue.

The usual symptom of an open is a loss of volume or total lack of signal. In most instances of sets having three dials, the trouble, if it is an r.f. stage, will isolate itself by the fact that one of the dials will have very little effect on the tuning. Again it may show itself by a zero reading of the voltmeter connected between the plate terminal of the tube socket and B minus, which of course means an open primary in an r.f. coil. A simple test in such a case is to place the fingers, or a 2-megohm grid leak, across the primary terminals of the suspected transformer. If the set is inoperative because of an open-circuited primary the fingers or the grid leak will, I have found, cause the set to function, though not at its maximum efficiency. The fingers may also be used to determine whether or not the open is in the audio amplifier by touching the grid lead to the detector tube. If the audio system is o.k. there will generally be produced a low howl from the loud speaker.

Open circuits in the r.f. amplifier are among the most difficult of troubles to locate. In the case of open grid suppressors in modern a.c. sets, for example, the writer has found that few if any of the set checks will show this trouble, which manifests itself by lack of volume — a condition which might be attributed to a number of other causes. A quick test for faults in these resistors, which are usually of the wire-wound type, is to touch the stator plates of the variable condensers with the point of an ordinary lead pencil. If the suppressor is open there will then be a noticeable increase in volume; if not, the volume will decrease.

An unusual open was recently encountered by the writer in a Thermiodyne TF6 which for a time was very baffling. The set check showed that all the coils and connections were perfect, yet a jar would either cause the signals to disappear or come in more strongly. It certainly looked like an open or loose connection, and that was what it turned out to be, but in a very unusual place—the gang condenser. The condenser was of standard design, that is, the stator plates were wedged into aluminum supports, and it was found that the plates in the second condenser had become loose where they fitted in the stator support. Some ingenuity was necessary in remedying this trouble, as it was impossible to get a new gang condenser for some time, and difficulties in soldering aluminum made it impractical to solder the plates in place. As a solution a magneto file, such as is used to clean breaker points, was ground to a chisel edge, and a wedge driven under the condenser to break the force of pounding upon it. Then with the improvised chisel, which fitted easily between the stator plates, a burr was struck on each side of the loose plates, causing the metal of the plate supporter to grip them tightly. The job was reassembled, and the contact formed between the plates and the supporter was found to be sufficient to make the set operate without fading regardless of the amount of jogging.

At the shop we recently ran into another very

RADIO servicing problems, as they present themselves to the man in the field, is the subject dealt with in this article. Mr. Alcorn, who has a thriving service business of his own in Long Island, divides these problems into ten major groups, three of which he discusses in detail; the remainder will be treated in subsequent articles. If the great number of service men and professional set builders need any one thing, it is to exchange information with one another, and we hope, in these articles and a special page for service men which we shall soon inaugurate, to help in that direction. We will be delighted to hear from service men about the subjects they would like to have Mr. Alcorn discuss. Short illustrated contributions, not longer than 500 words, dealing with "kinks" in service work, are invited and if accepted, will be paid for at our regular rates.

—THE EDITOR.

peculiar open in the r.f. amplifier of a Radiola 18. This particular open had all the symptoms of a short-circuit. When the call for service came in over the phone the owner stated that the set had been performing satisfactorily when suddenly it had died down, come in strong again, and then stopped entirely. It looked as though the trouble came from a defective UY-227, and the only equipment taken on the call was a good tube. Upon arrival at the owner's home all the tubes were found to be lighting properly, but no signals came through. It was then noted that the power-pack was beginning to smoke; the set was therefore brought back to the shop, as it was thought that the power supply was at fault. Upon removal from the cabinet, one section of the voltage-divider resistance was found to be so hot that it could not be touched. Nevertheless, when the power unit was given the manufacturer's test it proved to be in good condition, and when connected to another receiver of the same type it worked without heating.

Next the receiver was given a continuity test and strange to say, came through with flying colors. There seemed nothing to which to attribute the heating of the voltage divider except a short-circuit. However, as a final test a set checker was used on the receiver, and when plugged into the third r.f. socket showed an open in the plate circuit. This was located in the primary of the third r.f. coil, and when remedied the set performed better than ever, according to its owner. In my opinion the heating of the voltage divider was caused by the feeding back to the power unit of the current that was supposed to flow through the defective primary. The symptoms were certainly those of a short-circuit and not an open. The reason that the open did not show up in the continuity test was that the break was so minute that the high voltage used in the test—we used 400 volts d.c. from a B-power unit that we happened to have in the shop—jumped the break and thus gave a reading on the meter. Fig. 1 shows the Radiola 18 circuit.

An easy method of localizing opens in the r.f. side of almost any receiver is the well-known one of disconnecting the antenna and connecting it successively to the grids of each of the r.f. tubes up to and including the detector. This method was tried without success in a recent case of an Atwater Kent Model 35 which had an open of such microscopic size that the circuit continuity seemed to be o.k. when tested. Still only two near-by and powerful stations would come through, and their signals came in accompanied by a hissing, frying sound. It was necesary in this case to resort to a voltmeter and low-voltage battery to locate the open in an r.f. coil. The coil had to be rewound.

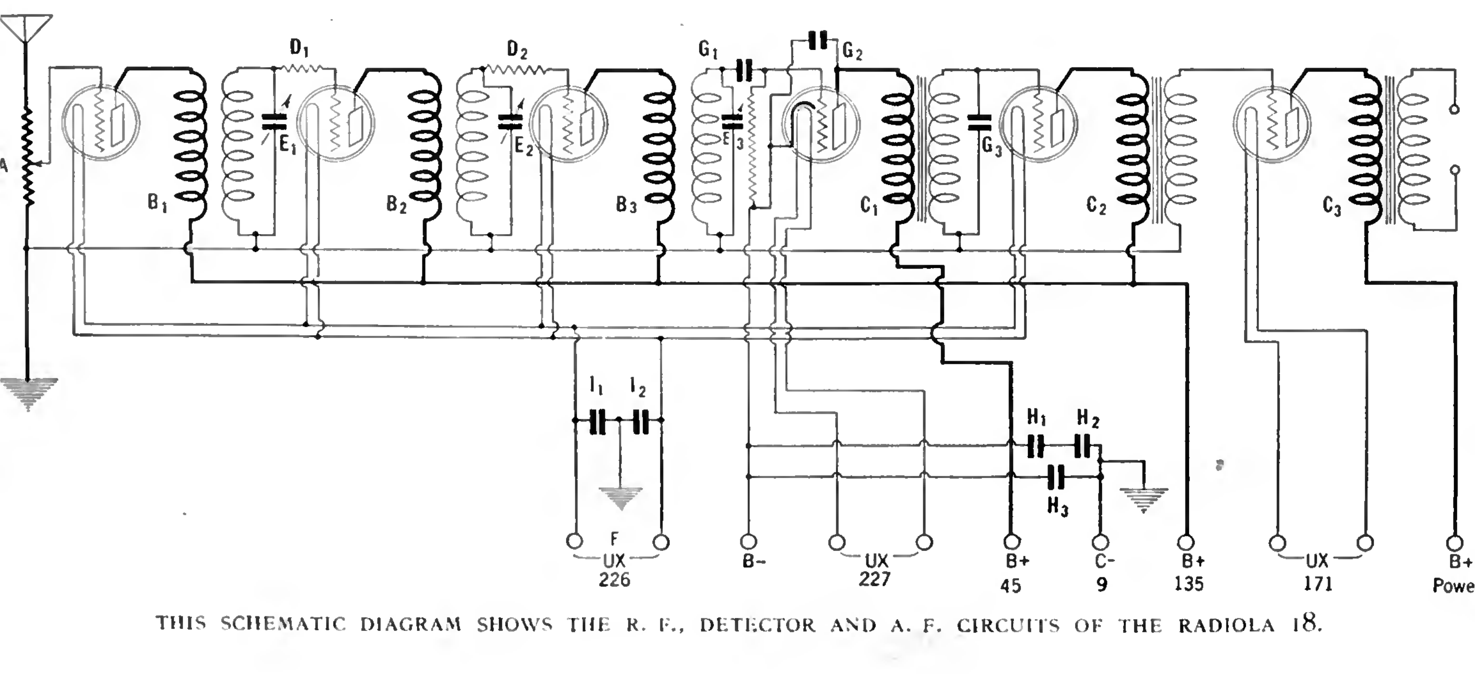
Another case occurred recently in which an open that appeared to be in the set turned out to be in a vacuum tube. The tube in question was used in the audio, and the first diagnosis was a burnt-out audio transformer. However, test of the transformers showed them to be in good condition. When a new tube was used in place of one of the audio tubes the receiver functioned perfectly. The defective tube was tested in the shop and showed no plate current, although it appeared to be in good condition. A section of the base was then cut off and showed an open circuit in the plate lead. This is the first case of this sort that we have encountered.

A curious case of coincidence once occurred when two sets in different parts of the town, identical in installation, came to us at the same time with exactly the same defect. The first diagnosis was an open circuit, but both sets were found to be in good condition, as were the antennas. Still neither of the receivers gave any signals, or at best very weak signals. The owner of one of the receivers was asked whether he had noticed anything unusual about his receiver previous to its breakdown, and recalled that about a week previous to the breakdown the set had stopped altogether and had started up again when he had opened a window. The window was the one through which the lead-in wire entered the house. An inspection of the lead-in wire showed that it was broken inside the insulation about a foot from the lead-in strip, and that when the window was raised it released the tension on the wire and allowed the two broken ends to meet and form a contact. However, after a week of constant tension the insulation stretched so much that it kept the two ends permanently separated.

A unique case of an open in an accessory occurred in a Zenith six-tube receiver equipped with a B-power unit, trickle charger, battery and relay. The combination had been giving good service for a long while when the service man was called in on the complaint that the set was very noisy. The set was turned on when the service man arrived, and a test showed it to be o.k. The man waited about half an hour, as the owner stated that the trouble did not always show up at first, but nothing happened. It seemed to be a case of local disturbance. The service man returned. He had hardly reached the shop, however, when the owner called by telephone to say that the receiver was "acting up" again. He was requested to leave the set going until the service man arrived. Upon arrival the service man found the loud speaker giving out a continuous buzz that the removal of the antenna, ground and three r.f. tubes did not diminish to any appreciable extent. The trouble turned out to be in the relay, the spring of which had somehow increased its tension to such an extent that it caused arcing at the contacts; this caused a noise that fed through to the set. It was necessary for the set to remain in operation from thirty to fifty minutes before this happened, the cause being the heating of the relay.

Before concluding it is well to call the attention of all service men to the importance of consulting the owner of a defective set as to any unusual effects he has noticed in its operation—just as a doctor inquires as to the symptoms of a patient. Many times the hints dropped by the set owner are invaluable in localizing the trouble and making an exhaustive test unnecessary. Another thing that all service men should ask is whether any attempt has been made to remedy the set before he arrived. In many cases an inexpert attempt to remedy a minor trouble has resulted in serious breakdown. A recent case occurred where the only trouble was the removal of the attachment plug of a light-socket operated receiver. The owner, who knew nothing of radio, attempted to remedy the receiver by changing six connections on the power unit. He said nothing of what he had done, and a service fee of ten dollars was charged against him for the tests which were necessary. If he had been asked or had told of his own attempt, the repair could have been made in a few minutes.

The foregoing are among the most unusual cases of open circuits encountered by the writer, and it is quite certain that equally peculiar cases will turn up in the future. It is hoped that space will permit to pass these on to the readers of RADIO BROADCAST. The next article in this series will be devoted to troubles arising from defective parts—a category that includes a wide variety of radio "griefs." The article will also include a description of the construction and use of the set tester referred to in this article.



THIS SCHEMATIC DIAGRAM SHOWS THE R. F., DETECTOR AND A. F. CIRCUITS OF THE RADIOLA 18.

No. 9 RADIO BROADCAST'S HOME-STUDY SHEETS November, 1928

The Effects of an Electric Current

SUPPOSE we have a source of electricity, a battery for example. How can we be made aware of its presence? To demonstrate the effects of the electric current, which are (A) chemical, (B) heating, and (C) magnetic, we shall need the following apparatus:

LIST OF APPARATUS

1. Six-volt storage battery or three dry-cells;
2. Mariner's compass costing about $1.00;
3. One-half pound of bell wire;
4. Copper-sulphate crystals, about 25 cents worth;
5. Glass tumbler;
6. Rheostat, 30 ohms;
7. Two Morse Eureka spring clips;
8. Two Fahnestock clips;
9. Brass angles, screws, bakelite strip, etc., for mounting compass;
10. Metals, such as brass screws, zinc battery case, iron, etc., for chemical experiment.

PROCEDURE

A. *To demonstrate the magnetic effect of the electric current:*

1. Wind about 30 turns of bell wire into a coil about six inches in diameter. The exact size of wire, number of turns, and size or form of coil are not important. At about the 10th and 20th turns make a twist in the wire and scrape the insulation from it so that the Eureka clip may be attached to these points.
2. Mount the compass on a supporting stand in the center of the coil as shown in Fig. 2.
3. Connect the rheostat, coil, battery, and clip as shown in Fig. 1.
4. Place this home-made assembly, known as a galvanometer, with respect to the earth's North and South poles so that when looking down on the device the compass needle is parallel with the coil.
5. Note the effect on compass needle when: (a) the clip is placed on various turns of wire and the circuit is closed by moving rheostat arm, (b) the battery connections are reversed, and (c) the voltage is varied by using only one, two or three cells of the battery with rheostat in same position.
6. Remove compass from its support and place it over, and then under, one of the wires connecting the battery and coil. Close circuit to coil. Note effect on needle when (a) position of compass is changed, (b) battery connections are reversed, (c) strength of current through wire is changed with rheostat arm and (d) distance of compass from wire is increased.
7. Note what is said about electro-magnetism on pages 100-105 of the Signal Corps book, "Principles Underlying Radio Communication." ($1.00 Government Printing Office).

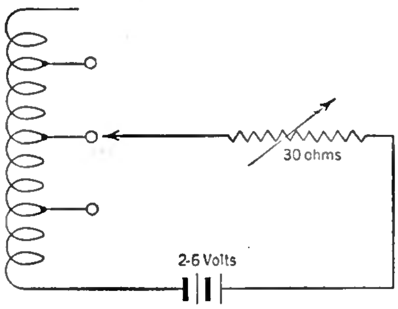


FIG. 1

B. *To demonstrate chemical effect of the electric current:*

1. Place a few crystals of copper sulphate in a glass container, such as a tumbler, and cover with water. Attach a large copper lug, a washer or a penny with a hole in it to a wire and connect it to one terminal of the battery. To the other terminal of the battery attach a wire to which may be connected, by means of an Eureka clip, with the various metals such as a steel screw driver, iron screws, brass strip, nickel-plated binding posts or washers, part of the zinc case of a dry cell, etc.
2. Note effect upon these metals when they are submerged in the copper-sulphate solution and current is passing through the circuit.
3. Reverse battery connections in each case and note result.
4. If a voltmeter, reading not over 5 volts, is handy, connect its terminals to the two wires from the copper-sulphate container. Note the voltage developed by the cell and its polarity when various metals are used. Use galvanometer already described if voltmeter is not available.
5. Replace copper-sulphate solution with a small amount of the electrolyte from the storage battery. Remove electrolyte from battery with a hydrometer or medicine dropper, taking care that no acid touches anything but the glass container. Repeat experiment above. Do not return electrolyte to the battery, since it is now quite impure. Dilute it with water and throw it away. If some of the acid gets on the hands or clothing, cover acid at once with ammonia or borax solution.

FIG. 2. DEMONSTRATING MAGNETIC FORCE

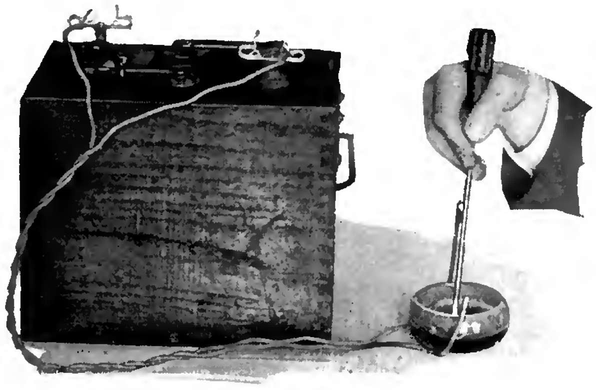


FIG. 3. DEMONSTRATING ELECTROLYSIS

C. *To demonstrate the heating effect of the electric current:*

1. If you have not already accidentally demonstrated the heating effect of the electric current in experiment A by turning the rheostat too near the "all out" position, do so now, taking care not to let the current flow through the last few turns of the rheostat long enough to burn them off.

DISCUSSION

A. The fact that the compass needle moves when it is near a wire, or a coil, carrying an electric current indicates that a magnetic field surrounds such conductors. When the current is turned off this field no longer exists and the needle is then influenced only by the earth's magnetism. The stronger the current, or the greater the number of turns of wire, the greater is this electric field, and for this reason it will exert an influence on a compass at a greater distance, or at a given distance the needle will be caused to swing a greater number of degrees. When the direction of the current flow through the wire or the coil changes, the needle changes its direction too. The galvanometer, therefore, is a sensitive detector not only of the existence of current but of its strength and direction too. Measuring instruments, such as voltmeters and ammeters, utilize the principle demonstrated here although in a much more exact and precise manner.

B. When two dissimilar metals are placed in a solution—copper and zinc in a copper-sulphate solution, for example—and a current is passed through the circuit, various things happen. The solution may change color, bubbles may be seen coming from one of the metals, or one piece of metal, known as the electrode, may have a deposit on it. This is the principle which underlies the electroplating of metals. Storage and dry cells are commercial applications of the fact demonstrated in paragraph B4, that two dissimilar metals in a proper solution develop a voltage.

C. The fact that a wire gets hot when sufficient current flows through it demonstrates another of the effects of the electric current. The amount of heat generated per unit of time depends upon the strength of the current and the resistance of the wire. This effect is made use of in electric irons, water boilers, toasters, etc. Some wires when heated change in length appreciably. If such a wire is stretched between two fixed points, the extent to which it sags may be used to determine the amount of current flowing. A device using such a principle is known as a "hot-wire ammeter" and such meters are used to measure antenna current, or for measuring current in circuits where an electromagnetic type of meter cannot be used.

QUESTIONS

1. Suppose current flows out of a battery from the positive terminal through the circuit and into the battery at the negative terminal. Can you determine a law relating the direction of current flow and the movement of the compass needle?
2. Do you know the "right-hand rule" for determining direction of current flow and needle-swing?
3. Can you explain what happens in the process of electroplating?
4. Why is a voltage developed in the copper-sulphate experiment?
5. What determines the polarity and magnitude of the voltage?
6. What are the bubbles appearing at one of the metals in the acid solution?
7. What generates the heat in a wire when current passes through it?
8. Do you know the law applying to resistance, heat, and current?
9. Why is manganin or nichrome wire used instead of copper where considerable heat is to be developed?

NOTE. The answers to these questions will be found in the Signal Corps book.

No. 10 RADIO BROADCAST'S HOME STUDY SHEETS November, 1928

Alternating Current

Part III

HOME-STUDY Sheets 7 and 8 gave some of the properties of a.c. circuits, and of the effects of an inductance upon such circuits. Since radio circuits are made up largely of inductances and capacities, it remains to study the effect of a condenser upon an a.c. circuit.

In many ways the effect of a coil and a condenser are opposite, for example, the larger the inductance the more it opposes the flow of a.c. current, but the larger the condenser the less it opposes the flow of a.c. current. The higher the frequency of the a.c. voltage, the less current will flow through a given inductance and the more current will flow through a condenser. When a combination of coil, condenser, and frequency is chosen so that a condition called resonance occurs, the effects of the inductance and condensr are exactly equal and opposite, so that their opposition to the flow of a.c. currents cancel each other.

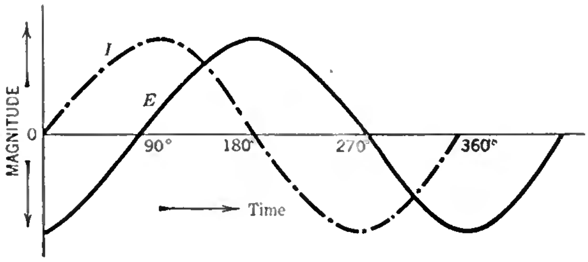


FIG. 1

CAPACITY REACTANCE

The opposition to the flow of a.c. currents offered by a condenser is inversely proportional to its *capacity*, the property of a condenser which tends to prevent any change in the voltage of a circuit

When current flows into a condenser, from a battery, for example, a voltage is built up across the plates. When this voltage equals the voltage of the battery no more electricity flows into the condenser, and we say it is charged. If the battery is removed, and a wire connected across the plates of a condenser, a spark jumps and the quantity of electricity stored there rushes through the wire. The condenser is now said to be discharged. When an a.c voltage is impressed on a condenser, the quantity or charge flows into it until the condenser is at the same voltage as the charging voltage. At this point, the voltage of the a.c. circuit changes polarity; that is, it is now in the opposite direction. The condenser, however, is still at its original polarity, and tends to discharge into the line and to maintain the voltage of the line. A condenser, then, helps to maintain the voltage of a circuit constant, and by so doing it resembles a reservoir which is filled up when the voltage is high, and is allowed to discharge when the voltage is low.

When the condenser is charged, it is surrounded by an electrostatic field just as a coil carrying a current is surrounded by an electromagnetic field.

The opposition which a condenser offers to the flow of current is known as its *Reactance*, and is measured in ohms just as resistance or inductive reactance is. This capacity reactance is inversely proportional to the capacity and the frequency of the circuit. The abbreviation and formula for capacity reactance are,

$$X_C = \frac{1}{6.28 \times C \times f}$$

Thus, doubling the capacity or the frequency, halves the reactance.

Since the voltage across a condenser does not rise to its maximum value as soon as current flows into it, there is a lag between the times of maximum current and maximum voltage. However, as we express the current phase with respect to the voltage phase, we say the current into a condenser leads the voltage across it. As a matter of fact, the maximum voltage is not reached until the current has gone through 90 degrees, or one fourth of its cycle. In other words, the current in a capacity circuit is said to lead the voltage by 90 degrees. This is illustrated in Fig. 1 in which the maximum value of voltage is reached 90 degrees after the maximum current. It is also illustrated in Fig. 2 in which are two arms rotating at the same speed but 90 degrees apart. In the case of an inductive circuit the maximum value of the voltage is *ahead* of the maximum value of the current; in the capacity case the voltage is *behind* the current.

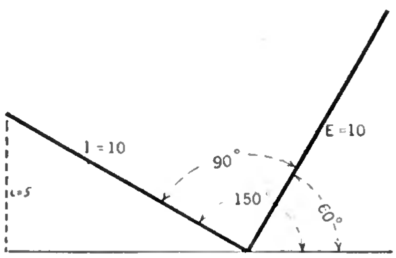


FIG. 2

Since the maximum values of current and voltage are 90 degrees apart, we must take this fact into account when we desire to know the instantaneous voltage or value of the current. If the voltage is at the 60-degree phase, the current is at the 150-degree phase. This angle of 90° is called the angle of *lead*, or the *phase angle* between the voltage and current. The instantaneous value of the current is given by

$$i = I \sin (\phi + 90°)$$

EXAMPLE. What is the instantaneous current in a capacitive circuit when the voltage is at the 60-degree phase if the maximum current is 10 amperes? The answer may be calculated as follows:

$$\begin{aligned} i &= 10 \sin (60 + 90°) \\ &= 10 \sin 150 \\ &= 10 \times .5 \\ &= 5 \text{ amperes} \end{aligned}$$

Note: The sin of angles greater than 90° may be found from the expression, $\sin (90° + A°) = \sin (180° - A°)$

Fig. 3 is a vector diagram of the above example. It is drawn to scale so that the various lengths of lines represent the various values of current and voltage.

CURRENT IN CAPACITIVE CIRCUIT

The current in a resistance circuit is given by Ohm's Law; the current is equal to the voltage divided by the resistance, i.e., $I = \frac{E}{R}$

The current in an inductive circuit is equal to the voltage divided by the inductive reactance, i.e. $I = \frac{E}{X_L}$

Similarly, the current in a capacitive circuit is equal to the voltage divided by the capacitive reactance, i.e., $I = \frac{E}{X_C}$

$$I = E \times 6.28 \times f \times C$$

and if the voltage is effective, maximum or instantaneous, the current has corresponding values.

IMPEDANCE

Suppose a circuit has resistance and capacity, resistance and inductance, or a combination of all three factors, each of which is tending to oppose the flow of a.c. current. What is the resultant opposition or *impedance?* In a resistance or reactive circuit we can add the several values to get the final resultant—remembering that the effect of a capacity is opposite to that of an inductance so their reactances must be subtracted—but when resistance and reactance are combined we cannot add them algebraically. They must be added vectorially, that is according to the formula

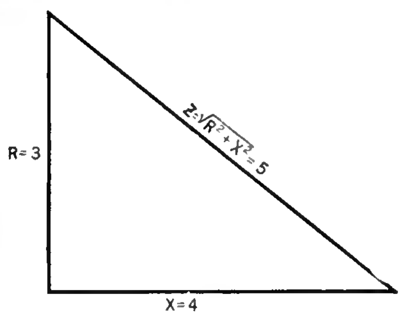


FIG. 3

$$\begin{aligned} Z^2 &= R^2 + X^2 \\ Z &= \sqrt{R^2 + X^2} \\ &= \sqrt{R^2 + (X_L - X_C)^2} \end{aligned}$$

This can be done by arithmetic, or by graphical means.

Example. What is the impedance when $R = 3$ ohms, $X = 4$ ohms?

$$\begin{aligned} Z^2 &= 3^2 + 4^2 \\ Z &= \sqrt{9 + 16} \\ &= 5 \end{aligned}$$

This expression may remind the experimenter of one of the first laws in geometry he learned, namely, the "square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the two sides." If, therefore, in Fig. 3, we lay off a line equal in length to three units and label it R, and make another line perpendicular to it equal to 4 and call it X, the length of the line that closes the triangle will be equal to Z.

The reactance, X, in this problem can be pure a inductive reactance of 4 ohms or a capacity reactance of 4 ohms, or a combination of inductive and capacitive reactance such that the resultant obtained by subtracting them equals 4 ohms. For example, if $X_L = 8$ ohms, $X_C = 4$ ohms then

$$X = (X_L - X_C) = (8 - 4) = 4$$

or if $X_L = 4$ ohms, and $X_C = 8$ ohms, then

$$X = (X_L - X_C) = (4 - 8) = -4$$

When, however, this value of minus 4 ohms is squared it becomes a positive quantity equal to 16 and may be fitted directly into the equation to determine the impedance.

PROBLEMS

1. Plot the reactance of a 1-mfd. condenser as the frequency is varied from 100 cycles to 10,000 cycles. What is the reactance of a 0.001-mfd. condenser at 10 kc.? At 1000 kc.?
2. Make a vector diagram for the following condition and solve by means of the formulas above. In a capacitive circuit the instantaneous voltage at the 30-degree phase is 5 volts; what is the instantaneous current if the effective current is 10 amperes?
3. What is the reactance at 1000 cycles in a circuit which has a 0.25-henry inductance and a 0.01-mfd. condenser? If the condenser has a capacity of 0.001 mfd.?

PLOTTING TRANSFORMER CURVES IN A RADIO LABORATORY

A New Audio System for Dynamic Speaker Reproduction

By FRANK C. JONES

Consulting Engineer, Gray & Danielson Mfg. Co.

THE question as to whether each piece of apparatus in a radio receiver should be perfected, or whether better results would be obtained if the entire system were designed to have a "flat characteristic," has been the cause of considerable discussion.. The advantage of the latter method is that a higher over-all amplification may be secured. The Remler amplifying system employs two audio-frequency stages, each of which produces some distortion, but the defects of one compensate those of the other.—THE EDITOR

IN ORDER to reproduce radio programs in sufficient volume to fill a room from a loudspeaker, some type of audio amplifying system following the detector tube is necessary. Immediately difficulties are inevitable from this necessity, since to obtain good reproduction it is necessary to amplify equally all tones or frequencies up to at least 5000 cycles and down to less than 100 cycles per second. There are several types of audio amplifiers in widespread use which must first be considered briefly before going on to a description of a new audio system designed to overcome many of the defects of present systems.

RESISTANCE AND TRANSFORMER COUPLING

FIRST let us consider the usual resistance-coupled amplifier where the plate is connected to the next tube through a coupling condenser and the plate and grid potentials are fed in through resistances. If the plate resistor, R_1, in Fig. 1, is equal to or greater than the plate impedance of the tube, the tube will operate over a straight part of its characteristic curve, so that the voltage impressed on the first grid circuit may be amplified without distortion. Now if the coupling condenser, C, is made so large that its reactance is small in comparison to the grid resistor value, the loss in amplification will not be great. However, a large condenser takes a longer period to discharge, so that if a large a.c. voltage should be impressed across it—enough to swing the grid of the next tube positive—the tube will block and become inoperative. Using a small value of grid resistor, R2, or a small coupling condenser, the low frequencies will be discriminated against enough to cause the response curve to fall off rapidly. Another drawback to resistance-coupled amplifiers is the low gain obtained when using ordinary 201A or 226 tubes. The use of high-mu tubes will overcome this, but then the high frequencies may be lost due to the larger value of effective tube input capacity. This effect is generally overlooked, although it is actually very important, as can be seen from the following. The input capacity of a tube is obtained from the formula,

$$C = C_{gf} + C_{gp}\left[1 + \frac{\mu r_p}{r_p + r_i}\right]$$

Where Cgf = grid-filament capacity of tube.
Cgp = grid-plate capacity of tube.
r_p = plate resistance of tube.
r_i = coupling resistance.

A typical example is

$$C = 6 + 12\left[1 + \frac{30 \times 250{,}000}{250{,}000 + 100{,}000}\right] = 270 \text{ mmfd.}$$

This value is enough to practically short-circuit the higher audio frequencies. The higher the amplification constant of the tube, the greater this capacity will be.

The latter effect is present in impedance coupled amplifiers to even a greater extent than in other systems because the distributed capacity of the coupling choke coils adds to this capacity. The actual tube input capacity may be less but the other capacities generally more than make up for it. The low frequencies may be lost since the impedance at the lowest frequency desired must be several times greater than the tube impedance. The principle of resonance may be used to overcome this loss at low frequencies but not the loss at the upper audio frequencies.

Another factor for either of the above systems is the relatively low gain, so that with 201A or 226 tubes about three stages would have to precede a type 250 power tube. This means a four-stage amplifier, which is uneconomical besides having wonderful possibilities of singing or motor-boating.

The next amplifier to be considered is the transformer-coupled type. This type of amplifier has been developed about as far as it can within practical limits using special alloy cores and special windings. By keeping the turn ratio fairly low, 2 or 3 to 1, the response curve can be made to cover a frequency range of from 70 or 80 cycles up to 5000 or 6000 cycles without much droop at either end. The advantage of transformer coupling lies in the fact that low-mu tubes may be used and good gain per stage may still be obtained. Herein also lies a disadvantage, since with the new dynamic loud speakers and type 250 power tubes, a greater amount of gain is required. Let us consider the requirements set up by the use of a good dynamic loud speaker.

LOUD SPEAKERS AND POWER TUBES

ANYONE who has listened to a good dynamic loud speaker will admit that this type is very much better than the magnetic drive types. The improvement is so great that this coming year will see a rise in popularity probably as great as the magnetic-cone speakers had over the old horn-type speakers of a few years ago. The older type of cone speakers using a magnetic drive unit, are incapable of reproducting low notes or very high notes either. The magnetic type of speaker that will actually reproduce tones below 200 or 300 cycles per second is very rare and none will give a true response below 100 cycles. The author has had the opportunity of running response curves on about three dozen different types of loud speakers and it was found that the response below the limits mentioned is only apparent; that is, the response is not actually the real low tones but consists of higher harmonics. For example, one very excellent magnetic-type speaker at 60 cycles gave a good apparent response but when the wave was analyzed it was found to consist of less than 5 per cent fundamental tones of 60 cycles. All of the "noise" consisted of higher harmonics which would mean very serious distortion of the low frequencies in music reproduction. On the other hand, a good dynamic loud speaker in a large baffle-board or large cabinet is capable of true response down to 30 or 40 cycles and up to between 5000 and 7500 cycles per second. Below the cut-off of the baffleboard or cabinet the response is similar to a magnetic-type speaker in that it consists nearly entirely of harmonics. A dynamic speaker requires an amplifier of large power rating if low frequencies are to be reproduced without overloading. A good loud speaker mounted in a large cabinet, or in a large baffleboard, or better yet, in a wall, will take nearly the full output of a type 250 power tube for even good room volume. A good deal of power is necessary for the low notes, and the better the frequency response range of a loud speaker, the greater must be the power output of the audio amplifier for the same apparent volume. A type 250 power tube or its equivalent must be used to prevent overloading on the very low notes such as may be transmitted from an organ, a bass viol or tuba, or even a bass voice. To hear the bass notes in their proper relation to the higher notes from a radio receiver is to have real enjoyment from good radio programs.

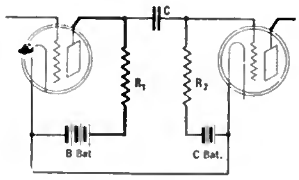


FIG. 1

To project equal volumes of sound into the air at 1000 and 100 cycles it requires a much greater movement of the sound-producing diaphragm at the lower frequency. The dynamic speaker has the ability to reproduce these low notes partly because the movement of its diaphragm may be much greater without mechanical rattling than is possible in the magnetic type. These large movements, in turn, imply that considerable electrical power is available to drive the moving parts of the speaker, and this in turn means that a power tube with considerable output must be used. The 250-type tube has sufficient output for this purpose.

THE IMPORTANCE OF THE TURN RATIO

To work a type 250 power tube to its full capacity the audio transformers preceding it should have a rather large turn ratio in order to prevent overload of the detector tube. A detector tube produces higher harmonics of any audio tone, and these are a source of distortion, since they change the character of the reproduced tone. The greater the output required of the detector tube, the more apparent this effect becomes, so it is desirable to limit the detector tube output to less than $\frac{1}{3}$ of a volt. With outputs of less than $\frac{1}{3}$ of a volt the ordinary 201A detector tube distortion is nearly negligible. Now consider the case where a pair of transformers having an effective turn ratio of 3 to 1 are used. The voltage available to swing the grid of the power tube can be figured from $E = \frac{1}{3} \times 3 \times 8 \times 3 = 24$ volts, which is not sufficient. This figure of 24 volts shows that the detector would have to put out nearly 1 volt across the primary of the first audio transformer to obtain a 70-volt power tube grid swing, and this would be an enormous overload on the detector. The above values of voltage are all in terms of maximum a.c. voltage, not average values, and the first amplifier tube was assumed to have an effective gain of 8, since the mu of a 201A tube is about 8.5 or more.

This means that the transformers will have to have a much larger turn ratio than 3 to 1 unless more than two stages are to be used. More than two stages are rather undesirable from a cost and space required basis as well as because of more tube noise and motor-boating possibilities. Increasing the turn ratio means that the primary windings will have to be diminished in size or the secondaries increased. Decreasing the primary turn lowers the primary impedance to low notes so that the response to these notes will be poor. Increasing the secondary turn increases the secondary capacity to ground or distributed capacity to such an extent that the higher frequencies are lost. This is very important because brilliant reproduction depends on the presence of frequencies up to 5000 or 6000 cycles per second.

The only way seems to be to cut down on the primary number of turns, since even resonating the distributed and shunt capacities with the transformer leakage reactance does not make a good high-frequency response when a large secondary winding is used. By using a large core of very high-grade material, a nickel-steel alloy, the impedance presented to the tube can be increased so that it is still several times that of the tube even at the low frequencies. The impedance increases with frequency, so that most of the voltage generated by the tube appears across the transformer primary for higher notes. Since the primary impedance is less for lower frequencies, the proportion of voltage drop across the tube impedance is greater, causing a droop in the response curve. It was found by laboratory tests that a very good transformer of as high as 6½ to 1 ratio could be designed with a frequency response as shown by the curve of Fig. 2. There is a drop on the low frequencies even when using a 112A tube having a plate impedance of about 5000 ohms. Using a 201A tube having a plate impedance of about 10,000 ohms, there is a very bad drop at both the high and low frequencies, giving the effect of a peaked amplifier. Using a 112A tube, such a transformer would be fine for the second stage but would be hopeless for connecting to a detector having a high plate impedance. That problem and also the one of compensating for the low frequency droop of the second stage were solved as in the manner described below.

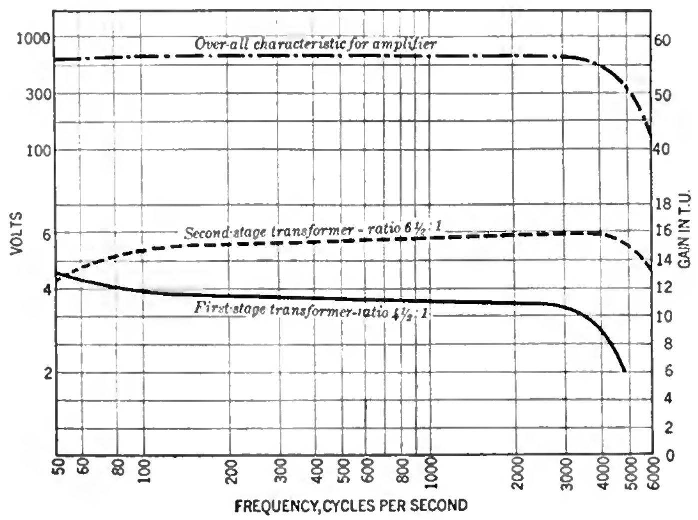


FIG. 2. RESPONSE CURVES OBTAINED WITH HIGH-RATIO TRANSFORMERS

A RESONATED PRIMARY

For several years the different telephone repeaters and many broadcast station amplifiers have used the principle of resonance in the transformer primaries to bring up the low-frequency response. There is no reason why this arrangement should not be used in radio receiving set amplifiers, so a first-stage transformer was designed with primary resonated at about 30 cycles per second. Fig. 3 shows a complete audio amplifier with the first transformer primary winding resonated by means of condenser C_1. Resonance has the effect of lowering the total plate circuit impedance to that of the a.c. resistance of the circuit only. The action is as follows: At resonance the current is increased through the detector plate circuit load, since the impedance at resonance is equal to the resistance component only. This means that the voltage drop across the condenser and across the inductance of the primary winding will be increased due to the increased current flow. The increased voltage drop across the primary, causes a larger voltage to be generated across the secondary, with a rise in the response curve. The amount of rise at resonance depends on the circuit constants, that is, the plate impedance of the detector tube, the value of the resistance, R_1, and the relative sizes of the condenser, C_1, and the primary inductance of the transformer. The resistance, R_1, may be made part of the resonant circuit by making it relatively small, or it may be made high, on the order of 100,000 ohms, so that it tends to isolate the resonant part of the audio circuit from the plate supply unit. In this case it confines the audio frequencies to the path through condenser C_1 and the primary winding to the filament. By keeping R_1 high in value, the loss due to it at higher frequencies is reduced. Since the audio-frequency path in this circuit is isolated from the plate-supply unit, the chances of audio regeneration or motor-boating are practically eliminated. This removes a bugbear which is generally very troublesome in high-gain amplifier systems.

An auto-transformer connection is used in the first stage, since the effective turn ratio is much greater for the same total number of turns. The response characteristic of such a resonated transformer is shown by the lower curve of Fig. 2. The resultant characteristic for the two transformers is shown on the same curve sheet and it is flat down to 50 cycles per second. Certainly no ordinary transformer-coupled amplifier could be designed which would amplify so evenly all frequencies as will this special combination. The total gain using a 112A tube and a type 250 power tube is about

57 TU. This does not include the detector audio gain.

The use of the same resonating idea in the second transformer is unnecessary, since we are interested only in obtaining a perfectly flat characteristic with a very large voltage gain. One difficulty is that the d.c. voltage drop through a shunt resistance would be enormous unless small values were used. For example, 3 milliamperes through 100,000 ohms would cause a 300 volt drop. The heating effect would be troublesome also since nearly one watt would have to be dissipated in the form of heat. If low values—less than 30,000 ohms—were used, the audio-frequency loss through the shunt resistance would be a large percentage of the gain of the transformer. In that case an ordinary low-ratio, high-quality transformer might as well have been used.

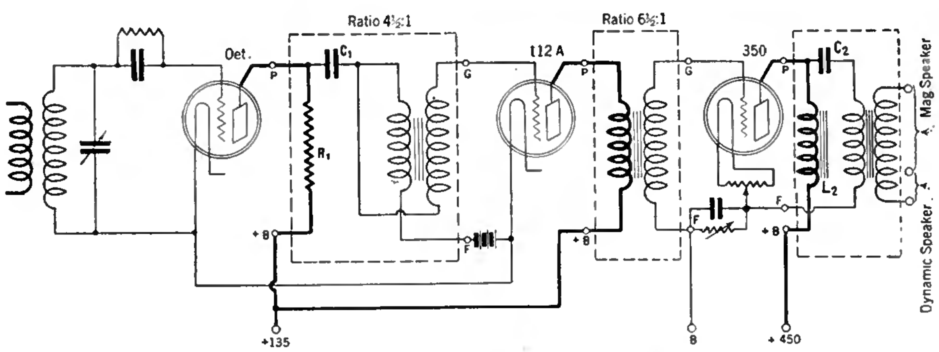


FIG. 3. SCHEMATIC DIAGRAM OF COMPLETE REMLER AMPLIFIER

THE OUTPUT TRANSFORMER

IN CONNECTION with the complete amplifier system, the last, and perhaps the most important link in the chain, is the output device. It was found that the best output transformers on the market were quite unsatisfactory below 200 cycles per second when the full plate current of a type 250 power tube was flowing through the primary. Core saturation takes place and even with a good-sized air-gap in the core few notes below 200 cycles reach the loud speaker. However, an output transformer is quite necessary with a dynamic loud speaker in order to match properly the load to the power tube. By keeping the d.c. current out of the output transformer by means of a choke coil, L_2, and condenser, C_2, as shown in Fig. 3, the transformer may be made very excellent for even the very low frequencies. The condenser, C_2, may be made to resonate with the transformer primary to compensate for the loss due to the shunt choke coil, L_2, and series condenser reactance on the low frequencies. Another advantage is that the audio-frequency path is through the condenser and transformer primary back to filament instead of through the power-supply unit. This prevents audio feedback to preceding stages.

The result is a very stable high-gain amplifying system which has more gain than even an audio amplifier using a screen-grid tube in the first stage. The use of a screen-grid tube, even as a space-charge amplifier, means that impedance coupling should be used between that tube and the power tube, which gives, roughly figuring, $\frac{1}{4} \times 3 \times 50 \times 1 \times 4 \times \frac{2}{3} = 100$ volts across the output device. This assumes a $\frac{1}{4}$-volt detector output, a 3 to 1 transformer, a gain of 50 in the screen-grid tube, a gain of 4 in the power tube and that $\frac{2}{3}$ of this voltage appears across the output device and $\frac{1}{3}$ across the power tube plate resistance. For the amplifier described, using $4\frac{1}{2}$ and $6\frac{1}{2}$ to 1 ratio transformers and tubes giving a gain of 8 and 4, the total voltage appearing across the output would be $\frac{1}{4} \times 4\frac{1}{2} \times 8 \times 6\frac{1}{2} \times 4 \times \frac{2}{3} = 156$. The ordinary amplifier using 3 to 1 transformers and tubes giving the same gains of 8 and 4 would give an output of $\frac{1}{4} \times 3 \times 8 \times 3 \times 4 \times \frac{2}{3} = 48$.

A MODIFICATION FOR A.C. OPERATION

THIS amplifier having such an excellent frequency characteristic should be used preferably with d.c. filament tubes in the r.f. stages, detector and first audio stage, since the amplification is so high at 60 cycles. However, experiments with special amplifiers cutting off very sharply just above 60 cycles per second, have shown that the hum when using a.c. tubes may be made nearly negligible. The reason for cutting off above 60 cycles is apparent when it is remembered that ordinary loud speakers are excellent harmonic producers on low frequencies. The use of raw a.c. on the filaments of the tubes causes a 60-cycle component to be impressed in the grid circuits with the result that if the amplifier system is good as low as 60 cycles, this frequency will be amplified and reproduced by the speaker. The speaker, in case it is a cone or small horn will reproduce it as 120 cycle and higher tones. The point is that by not amplifying the 60 cycle component, practically all of the composite a.c. hum in the loud speaker is eliminated.

Immediately the idea of resonating the primary of one of the transformers at about 80 cycles, was used to make the complete amplifier cut off sharply just above 60 cycles per second. The cut-off is a great many times sharper below resonance than when the transformer itself is made to have a fairly good audio response. The audio voltage drop across the resonating condenser increases as the frequency becomes less, giving a very sharp cut-off below resonance. By designing the circuit constants properly, one transformer may be made to compensate for the other as shown in Fig. 4 from about 5000 or 6000 cycles down to at least 80 cycles per second. This makes an ideal arrangement for receiving sets using a.c. tubes, since the low notes are well reproduced when a good dynamic speaker is used. Nearly 95 per cent. of the very low notes such as those from an organ, as played over the radio, are between 80 and 200 cycles per second. Very few people realize this and most people will quite willingly swear that they hear 30- to 50-cycle notes in their radio sets when in nearly all cases their loud speakers and amplifiers will not reproduce anything below 100 cycles per second.

Another advantage of cutting off sharply a little below 100 cycles is that a smaller power tube may be used, such as a 171 tube. The apparent room volume of sound with the a.c. system will be about the same as with the first d.c. amplifier system developed, since in this case the lowest note reproduced will be about 70 cycles as against 25 or 30 cycles in the d.c. system. This makes more power available for the tones which are reproduced. Incidentally, the cost of manufacturing such transformers is less. Most a.c. set manufacturers use audio transformers which will not pass 60-cycle signals, in order to minimize a.c. hum and in so doing generally lose in efficiency up to 300 or 400 cycles. This is bound to happen because it is not possible to obtain a really sharp low-frequency cut-off using ordinary transformers. The resonant primary principle should go far towards solving the a.c. hum problem in a.c. receivers.

It will be noticed that only the transformers working out of the detector tube in both the d.c. and a.c. systems have resonated primaries. This arrangement keeps the d.c. plate current out of the primaries and so prevents core saturation and generation of harmonics due to this effect. By the use of very large cores of nickel-steel alloy, the chances of core saturation from d.c. are practically eliminated. If small cores are used and large primaries, that is, a large number of turns, core saturation may take place with bad distortion effects. The transformers described are built along ample lines to overcome the possibility of trouble from core satuation.

The possibilities of audio amplifier systems using the low-frequency resonated primary principle are many and it is quite likely that this scheme will be widely used to make better audio amplifier systems. It is the engineer's problem to forever strive towards perfection, never reaching it but always advancing; and this design, it is hoped, is a step in that direction.

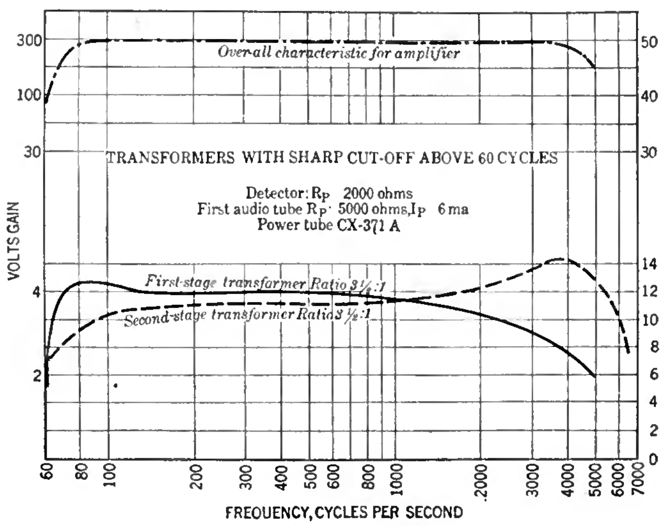


FIG. 4. RESPONSE CURVES OBTAINED WITH $3\frac{1}{2}$ TO 1 RATIO TRANSFORMERS

AS THE BROADCASTER SEES IT

BY CARL DREHER

Sound Motion Pictures—Part II

IN OUR October issue the processes of synchronous sound and movie-picture recording and reproduction were described in a general way. In successive articles some of the points which were only briefly touched on in the first paper will receive further discussion. I do not expect to present any original material in this series nor to assume a professional tone. The object is merely to bring together data from widely scattered sources which are not readily accessible to the many radio broadcast operators, motion-picture projectionists, and others who are interested in sound-movie technique.

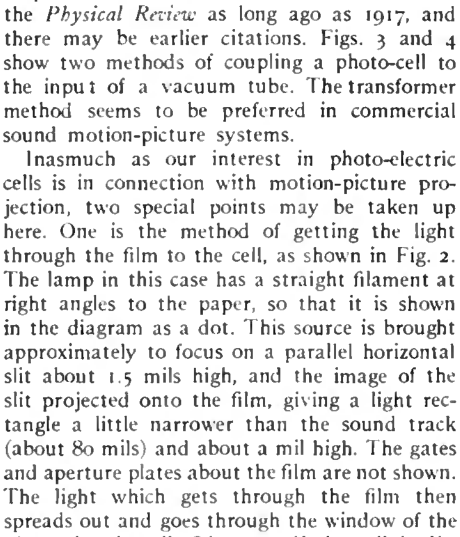
One portion of the reproducing equipment which was merely mentioned in the October article is the photo-electric cell used in film systems. This variety of electron tube has been likened to an electric eye; its function is to transform optical variations into proportionate electric currents. In the art of sound reproduction from films, as well as in television, the photo-electric cell plays a part analogous to that of the microphone in telephony. The microphone, however, takes speech or music directly from the air, whereas in motion picture work the photocell receives light which has been modulated by a film record. In this application, therefore, the rôle of the photo-cell is more strictly parallel to that of a phonograph pick-up, which takes mechanical vibration from a rotating disc and transforms it into corresponding electric pulsations.

Fig. 1 shows a schematic view of a photo-electric cell. The bulb is made of quartz or glass, coated on the inside with silver, except for a window a half inch or so in diameter which remains clear for the passage of the light which is to act on the cell. Opposite the window a layer of the active material of the cell is deposited on the silver. This substance is usually a compound of the so-called alkali metals, potassium, rubidium, or caesium, which have similar chemical and physical properties. They resemble silver in appearance and are quite soft. Some of their compounds, such as potassium hydride, have marked photo-electric qualities; that is, light causes them to emit electrons much as heat makes the filament of a vacuum tube do the same thing. The next step, referring to Fig. 1 again, is to place an anode in the tube to pick up the electrons as they are released. If this anode is placed in the path of the light coming in through the window it is made in the form of a wire loop but it may also be a small metal plate displaced a little to let the light pass. The final step is to connect between the photo-electric cathode and the anode a circuit for coupling the cell to the input of an amplifier and for keeping a positive potential on the anode so that it collects the emitted electrons more effectively. Frequently a gas, such as argon, is used to increase ionization and thus to make the cell more sensitive. Even so the space current in such devices amounts to only a few microamperes.

The photo-electric cell is liable to the same difficulty as a carbon telephone transmitter—it has its inherent noises arising from internal turbulences and the input must be high enough, even at its lowest levels, to override the noise. The exciting lamps used are on this account of the high-intensity type, so that the amount of light passing through the film during low volume portions will still meet marginal requirements. In some other respects the photo-electric cell is superior to the best grades of microphones. It has no natural period of its own and any lag which it may introduce would have to be measured in billionths of a second; the response, to all intents and purposes, is instantaneous. Selenium, the substance which was used as the original intermediary between light and electricity, did not change its resistance immediately under the influence of light.

As the energy output of the photo-electric cell, although accurately proportional to the light entering it, is so small, it must be used, even for measurement purposes, with vacuum-tube amplifiers. This combination was described in the *Physical Review* as long ago as 1917, and there may be earlier citations. Figs. 3 and 4 show two methods of coupling a photo-cell to the input of a vacuum tube. The transformer method seems to be preferred in commercial sound motion-picture systems.

Inasmuch as our interest in photo-electric cells is in connection with motion-picture projection, two special points may be taken up here. One is the method of getting the light through the film to the cell, as shown in Fig. 2. The lamp in this case has a straight filament at right angles to the paper, so that it is shown in the diagram as a dot. This source is brought approximately to focus on a parallel horizontal slit about 1.5 mils high, and the image of the slit projected onto the film, giving a light rectangle a little narrower than the sound track (about 80 mils) and about a mil high. The gates and aperture plates about the film are not shown. The light which gets through the film then spreads out and goes through the window of the photo-electric cell. Of course if the cell is displaced, so that only part of the light gets through, there will be a corresponding loss in volume, so the whole system must be properly lined up. If the filament of the exciting lamp sags, the image cannot be accurately centered on the slit, and a loss of volume results. In this case, as well as when the glass of the high intensity lamp begins to darken, the lamp must be replaced. However, a loss in volume may also result from a photo-cell losing its emitting qualities. A microammeter is useful in checking this.



FIGS. 1 AND 2

These drawings show how photo-electric cells are used in sound motion-picture apparatus

The method of fading from one projector to another, insofar as it affects the photo-cells, is another point of interest. This is shown in Fig. 5. A potentiometer with a neutral midpoint is the essential part of the diagram. As the transformers pass only the alternating component of the photo-cell current, the operation of the potentiometer will be noiseless. It will be noticed that there is considerable similarity between this circuit and microphone mixers in broadcasting.

Commercial Publications

NATIONAL RADIO TUBE COMPANY. This concern, whose address is 3420 Eighteenth Street, San Francisco, is circulating an offer to rebuild burned out, or otherwise defective transmitting tubes, for broadcast stations. They claim means of re-processing tubes so that they will be as good as new at about half the cost of a replacement.

GENERAL RADIO COMPANY. The *General Radio Experimenter* continues to present material of interest to broadcasters. The May issue contains an article on "An Artificial Cable Box." Such a device makes it possible to simulate the behavior of actual telephone lines and cables in the laboratory. The circuit used is shown in Fig. 6. Here the loop resistance of the section, 4R, and the shunt capacitance C, are made the same as the equivalent quantities in the type of line whose behavior is to be studied.

Inasmuch as an actual cable has its constants distributed along its length, an artificial cable simulates the behavior of a real one more closely when it is built up of a considerable number of uniform sections.

A type of cable box with the designation 321-C, marketed by the General Radio Company, is the electrical equivalent of 32 miles of standard paper telephone cable in the usual wire gauges. Within a cabinet 15 by 8 by $5\frac{1}{2}$ inches there are seven units of the following electrical lengths, respectively: 19–8–4–2–1–0.5–0.5 miles. These are controlled by telephone key switches so that any combination may be secured, making it possible to get any length up to 32 miles in half-mile steps.

The 16-, 8-, and 4-mile sections are not lumped, but built up of 2-mile units, and the smaller lengths are similarly split up. The resistance elements, wound non-inductively, are calibrated to 0.25 per cent., while the rolled paper condensers have a precision of 0.5 per cent. The maximum potential which may be safely applied to the box is 300 volts.

Boxes of this type are supplied to represent 16, 19, and 22 gauge non-loaded paper cable. The constants at the mean speech frequency, 796 cycles, are given as follows:

Gauge	Resistance per Loop Mile	Capacity per Mile
16 B & S	42.2 ohms	0.062 mfd
19	83.2	.062
22	171.	.073

In cables of this type the inductance may be neglected, but General Radio also designs special artificial circuits to simulate loaded lines, in which case an appropriate amount of inductance is included in each loop mile, or open wire lines.

The same issue of the *Experimenter* describes a 600,000-ohm potentiometer suitable for use in the grid circuit of an amplifier tube as a gain control. The circuit, which is familiar to most broadcast engineers, is shown in Fig. 7. Such a potentiometer requires a high resistance in order that it may not draw appreciable current from the preceding element. This particular design, known as the Type 452, covers 30 TU in 15 steps of 2 TU each.

The August issue of the General Radio Company's bulletin contains a discussion of electrical filters, which are divided into four groups: (1) Low-pass filters which cut off all frequencies above a certain value; (2) High-pass filters which cut off all frequencies below a certain value: (3) Band-elimination filters which block all frequencies between certain limits; and (4) Band-pass filters which block all frequencies on either side of a section which is permitted to get through.

Classes 1, 2, and 4 have been discussed previously in this department. Type 3 is new in this respect, and as it is not described in the General Radio article I might point out that an audio rejector of the sort shown in Fig. 8 is an elementary form of band elimination filter. In parallel with the speech coil of a loud speaker, for example, it may be used to smooth out a peak in the response. The effect of the resistance in series with the capacitive and inductive elements is to broaden the resonance curve and to limit the effect of the device. If the resistance is very low practically no current of the resonant frequency will get past the shunt circuit, but by adjusting the resistance one may balance the by-passing effect of the shunt circuit against the undesired peak in the instrument under treatment and get a flat over-all characteristic. Compare this use of the resistance element with its similar function in a line equalizer (Fig. 9) which is also a form of filter.

Coming back from this digression to the General Radio discussion, we note there sketches of sections of high-pass and low-pass filters, here reproduced as Figs. 10 and 11, respectively. The types of filters regularly marketed by General Radio are of these classes, designed for impedances of 600 and 6000 ohms, and with cut-off frequencies of 500, 1000, and 2000 cycles. That is, one may order from stock a 6000-ohm filter of the high-pass type, for example, to cut off everything below 1000 cycles.

It may be shown that, given the iterative impedance Z and the cut-off frequency F for which a filter is to be designed, the value of the elements is given for a high-pass filter section by

$$C_1 = \frac{0.07958}{FZ} \text{ farads}$$

$$L_2 = \frac{0.07958Z}{F} \text{ henries}$$

while for a low-pass filter we have similarly

$$C_2 = \frac{0.3183}{FZ} \text{ farads}$$

$$L_1 = \frac{0.3183Z}{F} \text{ henries}$$

In each case F is in cycles per second, while Z is in ohms.

The September issue of the *Experimenter* carries as the leading article, "Notes on Group Address Systems," by C. T. Burke. Since papers on public address technique have appeared in this department of RADIO BROADCAST Mr. Burke's discussion will not be abstracted here, but it should be interesting as a general treatment for broadcast operators who have not devoted attention to the subject. A schematic diagram is included.

This issue also contains a description of the Type 426-A thermionic voltmeter, including a diagram of the bridge circuit employed with the vacuum tube. The range is 0-3 volts, and under the usual conditions of use the calibration is maintained to within 0.5 per cent. for about 1000 hours, and is good over the whole audio-frequency range. Even at 20 kilocycles there is only a 2 per cent. error, and less than 3 per cent. at 300 kilocycles. At broadcast and higher frequencies the calibration is no longer valid. The entire instrument, including the battery, is self-contained.

Another item in the September issue concerns the Type 532 Station Frequency Meter, the entire scale of which covers only 0.3 per cent. of the frequency of the designated station, the variable condenser being connected across a larger fixed capacity. This gives ten scale divisions per kilocycle. The resonant frequency is read by an ingenious method, which consists in connecting across the main condenser a small auxiliary capacity to shift the peak of the meter from one side of the station peak to the other. The frequency meter is adjusted until the indicating galvanometer does not change its reading when the button connecting this condenser is pressed. This gives a more accurate setting than an attempt to find the exact peak by the maximum galvanometer reading. The accuracy of this meter is certified as within 500 cycles with a temperature variation of not over 5 degrees Fahrenheit from the temperature specified in the calibration. The guarantee is for six months, after which the instrument must be recalibrated.

The General Radio *Experimenter* is a very commendable publication, to my mind, and broadcast technicians should get their names upon its mailing list. It is sent free on application to the company's offices at Cambridge, Mass. It is a commercial publication, but the discussions are severely free from advertising blather and generally contain as much general theory on the subject as specific description of the General Radio Company product. A commercial publication which is scientifically and informatively written is better than a sensational medium whose ultimate commercial aims are less frankly revealed, and if you fail to extract a few dollars' worth of data from the *Experimenter* it is your fault.

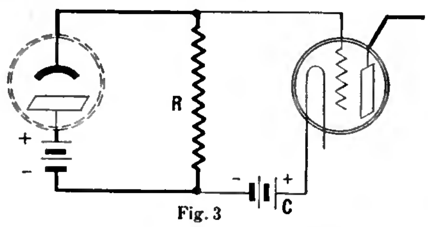


Fig. 3

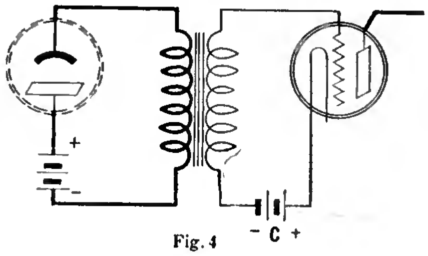


Fig. 4

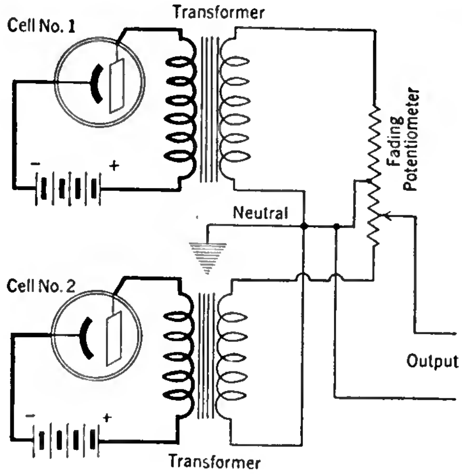


Fig. 5

PHOTO-ELECTRIC CELL CIRCUITS USED IN SOUND MOTION PICTURES

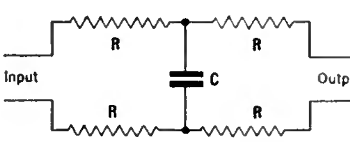
Fig. 6


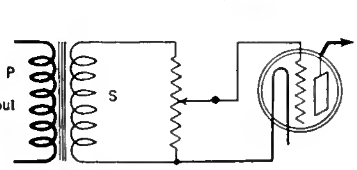
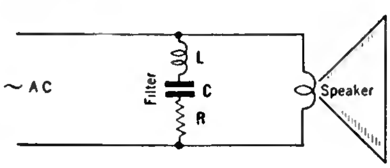
Fig. 7


Fig. 8


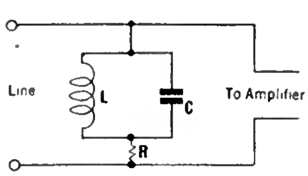


Fig. 9

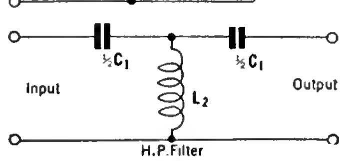


Fig. 10

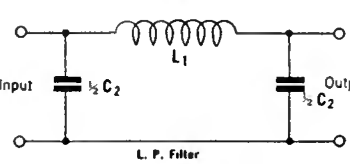


Fig. 11

A GROUP OF INTERESTING FILTER CIRCUITS

A and B Power from the D. C. Lines

By WILLIAM B. DALL

WHERE 110 volts d.c. is the house-lighting current supplied by the local power company, there is opportunity for supplanting storage or dry batteries for both filament and plate circuits in a radio set by means of comparatively simple and inexpensive devices. These have been described in the columns of radio periodicals and are fairly well understood by those who "roll their own" in d.c. districts.

There are a few pitfalls in this sort of apparatus which have been touched on in the form of warnings, but practicable solutions do not seem

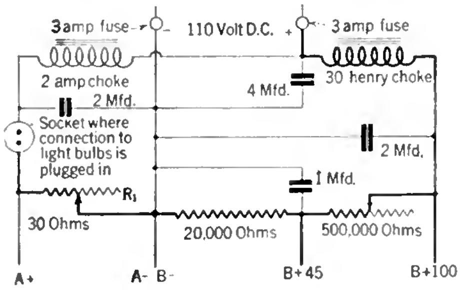


FIG. 1

to be generally known. The purpose of this article is to indicate means for polishing off some of these rough edges.

First let us state briefly the sort of A battery substitute used. In simplest form it is a bank of electric light bulbs, wired in parallel, in series with the filament circuit of the radio set and the light socket. The total wattage of the bulbs is adjusted to the current consumption of the set, the basis being about 30 watts per quarter-ampere tube. This is a little in excess of actual needs, but the excess may be bypassed around the set through a 30- or 50-ohm rheostat, R, in Fig. 1, the varying of which offers a form of filament control to compensate line voltage variations. This resistance is *across* the current source, and consequently the current into the set increases as the resistance is increased. The bank of bulbs may be one or several reading lamps which in the evening would be lighted anyway, and, as a result, the set current costs the user nothing additional except for daytime operation.

HOW TO REDUCE COMMUTATOR HUM

A CHOKE coil, capable of carrying about 2 amperes, and capacities across the line, although not always necessary, are frequently used as a filter to curtail commutator hum which is present in the d.c. supply voltage. See Fig. 1.

The writer has found that various types of 5-volt tubes operate with complete satisfaction at $4\frac{1}{2}$ volts. His ear at least can detect no difference between a set operating at $4\frac{1}{2}$ and one operating at 5 volts. An inexpensive and compact dry battery of $4\frac{1}{2}$ volts is everywhere available in the form of a C battery. If the voltage at the set is adjusted to $4\frac{1}{2}$, and a $4\frac{1}{2}$-volt C battery is placed across the A substitute, the plus to plus and the minus to minus, the hum, if there be any in the speaker, will decrease to a negligible amount. In normal operation there will be no current drawn from the battery and its life will consequently be long.

This little battery has another important function if used as indicated, which cannot be performed by high-capacity condensers. It will absorb what otherwise might be a considerable voltage rise and so protect the tubes in the set against burn-out.

The danger in the use of the d.c. A battery substitute described, lies in the fact that if a tube be removed from the set while the current is on, or if a tube filament should fail or a filament prong become open-circuited, the voltage at the A plus and A minus posts will at once increase considerably. Excess current will consequently be forced on the remaining tubes in the set. If that shock blows a second tube, another rise occurs and the remaining tubes are sure to go. With the handy little $4\frac{1}{2}$-volt battery across the set, one tube may be taken out of a 4-tube set and the voltage on the remaining three will rise only about $\frac{3}{10}$ of a volt (varying a bit with the internal resistance of the battery), instead of jumping about $1\frac{1}{2}$ volts as would be the case without the dry battery shunt. Consequently a tube filament may fail and the other tubes in the set will be perfectly safe. On the same principle this battery also absorbs voltage surges.

Were the dry battery to be left in this circuit after the house current was turned off it would drain itself in a few moments in a vain endeavor to supply current to the set. To make disconnection of the battery automatic, a relay comes in handy wired as indicated in Fig. 2. Any of the types used for cutting out chargers and cutting in B power units will serve. In such a relay the two contacts on the plug by which connection is usually made to the light socket may be connected to A plus and to A minus, and the leads from the B power unit socket on the relay connected to the C battery. The actuating coil of the relay goes in series with the A plus lead. It is essential that this coil lie between the point at which + C is connected and the line, and *not* between the C battery connection and the set. In the latter position the relay will not function properly and there would be a considerable drain on the C battery as the latter would still be feeding the set through the relay. In the correct position, the relay action is instantaneous. One C battery lead may be broken, or two, as many commercial relays are equipped with a double set of contacts.

WAYS FOR ECONOMIZING ON CURRENT

OPERATING multi-tube sets on 110-volt d.c. for filament supply is not economical unless the current-limiting resistances (in the case described, electric light bulbs) are used at the same time for lighting the room. A six-tube set using quarter-ampere tubes would require the use of the equivalent of 180 watts of such bulbs, which, on an average use of four hours per day, would add 22 kilowatt-hours to the electric light bill each month. To cut this current consumption the kink is to use the 199-type tubes up to, but not including, the last audio stage.

If five tubes be so changed, we have .06 x 5 = 0.3 ampere, instead of .25 x 5 = 1.25 ampere for 201A-type tubes, a saving of nearly one ampere of filament current. The saving is nearly 120 watts, or two thirds of the original consumption. A 15-ohm rheostat in series with the A plus lead to the 199-type tubes is sufficient to cut the $4\frac{1}{2}$ volts across the A-battery substitute to 3 volts for the set of five 199's.

If the reading lamp used in connection with this A-battery substitute is to be lighted at times when the set's operation is not desired, a snap switch, indicated in dotted lines in Fig. 2, may be connected across the A plus and A minus just back of the relay. When that switch is open, the lamp will light and the set operate; when that switch is closed, the lamp will light but the set will be off. It is understood, of course, that the switch on the set itself is always left in the "on" position, the whole apparatus being controlled from the light socket at which the current originates.

A B-POWER UNIT FOR D.C. OPERATION

THE B-power unit side of a 110 d.c. outfit is simple. One 30- to 60-henry choke, of d.c. resistance not exceeding 600 ohms (preferably lower), and two 4-microfarad condensers (good by-pass condensers will do, as the voltage does not exceed 110) comprise an adequate filter. Allowing for a voltage drop through the filter, an output of 90 to 100 volts is obtained. One variable high resistance gives the 45-volt tap for detector. Fig. 1 shows the hook-up.

With a push-pull last stage audio for four power tubes, as described in RADIO BROADCAST for May, 1928 (page 18–19), the B plus is taken directly from the light-socket connection around the filter, since thereby the full 110 to 115 volts is obtained for the power tube plates and any hum is balanced out by the push-pull arrangement.

It is customary to equip these power devices with 3-ampere fuses. This is of course protection to the house fuses, but not to the radio apparatus. At 3 amperes, a short-circuit could play considerable havoc with good radio equipment. To obviate this danger, the writer has inserted an old 199 tube in series with the B plus 110-volt plate supply lead. This limits the current through this lead to 60 milliamperes. The drop across the tube at a drain of 40 mils is only 2 volts, and all tubes and associated apparatus are well protected. The 199 tube used may be an old one, whose decreased filament emission renders it unfit for radio set use.

The tapped choke output for push-pull stage is a satisfactory substitute in the use of two 30-henry chokes, the two outside connections going to the plates and speaker, and the inside common connection to both chokes going to the B plus. This kink permits the use of chokes which the builder may have on hand.

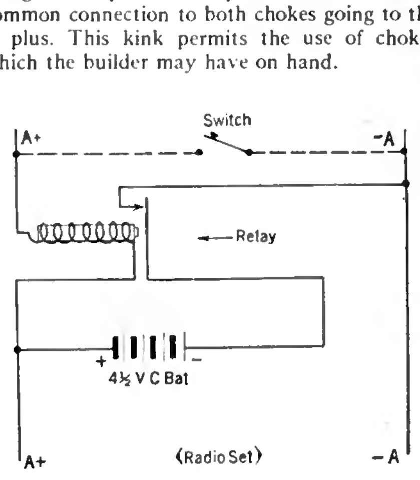


FIG. 2

Complete Equipment For Television Reception

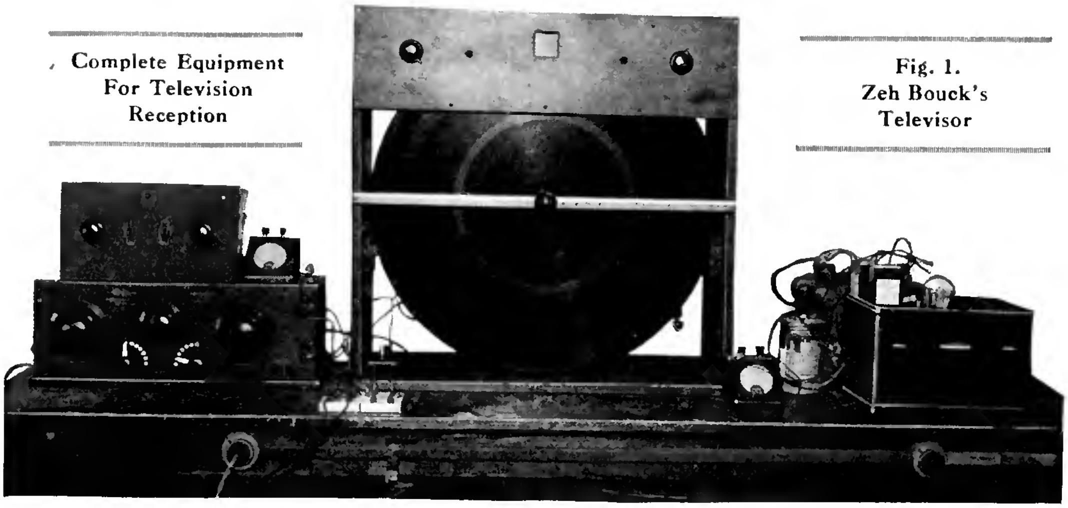


Fig. 1. Zeh Bouck's Televisor

Building Receivers For Television

By ZEH BOUCK

TELEVISION signals are transmitted to-day to a rapidly increasing number of experimenters throughout the world. The interest and pleasure associated with their reception is found in the novelty and fascination of the achievement with home-made apparatus rather than in esthetic considerations associated with the reproduction.

Television signals when properly transmitted and received portray the instantaneous characteristics of the object being scanned at the transmitter. This is accomplished by interpreting at the transmitter the visual aspects of the televised object as electrical variations which, at the receiver, are reconverted into properly distributed shades and high-lights.

The quality of the received picture depends upon how good a signal is transmitted in the first place, and upon how well it is reproduced at the receiving end. Here the amplifier used following the detector plays the important part. Theoretically the signal to be received should contain important frequencies from as low as the number of pictures per second to those lying far above the highest audio frequency used in music.

However, television programs in the broadcast band cannot contain frequencies above 5000 cycles since this is the highest frequency at which a broadcasting station is permitted to modulate, and even when the transmissions are on short waves, the improvement in reception obtained through the use of a special amplifier going up to 15 or 20 kilocycles isn't worth the expense of constructing it—at least it doesn't appear to be worth doing until the quality of the transmissions are much improved over what they are to-day. A start can be made with any good amplifier and, after the best possible results have been obtained from it, there will be time to construct an amplifier designed especially for television reception.

It is the purpose of these notes to describe the amplifier and scanning combination used by the writer. This apparatus will reproduce television images when attached to any receiver capable of delivering a signal of requisite strength from the desired transmitting station.

(*Continued on page 36*)

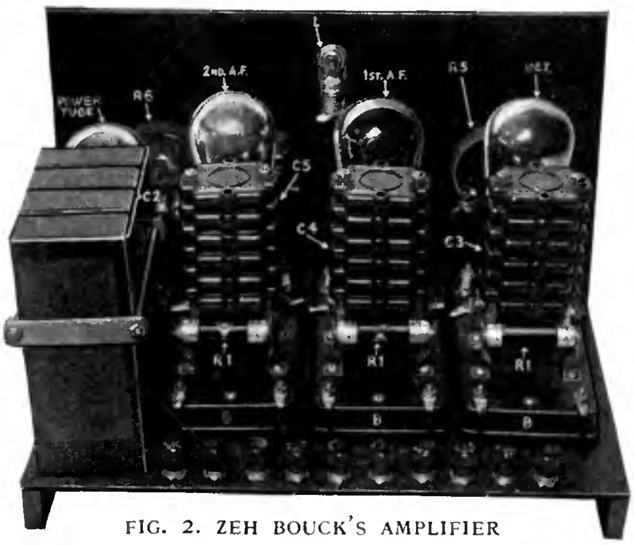


FIG. 2. ZEH BOUCK'S AMPLIFIER

By JAMES MILLEN

INSTALLING and operating an experimental television receiver is not difficult for the average radio set builder or amateur experimenter. In this connection a description of the equipment used by the writer should be of considerable interest, especially as the same apparatus may be employed by experimenters in other parts of the country for receiving any television station by merely selecting a scanning disc of the proper type for the particular signal being received. For instance, when using a 24-hole disc the WGY 21-meter television signal may be received all along the West coast. Then, there are the KDKA experimental signals which require a 60-hole receiving disc. The majority of stations, however, are transmitting a 48-line picture.

Any good receiver capable of being tuned to the wavelength of the desired television transmitting station may be used. The short-wave receiver employed by the writer is the standard kit sold by the National Company, all of the parts of which are available in the open market. It was described in detail on page 286 in the August, 1928 issue of RADIO BROADCAST. The 222-type r.f. tube is followed by a regenerative detector. This system prevents radiation—a problem which would soon become quite serious if all the short-wave receivers were of the radiating variety.

In building any type receiver, especially for short-wave reception, and particularly one for television work where a motor and scanning disc are located in the same room, considerable attention must be given to rigidity of construction. This applies to the coils and their mountings as well as the wiring and other parts of the set.

We find from experience that the ordinary audio amplifier, such as you use at present for speech and music, is good enough to provide picture reproduction sufficiently clear to distinguish forms, such as the outline of a hand or head, and to follow motion. This is perfectly O. K. for a starter, and your present audio amplifier can be used, provided it has at least the gain of a good two-stage transformer-coupled unit.

For receiving 3XK in Boston it was found ad-

(*Continued on page 37*)

IN THIS article are given descriptions of the work of two experimenters well known to readers of RADIO BROADCAST—*Zeh Bouck and James Millen—both of whom have set up apparatus and successfully received television programs. The differences in the apparatus—especially the amplifier equipment—will give the reader a good idea of the circuits which may be adapted to present day television reception. As the art develops more stringent requirements will be set up as to the characteristic of the audio amplifier but it is evident from the data given here that for the present at least almost any good amplifier may be used.*

—THE EDITOR.

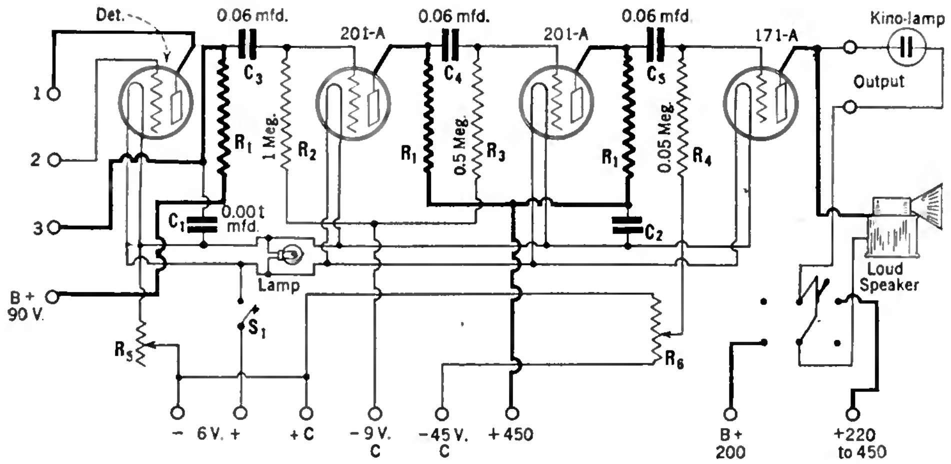


FIG. 3. SCHEMATIC DIAGRAM OF TELEVISION AMPLIFIER

(*Continued from page 35*)

The essential parts of a television reproducer are a tuner (any kind will do that is capable of providing a good loud-speaker signal in ordinary reception), an audio amplifier, a neon tube and a scanning disc turned by a motor mechanically arranged so that the holes in the disc scan the surface of the glowing plate.

The amplifier used by the writer is shown diagrammatically in Fig. 3, while constructional points are suggested in the pictures, Figs. 1 and 2. The amplifier can be built from any standard apparatus; it employs the usual three-stage resistance-capacity-coupled circuit.

APPARATUS REQUIRED

THE following is a complete list of the parts required for the construction of the writer's television amplifier:

- R_1—3 Wire-wound resistors, 100,000-ohm;
- R_2, R_3, R_4—3 Grid-leak resistors, 1-meg., 0.5-meg., and 50,000-ohm, respectively;
- R_5—1 Rheostat, 10-ohm;
- R_6—1 Potentiometer, 200,000-ohm;
- C_1—1 Mica fixed condenser, 0.001-mfd.;
- C_2—4 Filter condensers, 400-volt, 2-mfd.;
- C_3, C_4, C_5—6 Mica condensers, 0.01 mfd.;
- L—1 Pilot light;
- S_1—1 Toggle switch;
- 4 Vacuum-tube sockets, UX-type;
- 6 Resistor mountings;
- 10 Binding posts;
- 1 Front panel, 7 x 10 x $\frac{3}{16}$-inch;
- 1 Sub-panel, 7 x 10 x $\frac{3}{16}$-inch;
- 2 Sub-panel brackets.

The pilot light and toggle switch are, of course, unessential, but were incorporated in the amplifier for convenience. The amplifier eventually will be mounted in the cabinet, and the pilot light will give some indication of current conditions behind the panel. The switch (S_1) controls the filaments of the detector and amplifier tubes, while the other switch, visible in the pictures, was used to start the motor turning the scanning disc.

The four filter condensers (C_2) are connected in parallel to bypass the amplifier plate voltage, and reduce the tendency to motorboat. In the amplifier pictured the coupling condensers are built up in stack form, and consist of six 0.01-mfd. mica condensers.

In operation it will be convenient to be able to switch easily from the loud speaker to the neon tube, an operation that is facilitated by the double-pole, double-throw switching arrangement suggested in Fig. 3. By means of the two battery taps the voltage applied to the tube is practically the same with either the loud speaker or neon tube, thus prolonging the life of the 171A tube and making unnecessary any variation in the C-bias potentiometer, R_6. When the amplifier is operating the loud speaker about 200 volts are employed, while with the neon tube the full 450 volts is applied. These voltages can be sup-

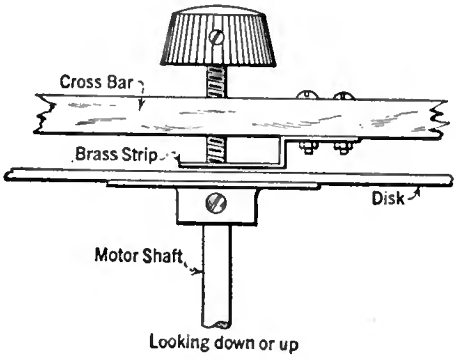


FIG. 4. MECHANICAL SPEED CONTROL

plied either by a B battery or a power-supply unit. A Receptrad Powerizer was used in the author's laboratory as shown in the picture of the entire set-up, Fig. 1.

SCANNING DISC ASSEMBLY

THE televising apparatus consists of the scanning disc driven by an adequate motor, some form of motor speed control, and the neon tube, combined in a convenient and efficient mechanical arrangement. A box frame, such as is illustrated in the pictures, Figs. 1 and 5, provides a simple and satisfactory unit. The motor shelf is so positioned that the driving shaft can be centered exactly. The shelf is clamped between cushions of soft rubber which reduce the vibration.

The neon tube is mounted with its plates parallel to the scanning disc, so that the holes in the latter pass over its entire surface. The neon tube is a Raytheon Kino-Lamp and it should be placed in a horizontal position on the upper shelf as close to the scanning disc as possible. The Baldor type-MV2 variable-speed motor may be used for turning the disc. For observing the picture square hole, $1\frac{1}{2}$ x $1\frac{1}{2}$ inches, is cut in the face of the front panel exactly in front of the plate of the neon tube.

The inside dimensions of the entire box, as pictured, measure 25 x 25 inches. It is built of half-inch wood (heavier material is desirable) and the front panel is 7 x 26 inches. Two ten-ohm rheostats, connected in series, are mounted on the panel, and these provide a very accurate motor control. The rheostats are in series with some additional resistors in accordance with the directions accompanying the motor.

By means of the rheostats, in conjunction with a simple mechanical brake described in the paragraph on operating directions, it is possible to maintain the speed of the motor sufficiently close to synchronism with the transmitting disc.

THE CIRCUIT ARRANGEMENT

THE detector tube has been incorporated in the amplifier constructed by the writer. When used with the average receiver, posts one and three in Fig. 3 will be bridged, and post two will be plugged into the grid prong on the detector socket of the receiver. In the case of a regenerative receiver, the plate of the exterior detector tube will be wired to the plate terminal on the detector socket while post three will be led to the plus detector terminal on the set. In other words, the tickler or regenerative coil is connected in between the plate of the detector tube and the coupling resistor. If it is desired to use the detector socket in the receiver (and this may be the more simple procedure in many cases) post three is led to the plate terminal of the detector tube.

The neon tube is connected in place of the loud speaker or output device. This is a simple series connection and is quite effective. While there are other systems of inputting to the neon tube, concomitant complications hardly recommend them for an initial attempt.

The apparatus described was designed primarily for the reception of the television signals broadcast from WRNY, New York City, employing a 48-hole disc at a speed of 450 revolutions per minute. A National Company disc is used in the illustrated apparatus.

OPERATING DIRECTIONS

THE signal is first tuned in on the loud speaker in the usual way, a loud clear signal being the desired result. The motor should be started and the disc brought up rapidly to approximately the speed desired. This can be accomplished by means of a switch short-circuiting the speed-governing resistors.

The output of the amplifier is now switched over to the neon tube, which, when the television signal is received, should show a definite pattern when viewed through the disc. As the disc approaches synchronism with the transmitting disc, the pattern will resolve itself into more definite lines slanting away from the perpendicular. The lines become more and more perpen-

(*Continued on page 37*)

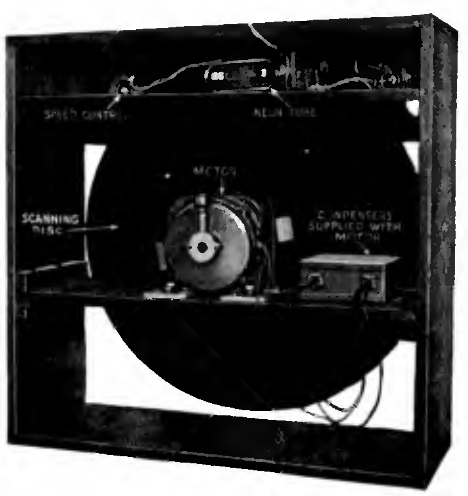


FIG. 5. REAR VIEW OF TELEVISOR

(*Continued from page 35*)

visable to use a three-stage amplifier using National transformers—see Fig. 3. Then again, the pictures being transmitted by 3XK at present are merely silhouettes, which do not require an amplifier with as wide a frequency range as if half-tones were being transmitted.

As a rule, with a three-stage a.f. unit, the amplifier noise will not be very great. Vibration from the receiving disc or its motor, which are transmitted to the amplifier or especially the detector tube, however, will introduce a periodic noise that will cause a black streak across the field of the picture. Any periodic interference, such as a 60-cycle hum, that may get into the signal will also cause streaks across the picture, but these will not remain stationary, but will move upward or downward across the field of the picture.

THE OUTPUT CIRCUIT

THE output circuit of the amplifier is arranged so that the neon or Kino-Lamp is always illuminated, and, when a station is received, the brilliancy of illumination merely varies in accordance with the signal. A good background will be obtained if the d.c. current through the neon tube is limited to 10 or 20 milliamperes. More current will cause the lamp to glow brighter and brighter but there is no advantage in this so far as the picture is concerned and it only serves to shorten the life of the lamp. Accordingly, care should be taken to adjust the current to the minimum satisfactory value.

A Clarostat has been found excellent for such use, and it may be mounted conveniently on the front of the frame supporting the scanning apparatus, as shown in Figs. 1 and 2. For illuminating the Kino-Lamp either a standard high-grade B socket-power unit or heavy-duty B batteries may be used.

Several different concerns are manufacturing scanning discs suitable for use in receiving the signals now on the air. The better grade discs are well made mechanically, so as to run true and require little power. The holes in such discs are also punched to the degree of accuracy necessary if the received image is to be free from black lines and streaks. The National disc uses radially-shaped holes, rather than round holes, for with this design the "lines" across the image are much less obvious.

In driving the scanning disc successful results have been obtained with a number of different types of small motors. However, the motor which the writer is using at present is the $\frac{1}{8}$-horsepower type-YIV variable-speed condenser-type Baldor which is intended for operation on 110-volt, single-phase, 60-cycle a.c. line. This is a ball-bearing motor that operates very smoothly and quietly. The swish of the disc through the air constitutes the major portion of the noise, and this is quite insignificant. Special rubber vibration absorbers are supplied with the motor for mounting purposes.

MOTOR SPEED CONTROL

THE diagram (Fig. 3) shows the method for speed control. For the variable resistor R_2, a 75-watt, 4- to 100-ohm wire-wound resistor with a sliding contact is used. The other resistor may be a 10-ohm 10-watt resistance. This is labeled "R_1" in the diagram and is shunted by the push-button speed-control leads.

The resistance R_1 is so adjusted that with the push button released, the motor runs at slightly below the proper synchronous speed. Then, when the push button is depressed, the disc tends to speed up.

Do not mount the television receiver in the same cabinet with the disc. Vibrations of the motor will introduce a synchronous noise that will result in a series of horizontal lines being drawn across the picture. Therefore, it is important to keep the receiver and amplifier on a support separate from that for the disc.

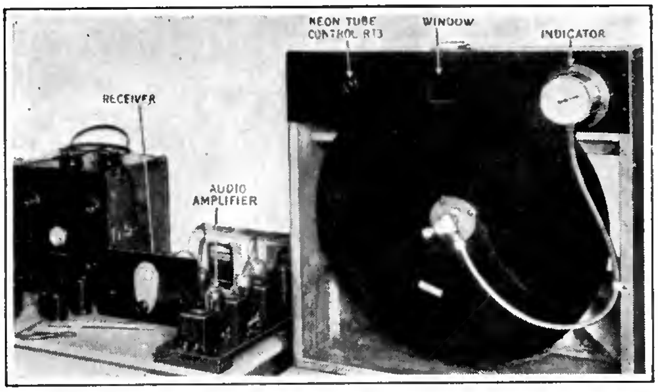


FIG. 1. GENERAL VIEW OF TELEVISION LAYOUT

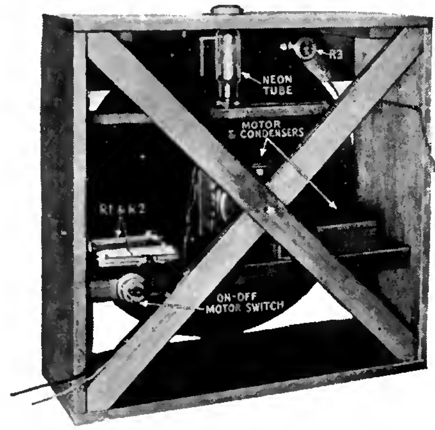


FIG. 2. REAR VIEW OF SCANNING DISC

The experimenter will find that the following convention has been adopted by the Raytheon Company in regard to neon tube mountings. The tube is fitted with a standard UX base. The plates inside the tube are placed in a plane at right angles to the axis of the "Pin" of the base. If the pin, therefore, is pointed toward the disc when inserted in the socket, the plates inside the tube will then be parallel to the disc. The tube should be mounted at the proper height to cover the $1\frac{1}{2}$-inch square scanned by the revolving disc. The plates are connected to the "plate" and "filament" prongs of the tube base.

Zeh Bouck's Televisor

(*Continued from page 36*)

dicular as the correct motor speed is approached, finally forming the image of the televised object. Final tuning should now be effected on the receiver. Also, the bias to the last tube should be varied, by means of the high-range potentiometer R_6, for best results.

MECHANICAL BRAKE NEEDED

IT IS desirable to use some simple form of mechanical brake in conjunction with the rheostats to control the motor. The device shown in Fig. 4 was designed by the writer for this purpose.

An iron cross piece was fastened to the box housing the revolving apparatus so that it crossed in front of the motor shaft. A hole was drilled to the exact center of the shaft, and the nut from a $\frac{1}{4}$-inch iron bolt was soldered to the cross arm. A brass strip was bent as shown in the illustration, and bolted to the cross piece. The head of the $\frac{1}{4}$-inch bolt was sawed off and a knob mounted on the end. By screwing in the bolt, the brass strip is pressed against the end of the shaft, giving a very delicate braking action. The brass strip should be taped where it touches the shaft.

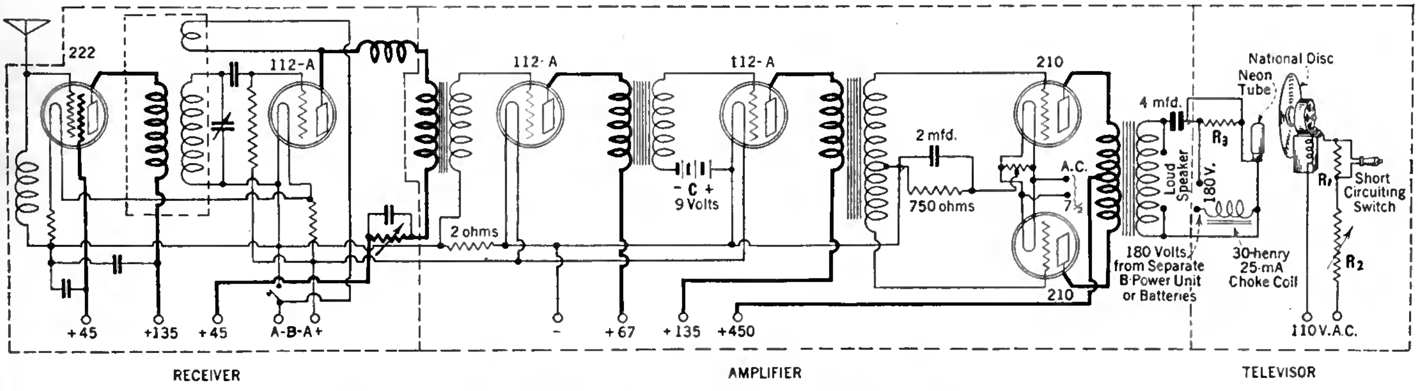


FIG. 3. COMPLETE SCHEMATIC DIAGRAM OF JAMES MILLEN'S TELEVISION RECEIVER

A Modulator for the 1929 Short-Wave Transmitter

By ROBERT S. KRUSE

A WRITER on the Hartford *Times* tells me that all radio men write stories badly; that is, they always leave the thrill until the last, instead of putting it into the headline. In this three-part tale of improved short-wave transmission, I seem to be guilty of this offense, for I am waiting until the third installment to speak of the uses of such transmitters, and, of course, that is where the thrill comes in. For the present we shall give additional data on the constant-frequency transmitter described last month, and explain those devices which make it useful, which is to say the key or microphone.

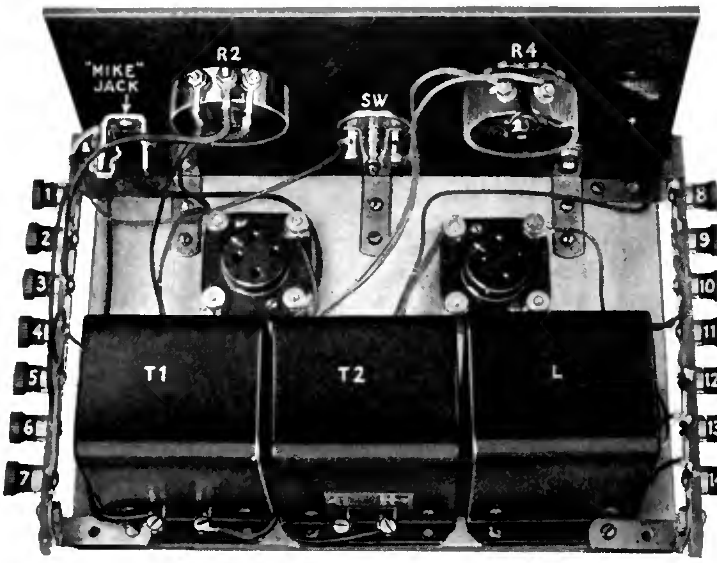


FIG. 1. TOP VIEW OF MODULATOR UNIT

A transmitter without modulation is useless, since it can send out only a "carrier wave." To place variations on that carrier which a radio receiving set can "unscramble" into code or voice is the business of the apparatus described in this article. It was explained in the October issue that voice, or radio-phone transmission, has the advantage of speed while, with the same power, radio-telegraph transmission has the advantage of greater range. Very evidently these two systems may be used with the same transmitter to excellent advantage, and it is my suggestion that provision be made for both.

CONCERNING INTERFERENCE

TO MANY amateurs a recommendation of radiophone is as a rag to a bull; it causes them to paw up dirt and bellow about the awful interference caused by the microphone-operated sets. This opinion is a bit out of date. Two years ago amateur oscillators were so unstable that the addition of modulating equipment did have a distressing way of causing the signal to smear over a wider band than one cares to think of. Also, the transmitters did exactly the same thing when keyed, but, in that case, the interference consisted of mumbles, thumps, and "yips" which were harder to identify. Since that time our preaching for better tuned circuits has had a good effect, and the coming of crystal-control has set examples. As a result the number of good amateur radiophones has increased so that we must withdraw the accusation against the phone.

To sum up—with an oscillator-controlled battery set we may modulate with key or voice as we please with no fear of "wobbulation" being added to "modulation." The circuit of the oscillator-amplifier set-up is shown in Fig. 3.

THE CIRCUIT ARRANGEMENT

THE circuit is the almost standard Heising constant-current arrangement. In Fig. 2A we review the general principle. Current from the battery flows through the high-inductance choke, L, to the point B, then divides and returns in two parts through the two resistances R_1 and R_2. If we suddenly change the setting of the variable resistence R_2 we find (by watching the meter I) that the current through R_1 changes for only a moment when this is done. The explanation is this; the choke L is (after the fashion of inductances) an electrical "stand-patter," i.e., always opposing a sudden change. Thus, if we suddenly reduce R_2 we do not change the *total* current through the choke immediately but simply change its division between the two paths, therefore, the current through A drops sharply until L finally agrees to allow more current to pass. On the other hand, if we suddenly raise the resistance of R_2 we force additional current through R_1 until L permits the total current to die down. Thus, the effect of any *sudden* changes in R_2 causes corresponding sudden changes in the current passing through R_1.

A TRANSMITTER, according to Mr. Kruse, without a means of modulation is as bad as a ship without a sail. Inasmuch as the transmitter itself was described in October, a transmitter that is designed to stay on its assigned frequency, the modulation equipment necessarily had to follow. Here it is.—THE EDITOR

In Fig. 2B we show how this principle is used in our set. The oscillator tube feeds radio-frequency power to the grid of the r.f. amplifier tube where it is amplified and passed to the circuit L_2 C_3. The current is then transferred to the antenna, but this does not concern us just now. The plate power for the amplifier tube is supplied through a choke coil L, of at least 6 henries, just as the current in Fig. 2A was supplied. The radio-frequency choke (r.f.c.) is to prevent the r.f. wandering into L and the tube "Mod" where it would be wasted. The vacuum tube labeled "Mod," which is used as a voice-operated resistance, is substituted in the circuit in place of the resistor R_2. A microphone and amplifier feed voice-currents to the grid of this tube, and, as they cause the voltage of this grid to change, the current to the amplifier tube varies, causing corresponding changes in the r.f. current in the L_2 C_2 circuit from which the antenna power is taken. It is only fair to say that this method of operation does not permit the highest amplification to take place in the amplifier and that a "straight" r.f. amplifier should be added if the full power-rating of that size of tube is desired. However, this added complexity does not seem warranted in a small set since the range increase is not large.

The circuit arrangement in complete form is shown in Fig. 3. The picture in Fig. 1 shows how simply the whole works goes together. In listing the particular makes of apparatus which are given below, the writer has no particular desire to favor any manufacturer but rather his motive is to remove uncertainty by listing those parts which have been used with satisfaction in short-wave transmitters. In several cases it was found that other equipment, which seemingly had every right to be as good, was thoroughly unfitted for this somewhat special purpose. If changes in the assembly are considered necessary they should, therefore, be made one at a time and the effect noted. The parts used in my set-up are as follows:

LIST OF APPARATUS

Mike—Western Electric type 348BW or Federal type 260W.

R_1—Used to reduce microphone current to proper value. Not necessary in most cases.

R_2—Gain control. Frost 100,000- or 200,000-ohm type.

R_3—Shunt resistance, exchangeable in clip to suit tube and transformer used. 1 megohm is usually satisfactory.

R_4—Filament rheostat, 6-ohm.

L—General Radio choke, type 485-S.

TR_1—General Radio type 485-M (for single button mike)

TR.—General Radio type 485-D

SW—Switch to cut off d.c. filaments and microphone. No a.c. circuits should go through or near this switch.

CONCERNING TUBE EQUIPMENT

FOR the sake of simplicity, and to minimize A.C. hum, it is recommended strongly that for voice operation 201A-type tubes be used in the oscillator (see p. 344 of October RADIO BROADCAST) and in the first socket of the modulator, and that their filaments be operated from a 6-volt storage battery, which is necessary for the microphone in any case. The r.f. amplifier tube in the October article and the modulator tube in the present set-up may be a 112-, 171-, or 210-type tube, or a corresponding a.c. tube. The UX250 may be used but is not recommended. It is possible to use a.c. tubes in place of the 210 tubes recommended, but make sure that they are of the "heater" type, such as the Arcturus tubes or the UY227, and not of the "thick-filament" type represented by the UX226. Care must be taken to keep the filament leads clear of the grid circuits and even with these precautions the hum problem is apt to be bothersome. With batteries on the tubes mentioned above this difficulty is removed. Still another combination is possible, namely to operate 201A-type tubes in the first sockets and 210-type tubes in the Amp. and Mod. sockets with a.c. on all the filaments. This is done by connecting the 201A filaments in parallel and running them through two equal fixed resistors to posts D and F of the October set-up. If the October set alone is used for c.w. these resistors must produce a drop of 1.25 volts each at a current of ¼ amp., therefore, they must have a resistance of 2.5 to 3 ohms. If the complete set-up, i.e., oscillator,

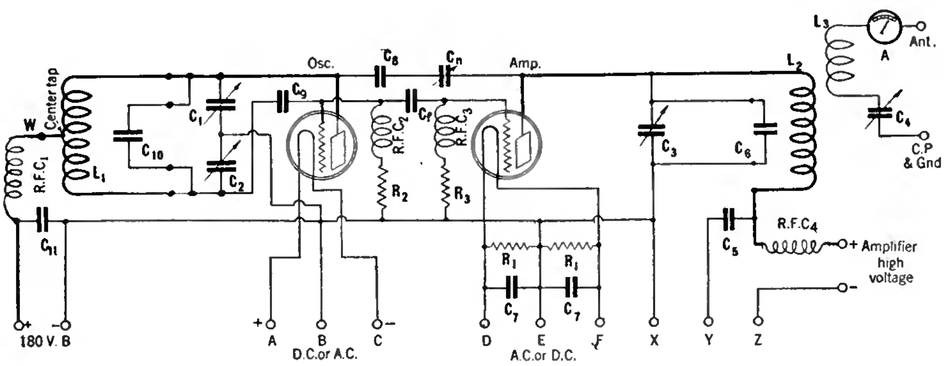
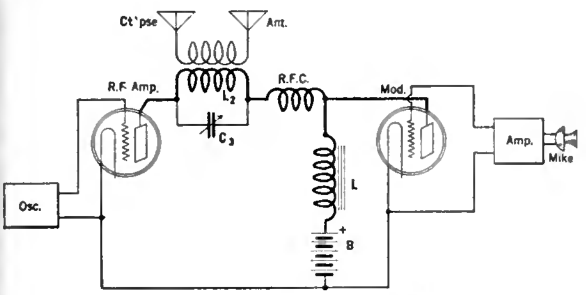


FIG. 3. THE SCHEMATIC DIAGRAM OF OSCILLATOR-AMPLIFIER



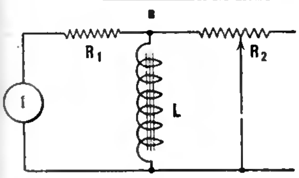


FIG. 2

Diagram A (left): schematic showing constant-current modulation principle. Diagram B (above): circuit used in set. A by-pass condenser between B- and the plate side of R.F.C. would improve results.

amplifier, and modulator is being used the current will be ½ amp. and the resistors may have a resistance 1.25 to 1.5 ohms each. A pair of ¼- or ½-ohm filament-ballasts resistors will do very nicely. It is advisable to twist all a.c. leads into pairs and to inspect the various center-tapped resistors to make sure they are in good condition. An open resistor will cause considerable noise; an off-rating one will produce less noise that is still quite noticeable.

THE UX-210 TUBE

IF ONE uses 112- or 171-type tubes in the r.f. amplifier and modulator sockets it is possible to cut down the plate voltage of the oscillator, thus reducing the drain from the batteries. This should not be carried to the point where unsteadiness results. In my particular set 90 volts at the oscillator handles a 171-type amplifier running at 300 volts with very fine steadiness.

When using the UX-210 tube or equivalent in the amplifier and modulator sockets the oscillator tube should have a plate potential of approximately 180 volts. It must, of course, never show plate-heating to a visible degree. If desired, the feed condenser C_f may be changed in size, provided it is not made large enough to cause difficulty in reaching down to the 10-meter band. The neutralizing condenser C_n must of course be readjusted when such a change is made.

Since the 210-type tube is used with the thought of obtaining an increased output it is operated at high voltage and with a plate current of about 40 milliamperes per tube—making 80 for the modulator and amplifier. This current would destroy the windings of the National type 90 choke in the plate circuit of these two tubes, and, therefore, it must be replaced by a more substantial choke which will operate over all the wavebands we are interested in. I can find none of the transmitting-type chokes which will do this, and, therefore, suggest a combination consisting of a single-layer choke in series with a General Radio type 379 T, Aero Products type 248 (transmitter type) or a National Type 90 re-wound with No. 32 or 34 d.c.c. wire. The single-layer choke, which is substituted in the clip for the former choke, consists of a ⅜" rod of insulating material wound for 1½" with a single layer of No. 34 or 36 d.s.c. or s.c.c. wire. The other choke may be mounted on the back of the panel near the amplifier tube and antenna ammeter. Its business begins at 20 meters where the little choke stops.

In Fig. 8A other changes are suggested that may be necessary if the 210-type tubes are operated at voltages above 250—as they usually are since their rating is 350. The condenser C_5 should be replaced by a 1000-volt Sangamo unit of the largest capacity available. If this cannot be done conveniently a change to the shunt method of feeding (shown in Fig. 8B) is advised. This may be necessary in any case if voltages above 400 are used. Here C_5 replaces C_6.

The 250-micro-microfarad plug-in condenser (C_6) used to load the amplifier plate circuit will not survive with the 210, therefore one of two things may be done. Either the coil inductance must be increased or else the 250-mmfd. tuning condenser C_3 should be replaced by a 500-mmfd. Equitune. The dial degrees of the two tuned circuits, i.e., the oscillator and the amplifier, will then not run together as nicely as was the case before. Of course, if one is really fussy about this point it is possible to use two Equitunes, of the 250 size, set end to end and connected in parallel, one being fixed at maximum and the other variable as usual. Personally, I prefer increasing the inductance.

Finally—if someone wishes to use a 210-type tube as oscillator, that too can be done by connecting posts ABC in Fig. 3 to DEF in Fig. 5. The plate potential of the oscillator should not be increased above 180 volts. This combination isn't bad at the upper wavebands but offers some slight difficulty at 10 meters. At present I cannot give the exact dimensions of the somewhat smaller coil that will be required. The diameter will be about 1" smaller than shown in the October article. The other wavelengths will shift somewhat but not badly, because of the large condenser which is used.

KEYING AND OPERATING WITH VOICE

NO MATTER which sort of operating is to be taken up the first job is to secure a steady output. Some suggestions were given in the October article. To these can be added the fact that it is of comparatively little importance what plate voltage is used as long as the plates remain at a sane temperature. For the oscillator this means no visible color, for the amplifier it means a red that is not too violent. The type of tube used and the recommendations of the maker should be considered. It is helpful to listen to the un-modulated output with a little "breadboard" receiver using the circuit of Fig. 6. With a 199 tube and a 22-volt battery the whole thing can be put on a 7" x 10" base, including a 4½-volt C battery for the filament supply. Shielding is neither necessary nor desirable for such a device; it is a nuisance in fact. When the note seems O.K., and free from 60-cycle ripple, one may key slowly and then proceed with voice-modulation. For this the pick-up receiver is stopped from oscillating.

"PERFECT MODULATION"

THE voice-input system shown will do good work if given a chance. There are several ways of making the adjustments. One is to have an assistant speak into the mike—preferably reading steadily from a book—while various things are changed and the results noted as the signal is heard

FIG. 4. FRONT VIEW OF MODULATOR UNIT

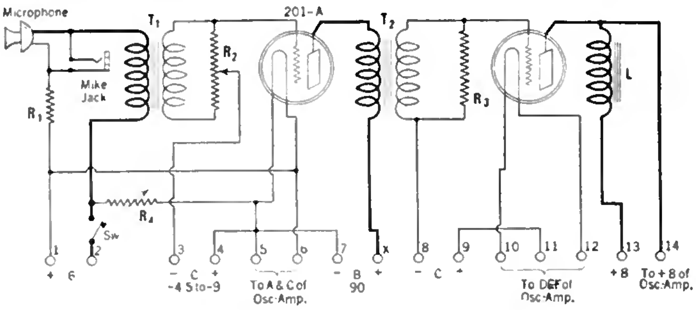


FIG. 5. SCHEMATIC DIAGRAM OF MODULATOR

in the phones of the pick-up receiver. The assistant *must* enunciate decently as otherwise he is worse than useless. He also *must* hold the mike in the proper position and at the correct distance. With these conditions as a good start one may now adjust the gain control, microphone voltage and bias of the modulator tube. The bias may be set at 10 per cent. of the modulator plate voltage at the beginning, and varied from this point. In general a large bias has an advantage in keeping the tube cool. If one has meters available it will be found good practice to adjust the currents to modulator and amplifier tubes so that they are of nearly equal value. Having once found a good setting one may watch the antenna meter thereafter, judging from its movements the degree to which things remain the same. A better way of doing this is to put a d.c. milliammeter in the modulator plate lead—and leave it there.

If an assistant is not available one may place the "mike" before a good loud speaker running at a moderate level on some decent input—not a jazz band. The listening is then done as before. It is scarcely necessary to say that all adjustments of this sort should be made with the antenna cut off.

The beginner will find himself confused when trying to determine the difference between good and bad speech from his own set. He is able to find some help from the fact that a bad phone makes no difference between the letters F and S, and very little between P, B, D and T. In addition to this it very probably will "blast" on some notes and on some of the vowel letters, especially O. Repeating alphabet and the groups of letters just mentioned, together with reading and counting are all good tests. One entirely useless test is to get on the air and work someone. The truth does not lie in that quarter—or perhaps I lack faith through being neither a "brass-pounder" nor very much of a "ragchewer," but mainly an occasional transmitting experimenter.

One very important point to remember is that the best of phones will not compensate for sloppy handling of the "mike." One *must* keep at a fixed distance and speak in an even tone of voice. Looking around the room does not help, nor does a cigarette or cigar between the lips. Consider the good care taken in broadcast announcements as compared to the ignorant use of the same equipment by a new speaker on his first broadcast from a not-too-good station.

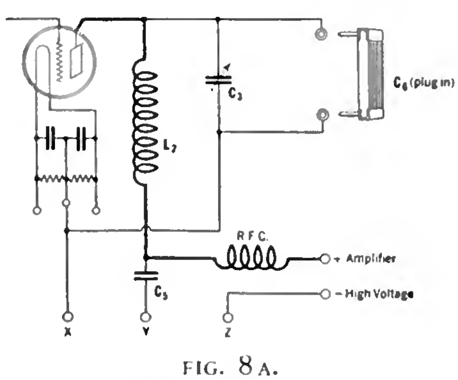


FIG. 8A.

This circuit is utilized when a 210-type r.f. tube is used with a plate potential in the order of 400 volts

AND AS FOR THE KEY—

WITH the key one may do many things incorrectly. The best rule is to send little and listen much until one learns the manner in which not to do things. This is easily done for

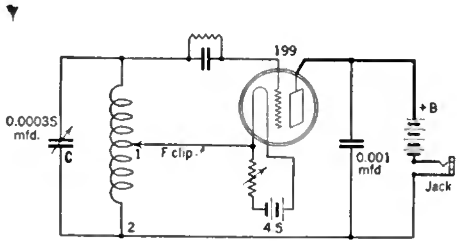


FIG. 6. PICK-UP RECEIVER USING A 199 TUBE

the average performance is not perfect and the air is still cluttered up with tireless "CQ" callers who make the most imperfect phone seem holy and pure. When one does call—let it be at a speed where the sending will be readable for "It isn't the words per minute but the messages per hour that count"—and again—"What profiteth speed when but used to repeat what was sent badly?"

Of the set itself little need be said when operating for radio-telegraph transmission only. The connections are explained in the diagrams; the standard practices are too lengthy to be put down here. The Radio Manual by Sterling at this moment seems alone to contain the new regulations.

One comment with regard to the set can be made. If for any reason it is desired to use C bias on the r.f. amplifier tube in place of the unorthodox resistance bias shown in the October paper this may be done by feeding the C battery to the clips of the cartridge-resistance-mounting. The oscillator-amplifier set-up has been so laid out that the C battery can be placed behind it and leads run in without difficulty. If, as in my case, the intention is to use the set-up portably the clips themsevles should not be disturbed.

Perhaps I have been wrong in the assumption that tuning the oscillator-amplifier is self-evident. The procedure is to set the oscillator with the aid of the wavemeter, then to place the little lamp-loop near the amplifier plate-coil (Aero Coil L_2) and tune that circuit for greatest brightness, finally to revolve the antenna condenser until the greatest antenna meter reading is obtained. Warning—the antenna meter is easily burned out if kept off-scale long. If it runs off—detune or pull the switch instantly. Then shunt the meter with a length of wire—6 inches at a guess—and try again. If it still runs off shorten the shunt until it does not. The process takes some practice and should be done for all the bands after which we will be ready to—but that's next month's story.

AMATEUR WAVELENGTHS

THAT there be no confusion regarding who may transmit, and what frequencies are available for amateur operations, the following quotation from "Revised Amateur Regulations" dated March 6, 1928, and signed by W. D. Terrell, Chief, Radio Division of the Department of Commerce, gives all the necessary information.

"An amateur station is a station operated by a person interested in radio technique solely with a personal aim and without a pecuniary interest. Amateur licenses will not be issued to stations of other classes.

"Amateur radio stations are authorized for communication only with similarly licensed stations, except as indicated below, and on wavelengths or frequencies within the following bands:

Kilocycles	*Meters*
401,000 to 400,000	0.7477 to 0.7496
64,000 to 56,000	4.69 to 5.35
30,000 to 28,000	9.99 to 10.71
16,000 to 14,000	18.7 to 21.4
8,000 to 7,000	37.5 to 42.8
4,000 to 3,500	75.0 to 85.7
2,000 to 1,500	150.0 to 200.0

and at all times unless interference is caused with other radio services, in which event a silent period must be observed between the hours of 8:00 p. m. and 10:30 p. m., local time, and on Sundays during local church services.

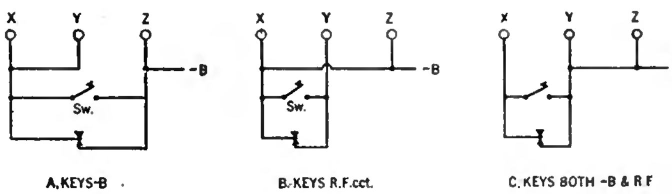


FIG. 7. CONTROL CIRCUITS

Amateur radio telephone operation will be permitted only in the following bands:

Kilocycles	*Meters*
64,000 to 56,000	4.69 to 5.35
3,550 to 3,500	84.5 to 85.7
2,000 to 1,715	150.0 to 175.0

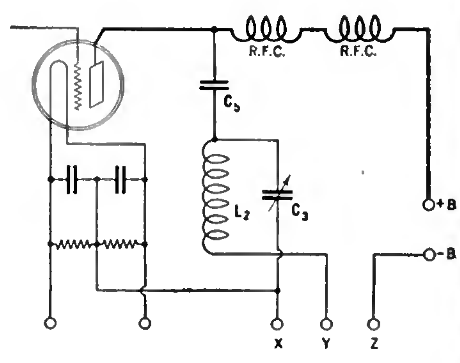


FIG. 8B

This arrangement must be employed if the condensers will not stand the high amplifier plate voltages

No. 11. November, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

Freshman Model "G" Radio Receivers

MODEL "G3"

The Model "G" Freshman receiver is six-tube tuned radio-frequency set having three stages of tuned radio-frequency amplification, a detector and two stages of audio-frequency amplification. The receiver is operated directly from 110- to 120-volt 60-cycle alternating-current house-lighting mains and employs the G-60-S power-supply unit to convert the current into the form necessary for the operation of the receiver. In normal operation the receiver has all its grid returns grounded to the frame and its filaments floating at pos tive potentials above the frame to furnish the necessary grid-bias voltages. The power-supply unit contains a transformer for heating the various filaments and a rectifier-filter system for furnishing the plate current.

1. *The Tuning System.*
This receiver has four tuned circuits, including a tuned antenna stage. The primary of the antenna r.f. transformer connects to A and A_2, the first terminal to be used with a long antenna and A_2 to be used with a short antenna. Across the first tuning condenser, C_1 is connected a midget condenser C_5 to permit adjusting the first tuned circuit to exact resonance.

The method of preventing oscillations in the r.f. amplifier is unusual. "Equaphase" is the name which has been given to this part of the circuit, as indicated in the circuit diagram. The circuit, consisting of R_1, C_6 and the effective primary inductance, of the r.f. transformer, when properly adjusted acts like a pure resistance at all frequencies and the tube cannot oscillate.

2. *Detector and Audio System.*
A leak-condenser system is used in the grid-circuit of the detector in this receiver. This is followed by a two-stage transformer-coupled a.f. amplifier. A small fixed condenser in the plate circuit of the detector bypasses the r.f. current to ground and provides the low-impedance path for the r.f. current, essential if the detector is to operate efficiently. No output device is included in the set but it generally is advisable that one be used unless the loud speaker is equipped with a coupling transformer that can carry safely about 20 milliamperes, the plate current of a 171A-type tube.

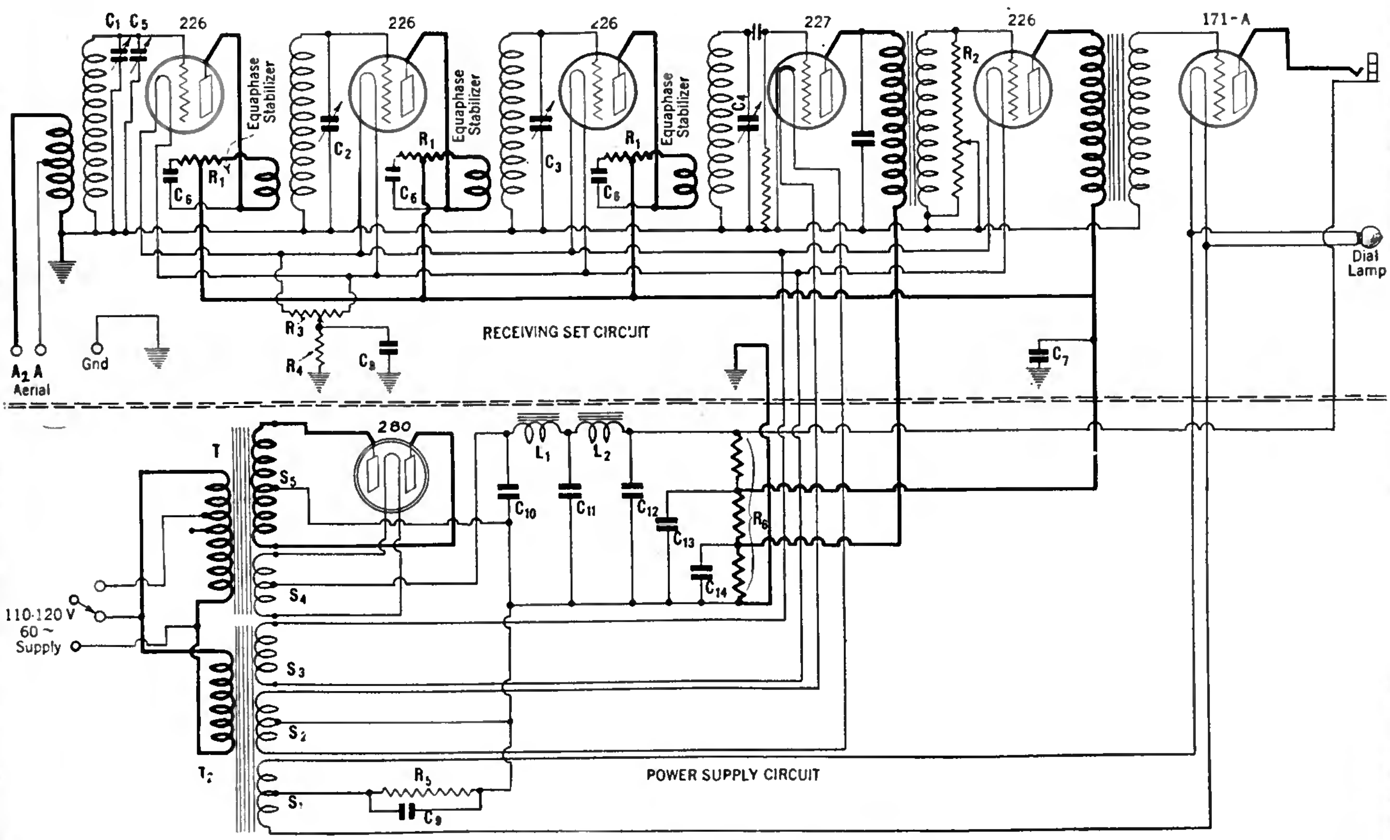
3. *Volume Control.*
The volume control consists of a high-resistance potentiometer, R_2, connected across the secondary of the first-stage audio-frequency transformer. The low-potential end of the secondary of this transformer is grounded as is the movable arm of the potentiometer.

4. *Filament Circuits.*
The filaments of the three radio-frequency and first audio-frequency tubes are connected in parallel and supplied with current from a 1.5-volt transformer winding (S_3) in the power supply. The midpoint of this circuit is obtained from the center-tapped resistor (R_3) connected across the filament circuit. The heater leads from the 227-type detector tube are fed from the secondary (S_2) which delivers 2.5 volts. The winding is arranged with a center tap which is grounded to prevent hum. The secondary S_1 supplies 5 volts for the 171A-type power tube, and this winding is also used to light the dial lamp.

5. *Plate Circuits.*
The plates of 226-type tubes in the r.f. and first a.f. stages are supplied with a plate potential of about 130 volts from the power unit. The plate of the detector receives about 50 volts. The plate of the power tube receives about 180 volts, which is the maximum permissible voltage for a 171A-type tube.

6. *Grid Circuits.*
At a plate potential of 130 volts, 226-type tubes require a grid bias of about 9 volts which is supplied, in this receiver, by the resistor R_4 connected between the ground and the center-tapped resistor, R_3. This resistor is bypassed by condenser C_8. The grid leak of the detector is returned directly to the cathode of the 227-type tube. A grid bias of about 40 volts for the 171A-type tube is obtained by connecting a 2000-ohm resistor (R_5) as shown.

7. *Power Supply.*
The B-power unit employs the power transformer (T) with two secondary windings, S_4 and S_5. The 280-type rectifier tube is supplied with filament current from S_4 and plate voltage from S_5. The filter system consists of L_1, L_2 and C_{10}, C_{11}, and C_{12}, and the voltage-dividing resistor R_6 with the necessary by-pass condensers C_{13} and C_{14} connected across the output terminals of the filter. Transformer T_2 supplies filament energy for the various tubes in the set. The receiver is designed for operation on a 110- to 120-volt 60-cycles a.c. supply.



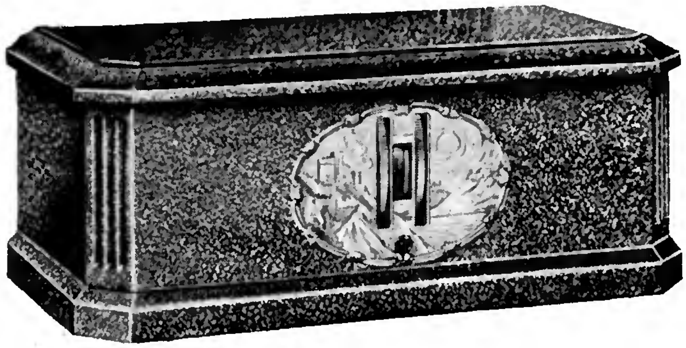
THE RECEIVER CIRCUIT

No. 12. November, 1928.

RADIO BROADCAST'S Service Data Sheets on Manufactured Receivers

Freed-Eisemann NR-80 Receivers

THE NR-80 is one of the latest receivers developed by the Freed-Eisemann Company. The set is mounted in a reinforced steel cabinet and is designed for use on 110- to 120-volt, 60-cycle alternating-current supply.



THE NR-80 RECEIVER

TECHNICAL DISCUSSION

1. *The Tuning System.*

There are four tuning condensers, C_1, C_2, C_3 and C_4. In the antenna circuit is employed a special choke which is designed to give somewhat greater gain at the low-frequency end of the broadcast band, thereby off-setting, to some extent, the opposite characteristic of a tuned r.f. amplifier. The antenna circuit does not require any tuning condenser. To compensate for the slight variations in the tuning coils of the individual stages small "vanes" are used. These may be moved nearer to, or away from, the main inductance of the tuning coils, and are adjusted at the factory to the correct position. Each r. f. transformer is shielded as indicated by the dotted lines. The various tubes are neutralized by connecting neutralizing condensers, marked N.C. in the diagram, from the grid of the tube to the secondary of the following r.f. transformer.

2. *Detector and Audio Systems.*

The grid leak and condenser type detector used in this receiver utilizes a 0.00025-mfd. grid condenser and a 2-megohm grid leak. The detector tube is a type 227. The plate circuit feeds into a two-stage transformer-coupled amplifier using 3:1-ratio transformers. The 171A-type power tube feeds into an output transformer with a turns-ratio of 1:1; the purpose of this transformer is to keep the d.c. plate current of the power tube out of the loud-speaker circuit. The plate circuit of the detector tube contains a condenser C_5, with a value of 0.001 mfd. to bypass the r.f. currents to the ground.

3. *Volume Control.*

The volume control of the receiver is located in the r.f. amplifier. It consists of a variable resistor, R_1, with a value of 2000 ohms. It is connected directly across the primary of the last r.f. transformer. As the arm of the unit is rotated in the direction which reduces its resistance, it gradually shunts the primary winding and decreases the amount of signal voltage which is fed into the detector tube.

4. *Filament Circuits.*

Four filament windings which supply current to the tubes in the receiver are placed on the power transformer. A 1.5-volt winding (S_3) supplies all the 226-type r.f. tubes, a 2.5-volt winding (S_4) supplies the 227-type detector tube, another 1.5-volt winding (S_5) supplies the first audio tube, and a 5-volt winding (S_6) supplies the power tube. Two 1.5-volt windings, one for the r.f. tubes and one for the first audio tube, are used so that a better hum balance may be obtained. These windings are shunted by potentiometers R_2 and R_3, each of twenty ohms, which are adjusted at the factory to the point of minimum hum in the loud speaker.

5. *Plate Circuits.*

Three different values of plate voltage are supplied to the receiver by the power unit. The same value of voltage is supplied to the plates of the r.f. tubes and also to the plate of the first a.f. tube; this potential is approximately 100 volts. The detector receives about 45 volts, and 157 volts is delivered to the plate of the power tube. Individual 0.5-mfd. bypass condensers C_6, C_7 and C_8 bypass the plate circuits of the various r.f. tubes so that there will be no r.f. current flowing through the power unit where they might cause coupling which would make the r.f. amplifier oscillate. These condensers also serve to bypass the audio-frequency currents in the plate circuit of the first a.f. stage.

6. *Grid Circuits.*

The grid circuits of the r.f. tubes obtain a bias from the power unit and somewhat greater bias is supplied from the power unit to the first audio tube. To obtain bias on the power tube a separate resistor is used, R_2 in the diagram, with a value of 1650 ohms. These various resistors which supply bias are bypassed by various condensers in the condenser block. If these resistors were not bypassed, an audio-frequency voltage would be impressed back on the grid circuits of the various tubes and either an increase or decrease of amplification at certain frequencies would result.

7. *The Power Supply.*

The power supply is a conventional one using a 280-type tube as the rectifier in a full-wave circuit. The filament of the rectifier is supplied with current by a secondary winding (S_1) on the power transformer T. Plate voltage for the rectifier is supplied by secondary S_2. The output of the rectifier feeds into a filter system consisting of C_9, C_{10} and C_{11} located in the condenser block and L_1 and L_2, which are filter choke coils.

The output of this filter system in turn feeds into the potential divider, R_3 consisting of a number of fixed resistors connected in series and having the values indicated on the diagram. At the junctions between these resistors wires are connected for obtaining the various voltages required for the correct operation of the different tubes in the receiver. Power to the receiver is controlled entirely by the switch connected in series with the primary winding of the power transformer.

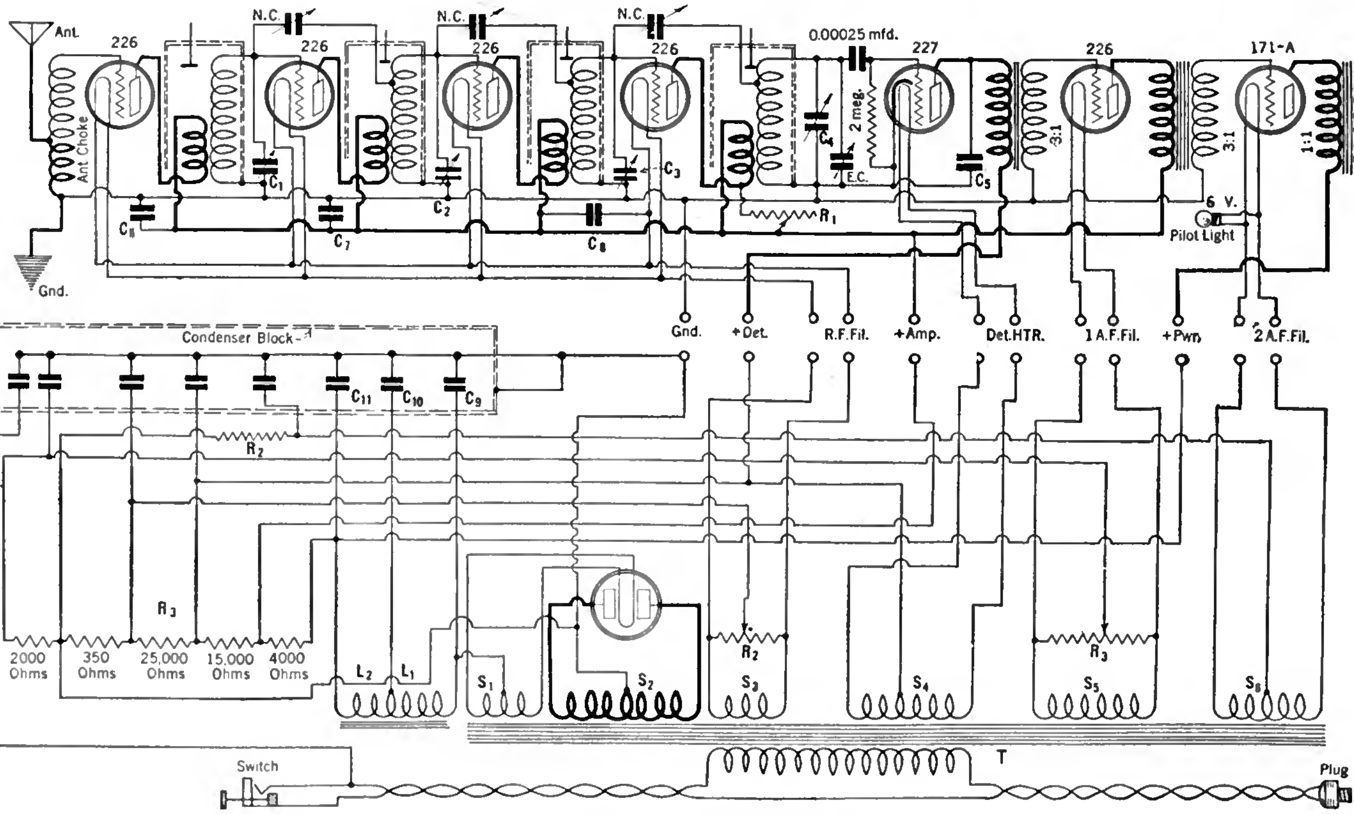
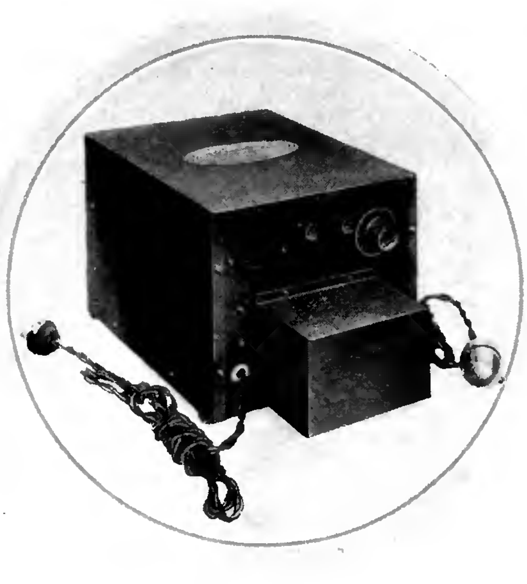


DIAGRAM OF RECEIVER AND POWER SUPPLY

The Improved Knapp A-Power Unit

OBTAINING a satisfactory source of power for heating the filaments of tubes in a radio receiver has been one of the chief problems confronting engineers since the early days of broadcasting. Of course, from the electrical viewpoint the storage battery is ideal for the purpose, but broadcast listeners and radio experimenters demand a device which is capable of providing equally satisfactory results and which does not require constant attention. When a receiver is operated with a storage battery it is necessary to recharge the battery and add distilled water at quite frequent intervals.

Filament-supply units consisting of a power transformer, rectifier and filter system have proved to be one of the best solutions to the A-power problem, and this article describes one of the most recently developed devices of this type. It is known as the Knapp A power, and was developed in the engineering laboratories of Knapp Electric, Inc., of Port Chester, N. Y. The unit is available as a kit, i.e., in knocked-down form, and the information contained in this article relative to the electrical characteristics, assembly and operation of the device was supplied by the manufacturer.



THE POWER UNIT WITH METAL CASE IN PLACE

The Knapp A Power converts current supplied by a standard 110-volt a.c. line into a filtered 6-volt d.c. supply, which is satisfactory for the operation of standard radio tubes. The rectifier and filter condensers of the unit are of the dry-electrolytic type, thus avoiding entirely the usual maintenance operation of adding distilled water to the cells. Also, because of the enormous capacities which it is possible to obtain with dry-electrolytic condensers, the a.c. hum is eliminated almost entirely in the filter circuit and cannot be detected with the usual receiver.

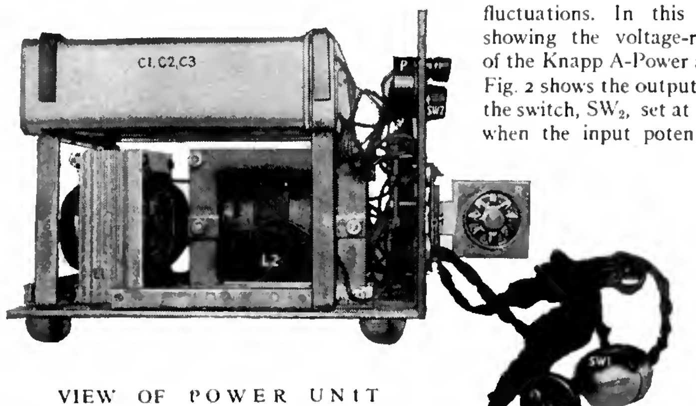
From a practical viewpoint this A-power unit has other advantages. When operated from a 110-volt a.c. supply it may be employed to supply filament current to any standard home-made or factory-constructed receiver using up to 8 tubes of the 201A type, or a combination of tubes which requires a filament current of not greater than 2 amperes. The unit may be connected directly with the A binding posts of the receiver without making any changes in wiring, and it is connected with the house current by inserting a plug in a wall receptacle. The efficiency of the device is comparatively high; that is, it should not increase the electric bill more than 25 or 50 cents per month.

SIMPLE ELECTRIFICATION SYSTEM

ANOTHER thing which should be pointed out in connection with this power unit is that it provides the nucleus for converting any d.c. receiver into a completely-electrified set. Many excellent devices are available which provide B and C potentials for the operation of all types of receivers, thus the use of batteries may be avoided entirely. Provision is also made in the unit for controlling the power to the B-supply unit with the switch employed for turning the A power on and off; for this purpose a standard 110-volt receptacle is included in the unit.

Power units of the type described in this article are not a new development; in fact, they have been in use generally for almost a year. In the March, 1928, issue of RADIO BROADCAST an article entitled, "A New A-Power Unit" by Ralph Barclay described an early model of the device now under consideration. This power unit has provided many readers with excellent results, but the new model is improved considerably and is capable of giving better performance, especially with modern receivers which employ amplifiers with better bass-note reproduction characteristics. Also, in the July, 1928, issue of RADIO BROADCAST the early model of this power unit was the basis of the power unit described in an article entitled, "An Interesting A-B-C-Power Unit and One-Stage Amplifier" by J. George Uzmann. This article served to illustrate how any home-made or factory-constructed set could be electrified easily and inexpensively.

A glance at the pictures and diagram on these pages shows how the new Knapp A power differs from last year's model. In the first place, it is completely enclosed within a metal case, more pleasing in appearance and of more sturdy design. The electrical circuit has been improved but is fundamentally the same as before. It was found that the general use of high-quality amplifier systems in 1929 receivers demanded that the background of a.c. hum be reduced still further than it was in last year's model, and this improvement was effected by a change in the choke construction and through the use of an extra high-capacity, dry-electrolytic condenser. Another improvement is found in the rotary switch which replaces the old-style, plug-type voltage adjustment. The result of these changes is that the unit is not only more efficient electrically but it requires less space in the cabinet.



VIEW OF POWER UNIT
WITH METAL CASE REMOVED

POWER UNIT VS. A. C. TUBES

BEFORE continuing further with this article it might be wise to clear up one point which probably has entered the minds of many readers; namely, why should a power unit be employed for supplying filament current for d.c. tubes when it is possible to electrify a receiver with a power transformer, wiring harness, and set of a.c. tubes? Of course, both systems possess merit, but it is safe to say that the A-power unit provides the simpler and more "sure-fire" method of the two, as in order to employ a.c. tubes it usually is necessary to make a number of changes in the circuit as well as several adjustments to reduce the hum. Also, the arrangement of apparatus in a set may be such that the constructor will not be able to eliminate the hum without considerable difficulty.

When comparing the cost of equipping and operating receivers with these two systems of electrification several points must be taken into consideration. With the power-unit method the cost of electrifying the set is limited to the cost of the power unit, but when a.c. tubes are installed it is necessary to buy a power transformer, wiring harness, volume control, voltage regulator, complete set of tubes, etc. With both systems the current consumed from the 110-volt line is about the same, but the cost of replacing tubes is two or three times as great when a.c. tubes are used. In both cost and simplicity it would seem, therefore, that the method of obtaining light-socket operation by the use of a B-power unit in conjunction with an A-power unit, is to be preferred to rewiring the receiver for the use of a.c. tubes. A set will operate from an A-power unit just as satisfactorily as from a storage battery—and the power unit requires no attention.

In selecting an A-power unit the amount of current and voltage which it will deliver at the output binding posts is another important factor; that is, it is necessary to make sure that an ample supply is available for heating the tubes of the receiver, notwithstanding normal line voltage fluctuations. In this connection two graphs showing the voltage-regulation characteristics of the Knapp A-Power are given in Figs. 2 and 3. Fig. 2 shows the output voltages obtainable with the switch, SW_2, set at each of the eight contacts when the input potential is 116 volts. Fig. 3 indicates the output of the power unit with the switch, SW_2, on the fifth contact when input potentials of 95, 100, 105 and 110 volts are applied.

The graphs described above show that the power unit is capable of supplying about two amperes of rectified current at a potential of six volts, or in other words it will deliver ample power for heating the filaments of eight tubes of the 201A, 112A or 171A types. Secondly, it is shown that by means of the rotary switch, SW2, the voltage may be adjusted to the proper value for receiver whether the line voltage is above or below normal.

CONSTRUCTION OF UNIT

THIS article has now reached the point where the construction of the A power unit may be considered. The reader interested in building the power unit will find a complete list of the apparatus used in this new model at the end of this article. Also, there are two pictures which show the appearance of the unit, and a complete schematic wiring diagram is given in Fig. 1.

The picture of the completed power unit shows clearly the outward appearance of the device. All of the apparatus is housed within the metal case and the voltage-control switch is regulated by the knob on the right of the panel. The output binding posts are located in the center of the panel near the top, and at the left of the panel is a receptacle for plugging-in the B socket-power unit. The metal box mounted on the front panel conceals the rectifier unit, the cord on the left is for connection with the light socket and the cord on the right is equipped with a switch for turning the unit on and off.

Fig. 1 shows the complete wiring of the unit. T is a power transformer having a secondary with eight taps for voltage control, and R is a full-wave dry-electrolytic rectifier. The two heavy-duty choke coils, which are of identical construction, are located at L_1 and L_2, and the three dry-electrolytic condenser units, also of similar design, are connected at C_1, C_2 and C_3. P is the receptacle for the power lead from B-power unit, SW_1 is the off and on switch, and SW_2 is the voltage control.

The actual construction of the power unit is very simple. The assembly divides itself into three major steps; viz, mounting parts on base plate, mounting parts on front panel and assembly of mounting contacts for the rectifier unit. After the parts have been mounted the wiring may be accomplished quickly and easily.

The base plate for the power unit is die cast and has been drilled with all holes necessary for mounting the chokes, transformer, condenser brackets, front panel and steel box body. First, the two choke coils, L_1 and L_2, are mounted in place in the positions indicated in the picture. Next, the transformer is fastened on the right side of the base opposite the choke L_2 so that the taps are on the front edge. However, before mounting the transformer the primary leads should be arranged so that they pass through the top and they should be scraped free from insulation. To complete the assembly of parts on the base the condensers are fastened in place with their brackets, as indicated in the picture.

The front panel of the power unit is supplied with all necessary holes drilled and tapped, and the mounting of parts requires only a few moments' time. The receptacle for the B socket-power unit is first mounted in the large hole provided for it in the upper left corner, the eight-contact switch is mounted in a similar position on the right side of the panel, and the output binding posts are located in the two holes in the center of the panel near the upper edge.

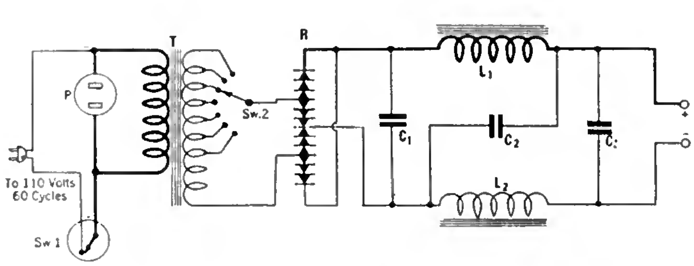


FIG. 1. SCHEMATIC DIAGRAM OF THE POWER UNIT

The assembly of the rectifier mounting contacts is very simple. Five holes are drilled in the front panel for the contacts which are fastened in place with nuts and washers.

The wiring of the unit is shown clearly in the diagram and an explanation of the connections is hardly necessary. In wiring the complete unit only eight feet of rubber-covered hook-up wire is needed and, of course, the connections should be soldered if best results are desired.

OPERATION

AFTER the construction of the Knapp A Power has been completed the wiring should be checked carefully, and then the unit may be placed in operation. However, before the unit is connected to a radio receiver it should be operated for at least an hour without load. This precaution is necessary to insure the elimination of all moisture which may have collected in the condensers.

Through experience it has been found that best results are obtained from the power unit when it is used every day. On the other hand, if the receiver is not used for a week or two the power unit should be disconnected from the set and operated for an hour without load. Also, the operation of the power unit may be improved materially by operating it without the receiver connected two or three hours each month.

After long service it will be found that the output voltage of the power unit will begin to decrease and it will be necessary to correct the control, Sw_2, to a tap giving greater voltage. The rectifier unit will finally require replacement. It is a very simple task to put in a new rectifier and these units are available at all radio stores.

In operating the power unit there is only one knob, Sw_2, which may be adjusted and this controls the output voltage of the unit. In adjusting this control the proper setting may be determined by placing the switch at the lowest tap which provides satisfactory performance, but a much more satisfactory arrangement would be to connect a 0-10 volt d.c. voltmeter across the output binding posts of the power unit. The meter is particularly valuable in districts where there are frequent variations in the line voltage.

LIST OF PARTS

THE following is a complete list of the apparatus included in the Knapp A Power Kit:

T—One Power Transformer
L_1, L_2—2 Heavy-duty a.f. choke coils
C_1, C_2, C_3—3 Dry-electrolytic condensers
R—One Elkon dry-electrolytic rectifier unit
SW_1—One Pendant switch and cord
SW_2—One Special 8-point switch, knob and plate
P—1 Receptacle for B unit
1 Attachment cord and plug
1 Celeron front panel
1 Base plate
1 Set of condenser brackets and clamp angles
1 Metal box and cover
1 Rectifier cover
1 Celeron connector strip
1 Rubber bushing
2 Output binding posts
1 Roll of hook-up wire
Mounting screws, nuts, bushings, etc.

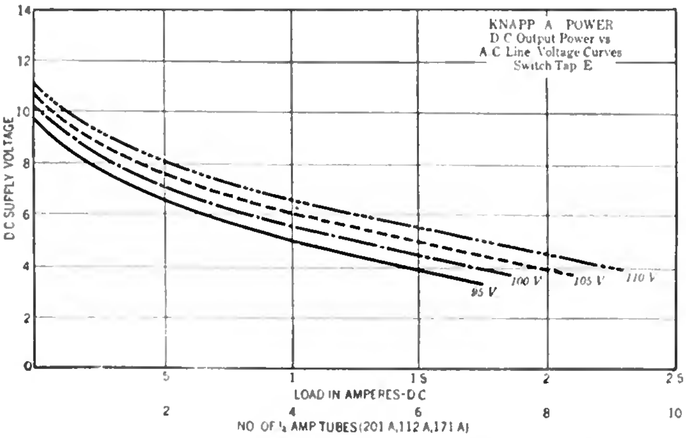


FIG. 2.

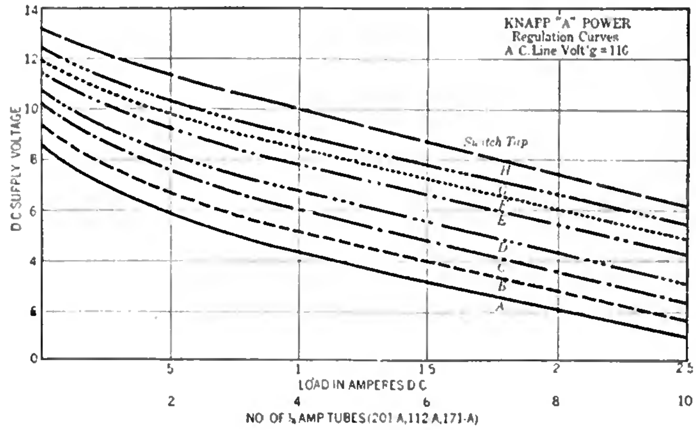


FIG. 3.

THESE GRAPHS SHOW THE OPERATING CHARACTERISTICS OF THE KNAPP A-POWER UNDER VARIOUS CONDITIONS

An Amplifier and Power Supply for the "Vivetone 29"

By R. F. GOODWIN

THE amplifier and power-supply unit described in this article was designed especially for use in connection with the "Vivetone 29" receiver which was presented in the October issue of Radio Broadcast. *However, equally successful results may be obtained when the unit is connected with other standard a.c. receivers. The amplifier of the unit employs two transformer-coupled stages with a 310-type tube in the output circuit. The power-supply circuit provides normal values of B potential for the receiver and amplifier, as well as the necessary a.c. potentials for heating the filaments of the tubes.*—The Editor.

IN THE October number of this magazine the writer introduced the "Vivetone 29" receiver. Readers of the article will recall that in the design of the tuner quality and efficiency were the main objectives. These same qualities are outstanding in the power supply and amplifier unit which has been designed to work in conjunction with the tuner, and which is described in this article.

Power amplification is, of course, an admitted necessity in the modern receiver. Radio entertainment is no longer a novelty or plaything, and radio builders and owners now demand the quality of reproduction that comes only with power amplification and the use of an up-to-date loud speaker, such as the dynamic cone. This quality is assured in the Vivetone amplifier by the use of a 310 tube in the output and a scientifically designed coupling device. It has enough reserve power to eliminate the danger of overload distortion, and it will be found that full volume is seldom necessary for satisfactory reproduction in the home.

The power supply incorporated in the unit furnishes all the operating voltages for the amplifier and the tuner, and serves to make the ensemble completely light-socket operated. One of the most important features of the power supply is the incorporation in it of an adequate means of voltage control. This feature appears to have been neglected in most of the designs of our present all-electric receivers.

Practical control of voltage is accomplished in the Vivetone power unit with two low-resistance power rheostats, one being a 50-ohm voltage-control rheostat, PR-050, which is connected in series with the primaries of both the power transformers, while the other is a 0.2-ohm rheostat, PR-210, which is connected in series with the $1\frac{1}{2}$-volt secondary winding of the low-voltage transformer, T-2445. Fig. 1 shows the location and wiring of these parts.

Many may wonder why a rheostat was not also connected in series with the $2\frac{1}{2}$-volt winding. The reason is, first, that the $2\frac{1}{2}$-volt windings of these transformers generally have the correct voltage, whereas the $1\frac{1}{2}$-volt winding will be found to deliver slightly more than its rating; and second, the voltage-control rheostat will take care of any change in line voltage that would increase or decrease the voltage of the $2\frac{1}{2}$-volt secondary or any of the other voltages after they have been once adjusted. Therefore, only one secondary rheostat is required, which is in the $1\frac{1}{2}$-volt circuit.

This method of voltage control is not automatic; it need not be, because line voltage variations seldom occur more than once or twice in 24 hours, with the exception of dark stormy days when the power station is heavily taxed. Under such conditions the voltage control, PR-050, is decreased until the meter on the receiver panel reads one or two tenths be'ow the proper specified reading.

Although it was designed especially for the "Vivetone 29" receiver, the amplifier power unit can be used with other a.c. tuners as an audio channel and power supply. It will operate excellently as a phonograph amplifier by connecting a good electrical pick-up unit across P and B plus of the first-stage transformer.

CONSTRUCTION

THE entire amplifier and power unit is constructed on a baseboard measuring 8″ in width and 10″ in length, being $\frac{1}{2}$″ thick. The audio portion, as shown in Fig. 2 and 3, is mounted at the left-hand end of the baseboard and the supply portion on the right. A Micarta 8″ by 20″ panel is used to mount the necessary resistances, binding posts, a.c. outlet and speaker jack.

The audio portion incorporates two stages of transformer-coupled audio amplification utilizing the new Thordarson R-300 transformers. For the output a choke and condenser device is used to prevent the high voltage from damaging the speaker windings. For the first audio stage a type CX-327 tube is used, and in the last stage a CX-310 power tube is required.

The power supply portion utilizes a half-wave rectifier system using a CX-381 tube. The voltage required to operate this tube is procured from a Thordarson R-210 power pack. It supplies the high voltage for the plate of the rectifier and has two filament windings, one for the rectifier tube and one for the 310 power tube. There are also the two necessary filter chokes incorporated in the unit.

The low-voltage transformer, T-2445, which supplies the voltage for the 326 and 327 tubes and the pilot lamp, is also rather compact in design. It will be noticed that this unit is mounted alongside of the power pack, R-210. Next to it is the filter condenser block, PL-575, a 12-mfd. unit properly divided with terminals placed so as to simplify wiring.

Since the entire layout of the parts is so clearly shown in the top view and the picture wiring diagram, Figs. 2 and 3, it will be unnecessary to give further details concerning their positions.

OPERATION

A STUDY of Fig. 1 and the figures in the article in the October number of Radio Broadcast (page 367–368) illustrating the construction of the Vivetone 29 receiver, will show the constructor exactly how to connect the two units for operation. The only operating adjustment that is necessary on the power unit is the adjustment of the voltage-regulating rheostats, which is a very simple matter.

To obtain smooth voltage regulation from the power unit is a simple matter. With all the specified tubes in their respective sockets, all the leads of the receiver correctly connected to their proper posts on the power unit, and an a.c. voltmeter temporarily connected across the heater terminals of the detector tube socket (type 27 tube) the house power is turned on, the secondary rheostat, PR-210, turned entirely to the left (full resistance), and the voltage control rheostat, PR-050, turned entirely to the right. Allow the detector tube about one minute to heat up and then adjust the setting of the voltage control rheostat, PR-050, until

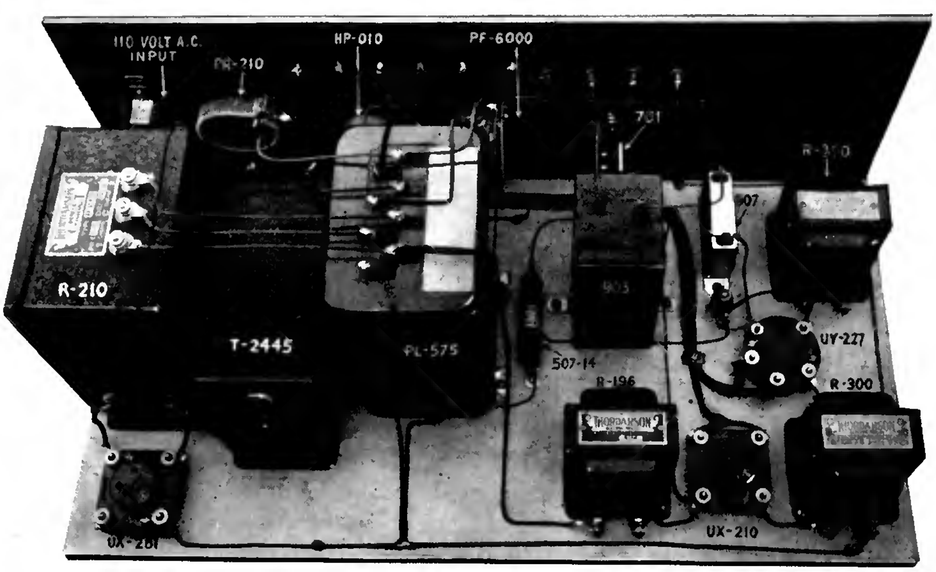


FIG. 2
Rear view showing layout of parts on baseboard

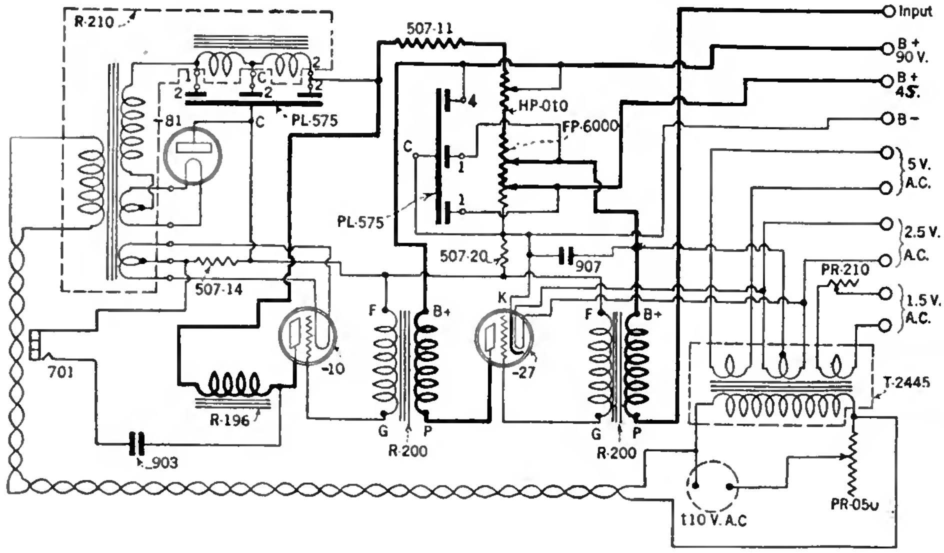


FIG. 1

Schematic diagram of Vivetone Power Unit

the meter registers approximately $2\frac{4}{10}$ volts (but not over $2\frac{1}{2}$ volts).

The meter is then disconnected from the detector socket and temporarily connected to the filament terminals of one of the r.f. sockets. Then the position of the secondary rheostat, PR-210, is corrected until a reading of approximately $1\frac{1}{2}$ volts is obtained. With this done the meter is connected permanently to the heater terminals of the detector socket. The setting of the secondary rheostat is then permanent and is not to be disturbed.

To complete the regulation process, the proper B voltages are to be determined. To accomplish this a high-resistance voltmeter would greatly simplify matters but for the benefit of those who have no meters the position of the arm of HP-010 on the power unit should be approximately halfway between both end terminals, whereas the arm of HP-6000 should be approximately three quarters of the way to the right (farthest from the negative end). The fourth terminal of PP-6000 should be approximately $\frac{1}{4}$ of an inch from the negative end terminal. This completes the regulation of voltages.

Now if a line variation occurs it will be indicated by the a.c. voltmeter, and only the voltage control rheostat, PR-050, need be manipulated to compensate for the line variation. In other words, by increasing or decreasing the resistance of this control all the voltages, a.c. and d.c., will increase or decrease respectively. By keeping the a.c. meter at approximately $2\frac{4}{10}$ volts all these voltages will be permanently correct.

In tuning the receiver there is really nothing difficult. After the current has been turned on, the tubes should be given at least a minute to heat up; then signals should come in with great volume and without hum. Should there be any noticeable hum it can be eliminated by correcting the arm position of the potentiometer, PP-015, on the receiver chassis. It should be remembered that the arm of the resistor, PP-2000, on the set chassis should be approximately one third of the way from front end terminal when the condenser plates are completely meshed.

Should the reader desire complete constructional blueprints or detail information concerning the function of the receiver they may be obtained by addressing the writer in care of this magazine. The blueprints are priced at $1.00 and are sold at their actual cost, including postage. They consist of complete full-size wired layout drawings, schematics, panel layouts, etc. of both Vivetone receiver and power unit number one. Blueprints describing another power unit have also been prepared. This unit consists of a push-pull 310 power amplifier utilizing a 327 in the first stage, as in power unit number one, and a full-wave rectifying system using two 381 rectifier tubes. This unit is suggested for those who require tremendous volume and wish to use more than one speaker.

LIST OF PARTS

[The list below gives the parts used in the unit described by the writer. Since all the parts are of standard design, the substitution of mechanically and electrically equivalent parts can be made by the experienced set builder.—THE EDITOR.]

Cost of Parts—Not over $95.00

- 1 Thordarson filament-supply transformer type T-2245
- 1 Thordarson power pack, type R-210
- 1 Thordarson choke coil, type R-196
- 2 Thordarson audio transformers, type R-300
- 1 Dubilier condenser block, type PL-575
- 1 Dubilier condenser, 1.0 mfd., No. 907
- 1 Dubilier condenser, 2.0 mfd., No. 903
- 1 Centralab heavy-duty potentiometer 10,000 ohms, type HP-010
- 1 Centralab fourth-terminal potentiometer, 6000 ohms, type PF-6000
- 1 Centralab power rheostat, 50 ohms, type PR-050
- 1 Centralab power rheostat, 0.2 ohm, type PR-210
- 1 Ward Leonard resistor, 10,000 ohms, No. 507-11
- 1 Ward Leonard resistor, 1000 ohms, No. 507-14
- 1 Ward Leonard resistor, 225 ohms, No. 507-20
- 1 Benjamin five-prong, green top socket, No. 9036
- 1 Benjamin four-prong, black top socket, No. 9040
- 1 Benjamin four-prong, red top socket, No. 9040
- 1 Yaxley junior jack, No. 701
- 1 roll flexible "Braidite" wire
- 1 roll Solid "Braidite" wire
- 10 Eby Binding posts
- 1 Westinghouse Micarta panel, $1\frac{1}{2}$" x 11"
- 1 Westinghouse Micarta panel, 1" x 2"
- 1 Westinghouse Micarta panel, 20" x 8"
- Nuts, screws, etc.

For operating the unit in conjunction with an r. f. tuner, the following accessories are required:

- 1 Cunningham cx-381 rectifier tube
- 1 Cunningham cx-310 power tube
- 1 Cunningham cx-327 tube

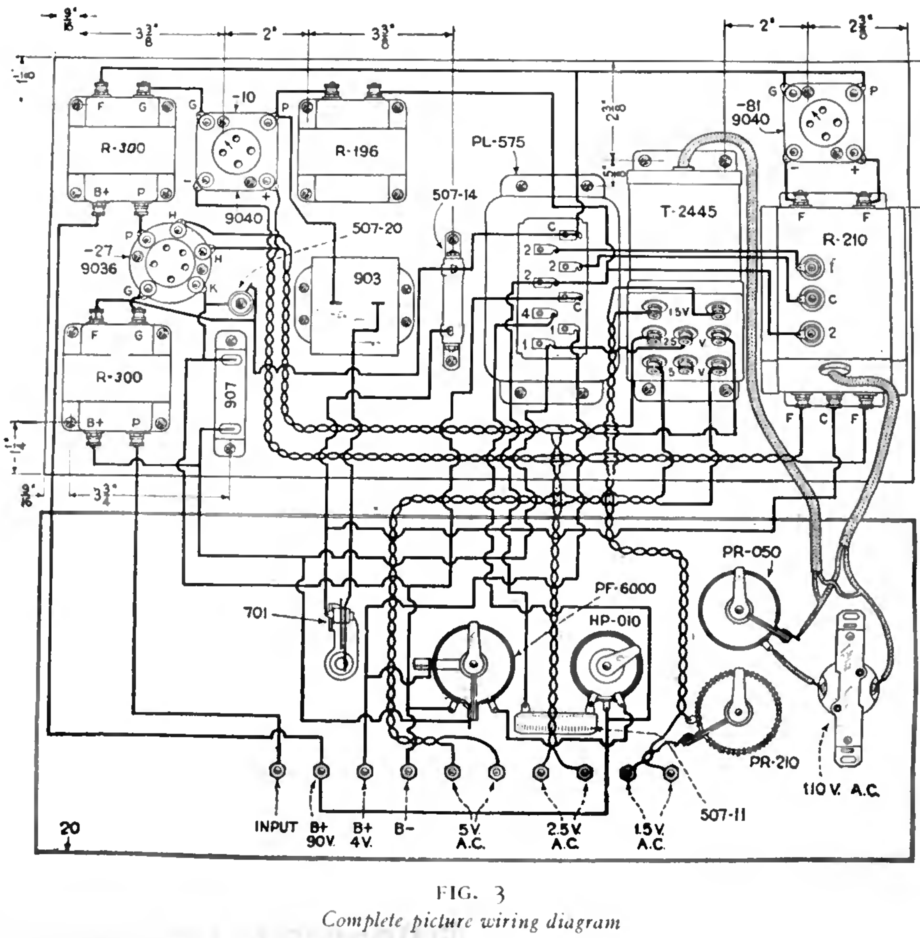


FIG. 3

Complete picture wiring diagram

"Our Readers Suggest—"

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

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

—THE EDITOR.

Short-Wave Plug-in Coils

THE idea of using "dud" tube bases as a mounting for short-wave coils is certainly a good one, but some fans seem to have difficulty in making a really rigid job. The method illustrated in Fig. 1 has been in use in the writer's set for some time, and although the coils are subject to a lot of rough usage, they are just as strong and rigid as when first made.

The solution to the difficulties associated with these coils is found in winding the coils themselves on separate forms rather than on the tube base. This also provides greater latitude in winding specifications.

The coils are wound on a piece of thin bakelite tubing somewhat larger in diameter than a tube base. Holes $\frac{5}{32}$ inch in diameter are drilled 120° apart around the bottom edge of the tubing to admit a $\frac{6}{32}$ machine screw. Holes are also drilled and tapped 120° apart about $\frac{1}{4}$ inch from top edge of the tube base. The tubing is supported from the base by small collars made of brass tubing, and cut just long enough to fill the space. The whole is held together with $\frac{6}{32}$ round-head machine screws, as illustrated in Fig. 1.

After the coils are wound, they are given a coat of cement made of celluloid dissolved in amyl acetate which insures the wire remaining tight. The number of turns to use is not specified, as this information has appeared several times in RADIO BROADCAST and of course varies with the tuning condenser and also with the diameter of the coil. The reader is referred particularly to the description of the Cornet receiver of Lieutenant Wenstrom, which appeared in September RADIO BROADCAST.

Some readers may find difficulty in removing the vacuum tubes from their bases. The easiest method seems to be to pour a little wood alcohol through a small hole drilled in the base. After standing awhile the cement will be softened enough to pull the tube and base apart, when the solder is melted from the prongs.

C. S. TAYLOR, Ft. William, Canada.

Receiving Without an Aerial

THE writer has discovered that his particular Atwater-Kent receiver functions quite satisfactorily when operated without an aerial, the ground wire being connected to the antenna post, and the ground post left unconnected. Operation is more selective and good volume is had on fairly distant stations. Occasionally a variable condenser, in series with the ground lead, is effective.

GEORGE N. COOK, Allenwood, Pa.

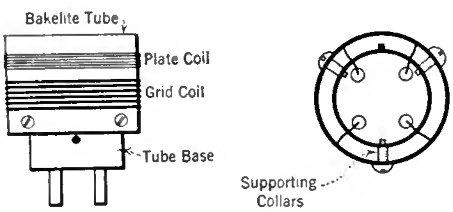


FIG. 1. COIL KINK

Tube-base plug-in coils of very rugged construction may be made by mounting a bakelite tube on an old tube base.

Polarity Indicators

IT IS often necessary to find the polarity of a line or pair of wires from a battery. In the absence of a meter the following methods may be used to determine the polarity of a source of direct current.

A small section of blueprint paper, such as is used in reproducing mechanical drawings, should be moistened and the two leads brought into contact with the surface. For voltages up to one hundred, the leads should be separated about one-half inch; for higher potentials this distance should be increased correspondingly. When the two leads are removed there will be a small bleached section where the negative lead touched the paper.

Another simple test for polarity can be made with a potato. The potato is cut in half. Stick the two wires to be tested into the freshly cut surface, about one inch apart. In a short time you will find that the potato has turned green around the negative wire.

J. B. BAYLEY, Jersey City, N. J.

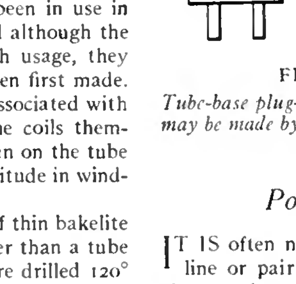


FIG. 2

When a.c. tubes are used this simple circuit will often effect a marked reduction in hum.

STAFF COMMENT

The blueprint paper should be partially exposed before being used for the test. The potato idea is an old one but worth reprinting for the benefit of the new fan. The salt-water test is also simple and definite. Place two leads from the doubtful d.c. source into a glass of salt water. Bubbles will rise to the surface about both leads, but more bubbles will surround the positive wire.

Reducing Hum in the Detector

WHEN a combination of A and B socket-power units is used with d.c. tubes, a slight amount of a.c. hum generally is present in the loud speaker output. This hum can be reduced materially, if not eliminated, by connecting a 30-ohm potentiometer across the filament terminals of the detector tube. The grid return is then connected to the slider contact of the potentiometer, instead of to one side of the filament. When the potentiometer is adjusted to its mid-position, or approximately so, practically all trace of a.c. hum should disappear. A 1.5-volt flashlight cell, connected as in the diagram, Fig. 2, will provide the positive or negative grid bias required for the operation of 201A- or 200A-type tubes respectively.

CHARLES D. SAVAGE, Portland, Ore.

Reducing Hum in A.C. Sets

A GREAT deal of the hum in an a.c. home-constructed set comes from parallel leads and leads placed too close to the power transformer. A simple way to overcome this difficulty is to use the conventional automobile "BX" cable for all filament wiring and then ground the metal casing on these leads as well as the transformer shell. This trick has cured more than one baulky set.

J. B. BAYLEY, Jersey City, N. J.

STAFF COMMENT

The remedy suggested by Mr. Bayley will be effective in many cases. Shielding of the type he suggests should always be used, as a precaution, in wiring a.c. amplifiers for television reception. Small size BX cable can be obtained at any automobile-supply store or large garage.

Improving Capacity Feed-Back Regenerative Circuits

I HAVE just built the adapter described in your July issue and, while I think it provides the last word in satisfactory performance, I observe the presence of the familiar trouble of jumping suddenly into oscillation. The setting of the plate condenser is too critical for voice. It follows the tuning condenser too closely, to say nothing of the fact that the dial setting of the tuning condenser is affected by changes in the coupling condenser. This is an objection I have noted in all receivers employing this system of oscillation control.

However, as soon as a universal-range Clarostat was connected across the tickler, these objections disappeared. The variable resistor be

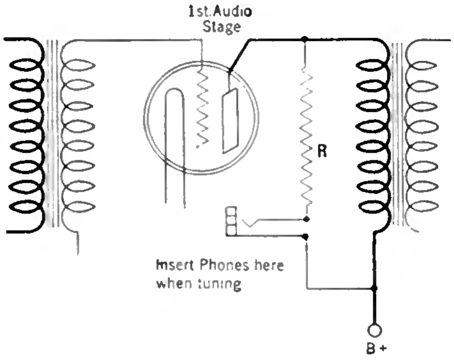


FIG. 3. SIMPLE OUTPUT CIRCUIT

With this arrangement it is possible to change from phones to loud speaker without disturbing the tuning adjustments.

comes the main control and should be mounted on the panel and the midget condenser, now an auxiliary, is relegated to the sub-panel. The over-all flexibility, ease of tuning, and reduction of body-capacity effects show a marked improvement.

E. W. MATTHEWS, Augusta, Ga.

STAFF COMMENT

The control of regeneration by means of a variable resistor connected across the feed-back coil is not new, but it seldom is employed in capacity-controlled circuits. However, as a matter of general principle, the use of a continuously variable resistor, so connected in any regenerative circuit, will provide the smoothest possible regeneration. The resistor, as suggested, is connected directly across the terminals of the tickler coil.

Tuning-in With a Distant Loud Speaker

REGENERATIVE detectors, followed by two audio stages, are found in many modern and ancient receivers. When the speaker is moved to some remote point, the operator is confronted with the problem of tuning the set by the phones. This is easy enough to accomplish in itself, simply by plugging into the detector jack, but it will be found, as a rule, that when the phones are removed, the constants of the plate circuit are so changed that the point of optimum regeneration is passed, and the set may even break into oscillation. If we plug into the loud-speaker jack, we get unbearably loud signals which may injure the phones, to say nothing of the ears!

There are many what might be called "orthodox" ways of overcoming this difficulty, probably the simplest of which is shown in Fig. 3. The value of the resistance R depends upon local conditions. Between 5000 and 10,000 ohms will fit most cases, but the best way, if you have a Clarostat or Royalty or other make of variable high resistance handy, is to connect it at R, set it to a comfortable volume of an average signal, measure the resistance and buy a cheap power-unit resistor near the value found, which is wired into place permanently.

W. BRUCE ROSS, Westmount, P. Q.

STAFF COMMENT

A perhaps more universal and equally simple arrangement for tuning with the telephone receiver, is to shunt a Centralab modulator plug (or any variable resistor having a range between one hundred and two thousand ohms) across the telephone receivers and plug the phones into the loud speaker jack. The volume can be adjusted, to a comfortable degree, by means of the resistor, and the set always is tuned to approximately the same volume.

Home-Made I.F. Transformers

IN THESE days of cheap retail radio prices, there are few pieces of apparatus that the fan will find it worth while to make. However, the intermediate r.f. transformers for a super-heterodyne are an exception. Efficient transformers may be made easily at a considerable saving by the super-heterodyne enthusiast. The following notes describe an intermediate transformer, designed for 201A or similar tubes, having a natural wavelength in the circuit of about 2000 meters—giving a wide separation between repeat tuning points on the oscillator dial.

Two discs of wood ¼ inch thick by 1¼ inches in diameter and a wooden core ¼ inch thick by ½ inch in diameter are required for each transformer. These pieces are assembled as in Fig. 4.

Small wire brads may be used to fasten the discs to the core. Before winding, two holes should be drilled in each disc, near the outside for connecting terminals.

The windings consist of 200 turns for the primary and 800 for the secondary of number 32 s.c.c. or enameled wire. The wire should be wound haphazard fashion. First wind the primary over which place a layer of thin paper and then wind on the secondary in the same direction as the

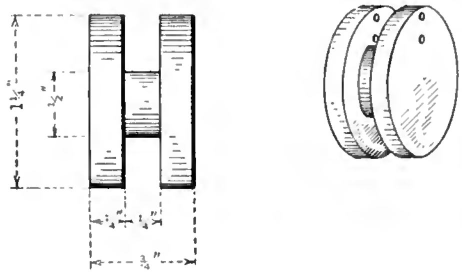


FIG. 4. DETAIL OF SPINDLE

The coils of an intermediate-frequency transformer may be wound on this simple spindle. Heavy cardboard may be used for the end pieces if desired.

primary. Boil the completed unit in paraffine (make sure that the paraffine is not hot enough to smoke) for about a half hour. Terminal posts may now be inserted in the four holes drilled in the discs and marked PRIMARY, Plate and B plus, and SECONDARY, Grid and Filament. The start of the primary is connected to the B plus and the finish to the plate. The start of the secondary goes to the filament and the finish to the grid.

No matching of the transformers is necessary as they were found to tune close enough.

No filter circuit is required as the combination of two or three of these transformers provides a band-pass of about the correct width.

R. W. TANNER, Springfield, Ohio.

Prolonging the Life of the 171A

THE Laboratory Information sheet number 204, appearing in July issue of RADIO BROADCAST contained information concerning the short life of the 171-type tube, used in a.c. sets.

As a radio service man with considerable experience in servicing electric sets, I can name two causes for the trouble, other than fluctuating line voltage

I believe that the greatest source of difficulty arises from using 171A-and 371A- type tubes in sets which were designed for the 171 or 371 types. As these newer tubes draw only one-quarter ampere filament current, naturally the filament-supply winding on the transformer, which has been designed for a one-half ampere load, will provide an increase in voltage, and soon ruin a quarter-ampere filament. This same effect has also been found in battery sets where the audio tubes are controlled by a fixed resistor.

The remedy is extremely simple. Shunt a 20-ohm resistor across the filament terminals of the tube sockets, thereby adding another quarter-ampere load to the circuit, and the tube will then have a normal life.

Another trouble which I have run across is due to a low value of grid voltage on the tube. This is sometimes caused by a variation in the resistor which provides the voltage drop for the negative bias. When this grid voltage is low, the tube draws an excessive plate current, which soon lowers its electron-emitting characteristic.

This can be prevented by adding sufficient resistance to the C-bias resistor, to bring the grid voltage up to the proper value to balance the plate voltage, which figure may be determined from the tube chart, supplied by the manufacturer of the tube. Probably an additional 100-ohm unit would be good as a trial resistance.

I cannot recall a single instance of power tube failure, where the tube itself has been at fault.

A. H. GOUD, S. Portland, Me.

STAFF COMMENT

If it is possible to locate conveniently the resistor through which the filament current to the power tube is fed (in the case of d.c. sets designed for the 171 tube), this can be replaced by a 4-ohm resistor, or any quarter-ampere ballast resistor, with the same result.

Special Soldering Irons for Difficult Jobs

SET-BUILDERS and repairmen are running continually into odd soldering jobs which require a great deal of valuable time and are very trying on the patience. A set of irons similar to those illustrated in Fig. 5 will make soldering less troublesome.

The general type, shown in diagram A, is followed by the manufacturers of both electrically and externally-heated irons.

Mounting the heads at right angles to the shafts as shown in drawings B and C greatly facilitates working in out-of-the-way places. Drawing D shows a third modification with the head at a forty-five-degree angle to the shaft making an arrangement that should do the trick when all others fail.

A copper bar, one-inch square, was used for all the irons mentioned and found to be quite satisfactory.

GEORGE W. LINN, New York City.

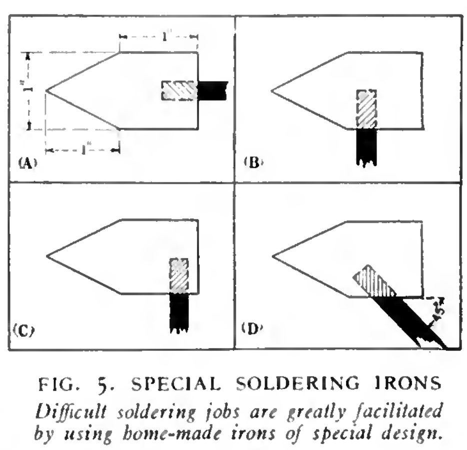
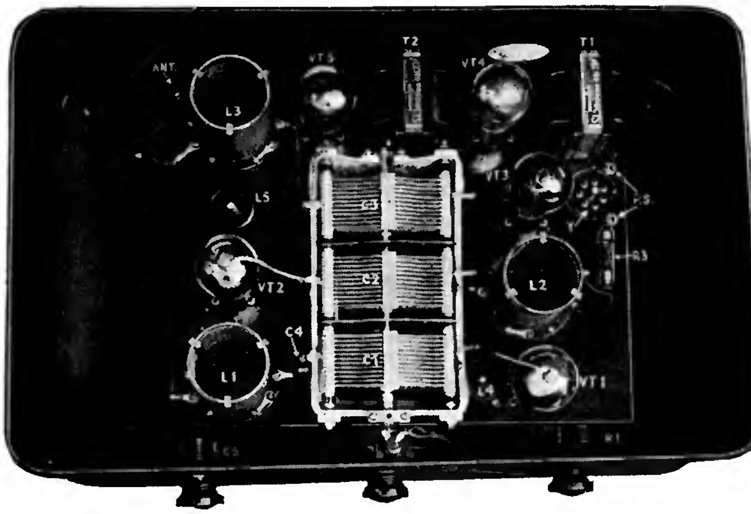


FIG. 5. SPECIAL SOLDERING IRONS

Difficult soldering jobs are greatly facilitated by using home-made irons of special design.



THIS PICTURE SHOWS THE ARRANGEMENT OF APPARATUS ON THE CHASSIS OF THE RECEIVER

The "Chronophase" Screen-Grid Receiver

By BERT E. SMITH

Aero Products, Inc.

WHEN the course of research, which was undertaken for the purpose of determining the best type of circuit arrangement, as well as coil construction for the screen-grid tube, left no doubt that the final method evolved gave the optimum results not only with this tube but also with standard a.c. and d.c. tubes, it was decided to proceed with the construction of a receiver utilizing this arrangement which, from its characteristics of adjusted phase relations, was called the "Chronophase."

Inasmuch as the "Chronophase" receiver was being planned to secure "DX" reception, through strong local interference, it was decided that a signal strength of one per cent., fifty kilocycles on each side of the resonant frequency, was the maximum allowable. With an experimental set-up entirely unshielded and with the coils separated by eight inches, it was found that such selectivity was secured by the use of two stages of radio frequency utilizing a 200-foot antenna approximately 50 feet high.

Next came the question of audio-frequency amplification. The most powerful audio equipment which can be built into a receiver, in most instances, will employ a 171-type tube which has an amplification factor of about three. With this tube in the last stage 650 milliwatts of undistorted output is obtained under proper load conditions when an alternating potential having a value of 28½ volts r.m.s. is impressed on the grid. A transformer recently has been made available of a type with a much flatter curve over the audible range than is ordinarily obtainable and continuing the flat portion of this curve out beyond the audible range so that there will be no loss of overtones and harmonics. These transformers give a voltage amplification of 3, so if we use a 201A-type tube in the first stage of the audio amplifier, we have an amplification factor between the detector output and the input to the grid of the last audio tube of 3 x 8 x 3 or 72. Since our tube required a maximum voltage of 28.5 r.m.s. to secure its greatest possible output, the corresponding detector output would have to be about 400 millivolts which is readily obtainable following two stages of r.f. amplification with a voltage amplification of about eleven per stage, which is provided by the "Chronophase" stages.

MECHANICAL DESIGN

HAVING both the audio-frequency and radio-frequency amplifiers determined, it was now only necessary to design the receiver in such a way that no serious losses would result in the layout and construction.

Always presuming that the coils and condensers of a radio-frequency amplifier are of the best quality obtainable, one of the most prolific sources of difficulty has been found to be in long leads, particularly in the grid circuits which are prone to pick up unwanted signals. The plate leads come next in sensitivity to external influences. In order to keep both of these as short as possible, the arrangement of parts indicated in the picture was employed. Stators of the condensers, which perforce must be in the grid circuit anyway, are used as grid leads, allowing the placing of each tube very close to the subsequent radio-frequency transformer, and permitting extremely short leads. A triple condenser with trimmers for compensating any slight differences in capacity is used to tune the amplifier. It was deemed advisable because of antenna variations to put the midget condenser, used as a vernier for the first stage, on the panel. A variation of this was required on both sides of the normal capacity of the condenser.

The illustration shows the complete layout finally adopted for the receiver. The Central Radio Laboratories manufacture a special step-less variable resistance for the stabilizing control which can be adjusted to hair-line accuracy. The Allen-Bradley grid leaks used are built from a solid block of non-hygroscopic carbon this unit is unaffected by weather changes, making it possible to solder the grid leak permanently into place without using the ordinary grid-leak clips which are a fertile source of trouble, due to oxidized and poor connections and consequent noisy operation.

The fixed condensers were also selected with great care, since they are in such a position in the "Chronophase" system that too great a phase-angle difference in the dielectric would seriously affect the operation of the circuit.

An inspection of the picture will show that there are practically no connections on the top of the subpanel other than those running from the stators of the variable condensers to the No. 6 terminals on the coils. The coils are mounted with three machine screws, and the 0.001-mfd. condensers between the plates of the tubes and the taps on coils are connected to the mounting screw between terminals 3 and 4 on the underside of the panel. A piece of flexible wire is attached to the top of this screw, the other end of which can then be connected to whichever terminal of the coil gives the desired results as will be explained later.

WIRING THE RECEIVER

AFTER making these connections, wire up the filament circuit, twisting the leads into a cable which more or less follows the outside lines of the sides and back of the panel. All filament, B-plus, and C-minus wires can be twisted into the cable wherever convenient, but the plate and grid leads should always be kept free, with the exception of the audio output lead which can be cabled with everything else.

When the wiring job is completed the set can be tested out before being put into the cabinet by placing an old dial on the condenser shaft and attaching the oscillation control and midget condenser with flexible leads. The circuits should be balanced, as will be explained in another paragraph, after it is mounted in the cabinet by attaching the mounting pillars to the screws in the subpanel in such position that they will be exactly over the bottom holes in the cabinet. Lower the set into the cabinet with the front end down and start the condenser shaft into the dial, and then dropping it back in until it fits into place. Now connect the flexible leads which were left for the midget condenser and resistance, tighten up the screws in the holes in the bottom of the cabinet and the set screw binding the dial to the shaft, and the set will be ready for operation.

The matter of balancing up the set is not at all difficult but will require quite a bit of time. In most cases, regardless of the type of tube used, the set will be found to operate to the best advantage with the antenna on tap No. 2, the first radio-frequency coil connected to tap No. 3, and the second radio-frequency coil at tap No. 1 or tap No. 2. For a comparatively short antenna, it may be desirable to put the tap on the antenna coil on No. 3 or No. 4, and for maximum selectivity with a long antenna, tap No. 1 should be used.

BALANCING PROCEDURE

A SUGGESTED method of procedure for balancing is as follows:

After connecting the taps as suggested, tune-in a station which will give a fairly weak signal when the set is not oscillating. Turn up the stabilizer until the set oscillates. Then, with the set in oscillation, adjust the trimmer units on the two rear sections of the multiple condenser until maximum volume is obtained, retuning to a weaker station if necessary, so that while adjusting, the volume is always kept at a comparatively low value. When perfectly balanced, the set should go into oscillation with the stabilizer about one third of the distance from minimum resistance, and should go in and out of oscillation at the same point; that is, it should be unnecessary after the set breaks into oscillation to retard the control beyond the point where it went into oscillation to clear it up again. If the set does not oscillate easily enough, raise the tap on the detector input coil. If it oscillates too easily, reduce this to tap No. 1. If insufficient selectivity is obtainable even with the antenna coil at tap No. 1, reduce the tapped portion of the middle coil. With everything properly adjusted, the removal of the cap from either of the screen grid tubes should practically stop the set from operating, although if it is tuned to a strong local station, the removal of the cap from the second tube may leave a trace of signal. Touching the first section of the tuning condenser should completely stop operation. Touching the second section should almost stop operation and touching the third stage, should reduce the volume considerably.

If the set is lacking in volume, or if a continuous high-pitched whistle or growling note is heard, a 1.0- or 2.0-mfd. condenser should be connected across the B minus and B plus 180-volt taps.

Using the particular receiver described in the article, on a 200-foot antenna, sufficient selectivity was obtained to bring in WOC while WEBH and WBBM were both in full operation, although WEBH is located within a mile of the point where the set was tested. With the same adjustments exactly, and during the same evening, the set brought in stations over a thousand miles distant with full loud-speaker volume. Over a short period of testing, stations on both coasts were received.

The need for careful adjustment of both taps and trimmers on the multiple condenser cannot be too strongly emphasized. If either adjustment is not correct, there will be a pronounced lack of selectivity and the receiver will probably bring in nothing but local stations.

OUTPUT DEVICE NEEDED

IT PROBABLY will be noticed that no provision has been made on this receiver for an output device. Many of the modern types of dynamic speakers contain a transformer and, accordingly, it is unnecessary or desirable to have an additional transformer built into the receiver. Furthermore, some builders prefer a choke and condenser output coupling, while others are strongly in favor of an output transformer. So with the idea of leaving the receiver as versatile as possible, the matter of output device was left to the builder.

Under no circumstances, however, should the set be used without some kind of satisfactory device to keep the direct current from the loud speaker windings.

[NOTE: The voltages suggested by the author for use on the screen-grid tubes are higher than those recommended by the manufacturers of these tubes. Normal screen-grid, control-grid, and plate potentials are 45, 1.5 and 135 volts, respectively. The simplest way to get such voltages to the proper places within the set is to connect the screen-grid leads to the blue 45-volt lead which at present is connected only to the primary of the first audio transformer. To get 135 volts on the plates of these tubes it will be necessary to run a separate lead to a 135-volt source, or to operate the power tube at this voltage when no change in the wiring will be necessary. The 10-ohm resistor R_4 should be connected in the plus filament lead to the two screen-grid tubes instead of in the negative lead.

In the Laboratory the difference between operating the receiver at normal voltages and those recommended by the Aero Products Company was hardly noticeable, although this is evidently not true in all cases, since the Aero Company advises that they obtained much better results with higher voltages. The disadvantage of using higher than the rated voltage is that shorter tube life results.—THE EDITOR.]

LIST OF APPARATUS

THE following is the list of parts recommended by the author of this article. Other parts of similar characteristics may be used if the constructor desires. The coils are 2" in diameter, wound with 90 turns of No. 22 B & S d.c.c. wire air spaced .005 inches and tapped as shown on the circuit diagram. The list price of the parts in kit form is $74.50.—THE EDITOR.

- C_1, C_2, C_3—1 Aero gang condenser, .00035-mfd., Type AE-2155
- C_5—1 Aero midget condenser, No. 940
- C_6, C_7, C_{10}—3 Aerovox mica condensers, .001-mfd.
- C_8—1 Aerovox mica condenser, .003-mfd.
- C_9—1 Aerovox mica condenser, .00025-mfd.
- L_1, L_2, L_3—1 Aero coil kit, No. U-203
- L_4, L_5—2 Aero NoSkip chokes, No. C-60
- R_1—1 Aero variable resistor, Type AE250
- R_2—1 Bradley Grid leak, 3-megohms
- R_3—1 Daven ballast, No. 5
- R_4—1 Yaxley resistance, No. 810
- T_1, T_2—2 Aero audio-frequency transformers, Type AE770
- Y—1 Yaxley cable connecter, No. 669
- A—Aero split-brass bushings, Type S-1
- 1 National dial, Type E
- 3 Kurz-Kasch walnut knobs, No. 98
- 2 Carter screen-grid connecters, No. 342
- 1 Eby Junior binding post
- 1 Aero cabinet, Type 400
- 1 No. 20 drilled Formica base-panel with all sockets, grid-leak clips, etc. mounted
- 9 Kellogg solder connecters, No. 2
- 50 ft. Rubber-covered stranded hook-up wire
- 4 ft. Rosin-core solder
- 5 Aero S4 mounting posts
- 3 Aero S3 bakelite bushings
- 1 Aero No. 3 screw assortment
- Brass machine screws R. H., N. P., 5⁄8" x 6⁄32"

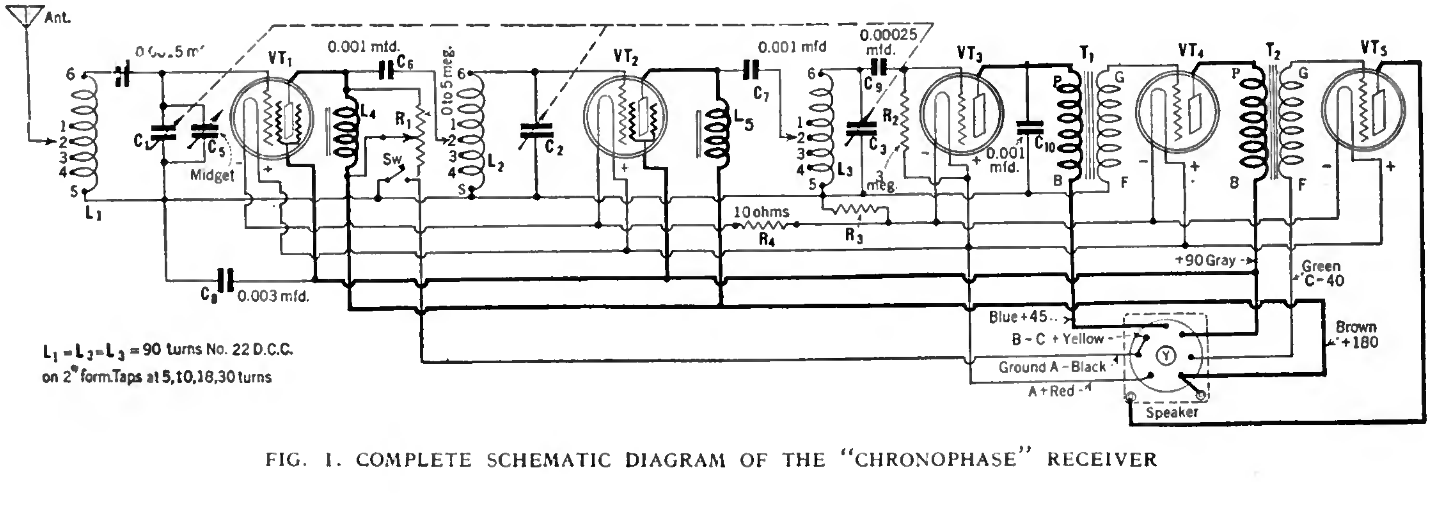


FIG. 1. COMPLETE SCHEMATIC DIAGRAM OF THE "CHRONOPHASE" RECEIVER

Who Are the Fellows of the Institute?

BY CARL DREHER

A FEW years ago, before industry deprived me altogether of leisure, I was returning by train from a walking trip in the country which had lasted several days and left me with a coat of tan and a considerable growth of beard. The train boy, happening to speak to me when I purchased some of his wares, began a sentence with the words, "All right, sir," but, glancing up at me as his lips formed the sibilant of the respectful title, and beholding my sweater and beard, he changed it hurriedly to "Feller." He was a class-conscious train boy. I reflected that the word Fellow has numerous meanings, and I could not tell whether he intended the one numbered in Webster 2. *A companion; comrade; associate; contemporary* or 3, *An equal in power, rank, character, etc.;* or perhaps even 6, *A man of low breeding or of little worth;* but I bought the lemon drops anyway.

Little did that snobbish youth know that the term which he used disparagingly also has learned associations, and, in scientific circles, entitles one to all the honors of a bishop among the men of God. Nevertheless, it is so, as he would see were he to consult the 1928 Year Book of the Institute of Radio Engineers. Of a total of 4200 members on December 1, 1927 (it is probably thirty or fifty per cent. greater by this time), 3543 were resident in the continental United States, the Canal Zone, Philippine Islands, and Alaska, and of all these radio engineers and aspirants under the flag of the United States only 74, I ascertained by a statistical investigation, are Fellows. It is easy, if one is of normally good character, to become an Associate Member. Full Members, although not born, may be made. But a Fellow! He is one of the 2 per cent., and a rare zoological specimen even at a meeting of the Institute. Contrary to the advertisements celebrating the prevalence of a certain affliction, four out of five cannot even hope to get it, and most of the remainder are turned down by the Committee on Admissions, of which Dr. Frank Conrad was Chairman in 1927, while Mr. R. A. Heising holds the helm this year. In 1927 10 Members had the temerity to seek admission to the Fellow grade; six were admitted, while four applications were denied. One Fellow was elected directly.

The Constitution of the Institute provides that a Fellow shall not be less than thirty years of age. He may be elected under one of several provisions. If he is a radio engineer by profession, "he shall be qualified to design and take responsible charge of important radio work; he shall have been in the active practice of his profession for at least seven years, and shall have had responsible charge of important radio work for at least three years." As a professor of physical science or of electrical engineering he is subject to equally severe requirements, if he seeks the honor in that section. By "notable original work in radio science," inventions, or contributions to literature giving an applicant 'a recognized standing at least equivalent" to the above he may also hope to become a Fellow. Under these provisions noted radio executives, like Mr. Sarnoff and Mr. Young, are admitted to the august company of their own chief engineers, and, like them, pay annual dues of $15, but they don't have to read the *Proceedings* unless they want to.

Moved by a perhaps unseemly curiosity, I recently read through the list of members of all grades published in the 1928 Year Book to see what the 74 indigenous Fellows did during their business hours. Thirteen, I found, are engineers employed by Radio Corporation, General Electric, and Westinghouse, and two are non-engineering employees of this group of companies. Ten are engineers for the American Telephone and Telegraph Company. Seven are engineers for miscellaneous radio concerns. Six are consulting engineers. Eleven are executives. One is in the sound-movie business. Two are definitely outside of radio in their business connections. Professors of engineering or allied subjects at universities number 6. There are 3 army or navy officers, and 5 in civilian government positions. In 6 cases no vocational information is given.

CHIEF OF THE INSTITUTE
Dr. Alfred N. Goldsmith, president, the Institute of Radio Engineers

My object in printing this is to render some of the impassioned opponents of the big corporations privy to the hitherto unrevealed fact that over a third of the leading radio engineers of the country are already in the hands of these octopi, and all of them may be swallowed unless Congress does something about it.

Other interesting facts may be gleaned from the Year Book. As they are published for all to see, I may be permitted to comment on them without scandal. Note, that Major E. H. Armstrong, indubitably one of the genuinely great men of radio, did not become a Fellow until 1927. He could have been one any time after he wrote his classical paper on the vacuum tube, in 1915, or as soon thereafter as he became 30 years old. Why didn't he bid for the honor sooner? Maybe he just didn't give a damn; that would be like Armstrong. W. R. G. Baker, Managing Engineer of the Radio Department of General Electric, is still down as an Associate; he has since come up for the grade of Fellow, however. More than one of the luminaries skip the Member grade, apparently. Stuart Ballantine became a Fellow in 1928, also, rising from Associate; he must be one of the youngest among the Fellows, but his recondite and brilliant researches deserve the honor. Harold H. Beverage remains a Member in the 1928 Year Book. Mr. H. O. Boehme is also down as a Member ('15). If you don't remember him, you don't remember the Atlantic Communication Company either, and if you don't remember the A. C. C. you are no radio man. But where is the name of George H. Clark? He doesn't seem to be a member of the Institute at all, these days. John M. Clayton, the Secretary of the Institute, is a Member. Powell Crosley, Jr. is a Member. H. P. Davis, the Vice-President of the Westinghouse Company, who is probably responsible in greater measure for the existence of broadcasting than any other man and who is an engineer to boot, is not listed. Dr. J. H. Dellinger was elected a Fellow in 1923 and became President of the Institute in 1925. Carl R. Englund of the Bell Telephone Laboratories, one of the most brilliant controversialists in the Institute, was only an Associate in 1927; he has since been elevated to the Fellow grade. C. L. Farrand seemingly has no desire to rise above the Member degree. A. H. Grebe, although a Manager for three years, remains an Associate. Similarly David Grimes. And ditto Charles A. Hoxie. So does Edward J. Nally, the first President of the Radio Corporation of America, modestly remain an Associate. Hudson R. Searing, an electrical engineer who was one of the pioneers among the New York amateurs, and Harry W. Secor, who was writing radio articles during the years of radio antiquity, are both associates, Mr. Secor since 1912, when the Institute was founded. Hendrik J. Van Der Bijl, the author of the well-known text on vacuum tubes, is a Member in South Africa. Irving Vermilya is a Member also; ten years before there were broadcast listeners to be annoyed, he was a master of spark sets from one end of Long Island Sound to the other.

On the same page of the Year Book one's eye strikes the name of Manfred von Ardenne, the German baron who, as a radio engineer and mathematician, was able to hold his own with some of the Fellows of the Institute during his visit a year ago, but who is so young that he can only qualify as a Junior. Finally, among the Z's, just before the name of Prof. Jonathan Zenneck, the Fellow who came from Germany this year to receive the Institute's Medal of Honor, there is Harold R. Zeamans, who ranks among the Associates, for he is a lawyer and not an engineer, but for all that he is one of the oldest members of the organization and has been presenting it with legal counsel since 1912.

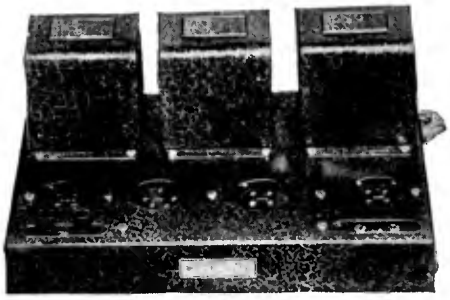
Thus there are great and prominent men on the lower ranks of the hierarchy, as well as among the Fellows. Prominent or not, they can vote, speak their minds at the meetings, and preserve the *Proceedings* in their libraries. There are, however, privileges which they do not enjoy. Only the Fellows have the right to wear badges with blue lettering on a gold background, only Fellows may aspire to election to the offices of President and Vice-President, and only Fellows are *ipso facto* famous.

New Apparatus

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

Two-Stage Power Amplifier for A.C. or D.C. Operation

X71
Device: National Push-Pull Amplifier. This is a complete two-stage transformer-coupled power amplifier. It does not contain any power supply, but it may be light-socket operated by the use of a 227-type tube in the first audio stage and two 210- or 250-type tubes in the output stage, which is push-pull. An extra socket is provided so that those who desire may use a 112A-type tube in the first stage and operate the amplifier from a storage battery. Resistances are contained within the device so that the proper C-bias potential is supplied automatically to the tubes. The unit is wired completely.
Manufacturer: National Company, Inc. Price: $40.00 completely wired but without tubes.
Application: The amplifier may be used readily in conjunction with radio tuners or it may be used with a phonograph pick-up for the electrical reproduction of phonograph records. It may also be used to replace poor audio systems in old sets, thereby improving the quality of the reproduction.



THE NATIONAL TWO-STAGE POWER AMPLIFIER

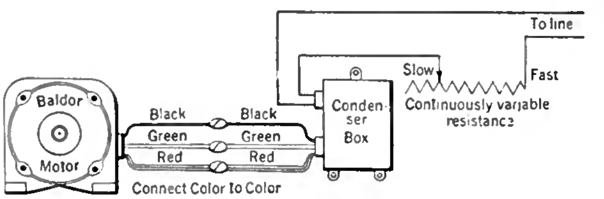


FIG. 1.

Diagram shows method of connecting Baldor motor with condenser block and a.c. line

Improved Motor for Television

X72
Device: Baldor Ball-bearing Motor. These motors are intended for use in television receivers for driving the scanning disc. Two types are available.

Type Y1V is a 1/8-HP, 110-Volt, 60-cycle, single-phase, 1800-RPM motor designed for receiving sets using a 24-inch scanning disc. It is designed to maintain a constant speed between 750 and 1700 RPM with a 5- to 45-ohm variable resistance. Price: $30.00.

Type M2V is a 1/15-HP, 110-Volt, 60-cycle, single-phase, 1800-RPM motor for receiving sets employing 9- to 18-inch aluminum scanning discs. The motor revolves 1750 RPM at full load and a variable speed range of 750 to 1700 RPM is obtained with a 60-ohm rheostat. Price: $23.00.

Machined flange for scanning disc for all motors. Price: $3.00.

Rubber-cushioned base. Price: $2.50.
Manufacturer: Interstate Electric Company.
Application: This motor is of the induction type, not relying upon a commutator either for starting or running. Because of the fact that the motor is placed in close proximity to the television amplifier, tiny sparks, such as are produced by brushes sliding over the surface of a commutator while the motor is running, would create disturbing electrical waves, which if picked up by the amplifier may cause distortion or fogging to such a degree that the sought for picture would be a failure. This motor is silent in operation and free from hum, either of which affects the amplifier because of distortion and lack of clearness. The circuit is given in Fig. 1.

The following excerpt from one of the engineering Test Department Reports of the Interstate Electric Co. is of interest: "The scanning discs as used to-day for television reception are anywhere from 9 to 24 inches in diameter, and 1/16 or 1/8 inch thick, usually of aluminum. These discs, may be driven by an M2V, 1/15 HP; Baldor motor, which has ample power for this purpose. As a matter of fact, with a 15-inch disc the motor may run up to within 50 to 75 revolutions of synchronous speed which is 1800 RPM. In order to reduce this speed to what is required it is only necessary to place a series resistance in the circuit with a means of short circuiting about 15% of the total resistance in the form of a key. For example, for a disc 15 inches in diameter, 1/8 inch thick with a required speed of 1080 RPM there is required a fixed resistance of 160 ohms with a key shunting around 25 to 30 ohms.

"There is a means of obtaining somewhat more stable operation, which is to load the motor in some way (a flat disc is practically a frictionless load), as for example, by a fan. If we place six small blades, 1 by 2 inches on the side of the scanning disc, we will have accomplished the result we are looking for; namely, a slight load on the motor, enabling the operator to hold the speed of the disc more nearly constant. The motor now requires only a 30-ohm fixed resistance with approximately 5 ohms short circuited with a key, assuming a 15-inch diameter disc is used and a speed of 1080 RPM is desired."

NEW PORTABLE METER MADE BY WESTINGHOUSE

High Grade A.C. Meters

X73
Device: Portable Alternating-Current Instruments for Laboratory Use. The Westinghouse Company have recently developed a new line of portable alternating-current instruments for laboratory use. These instruments are operated on the electric-dynamometer principle, containing two stationary coils and a moving coil. The unit shown on this page is a single-phase wattmeter. The unit illustrated has a case made of wood. However, they are now being manufactured with cases of built-up sheet micarta. This construction of case is novel and gives the units a great many advantages which wooden cases do not possess. The finish on the micarta case is that of burl walnut and is very hard, not easily scratched or marred like the finish on the wooden case instruments. The dials of the instruments are metal under which is a mirror so as to prevent parallax reading of the knife-edge pointer. The scale is 5½" long with quite uniform markings throughout. Although the design of these instruments is primarily for alternating current use they can be used on direct current and are just as accurate as on alternating current when the average of the direct and reverse readings are taken. The instrument element has an iron shield around it so as to make it immune from external stray magnetic fields. The accuracy of the instrument is ¼ of 1 per cent., of full scale deflection. The terminals supplied on the instruments are non-removable, engraved with the scale value and have large contact surface.

Ammeters are made in double-scale ranges from ½ to 30 amperes in capacities multiple of 2. The voltmeters are also made in double ranges of multiples of 2 capacities, from 3 volts to 600 volts. The double range 0-3 and 0-6 volts or 0-7½ and 0-15 volts are particularly desirable for measuring the filament voltages of the radio tubes in laboratory testing. The instruments are also provided in single-phase wattmeters with voltages as low as 30 volts up to 600 volts and currents from ½ ampere up to 30 amperes.
Manufacturer: Westinghouse Electric and Manufacturing Company.
Application: The usefulness of such instruments in any electrical laboratory is obvious. The

ranges being manufactured cover all values of current, voltage, and wattage ordinarily dealt with in radio work.

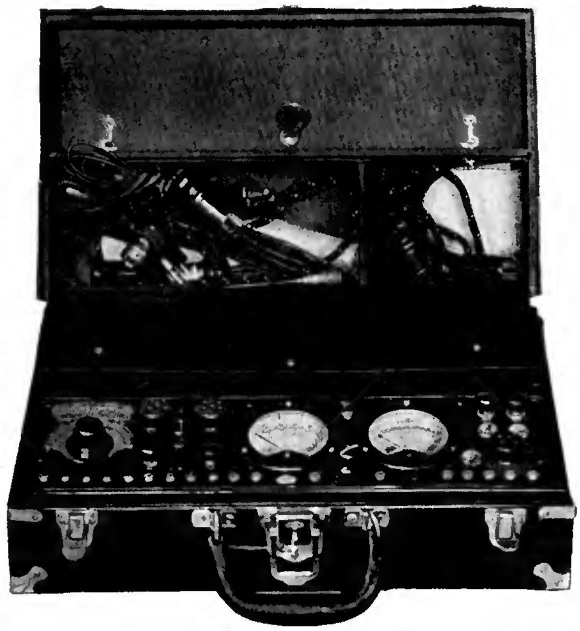
An Adjustable Resistor Network for B-Power Units

X74
Device: Truvolt Divider. A compact unit consisting of a network of resistances mounted in a small nicely finished container and designed for use in conjunction with all types of B-power units delivering voltages not in excess of 220. It permits one to obtain readily output voltages of various values between 0 and 180 and to also obtain two values of C voltage. It can be used with any type of rectifier or filter circuit.
Manufacturer: Electrad, Inc. *Price:* $12.50.
Application: The problem of obtaining from the output of a B-power unit the correct voltage for application to any given receiver is a serious one. Fixed resistances across the output of a B-power unit have the disadvantage that the voltage which will be delivered from the various taps varies considerably according to the amount of current drawn from these taps. The use of variable resistances for each tap has the disadvantage that the range of voltage which can be delivered from each resistance is very wide and therefore rather difficult to adjust accurately. A compromise between these two is probably the best. We therefore make use in the Truvolt Divider of the combination of fixed and variable resistances so that the voltage from each tap is approximately fixed but can be varied over a range sufficiently wide to adapt the unit to practically any receiver. This might be called a universal divider since it can be used interchangeably with any receiver and any power unit and can be adjusted to supply the correct voltages to the set. The unit will find application not only in the construction of new power units but in conjunction with old power units which perhaps deliver incorrect voltages or have not sufficient voltage taps. Also by using the Truvolt Divider we can obtain from a power unit that ordinarily delivers only B voltages two values of C voltages as well as the B voltages.

The Truvolt Divider is designed to supply four B voltages and two C voltages. The voltage obtained from the B1 tap is the maximum voltage from the B-power unit. Tap B2 supplies an average voltage of 135 but this voltage can be adjusted to any value between 110 and 160 volts. Tap B3 supplies an average of 90 volts which can be adjusted between the limits of 65 and 110 volts. Tap B4 is the 45-volt tap capable of supplying a range of voltages from 20 to 55. Tap B5 is the negative B. Tap C6 is the low voltage C terminal and it will supply a grid bias from minus 1 to minus 20 volts. For higher C biases tap C7 is used. It supplies voltages from minus 20 to minus 40. The connection of this device to a typical B power unit is indicated in Fig. 2.

Because the resistances used in this divider are of a type which can be accurately calibrated it is possible by the use of either tables or curves to adjust the various controls to give the proper voltages without the use of a voltmeter. If a voltmeter is available, it of course affords a simple, rapid, and certain method of adjusting the unit. The voltmeter is shunted between that particular tap which is being adjusted and the negative B and the control varied until the correct voltage is supplied. This test is, of course, made with the receiver connected to the unit.

Many experimenters desiring to use this device will probably not have available a high-resistance voltmeter; for them it would be helpful to have the booklet supplied with the divider, which describes in detail how to adjust the resistors for any given receiver. This booklet, which is called the Truvolt Divider Manual, is not only very helpful in adjusting this device, but also contains a great deal of excellent information in connection with the output circuits of a B-power unit.



RADIO TEST SET MADE BY SUPREME INSTRUMENT CORP.

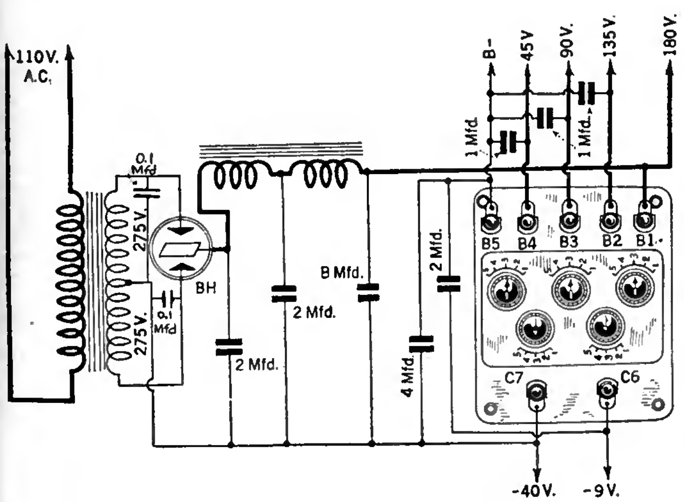


FIG. 2.
Method of connecting Truvolt divider in a B-power unit

Useful Tester for Radio Sets

X 75
Device: Set Tester. This tester is designed to aid in servicing all types of a.c.- and d.c.-operated receivers. The following paragraphs indicate some of the tests which may be made.

In balancing the various tuning condensers in a single-control receiver the tester is very useful. This test is made by placing a tube in one of the sockets of the tester and inserting a plug into the power-tube socket of the receiver, thus converting the tester into an oscillator. When these connections are made, and the set is turned on, it will be found that the milliammeter in the tester will jump as the set is tuned to resonance with the oscillations produced by the tester. Each individual tuning condenser is then adjusted to resonance, as indicated by the movement of the meter.

The tester will measure the normal emission, and the emission when oscillating, of all types of tubes. In addition it will indicate the plate voltage, grid voltage, and filament voltage of each tube of a set, both under load condition and with no load. Another important application is the detection of open, short, and high-resistance joints in any parts of the circuit.

The instrument contains a complete set of tools with space for spare tubes. The supplies include a ratchet screw driver, soldering iron, hook-up wire, various adapters, test leads, etc.

The instruments in the tester are: a double-range milliammeter, 0-50 and 0-100; a triple-range voltmeter, 0-10, 0-50, and 0-250, and a triple-range a.c. voltmeter, 0-3, 0-18 and 0-150.

The photograph illustrates the Model 100A instrument priced at $108.50.
Manufacturer: Supreme Instrument Corporation.
Application: Indicated above. It should prove invaluable to service men.

Hook-up Wire for Various Uses

X76
Device: Celatsite Hook-up Wire. The following kinds can be obtained.

1. Celatsite Flexible Wire. A flexible hook-up wire consisting of tinned stranded copper wire covered with a non-inflammable insulation. Available in the following colors and wire sizes.

No. 22—$ .70 per 25-ft.
No. 20— .75 " "
No. 18— .80 " "
No. 16— 1.00 " "
No. 14— 1.00 " "
Colors: Black, Yellow, Red, Green, Brown, Slate, Blue, White, Maroon.

2. Celatsite twisted wire for a.c. filament circuits. One strand of Red and one strand of Black No. 18 Flexible Celatsite twisted together. The two colors are used so that, if desired, the same sides of all filaments can be maintained at the same relative potential. Packed in 25 ft. coils. *List price:* $1.75 per carton.

3. Solid Celatsite wire. Bus-bar made of tinned No. 14 copper wire and covered with a non-inflammable insulation. Strips easily for soldering. Available in same colors as the flexible wire. *Price;* $.09 per 30-inch length.
Manufacturer: Acme Wire Company.
Application: The above material has been used in the Laboratory for some time in constructing receivers and power units and has been quite satisfactory.

Manufacturers' Booklets

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

72. PLATE SUPPLY SYSTEMS. Technical information on audio and power systems. Bulletins dealing with two-stage transformer amplifier systems, two-stage push-pull, three-stage push-pull, parallel push-pull, and other audio amplifier, plate, and filament supply systems. AMERICAN TRANSFORMER COMPANY.

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

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

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

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

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

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

89. SHORT-WAVE TRANSMITTING EQUIPMENT. Data and wiring diagrams on construction of all popular short-wave transmitters, operating instructions, keying, antennas; information and wiring diagrams on receiving apparatus; data on variety of apparatus used in high-frequency work. RADIO ENGINEERING LABORATORIES.

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

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

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Laboratory Information Sheets

(Nos. 1-190)

in

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

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

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

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

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

120. THE RESEARCH WORKER—A monthly bulletin of interest to the engineer and home builder. Each issue contains special articles on radio design and construction with special emphasis on resistors and condensers. AEROVOX WIRELESS CORPORATION.

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

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

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

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

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

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

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

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

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141. AUDIO AND POWER UNITS—Illustrated descriptions of power amplifiers and power supplies, with circuit diagrams. THORDARSON ELECTRIC MFG. CO.

142. USE OF VOLUME AND VOLTAGE CONTROLS. A complete booklet with data on useful apparatus and circuits for application in receiving, power, amateur transmitter, and phonograph pick-up circuits. CENTRAL RADIO LABORATORIES.

143. RADIO THEORY. Simplified explanation of radio phenomena with especial reference to the vacuum tube, with data on various tubes. DE FOREST RADIO COMPANY.

144. A.C. DETECTOR TUBE. Data on characteristics and operation of 2.5-volt a.c. detector tubes. ARCTURUS RADIO COMPANY.

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146. RECEIVER CIRCUIT DATA. Circuits for using resistances in receivers, and in power units with descriptions of other apparatus. H. H. FROST, INC.

147. SUPER-HETERODYNE CONSTRUCTION. Construction and operation of a nine-tube screen-grid super-heterodyne. SET BUILDERS' SUPPLY COMPANY.

148. SHORT-WAVE RECEIVER. Constructional and operation data on a four-tube short-wave receiver. KARAS ELECTRIC COMPANY.

149. FIVE-TUBE SCREEN-GRID RECEIVER. Blueprint with full constructional details for building a broadcast receiver using two screen-grid tubes. KARAS ELECTRIC COMPANY.

150. FIVE-TUBE A.C. RECEIVER. Blueprint for constructing a five-tube a.c. receiver employing the "equamatic system." KARAS ELECTRIC COMPANY.

THEY'RE THERE IN THE WORLD'S FINEST RECEIVERS

STANDING guard at the door of tone, Thordarson audio and power transformers do their part in making real musical instruments of hundreds of thousands of radio receivers annually.

Leading receiver manufacturers are well aware of the important relationship between the choice of transformers and the musical characteristics of their instruments. No wonder, then, that the majority of manufacturers of quality radio receivers have turned to Thordarson as the logical transformer source.

When buying your receiver, insist on Thordarson amplification and power supply. The set manufacturer who uses Thordarson transformers can be depended upon to have the balance of his receiver in keeping with this high standard of performance.

Custom set builders will find Thordarson transformers to meet every radio need at their nearest parts dealer.

THORDARSON
RADIO TRANSFORMERS
SUPREME IN MUSICAL PERFORMANCE

3585

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, set builder or service man. 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 newsstands, or from the Circulation Department, Doubleday, Doran & 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.

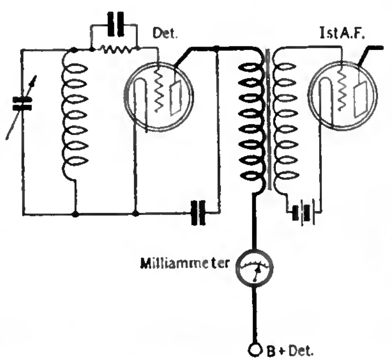
No. 233 Radio Broadcast Laboratory Information Sheet **November, 1928**

Balancing Radio Receivers

AN EASY METHOD

THE change in the plate current of the detector tube, when a signal is being received, may be utilized to balance the various tuned circuits in a single-control receiver. If the several tuned circuits in a multi-stage r.f. amplifier are not properly ganged, the set will be insensitive and the selectivity will be poor. It is essential, therefore, that the various stages be accurately aligned. How this can be done is the subject of this Laboratory Sheet. The method used is simple and is based on the action of a detector when a signal is being received.

If a milliammeter with a range of about 2 milliamperes is connected in series with the B-plus lead to the detector, as indicated in the diagram, it will be found to read about 1 mA. if the detector is of the grid leak and condenser type and about 0.2 mA. if a C-battery type detector is used. If a station is tuned-in, the plate current of the detector tube will decrease if the former arrangement is used and increase with a C-battery detector circuit, the amount of the increase or decrease being proportional to the strength of the signal—the stronger the signal the greater the change in current. Therefore, when the set is accurately tuned and all of the condensers are perfectly aligned the deflection of the meter—and therefore the output of the set—will be greatest.



Balancing therefore becomes a matter of tuning in some station, preferably one operating on a short wavelength, and then adjusting the various condensers, by whatever means are provided by the manufacturer, so that the greatest change is indicated on the meter in the plate circuit of the detector. When circuits have been adjusted so that the greatest current change is obtained, the set is balanced. It is best to make this adjustment with the set tuned to a short wavelength, for it is in this part of a receiver range that the greatest lack of balance is liable to occur.

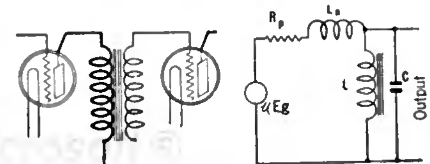
No. 234 Radio Broadcast Laboratory Information Sheet **November, 1928**

The Audio Transformer

OPERATION AT HIGH AUDIO FREQUENCIES

IN LABORATORY Sheet No. 227, in the October number, we studied the characteristics of audio transformers and pointed out that the lowest frequency response depends upon the ratio of the reactance of the transformer to the plate resistance of the tube. Here we will consider the high frequencies. For convenience we have reprinted here the diagram from Sheet No. 227.

At high frequencies the reactance of L is very large in comparison with C, and it may therefore be neglected. Essentially, we then have a circuit consisting of Rp, La and C in series. As La and C come into resonance, the impedance of the circuit will decrease and more current will flow, thereby tending to increase the voltage across C, which is the voltage applied to the grid of the next tube. However, the voltage across C, for a given current, is inversely proportional to the frequency, and this will tend to lower the voltage across it at high frequencies. In some transformers, however, there is a marked peak at about 6000 cycles, corresponding to the resonant frequency of La and C in series, the output falling off rapidly beyond the point.



(A) (B)

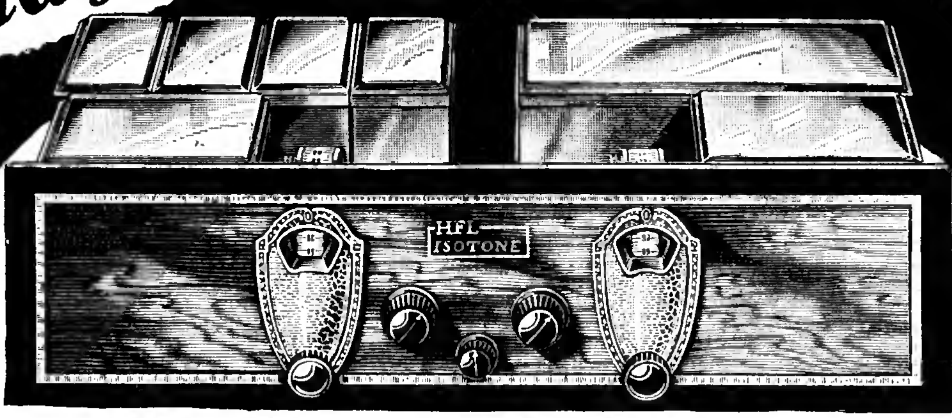
If this upper resonant peak is very pronounced the gain of the entire amplifier will increase greatly at this point, tending to make the amplifiers oscillate. Good design requires that the peak be kept as small as possible.

At frequencies higher than that at which La and C resonate, the reactance of La continues to increase, and the reactance of C to decrease; therefore, the voltage across C rapidly falls. If some transformer curves are examined, it will frequently be found that the curve drops rapidly beyond the upper resonant point.

The problem of design is to adjust the leakage inductance, La, and the effective capacity, C, so as to give satisfactory high-frequency response.

HFL

Distance Range That Staggers the Imagination! With the Wonder Receiver of the Century



The Model 10 HFL Isotone

SCREENED GRID . . . CUSTOM BUILT . . . RADIO PHONOGRAPH

THE HFL Isotone is unquestionably the most sensitive receiver that the world has ever seen. It will absolutely out-distance all other receivers regardless of price or type of construction. The amazing sensitivity of the HFL screened grid amplifier remains unequalled. No other commercial amplifier permits a gain of 65 per stage *under actual operating conditions.* The HFL Isotone is the supreme radio achievement. It's position has been definitely established in radio laboratories the country over.

2000—3000 Mile Range

So sensitive is the HFL Isotone that stations over 2000 miles away *have to be turned down.* Tremendous volume is obtained from stations all over the North American continent. The HFL Isotone will receive any station in the world that is putting enough signal voltage into the antenna to actuate the first tube in the receiver.

One Spot Tuning

The 450 kilo cyle screened grid amplifier allows absolute one spot tuning. Extreme selectivity is gained by hand tuning each transformer with a small variable condenser. An entirely new method of control permits the tubes to be operated in their most sensitive condition—just below the oscillating point. The HFL Isotone will actually select an *8 kilo cycle band* when the amplifier is worked at maximum. Dual detection (an exclusive H F L development) allows reception of the weakest signals and still permits the undistorted handling of powerful locals.

A.C. or D.C. Operation

Through the use of an ingenious system of filament control, the HFL Isotone operates perfectly with batteries or the special HFL—A.C. power supply. The same tremendous reserve power is available with batteries. The same crystal clear tones are developed with A. C. Only 30 mils. of plate current are required by the entire receiver *including the two power tubes.*

Phonograph or Radio

A special method of switching and ballasting allows an instant choice of phonograph or radio music by simply throwing the master control switch on the front panel. Both kinds of music are so amazingly realistic that no human ear can discern the difference between an original selection and an H F L reproduction. An automatic ballasting shunt—another exclusive H F L feature—prevents audio tube overloading when the six radio frequency tubes are *disconnected during phonograph operation.* The three stage, push pull audio amplifier is a marvel of electrical design. Not only does it faithfully reproduce every musical frequency, but it actually corrects the flaws in broadcast transmissions and phonograph records.

45 Minute Construction

The HFL unit method of construction is the sensation of the 1929 radio season. Every item necessary to build a perfect Isotone comes in a factory sealed carton. Each of the three main units is wired and laboratory tested at the factory. *Only ten wires* are connected by the set builder. An exact, progressive method of assembly eliminates every chance of error. We stand ready to prove, at any time, that a standard HFL Isotone can be fully constructed in less than forty-five minutes.

Absolute Guarantee

We guarantee, absolutely, that a standard HFL Isotone receiver operating under favorable conditions will receive over a distance of not less than 1500 miles. We guarantee every HFL unit to be mechanically and electrically perfect. Any unit believed defective will be immediately replaced at no extra charge. We reserve the right to select a location and *prove by demonstration* that it will receive over 1500 miles.

Set Builders write for special data

Free circuit diagrams and all information

HIGH FREQUENCY LABORATORIES
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Chicago, Illinois

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Without obligation please send your new ISOTONE booklet.

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Please print plainly

No. 235 RADIO BROADCAST Laboratory Information Sheet **November, 1928**

Television

FREQUENCY BAND REQUIRED

IN TELEVISION transmission a problem which must be given careful consideration is the width of the band of frequencies which must be transmitted to reproduce at the receiver end, with good quality, the scene being scanned by the television transmitter.

Theoretically, a television signal contains components of all frequencies from zero to infinity. In practice the frequency band is much more restricted and depends upon various factors.

The width of the band of frequencies which must be transmitted is a function of the number of elements scanned per second at the transmitter. For example, if the number of lines into which the picture is broken—which is equal to the number of holes in the scanning disc—is 50, then the number of elements into which the picture will be broken will be 50 times 50, or 2500. If we transmit 20 pictures per second, the total number of elements transmitted per second will be 50,000. The highest frequency which must be transmitted, to get good quality, can be taken as equal to half this figure, or 25,000 cycles. The table given herewith shows how the value of the highest frequency which should be transmitted varies with the number of scanning lines and the number of pictures per second. For example, a 50-line picture sent 15 times per second requires up to 19,000 cycles.

A station transmitting within a broadcast band is limited to 5000-cycle modulation. Therefore, any broadcast station transmitting television programs and using a number of lines and number of pictures per second such that requires a frequency band greater than 5000 cycles must either modulate above the legal limit or suppress in the amplifiers the frequencies above 5000 cycles.

No. of lines	*No. of pictures per second*		
	10	15	20
25	3,100	4,700	6,000
50	12,000	19,000	25,000
75	28,000	42,000	56,000
100	50,000	75,000	100,000

No. 236 RADIO BROADCAST Laboratory Information Sheet **November, 1928**

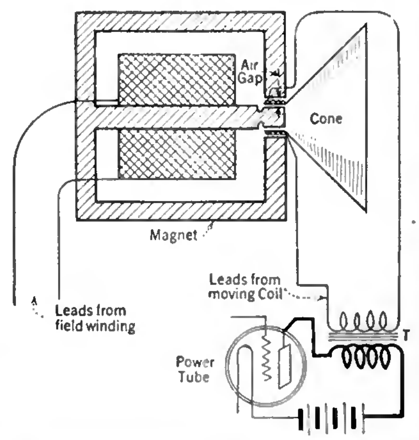
Moving-Coil Loud Speakers

THEIR OPERATION

THE important characteristic of the dynamic or, more properly named, moving-coil type loud speaker is the fact that it has a coil fastened directly to the cone, which is caused to move back and forth in an air gap in a magnetic circuit, the movements being in accordance with the frequencies flowing through the coil.

The moving coil is mounted at the apex of the cone, as indicated in the diagram, and connects to the secondary of the transformer, T, the primary of which connects to the plate of the power tube. The moving coil of a well-designed unit has a fairly constant impedance over the entire range of audio frequencies and the transformer, T, is designed to "match" the coil's impedance to the output impedance of the tube. So long as the power tube works into an impedance about equal to or somewhat greater than twice the tube's plate impedance, satisfactory power transfer from the tube to the moving coil will be obtained. The instructions covering the use of one of these loud speakers should indicate what tubes or combination of tubes are recommended for use with the unit.

The term "dynamic loud speaker" is not a very accurate description of a type of loud speaker whose distinguishing feature is that it has a moving coil. The word "dynamic" is defined as "mechanics treating of the motion of bodies and of the action of forces in producing or changing their motion." Since all loud speakers move they can all be called "dynamic." We have seen descriptions and advertisements of "dynamic" loud speakers which consisted mainly of an ordinary electromagnetic unit coupled to a cone. This term used to describe such loud speakers is probably misleading to some although technically it is not incorrect.



No. 237 RADIO BROADCAST Laboratory Information Sheet **November, 1928**

Power Output

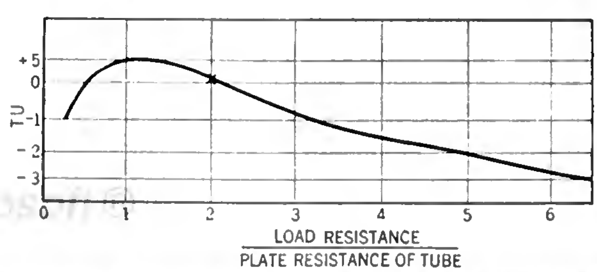
HOW IT DEPENDS UPON IMPEDANCE RATIOS

IT HAS been proved mathematically and experimentally that a tube delivers the maximum amount of *undistorted* power when it works into a load resistance equal to twice the plate resistance of the tube; maximum power output, however, is obtained when the load resistance equals the tube's plate resistance. The curve on this sheet indicates relatively in TU how the power in the load varies with the ratio of the load resistance to the tube's plate resistance (sometimes called plate impedance). The X on the curve indicates where a tube is normally operated, the load resistance at the point being twice the tube resistance.

We frequently see statements to the effect that the loud speaker we use must be matched to the tube to get the largest amount of undistorted power into the loud speaker. Such is the case, but the curve indicates that there can be considerable mismatching without serious loss of power. For example, even when the load resistance is about five times greater than the tube's resistance, there is only a 2 TU loss—a loss which would hardly be noticeable to the ear.

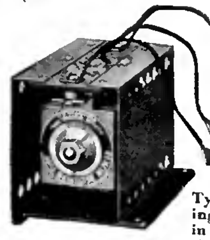
It is unwise, however, to work a tube into a load resistance less than its own resistance, because under such conditions the tube's characteristic is curved (see Laboratory Sheet No. 124) and this curved characteristic introduces distortion.

In cases where the element of the loud speaker has a low impedance, for example, it is necessary to use a transformer between the tube and the loud speaker to compensate the differences in impedance. A moving-coil type, i.e., dynamic loud speaker, might have an impedance of, say, 20 ohms at some frequencies, and if it is to be used with a 2000-ohm tube (171A) which requires a load impedance of 4000 ohms to get maximum undistorted power, then the coupling transformer would have an impedance ratio of 4000 divided by 20, or 200, corresponding to a turns ratio of the square root of 200, or 14.

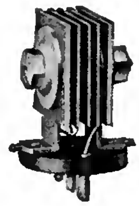


ELKON REPLACEMENT RECTIFIERS Are Saving Radio Fans MILLIONS of DOLLARS

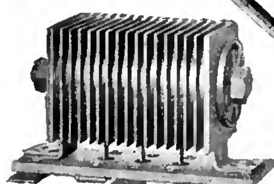
Type BNK for replacing the acid jars in Balkite Types N and K Trickle chargers



Type BJ for replacing the acid jars in Balkite Type J chargers



Type V-4 for replacing the rectifiers in 6 makes of Trickle chargers



Type M-16 for replacing the rectifiers in 11 makes of "A" Eliminators and 3 Ampere chargers

Millions of dollars are invested in radio chargers, eliminators, etc. which would be lost if it were not possible to replace the rectifying units when their life has been exhausted. All Elkon Rectifiers are replaceable.

HOW TO TELL IF YOUR RECTIFIER NEEDS REPLACING?

If your trickle charger no longer keeps your storage battery up the way it did when it was new, you need a new rectifier.

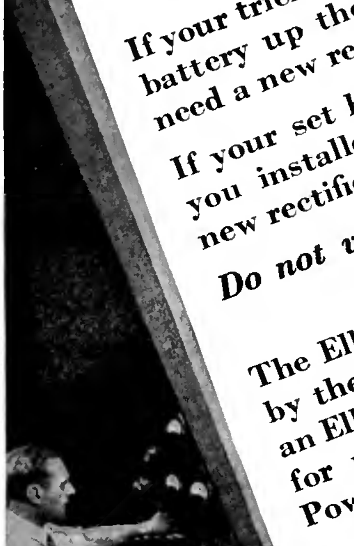
If your set has not the same pep as it did when you installed your "A" Eliminator, you need a new rectifier.

Do not void the Manufacturer's Guarantee on your Balkite Power Units

The Elkon Replacement Units and those made by the Fansteel Products Company containing an Elkon Rectifier, are the only ones authorized for replacement of the acid jars in Balkite Power Units.

See your dealer today—there are thousands of hours of good reception left in your power units as soon as you have replaced your rectifier or acid jar with a new dry Elkon.

Type EBH for replacing the BH type Tubes in "B" Eliminators



Every Elkon Rectifier goes through these exacting tests.

ELKON, INC.
Port Chester, N.Y.
Division P. R. Mallory & Co., Inc.

ELKON, Inc., Radio Department
291 Fox Island Road, Port Chester, N.Y.
Please send me complete information on the Elkon Radio Products.

Name ....

Address ....

No. 238 RADIO BROADCAST Laboratory Information Sheet November, 1928

A Hook-up for Short-Wave and Broadcast Receivers

A METHOD FOR SWITCHING OVER

IT IS general practice in constructing short-wave adapters to arrange them with extension leads so that they may be plugged into the broadcast set in the detector socket in place of the regular detector tube. This practice is all right when one is building an adapter that perhaps will not be used continually, but when both the broadcast and the short-wave tuners are going to be used frequently, it is better to arrange the circuit as indicated in the diagram on Sheet No. 239, which permits one to change from broadcast to short waves by a simpler means than taking out a tube and plugging in an adapter.

The diagram shows the detector of the broadcast receiver and the detector of the short-wave receiver. They are both wired to the same A and B voltages, and either set is thrown in or out of operation by simply turning the proper filament switch, S_1 or S_2; S_1 turns on and off the broadcast receiver and S_2 similarly controls the short-wave set.

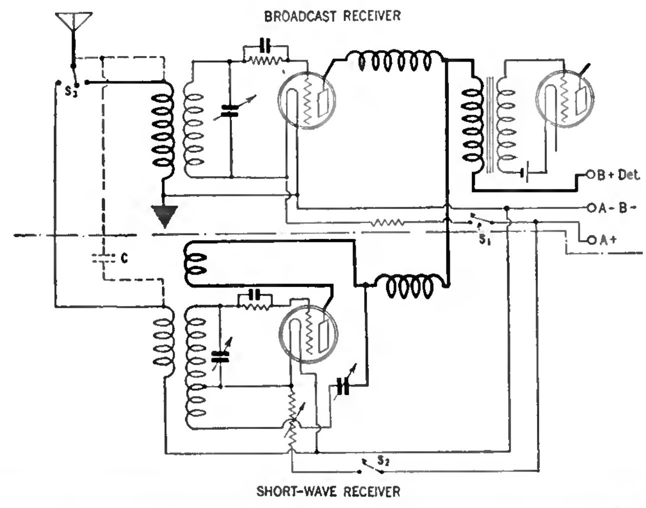
The two plates are permanently wired together, and for this reason the arrangement we have indicated should only be used when the two sets are located close to each other (which is usually the case) so that the plate lead running from one set to the other is not more than 1 or 2 feet long.

Most of us have available only one antenna to use with both sets. To use it with both receivers a single-pole double-throw switch, S_3, can be placed in the antenna circuit; thrown to one side it connects the antenna to the broadcast set, and thrown the other way it connects the short-wave receiver.

An easier arrangement, which works well in practically all cases (how well it works depends upon the characteristics of the two receivers) is indicated by dotted lines. The antenna is connected directly to the broadcast set and through a 50-mmfd. condenser, C, to the short-wave set. This small condenser will block the broadcast signals from the short-wave set but permit these latter currents to pass quite readily.

No. 239 RADIO BROADCAST Laboratory Information Sheet November, 1928

Circuit for Short-Wave and Broadcast Reception



No. 240 RADIO BROADCAST Laboratory Information Sheet November, 1928

Television

DATA ON THE BELL TELEPHONE LABORATORIES' METHOD

THE demonstrations of television given by the Bell Telephone Laboratories, associated with the American Telephone and Telegraph Company, rank higher, in our opinion, than any of the other demonstrations so far given, in quality of the results. In the following paragraphs are summarized some of the most important elements of the apparatus used by these Laboratories.

(a) The scanning discs contained 50 holes and revolved at a speed of 1062.5 revolutions per minute, giving 17.7 pictures per second.

(b) The output voltage of the photo-electric cells at the transmitter was about 10 microvolts.

(c) The range of frequencies decided upon as being essential for good quality extended from 10 to 20,000 cycles. Overall measurements on the final amplifier indicated a frequency characteristic constant within plus or minus 2 TU over this range.

(d) The signals from the transmitter were amplified and delivered to the transmission line at a level of 10 milliwatts. The amplification from the photo-electric cell to the line was 130 TU.

(e) Synchronization was accomplished by the use of synchronous motors containing 120 poles and having a synchronous speed of 1062.5 r.p.m. The angular phase displacement was above 0.07 degrees. This magnitude of phase displacement corresponds roughly to the angular twist in a steel shaft 6 feet long of 1 inch in diameter, operated at full load.

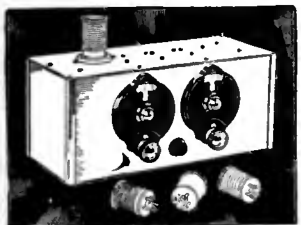
(f) With regard to the effect of extraneous currents due to noise, it was found that satisfactory results were obtained if the average picture currents were 10 times greater than the average noise currents.

This corresponds to 20 TU, or a power ratio of 100. In ordinary sound broadcasting the noise in the telephone lines is kept at a level 60 TU below 10 milliwatts, giving a power ratio of 1,000,000. It is evident that it is permissible to have the noise level much higher in television reception than in sound reception.

SM

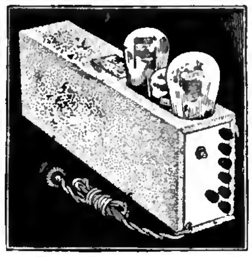
Volume to Fill Any House —the Last Word in Realism —from Any Phonograph [or Radio]

Listen-In on London with the Round-the-World Four



NOT with any ordinary radio receiver, of course—the Atlanti: is too wide for regular broadcast receivers to bring you London programs. But turn on your S-M "Round-the-World" set some night. Don't be surprised if the language you hear is a foreign one, or if the announcer mentions "Paris" or "Amsterdam," or "London" instead of the cities you are accustomed to hear from. Call your neighbors to listen if you want to—but be cautious about calling anyone who has already explored the mysterious short-wave channels with an S-M set—your wonders might sound very tame to him. Perhaps by this time he is only interested in New Zealand and Japan! For in short-waves *almost anything is possible;* amazing feats of distant reception are becoming a matter of common knowledge. (See prices on opposite page).

with this →



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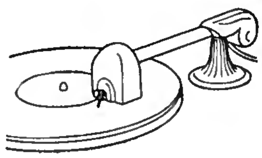

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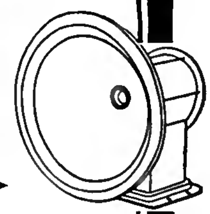
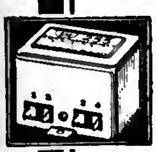
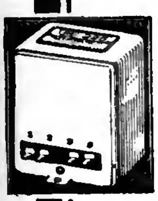


The new 2-stage S-M 678PD Phonograph Amplifier is priced so low that, while particularly adapted for dance halls and small theaters, it is ideal for the home also. Used with any 110 volt D.C. dynamic speaker, it takes input from any magnetic phonograph pickup, or from the detector tube of a broadcast or short-wave receiver, and, by means of its S-M Clough-system audio transformers, supplies to the speaker *undistorted* the full power output of its 250-type tube. All input power is taken from the 110 volt A.C. house-lighting mains. Price, wired, $73.00; complete kit, $69.00.

Or you can get 250-tube power *right in your present* set by inserting a 250 tube (with an adapter) in the last socket of the set, and using the S-M 675ABC Power Supply—which furnishes ABC power for the 250, and B power to the entire set (or full ABC power to A.C. tube sets). Price, 675ABC kit, $54.00, or factory-wired, $58.00.

True Tone Quality from New S-M Audios





S-M Clough-system audio transformers are guaranteed unconditionally to give better tone quality than others, with *higher amplification*, regardless of size, weight, or price. They sell in tremendous quantities, by simply comparing results with others in the *comparison amplifiers* used in S-M demonstrations at recent radio shows.

The large-size transformers (S-M 225, 1st stage; and 226, 2nd stage) are $9.00 each; the smaller ones (S-M 255 and 256) are $6.00 each. The above guarantee applies to *both sizes.*

We carry a full line of S-M Products: each of the kits, amplifiers, and power supplies listed on the opposite page is a specialty with us, and can be shipped promptly from stock. A new edition of our catalog is just out; it contains a splendid showing of the finest quality kits, parts, and accessories to be found anywhere. The coupon will bring it to you, free.

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