RADIO BROADCAST

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RADIO BROADCAST

Willis Kingsley Wing, Editor

DECEMBER, 1927

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Director of the Laboratory

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Contributing Editor

Vol. XII, No. 2

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AMONG OTHER THINGS. . .

PROBABLY the most interesting article in this issue from the point of view of the experimenter is the constructional data and operating and assembly instructions on the Cooley "Rayfoto" radio picture receiver. By the time this magazine is in the hands of its readers, all the essential apparatus will be available on the market and nothing will delay the experimenter in his experience in this new field. Radio Broadcast is glad to forward the names of readers who are interested in receiving printed matter and late bulletins to manufacturers who are supplying the various parts for the "Rayfoto" apparatus. After the appearance of Mr. Cooley's November article, a great number of our readers wrote us for this information which has been supplied. A letter should at once be addressed to the undersigned, asking for additional data in case you have not already written.

WASHINGTON is the center of interest these days, what with the International Radio Conference and the changes in the Federal Radio Commission. The death of Commissioner Dillon is a great loss to radio in the United States and it will be next to impossible to fill his place. The resignation of Commissioner Bellows removes one of the ablest members of the Commission, but President Coolidge has filled his place through the appointment of Sam Pickard, former secretary to the radio body. Mr. Pickard is a likeable and able individual and we believe his appointment is a wise one. Carl H. Butman, of Washington, was appointed as Secretary to succeed Mr. Pickard. Mr. Butman has long served Radio Broadcast as its Washington news representative and we are indeed pleased that the Commission has so wisely chosen a man who knows radio problems so well.

A WORD about the authors in this issue: William J. Brittain is an English writer on radio and scientific topics who has just returned from a European trip to see what is being done in television. Theodore H. Nakken is a research engineer for the Federal Telegraph Company. He is a pioneer in photo-electric cell work and is unusually familiar with radio progress abroad. Austin Cooley, whose "Rayfoto" picture apparatus has attracted national attention, is a native of the state of Washington, received his technical training at M. I. T., and except for his trip in 1926 with the MacMillan Arctic expedition, has been in New York for the past four years. John F. Rider is a well-known New York technical writer who is at work on an interesting series of "fact" articles about manufactured receivers.

THE next issue will contain another story about the Cooley "Rayfoto" radio picture system and its operation, as well as interesting data about push-pull power amplification. Another of Mr. Rider's articles about manufactured receivers will be featured as well as a wealth of constructional matter.

—Willis Kingsley Wing.

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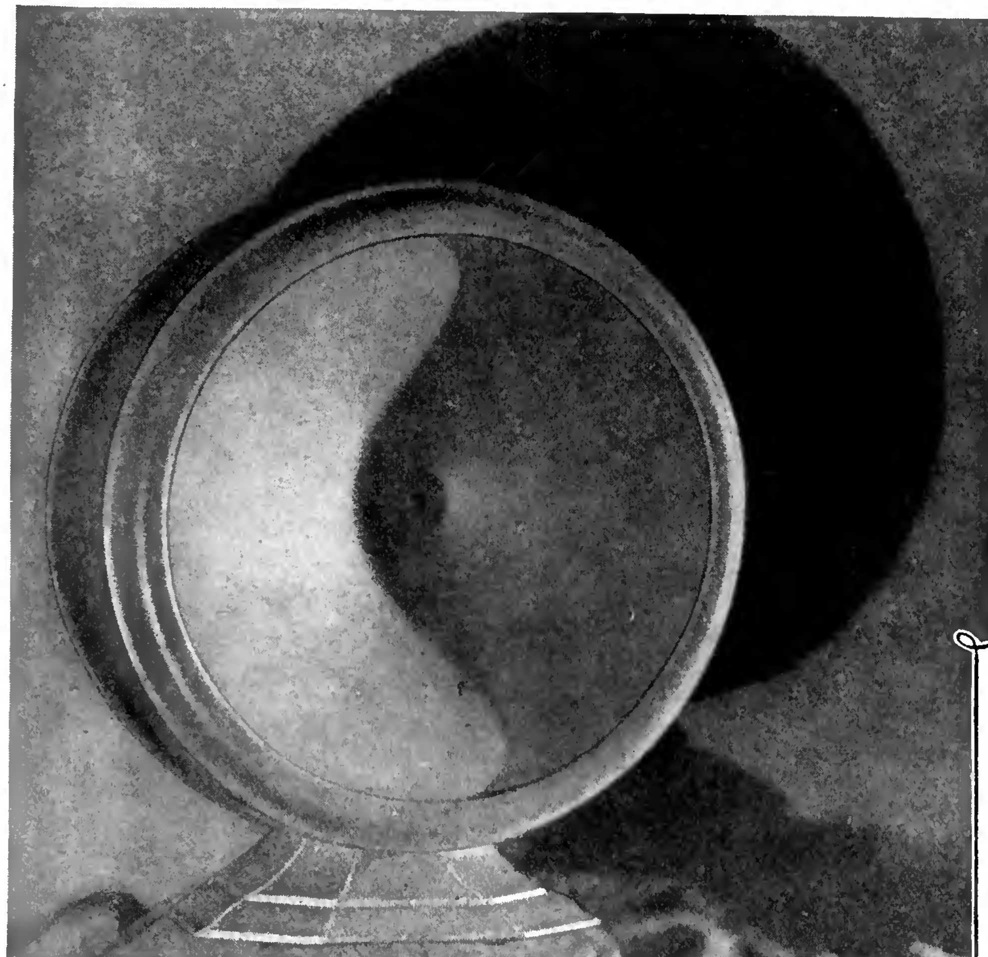

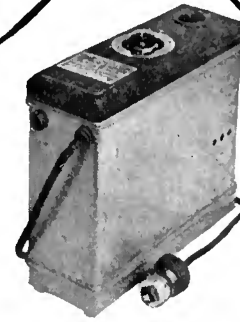

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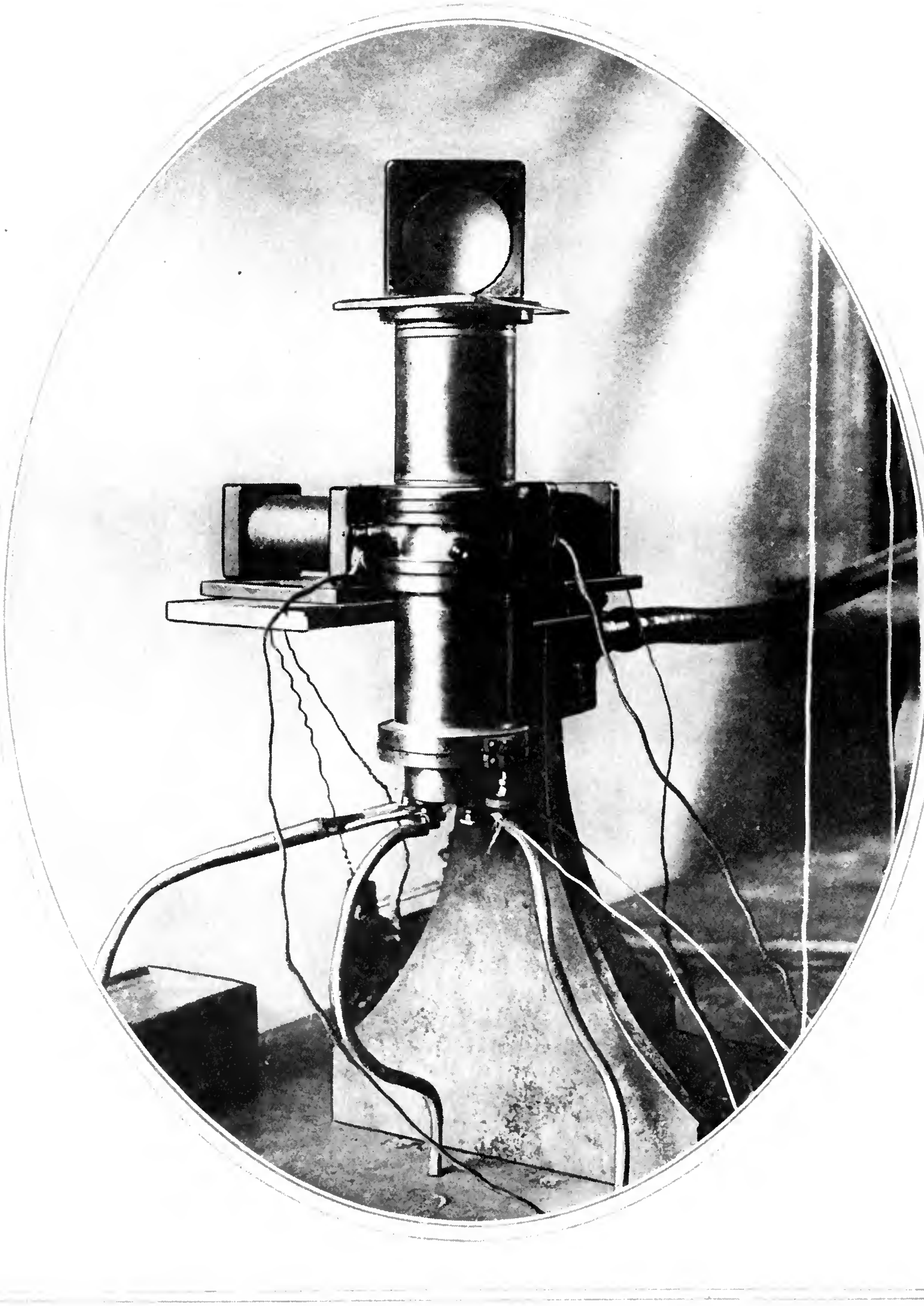
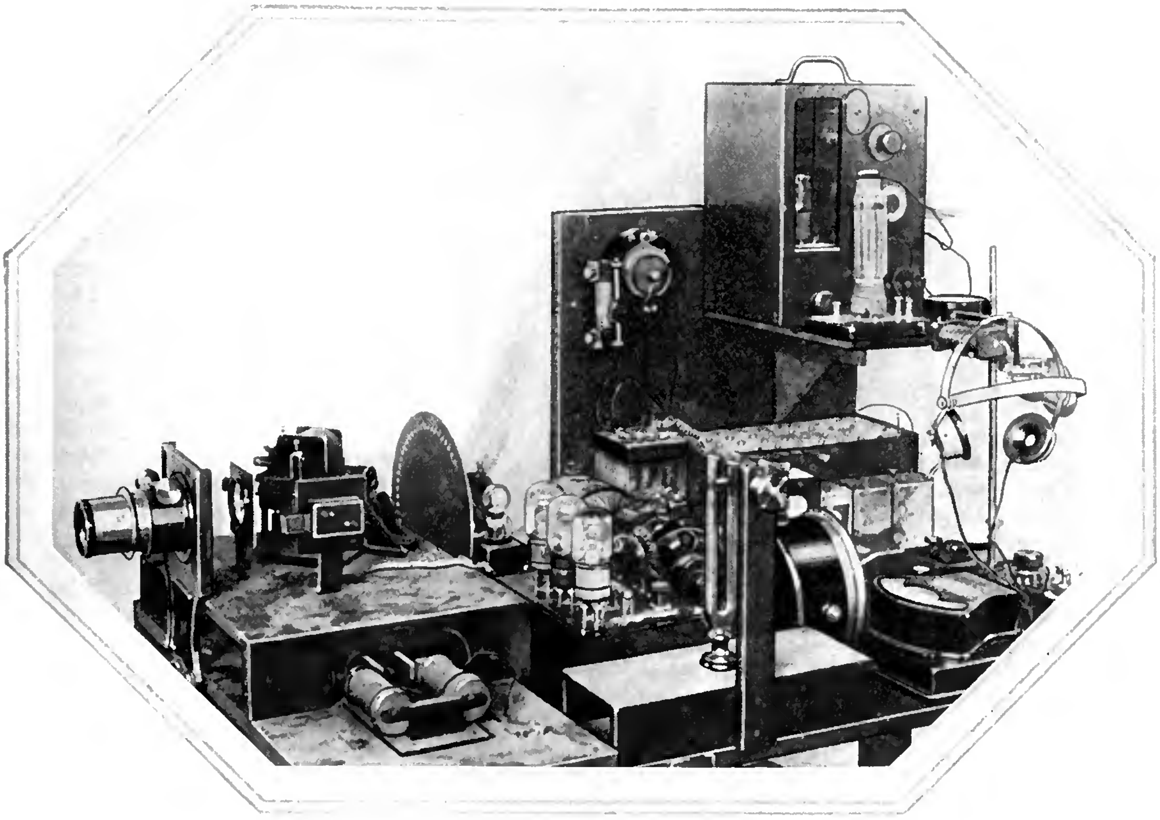


TELEVISION APPARATUS OF A EUROPEAN SCIENTIST

THIS equipment constitutes the television receiver developed by M. Holweck, who is collaborating with Edouard Bélin in the design of television equipment. M. Holweck is specializing in the receiving side of the installation. The received picture appears on the small circular screen at the top of the receiver shown in this illustration. Numerous other European scientists are devoting their time to the development of television schemes, and many and promising are the reports emanating from the various laboratories. M. Bélin is, of course, a Parisian and has done most of his work in France. The short story which begins on the succeeding page is from the pen of one who has visited many of the pioneers in the television field in Europe, and the information has, therefore, been obtained at first hand.



VON MIHÁLY'S TRANSMITTING APPARATUS

TELEVISION IN EUROPE

By WILLIAM J. BRITTAIN

WHAT is Europe doing towards the furtherance of television? America already knows quite a lot about the work of Baird, and the public company formed to develop his machines has made his name known in most countries. But aside from this, little is known of the progress of the many experimenters in this fascinating art on the other side of the Atlantic.

Recently the author went from England to find out what the Continental men are doing, what their apparatus is like, and whether they are preparing a surprise for the world, and in Berlin was found the man preparing the surprise. He is Dénes von Mihály, a young Hungarian, and chief consulting engineer to A. E. G. (the General Electric Company of Germany). An engineer brought from America for the purpose is making a simplified version of Von Mihály's apparatus to be shown in Berlin and London as a preliminary to forming television companies there.

The vital feature of Von Mihály's method is an oscillograph which consists of a tiny mirror mounted on twin wires. The mirror vibrates between two electro-magnets at speeds which sometimes reach thousands of times a second. Light reflected from the object—a face, a scene, or whatever it may be—is focussed by a specially constructed set of Zeiss lenses upon the mirror. The mirror, vibrating rapidly, sees each point of the object in turn, in the manner necessary for television, and flashes it to a photo-electric cell.

Von Mihály has made his own cell, and it sends out currents corresponding exactly to the intensity of light or depth of shadow of each tiny point as it is reflected upon it.

In his receiving apparatus Von Mihály again uses vibrating mirrors. An electric lamp, shining brightly or becoming dim as the current from the transmitter is strong or weak, is concentrated by lenses upon mirrors which repeat the action of the mirror at the sender and zig-zag a beam of light over a ground glass screen. The varying light beam, covering the screen eight times a second, makes up the picture.

To ensure that the sending and receiving mechanisms are working exactly in time—so that the mirror at the receiving end is shining light upon the centre of the screen at the same fraction of a second as the mirror at the transmitting end is "seeing" a bright part in the center of the object—Von Mihály uses a tuning fork arrangement on the same principle as those that have been used by experimenters in phototelegraphy. A tuning fork in the receiver, kept vibrating by an electro-magnet, acts as a switch, regulating current to other magnets which allow a wheel to progress one cog for every impulse, and so regulate the vibrations of the mirror. The apparatus at each end now fills a table, but Von Mihály says he can simplify it to work as a home set in conjunction with a one-tube radio receiver.

Behind this assurance is a secret. The secret is in a small black cylinder, five inches by two and a half inches. The inventor calls it his "little black wonder." He will not tell the world what is inside, but told the author that with it it is possible to do away with the great amplifiers necessary in other systems.

"Television sets for the home," he said, "will be simple and yet give a boxing match or a horse race. They will be sold in a few months for the equivalent of a hundred dollars."

Von Mihály has been working for thirteen years on television. He first became interested when he was twenty, after hearing a lecture on photo-telegraphy by Professor Arthurn Korn. He carried on his work for the Austria-Hungarian government during the war, and on July 7, 1919, gave his first crude demonstration of television. Ministers in the laboratory of the Telephon Fabrik in Budapest then saw on a screen the images of the letters M. D. and REX transmitted from the young engineer's home laboratory in another part of the city.

It was the writer's privilege to be present at a recent demonstration of Mihály's apparatus. The results obtained were considerably better than those of the early demonstrations referred to above, and the images were clearer than those seen by the author on Baird's screen. On the picture of a "televised" boy it was possible to see the collar, the wavy outline of the hair, the shape of the ear, the forehead, the eye, the nose, and the mouth, the latter merging into shadow on the left side of the face.

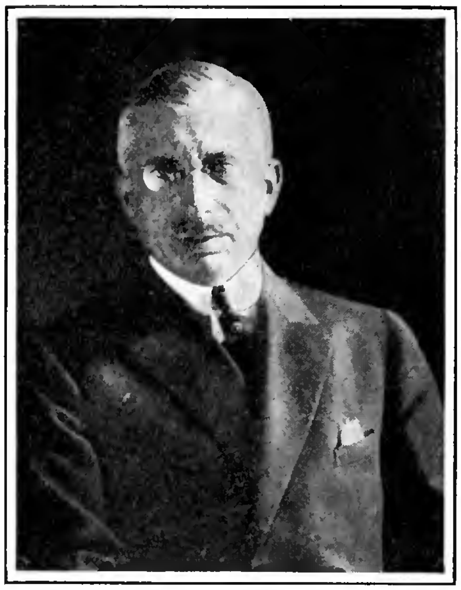
OTHER EXPERIMENTERS

PROFESSOR Max Dieckmann, whom I met in his station near Munich, Germany, has up to the present no result like this to show. He has achieved results, but has scrapped the transmitter and other apparatus that gave them.

"I used mirrors," he told me, "but I came to the conclusion that no mechanism could ever be made light enough and accurate enough for television. I am therefore trying to make use of electrons. By two electro-magnets, alternated by currents of different frequencies, I make the stream of electrons—or the cathode ray—zig-zag over the object, and I am now experimenting with devices to register the result of this 'exploring.'

"With electrons I think I have the real instrument for television. Electrons are almost weightless and can travel at any speed we need. All mechanism has a weight and inertia that in my opinion will always drag down efforts at perfect television. By perfect television I mean, of course, the reception of images as fine as published photographs. It is possible now to have crude television. You can have a picture on as large a screen as you like, but the larger the screen is the larger must be the patches making up the picture. Distance of transmission, too, offers little difficulty. We must concentrate on producing a finer image, and I believe electrons will enable us to do it."

Professor Dieckmann is retaining his

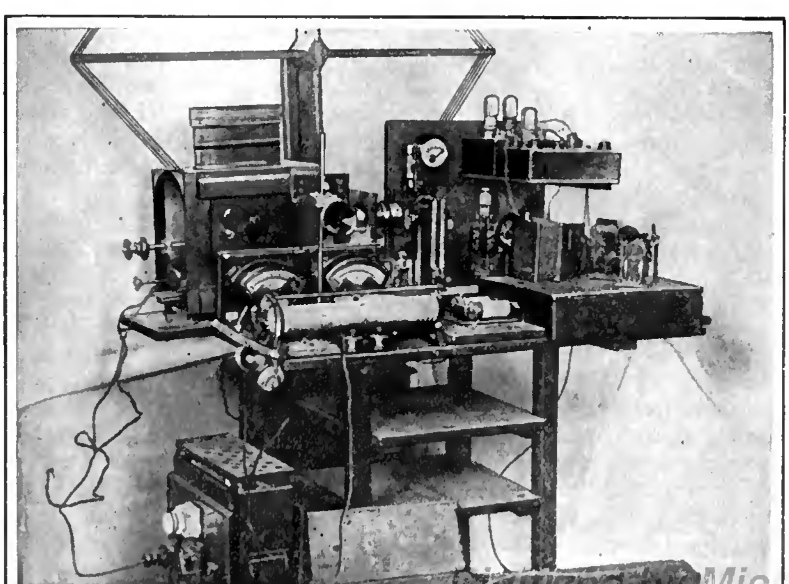


PROFESSOR MAX DIECKMANN

former receiver which already uses electrons. The receiver is like a bottle. The received currents vary the flow of electrons from a tube fixed to the neck of the "bottle." By magnets similar to those in his new transmitter the varying flow of electrons is made to zig-zag over a screen at the bottom of the "bottle" which glows as the electrons touch it. When a strong current, showing that a light part of the object is being encountered at the transmitter, sets off a heavy flow of electrons, the screen glows strongly at that part, and the glowing patches make up the picture.

With Mr. Rudolf Hell, his chief assistant, Professor Dieckmann is working with enthusiasm at his latest apparatus.

Mirrors form an essential part of the apparatus of M. Edouard Bélin, the scientist famed for his systems for phototelegraphy, who has large stations at La Malmaison, near Paris. M. Bélin inspired cartoons with a television machine thirty years ago. His latest apparatus looks businesslike.



VON MIHÁLY'S TELEVISION RECEIVING APPARATUS

Two rectangular mirrors, about half an inch long, set at right angles, are made to oscillate by cranks and connecting rods driven by an electric motor. A beam of light shines on the mirrors and is reflected zigzag in the usual way. For his object M. Bélin uses his hand. Light from the hand as the beam passes over it is caught by an eighteen-inch concave mirror at the bottom of a drum which concentrates the light on a photo-electric cell held by an arm half-way down the drum. With this apparatus, M. Bélin told me, he can record fifty thousand flashes of light and shade a second.

M. Holweck, collaborator with M. Bélin, is responsible for the receiver. He has designed a special form of cathode ray oscillograph in which as complete a vacuum as possible is kept by an air pump, also of his own design. M. Holweck is working to perfect the fluorescent screen so that it will vary its glow exactly according to the strength of the stream of electrons. He has also made the apparatus more sensitive so that a difference of potential of five volts between the grid and the filament will absolutely cease the flow of electrons. This means that slight differences of light and shade in the object, and therefore, tiny differences in the current received, are recorded on the screen.

Promising results are being obtained. At present M. Bélin is transmitting only the silhouettes of his hand. On the screen the outline of the hand can be seen clearly. The hand can be seen to move, and the fingers to bend. A silhouette of the profile of a face, and a simple photographic negative, have been transmitted with equal success.

"Our work is progressing gradually" said M. Bélin. "We have found it better to pass over the object a bright spot of light rather than illuminate fiercely the whole object. It we used flood lighting to obtain the same brilliancy as our spot light gives us over a person's face the intensity would be insupportable.

"Earlier in the year we were sending over our object in a thousand points; now we have reached two thousand five hundred. We cover the object eight times a second which means that in our ordinary experiments twenty thousand signals are flashed a second. We are greatly encouraged by our present results. In a few months we should have something to offer the world."

This is the stage European inventors have reached. Each one of them is watching carefully every step forward by other workers and trying to go a step further. Von Mihály is confident that all his system needs now is to be put on the market. Dieckmann and his young assistants are working quietly but eagerly. And all the time I was at the *établissement* Edouard Bélin I was filled with the boyish enthusiasm which permeates the atmosphere there.

Of hopes and plans it would be possible to write pages but in this article an attempt has been made to keep plainly to facts to let America know just what Europe is doing in television.

THE MARCH OF RADIO

NEWS AND INTERPRETATION OF CURRENT RADIO EVENTS

How the Radio Commission Can Set Radio to Rights

As THE peak of the radio season approaches, we look upon the situation with considerable satisfaction. Last year, broadcasting was in chaos and the Radio Act had not been passed; this year, progress has been made in the direction of restoring order. Public interest in radio is at a maximum; the Radio Show at New York broke all records for attendance at an industrial exposition. Manufacturers and dealers report brisk sales. Broadcasting now has the stimulus of two competing chains. Everywhere there is activity and progress.

The only sore spot in the radio situation is in the regulation of broadcasting. The Commission went about its task with diligence as soon as it was formed. It cleared the Canadian channels and put the stations back on even ten-kc. channels. Then it spaced the New York and Chicago broadcasters at fifty-kc. intervals, forcing time sharing in some cases to make it possible. After these commendable steps had been taken, the Commission confined its activities to juggling a channel here and switching a station there.

We understood that the assignments of June 15 were merely an experiment, a stopgap measure effective only until a comprehensive plan of allocation could be worked out, which would mean an end to the heterodyne whistle. The persistently optimistic announcements of the Commission that the broadcasting situation is now remedied give the impression that the Commission considers its major task completed.

At the opening of the Radio World's Fair, Admiral Bullard pleaded for more time to give the Commission an opportunity to do its work; at the Radio Industries Banquet, he made numerous proposals to the radio industry, many of them no less than amazing, but nowhere have we had a simple, direct statement of the future plans of the Commission. Does the Commission consider its task virtually completed or will it devote itself to a radical improvement of broadcasting conditions?

The Admiral's speech at the banquet contained some striking indications. Briefly, he stated that broadcasters should find a way to fix the responsibility for statements made in radio advertising; that direct advertising stations should be taxed; that radio ought to be a public utility regulated by public service commissions; that provision should be made to link up broadcasting for national sos calls, perhaps for such occasions as the loss of the President's racoon; that motors for electric elevators should be re-designed; and most ingenuous and amazing, that receiving sets should be equipped with crystals to permit of greater selectivity.

A few words at the very end of this astounding speech were devoted to the Commission's plans. With regard to the high power stations serving the long distance listener, "the Commission is looking forward to a time when the listener, on any night of good reception, can hear broadcasting stations from the Atlantic to the Pacific, from Canada to Mexico, without interference, on channels cleared for them, not by arbitrary rulings of the government, not by fixed and necessarily discriminating classifications, but by the normal, logical process of demonstrated fitness and capacity to render a great public service. Such a development is entirely practicable on the basis of allocations now in force. It requires no sweeping changes, but only a clear picture of the ideal to be attained, and a steady careful improvement of existing conditions. . . ."

Thus the ingenious Commission will by "orderly and natural, rather than by autocratic and arbitrary methods" bring us these ideal listening conditions. No one, unless it be the broadcast listener, will be imposed upon; only stations which elect by natural processes to eliminate themselves will be taken off the broadcasting lists.

The listener unless he lives within the shadow of a broadcasting station, that is, in that short distance which engineers like to call the service range, must put up with disagreeable heterodyne whistles. Only if we use "arbitrary" methods, which means actually applying the regulatory powers with which the Commission is endowed, can we hope for fewer stations. The natural tendency is toward increasing the number of stations and the power they use. The Commission leans upon a broken reed, if it expects "normal, logical processes" to eliminate stations. Rubber spine methods cannot help the broadcasting situation. There is only one solution, which we repeat, like Cato and his "Carthage must be destroyed," and that is the elimination of at least four hundred broadcasting stations.

What Can the Commission Do?

SECTION IV of the Radio Act authorizes the Commission to classify broadcasting stations, to prescribe the nature of service rendered by each, to assign bands and powers, and to determine the location of stations. There is no limitation on how far it may go in its work of classification.

Why does not the Commission use these powers? Why does it not classify broadcasting stations as (1) national, (2) regional, (3) local; divide the country into geographical areas and prescribe exactly how many

A RADIO TOUR OF THE CONTINENT

Capt. L. F. Plugge, an English radio enthusiast, spent the months of July and August on a tour which the accompanying map shows. There were two radio-equipped cars, one of which is illustrated. Each had a loop-operated super-heterodyne and a short-wave transmitter operating on 6660 kc. (45 meters). Intercommunication was attempted and reception conditions along the route noted stations of each class shall be licensed in each of those areas?

Public convenience and necessity clearly establish the point that interference among stations should not be tolerated and certainly the Commission should be competent, if it earns its keep, to determine how many stations of various powers will be accommodated in the present broadcasting band. In fact, all of these points have been analyzed for it by qualified experts in precise and unequivocal terms.

NATIONAL STATIONS, to which exclusive channels should be assigned, might be defined as follows: (1) *Power*, 10,000 watts or over; (2) *Service*, fifty hours a week or more; (3) *Location*, at least ten miles from all centers of 100,000 or more population and at a point more than fifty miles from the nearest national station and not within 200 miles radius of more than five national stations.

REGIONAL STATIONS, sharing channels with other regional stations more than 1000 or 2000 miles distant: (1) *Power*, 2000 to 5000 watts; (2) *Service*, at least twenty-five hours a week, and (3) *Location*, not more than 100,000 population within a five mile radius, nor more than five regional stations within 100 miles.

LOCAL STATIONS: (1) *Power*, between 250 and 500 watts; (2) *Service*, at least twenty-five hours; and (3) *Location*, such that there are not more than five local service stations within a hundred mile radius.

Such a program would, of course, require the elimination of stations in a few of the congested areas, a blessing to the radio audience. The stations so eliminated need not go out of business, but merely consolidate with others serving the same area. Stations of less than 250-watt power should be ruled off the air at once, not because they themselves contribute seriously to congestion but because their channels might better be assigned to national or regional stations.

Concrete suggestions, which are not only logical, but also require the exercise of some of the "arbitrary" powers conferred upon the Commission by law, may be in order. We respectfully suggest the promulgation and actual observance of regulations for the accomplishment of four objectives, the constitutionality of which cannot be questioned:

1. ALL STATIONS should be required to adhere to their frequencies and those failing to do so, after occupying their assigned channels for more than thirty days, should be fined $500 for each violation noted, *without any further consideration of their cases*. The Commission has been buncoed by whining station managements into the belief that staying on a channel requires extraordinary equipment and engineering genius. A station failing to adhere to its channel is not technically competent and not worthy of a franchise on the air. Furthermore, after its fourth offense, a station's license should be cancelled, without further consideration of the case. The ether space thus regained should not be assigned to a new ether nuisance, but utilized in relieving congestion where it exists. The Commission's leniency with regard to channel wobbling, to which it attributes practically all heterodyning, is a remarkable example of unwarranted bashfulness and consideration the stations don't deserve. The five hundred dollar fine for each violation of the Commission's regulations gives the Radio Act plenty of teeth but, to our knowledge, the Commission has never tried them out.

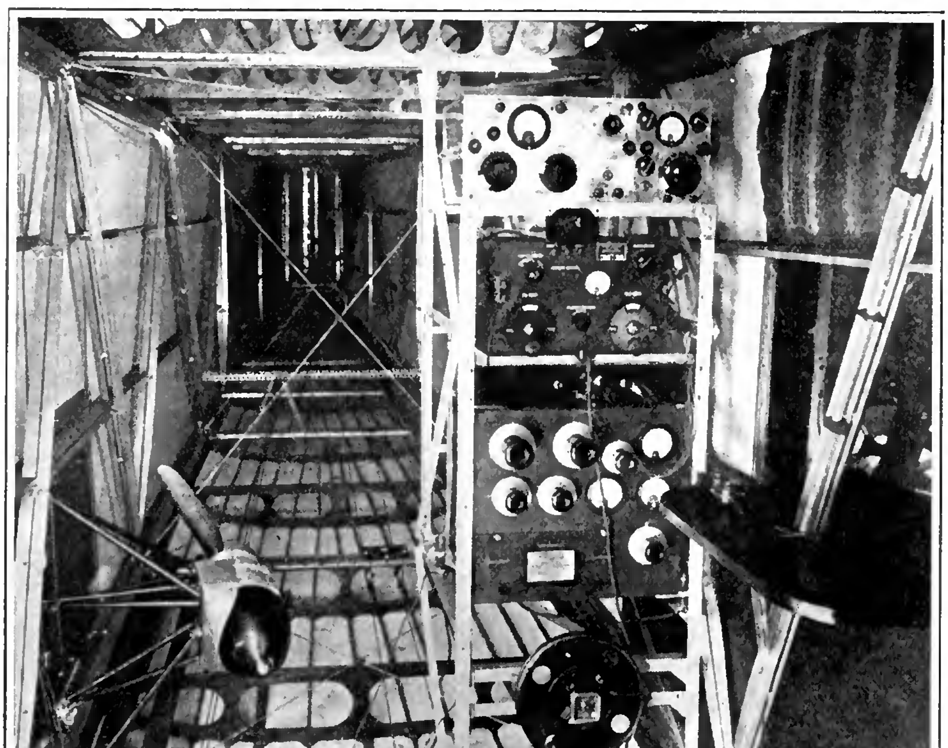
2. THE COMBINATION and consolidation of broadcasting in congested areas should be encouraged by guaranteeing to the consolidators the combined broadcasting privileges of the stations so consolidated. For example, four, full time, 500-watt stations, combined into one, should be permitted a power increase to 2000 watts, or two, half-time stations, forming one, should receive full time. Furthermore, all local and regional stations, not sharing the same channel, which combine, should be guaranteed privileged consideration on the basis of program merit, should they seek to secure full time on a single channel by challenging another station.

3. POWER INCREASES to local and regional stations shall not be granted where congestion exists, unless other stations, having a power equivalent to the increase, be absorbed. Thus, for example, for a thousand-watt station in New York to jump to 1500 watts, it should be necessary for it to absorb a 500-watt station.

National stations, on the other hand, serving large areas, should be encouraged to increase power, because they require clear channels and failure to employ the maximum power means that they are not making full use of the channel assigned to them.

4. THE COMMISSION, empowered to assign hours of broadcasting to stations, should conserve ether space by limiting licenses only to hours actually used by the stations concerned. It has left problems of time division to the stations themselves, instead of utilizing its power to help in relieving congestions. There are many broadcasting stations which are assigned fifty per cent. of the time on a channel which use only ten per cent. of it, while the other station on the channel is required to remain silent, although it has program material to fill the unused time. In congested areas, the assignment of the time should be based upon the average hours which a station broadcast over the same period in the preceding year. Increase over this time should be granted only upon the basis of program merit and service, or the unused time held to encourage consolidations and to accommodate other stations.

The present assignment of forty channels to New York and Chicago, nearly half the ether space in the eastern part of the United States, is an imposition upon the listener. Yet new stations are being licensed in New York and Chicago, although six stations in each of those cities have corralled ninety per cent. of the audience. This concentration of broadcasting facilities in two centers



A COMPLETE RADIO INSTALLATION ON AN AIRPLANE

Although the *Ville de Paris*, the Sikorsky airplane built for Captain Fonck, the noted French flier, never started toward Paris, plans for the flight were exceptionally complete. Top right shows the small transmitter and a larger set below it. In the center is a regenerative receiver and at the extreme bottom, the antenna reel. The motor generator unit is at the extreme left and supplies plate current for the transmitter. The generator and propeller can be swung out through the fuselage when in use of population forces the rural listener to contend with heterodyning all over the dials and precludes power increases in rural areas where better and bigger stations are actually needed.

The Federal Radio Commission has worked long and hard with its problem. It has done the best possible job without seriously disturbing or curtailing the privileges of the broadcasting station owners. But, so long as it fails to regard its duty as serving the interests of the listening public, and fails to use the ample powers conferred upon it by the Radio Act to reduce the number of stations on the air, ether congestion will remain the unhealthy disease of the broadcasting situation.

$100,000 to Improve Broadcasting

THE National Association of Broadcasters appropriated the sum of $100,000 to make a scientific study of broadcasting. It plans to employ field engineers and program specialists to visit individual stations throughout the country. The procedure of the Association in the effective utilization of this fund has not yet been established. If it is sensibly administered, very valuable contributions can be made in the technical, economic and program problems of the broadcaster. From the technical standpoint, studio methods, as they affect transmission quality, and the correct operation of the broadcasting stations to help in eliminating ether congestion are fruitful subjects for research. The Association might well help in determining just what the capacity of the broadcasting band is with regard to power, service range and geographical location of stations.

In the field of program technique, critical study of the outstanding features and systematic examination of voice and musical instruments which make good broadcasting could be very helpful. An investigation of the possibilities of building high grade programs by the use of recording methods, as suggested by Edgar H. Felix in a speech before the Association, might also be studied with a view to investigating its practicability. Mr. Felix suggested the recording of "scenes," blending the voices of speakers and pick-up music through mixing panels and the "editing" of programs much as films are cut and assembled, until the ideal feature is assembled. When thus worked over and perfected, it may be presented as often and through as many stations as its popularity warrants, without further cost for talent. This suggestion may result not only in better planned and coördinated programs, but it may help to reduce the mounting wire costs which commercial broadcasters now meet.

In the field of commercial broadcasting, a close study of the methods used to associate the commercial program with the product of its sponsor and to secure the most effective results in a manner pleasing to the listener might help to increase the effectiveness of commercial broadcasting, an end which is necessary to aid economic stabilization of broadcasting stations.

The National Association of Broadcasters is to be commended for its foresight in making this substantial expenditure, which is likely to be returned many fold through better broadcasting and larger audiences.

© Henry Miller

THE LATE COL. JOHN. F. DILLON

Colonel Dillon, member of the Federal Radio Commission from the Pacific Coast, died early in October. His loss will be keenly felt by the Commission and the radio world at large. A practical radio man of wide experience, Colonel Dillon had served in various technical capacities in the Signal Corps, and as radio inspector in charge of the Eighth District when headquarters were in Cleveland in 1913 and 1914. He was later transferred to San Francisco as Radio Supervisor for the Sixth District and it was from this duty that his appointment as a Radio Commissioner called him. His wide practical experience with government, amateur, and commercial radio made Colonel Dillon one of the most valuable members of the Radio Commission

What to Tell the Consumer—And Where

AFFLICTED with the expanded craniums resulting from mushroom growth, the larger manufacturers of the radio industry are often flattered into advertising excesses which ultimately cause financial embarassment. As typical of this trend, we received a dealer notice, not long ago, describing a new type of A, B, and C power device which was to make its debut to the world principally through three publications having a combined circulation of over three million copies. Although a prophet is not often recognized in his own country, so frequently has the folly of plunging into expensive national mediums been demonstrated to the radio industry, that most manufacturers first make an effort to sell the merits of their products among the more influential radio listeners.

The general public has been too frequently fooled by innovations to become immediate buyers through the medium of an advertising flash in national weeklies. They are inclined to consult the most expert enthusiast whom they can reach before they are willing to risk their money on a device which may fail. The more successful manufacturers establish their products among the more influential groups of radio buyers before they plunge recklessly into national campaigns in behalf of products which do not have behind them the weight of acknowledged approval of the better informed radio enthusiast. The influence of the radio enthusiast, like halitosis, is often the insidious element which prevents the success of the national advertising campaign which is not supported by the goodwill of well informed broadcast listeners and constructors.

WHAT BROADCASTERS WANT

A LIST of hearings scheduled by the Federal Radio Commission early in October indicates the evils of requiring hearings upon all applications, regardless of their merit. For example, WBAW, Nashville, Tenn., a 100-watt station, operated by a drug concern, seeks to increase its power to 10,000 watts, making it necessary for nineteen stations to defend themselves against this unwarranted incursion of their service range by the drug store carrier. There is no channel available for any new 10,000-watt stations anywhere.

Another hearing is demanded by WJBL of Decatur, Illinois, operated by a dry goods store, calling for a power increase which would damage the service of ten stations, including such widely recognized stations as WBAL and WJAX.

WORD, the Peoples Pulpit Association in Chicago, seeks to occupy the channel of WTAS and WBBM, both well established and serving large groups. There is little question but that the defending stations will be able to show the Commission the presumptuousness of those demanding these hearings, but it is unfortunate that lawyers, witnesses and disorganization of station staffs are required to do so.

"RADIO INDUSTRY" STANDARDS

H. B. RICHMOND, Director of the Engineering Division of the R. M. A., perhaps inspired by our suggestions as to the desirability of one set of radio standards rather than two, in an article in the R. M. A. *News*, suggests that the R. M. A. and the N. E. M. A. should combine their work of writing radio standards. Although, as Mr. Richmond points out, the R. M. A. has ten times as many members as the Radio Division of the N. E. M. A., the long engineering experience of the older organization and the great importance of the manufacturers comprising it, makes its coöperation in writing standards of vital importance. Mr. Richmond's fair exposition of the situation is a long step toward affecting a consolidation of the standards committees of both organizations, vitally necessary if either of them are to be in the least effective.

WHY THE SOUTH HAS FEW STATIONS

SENATOR Simmons of North Carolina recently launched an attack upon the Federal Radio Commission, declaring that it showed favoritism to stations in the North. Illinois, Nebraska and Missouri, with a population of fourteen million, have more licenses to broadcast than the eleven states of the south with their population of twenty-seven million.

The Senator is correct in his facts, but he disregards the point that the south has not been sufficiently progressive to erect its share of stations with the consequence that the Northerners have already filled their wavelength bands. So long as the Commission disregards future needs by filling the ether bands with New York and

Chicago stations, there is not room enough for better broadcasting service in the more remote areas.

HOW THE RADIO BEACON WORKS

THE radio beacon operated at Hadley Field, New Jersey, the terminus of the New York-San Francisco air mail route, has proved remarkably satisfactory. Two directional antennas are used, set at right angles. By means of a mechanical keying device, the letter "A" (dot dash) is sent from one antenna and the letter "N" (dash dot) is sent from the second. The transmissions are so timed that the dots and dashes exactly interlock so that, at the points where the signals from both transmitters are received equally, a continuous dash is heard. That point of equal signal strength is exactly midway between the directional signals of the two antennas. The radio listener aboard the plane can determine from the signals he hears whether he is exactly on the course or to the right or to the left of his course, because, in the former case, he will hear the steady dashes, while off his course, he will hear either A or N, depending on whether he is to the left or the right of it. The closer to the landing field he approaches, the more narrow the midpoint at which the signals are heard to form dashes. A few hundred feet from the beacon station, a deviation of ten or twenty feet from the course is clearly indicated by the signal in the headphones.

THE NEW WEAF TRANSMITTER

IN SPITE of its 50 kw., the initial broadcasts of WEAF at Bellmore proved a disappointment to many New York listeners who have depended upon WEAF for their principal program service. There are large areas within twenty-five miles of New York which, due to the change of location, now receive a weaker signal from the 50-kw. transmitter than they did from the old 5-kw. at West Street. There have been other instances when the removal of stations, even a short distance from the congested areas to permit increase of power, have actually reduced the number of persons served.

The transmitting apparatus at Bellmore is the last word in perfected control. The operator in charge sits before his desk and manipulates a number of buttons controlling each operation in the station, which has the proportions of a fair sized power house. If one of the water-cooled rectifier, oscillator or modulator tubes burns out, a light indicates the faulty tube. Pressure of a control button takes it out of service and connects a substitute without interruption of broadcasting.

The receiving set used to maintain the SOS watch has a range of several thousand miles and will be used to advantage by WEAF's operator. WEAF's SOS watches already have the remarkable record of being the first to hear SOS calls in the New York area and notify naval and coast guards in one case out of each three and of hearin the SOS simultaneously with naval and coast guard stations in the same proportion. Most broadcasting stations continue blithely on the air through SOS calls until the silence of the ether around them impresses them with the fact that there must be something wrong.

NEWS OF THE PATENT FIELD

ELEVEN claims of F. A. Kolster's patent 1,637,615, were declared invalid in a decision by the Second Assistant Commissioner of Patents on the grounds that the applicant's combination claim to a radio compass having a coil form of antenna was not novel and was well known at the time the applicant entered the field. ❦ ❦ ❦ THE PATENT Office *Gazette* mentions the following suits over radio patents: Westinghouse vs. Allen Rogers, Armstrong 1,113,149; Radio Frequency Laboratory, Inc. vs. Federal Radio Corporation, Warren patent 1,603,432. ❦ ❦ ❦ THE DUBILIER Condenser Company has filed against the Radio Corporation of America on various socket power patents. ❦ ❦ ❦ JOHN V. L. HOGAN filed against the American Bosch Magneto Company, Stewart Warner Corporation, Freed-Eisemann, Freshman, and Splitdorf for recognition of his patent 1,014,002, and also against a large department store for its sale of Crosley, Stromberg Carlson, Federal and Fada sets which he alleges infringe his basic patent. ❦ ❦ ❦ A. H. GREBE and Company, Stewart-Warner, and the Consolidated Radio Corporation (Wells Gardner, Chicago and Precision Products Company, Ann Arbor, Michigan) are now R. C. A. licensees.

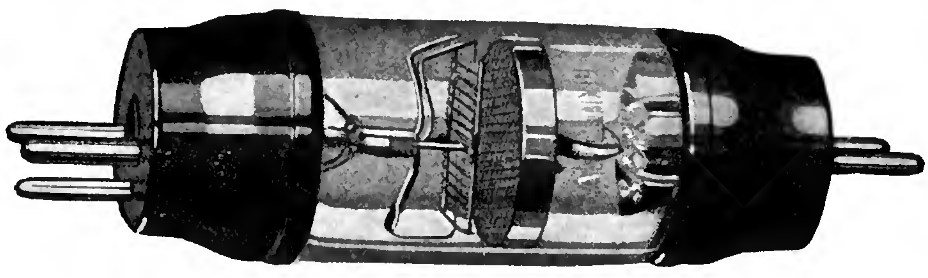
The Month In Radio

THE Eastman Kodak Company suggests that RADIO BROADCAST encourage the use of the term "phototelegraphy" rather than "telephotography" in referring to the radio transmission of pictures. "Telephotography" is used among photography experts to denote the taking of pictures over long distances by the use of special lenses, although Webster approves the use of the term to describe the transmission of pictures by radio or wire. Indeed, so extensive has been this latter use in scientific circles that it would require much more than the approval of RADIO BROADCAST to bring about a change in the accepted terminology. Perhaps a compromise may be suggested which may help to eliminate the confusion. Why not refer to telephotography in the sense of transmitting pictures by wire or radio, as "radio photography" or "wire photography," as the case may be? ❦ ❦ ❦ RADIO will perform a new feat in eliminating the isolation of explorers when the Army Signal Corps and the Pathe Company participate in their exploration of the Grand Canyon of the Colorado. The expedition will traverse the entire length of the canyon, taking moving pictures and collecting data of scientific and educational value. Accompanying the explorers will be a radio telephone transmitter which will be used to link them with broadcasting station KGO, from which reports will be broadcast through a chain of stations. The explorers will venture into dangerous and heretofore inaccessible parts of the canyon. ❦ ❦ ❦ WE NOTE in the list of changes ordered by the Federal Radio Commission, authorization to move KFKX from Hastings, Nebraska, to Chicago, Illinois. KYW has shared its channel with KFKX. The result of the move is to give Chicago listeners the full use of the channel without increasing station congestion. Nebraska and the great open spaces, however, suffer a curtailment of broadcasting service. ❦ ❦ ❦ KOIL is now transmitting its regular programs on 4910-kc. (61.06 meters), as well as its regular channel in the broadcasting band. KOIL is a member of the Columbia chain. ❦ ❦ ❦ THE MACKAY Companies purchased the Federal Telegraph Company's communication system, according to a recent announcement. The Federal Company's equipment consists of high powered arc stations installed along the Pacific Coast for point-to-point service in California, Washington and Oregon, and ship-to-shore service on the Pacific. ❦ ❦ ❦ WE ARE opposed to the radiation of the same program by stations covering the same service area. The listener is entitled to as much variety as the congested ether permits and the employment of two channels to do what may be done effectively with one is a waste of ether space. This practice is frequently indulged in by chain stations. ❦ ❦ ❦ A NOVEL use of broadcasting was employed by the United Gas Improvement Company of Philadelphia to warn its customers that gas service had been temporarily discontinued because of damage by an accidental blast. Undoubtedly, this prevented many accidents upon the resumption of service. ❦ ❦ ❦ THE *American Agriculturist* should be able to write a volume on the service of radio to the farmer as a result of the contest which it recently announced. It offers not too large prizes to farmers writing the best letters on the service which radio renders them. There have been many instances of thousands of dollars of saving through weather and market information. ❦ ❦ ❦ ❦ ❦ ❦ BROADCAST LISTENERS in Germany now number 1,713,899, according to *Wireless Age*, an increase of 78,171 in a three months' period. ❦ ❦ ❦ THIRTY MILLION dollars worth of radio apparatus was involved in international trade in 1926, of which about thirty per cent. consisted of American shipments, twenty-five of German, and twenty per cent. of British. Exports from the United States decreased twelve per cent. in 1926 as compared with 1925, but the figures for the first half of this year show a revival of business. During the first half of 1927, American exports, were $3,705,861, an increase of $450,000 over the same period for the previous year. ❦ ❦ ❦ OUR BRITISH contemporary, *Popular Wireless*, made some measurements as to the radiation range of a two-tube receiver, consisting of one stage of r. f. and detector. The set was presumably a non-radiating one, but actually its radiations were readily heard at a distance of twelve miles, although but fifty volts of plate battery were used. The radiations were found to blanket an area of nearly two hundred square miles in which some five million people reside.

A TUG CAPTAIN WHO CAN TELEPHONE FROM HIS BOAT

More than forty British-Columbian tug-boats, used in towing lumber on the waterways, are equipped with 50-watt radiophone sets, tuned to 1507 kc. (199 meters). The view above shows a Captain's cabin and the complete receiving and transmitting installation

APPLICATIONS OF THE FOUR ELECTRODE TUBE



AN ENGLISH SHIELDED-GRID TUBE

In England and on the Continent, four-electrode tubes have been available for some time. The original research is credited to Schottky in Germany and the "shielded-grid" tube which has recently appeared in this country is credited to Dr. A. W. Hull

By THEODORE H. NAKKEN

A REVIEW of the progress of receiver design, which is possible by turning over the advertising pages of some early radio magazines, would offer some surprising evidence. We would see that mechanical improvements, refinements, and modern methods have been the cause of radical changes in receiver pattern, and have so simplified operation of tuning as to make the modern receiver seem as far in advance of its forbears as is the present-day automobile ahead of the automobile of fifteen years ago. Yet we would note that there has been no basic change in the type of circuit used. The regenerative receiver of ten years ago still stands unchallenged as a sensitive device for translating signals from a distant broadcasting station.

In searching for the reason of this lack of change in circuit arrangement, it will occur to us that we have reached a limit, and that it is almost impossible to obtain greater amplification than the present-day receiver gives us. And this limit is easily located as lying in the inherent characteristics of the vacuum tube as manufactured to-day. Even with its better filaments and better all round design, the vacuum tube of to-day has exactly the same fundamental characteristics as it had when first conceived and built as an experiment. It follows, then, that if any improvements in receivers are to be expected, such improvements will not be realized before radically improved vacuum tubes are made available.

But if we boldly lay the lack of actual progress at the door of the commercial vacuum tube, we must state why the tube should be responsible and how its inherent faults can be eliminated. The indictment against the present-day vacuum tube covers in the main two points—lack of amplification and the tendency to cause oscillations due to inter-element capacity. Another charge that may be brought forward is inefficiency, but this is almost identical with its lack of amplification. How to improve these conditions seems at the present time more important than all other efforts combined to make better receiver circuits, and so we will try to indicate shortly why the vacuum tube is inefficient, and how we can largely do away with the inter-element capacity, so as to get better all around performance from any circuit.

The ordinary vacuum tube contains three elements—filament, grid, and plate. The filament acts as a source of electrons when heated; the plate, by virtue of its positive potential, causes these electrons to be attracted to itself and thus establishes a plate current; the grid, interposed between filament and plate, governs the amount of electrons that can reach the plate, acting, therefore, as a controlling element of the plate current. The grid, generally being held at a negative potential, tends to prevent electrons from wandering away from the source (the filament). The plate attracts electrons only by virtue of its high positive potential, and overcomes the repelling effect of the grid.

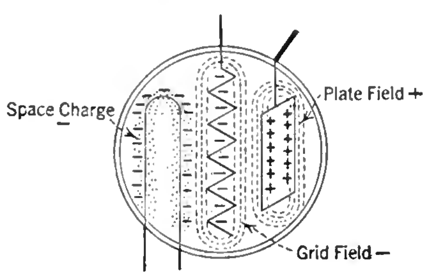


FIG. 1

In the three element tube there are three static fields which govern the tube's functions. From this diagram it is seen that there are two negative fields, both of which impede the flow of electrons to the plate

It is not only the grid that tends to repel the electrons emitted by the filament but this repellent action is also exercised by the electrons themselves. In fact, we may say that the filament is surrounded by a cloud of electrons, which therefore constitute a negative charge, trying to drive the electrons back instead of allowing them free passage to the plate. See Fig. 1. Hence the plate must not only overcome the effect of the negative grid, but it also must nullify the effect of this cloud of electrons, which generally is called the space charge, in addition to its duty to attract electrons and thus establish the plate current.

There are two combined factors then which tend to retard the flow of electrons from filament to plate—space charge and the grid, and both are counteracted by the plate potential. It follows that part of the plate potential is utilized only to overcome the repellent action of space charge and grid, and of course, as far as amplification goes, this part of the plate potential is virtually useless. We may then say that the statement to the effect that the tube is inefficient is proved, the more so when it has been established that, in most designs, only from 10 to 15 per cent. of the plate potential is actually available for the establishing of plate current, and the remaining potential serves the purpose indicated.

We know that the space charge is virtually a constant and its effect is added to that of the grid effect. The space charge, having its sphere of influence much nearer to the source of electrons than the grid, is much more powerful in its action, and thus a variation in grid potential, while representing a comparatively large change of the grid action on the flow of electrons, is decreased in its effect by the fact that it represents only a comparatively small change in the total sum of the retarding action of grid and space charge combined. Here again we may say that the tube is proved to be highly inefficient, but now in the sense that the presence of the space charge prevents the grid from being fully effective.

It follows from the foregoing remarks that the main reason for the inefficiency of the vacuum tube may be sought in the presence of the space charge. In fact, if the latter were absent, we would need only a small plate potential to obtain the identical results as at present, with the additional advantage that the grid would be fully effective because the grid field would be the only factor governing the magnitude of the electron flow to the plate, instead of only part of the sum of two factors, of which the second one, the space charge, is by far the greater. The truth of the matter is that, if only the space charge were absent, the grid effect would be from three to four times greater than at present, *i.e.*, without any

FOR the last four years, foreign radio periodicals have contained a wealth of articles on the advantages of the double-grid tube. These tubes are chiefly used by our foreign neighbors because of their economy, but it has been inevitable that these tubes should make their appearance in this country. More than a year ago, two manufacturers brought sample double-grid tubes to the Laboratory but the time was not yet ripe for their general introduction. In April, 1926, Dr. A. W. Hull of the General Electric Laboratories described his "shielded-grid" tube in the Physical Review *and on October 1st the New York newspapers carried the announcement of the Radio Corporation that a "shielded" grid tube—the* UX-222*—was in the process of commercial development and would be ready for the general public "some time in the future." Believing that our readers would be interested in a review of important information on double-grid tubes, the following article was prepared at our request by Mr. Nakken who is familiar with the use and operation of multi-grid tubes on the Continent.*—THE EDITOR.

further changes in the tube the amplification factor would jump from, say, 8 to 30, yet the internal impedance of the tube would remain the same

THE FOURTH ELEMENT

When we consider the static fields present in the vacuum tube we will see that we can count three—space charge, grid field, and plate field. The former two are negative while the latter is positive. The space charge, as we have seen, is a constant, or virtually so, and must be nullified by part of the positive plate field. If, then, a second positive field were introduced, nearer the filament, and thus nearer the space charge, a fairly low potential field would easily nullify the latter's effect. Obviously this can easily be done by a fourth element, which would, of necessity, be placed either between filament and grid, or between grid and plate. This element, however, should not obstruct the flow of electrons from filament to plate, hence it should be an open structure, and for this reason logically take the form of a very open grid. In this way the four-element (double-grid) tube was born.

Let us consider for a moment that such a grid is placed between filament and grid, as in Fig. 2. Due to the construction of the tube it is much nearer the filament than the plate, and as the influence of such a field is inversely proportional to the cube of the distance, it becomes apparent that, if this grid is placed at, say, one third of the distance between filament and plate, its field is 27 times more effective than the plate field. Thus, if in the ordinary tube 90 volts is used on the plate, approximately 3 volts would suffice on this fourth element to completely do away with the space charge effect. This, first of all, increases the percentage effectiveness of any

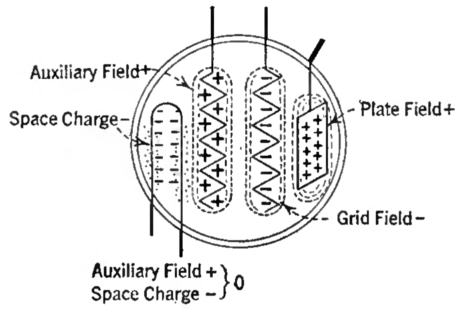


FIG. 2

When an auxiliary positive field is introduced into the tube, the negative field due to the filament is overcome, leaving the total negative field (which is detrimental to the progress of electrons to the plate) in a much reduced condition

potential change on the controlling element, the grid proper, so that we reach automatically a much higher amplification factor, and secondly, makes it possible to decrease the plate voltage considerably, say to ten or fifteen volts, and still retain a tube of the same general characteristics as the three-element original.

It should be noted here, that we have assumed that this fourth element is built into an ordinary tube. The result then is that we have not increased the capacity between the plate and grid, and thus have not increased the tendency of the tube to oscillate due to capacitive feedback. This is a very important consideration, because it is easy enough to build an ordinary three-element tube with as high an amplification factor, as is done with modern high-mu tubes. But the latter is accomplished by narrowing the grid, *i.e.*, by increasing the plate-to-grid capacity, and hence such tubes are almost completely unfit for radio-frequency amplification. In such a tube the tendency for capacitive feedback is increased tremendously, and this capacity affords an easy path for the signal potentials to escape via the plate and become ineffective. As will be seen in Fig. 3, there is nothing strange in the hookup of a four-element tube, the extra electrode being hooked directly to some part of the B battery.

Milestones in Vacuum Tube Progress

Edison discovered "Edison Effect"	1883
Fleming experimented with Edison Effect	1896
Fleming patented the two-element rectifier tube	1905
DeForest added third element to Fleming valve	1907
Tubes used in transcontinental telephony	1914
Radio telephony from Arlington to Honolulu	1915
Introduction of "hard" tubes to general use	1920
Appearance of thoriated filaments	1923
General use of power tubes	1926
Development of high-current low-voltage filaments	1927
Development of shielded-grid tube	1927

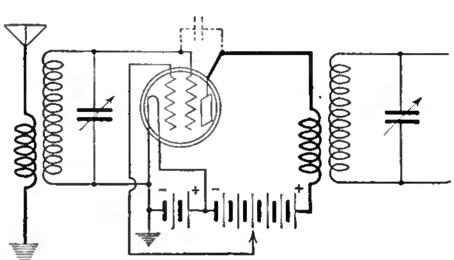


FIG. 3

This diagram is that of a single radio-frequency amplifier using a double-grid tube, the inner, grid being at a positive potential with respect to the filament. The grid-plate capacity remains unchanged

We will now consider the second possibility in construction, *i.e.*, that of placing the fourth element between grid and plate. Of course it must take the form of an open grid, as its purpose again is only to create a positive field, to be used to nullify the space charge effect.

Let us suppose that the tube is now so constructed that this element is placed halfway between filament and plate, in which case it follows that its effect on the space charge is eight times greater than the same potential on the plate. If, then, normally the plate has a potential of 90 volts, a positive potential of 12 volts will be equally effective when applied to the fourth element, so that once more the plate voltage can be decreased to, say, 22½ volts. Due to its open construction the positive grid offers no obstruction to the flow of electrons, and itself draws only a very small current. Once more we make the grid fully effective in its influence upon the flow of electrons, so that the amplification factor of the tube has been materially increased.

But simultaneously we have attained another effect, which merits close investigation. The positive grid, being held at a constant positive potential by the expedient of connecting it to a point on the B battery, may be stated to be constantly at a certain potential above ground potential. But after all, it *is* grounded. As it is interposed between plate and grid, it has the effect of splitting the capacity between these two elements into two capacities, in series as can be readily seen in Fig. 4, because it acts the same as if a grounded plate were inserted between two condenser plates. And as its structure is very open, its capacity to each of the elements

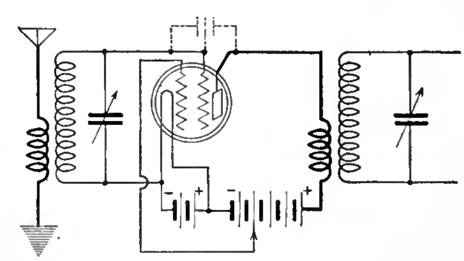
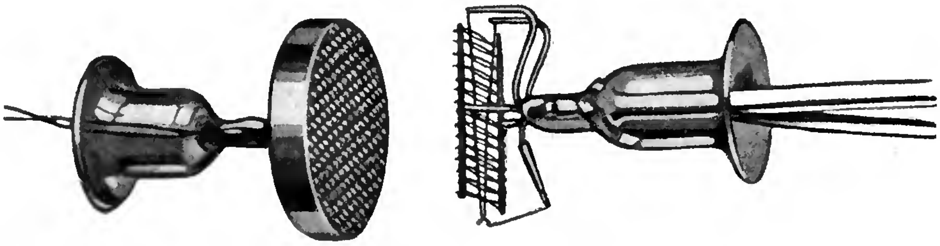


FIG. 4

If the outer grid of a double-grid tube is made positive, the resultant grid-plate capacity of the tube is greatly reduced. At the same time it is possible to build tubes with much greater amplification factor. The plate-grid capacity is reduced owing to the fact that two "condensers" are now in series

of the tube is very small indeed, smaller in fact than the capacity between plate and grid originally was. As the two capacities are in series, the resultant capacity between plate and grid is smaller than either one of the two, and hence we have, in this particular construction of the double-grid tube, almost completely eliminated the plate-grid capacity, with all its baneful effects on receiver efficiency.

Thus, this type of vacuum tube has even greater advantages than when the positive grid is placed between filament and grid. We have created a tube which is highly efficient as to



THE "INNER WORKS" OF AN ENGLISH SHIELDED GRID TUBE

One really ought to call them "shielded-plate" tubes, for the grid differs but little from that in ordinary tubes, while the plate is housed behind the shield. This illustration and that which heads this article are reproduced from *Wireless World* (London)

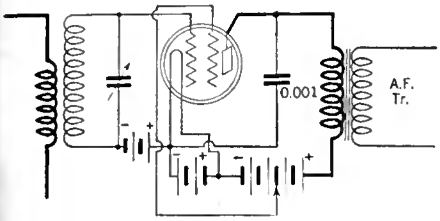


FIG. 5

In this detector circuit the outer grid is positive, the inner grid biased negative to prevent overloading

plate potential, its amplification factor has been increased considerably, and the plate-grid capacity has been largely eliminated, so that the tube may be called self stabilizing.

No wonder then that the European amateur uses these double-grid tubes quite extensively, for the upkeep of a small receiver with tubes of this kind is very economical.

Let us for a moment imagine what can be done

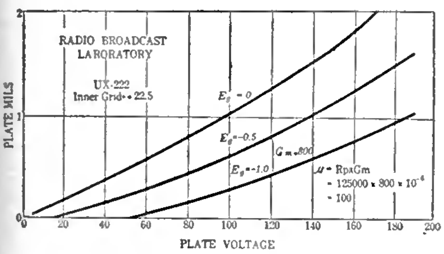


FIG. 9

Measurements made in the Laboratory of Radio Broadcast show that when the inner grid is positive, the mutual conductance of the tube may rise to as high as 800 while the plate impedance is 125,000 ohms, indicating a voltage amplification factor of 100. Plate voltage-plate current curves are shown here

with tubes of this kind. In an ordinary receiver employing two r.f. stages we may be glad if we get a voltage amplification of about eight per radio stage, so that the total amplification before detection is only sixty four. With tubes of this new design, and an amplification factor of, say, 25, we get an amplification before detection of 625 under the same circumstances, and with less trouble, because the capacitive feedback is as much more easily controlled.

An ordinary detector gives an additional amplification of about four, so that with the commercial receiver and ordinary tube the detector delivers a signal with a voltage amplification of about 250. The new tube as a detector would give an amplification of about 12, so that its signal would represent an amplification of 7500 times after the two r.f. stages—and this is voltage amplification only.

Due to this enormous amplification, the conventional condenser and grid leak should of course be discarded for a negative potential on the detector grid, as shown in Fig. 5, because otherwise the detector would surely be overloaded.

For audio amplification the type of double-grid tube used is almost immaterial, but as only the one type (with extra element between plate and grid) gives great advantage of decreased inter-element capacity, and thus will be employed in the r.f. stages, we may just as well use it for the audio stages too. With a good three to one transformer one stage will give us an amplification of about 90, so that the total reaches, after the first stage, 675,000, as against

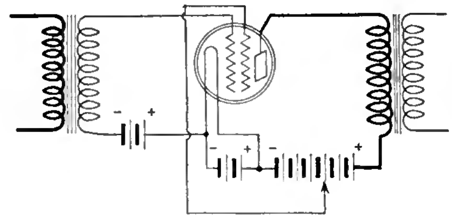


FIG. 6

A transformer-coupled audio amplifier stage using a tube whose outer grid is positive to reduce the space charge and make the plate voltage more effective

ordinary tubes, with the same transformer, 24 for one audio stage and a total amplification of 6000. One perceives that almost unlimited perspectives in receiver design are opened up, that

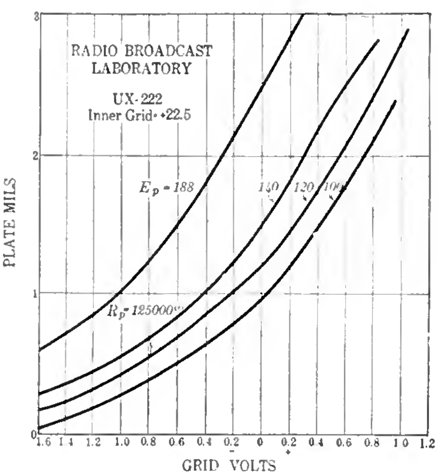


FIG. 10

Grid voltage-plate current curves on the new UX-222 tube with the inner grid positive. Note that the grid voltage lines are only two tenths volts apart indicating a large amplification factor

enormous volume may be expected, and distance undreamed of may be covered.

A study of the diagrams will reveal that the tubes are hooked up almost in the same way as ordinary tubes, with the exception of the posi-

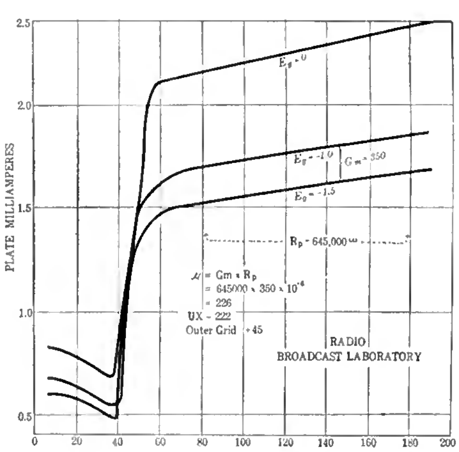


FIG. 11

The most interesting curve of all—the plate voltage-plate current data with positive outer grid. Note the negative resistance at low plate voltages, the rapid rise when the plate voltage equals that of the outer grid, and the very flat straight portion where the tube is ordinarily worked

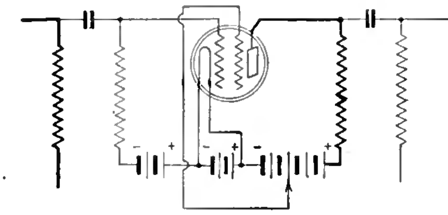


FIG. 7

A resistance-coupled low frequency amplifier with the outer grid of the tube positive

tive grid connection. Figs. 6 and 7 show different audio stage hookups.

The names "double-grid" tube is in the author's opinion, a misnomer. Generally we call the controlling element the grid, and as the fourth element in no way serves as a controlling element, it should not be called a grid, but simply the auxiliary element, or fourth element. Others have called the peculiar action of the fourth element between grid and plate a shield-

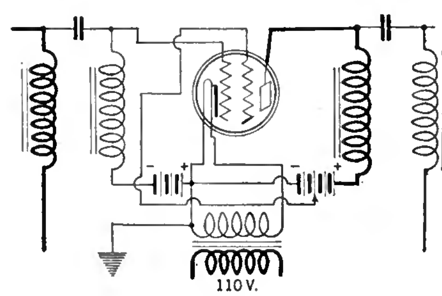


FIG. 8

The circuit of a special a.c.-operated double grid tube in process of development.

ing one, and call a tube thus constructed a shielded grid tube. It will be perceived that there is a good reason for this name, because the grid is actually more or less shielded against the plate effect, causing it to be remarkably stable.

EDITOR'S NOTE

THE curves presented here were made in the Laboratory and show the interesting characteristics of the UX-222—the R. C. A. "shielded grid" tube. Followers of our tube articles should note the extremely flat plate-current plate-voltage curve indicating an impedance—with the outer grid positive—of about 650,000 ohms, the negative resistance or falling characteristic at low plate voltages, and the high amplification factor of 222 secured by multiplying the mutual conductance by the plate impedance. If it is possible to place a load in the plate circuit of this tube, say at broadcast frequencies, of 650,000 ohms, a voltage amplification of 111 will result, compared with the usual amplification of about 10 for a single tube and its accessory apparatus.

With the inner grid positive, the mutual conductance rises, the plate impedance falls, and the amplification factor drops to about 100. Under these conditions the tube can be used in a resistance—or impedance—coupled low-frequency amplifier.

Experimenters will delight in this tube. Its possibilities are many and diverse. It will not revolutionize the radio industry, newspapers to the contrary, nor will it produce an entirely new era in receiver design. It is just one more step toward the ultimate goal of—what? Radio Broadcast will publish additional data as it is available on the use of tubes of this type.

The PHONOGRAPH *Joins*

By Way of Introduction

NOT many months ago, Carl Dreher suggested in his department in RADIO BROADCAST, that a radio broadcast program was almost the most ephemeral thing in the world. Thousands of dollars are spent to engage talent, wires covering half a continent are hired, advertising is scheduled in newspapers, several studio rehearsals are held, and finally the elaborate program is put on the air. For an hour it lasts—but it can never be repeated. If you did not hear it, all the king's horses and all the king's men couldn't put it into your loud speaker again.

If it is not possible to reproduce a complete radio program in one's own home, one can at least recreate the equivalent. A very great number of well-known radio artists are regularly recording for each of the important phonograph companies. Their records—electrically cut—are available everywhere.

These pages list a few of the records made by artists who are perhaps better known to the radio listener than to the average purchasers of phonograph records. Here are fine recordings made by the favorities of the Atwater Kent hour, and the famous artists of the Victor, Brunswick and Columbia hours. As for the jazz bands, the comedy duos, and other entertainers with a more local fame, they, too, are forever at your beck and call on the black discs.

One of the most important advances made in recent years—for which we must thank the scientists—is the great progress made in the reproduction of music and speech by electrical means. All radio folk know how audio amplification has been improved, what with new amplifiers of excellent characteristics, better loud speakers, and so forth. An equally important improvement has taken place in the phonograph field. Now the phonograph, with its electrically cut records and its acoustically excellent exponential horns or cone loud speakers, will rival the musical fidelity of the best radio receiver.

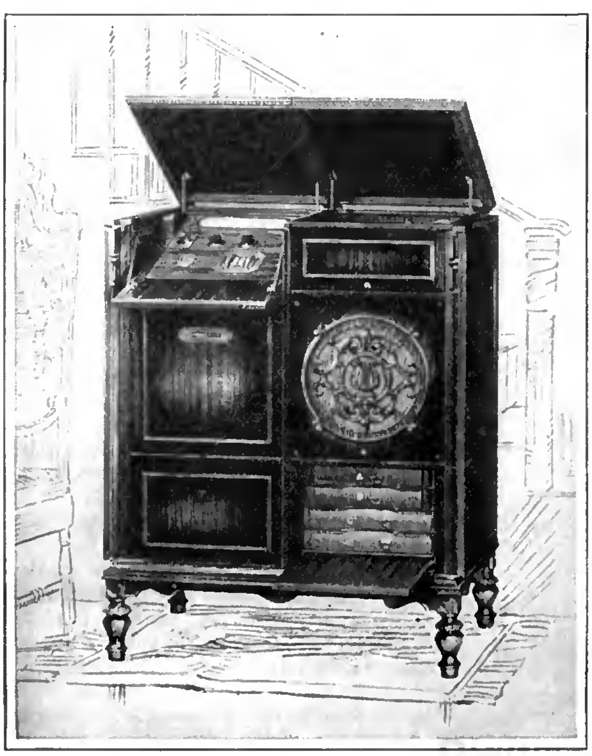
NEW RECORDS BY RADIO FAVORITES

Released Since September

What Do We Do On a Dew-Dew-Dewy Day Is It Possible?	Shilkret-Victor Orchestra Kentucky Serenaders	20819	*Victor*
The Tap Tap If I Had a Lover	Kahn's Orchestra Shilkret and Victor Orchestra	20827	"
President Coolidge Welcomes Colonel Lindbergh at Washington, D. C., June 11, 1927—Parts 1 and 2	Hon. Calvin Coolidge	35835	"
President Coolidge Welcomes Colonel Lindbergh at Washington, D. C., June 11, 1927—Part 3	Hon. Calvin Coolidge	35836	"
Colonel Lindbergh Replies to Pres. Coolidge	Colonel Charles A. Lindbergh		
Colonel Charles A. Lindbergh's Address Before the Press Club of Washington, D. C., June 11, 1927 Colonel Lindbergh's Souvenir Record—*Concluded*	Colonel Charles A. Lindbergh	35834	"
Ciribiribin (Waltz Song) Il Bacio (The Kiss) (Aridti)	Bori	1262	"
Indian Love Call (from Rose-Marie) Rose-Marie (from Rose-Marie)	Virginia Rea Murphy	4015	"
Old Black Joe (Foster) Uncle Ned (Foster)	Tibbett	1265	"
Actual Moments in the Reception to Colonel Charles A. Lindbergh at Washington D. C.,—Parts 1 and 2		20747	"
At Dawning The Waltzing Doll	Victor Concert Orchestra	20668	"
Kentucky Babe Mighty Lak' a Rose	Vaughn De Leath	20664	"
Angels Watching Over Me Climbin' Up the Mountain	Utica Jubilee Singers	20665	"
Sam's Big Night The Morning After	"Sam 'n' Henry"	20788	"
Just Like a Butterfly Just Another Day Wasted Away	Franklyn Baur Marvin-Smalle	20758	"
Under the Moon Sing Me a Baby Song	Stanley-Marvin Vaughn De Leath	20787	"
You Don't Like It—Not Much Oh Ja Ja	The Happiness Boys	20756	"

The public has suffered rapid education. They have learned that faithful reproduction of the original is possible in radio sets and in phonographs alike. And if the growth of broadcasting were not enough to sharpen the interest in music of all kinds, the new phonographs and the new records have come along to broaden the domestic entertainment horizon.

The radio receiver has taken its place as a musical instrument—a medium of entertainment—along with the phonograph and the piano. The radio set in the public consciousness is no longer merely a scientific marvel and mystery. And since they are so closely related because of what they can bring to the home, the phonograph and the radio set have been drawn closely together in association of ideas and in actual physical form. Those who wish to buy a combination radio-phonograph can choose many fine models from five or six well-known manufacturers. Those who already have a radio receiver which they wouldn't trade for the royal throne of Roumania can make their audio amplifier and loud speaker do double duty in reproducing phonograph records or a radio program—according to the whim of the owner. All one needs beside a good loud speaker system is any kind of turntable which will twist the record at an even speed of 78 revolutions per minute, and a good electro-magnetic pick-up. And there are many of the latter on the market.



A COMBINATION RADIO-PHONOGRAPH FROM BRUNSWICK

The Brunswick Panatrope-Radiola, model 138C. This instrument contains a Radiola 28 super-heterodyne receiver with enclosed loop, which can be controlled by the dial in the front of the left-hand panel. On the right is the Panatrope and below it the cone loud speaker working out of a UX-210 amplifier which is also the amplifier for the radio set. The instrument, complete with all tubes for 60-cycle a. c. operation lists at $1150

FAVORITES IN CHICAGO

"Sam 'n' Henry"—Correll and Gosden who nightly disport before the twin microphones of WGN and amuse countless WGN listeners. Their verbal antics are embalmed on Victor records, listed above

the RADIO Set

New Records by Radio Favorites

SOMETHING TO TELL STOP, GO!	Shilkret-Victor Orchestra	20682	*Victor*
I AIN'T GOT NOBODY ROODLES	Coon-Sanders Orchestra	20785	"
MY WIFE'S IN EUROPE TO-DAY A LITTLE GIRL—A LITTLE BOY—A LITTLE MOON	Fry's Million Dollar Pier Orch.	20726	"
BABY FEET GO PITTER PATTER SOMETIMES I'M HAPPY	Vaughn de Leath	3608	*Brunswick*
WHEN DAY IS DONE NO WONDER I'M HAPPY	Radio Franks, White and Bessinger	3588	"
AIN'T THAT A GRAND AND GLORIOUS FEELING? MAGNOLIA	Harry Richman	3583	"
JUST A MEMORY (VOCAL CHORUS BY ELLIOT SHAW) JOY BELLS (VOCAL CHORUS BY VAUGHN DE LEATH)	Harold Leonard and His Waldorf-Astoria Orchestra	1105D	"
OOH! MAYBE IT'S YOU (VOCAL CHORUS BY FRANKLYN BAUR) SHAKING THE BLUES AWAY (VOCAL CHORUS BY FRANKLYN BAUR)	Harry Reser's Syncopators.	1109D	*Columbia*
JUST A MEMORY MY HEART IS CALLING	Franklyn Baur	3590	*Brunswick*
NO WONDER I'M HAPPY JUST ONCE AGAIN	Ernie Golden and His Hotel McAlpin Orchestra	3604	"
BABY FEET GO PITTER PATTER THERE'S ONE LITTLE GIRL WHO LOVES ME	Abe Lyman's California Orchestra	3605	"
FANTASY ON ST. LOUIS BLUES PARTS 1 AND 2	Don Vorhees and His Earl Carroll's Vanieties Orchestra	1078D	*Columbia*
AIN'T THAT A GRAND AND GLORIOUS FEELING? I AIN'T THAT KIND OF A BABY	Paul Ash and His Orchestra	1066D	"
LEONORA PAREE!	Leo Reisman and His Orchestra	1083D	"
HERE AM I—BROKEN HEARTED HAVANA (VOCAL CHORUSES BY FRANKLYN BAUR)	Cass Hagan and His Park Central Hotel Orchestra	1089D	"
SWANEE SHORE MEET ME IN THE MOONLIGHT	Harry Reser's Syncopators	1087D	"
DO YOU LOVE ME?—VOCAL CHORUS BY F. BAUR HONEY—VOCAL CHORUS BY VAUGHN DE LEATH	The Columbians	1068D	"
AIN'T THAT A GRAND AND GLORIOUS FEELING? VO-DO-DO-DE-O BLUES	Van and Schenck	1071D	"
THAT SAXOPHONE WALTZ I COULD WALTZ ON FOREVER WITH YOU SWEETHEART	Art Gillham-The Whispering Pianist	1081D	"
GID-AP, GARIBALDI OH! YA! YA!	Billy Jones and Ernest Hare (Happiness Boys)	1074D	"
FOR THEE (POUR TOI) (GORDON) FROM OUT THE LONG AGO (STRATTON AND DICK)	Barbara Maurel	140M	"
JUST ONCE AGAIN (CHORUS BY F. BAUR) LOVE AND KISSES	Paul Ash and His Orch.	1090D	"
ARE YOU HAPPY? GIVE ME A NIGHT IN JUNE	Ipana Troubadours	1098D	"
SONG OF HAWAII HAWAIIAN HULA MEDLEY	South Sea Islanders	1111D	"
TWO BLACK CROWS, PART 3 TWO BLACK CROWS, PART 4	Moran and Mack	1094D	"
MAGNOLIA PASTAFAZOOLA	Van and Schenck	1092D	"
THE VARSITY DRAG (VOCAL CHORUS BY BAUR, JAMES, AND SHAW)	Cass Hagan and His Park Central Orchestra	1114D	*Columbia*
DANCING TAMBOURINE	The Radiolites		
GOOD NEWS (VOCAL CHORUS BY BAUR, SHAW AND LUTHER) LUCKY IN LOVE	Fred Rich and His Hotel Astor Orchestra	1108D	"

THIS RADIO PROGRAM IS RECORDED

Colonel Lindbergh before the Washington microphones which carried his welcome-home ceremonies to the entire nation. Victor has made four excellent records from this event.

FOR the first time, phonograph records of a radio broadcast program are offered to the public. Victor has the distinction of pioneering and they offer three double-face records of the national welcome to Colonel Charles A. Lindbergh at Washington. On these three records you have the voice of President Coolidge, the interspersed announcements of Graham McNamee, a short address by Colonel Lindbergh, and his longer speech at the National Press Club. It's all there and if you close your eyes, it isn't hard to imagine that the events are just taking place—the cheers of the crowd, the applause which interrupts the speakers, the blare of the bands, and the quiet unruffled voice of Lindbergh.

The Victor Company arranged a direct wire from Washington, culminating in their studios through which their recording apparatus got the same program as each of the broadcasting stations. The ceremonies were recorded on forty-six record surfaces and finally edited down to the six surfaces now available. It is a good job from any point of view and Victor is to be congratulated. It is time that some of the historic events which are being offered to the radio listener with impressive regularity were preserved in permanent form. The next offering will be a championship fight, we suppose.

GUESS WHO

None other than Billy Jones and Ernest Hare—known to Eastern listeners of WEAF on Friday nights as the Happiness Boys. Their songs are recorded by Victor and Columbia

A PHONOGRAPH—RADIO COMBINATION FROM VICTOR

"Automatic Electrola-Radiola No. 955" is what Victor calls this beautiful instrument. Records are changed automatically and groups of 12 can be played without attention.
An 8-tube super-heterodyne with enclosed loop operating entirely from the light socket through the power supply for the vacuum tube amplifier and the cone speaker used alike for phonograph and radio reproduction. The radio receiver panel can be used in three positions. List price, $1550

MAKE YOUR OWN RADIO PICTURE RECEIVER

THIS article is the third in the series explaining the use and operation of the Cooley "Rayfoto" picture receiving system. The Cooley apparatus was demonstrated in actual operation at the New York Radio show and attracted an astounding amount of interest. Governor Alfred E. Smith of New York, who made the opening address of the Show, transmitted a part of a picture of himself, reproduced by the Cooley system over WJZ *and other stations of the Blue network. Many of the readers of this article undoubtedly heard that interesting broadcast. The subject of radio photograph reception is so large that it can be discussed only in part on each article. Our readers are advised to preserve carefully each of the articles in* RADIO BROADCAST *on this system, beginning with the first story in the October, 1927, issue. Pictures will be sent by broadcasting stations, using their regular assigned wavelength, and no tuning changes in your present receiver are necessary. Readers are urged to write us their experiences with the construction of the recorder. The development of the Cooley "Rayfoto" system opens for the first time to the American experimenter an important "next step" in radio development.*

—THE EDITOR.

By AUSTIN G. COOLEY

THE articles on the Cooley "Rayfoto" system in the October and November issues of RADIO BROADCAST explained how the system works, told something of the results to be expected, and gave some details regarding the operation of a picture receiver. This third article in the series gives some general and particular information about the system, and diagrams necessary for the construction of a Cooley receiver are also presented.

Many of the units for use in the radio picture receiver have been especially designed for the purpose and therefore possess the necessary characteristics for good results. They have been designed to take care of the present requirements of the receiver and are so flexible that they will still be suitable for use as the system may be gradually developed. Considerable care has been taken in this matter so that it will not be necessary to scrap any of the parts as the natural development of increased speed of reproduction and better quality are consummated. The approved parts, which have all been carefully tested, are made under the Cooley "Rayfoto" trade mark.

Arrangements are now under way to supply various broadcasting stations with phonograph records which will enable them to put Cooley pictures on the air. The radio editor of your local newspaper is the best source of information.

The complete set-up for picture reception by means of the Cooley system consists of three distinct units—the radio receiver proper, the amplifier-oscillator unit, and the printer assembly. The first—the radio receiver—should be capable of quality reproduction of radio programs for if it falls down in this respect it will assuredly do so when called upon to detect and amplify the incoming modulated wave which has super-imposed upon it the audible note representing the picture being transmitted.

Passing from the last audio stage of the receiver proper, the "picture signal" is further amplified in the amplifier-oscillator unit and it then modulates the output of the oscillator in accordance with the modulation produced by the picture. The varying output of the oscillator is made to cause corresponding variations in the output of the corona coil, and thus the intensity of the needle point discharge is made to produce an effect on the proper tallying with the original picture. The corona coil is included in the second unit although the actual needle at which the discharge occurs is naturally a part of the third—the printer-unit. This third unit consists of the needle, the drum upon which the photographic printing paper is wrapped, and the mechanism which causes the drum to revolve. It is purchasable as a whole, for there are few who possess the mechanical ability and facilities for the construction of such an intricate piece of mechanism.

The construction of the amplifier-oscillator unit from the approved parts is a simple matter. Fig. 1 shows a suggested layout while Fig. 2 is the schematic diagram. The following parts are necessary for this unit:

T_1—"Rayfoto" Amplifying Transformer
R_1—Variable Shunt Resistance for Primary of T_1
R_2—200-Ohm Variable Resistance Capable of Carrying 100 Mils.
R_3—12-Ohm Filament Rheostat, $\frac{1}{2}$-Ampere Capacity
R_4—"Rayfoto" Relay
T_2—"Rayfoto" Modulation Transformer
C_3—0.1-Mfd. Condenser
R_5—0.01-Meg. Grid Leak and Mounting
C_1, C_2—0.0005-Mfd. Fixed Condensers
C_4—0.0005-Mfd. Variable Condensers.
L_1—"Rayfoto" Corona Coil
L_2—Radio-Frequency Choke Coil
S_1—Filament Switch
S_2—Push Button or Special Switch
J_1, J_2, J_3—Double Contact Short-Circuiting Jacks
R_6—Filament Ballast Resistance
One Telephone Plug
Milliameter, 0-25-mil. Scale
Two Sockets
Fourteen Binding Posts
Base-Board
Panel
Brackets
"Rayfoto" Printer Unit

Although wide deviations from the layout shown in Fig. 1 are permissible, it is also quite possible that considerable "grief" will be experienced in many cases where original schemes are attempted. We therefore suggest that the home constructor follow our plan of layout and construction very religiously, at least on his first set. The photographs indicate very clearly the arrangement of the apparatus and the experienced home constructor should have little difficulty in putting the apparatus together.

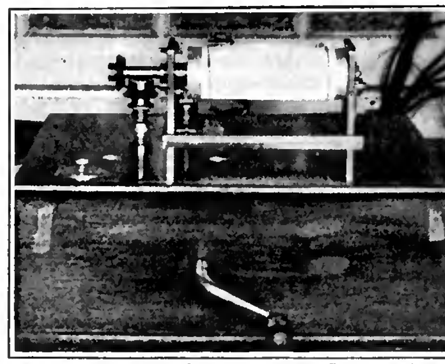
All but the radio-frequency circuits may be wired up in any convenient manner. We find

PICTURES RECEIVED BY THE COOLEY SYSTEM

These two photographs have not been retouched and were received at the demonstration at the New York Radio Show. Governor Smith, in his radio address opening the Show let radio listeners hear how his picture, above, sounded. The heading above shows Mr. Cooley and a part of his apparatus as set up in operation at the Show. Governor Smith's picture is on the receiving drum that ordinary No. 18 rubber covered fixture wire is very easy to handle and makes a reasonably neat job. Each circuit should be properly tested out, as will be explained later, before the wires are laced up in bundles. The radio-frequency circuit should be wired up with considerable care, the use of bus bar wiring or rigid wires having a fair amount of spacing between them, being recommended. No particular care need be taken to prevent losses in the radio-frequency oscillator circuit. The secondary of the corona coil, and its lead to the corona needle, however, require very special attention. This subject will be covered in another paragraph.

When the "Rayfoto" printer has been completed and set up with all connections to batteries, proceed as follows for testing and adjusting:

Place two 201-A type tubes in the sockets and see that the filaments are properly lighted and a good range of brilliancy is controlled by the rheostat, R_3, of the amplifier tube. With the input terminals open, plug a pair of phones in meter jack, J_2, for the amplifier. Turn the filaments on and off a couple of times to see if the



RADIO BROADCAST Photograph

THE PRINTER UNIT COMPLETE

With its spring motor. If the user desires to use the motor in a phonograph which he already has, the illustration on the next page shows a special unit made for that purpose

proper click is obtained in the phones. If it sounds satisfactory, plug in the milliammeter. If you find the milliammeter reading down scale, reverse the connections to it. Adjust the C battery until the plate current is a little less than one milliampere. The plate voltage on the amplifier should be about 180 volts and the C bias to bring the plate current down to 1 mA., will have to be around $22\frac{1}{2}$ volts.

Now connect a piece of wire between the plate terminal of the a. f. amplifier tube socket and the B plus terminal of the modulation transformer T_2, and connect the input of the amplifier to the output of the radio receiver. Tune-in any broadcast signal and watch the milliammeter to see if it varies in accordance with the incoming signal. The phones may be plugged into jack J_2 and the gain control resistance, R_1, varied to determine if the proper control is obtained.

Now connect the lead from the corona coil to

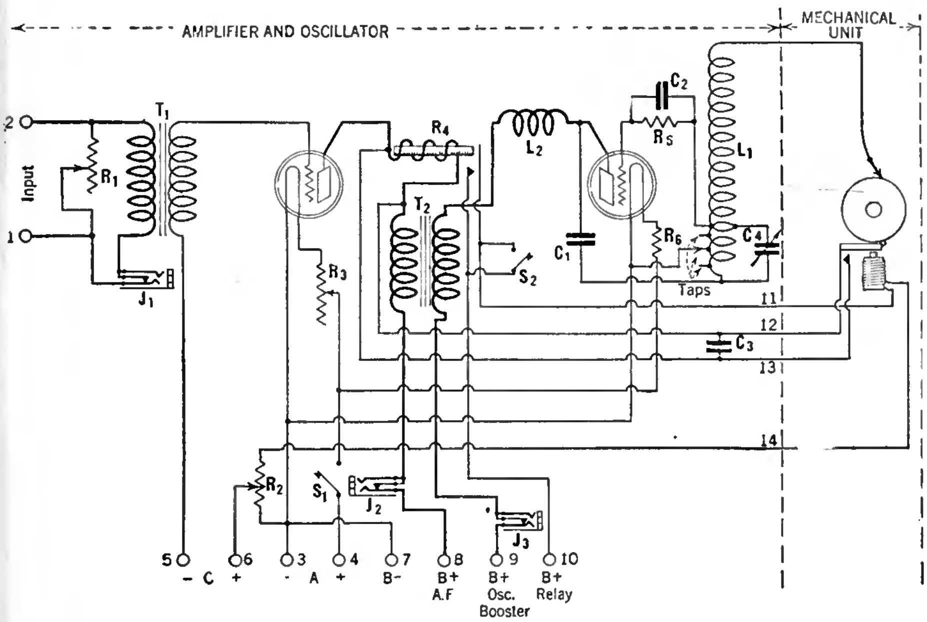


FIGURE 1

The circuit diagram of the amplifier and oscillator is given in this figure

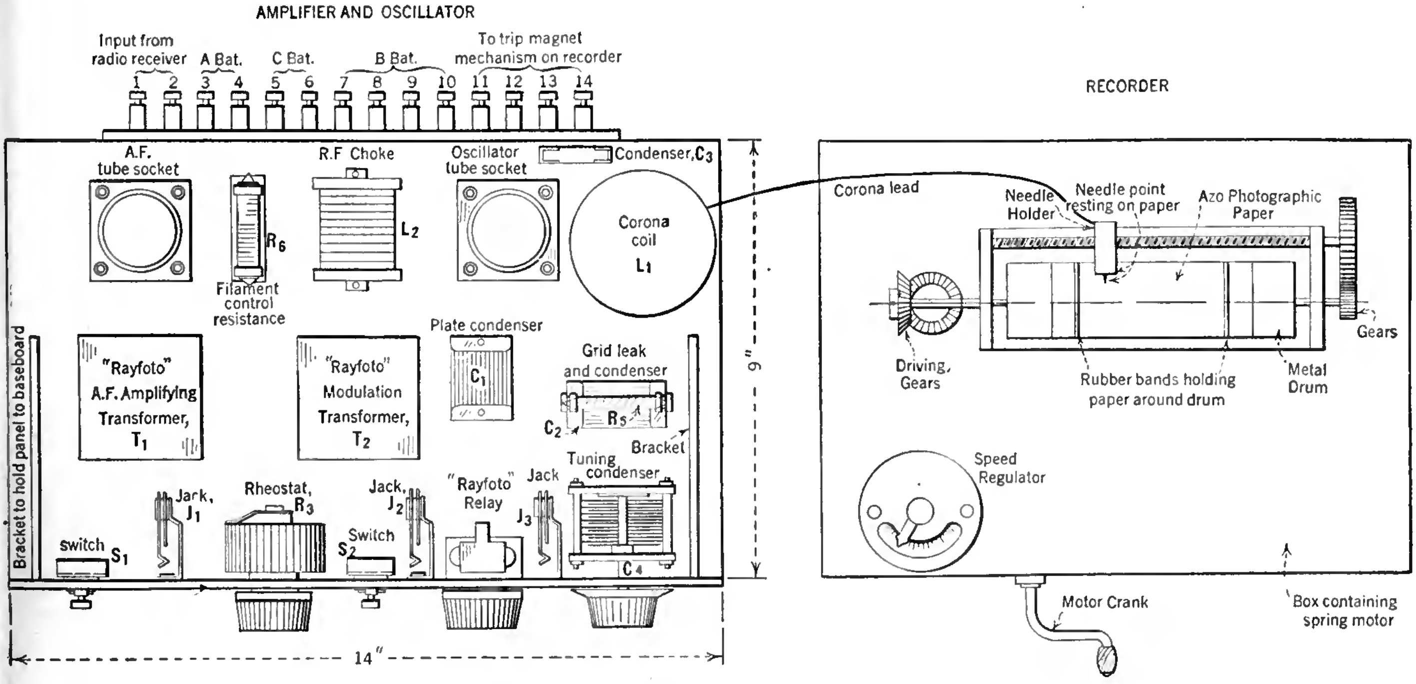


FIGURE 2

The suggested layout of apparatus shown in this drawing may be followed when you construct your amplifier-oscillator unit. The various identifying letters on the parts refer to similar letters on the circuit diagram given in Fig. 1. The lead from the corona coil, L_1 to the needle holder on the recorder should not be over three feet in length and should be supported where necessary by silk thread. The parts for the oscillator-amplifier unit can be purchased and then assembled at home, and no special precautions are necessary in constructing the unit. The wiring may be done in straightforward fashion. The corona lead is a No. 38 wire and should be carefully handled, otherwise it will break. If the lead is broken by accident, unwind about three turns from the coil to make a new lead. The record unit cannot be home constructed and must therefore be purchased as a complete unit. The recorder depicted in this sketch is a complete unit containing a spring motor. R_1 and R_2, not a part of the early model illustrated, may be located at any convenient point in the layout. A fixed condenser was used for C_4 in the first model. It is preferable that it be variable as indicated above.

the corona needle. Give this lead no more support than absolutely necessary. If this important lead needs support, it should only be by suspending it from small threads. The lead should be made as short as possible and in no case should be over three feet long. Place a small piece of Azo No. 4 photograph paper on the drum and let the needle rest on it. The paper may be held around the drum by means of two rubber bands.

Disconnect the input of the amplifier from the radio receiver and connect the booster terminal to about 90 volts of battery. Cautiously plug the meter in the oscillator circuit jack, J_3. If the meter registers over fifteen milliamperes, the circuit is not oscillating properly. Adjust the variable condenser until the current is brought down to less than ten milliamperes.

Now watch the point of the corona needle to see if a very small corona discharge takes place. If not, re-tune condenser C_4. If this does not bring results, try the various taps on the oscillator coil. If you are still unable to obtain any visible corona, increase the booster voltage to about 150 and try the different taps again. It may be found that all the condenser capacity is required to obtain a discharge. The length of the lead wire should then be shortened or a small fixed condenser, of about 0.0005-mfd., may be placed across the variable condenser. Only a good mica condenser should be used. If the discharge is strong enough to burn a hole in the paper, the booster voltage should be reduced. The taps should be tried to determine the best position of maximum discharge.

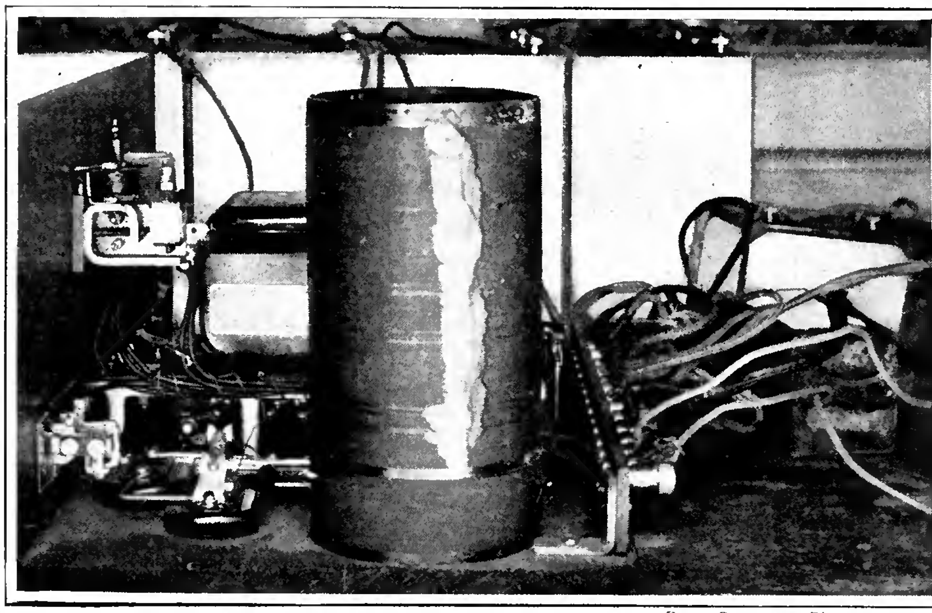
With the printing circuit operating properly, connect the input to the radio receiver and tune-in any broadcast signal. Take off the short circuiting wire on the trip magnet switch terminals and allow the drum to revolve with the needle riding on the paper. If the trip magnet does not trip from the radio signals, release the drum by operating the switch, S_2 across the relay circuit. Watch the needle point to see if the corona varies with the incoming signal.

GENERAL HINTS

AFTER the "Rayfoto" printer and recorder are set up for operation, trouble may be experienced in many cases due to feed-back from the corona circuit about which considerable information was given in the November issue. This trouble will depend greatly upon the characteristics of the radio receiver. To help avoid it, the experimenter should provide a separate set of small 22½-volt B batteries for the printer. As an additional precaution, the printer and recorder should be placed at a considerable distance from the radio receiver, say eight or ten feet, if convenient. After the apparatus is set up and working properly, attempts may be made to reduce this distance. Also experiments can be made with the battery circuits to determine the feasibility of operating the radio receiver and printer with the same B batteries. The experimenter will be aided greatly by the use of low-resistance B batteries. The filaments of the tubes in the "Rayfoto" printer may be operated from the same storage battery used for the radio receiver. All the above precautions should be taken to prevent feed-back before attempting to tune up the "Rayfoto" printer. If feedback still occurs after tuning up the printer, additional steps may be taken to suppress it.

If there is any feed-back from the printer circuit, the discharge will be strong and continuous. A high reading on the meter when no signals are coming in indicates feed-back.

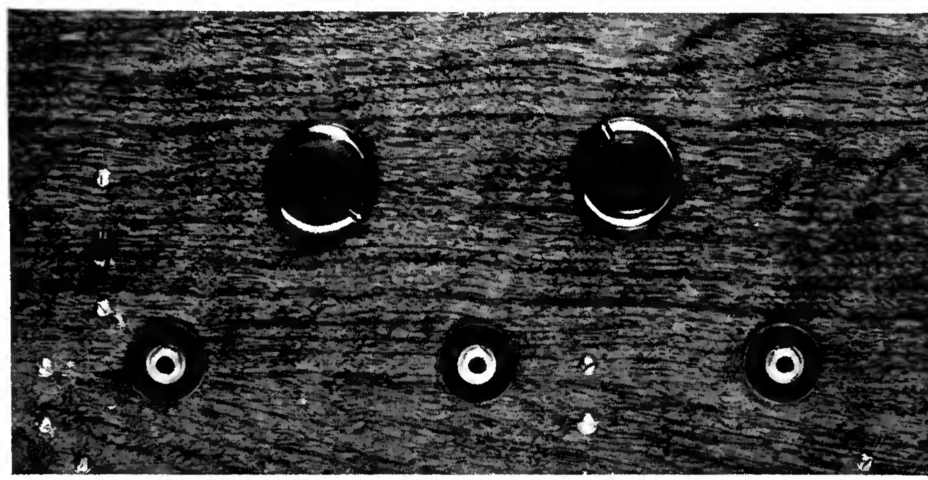
The last resort to prevent feed-back is to shield the printer circuit. The shielding should not be attempted before the unit is set up and ready

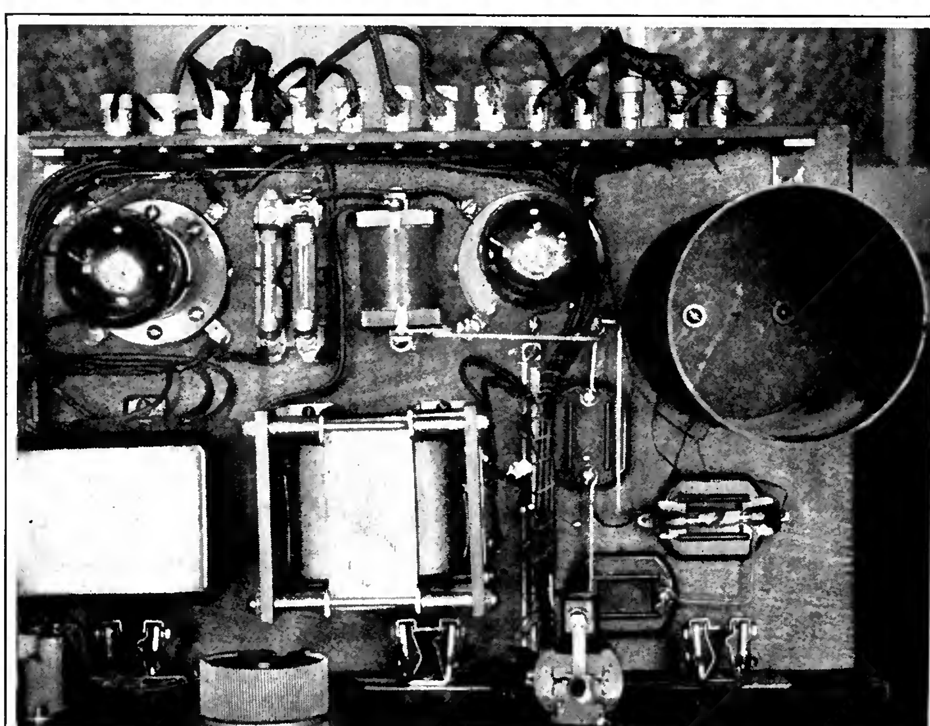


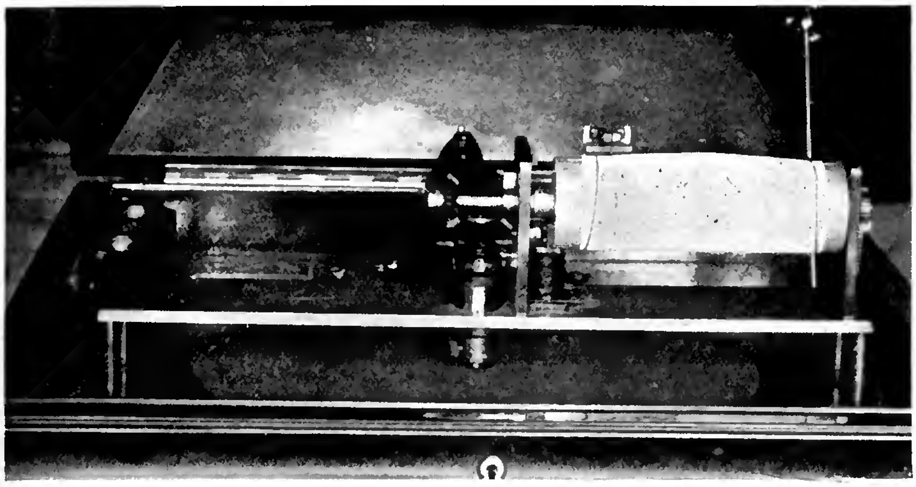
RADIO BROADCAST Photographs

THREE VIEWS OF THE AMPLIFIER-OSCILLATOR UNIT

The upper view taken from the side, shows the home-made relay mounted on the front panel and the corona coil is in the foreground of the picture. The center view shows the front panel layout and a top view is given below







RADIO BROADCAST Photograph

USING A PHONOGRAPH AND ITS MOTOR

The printer unit depicted above is designed for use with any standard phonograph and utilizes the spring motor in the phonograph for the operation of the drum

for operating because in many cases the shielding will do more harm than good if it cannot be first tested out in an experimental way.

Due to the different characteristics of radio receivers, we cannot give information here that will cover every case. In general, the proper results may be obtained by running very small gauge grounded wires parallel to the corona feed wire and separated from it by a number of inches. This may necessitate re-tuning the oscillator circuit. Experiments with shield wires and shield plates will eliminate feed-back in most cases.

In many cases it will help matters to adjust the neutralizing on the radio receiver or slightly de-tune one stage of radio-frequency amplification.

With the printer circuit working properly, we may now adjust the relay and trip magnet. Adjust the relay contacts so that they close before the armature strikes the magnet pole. With the contacts *closed*, you should be able to slide a piece of thin paper (the thickness of this page) between the pole and armature. The gap between the contacts when *open* should be equal to two thickness of the paper used on the cover of this magazine. If sparking is bad, it may be necessary to increase this slightly. A condenser across the contacts will do more harm than good as it will cause the contacts to stick unless the spring tension is excessive.

With the trip magnet contacts open, adjust the C battery so that the plate current of the amplifier is about five mils. Adjust the spring tension of the relay so as to barely hold the contacts open with the five mils. in the circuit. After this adjustment is made, return the C battery adjustment to its original point.

The voltage for the trip magnet should be as small as practical, consistent with strong operation of the magnet. The power for this magnet may be taken from the batteries operating the radio receiver if small batteries are used for the printer circuits.

With all the foregoing adjustments and tests made, the experimenter is ready to test his set out on picture signals. It is well to have the developer and fixer solutions made up in advance although it will not hurt to let the undeveloped picture stand for a considerable time if the paper is protected from light. Instructions will be found on the developer tubes and fixing powder cartons for making up the solutions so we will not cover that information here. Regular trays for the solutions should be used for the sake of convenience although any enamel or glass tray or dish will serve the purpose. In mixing up the solutions, it will do no harm if they are made a little more concentrated than the manufacturers specify, using about 6 oz. instead of 8 oz. of water.

With the trip magnet properly adjusted, the speed of the drum should be adjusted and checked by counting the number of revolutions of the drum. If a converter drum speed of 100 r.p.m. is used, the recorder drum speed should be about 105 r.p.m. The clutch should be free enough on the first tests so that the turntable will revolve with the drum in its locked position. By loosening up on a set screw on the collar directly below the spring, the clutch friction may be regulated.

To receive a Rayfoto picture, tune-in signals from the station transmitting the signals so that they are received with maximum intensity. If the meter in the amplifier circuit runs up over fifteen mils. on the strong signals, reduce the intensity by the volume control on the radio set or the gain control on the printer amplifier. In most cases it will be good practice to reduce the radio-frequency input to the detector circuit.

The minimum signal should be between one and four milliamperes. Adjustment of the minimum signal is more important than that of the maximum for if the minimum is too high, it will operate the relay when it should not, and if too low, it will cause irregular relay operation.

While the synchronizing pulse is being transmitted from the station sending pictures, the drum should revolve and trip regularly with only a brief period of rest or lap. By regulating the speed of the driving motor the lap can be regulated. If the lap should be very long, you will find that the speed is too slow and that the drum is tripping only on every second synchronizing impulse. Increase the speed.

After the drum is adjusted to trip regularly, a "range" should be taken; that is, the signal should be increased to the point where the relay trips from the minimum rather than the synchronizing signal, and then the signal should be decreased to the point where the relay does not trip at all. The operating adjustment should be about half way between the two points. The operating range of the relay should be as large as possible. If it is very small, it may be increased by increasing the amplifier tube's C-battery potential so that the plate current is practically zero when no signals are being received.

When the synchronizing adjustments are made and the paper placed on the drum, you are ready to start as soon as the picture signals begin. The paper should be drawn up to fit the drum tightly. If the center of the paper at the lap bulges out very far, a rubber band may be placed around the center of the drum and slid along when the needle approaches it. Care should be taken not to get the hand close enough to the corona feed wire to detune the circuit.

After the picture is received the paper is placed in the developing solution until developed to the proper density. It is then dipped in the washing bath and placed in the fixing solution. After remaining in the fixing solution for ten or fifteen seconds, it may be removed temporarily for observation purposes but should be replaced in this solution for ten or fifteen minutes and washed in running water for five or ten minutes, if it is desired to preserve the picture indefinitely.

In some cases the experimenter will experience excessive blurring, lack of detail, streaks in the pictures, improper contrast, etc. In the next issue of RADIO BROADCAST we will give more complete information that will enable the experimenter to clear out any such troubles should they arise.

The Freedom of the Air

EXCERPT from a news item in the New York *Times* of May 3, 1927, under the caption, "Pacifist Talk Hushed by Radio Station WGL:"

"We are proud that Mrs. Corson is a woman," Mrs. Ford said, "proud that she comes from Denmark, that country which upholds an ideal of peace, that country which said to the enemy, "If you must cut through our country, even if you must cut through our women and children"—

At this juncture Mr. Isaacson cut out the microphone through which she was speaking and substituted one in the studio through which music was broadcast as a stopgap.

Mr. Isaacson later explained to the radio audience what had happened. In discussing the incident later he said:

"We believe in free speech and I have always been willing to extend the use of our station to anyone to express his views, but there are certain things which are dictated by good taste. This was not the time nor the occasion for such a speech."

Excerpt from a news item in the New York *Sun* of July 18, 1927, under the caption, "Worm Controversy To Be Aired from WGL:"

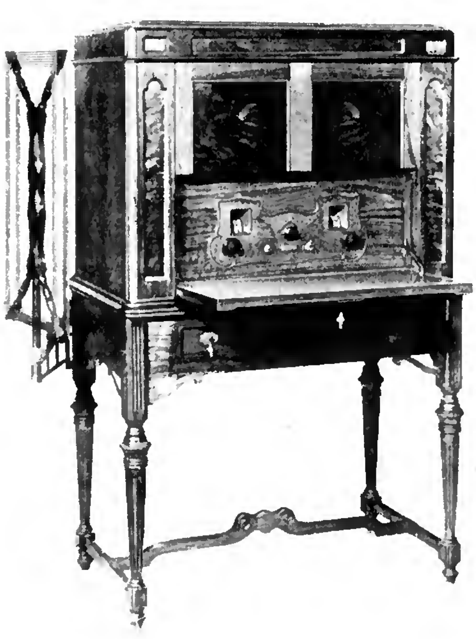
Fred B. Shaw, one time international fly fishing champion, will have an opportunity to discuss President Coolidge and his angleworm fishing to his heart's content to-night when WGL will allow him to broadcast, uncensored, his speech which was barred last week by another station.

"Our broadcast policy has always upheld free speech on the air," declared Dr. Charles D. Isaacson, program director of WGL, in extending the invitation to Mr. Shaw yesterday, "and for that reason we are only too happy to extend the privileges of our broadcast station to you."

A vexing question is thus cleared up for all time. What is free speech à la Isaacson? It is freedom to discuss angleworm fishing. But not to discuss war.

Beauty *the* Keynote *of*

AN INSTALLATION that is completely self-contained—the Bosch Model 57. Although there is a very efficient loop built in, provision has been made for the use of an outside antenna where desirable. The receiver employs seven tubes, and is tuned by a single main dial. A cone loud speaker is harbored within the cabinet. Price, $340. For power operation, $100. extra



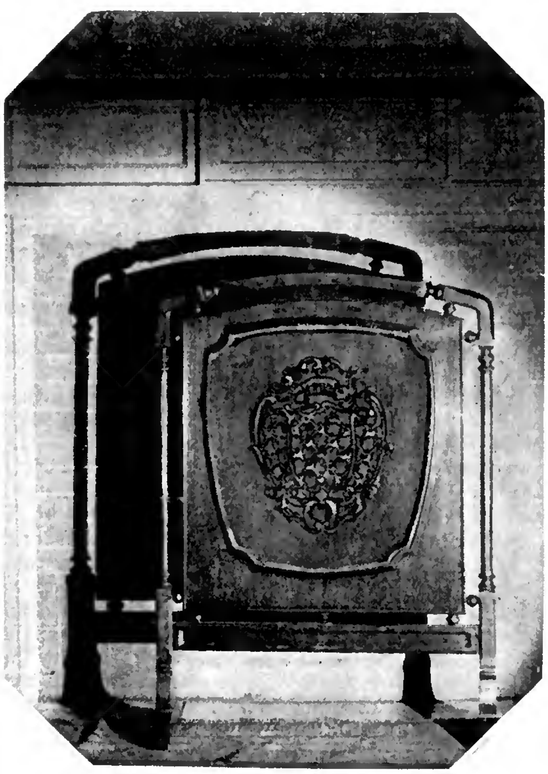
ANOTHER receiver which may be operated with either loop or outside antenna. This one is the Fada 8. There are, as the model number implies, eight tubes, but there is a switching arrangement whereby either seven or the eight may be used. There are four t.r.f. stages. All the radio and audio stages and tubes are individually shielded. When not in use the loop is folded behind the cabinet. Price, $400.

THE set builder can now obtain a cabinet for his receiver which is every bit as beautiful as those which house the most expensive of factory-built receivers. The Model 80 cabinet of the Musical Products Distributing Company, New York, here illustrated, is in combination walnut and satinwood. The set compartment measures approximately 28 inches long, 10 inches high, and 15 inches deep. Price, $250.

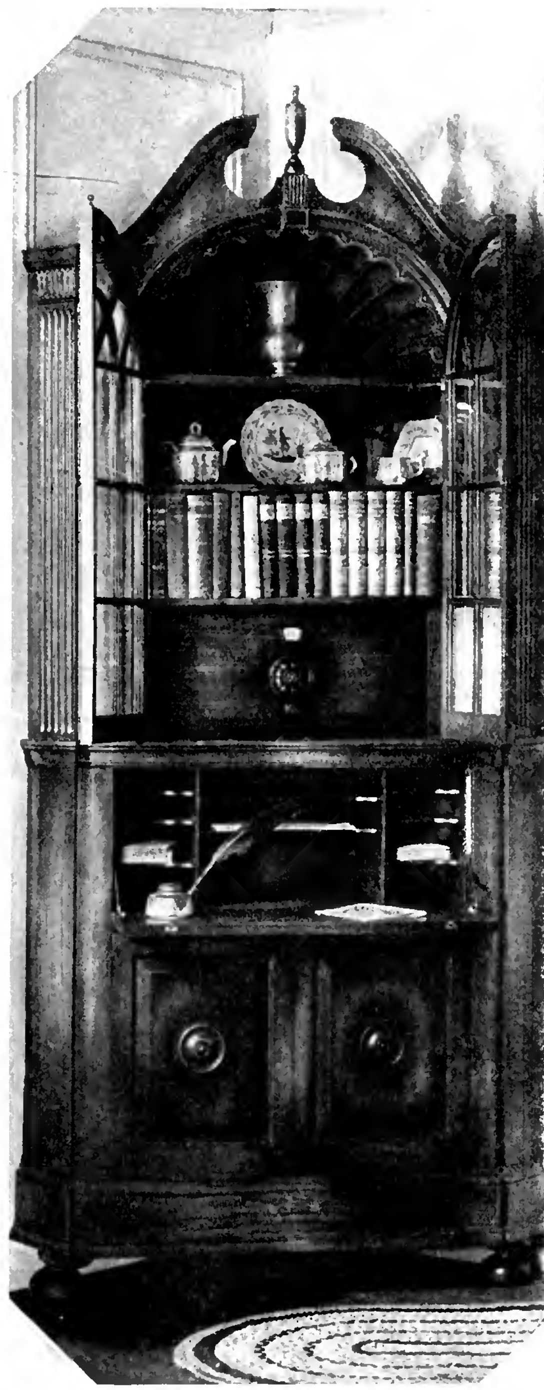
the New Radio Receivers

Making the Most of Surroundings

It is easy enough to discuss the offerings of the current radio season abstractly but one should visualize this year's radio sets in the proper domestic surroundings to appreciate what great strides have been made toward making radio a truly domestic bit of furniture. The illustrations on these two pages show radio equipment in home settings and who will deny their grace?



AN INTERESTING design in loud speakers, the new Amplion "Fireside." This loud speaker has a large cone mounted on a big sound-board, exceptional fidelity of reproduction being possible. The screen stand and long cord render the "Fireside" readily portable, making it easy to place the loud speaker anywhere in the room or outside on the porch. The panelling is of embossed walaut, attractively curved, combining a grille front and back. The height is 36¼ inches, and the cone is 16½ inches. Price, $97.50, with 20-foot cord



A TYPICAL example of the trend of the more expensive radio receiver, in which utility and beauty are in combination. We are taken back by this Winthrop secretary to America's younger days, when money was scarce and furniture was made to serve dual purposes. Nowadays a return to this state of affairs is demanded since home space is so scarce. The radio receiver built into the Winthrop is the popular Splitdorf single-control six-tube set. The price, complete with power operation and loud speaker, is $600.

What B Device Shall I Buy?

By HOWARD E. RHODES

TO WRITE of B power units in general terms, with the object of assisting in their wise selection, is not difficult because there are simple rules that can serve to guide the prospective purchaser. In the first place it should be realized that the satisfaction which any power unit gives in service frequently bears a close relation to its cost, for power units can be built to meet almost any price. Cheap units, constructed of inferior materials, are often capable of giving as good results as more expensive devices, during a single demonstration, but whether the cheaper device will stand up for as long a time in service is certainly open to question.

The first rule in the purchase of a B power unit should be insistance upon a well-known make, purchased through a reputable dealer, for only from such a source can you be assured of obtaining satisfactory service. One of the simplest and most satisfactory methods of appraising a B power unit to make certain that it will satisfactorily operate your receiver, is to give it a trial lasting several days in your own home, under actual working conditions. Only a reputable dealer selling a good product can afford to do this for you. A cut price dealer, with little or no interest in his customer once the sale has been made, cannot afford to sell a unit to you on the basis of a trial lasting several days. The unit purchased from a reputable dealer might cost somewhat more, but the higher price is justified because of the better service and greater assurance of satisfaction which you can obtain.

There are many things about a B power unit which must be taken more or less on faith. You can't tell, by looking at the device, what kind of chokes are used or if the condensers in the filter circuit have a sufficiently high voltage rating so as to prevent any possibility of breakdown. Then again, the design of the transformer supplying the rectifier and filter circuit is something that cannot be examined when you buy the unit. It is only by relying upon the reputation of the dealer and of the manufacturer whose product he sells, that you can have any assurance of a properly designed unit. If care is taken in the selection and use of a B power device, it will give satisfactory operation and lasting service for years.

In the list appended, we have given the important characteristics of about twenty-five well-known B power units. Since there are being made at the present time about one hundred and thirty of these units, it will be seen that the list is by no means exhaustive.

The proper selection of a B power unit is a matter of knowing the total plate-current drain of the receiver and of then finding a device that will supply the correct voltages to your receiver at this current drain. You must make certain that the maximum voltage available from the device when supplying a milliampere load equal to that of your receiver is sufficient to supply the power tube you are using. The maximum output voltage of the device should be 180 volts, or slightly more if a 171 type tube, with 40.5 volts grid bias, is used in the output; if a 112 type tube is used, with 9 volts grid bias, the maximum voltage should be about 135 volts. The information given in the appended list includes the maximum output voltage which the units will supply at various current drains.

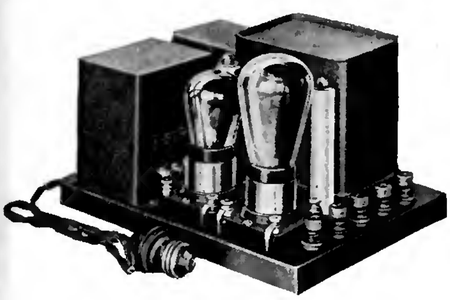
Of course, it is also essential that the power unit be capable of supplying the other tubes in the receiver with the voltages they require. These voltages are obtained from voltage taps on the power unit and in most cases the voltage that is obtained from any one of these taps varies with the current being drawn from it and the other voltage taps, and for this reason it is not possible to give any definite figures for the voltage output from these taps. Many power units use adjustable or semi-adjustable resistances so that the desired voltages can be obtained by proper adjustment of the resistance. These resistances should not be adjusted by guess but should be adjusted with the aid of a high-resistance voltmeter. This is a service any reliable dealer can give you.

There are some power units (those using glow tubes) which give practically constant output voltages independent of the load. If such a unit is purchased it may be connected to any receiver with assurance that the actual voltages being supplied to the receiver will be near enough to those marked on the terminals of the power unit for satisfactory operation.

As will be seen in the accompanying list, some of the devices have been approved by the National Board of Fire Underwriters and many of the other devices have been submitted for test but have as yet not been approved. The submission of B power units to the National Board of Fire Underwriters for their approval is a distinct step in the right direction. It gives the prospective purchaser the assurance that the unit conforms to definite standards designed to make certain that the operation of the device will be entirely safe.

The power input to a power unit is a measure of the cost of operating the unit. The input power to the average B power unit is about 25 watts, which is the amount of power required by a small electric light bulb. If we obtain power from the electric light company at the rate of ten cents per kilowatt hour, it will cost just about one quarter of a cent per hour to operate the average plate-supply device. To this cost of operating, we should, of course, add depreciation on the unit and the cost of tube renewals which must be made on an average of once a year.

All B power units for use with an alternating-current supply must use rectifiers of some sort. A majority of units use a tube for this purpose, but there are also quite a large group that use electrolytic rectifiers; thousands of B power units using either type of rectifiers have given satisfactory service. When purchasing a power unit avoid those using unknown makes of rectifiers. Whether you purchase a power unit current and delivers a steady fluctuating direct current to the output terminals of the device. Some power units use half-wave rectifiers and others use a full-wave rectifier. In the first case, only half of the alternating voltage is used and when full-wave rectification is used both halves of the alternating voltage wave are utilized. The filter system may contain either one or two sections. Whether a half- or full-wave rectifier is used or whether a one- or two-section filter is used is something that need not particularly concern the prospective purchaser. The design of the filter in either case should be such as to eliminate any hum, and so long as the device which you buy does not hum excessively, you may be sure that the filter circuit has been correctly designed for the type of rectifier used. The coils and condensers used in the filter circuit do not become weak with age, and a filter system capable of giving an output voltage free from hum will continue to do so unless some unit in the system completely fails.



B POWER UNITS FOR YOUR RECEIVER

The power unit at the left is the Erla Steadivolt BC Converter and it utilizes a Raytheon BH rectifier tube and a glow tube to maintain the output constant at all loads. It will supply up to 80 milliamperes at 180 volts. It lists at $40 including tubes. The Exide unit in the center and the Burns power device at the right both contain adjustable resistance units to regulate the voltage at the various terminals and further information regarding these two devices will be found in the listings on these pages

using an electrolytic or tube rectifier is a matter of personal preference.

WHEN YOU USE A B-POWER UNIT

A LOUD hum audible in the output of a receiver operated in conjunction with a B power unit may be due to coupling between the receiver and the power unit itself. If the hum is due to such a cause it can generally be eliminated by placing the power unit in some other position relative to the receiver. Also if hum is to be prevented it is essential that the negative B be grounded directly, and in some cases it is necessary to connect a 1-mfd. 200-volt condenser between the grounded negative B terminal and one side of the input power lead. If these simple remedies do not eliminate the hum it is likely that there is some defect in the unit itself and the dealer should be consulted for, if the power unit is operating properly it should produce practically no audible hum in the output. Every plate-supply unit must contain a transformer designed to step up the input voltage to an amount depending upon what output voltage is required and upon what type of rectifying element is used. The rectifier, whether it be a tube or an electrolytic device, modifies the alternating current obtained from the power supply and changes it to a pulsating direct current. The filter circuit smooths out the pulsation in the rectified

Facts About Some B Units

ACME APPARATUS CO., MODELS E-1, E-2, E-3, AND E-4

Maximum output voltage of a.c. models: 205 at 20 mA., 185 at 30 mA., and 160 at 50 mA. Uses Raytheon BH rectifier. Two adjustable voltages. Two-section filter. Approved by National Board of Fire Underwriters. Size: $8\frac{3}{4}$ x $3\frac{1}{4}$ x $7\frac{3}{4}$ inches. Models E-1, E-3, and E-4 for operation on 110 volts 60 cycles a.c. Model E-2 for operation on 120 or 220 volts d.c. Model E-1, with cable, for one- to twelve-tube sets, $50; Model E-2, with cable, for one- to twelve-tube sets, $25; Model E-3, with cable, for one- to eight-tubes sets, $85; Model E-4, with binding posts, for one- to eight-tube sets, $35.

ACME ELEC. AND MFG. CO., MODEL BE-40

Maximum output voltage; 200 at 20 mA., 185 at 30 mA., and 145 at 50 mA. Uses QRS rectifier. Two adjustable voltages. Full-wave rectifier. Two-section filter. Approved by National Board of Fire Underwriters. For operation on 110 volts 50-60 cycles a.c. Recommended for five- to eight-tube sets with power tubes. Size: $7\frac{3}{8}$ x $11\frac{1}{2}$ x $3\frac{11}{16}$ inches. Price, with tube, $34.50.

ALL-AMERICAN, MODELS A-1, A-3, A-4, AND A-8

Maximum output voltage of Model A-8; 200 at 20mA., 180 at 30 mA., 140 at 50mA. (with "high-low" switch in "high" position); 140 at 20 mA., 120 at 30 mA., and 70 at 50 mA. (with "high-low" switch in "low" position). Other models supply about 10 volts less. Approval pending by National Board of Fire Underwriters. Raytheon rectifier is used. Two-section filter. Adjustable output voltages. Model A-1 for operation on 110 volts 50–60 cycles a.c.; Model A-3, 25–40 cycles; Model A-4, 220 volts 50–60 cycles a.c.; Model A-8, 110 volts 50–60 cycles a.c. Size: Models A-1, A-3, A-4, 9 x 7 x $5\frac{1}{4}$ inches; Model A-8, 3 x 7 x 10 inches. Prices, including rectifier; Model A-1, $37.50; Model A-3, $42.50; Model A-4, $42.50; Model A-8, $27.50.

BURNS, MODELS 750-A, 750-B, AND 800-B

Maximum output voltage of Models 750-A and 750-B; 190 volts at 30 mA., and 180 volts at 50 mA. Model 800-B, 205 volts at 20 mA., and 190 volts at 30 mA. Uses Raytheon rectifier. Amplifier and detector voltages adjustable. Two-section filter. Approximately 20 watts a.c. input with 30 mA. load. Designed to operate 171 type power tubes. Size: Models 750-A and 750-B; $7\frac{1}{8}$ x $10\frac{1}{2}$ x $6\frac{3}{4}$ inches; Model 800-B, $4\frac{7}{8}$ x $10\frac{1}{2}$ x $5\frac{5}{8}$. Prices: Models 750-A and 750-B, $47.50 with tube; Model 800-B, $35 with tube.

AMRAD, MODEL NO. 280

Maximum output voltage; 200 at 20 mA., 180 at 30 mA., and 165 at 50 mA. Uses type 280 or 213 thermionic rectifier. One-section filter. Fixed output voltages. Full-wave rectifier. Twenty watts a.c. input at 30 mA. load. For operation on 100–120 volts 60 cycles a.c. Size: $10\frac{1}{2}$ x $6\frac{1}{4}$ x $7\frac{1}{2}$ inches. Price, without tube, $45.

ARCO B POWER

Maximum output voltage: 180 volts at 50 mA. Uses filamentless rectifier. Two-section filter. Full-wave rectification. Fifteen watts input with 30 mA. load. Size: $9\frac{3}{4}$ x $3\frac{3}{4}$ x $8\frac{7}{8}$ inches. For operaation on 110 volts 60 cycles a.c. Price, without tube, $32.50.

BREMER-TULLY B POWER

Maximum output voltage: 216 at 20 mA., 195 at 30 mA., and 150 at 50 mA. Uses Raytheon BH rectifier. Output voltages adjustable by fixed steps. Two-section filter. Full-wave rectifier. Seven watts input with 30 mA. load. Approved by National Board of Fire Underwriters. Will supply receivers having up to ten tubes. For operation on 110–115 volts 60 cycles a.c. Size: $4\frac{1}{2}$ x $9\frac{3}{4}$ x $6\frac{3}{4}$ inches. Price: $37.50, without tube.

BASCO B POWER

Maximum output voltage: 250 at 20 mA., 230 at 30 mA., 190 at 50 mA., and 175 at 60 mA. Uses Raytheon BH rectifier. Two-section filter. Full-wave rectification. Fixed detector voltage. Other voltages variable. A special primary rheostat functions to regulate output to supply different types of power tubes. Twenty watts input with 30 mA. load. Size: 12 x $4\frac{1}{2}$ x $7\frac{1}{4}$ inches. Price, with tube, $35.

King, Types M and V

Maximum output voltage: 238 at 20 mA., 215 at 30 mA., and 180 at 50 mA. Uses type 213 rectifier. One-section filter. Full-wave rectification. Type M has variable detector and amplifier voltages. Type V has variable detector voltage and fixed 90, 135, and power tube taps. Twenty watts input with 30 mA. load. Can supply up to nine tubes. Size: Type V, $9\frac{1}{2}$ x $4\frac{1}{2}$ x 7 inches; Type M, 11 x 6 x 6 inches. Prices: Type M, $45.00; Type V, $37.50.

Exide, Model 9-B

Maximum output voltage: 208 at 20 mA., 194 at 30 mA., and 180 at 40 mA. Uses electrolytic rectifier, arranged in bridge circuit for full-wave rectification. Two intermediate and detector voltages adjustable. Two-section filter. For operation on 105–125 volts 50–60 cycles a.c. Ten watts input with 30 mA. load. Approved by National Board of Fire Underwriters. Designed to supply sets with six or more tubes. A 112 or 171 type power tube may be used. Size, $6\frac{1}{2}$ x $11\frac{1}{8}$ x $9\frac{3}{4}$ inches. Price: $42.50.

General Radio, Type 445

Maximum output voltage: 200 at 20 mA., 185 at 30 mA., and 160 at 50 mA. Uses type 280 rectifier tube. Two-section filter. Output voltages adjusted by means of sliding taps on wire-wound resistance. C voltage available for power tube. Twenty-eight watts input with 30 mA. load. Designed to meet specifications of National Board of Fire Underwriters. Automatic switch breaks the 110-volt a.c. input circuit when cover is removed. Size: $15\frac{1}{4}$ x 7 x 7 inches. Price: $55.00, without tubes.

Freed-Eisemann, Model 16

Maximum output voltage: 135 at 30 mA. Uses type 280 rectifier tube. Also uses type 874 glow tube to maintain output voltages constant independent of the load. Two-section filter. Three C voltages available; $-4\frac{1}{2}$, -9, and -27. Twenty-five watts input with 30 mA. load. For operation on 105–120 volts 60 cycles a.c. Size: 7 x 7 x $9\frac{3}{4}$ inches. Price: $35.00, without tubes.

Majestic, Super-B Power Unit

Maximum output voltage: 186 at 20 mA., 156 at 30 mA., and 112 at 50 mA. Adjustable output voltages. Special "high-low" switch gives two voltage ranges. Full-wave rectification. Two-section filter. For operation on 110 volts 60 cycles a.c. Size: $10\frac{1}{2}$ x $5\frac{1}{2}$ x 9 inches. Price, complete with tube, $29.50.

Freshman, Model A

Maximum output voltage: 220 volts at 40 mA. Uses tube rectifier in full-wave circuit. Adjustable output voltages. Two-section filter. Unit supplies following C voltages: $-4\frac{1}{2}$ -9, -40. Thirty watts input with 30 mA. load. Designed to supply sets using up to seven tubes. Price complete: $45.

Muter B Power Units

Two types made, one for Raytheon BH tube, the other for 213 or 280 type rectifier. Maximum output voltage (Raytheon type); 200 at 20 mA., 180 at 30 mA., and 150 at 50 mA. Other type gives output voltages about 10 volts lower. Full-wave rectification. Two-section filter. Fixed output voltages. Twenty-one watts input with 30 mA. load. For operation on 110–120 volts 60 cycles a.c. Prices: Raytheon model, $26.50; other model, $24.50.

Presto-O-Lite "Speedway" B

Maximum output voltage: 188 at 20 mA., 175 at 30 mA., and 148 at 50 mA. Fixed output voltages. Compensation for variations in line voltage obtained by adjusting three-point switch. One-section filter. Full-wave rectification. Twenty-five watts input with 30 mA. load. Uses Raytheon BH rectifier. Size: 6 x 8 x 8 inches. Price: $37.00, including tube.

Sentinel, Model B-C

Maximum output voltage: 180 at 80 mA. Uses two rectifier tubes. Two variable voltages. Unit supplies two C voltages, $-4\frac{1}{2}$ (fixed) and $-4\frac{1}{2}$ to -45. Voltage control to compensate variations in line voltage. Beverly model is equipped with special instrument used to read the voltages being supplied by the various taps on the power unit. Prices, including two tubes, regular model, $44.50; Beverly model, $65.00.

Silver-Marshall, Type 656

Maximum output voltage: 170 at 20 mA., 160 at 30 mA., and 140 at 50 mA. Unit uses UX–213 (CX–313) rectifier and UX–284 (CX–384) glow tube. Glow tube maintains output voltages practically constant independent of load. Two-section filter. Twenty-five watts input with 30 mA. load. Size: $6\frac{1}{2}$ x $7\frac{1}{2}$ x 5 inches. Price: $38.50.

Stewart, U–80

Maximum output voltage: 190 at 20 mA., 175 at 30 mA., and 140 at 50 mA. Two-section filter. Full-wave rectification. Thirty watts input with 30 mA. load. Adjustable detector voltage. Rheostat in the primary to compensate differences in line voltage. Uses Raytheon type B or BH rectifier. Size: $11\frac{1}{2}$ x $4\frac{1}{2}$ x $8\frac{1}{2}$ inches. Price: $34.50.

Dis-ton, Types D-60 and D-25

Maximum output voltage: 215 at 20 mA., 200 at 30 mA., and 185 at 50 mA. Adjustable output voltages. Two-section filter. Full-wave rectification. Fifteen watts input with 30 mA. load. Unit uses two thermionic rectifiers. Supplies C bias up to 22 volts. Self-contained milliammeter indicates performance. Price $29.50, without tubes. *Type D-60*

Maximum output voltage: 120 at 20 mA., and 95 at 30 mA. Adjustable output voltage. One-section filter. Half-wave rectification. Nine watts input with 30 mA. load. Uses one thermionic rectifier. Size: 10 x 4 x 6 inches. Price: $23.50, with tube. *Type D-25*

Sterling, Type R-97

Maximum output voltage: 300 at 20 mA., 286 at 30 mA., and 262 at 50 mA. Adjustable output voltages. Full-wave rectification. Twenty-five watts input with 30 mA. load. Unit supplies C voltages up to 50 volts. Price: $55.00

Valley, Model 60

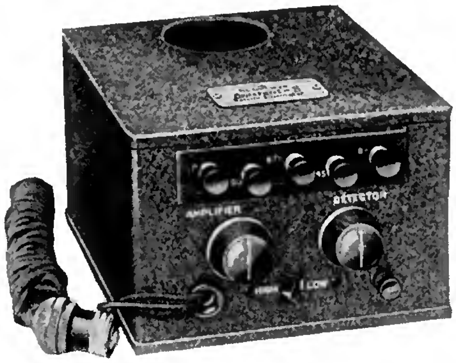
Maximum output voltage: High range—250 at 20 mA., 220 at 30 mA., and 175 at 50 mA.; Low range—200 at 20 mA., 180 at 30 mA., and 140 at 50 mA. Uses Raytheon BH rectifier. Two adjustable voltages. Two-section filter. Full-wave rectification. Eighteen watts input with 30 mA. load. Size: $5\frac{3}{8}$ x $9\frac{3}{4}$ x $9\frac{1}{4}$ inches. Price: $50.00, including tube.

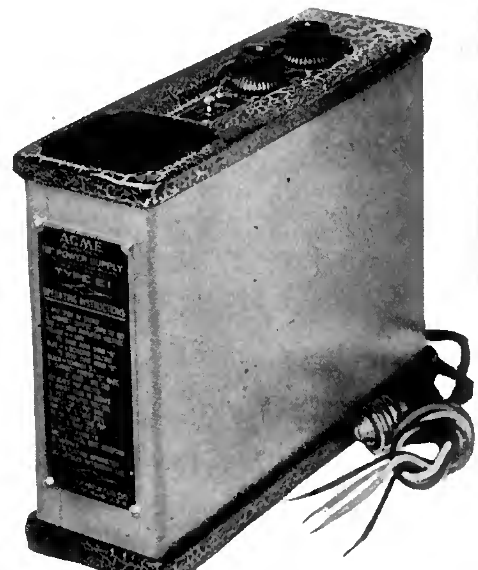
Valley, Model 40

Maximum output voltage: 170 at 20 mA., 145 at 30 mA., and 110 at 50 mA. Uses Raytheon BH rectifier. Two adjustable voltages. One-section filter. Full-wave rectification. Seventeen watts input with 30 mA. load. Size: 9 x $4\frac{1}{4}$ x $7\frac{3}{4}$ inches. Price: $37.50, with tube.

Compo, Model B-C

Maximum output voltage: 180 at 50 mA. Two-section filter. Full-wave rectification. Uses Raytheon BH rectifier. Uses Raytheon BR regulator tube to keep voltages constant. Unit supplies adjustable C voltages up to 50. Twenty-eight watts input with 30 mA. load. Size: $10\frac{1}{2}$ x $5\frac{1}{4}$ x $8\frac{1}{2}$ inches. Price: $57.50, with tubes.





THREE MORE LINE SUPPLY DEVICES

The Acme B power unit incorporating two variable resistances to compensate differences in load imposed on the device by different receivers is shown at the right. The All-American Constant B is illustrated at the center and contains a "high-low" switch to adapt the device to different loads and line voltages. The C potential as well as B potential can be obtained from the Valley unit at the left

Measuring the "GAIN" of *your* RECEIVER

Stromberg-Carlson engineers testing the audio-frequency characteristics of one of their No. 744 receivers. The apparatus consists of a "beat frequency" oscillator which produces the audio tones, and meters for measuring the extent to which these frequencies are amplified within the receiver

By KEITH HENNEY

Director of the Laboratory

OUR present broadcasting structure is made up of three intimately connected components, the broadcasting station, the receiving equipment, and the intervening medium. The broadcasting station has one *raison d'etre*—to translate sound impulses into electrical waves; the receiver's only purpose is to accomplish the opposite—to translate these electrical waves back into sound impulses. The intervening medium is the connecting link between the transmitter and the receiver, an inefficient link it is true, performing its task with many vagaries, and for reliability's sake it might be very well displaced by a metallic conductor. The radio medium, however, has the advantage that for broadcasting purposes, the communication is radiated in all directions, and is not confined to a direct path between two points.

We have already outlined in the November RADIO BROADCAST what the transmitter does when it lays down a "field strength" about the receiver, how this field strength is measured, how much is necessary for various degrees of service, and how field strength and the attributes of sets, selectivity, sensitivity, and fidelity, are related.

It was pointed out that the greater the field strength, or the more sensitive the receiver, the more powerful the corresponding loud speaker signal. We are now faced with the problem of ascertaining how sensitive a receiver must be to deliver a certain signal from a certain field strength, how selective a set must be to shut out unwanted signals in favor of the desired program, and what the degree of fidelity must be to furnish sufficient realism to make a receiving equipment no longer a "radio" but a musical instrument.

What we must do is to answer the following questions, presupposing a station to deliver a certain field strength at a certain point:

How loud will be the resulting signal from a certain receiver? How can it be measured? What will happen if another station a given number of kilocycles away goes on the air and lays down a certain field strength about the receiver? If the receiver is sufficiently sensitive and selective, how do these factors influence the fidelity?

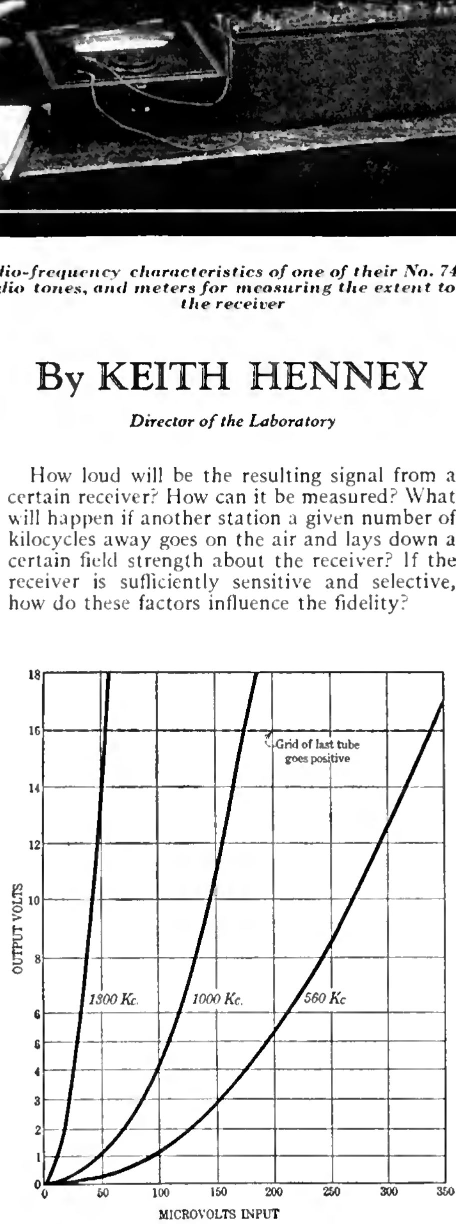


FIG. 1

When one measures the output voltage of a receiver of several years ago as the input voltage is changed, he gets a curve similar to those shown above. Note the steep 1300-kc. curve indicating extreme sensitivity, and the decreasing sensitivity as the radio frequency is decreased

Since radio receivers were first made, qualitative answers to these questions have been the stock in trade of all engineers. It is only within the last year that quantitative answers have been generally available, especially when one considers the receiver as a single unit, and desires answers to his questions not with regard to the component parts that make up that receiver but with respect to the ensemble equipment. Methods for determining the characteristics of coils, condensers, transformers, and other individual units that go to make up a "radio," have been known and used for several years. In England great emphasis has been laid upon and many arguments built around such measurements as contrasted with those which include everything in a receiver between antenna and loud speaker. While it is true that the characteristics of such units can be combined to produce a fair approximation of what the complete receiver will do, an overall measurement carries much more conviction to the engineer.

An interesting experiment was carried out at station WOR some time ago, and more recently by WLW, to enable listeners to determine how low and how high in audio frequencies their receivers were responsive. At WLW, where a Wurlitzer organ forms part of the studio equipment, continuous tones varying from the lowest to the highest organ note were put on the air. First the pure note of the open diapason was transmitted and then it was played with various harmonics added. This enabled the listener to determine not only the acoustic limits of his receiver and loud speaker but the change in quality as the harmonics modulated the original pure note.

In laboratory the business of performing the same experiment or that of investigating the sensitivity and selectivity of the receiver under better controlled conditions consists in moving the transmitter nearer the receiver, and decreasing its power accordingly. This eliminates the vagaries of the intervening medium, and when the transmitter is finally connected metallically to the receiver a set-up results which is sufficiently flexible that everything can be varied and measured at the same time. A miniature broadcasting station is necessary. This must consist of an r.f. oscillator whose output can be regulated and measured, an audio-frequency oscillator variable from the lowest to the highest audio tone ordinarily broadcast and relatively free from harmonics, and some means of combining these two generators of electric and sound waves.

The Hazeltine Laboratories, under the direction of Chief Engineer MacDonald, made such tests on receivers which were under development there, and the results were published in the *Proceedings of the I. R. E.* in February, 1927, the first paper to be published in this country on such laboratory practice. The emphasis here, however, was more on component parts, such as radio-frequency amplifiers, coupling coils, and audio amplifiers than on the receiver as a whole. The data as published were most interesting.

In a discussion of this paper, appearing in the April, 1927, *Proceedings of the I. R. E.*, H. D. Oakley and Norman Snyder of the General Electric Laboratories described the methods used several years ago at the Schenectady Laboratory for measuring receivers.

The equipment was housed in two shielded rooms, one of which contained the radio and audio oscillators as well as a control device for regulating the voltage which was put on the receiver under test in the adjoining room. A standard Radiola 100 loud speaker was placed across the output of the receiver, and the voltage across it measured as the input voltage was varied.

To test the sensitivity of the set, that is, to tell how many output volts could be delivered with a given input radio voltage, the following procedure was carried out. The generator was set going at a certain radio frequency and this was modulated at 1000 cycles to a given degree of modulation. The input to the receiver was varied in small steps until the output tube overloaded. This was considered the upper working limit of the receiver. A specimen curve of output voltage plotted against input voltage is shown in Fig. 1. The receiver was a standard set of several years ago, and is not indicative of the better types of modern sets.

The data show that the receiver at 1300 kc. was roughly 6.5 times as sensitive as at 560 kc. and that to produce an output voltage of 16 at 1300 kc. required an input of only 51 microvolts compared to 335 required at 560 kc. At 1000 kc. the voltage required was roughly 175. The output voltage at 560 kc. divided by the input voltage gives a rough voltage gain of 46,000; at 1000 kc. the ratio is 102,000 and at 1300 kc. the gain is 300,000.

The data showed that the output voltage for each of the three frequencies was proportional to the input voltage squared, for which the detector tube is responsible.

TESTING SELECTIVITY

TO TEST the selectivity of the receiver, it was tuned to, say, 560 kc., and the output voltage read as the transmitting generator in the first of the two shielded rooms was varied in frequency but kept at constant amplitude. The receiver was then set at some other frequency and a similar set of data was taken. Specimen curves shown in Fig. 2, are taken from the *Proceedings of the I. R. E.*

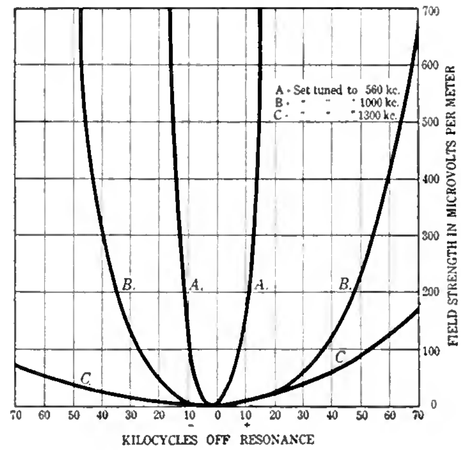


FIG. 2

These queer curves show the selectivity of a rather poor receiver. At 560 kc. the set is selective, at 1300 kc., curve C, it is as broad as the proverbial barn door. They are indicative of a poorly engineered receiver and were made on sets sold several years ago

The curves plotted from data obtained in this manner are given in Fig. 2, and show the field strength required to produce a given signal which differed from the frequency setting of the receiver by a certain number of kilocycles. For example, if the receiver were accurately tuned to 560 kilocycles, a signal 10 kilocycles off resonance, say 570 kc., required a field strength of 150 microvolts per meter to produce an interfering signal. At 1300 kc., a signal 66 kc. away, or 1366 kc., having a field strength of 150 microvolts per meter, would produce the same interference.

In other words the receiver was roughly one seventh as selective at 1300 kc. as it was at 560 kc. which, coupled with the fact that it was nearly seven times as sensitive at the same frequency, may demonstrate why the higher broadcasting frequencies were not so highly regarded by engineers of transmitting stations a year or so ago. There is no reason why a carefully designed and engineered receiver cannot be equally sensitive over the broadcasting band of 1000 kc. If the band were to be extended, in the direction of still higher frequencies, the problem placed upon design engineers would be considerable, but would not be insurmountable.

Receivers of the present day are better than these curves show. Methods of maintaining equal gain over rather wide frequency bands are well known, and up-to-date receiver manufacturers make every effort to include in their products the results of all well-known inventions. A receiver which squawks at 1300 kc. and is practically silent at 560 kc. is a poorly designed set, and should not be placed in the same class as others in which care has been taken to avoid just such criticism.

The method of measuring and rating receivers employed by the Radio Corporation of America was described in *The Proceedings of the I. R. E.* in May, 1927, by T. A. Smith and George Rodwin. An arbitrary loud speaker signal is set up and all measurements are made with a view toward determining the field strength required to produce this signal, which is that corresponding to an average audio-frequency (r.m.s.) voltage of 15 across a 5000-ohm resistance when a 400-cycle note modulates the transmitter to a degree of 50 per cent.

Having determined how much output voltage the receiver will deliver when a certain input voltage due to a certain field strength is impressed on it, mathematics will tell how much voltage or power will be delivered at other input levels, up to the overloading point of the amplifier tubes. The following relations express the manner in which transmitter antenna power, input receiver voltage, output voltage and power are interconnected:

Field strength $\propto$ transmitter antenna current.
Field strength $\propto$ square root of transmitter power.
Input receiver voltage $\propto$ field strength.
Output receiver voltage $\propto$ field strength squared.
Output receiver voltage $\propto$ transmitter power.
Output receiver power $\propto$ output voltage squared.
Output receiver power $\propto$ input voltage to the fourth power.

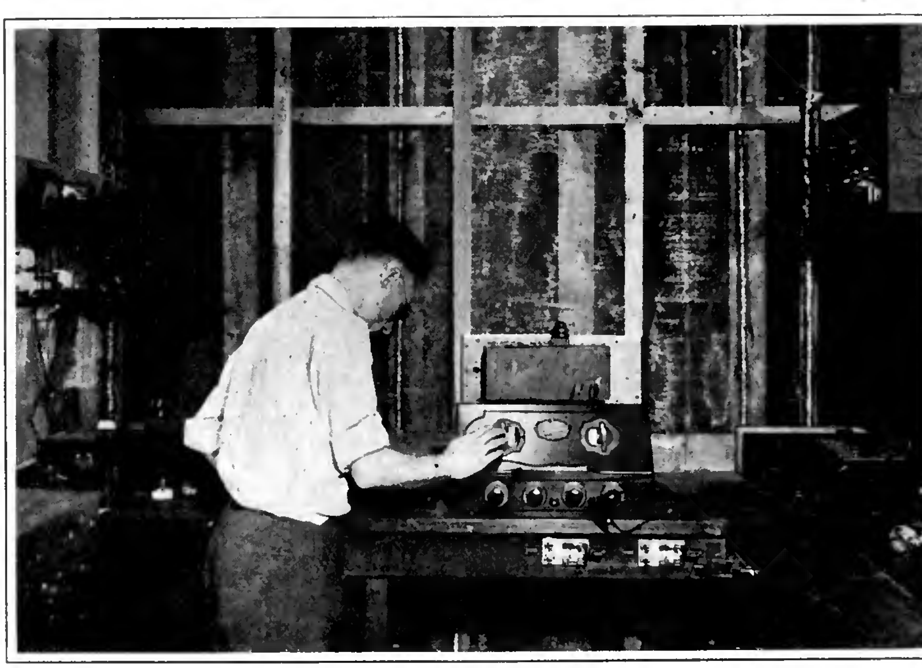


FIG. 3

The receiver is put through its paces in this shielded room at the General Electric Company. Only signals that are meant for the receiver arrive at its input via shielded wires; all others are excluded by the shielding surrounding the six room surfaces

Output receiver power α field strength to the fourth power.
Output receiver power α transmitter power squared.

The Greek letter alpha in the above relations means "is proportional to."

Doubling the transmitter antenna current multiplies the transmitted power by four, doubles the field strength, doubles the input receiver voltage, multiplies the receiver output voltage by four, and multiplies the power into the loud speaker by sixteen. These relations may be connected to what happens in one's receiver by the following facts. The average stage of audio amplification has a voltage gain of twenty-five, a two-stage affair having a voltage gain of roughly 300, or 50 TU, if a 171 type tube is used as the output tube. A good radio-frequency amplifier should have a voltage gain of about 50 TU, or 300, so that the overall gain in voltage from a modern well engineered receiver should be in the neighborhood of 100,000, or 100 TU. These figures in power amplification become respectively, for the two-stage amplifier and for the complete receiver, 30,000 and 10,000,000—truly enormous amplification.

In actual practice the R. C. A. engineers do not measure the voltage across the resistance in the output of the receiver while the input voltage is varied. An interesting short cut is used instead, which is possible from the phenomenon accompanying the function of detection.

When the receiver is tuned to a carrier wave, modulated or not, the average d.c. detector current changes, increasing when a C bias detector is employed, decreasing when the conventional grid leak and condenser method is used. Greater changes occur with greater field strengths, or the more nearly the receiver is tuned to the incoming signals. The change in detector plate current, then, is a measure of the effectiveness of the field strength or the sensitivity of the receiver.

To produce the arbitrary 15-volt signal across the 5000-ohm resistance in the receiver output requires a certain change in detector plate current. Once this is determined the audio amplifier can be dispensed with and all measurements may be made by noting the change in detector plate current. This method obviates the necessity of using modulated signals.

In the R. C. A. Laboratory the input voltages are fed to the receiver through a dummy antenna consisting of an inductance of 28 microhenries which has a resistance of 2 ohms, a capacity of 0.0004 mfd., and a resistance of 23 ohms. The curves obtained in this way show the same general characteristics as those given in the General Electric report, *i. e.*, low gain at low radio frequencies, high gain and poor selectivity at high frequencies. At the same time there is considerable loss of the higher audio frequencies at the longer wavelengths, due to the excessive sharpness of tuning, or selectivity.

While it is true that only a few of the larger and better-known receivers are engineered with these thoughts and these laboratory measurements in mind, it is a fact that more and more radio manufacturers are becoming aware that good engineering is a priceless asset. The article in this issue of Radio Broadcast on the Fada receivers, by John F. Rider, and others to follow on other well-designed receivers, proves this statement. The Laboratory is preparing data on manufactured sets using the methods of measurements mentioned above and as fast as the material is ready, it will be presented to Radio Broadcast's readers.

FIG. 4

Signal generating apparatus used at the General Electric Laboratories for testing the characteristics of receivers. This apparatus is housed in a shielded room, and consists of a Heising modulated generator capable of oscillating at any frequency in the present broadcasting band modulated at any audio frequency between 40 and 10,000 cycles

All About Patents

Inventions and Patents, Their Development and Promotion. By Milton Wright, LL.B. Published by the McGraw-Hill Book Company, Incorporated, New York. Price, $2.00. Pages, 225.

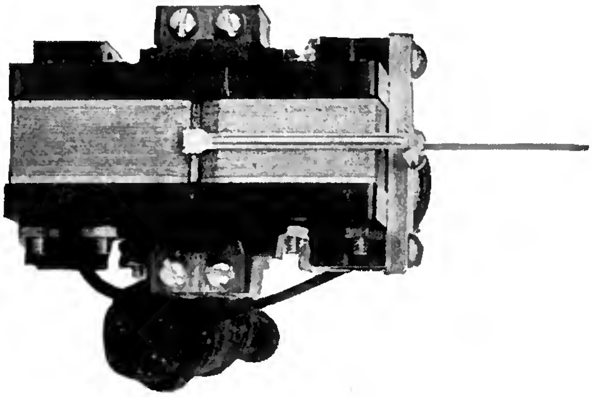
A VERY useful contribution to the bewildered inventor, throbbing with the thrill of a discovery, is the sage and practical counsel of Mr. Milton Wright, as embodied in his new book, "Inventions and Patents." There is nothing assuming about the writer's style; the work is not overburdened with technical legal arguments, although the subject is a highly technical one, and there is no obscure language to confuse the uninitiated.

The subject matter of the volume is devoted broadly to all the problems which face the inventor. He is told what is patentable and what is not patentable, what constitutes a practical invention, what steps to take to facilitate securing a patent and how to protect it after it is secured, how to select a good patent attorney, how a patent should be applied for, how to obtain financial support, what the problems of marketing and merchandising are, how to sell patents outright, on a territorial and on a royalty basis, and what steps to take against infringers. There you have it in one long sentence; certainly the scope of the book is broad enough to be a real aid to the floundering inventor.

Valuable cautions and dangerous pitfalls, which are the usual stumbling blocks to the uninitiated patent seeker and inventor, are disclosed. For example, how to keep records which aid in establishing date of conception and reduction to practice, is explained so that the inventor, heeding the advice given, will have no difficulty in later sustaining his invention in the courts. And again, the vital subject of how to select a patent lawyer and how to get the greatest value from his services is presented simply and clearly. The book abounds in practical illustrations which serve to clarify the force of the writer's arguments.

The reviewer does not hesitate to recommend a thorough reading of this volume to all those who believe they have a patentable idea and those who contemplate obtaining a patent. It is certain either to cause them to abandon the idea because it offers little or no possibility for profit, or else to secure a better and more easily protected patent. Considering that only one patent out of a hundred secured by hopeful inventors proves profitable, the discouragement of the impractical is as valuable a service as the encouragement of the promising. In this respect, Mr. Wright's dispassionate and constructive point of view differs materially from the flamboyant literature and booklets which unscrupulous patent lawyers distribute in the hope of inveigling misguided inventors to obtain patents, whether their ideas show promise or not.

—E. H. F.



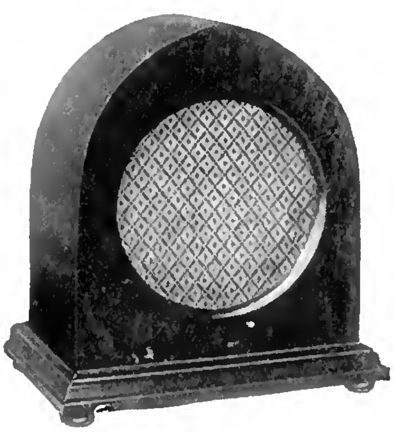
A LOUD SPEAKER ELEMENT
This is the driving unit used in the type 20-20 cone speaker manufactured by A. H. Grebe. The speaker is priced at $35.00

A PACENT OFFERING
This well made instrument uses a balanced armature construction that insures quality reproduction. Price, $35.00

LOUD SPEAKERS

A POWER CONE WITH B SUPPLY
The perfectly free mounting used in this Magnavox combination is responsible for its excellent reproducing qualities. It contains a 210 power-amplifier and B supply. Price, $242.00

THE "ALGONQUIN" CONE SPEAKER
An artistically designed cone priced at $15.00, the product of the Algonquin Electric Company



THE "NEUTROWOND" REPRODUCER
An attractive loud speaker finished in American walnut. Price $35.00

AN INNOVATION
This interesting loud speaker made by Frank B. Porter, Washington utilizes the structure above the base to conceal a tonal chamber. The actual element is with base. Various models retail for from $50.00 to $150.00

FADA
This 17-inch table cone sells for $25.00, Model 315 A. Fada manufactures other more expensive models selling for up to $50.00

POWER DEVICES

FOUR OR SIX-VOLT A-POWER
A combination storage battery and full-wave dry rectifier available in four and six-volt models, made by Triple A Specialty Co., Chicago. Price: either model, $39.50

THE BASCO A-B POWER UNIT
This device contains a B-Power unit and a storage battery-trickle charger combination. A visual indicator shows the state of charge of the battery. Price $75.

A TWO AMPERE "TUNGAR" BATTERY CHARGER
A well known product of the General Electric Company for charging A and B storage batteries. Price, $18.00

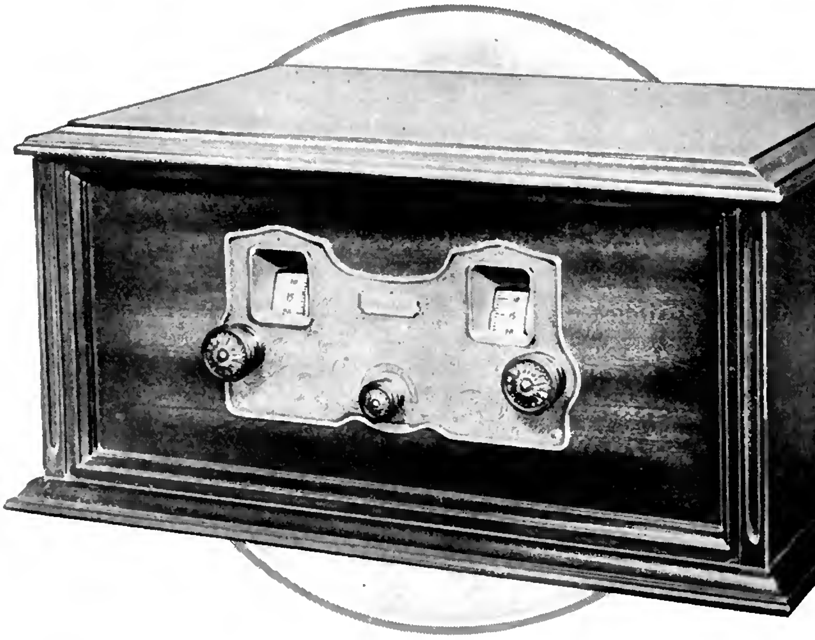
THE "ACME" B POWER UNIT
For use with receivers containing up to twelve tubes, including a 171 type power tube. A Raytheon rectifier is used. Price: $50.00

ANOTHER B POWER UNIT
This unit supplies up to 135 volts at a 60 milliampere load—more than enough for most receivers. Manufactured by the All-American Company and priced at $27.50

A POWER AMPLIFIER AND B SUPPLY
An A-B-C power supply for receivers using a.c. tubes. The unit contains one stage of power amplification using a 210 tube. Manufactured by the Radio Receptor Co., New York, and priced at $60.00

FACTS ABOUT THE FADA "SPECIAL" SET

By John F. Rider



JUST as the research laboratory is the prime mover of every business, whether cheese, steel, or clothing, it is also the heart of the radio industry. The radio public is awakening to the fact that research is a prime mover in the radio industry; that research, and research only, can produce faithful reproduction, ample volume, satisfactory selectivity, ease of control, and perfect stability. The result is recognition of research as the paramount factor, and consistent with this recognition, is the gradual stabilization of the industry—its gradual ascension to an impregnable position.

Research is directly responsible for every good receiver and for every development in radio receiver design since the day KDKA commenced its broadcasting activities. A good radio receiver cannot be produced without a research background.

As an example, let us consider a typical receiver, the design of which may be laid directly at the door of research. This receiver consists of three stages of radio-frequency amplification, a non-regenerative detector and two stages of audio-frequency amplification. It is known as the Fada "Special." But before we can enter into the mechanics of the receiver, we must first ascertain why the electrical design used was selected.

The problem placed before the engineering department was the development of a radio receiver limited to six tubes. The apportioning of the tubes was the first problem. How many stages of radio-frequency amplification should there be; and how many stages of audio-frequency amplification? Having developed audio-frequency transformers with known response characteristics and known gain per stage, and knowing that a two-stage audio amplifying system using their transformers would give the proper amount of amplification, the engineering department decided upon two stages of transformer-coupled audio amplification. Since the detector unit utilizes but one tube, the remaining three tubes can be applied to the radio-frequency system.

The development of the radio-frequency system brings to light many interesting features. Should the stages be tuned or untuned or a combination of both? Should the stages be shielded, and what material shall be used for the shielding? Since the receiver utilizes an antenna as the pick-up system, the three stages of radio-frequency amplification will give a high degree of sensitivity. The demand for selectivity necessitates the use of tuned stages of radio-frequency amplification. But the development of a three-stage tuned radio-frequency amplifier does not mean a simple decision to use three stages. Consideration must be accorded to the wavelength response of such a system. The average system possesses wavelength characteristics which fall in amplification as the wavelength is increased *i.e.*, the amplifying power of the radio-frequency amplifier is high at the shorter wavelengths and as the tuning dials are manipulated to tune to the longer wavelengths, the amplification decreases, and at 550 meters is a fraction of that at 250 or 300 meters. This situation must be avoided; it is desirable that the receiver should possess equal amplification over the entire broadcast frequency spectrum.

Since the allocation of frequencies to broadcasting stations is such that excellent selectivity can be obtained with two stages of well-designed and shielded tuned radio-frequency amplification, the third stage can be utilized to balance the two tuned stages and give the system the desired wavelength response characteristic. The radio-frequency system would, therefore, consist of two stages of tuned radio-frequency amplification and one stage of untuned radio-frequency amplification.

The decision to shield the individual stages was immediate, since shielding, if properly carried out, is conducive to better radio receiver operation and consequently better radio reception and better stability is thus attained in the radio-frequency stages because coil interaction is eliminated. By the elimination of coil interaction, neutralization is made more effective. Better tone quality is also obtained, because by eliminating coil interaction, the side-band characteristics planned in the design of the tuned stages are actually obtained. Selectivity is augmented, because direct coil pick-up is precluded. The elimination of coil pick-up also means greater amplification in the radio-frequency system.

The selection of the shielding material is governed by the effect the shield has upon the inductances used in each stage. In order to minimize the electrical effect upon the coils, a material with a high conductivity must be used, since high conductivity means lower losses. Aluminum was decided upon, and the shield takes the form of a can, completely enclosing the radio-frequency transformer. With the shields of proper diameter and properly located with respect to the coils, the losses introduced are so small as to be entirely negligible.

In view of the fact that the radio-frequency coils are shielded, it is possible to make use of the most efficient type of winding—the single-layer solenoid. Without shields, a cascade system employing such coils would be quite difficult to control. The selection of the single-layer solenoid was also based upon the fact that it can be wound with the greatest degree of accuracy, particularly so when the winding form is grooved, and the turns are wound in these grooves.

The receiver is to be dual tuned, requiring two condensers controlled by one drum dial and another single condenser controlled by the other drum dial. Such control is simple because of the precision methods employed in the testing and matching of the coils and tuning condensers. Each tuned transformer consists of three windings, the primary, the secondary, and a neutralizing winding. Each of these windings is matched on a radio-frequency testing instrument, to within one eighth of one per cent. The coil under test is plugged into an oscillator circuit and a resonance point obtained with a standard condenser. This condenser is so graduated that a 10 per cent. variation in resonance is spread out across the 100-division dial. The dial settings for the resonance point for each winding are noted and the coils segregated according to these figures. The result is that each group of three coils consists of coils with windings which never vary more than one eighth of one per cent.

The same precision in testing applies to the tuning condensers, and because of the mechanical design of these condensers, full accuracy is maintained during the operating life of the unit. Each completed tuning condenser is made to within one per cent. plus or minus, of its rated capacity, and each condenser in a group of three is matched to within one eighth of one per cent of the others. The matching of the variable condensers is carried out by means of a special radio-frequency measuring instrument designed for the purpose.

The construction of variable condensers which will not vary more than one per cent. calls for detailed engineering. The brass used for the plates must be very accurate, the tolerance limit being 0.0005 of a mil in thickness. To assure perfect alignment of the condenser plates and a smooth rotary action, large bearings are used, these latter being approximately ⅝" in diameter. To further assure perfect alignment of the brass plates, each plate is individually stipled and leveled.

But the precision construction and matching of coils and condensers is not sufficient to assure perfect operation. It is necessary to assure perfect mechanical support for these units—supports which will be identical in every receiver of similar design. It is necessary to select a base for the condensers which will assure easy operation not for a short while, but for years to come

Again engineering comes to the fore, with a pressed steel chassis ⅛" thick, punched out on a 100-ton press. One operation punches all the holes necessary and also forms the chassis. The result is uniformity of mounting holes.

R. F. CHARACTERISTICS

WITH the condensers, coils, and shields on hand, we go back to the radio-frequency system. The overall gain curve of the three-stage radio-frequency amplifier, consisting of the two tuned stages and the one untuned stage, is shown in Fig. 1. Here we see a beautiful example of research and engineering. With the exception of the zone between 200 and 212 meters, (1500 and 1410 kc.) the amplification does not vary more than 11 per cent. from 212 to 550 meters. Between 200 and 212 meters, the curve rises with the increase in wavelength, and the difference between the lowest point, 200 meters, and the highest, 250 and 500 meters, is only 17 per cent. With such small variance in amplifying power, the owner can manipulate the dials of his receiver from 200 to 550 meters, and know that the sensitivity of the system is practically uniform over the complete scale.

But the design of a radio-frequency system does not consist solely of the development of an amplifier which will possess the wavelength response curve shown. It is also imperative to accord detailed consideration to the shape of the resonance curve of each individual tuned stage, since the resonance curve manifests a great influence upon the tone quality of the receiver. In this respect, there is a close association between the radio-frequency amplifier and the audio-frequency system. Many owners of radio receivers are unaware of the effect the resonance curve of the radio frequency stages has upon the tone quality obtainable with the receiver employing three stages of radio-frequency amplification. Fans are too prone to overlook the side-band characteristics of the radio-frequency stage. They forget that while the radio-frequency stage is tuned to the frequency of the carrier wave, it is also necessary to consider that this carrier wave is modulated by audio frequencies ranging from 30 to 5000 cycles. Also that the effect of these modulating frequencies is to create a modulated carrier wave whose frequency spectrum is 10,000 cycles wide. In other words, if the carrier wave (unmodulated) is 750,000 cycles (400 meters) when modulated, this wave is broadened to cover from 745,000 to 755,000 cycles. The 5000 cycles above the carrier and the 5000-cycle-band below the carrier constitutes the side-bands. Hence the resonance curve of the radio-frequency stage must be broad enough to cover this band of 10,000 cycles even though the circuit is actually tuned to 750,000 cycles. If the curve is too sharp, some of the higher side-band frequencies will be suppressed. If the curve is too broad, selectivity will be marred. Hence both selectivity and sideband suppression must be considered in the design of the radio frequency amplifier. With a known value of "Q", which is the factor of selectivity, being the ratio of the reactance to the resistance of the circuit at a certain frequency, it is imperative to know the side-band suppression in the radio-frequency amplifier and to give it consideration in the design of the associated audio-frequency amplifying equipment. An example of various degrees of sideband suppression in tuned circuits is

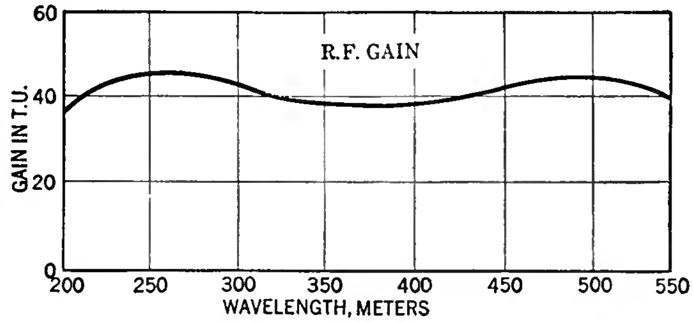


FIG. 1

The curve shows the gain from the antenna to the input to the detector. The sensitivity of the r. f. amplifier is high and the amplification flat

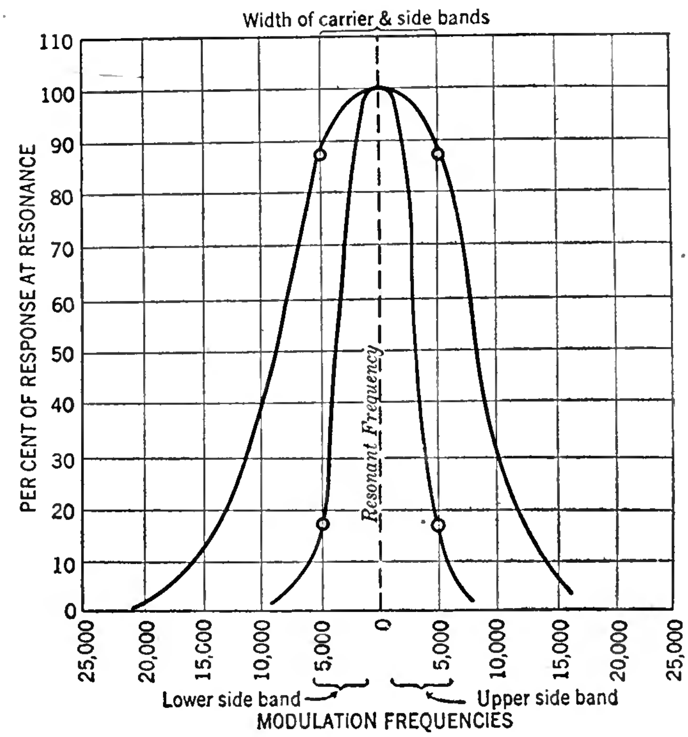


FIG. 2

Tuned circuits that are too selective impair quality. The outer curve shows the response in a well-designed circuit

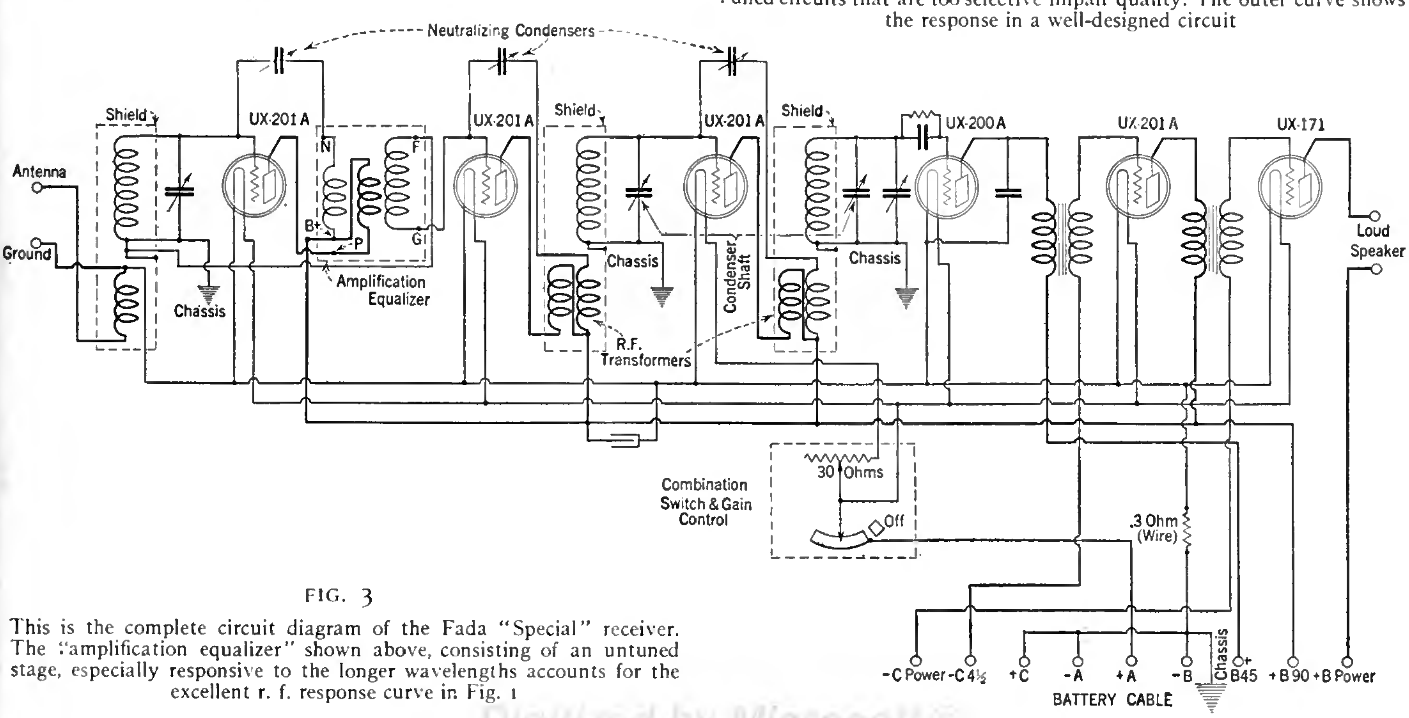


FIG. 3

This is the complete circuit diagram of the Fada "Special" receiver. The "amplification equalizer" shown above, consisting of an untuned stage, especially responsive to the longer wavelengths accounts for the excellent r. f. response curve in Fig. 1

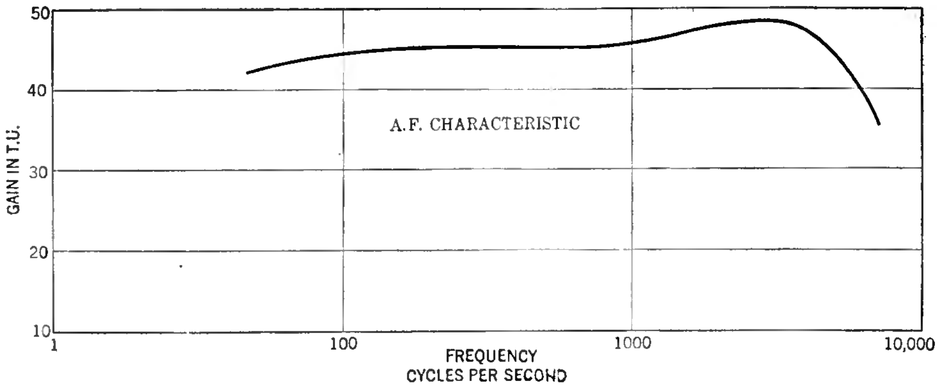


FIG. 4, OVERALL A. F. CHARACTERISTICS

shown in Fig. 2. Curve A shows 80 per cent. suppression on 5000 cycles and curve B shows 15 per cent. suppression at 5000 cycles. Curve B is broader than A, but the proper amount of selectivity is obtained by virtue of the cumulative effect of a number of stages.

THE DETECTOR

FROM the radio-frequency system we pass on to the detector circuit. A choice of two systems of detection is available—the grid bias method or the grid leak-condenser arrangement. Because of the increased sensitivity, resulting in greater output, the grid leak-condenser system is used.

From the detector we pass to the audio-frequency amplifying system. We made mention in a previous paragraph that transformers were used, but the design of a transformer-coupled audio amplifier cannot be consummated by simply deciding upon transformers. Sometimes these characteristics of the transformers to be used are exactly what the requirements call for; sometimes they are not. With specific requirements on hand, audio-frequency transformers must be designed to fill the need. The design is a detailed process. First the tubes to be used must be decided upon, and their electrical constants must be taken into consideration. The core material for the transformers must be selected, and the inductance of the primary and secondary windings must be calculated in order that the transformer possess certain predetermined characteristics. The method of winding must be decided upon so that distributed capacity is low and so that satisfactory response on the higher audio frequencies is obtained.

Detailed consideration must be accorded to the regeneration existing in the completed audio-frequency amplifier. This is very important. The overall response curve of a two-stage audio system with regeneration in the amplifier will differ from that of a single unit. If the single unit is designed to match the radio-frequency system, the operation of the completed two-stage amplifier will be entirely different. It is also essential to consider the loud speaker to be used. This unit, too, possesses operating characteristics which must be taken into account. The combined operating characteristics of the radio-frequency amplifying system and the audio-frequency amplifying system must be such as to produce best results with a particular loud speaker or with a group of good loud speakers.

The completed two-stage audio amplifier of the receiver under consideration—the Fada "Special" possesses the overall audio frequency characteristics shown in Fig. 4. The amplification is shown on the ordinate or the left vertical line. The audio frequencies are shown on the abscissa or the horizontal line. The frequencies are plotted on a logarithmic scale. As is evident, the curve is practically flat from 50 to 1000 cycles, rises from 1000 to 3000 cycles, and then falls gradually to 5000 cycles. The maximum difference in amplification between the lowest and the highest points is only 12.5 per cent., which difference is negligible, since the average ear will not discern intensity variations of such small proportions.

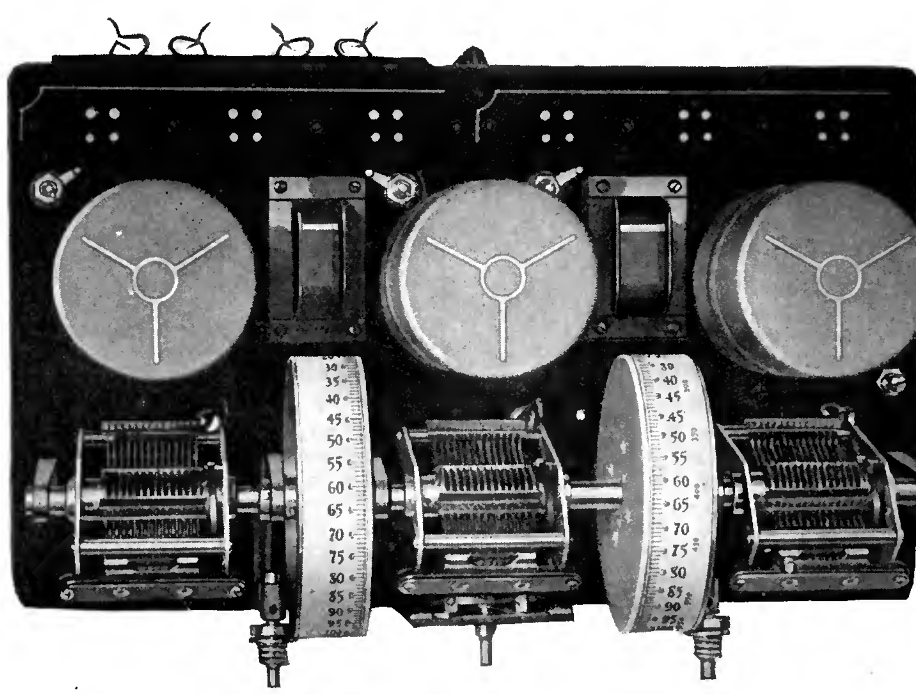
The development of the receiver is completed. Let us now consider the engineering involved in the testing of the receiver. Each receiver must undergo various tests during the process of production. The designing of this testing equipment is also in the hands of the engineering staff. Without testing equipment all the effort placed in the design of the individual parts and systems will have been for naught. Without a testing department the life of a radio plant would be very short.

The first test is a continuity test of the assembled chassis. This makes necessary testing with meters in each and every circuit, showing the voltage across the tube filament, the filament current, the plate current, the plate voltage and, continuity in the grid circuit. The filament current and filament-voltage meters show the operating action of the units incorporated in these circuits. The same is true of the plate-voltage and plate-current meters. Open circuits in the plate circuit will be shown on these meters. By simultaneously testing all the circuits, it is easy to select the faulty circuit if one is present in the receiver. The location of the fault is also noted. By having meters in every circuit it is unnecessary to hunt haphazardly.

The second test is to determine the efficacy of the neutralizing system, and the adjustment of the neutralizing units. In this test the assembled and wired chassis is connected to a series of meters, and the input system is coupled to a dummy antenna which obtains its energy from a local radio-frequency oscillator. The dummy antenna simulates an average outdoor installation. The meters show excessive regeneration in any of the tuned circuits, when these circuits are made resonant to the frequency of the oscillator. The neutralizing system is then adjusted until all signs of excessive regeneration in the radio-frequency amplifying system disappears. Incidentally, this same method of testing is employed to determine the overall gain of the radio-frequency amplifier.

When measuring the amplifying power of the radio-frequency system, from the grid of the first radio-frequency amplifying tube to the grid of the detector tube, a constant predetermined radio-frequency signal is fed into the radio-frequency system. The input voltage is held constant on all wavelengths covered by the tuning system. The voltage across the grid filament circuit of the detector tube is measured with a vacuum-tube voltmeter.

The third test applied to the receiver is the "air" test, *i.e.*, the receiver is connected to an outdoor antenna and outside broadcasting stations are tuned-in. This test is a final check of all the tests applied to the receiver during the process of manufacture. The overall gain of the radio-frequency amplifier and the audio-frequency amplifier is again ascertained. With respect to the measurements of the audio-frequency system and the transformers used, each transformer is individually tested against a standard before being placed into service in the amplifier. Then the completed two-stage unit is again tested under actual operating conditions. With a known constant input, the total gain is finally measured with a tube voltmeter—the last of a series of thorough and efficacious tests.



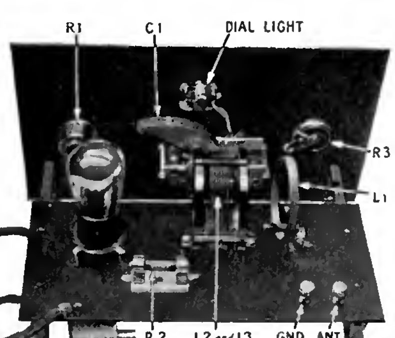
WHAT THE CHASSIS LOOKS LIKE

"Our Readers Suggest—"

TWO pages of Radio Broadcast *will regularly be devoted to publishing contributions from readers who have made interesting improvements in the use of ready-made radio products. These suggestions may deal with complete radio receivers, socket-power units, "kinks" in the placing of loud speakers, or slight circuit or mechanical changes in apparatus in general use. Our readers have a wealth of experience along these lines and these pages offer an opportunity for them to share their findings. Typewritten contributions from readers are welcomed which, if published, will be paid for at our regular space rates. In addition, a monthly award of $10 will be paid for the best contribution published each month. Address all contributions to Complete Set Editor,* Radio Broadcast, *Garden City, New York.*—The Editor.

A Short-Wave Converter for any Radio Receiver

THERE is to-day sufficient material being broadcast below 100 meters (3000 kc.) to interest the serious fan and to justify the construction of simple apparatus for its reception. In some cases the use of a short-wave receiver will make possible the reception of important programs beyond the range of the conventional receiver. The construction of a short-wave receiver is often an expensive proposition, and converters heretofore described have been rather complicated affairs. It is the intention of the writer to describe a simple and inexpensive converter which, when attached instantly to any broadcasting receiver, makes it possible to receive on wavelengths between 15 and 125 meters (20,000 and 2400 kc.) No change is made in the present receiver but by means of the converter the former is alternately available for short- or broadcast-wave reception.



THE SHORT-WAVE CONVERTER

The short-wave converter takes the form of a very simple and incidentally highly efficient short-wave receiver, the output of which is connected to the audio-frequency amplifier of the present broadcast receiver. A simple plug-in arrangement makes the change a matter of a few seconds.

The following is a list of the parts used in the short-wave converter illustrated and described:

L_1, L_2, L_3—Set Aero Short-Wave Coils.
C_1—Amsco 0.00025-Mfd. S. F. L. Condenser.
L_4—Silver-Marshall Choke, No. 275
R_1—Clarostat 0-500,000-Ohm Resistor.
R_2—Amsco 3-Megohm "Grid Gate," with Mounting.
R_3—Amsco 20-Ohm Rheostat.
C_2—Tobe 0.00025-Mfd. Fixed Condenser.
C_3—Tobe 0.001-Mfd. Fixed Condenser.
Three Four-Foot Lengths of Flexible Wire.
Sub-Panel Brackets, Hardware, and Old Tube Base.
National Type C Dial.
Amsco Floating Socket.
7 x 12 x $\frac{3}{16}$ Inch Celeron Panel.
7 x 11 x $\frac{1}{2}$ Inch Wood Baseboard.
Two "XL" Laboratories "Push" Binding Posts.

THE FRONT PANEL

The construction of the short-wave converter is best described in the accompanying illustrations. However, a word regarding the connecting plug may be of assistance.

The three wires leading respectively from the radio-frequency choke coil, A-battery minus, and A-battery plus, are led to the base of a discarded tube, as made clear by reference to Fig. 1. The glass of the old vacuum tube is broken off and the base cleaned out. The three wires are soldered to terminals inside the base, one to the A-plus plug, one to the A-minus plug, and one to the plate terminal. These terminals may be identified by holding the tube base, bottom down and the side pin toward you. With the base in this position, the two rear posts are A plus and A minus respectively from left to right, and the left-hand front post is the plate terminal. The base of the tube is now filled with a wax compound, such as the top of a discarded B battery. This is easily done by placing small pieces of the wax in the tube base and melting them with a hot soldering iron. The receiver may be wired with bus bar, but the author found coded flexible wire more convenient. All leads should be made as short as possible.

The function of the choke coil is important. If the Silver-Marshall one is not available, one may be made by winding 100 turns of 26 d.c.c. wire at random on a wood spool, $\frac{1}{2}$ inch in diameter with $\frac{1}{4}$-inch wooden core.

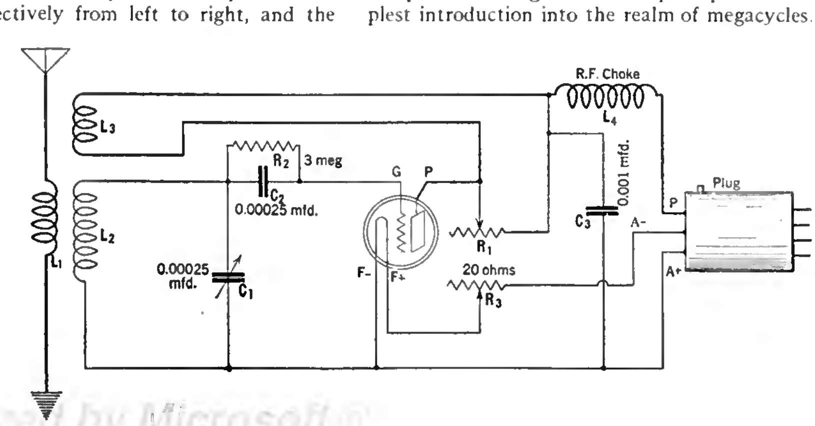
To operate the short-wave converter, remove the detector tube from the regular broadcast receiving set and place it in the tube socket of the converter. Next select the plug-in coil from the Aero set covering the wave band in which you wish to receive, and plug it into the coil jacks. Then insert in the detector tube socket of the regular broadcast receiver the plug made from the old tube base. When the antenna and ground have been changed to their respective posts on the converter, you are ready to listen-in. To do so simply leave the loud speaker where it is, or, if phones are used, these may be plugged in as usual in any stage for which a jack is provided on your particular receiving set. Turn the Clarostat until the receiver oscillates. Tune-in a station and clear up the signal by a further adjustment of the Clarostat or rheostat as required.

Perry S. Graffam.
Boston, Massachusetts.

STAFF COMMENT

WHILE the importance of short-wave reception cannot be overstressed, statements regarding its immediate and direct utility to the fan must be qualified. Radio Broadcast does not care to encourage the use of radiating short-wave receivers, and the more simple sets necessarily fall into this category. Serious experimenters, broadcast enthusiasts desiring to take up code work, and fans in isolated districts are, however, undoubtedly justified in conducting experiments along these lines. Mr. Graffam's inexpensive arrangement offers perhaps the simplest introduction into the realm of megacycles.

FIG. 1



Short-wave reception is by no means an unalloyed bliss as some avid publicity men would have us believe. Ninety-eight per cent. of the transmissions carried on below 100 meters is inter-communicative code work and the two per cent. of radio telephonic transmission is often marred by high speed fading.

Antenna Compensation in a Single-Control Receiver

ONE of the major problems in single-control multi-tuned circuit receivers is the elimination of the detuning effect of the antenna on the first radio frequency stage. Loose and variable coupling between the antenna primary and the first r.f. secondary is generally employed to compensate this influence. These arrangements, unfortunately, often lower the signal response of the receiver, and the set still functions best with antennas of definite electrical characteristics.

The arrangement proposed overcomes these difficulties and offers the following advantages:

It eliminates the antenna effect on any receiver.
It can be attached to any receiver without making more than one simple change.
No additional controls are required.
Sensitivity is never reduced. On the contrary it is often increased.
Any length antenna may be used with the receiver without making additional changes.
The device acts as a partial blocking stage in case oscillations are set up in the tuned amplifiers.

In brief, the device causes the radio-frequency impulses to be applied across a resistor to an extra radio-frequency tube, which is outputted to the original antenna primary.

The following is a complete list of parts necessary to make the change:

C_1—0.001-Mfd. Coupling Condenser. L_1—R. F. Choke Coil. Socket. 201-A Type Tube. R_1—¼-Ampere Ballast Resistor. Sw.—Battery Switch. R_2—1000-Ohm Resistor. Six Binding Posts.

This apparatus is easily wired on a baseboard in accordance with the diagram, Fig. 2.

The antenna is disconnected from the receiver and wired to post number one. The ground remains connected to the receiver and is also wired to post number two of the new stage.

Turn on the filaments to the receiver proper and the switch to the extra stage. Run a wire from the A battery plus post on the set to post number four. The extra tube will probably light. If it does not light, repeat the test with a wire from the negative A post.

If the extra tube lights with one side grounded and the other side connected to the A battery circuit, it is an indication that one side of the A circuit is grounded, as it will be in 90 per cent. of receivers. If this is the case, proceed as follows:

Leave the wire that lights the filament connected to post number four. Connect the antenna post on the receiver to post number five.

If, upon making the tests with the filament wires to post number four, the tube does not light, indicating that the filament circuit is not grounded in the receiver, the filament plus wire should be connected to post four and the filament minus wire to post three. The tube will now light, of course. Connect the antenna post on the receiver to post number five, and terminal six to the plus 90 volts, and the unit is ready for operation.

There is no change in the operation of the receiver whatever. If taps are provided on the antenna primary of the original receiver, slightly higher efficiency may be secured by experimenting with them.

If the experimenter is a bit more of an expert,

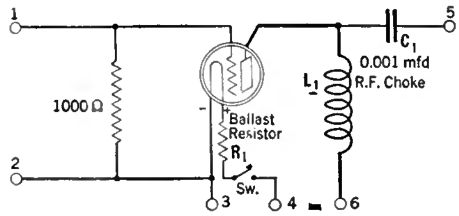
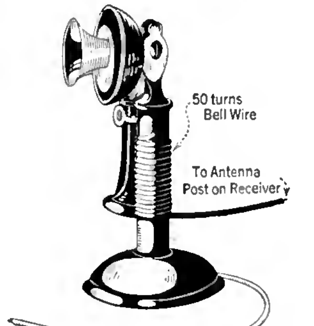


FIG. 2

the filament lead, or leads, to the antenna coupler tube may be led from the tube side of the set switch, making it possible to operate the antenna coupling tube by the same switch that controls the set filaments.

HAROLD BOYD.
Winchester, Virginia.



AN EMERGENCY ANTENNA

Fifty turns of bell wire are usually satisfactory

STAFF COMMENT

THE arrangement suggested by Mr. Boyd is quite practicable and is already used in several commercial and kit receivers. The tube coupling device is in the nature of an untuned radio-frequency amplifying stage, and, in some instances, may result in increased sensitivity. The r.f. gain, however, is generally small in comparison with the utility of the arrangement.

One thousand ohms is about the optimum value for the antenna coupling resistor. It seems to make little difference whether the resistor is inductive or not. The Lynch, Amsco "Metaloid," Carter, and Electrad are excellent resistors for this purpose. A variable zero to 2000 ohm resistor may be substituted for the fixed resistor recommended by Mr. Boyd and used as a volume control.

In a few cases it may be found that the load imposed by the coupling arrangement on the first r.f. transformer is no more favorable to tandem tuning than that of the average antenna. This can be compensated either by adjusting the compensating condenser across the first tuning section (if the main condenser is so equipped), or by winding a special primary over the first secondary. From six to ten turns of wire may be placed directly over the coil. One end is connected to post number five in Fig. 2 and the other terminal to plus 90 volts.

Increasing Response from a Loop Receiver

ALL receivers are more or less affected by location, but the loop set seems to be particularly susceptible to adverse conditions imposed by position. This is due to the fact that the loop is often surrounded by steel building framework and similar obstructions which the open antenna can rise above. Disadvantages of this nature were impressed upon the writer when moving from the top floor of a New York City apartment house to the second floor of the same building. The receiver, a Radiola super-heterodyne, worked perfectly in its original position eight floors higher up, but lost perhaps seventy-five per cent. in sensitivity when brought a hundred feet nearer the ground.

Its operation was brought up to normal by a simple device, thrown together in five minutes. A twenty-five foot antenna was strung on the roof of the building. Three turns of wire, harmonizing with the wire on the loop, were wound around the loop frame, twisting slightly about the original loop wire to keep it in place. One end of this extra wire was connected to the short antenna, while the other end ran to ground.

Sufficient energy is transferred to the loop circuit from the open antenna to compensate the losses imposed by an inferior location.

A. J. HOWE.
New York City.

STAFF COMMENT

THE device recommended by our contributor is, of course, a simple antenna coupler, the extra turns of wire functioning as the primary and the loop itself as the secondary. The arrangement is effective. On the ordinary super-heterodyne (that is other than the second harmonic type) the shortest antenna giving satisfactory reception should be used, to reduce the possibility of radiation.

The directional effect of the loop is largely eliminated by coupling to an open antenna in this manner. However, the selectivity of the super-heterodyne is such that this effect can be safely dispensed with.

A coupling device of this type is made commercially by the Jenkins Radio Company, Davenport, Iowa.

A Temporary Antenna for the Traveling Fan

EXTRA tubes and batteries are easily available in an emergency, but the occasion where a spare antenna would save the day is seldom provided for, so a word as to an excellent makeshift antenna may not be amiss.

A first class one, often equal to the average outdoor variety, may be secured by wrapping fifty turns of bell wire around a telephone desk stand. See Fig. 3. One end of the wire is connected to the antenna post on the receiver and the usual ground is used.

The writer, an inveterate radio enthusiast, discovered the possibilities of this arrangement when traveling across the country with a Fada neutrodyne, the operation of the receiver being somewhat limited by the facilities of the average hotel bedroom.

Subsequent experiments show this type of antenna to be equally efficacious with other receivers.

ALFRED A. MARKSON.
New York City.

STAFF COMMENT

THE use of the telephone as a substitute antenna is by no means a novelty, although the exact system of connection outlined here is not that generally advocated, but probably as efficient. The more widely used application of this idea is found in the use of a small metal plate upon which the telephone is stood, and which is connected to the antenna binding post of the receiver. Such metal plates, especially cut for the purpose, are commercially available. As the latter are not always immediately obtainable in an emergency, Mr. Markson's idea is a useful one.

HOW TO IMPROVE YOUR OLD RECEIVER

A radio set of other years can be brought up to date by improving the audio quality through new transformers, tubes and loud speakers or by the purchase of a complete power-supply-amplifier unit. These changes help greatly. R.f. Changes are not suggested

By EDGAR H. FELIX

THE articles appearing in the September and October issues of RADIO BROADCAST, dealing with the judging and attainment of good tone quality, resulted in hundreds of letters from readers, asking specifically how certain makes of receivers could be converted to give the high-grade tone quality described. It was the writer's intention to answer the letters directly in these columns, but their number grew so large that it would require an entire issue of the magazine to meet the demand for information. This article is based upon the questions raised in the letters and will serve as a concentrated answer to these letters.

Hundreds of thousands of radio enthusiasts are owners of receiving sets sufficiently selective to be satisfactory, but falling far short of the latest standards of tonal reproduction. So long as the receiver meets the simple requirement of being sufficiently selective, but not too selective, it can be converted to give good tone quality. The writer does not mean to imply that the radio-frequency end of the modern receiver is not as greatly improved as the audio end and that the most satisfactory measure, after all, is not to discard entirely the obsolete receiver. But not everyone is in a position to employ this remedy; some of us must reconcile ourselves to tuning with several dials and to great sensitiveness at the high frequencies, where it is not especially needed, and lack of sensitiveness at the low-frequency end, where it is most desired. Simplicity of control, and equal amplification throughout the wavelength scale, are features embodied only in the latest receivers. But, given satisfactory selectivity, an old receiver may be greatly improved so far as tone quality is concerned.

Exceedingly sharp tuning, such that high-power stations within fifty or a hundred miles are heard with considerable volume only when tuned-in precisely and always disappear with a whizz and hiss when detuned but one or two degrees from exact resonance, indicates selectivity too great for the attainment of good tone quality. Oftentimes a receiver behaving in this way can be made to tune more broadly, so that neither the low or high audio frequencies are cut off, by installing a somewhat longer antenna.

Having once determined that the radio-frequency end of the receiver does not tune too sharply, improvement of tonal quality is a matter of re-vamping the audio system. The essential requirements for good tonal quality are: (1) Audio-frequency transformers of sufficiently good quality to pass the entire tonal range; (2) tubes of sufficient power and emission to adequately handle signals of considerable magnitude (3) a power supply assuring correct A, B, and C voltages to every tube under actual operating conditions; and (4) a loud speaker capable of setting up sound waves throughout the audio scale.

Prior to recent developments in transformer design and material, resistance-, and impedance-coupled amplification were the only systems, within reach of the experimenter, capable of handling broad tonal range. These systems under proper conditions are not excelled in quality output by high-grade modern transformers, but require an extra stage so that they are not easily incorporated in a manufactured receiver, unless it is especially designed to accommodate them. During the last year, transformer development has reached such a point that two stages may be used to give the best of tone quality.

Transformers can be manufactured at a cost as low as forty cents, although the actual raw materials which go into the better transformers cost as much as eight times that figure. Expensive iron alloys, which magnetize and demagnetize rapidly, and high-inductance windings, are essential if the entire tonal range is to be amplified. Under no circumstances, can cheap transformers serve as well as well known expensive ones. In replacing transformers, to make the job worth while, confine yourself to the best. Some of the better receiving sets of earlier vintages, are not equipped with suitable transformers and the substitution of such makes as Amertran, Ferranti, Silver Marshall, Thordarson, General Radio, Rauland Lyric, Modern, All American, Pacent, Sangamo, and Samson, to mention some of the better ones, is decidedly worth while.

REPLACING OLD TRANSFORMERS

TO DETERMINE whether such substitution is feasible, open the cabinet and examine the audio-frequency transformers. See if they are easily removed and if the four terminals are so marked that you can put labels on the wires before you remove them, indicating the correct filament, grid, plate, and B+terminals. This will prevent confusion when you put the new transformers in place. Adhesive tape is a convenient form of label. Measure the space available for transformers because cheap transformers are often small. The high grade ones, with which you replace them, are likely to be somewhat larger and hence may not fit in the space provided for the old transformers. Where the problem requires moving of sockets and other parts, your local dealer can replace the transformers for you. His charge should be between two to five dollars, plus the cost of the transformers themselves.

The next link in the chain of audio reproduction concerns the tubes used. You cannot hope to secure good quality, if you do not use a power tube in the last stage. The UX-201-A (CX-301-A) tubes in the output stage are capable of only moderate volume with good quality. If you are attaining fair quality with such tubes now, after replacement of the transformers they may prove unsatisfactory, because the added energy in the low frequencies, impressed upon the output tube by the new transformers, will not be handled satisfactorily.

In the case of the storage-battery receiver, wired with but a single C battery connection, both the first and second stages are usually supplied with the same C battery voltage, generally 4½. Re-wiring of the set, however, is not necessary to put in an UX-171 (CX-371) or a UX-112 or CX-312. Manufacturers such as Na-Ald, have developed special sockets with flexible cable connections, enabling you to add the necessary grid and plate voltages to operate power tubes, without any wiring changes.

There is one exception to the general rule that replacement of the transformers and addition of a power tube will bring you better tone quality. Certain reflex receivers, which enjoyed a fairly wide sale three and four years ago, are not adapted to this simple conversion. The use of a grid bias and plate potential satisfactory for audio purposes may render the radio-frequency amplifier of these reflex sets quite unstable. Many of these receivers are such heavy consumers of plate current that discarding them is an economy. It is not worth while to attempt to improve them. You must treat them as you would an inherited 1902 one cylinder-automobile.

With dry-cell tube receivers, the largest output tube available is the 120 type. This is a great improvement in power handling capacity over the 199 type, but it is still far from sufficient to attain really good tonal quality. The further down the tonal range the reproducing system goes—and that is what gives body and richness to music and naturalness to speech—the greater must be the power available in the output tube.

The owner of such a dry-cell tube receiver need not, however, abandon hope, because he may employ a one-stage power amplifier, receiving its filament, grid and plate potentials, directly from the light socket, and employing the UX-210 (CX-310) in the output. This tube is of even greater power handling capacity than the UX-171 (CX-371) and, hence, capable of magnificent tonal quality, provided good transformers and reproducers are used in connection with them. These light socket units may also be used with storage battery outfits and are recommended to B battery users. The use of a power tube in the output stage considerably increases B battery drain and, as a consequence, the use of a light socket amplifier unit is an economy.

Such power supply devices are manufactured by General Radio, Farrand, Radio Receptor. Pacent, National, Timmons. Amertran, and the Radio Corporation. They furnish A, B, and C power, not only for the 210 or 171 tube, but also B and in some cases C voltages for the receiving set itself. Adding these amplifier-power supply devices to the existing receiver is a simple matter. The tonal reproduction secured is still dependent upon the grade of loud speaker and first stage transformer used but, so far as available power is concerned, the purchase of a good power amplifier and B supply unit settles that question.

SELECTING A REPRODUCER

HAVING now supplied transformers which actually amplify the entire range of tonal frequencies, having installed tubes of adequate power handling capacity, and having supplied them with the correct A, B, and C voltages, it is next necessary to obtain a loud speaker capable of setting up sound waves throughout the entire tonal range. A loud speaker which is seemingly satisfactory with poor transformers and power supply, often fails when the high-grade transformers and tubes are wired into circuit, because of the larger load and greater frequency range thereby impressed upon it.

Remedying an audio system requires that the entire audio system be put in good condition, because any one weak link will destroy the effectiveness of all the other remedial measures. If you have four worn out tires on your car, replacing one, two, or three of them is not sufficient to give you immunity from tire trouble. Many a person, dissatisfied with tone quality, has replaced his loud speaker and then wondered why great improvement did not result. In fact, it often happens that an exceptionally good loud speaker will sound worse than a bad one with a poor set. The good loud speaker sets up sound waves in exact accordance with the electric signal furnished it. A poor loud speaker may be so designed as to exaggerate the low notes, thus providing for their deficiency in a defective audio system. When a good loud speaker is substituted, the absence of low notes, due to unsuitable transformers, becomes more conspicuously apparent.

Every reproducer has an actuating element which sets up the sound waves—a sort of paddle which sets up air vibrations. With good reproducing systems, the loud speaker must be capable of setting up low frequencies as well as high ones, and consequently the actuating element, vibrating diaphragm, or cone surface, must often be large if it is to be successful. The horn, if one is used, must also be of large size, so that it does not impede the radiation of low frequencies. A long, goose-necked horn chokes off the low frequencies, while a large exponential horn can give you much of the true magnificence of the organ.

The writer cannot attempt to list entirely all good cones and horns, but he has personally tested Western Electric, Farrand Sr., Balsa, Rola, and Amplion, and found them capable of handling the output of 171 and 210 type tubes throughout the tonal range attainable by the best of amplifier systems.

Inferior loud speakers fail not only because they are incapable of mechanically setting up waves by reason of small moving surface or confined tubular horn areas, but also because the electromagnetic unit is incapable of handling the large output which is necessary to secure good tone. With the 210 and 171 types of tubes, an output transformer or choke and condenser feed to the loud speaker is absolutely necessary to eliminate the direct-current component from the speaker winding. We desire only to have the audio-frequency fluctuations in the loud speaker winding so that magnetic saturation is avoided. Silver-Marshall, General Radio, Federal, National, Pacent, Samson, Thordarson, Amertran, Muter, Amsco, and others make output devices.

One question which appeared in many of the letters received was the demand for more volume, or specific questions to the same effect, such as whether the use of a 171 tube would increase volume. None of the measures described have for their purpose the increasing of volume output of the receiver. The use of large power tubes simply increases the amount of signal volume which can be handled without distortion due to overloading.

By using the grade of transformers, tubes, and loud speakers mentioned, a signal so weak that it can hardly be distinguished by the phones in the detector output circuit is amplified to comfortable living room volume. If the signal is not sufficiently strong to give such volume, the remedy does not lie in additional audio-frequency amplification but in the use of a more sensitive receiving set. The best results are obtained if the detector tube's output is a signal just strong enough to be discernible in the headphones. Those complaining of weak signals should look to improving antennas and to increasing radio-frequency amplification. The audio system should not be expected to make up for deficiencies in the radio-frequency amplifier.

As a matter of fact, most of the receiving sets, even those of two and three years ago, are adequately sensitive. Many complaints of reduced volume may he attributed to the continued use of depreciated power supply and tubes, whose filaments have lost their emission.

It is an essential requirement of good tone that the power supply be adequate and that the tubes have plenty of emission. There is only one way that this can be determined definitely and that is by measurement. Your dealer should have a tube checker which he can bring to your set, or you should take the tubes to a well equipped radio store for testing. By taking out one tube, substituting for it a plug, connected by a flexible cord to the set checker or tube tester, and placing the removed tube in a socket provided on the tester, the A, B, and C potentials, and the plate-current output of the tube, can be measured. The writer recently tested an elaborate set checker made by a concern in Detroit, equipped not only to make the four measurements mentioned, but also the voltage at the terminals of the A battery, the completeness of all the circuits and, the mutual conductance of the tubes by the manipulation of a few well marked switches. Every dealer should have some such device. The use of a voltmeter does not tell the full story and no dealer is in a position to service adequately without measuring devices such as those made by Jewel, Weston, General Radio, Quick-Test, Hoyt, Hickok and others.

There were many well-known and widely advertised makes of receivers which last year became known for their mediocre tone quality and which this season have effected extraordinary improvements. The importance of tone quality has been widely recognized and manufacturers have realized that they cannot remain in the radio market unless their receivers are capable of high-grade reproduction. Name, reputation, price, and the willingness to submit their product to the test and approval of the recognized set expert, are guides to the set purchaser. Many receivers, described in most alluring terms in general magazines, do not meet the laboratory inspection of the expert. It is best to confine your purchases to sets recommended by well-informed enthusiasts who have some familiarity with the technical phases of radio. In the October issue, the writer gave suggestions for tests which may be made at the dealer's store when a receiver is being demonstrated, to give indication of its tonal capacity. It is suggested that the reader go over both the September and October articles before making purchases.

To summarize, the conversion of an old receiving set to give good tonal quality requires:

(1). That the radio-frequency amplifier of the receiver does not tune so sharply that near-by signals are heard only when precisely in resonance.

(2). Audio-frequency transformers be used of a quality and price sufficient to assure that they will amplify the entire range of frequencies from stage to stage.

(3). The output tube be of sufficient power capacity to handle the required range amplitudes.

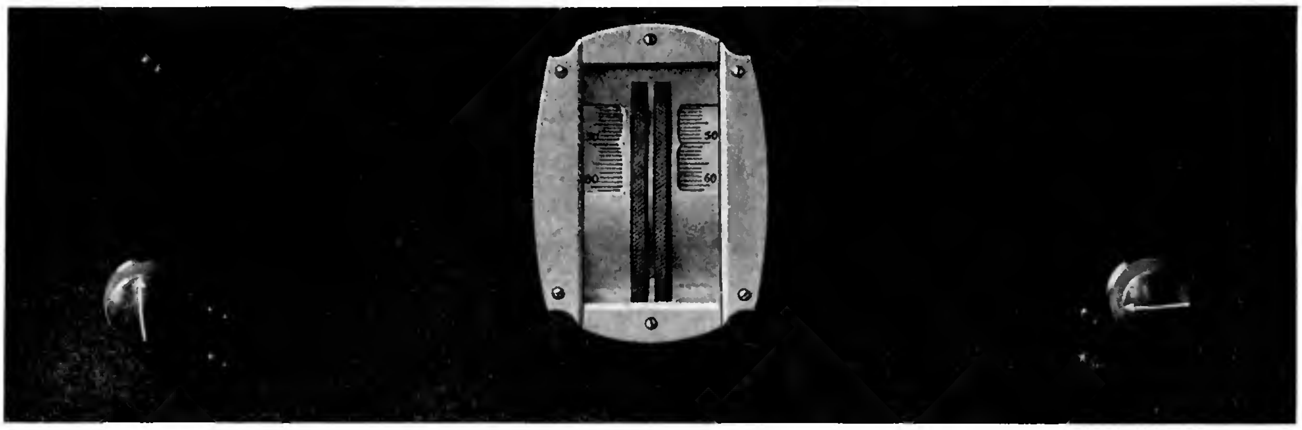
(4). The correct A, B, and C voltages be supplied to the tubes.

(5). That the loud speaker be capable of handling the tonal range.

In most cases, these objectives are attained by replacement of the audio-frequency transformers, installation of a power tube (in the case of dry-cell sets, the addition of a one-stage power amplifier and B supply which furnishes A, B, and C power for a 210 or 171 type tube), and finally, the use of a suitable reproducer.

A Quality Five-Tube A. C. Receiver

By JAMES MILLEN



FRONT VIEW OF THE RECEIVER

THIS article describes the construction of an a.c. operated receiver, the new type a.c. tubes being used to accomplish the electrification. In the preceding article in this series, published in last month's RADIO BROADCAST, some general information on a.c. tubes was given.

In explaining how to use these a.c. tubes with an actual receiver, we have chosen a circuit which embodies some of the features of the Browning-Drake receiver. Strict adherence to the instructions contained in this article will result in a light socket operated receiver equaling in sensitivity and selectivity a receiver operated on standard storage-battery type tubes.

Before going into details regarding the construction of this a.c. receiver, we will point out how the circuit differs from that of Browning-Drake sets. First, let us consider the r.f. amplifier. Most previous designs of the Browning-Drake receiver have used a 199 type tube as the r.f. amplifier, because the tendency for this tube to oscillate is less than with a 201-A type tube. A. c. tubes, however, have characteristics similar to the latter type, and since an a.c. tube is used in the r.f. stage of the receiver described here, it becomes necessary to devise some practical method of preventing this r.f. amplifier from oscillating.

In Fig. 4 is shown, at "A," the circuit of the original Browning-Drake radio-frequency amplifier using Hazeltine neutralization; at "B" we see the Browning-Drake circuit using the Rice system of neutralization. At "C" is shown the circuit arrangement for use of a 226 type a.c. tube. In the grid circuit will be noticed a non-inductive resistor, having an ohmic value of approximately 1000 ohms. It is the use of this grid resistor or, as it is more generally called, "suppressor," that makes possible the balancing of the circuit. As this resistor is not placed in the tuned circuit, it has no detrimental effect upon the selectivity of the receiver.

The arrangement shown at "C," Fig. 4, is used in the final model of the receiver illustrated in this article, and it will be noted that the plate voltage is fed to the plate of the tube through a choke coil, L_4, instead of through the primary winding of the r.f. transformer. The former method (feeding the voltage through a choke coil) tends to somewhat stabilize the operation of the receiver, especially when a socket-power unit is used for the B supply.

The antenna is coupled to the first coil in the usual manner, *i.e.*, through a 50–150 micro-microfarad midget variable condenser, to a center tap on the coil. If the antenna is over 40 feet in length, the connections should be as indicated in the diagram, but if a shorter antenna is used, the lead from the midget condenser may connect directly to the grid end of the coil instead of the center. In congested localities, excellent reception, with greatly improved selectivity, is obtained by using a 3-foot length of bus bar for an antenna. The bus bar should be attached directly to the grid end of the coil.

THE AUDIO AMPLIFIER

THE audio channel employed is capable of producing excellent tone quality and at the same time lending itself equally well for use with either the new a.c. tubes or the standard storage battery tubes. The wiring of the audio channel is shown in the complete circuit diagram. Fig. 2.

In the first stage is employed an impedance

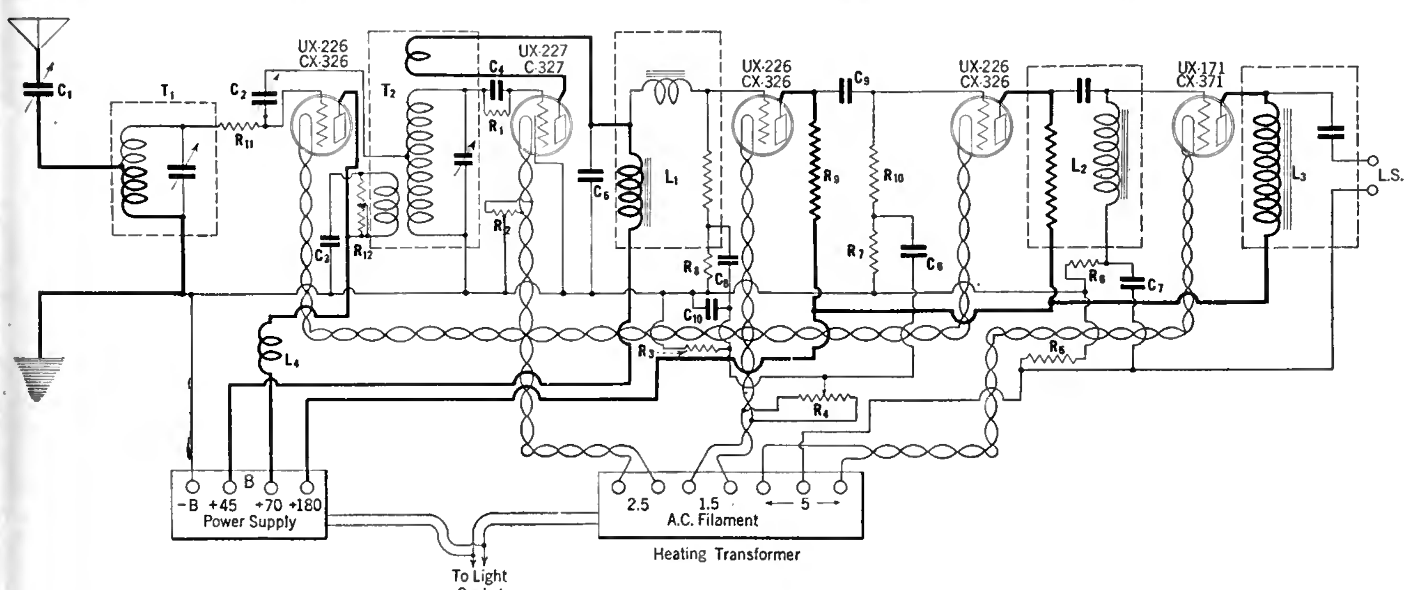


FIG. 1

Complete circuit diagram of the complete a.c. operated receiver

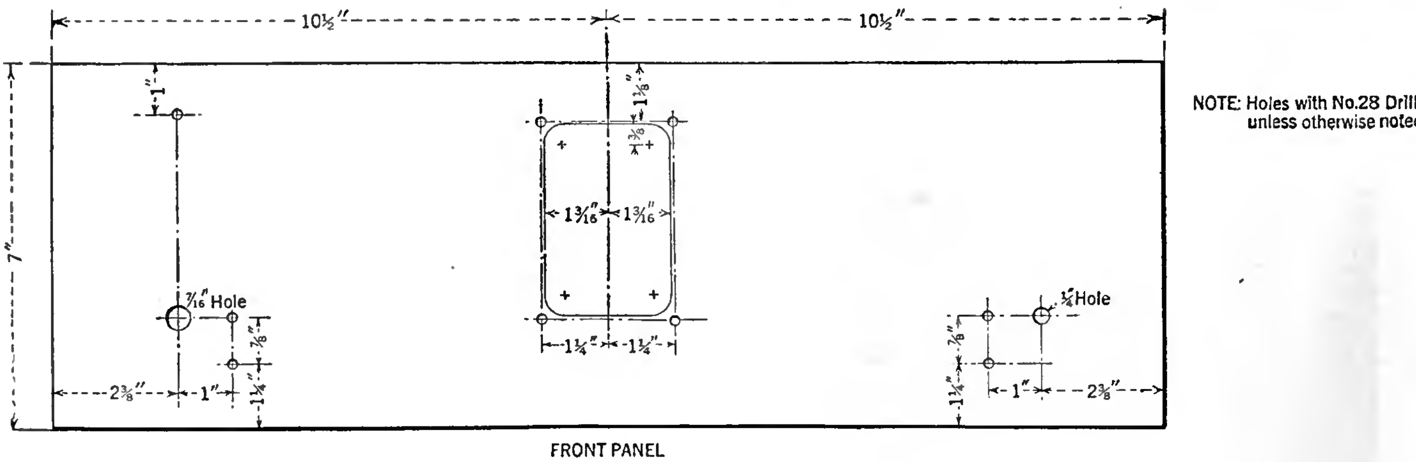
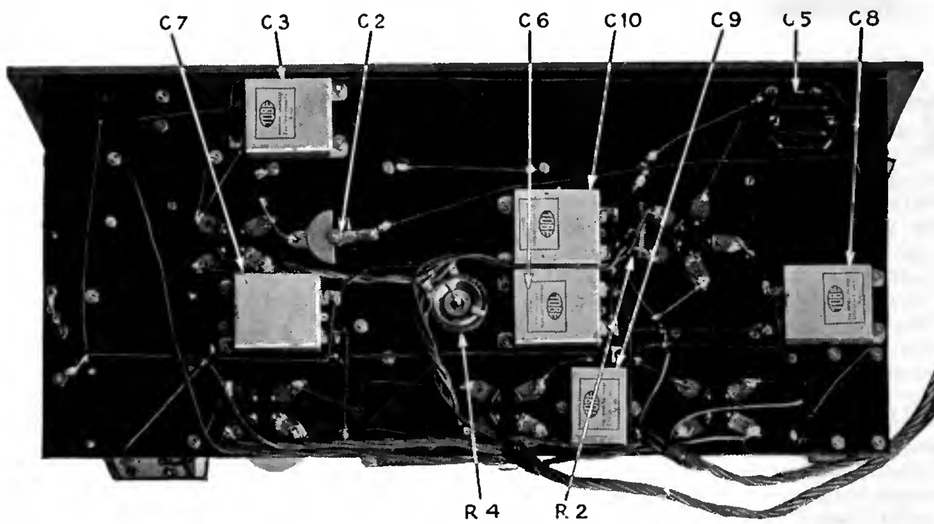


FIG. 2
How to drill the front panel

coupling unit which is incorporated a radio-frequency choke coil; in the second stage, resistance coupling is used, while the third stage employs a special arrangement of resistance and impedance with the impedance in the grid circuit of the power tube so as to eliminate any tendency of the amplifier to "motor-boat" when used with some types of B power units. A tone filter, L_3, is incorporated in the output circuit as a protective device for the loud speaker.

As will be noted from the circuit diagram, Fig. 1 resistance-capacity filters (R_6-C_7, R_7-C_6, and R_8-C_8) are employed in the grid circuits of each of the audio tubes. These filter circuits prevent "motor-boating" and make the operation of the audio amplifier entirely stable under all conditions. The grid bias resistances, R_3 and R_5, as well as the mid-tapped resistance, R_2, across the filament of the detector tube, are all of the fixed variety so as to eliminate needless adjustment and enable the home constructor to obtain the same excellent performance from his receiver as from the original laboratory model.

The various photographs, working drawings, and circuit diagrams accompanying this article give all the necessary details regarding the construction of this receiver and only a few ad-



FROM THE UNDER SIDE

The letters correspond with the parts list on page 137. On page 33 of RADIO BROADCAST for November, 1927, appeared a back panel view of this set to which reference may be made

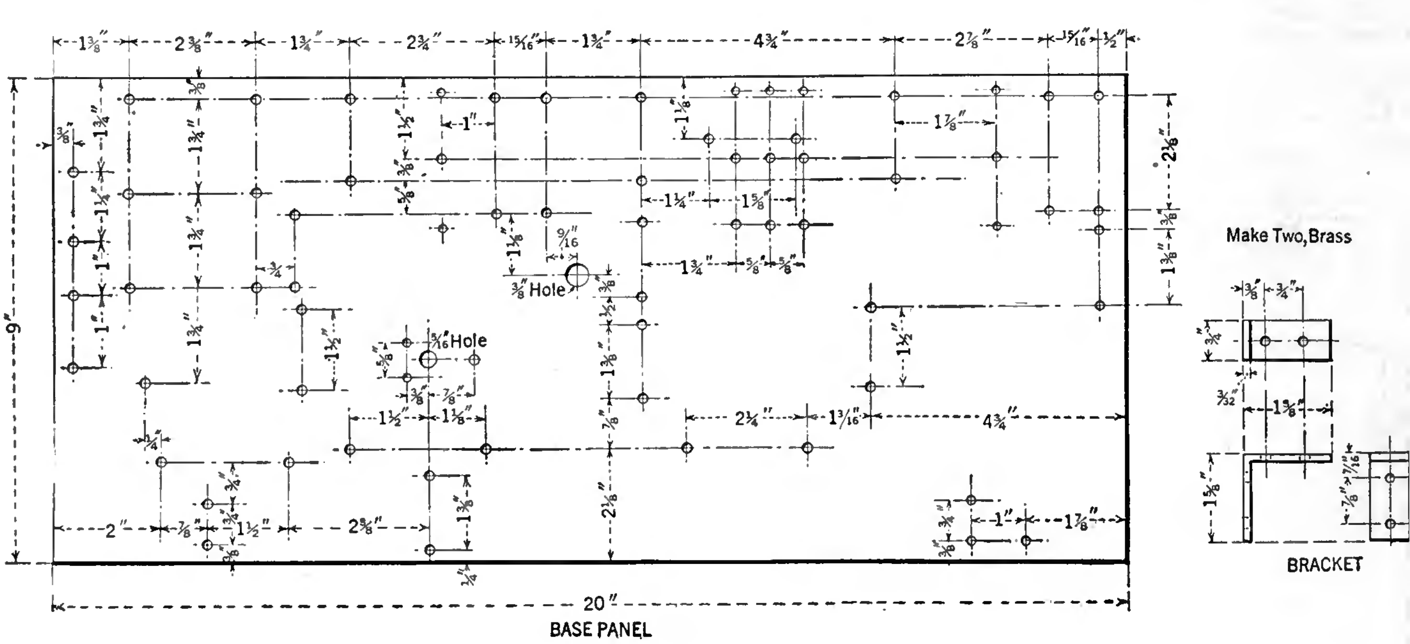


FIG. 3
How to drill the base panel

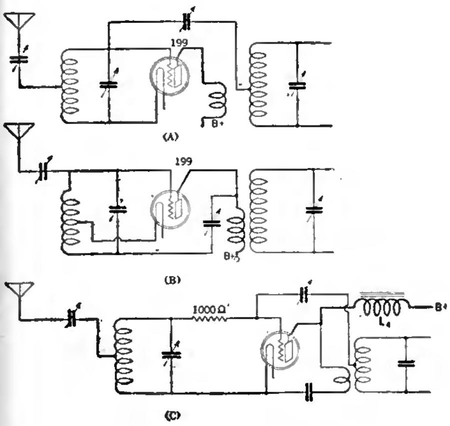


FIG. 4

The circuit of "C" is used in this set. This alteration in the usual Browning-Drake circuit is necessary because of the special problems arising from the use of a.c. tubes

ditional hints need be given in order to make possible the easy construction of the receiver.

As the illustrations show, the a.c. filament heating transformer is not built into the set, it being more convenient in this case to mount it as a separate unit within the usual battery compartment of the console if the latter is employed.

The first construction step is to drill the front and sub-panels in accordance with the details given in Figs. 2 and 3.

The next step is to mount the condensers, coils, sockets, and other parts on the sub-panel, as shown in the illustrations. Then, the sub-panel may be almost completely wired—all before attaching the front panel, which merely carries the dial, volume control resistor, and tickler adjustment.

The small General Radio neutralizing condenser should be disassembled and built right into the sub-panel after discarding the triangular bakelite back.

In the receiver shown in the illustrations, the resistor mountings and sockets were also disassembled and the contacts remounted directly on the sub-panel. Much needless work can be saved however by retaining the bases of the resistor mountings and sockets.

Instead of numerous binding posts the use of two cables is recommended. One cable should consist of the seven low-voltage a.c. leads to the filament transformer while the other cable should have four leads to the B power supply unit.

As the loud speaker cord may be plugged directly into the tip jacks on the front of the tone filter, it is necessary to provide but two binding posts—for the antenna and ground.

The wire to use for all connections as well as the cables should preferably be No. 18 tinned flexible rubber-covered wire. Such wire may be obtained from Acme and Corwin in different colors for making the cable and to facilitate the tracing of the set wiring itself.

With many UY-227 type detector tubes it will be found that the most satisfactory operation is obtained when the heater voltage is slightly below the rated 2.5 volts. For this reason it is recommended that a 6-inch length of resistance wire from an old 6-ohm rheostat be connected in series with one of the 2.5-volt a.c. leads, preferably right at the transformer terminal panel.

ADJUSTING AND OPERATING THE RECEIVER

THE adjustments necessary in order to obtain the best performance from the completed receiver are few and easily made. First, connect the antenna, ground, loud speaker, B-power unit, and filament heating transformer, and then turn on the 110-volt supply and wait for about a minute or so for the detector tube to reach its proper operating temperature. If a high-resistance voltmeter is available, the next step is to set the detector B voltage to approximately 45 and the r.f. B voltage to 70. Should a suitable voltmeter not be available, the r.f. and detector B voltage may be set by guess work and then readjusted for best results later. The next step is to set the potentiometer, R_1, for minimum hum. Generally this adjustment will be obtained when the contact arm is somewhere near the center of its arc. Occasionally, if the receiver should develop a slight hum, a slight readjustment of the potentiometer will remedy the trouble.

The antenna series condenser should be adjusted so that the two tuning condenser scales read somewhat alike.

The neutralizing condenser may now be adjusted so that the receiver does not oscillate at the shortest wavelength when the tickler coil is set for minimum regeneration. Generally the proper setting is with the movable plate of the neutralizing condenser turned in about a third of the way.

When making any of these adjustments, the volume control should be set for maximum volume in which position the receiver has the greatest tendency to oscillate. The following is a list of parts recommended for use in the receiver described in this article:

LIST OF PARTS

T_1—National B-D1E Tuning Unit (Without Dial)	$ 8.25
T_2—National B-D2E Tuning Unit (Without Dial)	11.75
National Drum Tuning Control	6.00
L_1—National Impedaformer, 1st Stage Type	5.50
L_2—National Impedaformer, 3rd Stage Type	5.50
L_3—National Tone Filter	6.50
R_2—General Radio No. 439 Center-Tap Resistor	.60
R_3—Lynch 500-ohm Suppressor	1.15
C_1—Precise No. 940 Midget Condenser, 50–150 Mmfd.	1.75
C_2—General Radio Midget Neutralizing Condenser.	1.25
R_6, R_7, R_8—Lynch 0.1-Meg. Standard Metalized-Filament Resistors	2.25
R_9—Lynch 0.1-Meg. Type C Metalized-Filament Resistors	1.00
R_{10}—Lynch 0.5-Meg. Standard Metalized-Filament Resistors	.50
R_{11}—Lynch 1000-ohm "Suppressor"	.75
R_5—Lynch 2000-Ohm Type P Wire Wound Resistor	1.25
R_1—Lynch 2-Meg. Standard Metalized-Filament Resistor	.50
C_3, C_6, C_7, C_5, C_{10}—Tobe 1-Mfd. By-pass Condensers	4.50
C_9—Tobe 0.1-Mfd. Bypass Condenser.	.60
R_{12}—Electrad Royalty Variable Resistor, Type K	1.50
C_4—Sangamo 0.00025-Mfd. Mica Condenser	.35
C_8—Sangamo 0.001-Mfd. Mica Condenser	.40
L_4—Samson No. 85 R. F. Choke	1.50
R_4—Carter 20-Ohm Midget Potentiometer	.75
Two Eby Binding Posts	.30
Four—General Radio No. 439 UX Sockets	2.00
One General Radio No. 438 UY Sockets	.50
Eight Lynch Single Resistor Mountings	2.80
Bakelite Panel, 7 x 21 Inches	2.75
Bakelite Sub-Panel, 9 x 20 Inches.	2.75
Wire, Etc.	.50
TOTAL	$75.70

ACCESSORIES

One CX-371 (UX-171) or Ceco J-71 Tube	$ 4.50
One CY-327 (UY-227) or Ceco R-27 Tube	6.00
Three CX-326 (UY-226) or Ceco R-26 Tubes	9.00
One UX-280 (CX-380)	5.00
One National No. F226 Filament Heating Transformer	10.00
One B-Power Unit, National Type M.	40.00
TOTAL	$74.50

Looking Back

THE STORY OF RADIO. By Orrin E. Dunlap, Jr. Published by the Dial Press, New York. Price $2.50; pages, 226; illustrations, 15.

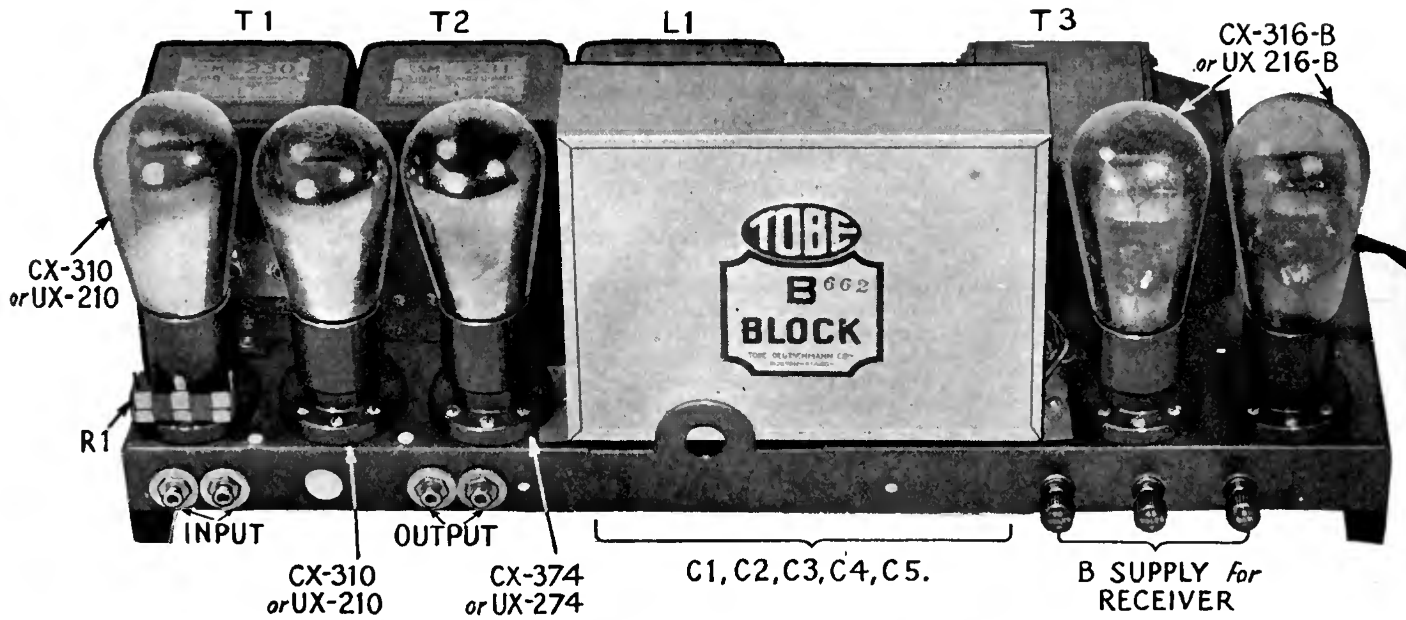
THIS book, by the Radio Editor of the New York *Times*, is a literary effort to squeeze some more thrills out of radio for the benefit of laymen who desire knowledge but do not want to struggle for it. There is nothing technical in its two hundred or so pages but, in a journalistic and often very interesting fashion, it gives a history of radio progress, and manages to touch on such topics as transmission theories, fading, radio direction finders, and piezo-electric control. The various branches of radio communication, such as aircraft work and transatlantic radio telephone circuits, are described; there are several pages on auditory phenomena; short waves and television are not neglected. The history of radio is told in the first person, presumably by the spirit of the ether, or some loquacious band of waves. The effort to sustain an appeal to the imagination results in some very silly passages, the worst one appearing in the introduction:

> Will the millions and billions of musical scores and countless numbers of spoken words ever return from the Infinite? Will the waves all roll back some day, all intermingled, the music of centuries, the works of all composers a hopeless jumble, a babel of voices, all so powerful electrically that the onslaught of invisible waves will burn up the ether and radio will be no more?

The answer is that this catastrophe will positively not occur, unless at that time God sees fit to suspend the second law of thermodynamics, retroactively.

But, with the exception of some of the chapter headings and captions, which have no conceivable relation to the text, this drivel is not representative of the contents of Mr. Dunlap's book. He is, in point of fact, an old radio man, and a Member of the Institute of Radio Engineers, and when he remembers that there is only one inimitable Judge Rutherford, he does a good job. What he says is, in the main, accurate, and jazzed up only within the limits permissible in such a book. He has at his fingers' ends, or in his scrap book, about all the interesting things that have ever happened in radio, and in "The Story of Radio" relates them for an audience to which they will be utterly new. The events of the war in the radio field dramatic, SOS episodes, the old Herald station, OHX, silent these fifteen years, all live again in Dunlap's pages, and it is pleasing to see their appearance in a more or less permanent record. Give the book to your son as a birthday present, if you have not already bestowed it on him for Christmas.

—C. D.



A PUSH-PULL POWER AMPLIFIER

The amplifier illustrated above is designed to give excellent quality reproduction of radio programs. The push-pull amplifier uses two cx-310 (ux-210) power tubes which are capable of supplying to a loud speaker large amounts of undistorted power. The entire amplifier is constructed on a pressed steel sub-base

A NEW "TWO-TEN" POWER AMPLIFIER

By William Morrison

THE combined push-pull power amplifier and light socket B power unit described on pages 163 and 164 of the July Radio Broadcast has recreated considerable interest in push-pull amplification. The device described consisted of a single-stage push-pull power amplifier built into a steel case and chassis assembly which also housed the power supply equipment. The latter furnished A, B, and C power to the push-pull amplifier and B power for the radio receiver as well. While this unit, termed for simplicity a "Unipac," possessed considerable merit, its power output, even with a pair of 171 type power tubes, would appear to be insufficient for really substantially distortionless reproduction, assuming that from 1.5 to 2 watts of power is required for good dance music volume, and that the amplifying system should possess a fairly flat frequency characteristic of from 30 to 5000 cycles.

The undistorted power output obtainable from the previously described unit is higher than is generally obtained from receiver output stages, and, in fact, is greater than is often obtained from some of the more popular power packs employing a 210 type tube, the operating voltages of which are often less than they should be.

As a result of the interest that has been displayed in this earlier push-pull "Unipac," a higher-powered model has recently been developed employing a pair of ux-210 (cx-310) type amplifier tubes capable of delivering from 3 to 4 watts of undistorted power to a good loud speaker. It is probably quite safe to say that this is one of the most powerful receiving amplifiers yet developed for the home constructor, and the quality of reproduction it provides is really remarkable. After listening to the push-pull amplifier of the type described here, the significance of the popular phrase "tube overloading," as applied to conventional receiving amplifiers, is really brought home.

This newer combination is illustrated herewith, and closely resembles the push-pull model previously described. The new "Unipac" consists of a full-wave rectifier, which may use either ux-216B (cx-316-B) or the new ux-281 (cx-381) type tubes, and a push-pull amplifier stage with the two ux-210 (cx-310) power tubes. A good idea of the details of the device may be gained from the detailed circuit diagram, in which the parts are lettered to agree with the list of parts on the next page.

The power supply uses a large, full-wave power transformer supplying 7.5 volts from two separate windings for lighting the rectifier and amplifier tubes. Its primary is designed for 105- to 120-volt, 60-cycle, lighting circuits, while a split high-voltage secondary supplies 550 volts a.c. (r.m.s.) to the plates of the rectifier tubes. Due to good transformer design, the ux-216-B (cx-316-B) rectifier tubes will deliver from 500 to 530 volts of unfiltered d.c. at a 106 mA load. This voltage is about all that may safely be used upon 210 type amplifier tubes

Facts About This Amplifier

Circuit: Single stage push-pull power amplifier

Tubes, Two cx-310 (ux-210) tubes in push-pull amplifier, two cx-316-B (ux-216-B) rectifiers, one cx-374 (ux-274) glow tube.

Cost: \$83.25, without tubes. (Tubes: \$38.50)

This power amplifier is capable of supplying 3 to 4 watts of undistorted power to a loud speaker. Complete A, B, and C power is obtained directly from the light socket. The rectifier and filter system are designed to supply the power amplifier tubes with about 500 volts for the plate and the necessary C bias. The unit is arranged to replace the second audio stage in a receiver. The unit is encased in a nicely finished metal cabinet

after a 40-volt drop has been allowed for in the filter system. The filter output is about 460 to 490 volts d.c., of which 35 to 40 are used for C bias on the amplifier tubes, the remaining 425 to 450 volts being actual plate potential supplied to the push-pull amplifier. The rectifier life will be quite good since each ux-216-B (cx-316-B) is called upon to furnish only 53 mA., while these tubes are actually capable of supplying 65 mA. A single ux-281 (cx-381) rectifier would deliver nearly the same power output as the two 216 type tubes, but the use of a single half-wave rectifier, such as the type 281, is generally to be discouraged as increasing the filtration problem and almost invariably resulting in an excessively high value of hum in the loud speaker. Two 281 type rectifier tubes, however, will give a higher output than two 216-B tubes by about 50 to 60 volts, and their use is recommended, not so much because of the increased power output, but because of their probable longer life due to oxide coated filaments and rather generous design.

The filter system is substantially the same as is used in the smaller "Unipac," except for the use of 1000-volt condensers, which are necessary because of the high voltages used. A combination selective and "brute-force" filter scheme is employed, resulting in very good filtration at high current values.

The amplifier stage consists of a split winding input transformer with a step-up ratio of 3:1 per tube, and a split winding output transformer matching the impedance of the ux-210 (cx-310) amplifier tubes to that of a Western Electric or similar loud speaker at 30 cycles. The overall voltage gain of the amplifier is about 20 to 22 times.

CONSTRUCTION

THE construction of the "Unipac" is quite simple, involving only the mounting of a number of standard parts upon a standard steel chassis, the wiring up of these parts, and the

THE POWER AMPLIFIER WHEN COMPLETED IS HOUSED IN A METAL CABINET

final attaching of the cabinet or ventilated housing after the unit has been tested. The parts needed are listed below:

T₃—328 Super Power Transformer	$18.00
L₁—331 "Unichoke"	8.00
T₁—230 Push-Pull Input Transformer	10.00
T₂—231 Push-Pull Output Transformer	10.00
Five 511 Tube Sockets	2.50
C₁, C₂, C₃, C₄, C₅—Type 662 Condenser Block	18.00
R₂—651 Resistor (Ward-Leonard) Set	7.00
Four Frost 253 Tipjacks	.60
R₁—Frost FT64 Balancing Resistance	.50
Van Doorn 661 Steel Chassis and Cabinet, with Hardware	8.00
Three Eby Binding Posts (B—, +45, +90)	.45
Twenty-Five Feet Kellogg Fabricated Hook-Up Wire	.20
	$83.25

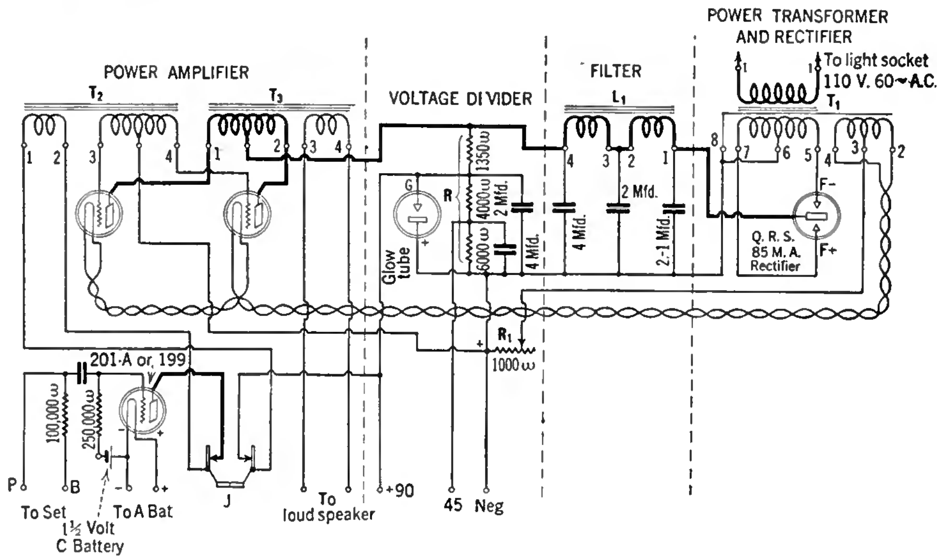
Unless otherwise noted, all the parts listed above are manufactured by Silver-Marshall.

The tubes required for the operation of the "Unipac" are as follows:

Two UX-216-B or CX-316-B Half-Wave Rectifier Tubes (CX-381 or UX-281 Optional)	$15.00
One UX-274 or CX-374 Ballast Tube	5.50
Two UX-210 or CX-310 Power Tubes	18.00
	$38.50

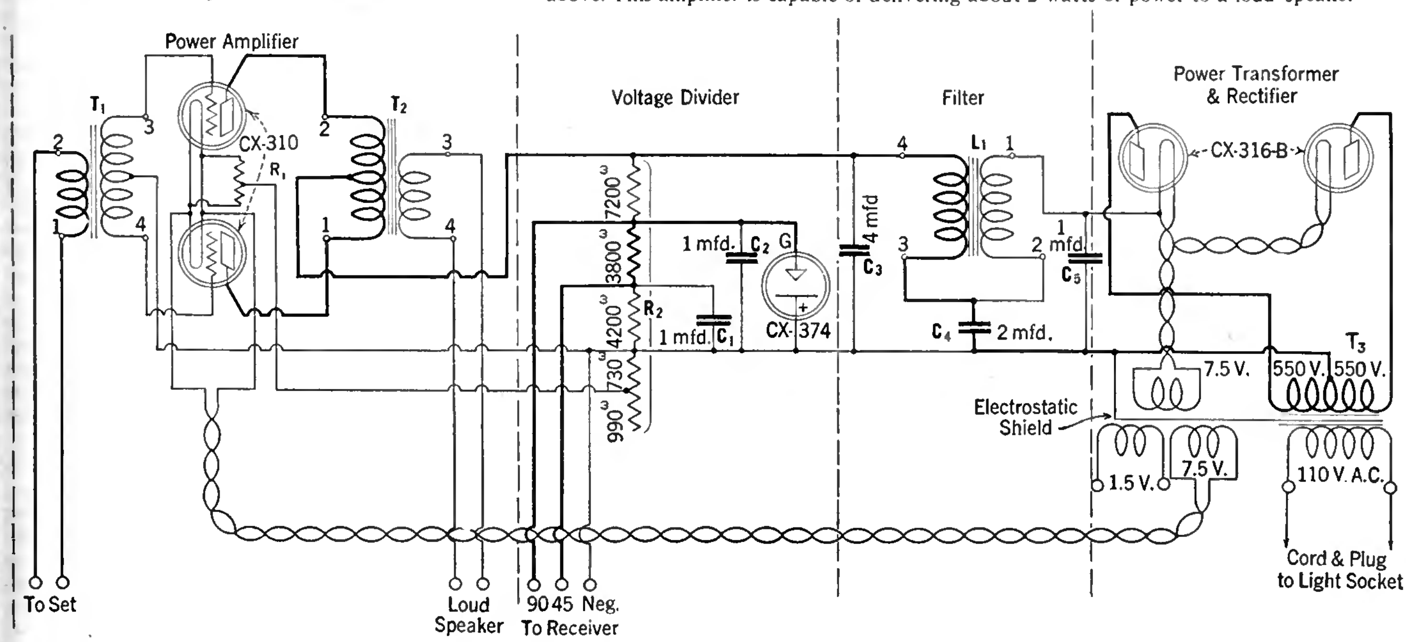
The "Unipac" will furnish ample power to a radio receiver at 45 and 90 volts with voltage held constant by a potential dividing resistance and a glow tube voltage-regulator, preventing high open-circuit voltages to develop, which might damage receiver condensers. The amplifier replaces the conventional second audio stage of a receiver, the input tipjacks connecting to the first audio stage output terminals of the receiver, and the loud speaker connecting to the output jacks of the "Unipac."

In operation, all tubes will get quite hot, as will the larger Ward-Leonard resistor. This is correct, as is a slight warmth noticeable in the power transformer core. It is necessary always to see that the B minus post is grounded, directly or indirectly through a condenser.



A 171 PUSH-PULL AMPLIFIER

The circuit of the 171 type push-pull amplifier described in the July, 1927, RADIO BROADCAST is given above. This amplifier is capable of delivering about 2 watts of power to a loud speaker



A 210 PUSH-PULL AMPLIFIER

The circuit diagram of the super-power amplifier described in the article given in this illustration. The 550-volt transformer, T3, at the right, supplies the two rectifier tubes with sufficient voltage so that when it is rectified and filtered each of the power amplifiers will receive about 500 volts each. A glow tube is incorporated in the circuit to maintain the voltages constant, independent of the load. The loud speaker is fed with energy through an output transformer.

The Listeners' Point of View

THE DX LISTENER FINDS A CHAMPION

By JOHN WALLACE

THE DX hound comes in for a lot of unwarranted disparagement. He is viewed askance by his more enlightened brethren as a benighted soul with a perverse idea of what radio ought to be used for. His greatest delight, as they picture it, is in attacking his receiving set with a screw driver and soldering iron, disemboweling it and putting it together a different way. He is said to prefer the faint whisper of call letters from some mission station in heathen Africa to hearing the Prince of Wales sing Frankie and Johnny from the local station. In his defense it has been iterated from time to time that his experimenting made radio what it is to-day. This vindication seems to us to be still a pretty sound one.

There are two types of DX hounds, the radicals and the conservatives. The extremists care for nothing but distance. They will labor into the small hours of the night to pick up the signal of a station half a continent away. Their standard of reception fidelity is not exacting—all they ask is that the *B*s be distinguishable from the *P*s. Once they have gained their quarry (which Mr. Webster describes as "the entrails of the prey, given to the hounds") their interest is over and they start in pursuit of some other station. We are in no special sympathy with this hunting breed of DX hound, but we will not have it said that he is quite useless. He has forced an increase in the range of receiving sets.

But the conservative hound likes to have a little sport with his catch after he's run it down. Once he has got a distant station he labors patiently at tuning it to shut off all extraneous noises. Not until he has the program coming in with the clarity of a local one is he satisfied. Then, if the program is a good one, he listens to it. With the pleasure he experiences from the program is an added stimulation in the realization that he is eavesdropping on a scene transpiring some hundreds of miles away with no connection between him and that remote city but some great open space and an assortment of ether waves. If a sympathy with his endeavours and an occasional emulation of them makes us a DX hound, then—we are a DX hound. Those who advance the protest that radio is now so much a matter of fact that they cease to marvel at its wonders present not half so good a defense of their attitude as they do a confession of their lack of imagination.

After all, the unique thing about radio is not that it brings music into your home—the phonograph did that years ago—but that it conquers distance. It was radio's ability to conquer distance that gave it its initial impetus, that seized the public imagination and bounded it along to an unprecedentedly swift success. It seems a bit of the basest ingratitude—a sort of biting the hand that feeds you—for radio to turn its back now on the characteristic that gave it birth. And, turning its back on it, it is, what with its two latest developments: chain broadcasting and wired broadcasting. Chain broadcasting, with its extended use of telephone wires has made the listener in large cities content to receive his distant programs from a station perhaps a few blocks away. Wired radio, while it still exists only as a rumor, is likely to come any time soon. Here the program will be circulated on the already existing electric power lines which enter almost every civilized household, and the program received will have spent no instant of its life bounding on an ether wave. This seems to us a distinct retrogression, technically at least. Of course we do not argue that a trip through the ether makes a program any better; under present conditions the wired program is frequently better in quality. But the one is genuinely *radio*, the other simply glorified telephony. In short, wired radio, and, to a lesser degree, chain broadcasting, summarily renounce the fundamental principle upon which radio was founded—space annihilation.

This renunciation seems to us premature. The possibilities of radio broadcasting have not been completely exhausted. Hardly a score of years of experimentation has been completed. Certainly the idea is worth a score more.

It may be very practically objected that atmospheric conditions, over which man has no control, simply render it impossible to extend further the range and reliability of radio reception. This is practically true. Theoretically it is false and since this is a theoretical article we will press our point further. A demonstrable increase in range has been effected within the past few years by increasing the power of transmitters and the efficiency of receivers. There has been no sign from heaven to indicate that this increase has reached its limit. So, having utterly no knowledge of the mechanical problems of radio, but an unbounded faith in the uncanny powers of its technicians we argue that they can further perfect it if they try. But if interest in long range broadcasting is abandoned it's a cinch they won't try.

Radio's unique contribution to what is drolly referred to as the "progress" of civilization is the conquering of space. We repeat ourself? As a follower of radio programs we are well aware that it has made an enormous contribution to mankind by making music once again part of his daily life. In this rôle it has been of incalculable benefit. However, this rôle, important as it is, is none the less a secondary one. It is possible for a man in his home to survive the evening without an after dinner concert, but a man at sea on a ship with a hole in it is dependent upon radio for his life. The city dweller can go to a concert hall when he craves music and entertainment, but the dweller at a lonely outpost in Canada is dependent upon radio for any break in the monotony of his existence. A catastrophe such as a cyclone or an earthquake may cut off wire communication with a devastated area but radio may still be able to penetrate and convey important, perhaps life saving, messages. Or, to cite a fanciful but none the less valid instance of the primary importance of radio as a long distance agent: in time of war an invading force could throttle all wired communication within the nation but a few well entrenched transmission stations could still reach the entire populace.

As we have said, further extension of the range of broadcasting, particularly in the face of the apparently unsurmountable difficulties it has already met, is dependent upon a sustained interest in achieving this end. So we think the vast army of DX hounds instead of being reviled should rather be looked upon as a desirable faction and, an important balancing element in radio's development.

While, personally, we are most frequently interested in the musical things radio has to offer, we look forward to the time when it will put us in easy touch with foreign shores. Perhaps some further use will be made of short-wave broadcasting and reception to this end. There would be a kick in that which not even the staunchest deprecator of DX could deny. But such an entertaining, and indeed instructive, state of affairs will not have been reached until after we first overcome the not inconsiderable distances in our own U. S. If we ever do this it will be due to the persistency of the DX hounds.

DAVID BUTTOLPH

The gifted young conductor of the National Concert Orchestra, regularly heard through the red network of the National Broadcasting Company

What We Thought of the First Columbia Broadcasting Program

SUNDAY, the eighteenth of September, witnessed the début of the long heralded Columbia Broadcasting System. The evening of Sunday, the eighteenth of September, witnessed your humble correspondent, tear stained and disillusioned, vowing to abandon for all time radio and all its works and pomps. We have since recovered and will go on with our story. The broadcast divided itself into three successive parts, descending in quality with astounding speed.

PART ONE: THE VAUDEVILLE

This program came on in the afternoon, after a half hour's delay due to mechanical difficulties—a heinous sin in this day of efficient transmission, but excusable, perhaps, in a half-hour-old organization. This opening program, at least, was auspicious. The performers were of superlative excellence. Bits from a light opera were well sung. A quartet gave a stirring rendition of an English hunting song. A symphony orchestra played some Brahms waltzes. A soloist sang "Mon Homme" in so impassioned a fashion that she must have swooned on the last note. Then a dance orchestra concluded the program with some good playing. The offerings were of such high quality that it was doubly disconcerting to have them strung together with a shoddy "continuity"—especially with such stupid and overdone continuity as the "and-now-parting-from-Paris-we-will-journey-to-Germany" type.

Continuity is a device used to bolster up weak programs. It is a bit of psychological trickery designed to keep the listeners listening even while their own good sense tells them that there is nothing being offered worth listening to. A good steak doesn't need to be served with sauce, but there's nothing like some pungent Worcestershire for camouflaging the defects of a bad one. The items offered on this afternoon program were good enough to serve ungarnished, and were cheapened by the introductory blah.

PART TWO: THE UPROAR

"Uproar," let us hasten to explain, is Major J. Andrew White's way of pronouncing Opera. We seek not to poke fun at this announcer; he is one of the best we have. (Though we think both Quin Ryan and McNamee outdid him in the recent fight broadcast). But his habit of tacking *R*s on the end of words like Americar and Columbiar doesn't fit into a high-brow broadcast as well as it does in a sports report. The Uproar was "The King's Henchmen" by Deems Taylor. Evidently no effort was spared to make the broadcast notable. A good symphony orchestra was utilized, capable singers were employed, and Deems Taylor himself was intrusted with the duty of unfolding the plot. But after all it was "just another broadcast." Musical programs into which a lot of talk is injected simply will not work. One or the other has to predominate. Either make it a straight recitation with musical accompaniment—or straight music with only a sparing bit of interpretative comment.

Mr. Taylor's music for this opera is delightful, the singing was admirable, but the total effect was disjointed and unsatisfactory. The composer outlined the story, but, enthralling as it may be on the stage, it was impossible to visualize the action with any degree of vividness from his words. We felt continually aware that there was really no action taking place, and the effort at make believe was too strenuous and detracted from an enjoyment of the music. It was less effective, even, than a broadcast from the regular Opera stage. Here the piece is likely to be more familiar and it is possible to conjure up its pantomime from remembrances of performances seen.

It is our humble and inexpert opinion that program designers are barking up a wrong tree and wasting a lot of energy in their unceasing attempts to fit spoken words into musical programs. But if they will persist let us suggest that they are going about the job in a blundering way with no proper realization of its difficulty. All present essays in this line fall into two classes: those which attempt to relate starkly the necessary information in a minimum number of words, and those which attempt to give a spurious arty atmosphere by the meaningless use of a lot of fancy polysyllables.

Neither method works. The first is distracting and effectively breaks up any mood or train of thought that may have been induced by the music. The fancy language system, besides being obviously nauseating, takes up too much time.

Program makers may as well realize soon as later that the simple possession of a fountain pen doesn't qualify a man for writing "script" or other descriptive text. It is a job calling for the very highest type of literary ability and one that can't be discharged by just anybody on the studio staff. The properly qualified writer should be able to state the information tersely, *but*, with all the vividness of a piece of poetry. Each word he uses must be selected because it is full of meaning, and of just the right shade of meaning. Any word not actively assisting in building up a rapid and forceful picture in the listener's mind must be sloughed off. A further complication: the words can't be selected because they look descriptive in type, but because their actual *sound* is descriptive. Altogether an exacting job; it would tax the ability of a Washington Irving.

It is highly improbable that a genius at writing this sort of stuff will ever appear; the ether wave is yet too ephemeral a medium to attract great writers. But there is no question that scriveners of some literary pretensions could be secured if the program builders would pay adequately for their services. This they will never do until they realize the obvious fact that the words that interrupt a program are just as conspicuous as the music of the program itself. It is incongruous, almost sacrilegious, to interrupt the superb train of thought of Wagner or Massenet to sandwich in the prose endeavours of Mabel Gazook, studio hostess, trombone player and "script" writer.

PART THREE: THE EFFERVESCENT HOUR

O dear! O dear! Whither are we drifting!

You have all heard the ancient story of the glazier who supplied his small son with a sack of stones every morning to go about breaking windows. Comes now a radio advertiser who deals in stomach settling salts with a program guaranteed to turn and otherwise sour the stomach of the most robust listener. The Effervescent Hour was the first commercial offering of the new chain and far and away the worst thing we ever heard from a loud speaker. We thought we had heard bare faced and ostentatiously direct advertising before, but this made all previous efforts in that line seem like the merest innuendo. The name of the sponsoring company's product had been mentioned ninety-eight times when we quit counting. An oily voiced soul who protested to be a representative of the sponsoring company engaged with announcer White in sundry badinage before each number, extolling the virtues of his wet goods and even going so far as to offer the not unwilling announcer a sip before the microphone. Stuck in here and there amidst this welter of advertising could actually be discovered some bits of program! But such program material it was. First the hackneyed "To Spring" by Grieg. Then "Carry Me Back to Old Virginia." Next some mediocre spirituals followed by a very ordinary jazz band and culminating with a so-called symphony orchestra which actually succeeded in making the exquisite dance of the Fée Dragée from the "Nutcracker Suite" sound clumsy and loutish—no mean achievement.

One long interruption occured while special messages were given to soda jerkers the country o'er, inviting them to enter a prize contest for the best encomium to the advertiser's wares. But the most aggravating interruptions were the frequently spaced announcements: "This is the voice of Columbia—speaking." This remarkable statement was delivered in hushed and reverential tones, vibrant with suppressed emotion, a sustained sob intervening before the last word. It was positively celestial. We have given a rather complete résumé of this program, but it may be warranted by the fact that probably not a dozen people in the country, beside ourself, heard it. No one not paid to do so, as we are, could have survived it. Perhaps this indictment of Columbia's opening performance is unkind in the light of subsequent offerings. Our stomach is still unsettled. Furthermore we will *not* make use of any of the Effervescent Hour's salts to settle it!

THIS MONTH'S prize for the ugliest and most cacophonous coined name plastered on any troup of radio performers is hereby awarded by unanimous and enthusiastic vote to WOW's popular entertainers the Yousem Tyrwelder Twins!

A FAMILIAR WBZ-WBZA PROGRAM GROUP

The Hotel Statler Ensemble Group, one of the best of the dinner orchestras in the New England territory. From left to right: Helen Clapham, Hazel McNamara, Katherine Stang, leader, and Virginia Birnie

AS THE BROADCASTER SEES IT

BY CARL DREHER

Drawing by Franklyn F. Stratford

Radio As An Electro-Medical Cure-All

THAT electricity plays a considerable rôle in the physiological functions is a fact well known and already extensively investigated. But outside of the area of verified or verifiable observations there is, as in every other division of science, a penumbra of dubious ideas, and beyond that lies what Theodore Roosevelt called, in one of the most apt of phrases, the lunatic fringe. Roosevelt was concerned with the field of politics, but politics have no monopoly of lunatics—nor knaves. The two are frequently coupled.

I am forced to these melancholy reflections on re-reading a newspaper article which was clipped for me during the summer. Under the caption, "Metal Lingerie As Radio Shield," it related the adventures of an afflicted governess in the radio realm. It seems that for years the lady suffered from "mysterious burns, bruises, blisters, and internal pains," which, of course, the doctors were unable to explain or cure. Thereupon a learned scientist (non-medical) came to her rescue. He subjected the sick woman to extensive tests, including the effect of ultra-violet, infra-red and X-rays, as well as short and long radio waves. She was very sensitive to all these oscillations and the professor decided that they might be responsible for her pains. He designed for her some metal screen lingerie to act as a shield against the nefarious oscillations. The method of keeping a ground on this intimate shield, as the wearer moves about, is not disclosed. Nor, unfortunately, are the results of the treatment reported. The article does state, however, that the afflicted woman. while previously in hospital near a radio station, heard sounds like the wind whistling through the shrouds of a ship, she would awake in the night with pains in her neck and ears, and hear a "dream-like voice." At this time she spent ten weeks in an insane asylum in the hope of being relieved.

There she was probably on the right track, and the fact that she entered the asylum voluntarily indicates some degree of insight, with a favorable prognosis if the patient came under the care of a skilled psychiatrist able to give her the requisite attention. She is almost certainly a mental case. The fact that she was bothered in the tests by electrical oscillations proves precisely nothing. If, as part of her psychosis, she was convinced that electrical waves made her ill, she would exhibit symptoms during any tests in the course of which she knew or suspected such waves were being generated. Even skin maladies may be of hysterical origin; this is the modern explanation of the "stigmata" which, in the Middle Ages, were taken for crosses printed on the bodies of certain persons by divine intervention, just as people might be possessed by devils through the machinations of Satan. Both beliefs are still firmly held in some parts, although their influence as a whole has decreased inversely with the spread of scientific ideas.

If radio waves were capable of exerting physiological effects professional radio workers in transmitting stations would certainly manifest whatever symptoms could result. Spending eight hours or more each day in an atmosphere where the field strength is many volts per meter, some of them, after thirty years, should be lamentably corroded in sensitive regions. But I have never heard of a radio man quitting a transmitting station because the waves were hurting him. I have seen them quit because they did not like the cooking, or the shape of the superintendent's nose, or the movies in the near-by town, but not one of them ever seemed to realize that Hertzian oscillations were whizzing through him at a velocity of 186,000 miles a second and might cause his vital juices to curdle. This seems to me cogent evidence. While many individuals might be resistant, surely among some thousand of exposures a considerable amount of pathology, definitely traceable to the ether waves, would by this time have accumulated. As for the pitiably feeble emanations a few miles from a station, which cannot even be heard until they are amplified on a grandiose scale, doing a man any harm—that chance is about as great as One-Eyed Connelly's hopes of becoming President of the United States. And the possibility of benefiting a patient physiologically, save incidentally through entertainment or education, is equally large.

But some of the apostles of the late Doctor Abrams' medical credo know better. One of them relates in a learned journal of his cult the story of his efforts to benefit the human race by "Improvement in Electronic Diagnostic and Treatment Apparati; Broadcasting Electro-Magnetic Radio Treatment Waves." He has made his diagnostic circuit bigger and better, he feels, by adding "amplifying attachments" as follows:

1. A solenoid with its South attached to the dynamizer and its North connected by wire to the head-band electrode of the subject, thence, through subject and grounded plates, to a metal stob driven two feet into the earth.
2. The South end of diagnostic set is connected to a second metal stob. These stobs are set eight or ten feet apart *on the magnetic meridian* as ascertained by the compass.
3. A small high-frequency machine for increasing the electric tension to drive all possible of the radiant force of disease through the diagnostic set and subject; and to stimulate the subject's reflexes so that they will act with their highest efficiency. . . .

What the "stob" part refers to I cannot say. The word is not in the dictionary.

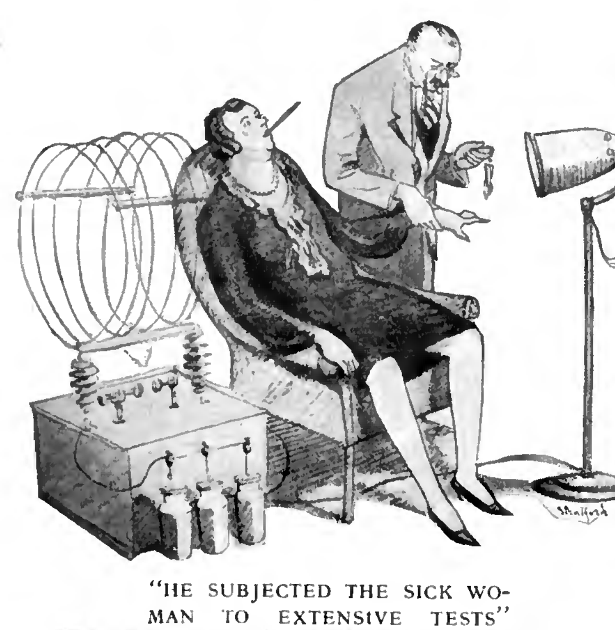
But the Doctor continues:

Later I added a one-stage radio amplifier to the above diagnostic outfit which multiplies its findings four times. Instead of carrying the wire leading from the last reflexophone to the head band of the subject, it is carried to the positive side of the one stage radio amplifier's transformer and then a second wire is carried from the negative side of the amplifier's transformer to the head-band electrode on the subject.

Now comes the actual radio application of the idea. A two-stage radio amplifier, according to the description, is attached to the "master oscilloclast." The electronic treatment is thus let loose on the world, first on a small scale:

In the electric store two doors away we secured specimens for electronic examination of four people and secured specimens from two people in a store in the same building with the treatment instruments. We then made electronic examinations of the six specimens and recorded what infections those people were carrying. After running the instruments some twenty days, we again secured specimens from the same people and made reëlectronic examinations. We found that four of the people were negative of their carried infections—the other two not quite negative but their infections had greatly reduced, showing that only a few more days of broadcasting would render them negative.

These experiments proving to us that infections could be destroyed at a distance of one hundred fifty (150) or more feet through air, brick walls, glass doors, windows, etc., we decided to broadcast the treatment waves out for a mile or more. We had made a five-stage radio-transmitting broadcasting instrument that multiplied the eighteen multiplication, of master machine, by fifteen hundred times making a total multiplication of master machine twenty-seven thousand (27,000) times—we then had erected a broadcasting aerial on top of a five story building and connected by wire the instruments, oscilloclast, two-stage amplifier, one treatment short circuited unit and the five-stage radio-transmitter to the aerial. We then started up the instrument. Then we secured a large radio receiving set (with loud speaker) from the electric company and set it up in a seven-passenger automobile and three of us,



"HE SUBJECTED THE SICK WOMAN TO EXTENSIVE TESTS" a skilled electrician and radio mechanic, chauffeur and myself, tuned at the curb in front of the electric company and could hear the working of the oscilloclast—we then drove five squares and tuned in and could hear the instrument and at intermediate points for a little more than a mile, showing that the treatment waves were being broadcast a mile or more.

We then secured specimens for electronic examination from a distance of half a block up to three miles and from many intermediate points. The number of specimens secured from beginning of broadcasting, from November 1, 1926, to present date, January 20, 1927, were thirty-three. We have found that out of that number twenty-three have been made negative—the balance, ten, have been greatly reduced, showing that it will only require a week or ten days further broadcasting of the treatment waves to render them negative.

The amplified treatment machines are run by batteries that are fed from the electric light socket and will last from four to six months; otherwise batteries only last a few days. The five-stage radio-transmitter is also fitted up with a large battery supplied by electric socket and it in turn supplies the dry batteries, making the apparatus very efficient and durable.

. . . In the last six weeks or more, with broadcasting outfit we have treated electronically a population of fifty thousand (50,000) on an average of two hours per day, making a total of one hundred thousand (100,000) hours per day. If the broadcasting electronic treatment waves have rendered negative two-thirds of the fifty-thousand (50,000) population and reducing the other one-third, as was proven in the thirty-three test cases (two-thirds made negative, one-third reducing) taken out of the same population we can readily see the great benefit and per day value to the people. Giving the value of one dollar per hour for treatment of each individual (which is a low tariff fee) we have a total of $100,000.00 per day.

If a transmitter fed from batteries can benefit the surrounding population to the extent of $100,000. per day, conceive of the value of a 100-kw. outfit devoted to the same philanthropic purpose! Why not make it 10,000 kw., while we are at it? Assuming that the professor's present equipment has a capacity of 20 watts, the 10,000-kw. set would be worth $50,000,000,000. a day to the citizens of the United States, on the valuation basis assumed in the first place. This is of the general order of the amount of business transacted in the country in a year. It is clear, therefore, that a stupendous wealth producing agency is in the hands of the electronic practitioner, which, I suppose, makes him feel very bad.

For my own part, I have some qualms. By broadcasting these electronic treatments, the learned Doc cures all the people within reach of their ailments. But why only the people? Any such general specific must also be good for animals. Horses will be cured of the blind staggers, tubercular monkeys will rise from their beds, sick cockroaches will report at the office fit for work. The rats, pediculi, and bed-bugs (*Cimex lectularius*) may benefit even more than human beings, who may thereby be crowded off the earth. I hope that the electronic broadcaster will consider this aspect of the matter and quiet my fears if he can.

Some Catalogues

BULLETIN No. 1 of H. F. Wareing and Associates, on *Modulator Reactors*, will prove of interest to some broadcasting stations. This company, whose address is 401 Pereles Building, Milwaukee, Wis., is in the business of supplying apparatus and service to broadcasting stations. The first bulletin includes a discussion of modulator reactor design, and a price list of types stated to be suitable for transmitters from 50-watt to 10-kilowatt size. The corresponding currents for which the chokes are built vary from 0.25 to 5.00 amperes, at d.c. voltages of 1000-5000. Ten- thirty-, and fifty-henry reactors are available. Bulletins on other broadcast station equipment are to be issued by H. F. Wareing and Associates at intervals, according to the announcement reaching us.

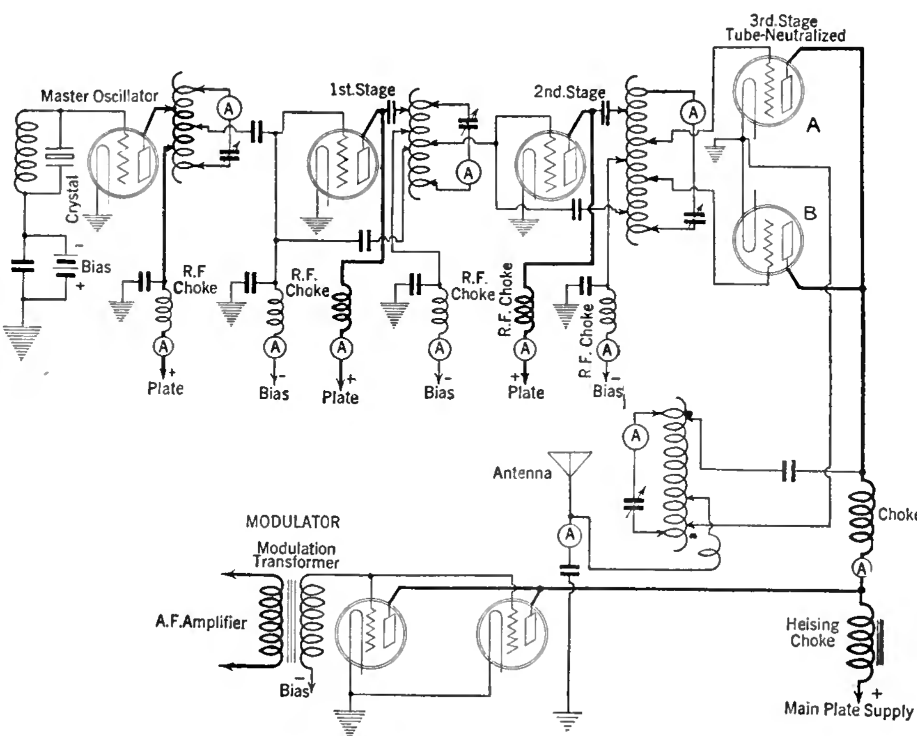
The Samson Electric Company of Canton, Massachusetts, distributes a "Radio Division Price List" including, besides the usual radio parts sold to receiver constructors, such items as microphone input transformers, tube-to-line and line-to-tube transformers, mixer equipment, and other specialized broadcast transmitter and public address material. They have made up a blueprint showing a small public address system assembled with their parts. Provision is made for microphone, radio set, and phonograph pick-up. There are three 0.25 ampere (filament) tubes, and apparently the output stage is push-pull, using 5- or 7.5-watt tubes. On this basis the volume capacity should approximately equal that of the Western Electric 3-A size P. A. system.

Design and Operation of Broadcasting Stations

18. *Piezo-Electric Control*

THE field of piezo-electric phenomena includes the generation of electrical potentials in various substances by the application of physical pressure, and, conversely, changes in physical dimensions directly correlated with electrical conditions. It is not a new division of physics; the piezo-electric properties of quartz, for example, were investigated by P. and J. Curie in 1889. The effect itself was discovered by the brothers some years earlier. Prof. W. G. Cady, about eight years ago, began the work which resulted in the application in the radio art of crystal frequency control. He reported his investigation of "The Piezo-Electric Resonator" in the *Proceedings of the Institute of Radio Engineers*, Vol. 10, No. 2, April, 1922. Oscillating crystals are used as frequency standards in wave meters and monitoring units, some practical forms much used by broadcasting stations being those produced commercially by the General Radio Company. RADIO BROADCAST has printed two comprehensive articles by M. T. Dow on crystal circuits and measurement applications (January and September, 1927). A direct form of frequency control of particular interest to broadcasters is that in which the transmitter functions as a radio-frequency amplifier, the master oscillator being a crystal-controlled tube. Some recent engineering publications on this aspect include three in the I. R. E. *Proceedings:* A. Crossley: "Piezo-Electric Crystal-Controlled Transmitters" (Vol. 15, No. 1, Jan., 1927); A. Meissner: "Piezo-Electric Crystals at Radio Frequencies" (Vol. 15, No. 4, April, 1927); and H. E. Hallborg: "Some Practical Aspects of Short-Wave Operation at High Power" (Vol. 15, No. 6, June, 1927). In the present article an attempt will be made to introduce the subject to broadcast operators who have not worked with crystal-controlled transmitters so that when they are called on to operate such equipment they will be in possession of some of the elementary facts.

In itself the use of a crystal is no guarantee of frequency stabilization to any required degree of accuracy. Some broadcasters seem to believe that the use of a crystal in almost any kind of holder, with some sort of radio-frequency amplifier following, will insure constant frequency radiation. Actually a crystal is of little use unless



THE CIRCUIT DIAGRAM OF A CRYSTAL-CONTROLLED TRANSMITTER

In actual practice, tubes A and B in the third stage generally consist of two banks of power tubes. The filaments of only one set of tubes are lighted and they deliver power to the antenna circuit while the other bank, with the filaments not lighted, acts as a neutralizing circuit to prevent the active bank from breaking into self oscillation. In operation, if an accident happened to the active bank, the filaments could immediately be turned off and the filaments of what was the inactive bank turned on. The latter bank of power tubes would then deliver power to the antenna while the other bank functioned as a neutralizing condenser very specific and delicate conditions of operation are maintained for it.

A piezo-electric substance for radio crystal control purposes must have certain internal atomic properties, and it must be hard, durable, and not easily broken down physically or electrically. Quartz is the best commercial product so far offered to fill these requirements. The manufacture of quartz crystals for radio purposes is a specialized subject and, as few broadcasters are likely to attempt grinding their own crystals, need not be discussed here. The crystal should be optically ground to oscillate at only one fundamental frequency. If the frequency is to remain constant, the crystal must be maintained under constant physical conditions as a prerequisite. This includes an unvarying contact pressure and temperature. When the temperature changes the dimensions of the crystal change and the natural frequency varies proportionately. The crystal must be kept clean; a drop of oil or water introduced between the holder and the quartz slab will usually stop oscillations altogether. It follows that in a broadcasting station installation the crystals are usually kept in a dust-proof box whose temperature is thermostatically controlled. Some commercial crystals, in addition, are sealed into small individual containers, provided with lugs designed to slip under binding posts. The actual contact with the crystal is inside the container. If springs or screw clamps are used to make contact with an open crystal care must be taken to secure parallel movement of the metal surfaces, so that the crystal is not subjected to pressure on part of its surface and left untouched elsewhere. A loose contact leads to brushing, heating, and possible cracking of the crystal. The capacity of the crystal holder should be small in order that its piezo-electric variations may exert the maximum governing effect on the circuit of which the crystal is a part. It will be noted that there is some design analogy between the old-style crystal detector stand and the quartz crystal holder of a modern tube transmitter; each has protean forms. Some illustrations of actual crystal holders will be found with the RADIO BROADCAST papers mentioned in the bibliography, and Crossley includes a detailed description of the contact requirements in his paper.

The radio-frequency energy in the initial crystal circuit may amount to a fraction of a watt, while the final stage may deliver many thousand watts to the antenna. It is clear that great care must be taken to prevent feed-back, parasitic oscillations, and unstable circuit conditions along the line. Under some conditions of circuit imbalance the crystal is likely to overheat and be damaged. The transmitter may stop oscillating. In the endeavor to control regeneration and secure circuit stability, designers have frequent recourse to shielding and neutralization of successive amplifier stages, and sometimes push-pull radio frequency amplification is employed, resulting in a series of balanced circuits analogous to those of low frequency telephone practice.

In a crystal-controlled telephone transmitter, modulation may take place in the final stage or at an intermediate point after the crystal but before the final stage. The advantage of modulation at a low power level lies in the possibility of securing ample modulator capacity relative to the radio frequency energy to be modulated. But if, for example, modulation takes place in one of the earlier stages at a power level of, say, 50 watts, care must be taken not to impair the audio-frequency characteristic of the transmitter by cutting of the side bands in successive tuned stages, and of course the power tubes must have sufficient capacity to handle the peaks of modulation. The Bell Telephone Laboratories engineers seem to incline toward low power modulation, while the Westinghouse and General Electric engineers prefer to wait until the full radio frequency power is developed before impressing the audio frequency on the carrier.

The power of successive stages depends on tube characteristics and the use to which the transmitter is to be put. Crossley shows a 150-600-kc. telegraph transmitter in which the crystal controls a 7.5-watt tube, which is followed by a 50-watt impedance-coupled amplifier, a 1-kw. tuned amplifier stage, and the final 20-kw. stage feeding the antenna. These figures and some others in this paragraph represent the nominal oscillator ratings of the tubes in question; the powers actually developed are generally less. Meissner mentions a telephone transmitter in which, after the crystal tube, 5-watt, 75-watt, 500-watt, and 3-kw. stages are found, the last named supplying 3 kw. to the antenna. The National Broadcasting Company's Bound Brook telephone transmitter (made by Westinghouse for R.C.A.) uses a 7.5-watt tube in the crystal stage, swinging a 250-watt tube, followed by two 250's in parallel (500 watts) before the final 40-kw. bank. Bellmore, built by General Electric for the N. B. C., uses more stages; the crystal, likewise governing a 7.5-watt tube, is coupled to another of the same size; then follow a 50-watter, two fifty-watters in parallel (100 watts), a 1000-watt tube, a single 20-kw. tube run at about a quarter of its rating, and the final 50-kw. stage. In both of these American transmitters, plate modulation of the final power stage is used. In the Bellmore transmitter the output of the crystal stage is purposely kept low as one of the design considerations, only about 0.5 watt being generated, while Crossley mentions getting 21 watts from a crystal-governed tube of the same type, in one of the U. S. Navy experiments. This divergence shows how design calculations determine operating conditions.

Fig. 1 is a schematic circuit diagram of a crystal-controlled telephone transmitter without the audio amplifier and the power supply to the modulator and r. f. output stage. The power ratings of the successive stages have been omitted because, as indicated above, various sizes of tubes might be employed in such a chain, according to the final output required, the tube characteristics, and other design factors.

The Small Broadcaster

IN A letter of some length, which we should print in full if the space were available, Mr. Robert A. Fox, formerly owner and manager of Station WLBP of Ashland, Ohio, takes me severely to task for my past animadversions on incompetent broadcast technicians, which he apparently thinks were aimed exclusively at small stations, and then goes on to a penetrating discussion of the small stations' economic problems.

Mr. Fox points out that in arranging high quality programs the small station is at a disadvantage, "for the simple reason that musicians do not charge you for their time according to the power of your station, but in accordance with the number of hours required of them." The advertiser, on the contrary, will pay more or less proportionately according to the power. The members of the station staff are in the same position as the musicians. The result is that one man must sometimes assume the staggering burden of acting as "station monitor operator, announcer (doing a nemo job of it), operator; chief engineer as well as salesman, financier, publicity agent, and program director," all this with one assistant. Even then the structure collapses under the fixed expense, and Mr. Fox concludes, "The small broadcaster is economically doomed." But, he insists, the failure is economic, not personal—"the fellows who have been operating under 1000 watts have more brains than those above 1000 watts."

They may not have more brains—nature does not distribute brains according to antenna watts, either in direct or inverse ratio—but they certainly have more courage. And, while economically they may be sick, they may yet survive, on some other basis, to see a better day, No one can say, at this juncture, that the small neighborhood station will not find a place in community life, with some form of coöperative support, in a frequency band wherein it can serve local interests without interfering with the large stations and networks aspiring to national coverage, and be in turn protected from interference by them.

As to the less material matter of my own attitude toward such enterprises, it is a curious commentary on our American attitude toward criticism in general that when a man states baldly, in public, unpleasant facts about institutions or people, he is immediately suspected of being hostile to those institutions and people. That it is his right and duty, once he has set up as a critic, technical or social, to discriminate between what he finds good and bad, is a basic fact not sufficiently recognized among us, in radio and elsewhere. There is still a lot of bad broadcasting and incompetent operation going on. No one with a pair of ears and the tonal discrimination of a tomcat can think otherwise. There is also a large and growing element of good showmanship, efficient operation, and skilled personnel, among both large and small stations, and I have not been backward in giving credit to those responsible for such progress. The standards have been lower among smaller stations, because of the lack of resources and, sometimes, because of the lack of time and skilled personnel. All these factors go together. If a man tries to act as announcer, engineer, operator, program director, and publicity representative of a station he will inevitably turn out a half-baked job in each capacity. He may be a hero, but he is not a broadcaster by 1928 standards. One may admire his courage and still tell him what one thinks of his audio frequency band and the quality of his sopranos. As for constructive contributions, I have tried to do my part by writing technical articles which are of use largely to the smaller broadcasters, because the information contained in them is common property among the operators of the bigger stations. Let that be weighed against my refusal to be a member of a cheering squad.

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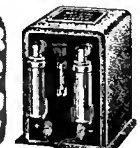

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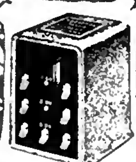

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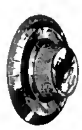
Write National Co. Inc., W. A. Ready, Pres., Malden, Mass., for new Bulletin 124

NATIONAL POWER TRANSFORMERS and FILTER CHOKES for AMPLIFIERS Specified generally. Transformer Type R, center tapped 600 v. secondary. Price $12.50. Transformer Type U, both 600 and 460 v. secondary $14.50. NATIONAL FILTER CHOKES - per pair in heavy case - Type 80, $10.00.

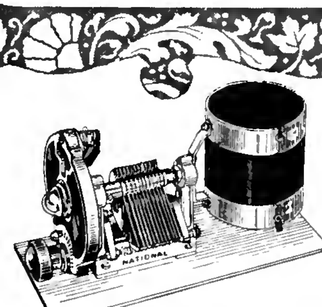


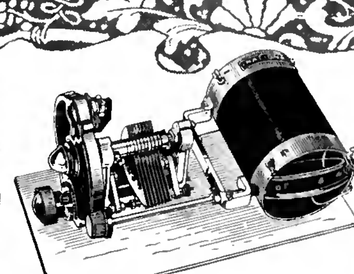
THE ORIGINAL VELVET VERNIER DIAL
TYPE A

ILLUMINATED VELVET VERNIER DIAL TYPE C

POWER TRANSFORMER
FOR PLATE SUPPLY UNITS

FILTER CHOKES
TYPE 80





NATIONAL TUNING UNITS — THE HEAVENLY TWINS

More National Tuning Units have been used by set builders than all other similar components combined.

Standard since 1923 — *Approved By* — The OFFICIAL Design

BROWNING & DRAKE

The *Radio Broadcast*
LABORATORY INFORMATION SHEETS

THE RADIO BROADCAST Laboratory Information Sheets are a regular feature of this magazine and have appeared since our June, 1926, issue. They cover a wide range of information of value to the experimenter and to the technical radio man. It is not our purpose always to include new information but to present concise and accurate facts in the most convenient form. The sheets are arranged so that they may be cut from the magazine and preserved for constant reference, and we suggest that each sheet be cut out with a razor blade and pasted on 4″ x 6″ filing cards, or in a notebook. The cards should be arranged in numerical order. An index appears twice a year dealing with the sheets published during that year. The first index appeared on sheets Nos. 47 and 48, in November, 1926. In July, an index to all sheets appearing since that time was printed.

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

—THE EDITOR.

No. 145 RADIO BROADCAST Laboratory Information Sheet **December, 1927**

Loud Speakers

GENERAL CONSIDERATIONS

IT HAS been realized for some time that a large diaphragm type of loud speaker is capable of giving somewhat better frequency response than can be obtained from a short horn. These large diaphragm loud speakers have generally been called cones because the large diaphragm in most cases takes the form of a right circular cone.

There are certain essential characteristics which must be striven for in designing a loud speaker of this type. What we desire in the diaphragm is to obtain a large surface of great stiffness or rigidity and, at the same time, extreme lightness. If such a material can be obtained, a very satisfactory loud speaker could be made consisting simply of a sheet of the material freely supported at the edge. Such a material having a high ratio of stiffness divided by mass is difficult to obtain, and it has been necessary to devise diaphragm shapes which will give the necessary stiffness and which will still be light. This is the reason why a cone shape has generally been used, for it will give the necessary characteristics.

Recently there was described in RADIO BROADCAST the Balsa wood loud speaker, which represents an attempt to obtain a large flat diaphragm using a tight material, with the required stiffness obtained through the use of slats radiating from the center. Because of the extreme lightness of Balsa wood it is possible to obtain in this way a very high ratio of stiffness to mass.

It is, of course, essential that any loud speaker, if it is to radiate sound effectually, be made as light as possible so as to require only a small amount of energy to move it. It is desirable that the entire diaphragm shall move and that the major resistance it encounters in moving should be that due to the energy required to move the air about the diaphragm and set up sound waves in the air. Any of the available energy that is used for other purposes represents a loss.

An excellent book, *Wireless Loud Speakers*, is published in England by Iliffe and Sons and written by N. W. McLachlan. The author says, in speaking of cone type loud speakers:

"There is a wide field for mathematical and experimental work regarding the behavior of diaphragms of various shapes and sizes. By exact measurement, coupled with analysis, it will be possible to pave the way to better reproduction and to evolve a diaphragm with qualities superior to those now used. Until this is done we must remain in ignorance of the action of diaphragms at various frequencies. The human ear may judge one diaphragm to be better than another, but it cannot give exact data."

No. 146 RADIO BROADCAST Laboratory Information Sheet **December, 1927**

B Power Device Characteristics

TYPICAL CURVES

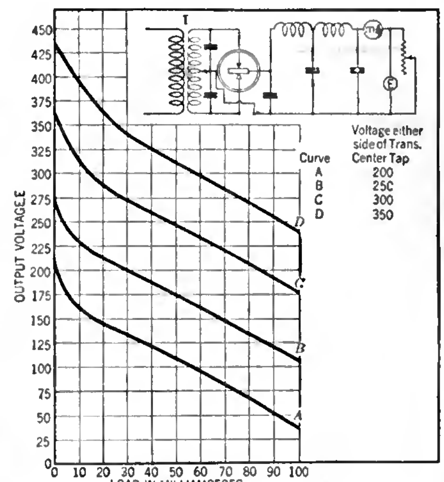
ON THIS Laboratory Sheet are given a group of curves, supplied by the Raytheon Manufacturing Company, which show how the output voltage of a typical B power unit varies with the transformer voltage. The circuit diagram of the rectifier and filter system used in making these tests is given on the curve. The curves apply when a type BH or similar tube is used as the rectifier. These curves indicate the following facts:

(A.) That the slope of all of the curves is the same. This is to be expected because the slope is determined entirely by the resistance of the circuit, which does not vary.

(B.) That an increase of 50 volts in the transformer voltage is effective in producing an average of 75 volts increase in the output voltage.

(C.) That the output voltages of the system at no load have approximately the same value as the transformer voltages.

(D.) That the total resistance of the rectifier-filter system is about 1340 ohms. (This value is determined by dividing the difference of any two voltages on the straight portion of any one curve by the difference of the corresponding load currents.) The resistance of the choke coils used was known to be 600 ohms so that the effective resistance of the rectifier is about 740 ohms.



No. 147 RADIO BROADCAST Laboratory Information Sheet December, 1927

"Gain"

SIMPLE MATHEMATICAL CALCULATION

THE diagram on this Sheet shows an ordinary tuned circuit with a source of high-frequency voltage, e, in series with it. The voltage e can be considered to be the voltage induced in the tuned circuit from another coil, the primary of a radio-frequency transformer for example. This voltage will cause a current to flow in the tuned circuit and the ratio of the voltage E, developed across the entire circuit, to the voltage e, induced in the circuit, is known as the "gain" of the tuned circuit. The more efficient the tuned circuit is, the greater will be the "gain." We will now derive a mathematical expression for the "gain" of a tuned circuit.

The current, I, flowing in a tuned circuit at resonance is:

$$I = \frac{e}{R} \qquad (1.)$$

where e = the voltage induced in the circuit and R = resistance of the circuit. The current flowing through the inductance coil, L, generates a potential across the coil, determined as follows:

$$E = \omega LI \qquad (2.)$$

where ω = 6.28 times the frequency of the current, L = inductance of coil in henries, and I has the same meaning as in equation (1.) Substituting in equation (2.) the value for I given in equation (1,) we have:

$$E = \frac{\omega Le}{R} \qquad (3.)$$

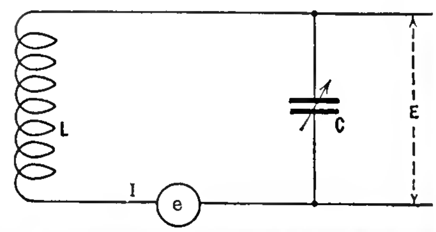
and dividing through by e we get:

$$\frac{E}{e} = \frac{\omega L}{R}$$

But, as stated previously, the ratio of E to e is the gain of the circuit. Therefore:

$$\text{Gain} = \frac{\omega L}{R} \qquad (4.)$$

This final expression indicates that, to obtain greatest efficiency from a tuned circuit, it is essential that the ratio of the inductance reactance (ωL) to the resistance of the coil should be made as large as possible.



No. 148 RADIO BROADCAST Laboratory Information Sheet December, 1927

An A. C. Audio-Frequency Amplifier

WHAT PARTS TO USE

THE introduction of the new a. c. tubes makes possible the construction of an a. c. audio amplifier with the necessary A, B, and C voltages supplied directly from the light socket. The list of parts necessary to construct such an amplifier is given on this Sheet. The circuit diagram is given on Laboratory Sheet No. 149.

An amplifier of this type is well suited for use with a small receiver consisting of one or more stages of radio-frequency amplification and a detector. The circuit has been so designed that B voltages for the r. f. and detector tubes can be obtained from the audio amplifier device.

The following parts are necessary to construct this amplier:

A—A. C. Tube, Type UX-226 (CX-326) or Equivalent.
B—UX-171 (CX-371) or Equivalent.
T_1, T_2—Two High-Quality Audio Transformers.
T_3—Filament-Lighting Transformer to Supply Tube A.
T_4—Power-Supply Transformer Designed for use in 171 Type B Power Units.
L_1, L_2—Filter Choke Coils.
L_3—Output Choke Coil.
C_1, C_2—1-Mfd. Bypass Condensers.
C_3, C_4—2 Mfd. Filter Condensers.
C_5—4-Mfd. Filter Condenser.
C_6, C_7, C_8—1-Mfd. Filter Condensers.
C_9—2-4-Mfd. Fixed Condenser.
R_1—30-Ohm Center-Tapped Resistance.
R_2—1500-Ohm Fixed Resistance Capable of Carrying 4 mA.
R_3—2000-Ohm Fixed Resistance Capable of Carrying 20 mA.
R_4—Tapped Resistance for Use in Output of B Power Units.

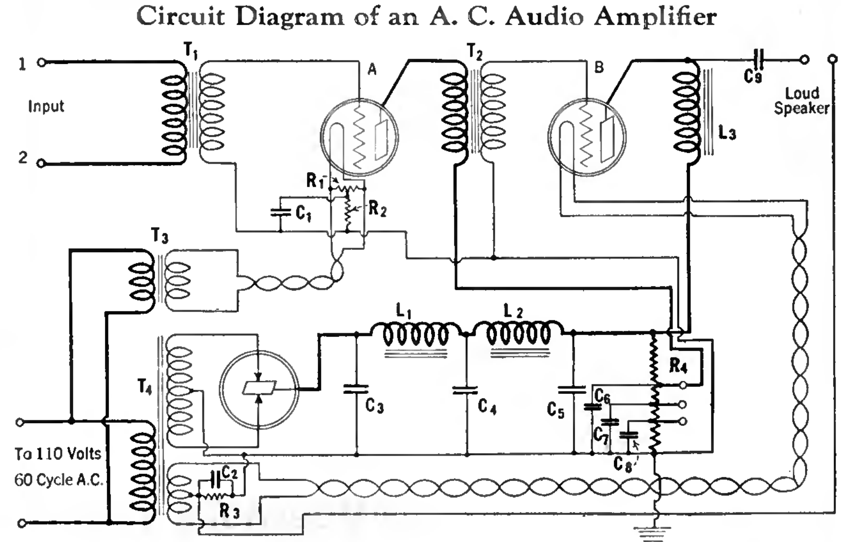
In wiring this amplifier, be sure to twist the filament leads to the two tubes, to prevent hum. C bias for the first tube, A, is obtained from resistance R_2, and resistance R_3 supplies the output tube with grid bias.

The input terminals of the amplifier should connect to the output of the detector tube, terminal No. 1 connecting to the plate and terminal No. 2 to the detector B plus.

To prevent hum it is essential that the negative B be carefully grounded.

No. 149 RADIO BROADCAST Laboratory Information Sheet December, 1927

Circuit Diagram of an A. C. Audio Amplifier



Here is the circuit diagram of an all a. c. audio amplifier. The list of parts is given on Sheet No. 148.

Silent Magic

Here is the Eveready Layerbilt "B" Battery No. 486, Eveready's longest-lasting provider of Battery Power.

Radio is better with *Battery* Power

TURN your radio dial, and presto! you turn your home into a theater, a concert hall, a lecture room, a cabaret, a church, or whatever you will. Turn the dial and your attentive ear does the rest. That is all there is to this magic of radio.

Or almost all. If a radio set is to work at its very best, attracting no attention to itself, creating for you the illusion that can be so convincing, you must pay a little attention to the kind of power you give it. There is but one direction, a simple one—use Battery Power. Only such power is steady, uniform, silent. It is called by scientists pure Direct Current. Any other kind of current in your radio set may put a hum into the purest note of a flute, a scratch into the song of the greatest singer, a rattle into the voice of any orator.

Don't tamper with tone. Beware of interfering with illusion. Power that reveals its presence by its noise is like a magician's assistant who gives the trick away. Use batteries—use the Eveready Layerbilt "B" Battery No. 486, the remarkable battery whose exclusive, patented construction makes it last longest. It offers you the gift of convenience, a gift that you will appreciate almost as much as you will cherish the perfection of reception that only Battery Power makes possible.

NATIONAL CARBON CO., INC.
New York UCC San Francisco
Unit of Union Carbide and Carbon Corporation

Tuesday night is Eveready Hour Night—9 P. M., Eastern Standard Time

WEAF–*New York*
WJAR–*Providence*
WEEI–*Boston*
WFI–*Philadelphia*
WGR–*Buffalo*
WCAE–*Pittsburgh*
WSAI–*Cincinnati*
WTAM–*Cleveland*
WWJ–*Detroit*
WGN–*Chicago*
WOC–*Davenport*
KSD–*St. Louis*
WCCO–*Minneapolis* / *St. Paul*
WDAF–*Kansas City*
WRC–*Washington*
WGY–*Schenectady*
WHAS–*Louisville*
WSB–*Atlanta*
WSM–*Nashville*
WMC–*Memphis*

Pacific Coast Stations—
9 P. M., Pacific Standard Time

KPO–KGO–*San Francisco*
KFOA–KOMO–*Seattle*
KFI–*Los Angeles*
KGW–*Portland*

EVEREADY
Radio Batteries
-they last longer

The air is full of things you shouldn't miss

No. 150 RADIO BROADCAST Laboratory Information Sheet December, 1927

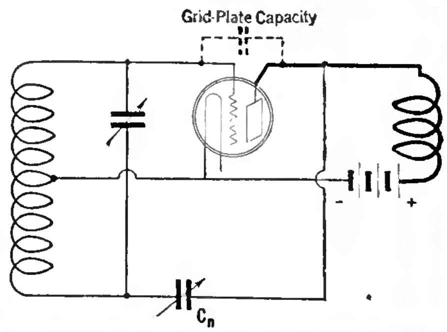
Oscillation Control

THE USE OF NEUTRALIZATION

IT HAS been pointed out many times that an ordinary three-element tube has an inherent tendency to oscillate due to the feed-back that occurs from the plate circuit to the grid circuit through the grid-plate capacity, indicated by dotted lines in the accompanying diagram. This diagram represents the circuit of a single-stage of tuned radio-frequency amplification, using the Rice system of neutralization, and the following explanation will make clear why the tube tends to oscillate and why the tendency to oscillate can be overcome by using some system of neutralization.

When a tube acts as an amplifier, the voltage developed in the plate circuit is greater than the voltage originally impressed on the grid circuit and, consequently, if the plate circuit is coupled to the grid circuit in any manner whatsoever, current will tend to flow from the point of high potential, that is the plate, to a point of lower potential, in this case the grid. If this current flowing to the grid circuit has the same phase as the original signal impressed on the grid, then the grid voltage will become somewhat greater and will be equal to the original signal in the grid circuit plus the voltage induced in the grid circuit from the plate. An increase in the grid voltage again produces an increase in plate voltage which in turn reacts back on the grid until the voltage is increased to a point where the losses in the circuit are overcome, and then the tube breaks into continuous oscillation.

It should be evident that if we can place in the circuit some device that will impress a potential on the grid kind of an equal and opposite to that caused by the coupling between the grid and plate, then the resultant effect will be zero and the tendency for the circuit to build up and break into continuous oscillation will be nullified. The Rice system of neutralization is one way of doing this, the circuit for which is shown in the accompanying diagram. The grid-plate capacity is shown in dotted lines and this is the capacity through which current flows from the plate to the grid circuit and which ordinarily causes the tube to oscillate. This capacity is neutralized in the Rice system by connecting condenser Cn as indicated.



No. 151 RADIO BROADCAST Laboratory Information Sheet December, 1927

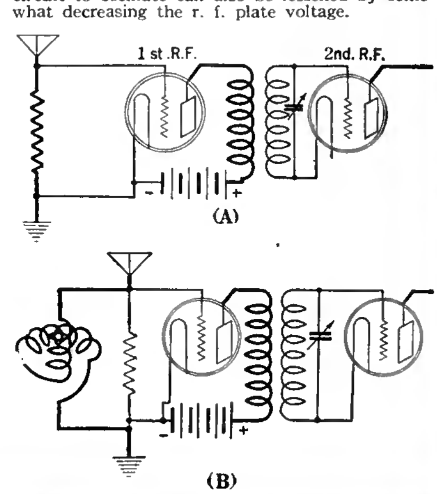
Single-Control

BOOSTING SENSITIVITY

ON LABORATORY Sheet No. 33, October, 1926, some facts were given regarding the tandem tuning of several condensers, to decrease the number of controls. It was pointed out that, to obtain single control, it is necessary to overcome the effect of the antenna circuit in some manner, and that a common method of doing this is as indicated in sketch A on this Sheet. The owner of a receiver of this type may greatly increase its sensitivity by connecting a variometer between the antenna and ground posts as indicated in sketch B. This, of course, adds one more control to the set but in those cases where greater sensitivity is necessary, the additional control is justified.

The increase in sensitivity that results when the variometer is used in the antenna circuit is due to the fact that it brings the antenna into resonance with the signals being received and the resultant gain in amplification is practically equal to that which would be obtained from an additional stage of radio-frequency amplification.

In some cases when this variometer is used, it will be found that the receiver tends to oscillate, or actually does oscillate, when all of the circuits are brought into resonance. Fortunately, however, most single-control receivers have a volume control in the radio-frequency system and it will be found that, by cutting down the volume control, a point will be reached where the set will stop oscillating and usually the actual volume obtained with the antenna circuit tuned will be much greater than that obtained before with the volume control turned to the "maximum" position. The tendency of the circuit to oscillate can also be lessened by somewhat decreasing the r. f. plate voltage.



No. 152 RADIO BROADCAST Laboratory Information Sheet December, 1927

Speech

SOURCES OF INFORMATION

THE nature of speech has been the subject of many scientific inquiries and many of the investigations in connection with speech have been recorded in various scientific journals.

Back in 1873, Alexander Graham Bell, familiar to us as the inventor of the telephone, did considerable work in analyzing speech and in "devising methods of exhibiting the vibrations of sounds opticallly," and much of the recent research has been done by engineers and physicists associated with the laboratories of the telephone companies.

A bibliography is given below of some of the important articles and books on the subject with which we are familiar. This bibliography is by no means complete in itself but if the references given are studied it will be found that some of them contain many references to other papers on the subject. I. B. Crandall's article, in the October, 1925, *Bell System Technical Journal*, in particular, contains about twenty-six references to other sources of information on speech and related subjects.

REFERENCE SOURCES

Bell System Technical Journal

C. F. Sacia and C. J. Beck; "The Power of Fundamental Speech Sounds." July, 1926.

I. B. Crandall: "Sounds of Speech." October, 1925.

C. F. Sacia: "Speech Power and Energy." October, 1925.

Irving B. Crandall: "Dynamical Study of the Vowel Sounds." January, 1927.

C. R. Moore and A. S. Curtis: "An Analyzer for the Voice Frequency Range." April, 1927.

Journal of the American Institute of Electrical Engineers

Jones; "The Nature of Language." April, 1924.

Martin and Fletcher: "High-Quality Transmission and Reproduction of Speech and Music." March. 1924.

Maxfield and Harrison: "Method of High Quality Recording and Reproducing of Music and Speech Based on Telephone Research." March, 1926.

Books

Miller: *Science of Musical Sounds.* Second Edition. Macmillan.

Sabine: *Collected Papers on Acoustics.* Harvard University Press.

The great improvements in radio power *have been made by* Balkite

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Balkite "A" *Contains no battery.* The same as Balkite "AB," but for the "A" circuit only. Enables owners of Balkite "B" to make a complete light socket installation at very low cost. Price $35.00.

Balkite "B" *One of the longest lived devices in radio.* The accepted tried and proved light socket "B" power supply. The first Balkite "B," after 5 years, is still rendering satisfactory service. Over 300,000 in use. Three models: "B"-W, 67-90 volts, $22.50; "B"-135,* 135 volts, $35.00; "B"-180, 180 volts, $42.50. Balkite now costs no more than the ordinary "B" eliminator.

Balkite Chargers

Standard for "A" batteries. Noiseless. Can be used during reception. Prices drastically reduced. Model "J,"* rates 2.5 and .5 amperes, for both rapid and trickle charging, $17.50. Model "N"* Trickle Charger, rate .5 and .8 amperes, $9.50. Model "K" Trickle Charger, $7.50.

**Special models for 25-40 cycles at slightly higher prices. Prices are higher West of the Rockies and in Canada.*

FIRST noiseless battery charging. Then successful light socket "B" power. Then trickle charging. And today, most important of all, Balkite "AB," a complete unit containing no battery in any form, supplying both "A" and "B" power directly from the light socket, and operating only while the set is in use. The great improvements in radio power have been made by Balkite.

The famous Balkite electrolytic principle

This pioneering has been important. Yet alone it would never have made Balkite one of the best known names in radio. Balkite is today the established leader because of Balkite performance in the hands of its owners.

Because with 2,000,000 units in the field Balkite has a record of long life and freedom from trouble seldom equalled in any industry.

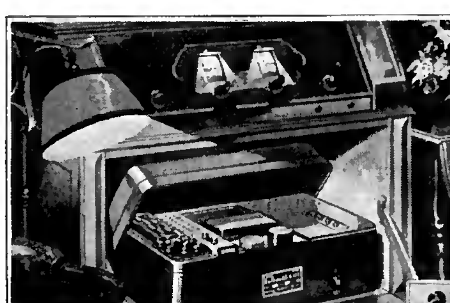
Because the first Balkite "B," purchased 5 years ago, is still in use. Because to your radio dealer Balkite is a synonym for quality.

Because the electrolytic rectification developed and used by Balkite is so reliable that today it is standard on the signal systems of most American as well as European and Oriental railroads. It is this principle that does away with the necessity of using tubes for rectifying current—that makes all Balkite Radio Power Units, including the new Balkite "A" and "AB," permanent equipment with nothing to wear out or replace.

Balkite has pioneered—but not at the expense of the public.

Radio power with batteries or without

Today, whatever type of radio set you own, whatever type of power equipment you want (with batteries or without) Balkite has it. And production is so enormous that prices are astonishingly low. *Your dealer will recommend the Balkite equipment you need for your set.*



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Radio Power Units

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 page 168. Order by number only.

1. FILAMENT CONTROL—Problems of filament supply, voltage regulation, and effect on various circuits. RADIALL COMPANY.

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

3. TRANSFORMERS—A booklet giving data on input and output transformers. PACENT ELECTRIC COMPANY.

4. RESISTANCE-COUPLED AMPLIFIERS—A general discussion of resistance coupling with curves and circuit diagrams. COLE RADIO MANUFACTURING 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.

6. B-ELIMINATOR CONSTRUCTION—Constructional data on how to build. AMERICAN ELECTRIC COMPANY.

7. TRANSFORMER AND CHOKE-COUPLED AMPLIFICATION—Circuit diagrams and discussion. ALL-AMERICAN RADIO CORPORATION.

8. RESISTANCE UNITS—A data sheet of resistance units and their application. WARD-LEONARD ELECTRIC COMPANY.

9. VOLUME CONTROL—A leaflet showing circuits for distortionless control of volume. CENTRAL RADIO LABORATORIES.

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

11. RESISTANCE COUPLING—Resistors and their application to audio amplification, with circuit diagrams. DEJUR PRODUCTS 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.

16. VARIABLE CONDENSERS—A description of the functions and characteristics of variable condensers with curves and specifications for their application to complete receivers. ALLEN D. CARDWELL MANUFACTURING COMPANY.

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

19. POWER SUPPLY—A discussion on power supply with particular reference to lamp-socket operation. Theory and constructional data for building power supply devices. ACME APPARATUS COMPANY.

20. AUDIO AMPLIFICATION—A booklet containing data on audio amplification together with hints for the constructor. ALL AMERICAN RADIO CORPORATION.

21. HIGH-FREQUENCY DRIVER AND SHORT-WAVE WAVEMETER—Constructional data and application. BURGESS BATTERY COMPANY.

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

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

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

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

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

51. SHORT-WAVE RECEIVER—Constructional data on a receiver which, by the substitution of various coils, may be made to tune from a frequency of 16,660 kc. (18 meters) to 1999 kc. (150 meters). SILVER-MARSHALL, INCORPORATED.

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

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.

59. RESISTANCE COUPLING—A booklet giving some general information on the subject of radio and the application of resistors to a circuit. DAVEN RADIO CORPORATION.

60. RESISTORS—A pamphlet giving some technical data on resistors which are capable of dissipating considerable energy; also data on the ordinary resistors used in resistance-coupled amplification. THE CRESCENT RADIO SUPPLY COMPANY.

62. RADIO-FREQUENCY AMPLIFICATION—Constructional details of a five-tube receiver using a special design of radio-frequency transformer. CAMFIELD RADIO MFG. COMPANY.

63. FIVE-TUBE RECEIVER—Constructional data on building a receiver. AERO PRODUCTS, INCORPORATED.

64. AMPLIFICATION WITHOUT DISTORTION—Data and curves illustrating the use of various methods of amplification. ACME APPARATUS COMPANY.

66. SUPER-HETERODYNE—Constructional details of a seven-tube set. G. C. EVANS COMPANY.

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

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

80. FIVE-TUBE RECEIVER—Data are given for the construction of a five-tube tuned radio-frequency receiver. Complete instructions, list of parts, circuit diagram, and template are given. ALL-AMERICAN RADIO CORPORATION.

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.

82. SIX-TUBE RECEIVER—A booklet containing photographs, instructions, and diagrams for building a six-tube shielded receiver. SILVER-MARSHALL, INCORPORATED.

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

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

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

86. SHORT-WAVE RECEIVER—A booklet containing data on a short-wave receiver as constructed for experimental purposes. THE ALLEN D. CARDWELL MANUFACTURING CORPORATION.

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

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

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

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

94. POWER AMPLIFIER—Constructional data and wiring diagrams of a power amplifier combined with a B-supply unit are given. NATIONAL COMPANY, INCORPORATED.

100. A, B, AND C SOCKET-POWER SUPPLY—A booklet giving data on the construction and operation of a socket-power supply using the new high-current rectifier tube. THE Q. R. S. MUSIC COMPANY.

101. USING CHOKES—A folder with circuit diagrams of the more popular circuits showing where choke coils may be placed to produce better results. SAMSON ELECTRIC COMPANY.

ACCESSORIES

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.

25. ELECTROLYTIC RECTIFIER—Technical data on a new type of rectifier with operating curves. KODEL RADIO CORPORATION.

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

27. DRY-CELL BATTERY CAPACITIES FOR RADIO TRANSMITTERS—Characteristic curves and data on discharge tests. BURGESS BATTERY COMPANY.

28. B BATTERY LIFE—Battery life curves with general curves on tube characteristics. BURGESS BATTERY COMPANY.

29. HOW TO MAKE YOUR SET WORK BETTER—A non-technical discussion of general radio subjects with hints on how reception may be bettered by using the right tubes. UNITED RADIO AND ELECTRIC CORPORATION.

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

31. FUNCTIONS OF THE LOUD SPEAKER—A short, non-technical general article on loud speakers. AMPLION CORPORATION OF AMERICA.

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

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

34. COST OF B BATTERIES—An interesting discussion of the relative merits of various sources of B supply. HARTFORD BATTERY MANUFACTURING COMPANY.

35. STORAGE BATTERY OPERATION—An illustrated booklet on the care and operation of the storage battery. GENERAL LEAD BATTERIES COMPANY.

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

37. CHOOSING THE RIGHT RADIO BATTERY—Advice on what dry cell battery to use; their application to radio, with wiring diagrams. NATIONAL CARBON 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.

54. ARRESTERS—Mechanical details and principles of the vacuum type of arrester. NATIONAL ELECTRIC SPECIALTY COMPANY.

55. CAPACITY CONNECTOR—Description of a new device for connecting up the various parts of a receiving set, and at the same time providing bypass condensers between the leads. KURZ-KASCH COMPANY.

(Continued on page 168)

Vital Factors

in attaining

High Quality Reproduction

Type 285
Audio Transformer

The Type 285 transformers give high and even amplification of all tones common to speech, instrumental, and vocal music. Available in two ratios.

Type 285-H Audio Transformer. **Price $6.00**

Type 285-D Audio Transformer. **Price $6.00**

Type 367
Output Transformer

This unit adapts the impedance of an audio amplifier to the input of any cone type speaker, thus promoting better tone quality and protecting the speaker windings against possible damage from A. C. voltages. Similar in appearance to the Type 285.

Type 367 Output Transformer. **Price $5.00**

High quality reproduction depends upon three things: correctly designed coupling units, proper use of amplifier tubes, and an efficient reproducing device.

For over a decade the subject of audio frequency amplification has been extensively studied in the laboratories of the General Radio Company with particular attention given to the design of coupling units.

As a result of this exhaustive research the General Radio Company has been, and is, the pioneer manufacturer of high quality Audio Transformers, Impedance Couplers, and Speaker Filters.

The latest contribution to quality amplification is the type 441 Push-Pull Amplifier, which is mounted on a nickel finished metal base-board and is completely wired.

If the amplifier of your receiver is not bringing out the rich bass notes and the mellow high tones as well as those in the middle register why not rebuild your amplifier for *Quality Reproduction* with *General Radio* coupling units?

Write for our Series A of amplification booklets describing various amplifier circuits and units.

GENERAL RADIO COMPANY
Cambridge, Mass.

Type 373
Double Impedance
Coupler

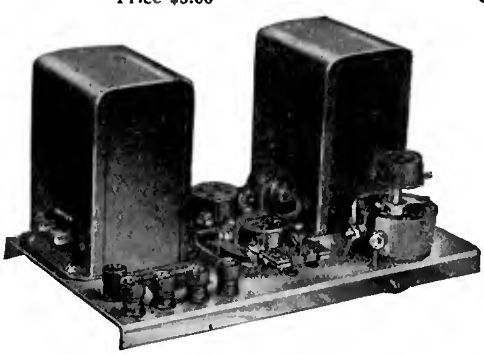
Many prefer the impedance coupling method of amplification to resistance coupling as lower plate voltages may be used and greater amplification may be obtained. The Type 373 is contained in a metal shell and connected in a circuit in precisely the same manner as a transformer.

Type 373 Double Impedance Coupler. **Price $6.50**

Type 387-A
Speaker Filter

The Type 387-A consists of an inductance choke with condenser. It offers a high impedance to audio frequency current and forces these currents to pass through a condenser into the speaker, thereby improving tone quality and protecting the speaker windings.

Type 387-A Speaker Filter. **Price $6.00**



Type 441 Push-Pull Amplifier

The Type 441 is completely wired and consists of two high quality push-pull transformers, with necessary sockets and resistances mounted on a nickel finished metal base board. It may be used with any power or semi-power tube to increase the undistorted output of the amplifier with the result that better quality is reproduced from the loudspeaker with more volume than is obtained from other methods of coupling.

Licensed by the R. C. A. and through terms of the license may be sold with tubes only.

Type 441 Push-Pull Amplifier	**Price $20.00**
Type UX-226 or CX-326 Amplifier Tube	" **3.00**
Type UX-171 or CX-371 Amplifier Tube	" **4.50**

Type 445 Plate Supply and Grid Biasing Unit

The Type 445 meets the demand for a thoroughly dependable light socket plate supply and grid biasing unit that is readily adaptable to the tube requirements of any standard type of receiver. Any combination of voltages from 0 to 100 may be taken from the adjustable "B" voltage taps. A variable grid bias voltage from 0 to 50 is also available. The unit is designed for use on 105 to 125 volt (50 to 60 cycle) A. C. lines and uses the UX-280 or CX-380 rectifier tube.

Licensed by R. C. A. and through terms of the license may be sold with tube only.

Type 445 Plate Supply and Grid Biasing Unit	**Price $55.00**
Type UX-280 or CX-380 Rectifier Tube	" **5.00**

GENERAL RADIO

LABORATORY EQUIPMENT

Parts *and* Accessories

"RADIO BROADCAST'S" DIRECTORY OF MANUFACTURED RECEIVERS

¶ A coupon will be found on page 172. All readers who desire additional information on the receivers listed below need only insert the proper numbers in the coupon, mail it to the Service Department of Radio Broadcast, and full details will be sent. New sets are listed in this space each month.

KEY TO TUBE ABBREVIATIONS

99—60-mA. filament (dry cell)
01-A—Storage battery 0.25 amps. filament
12—Power tube (Storage battery)
71—Power tube (Storage battery)
16-B—Half-wave rectifier tube
80—Full-wave, high current rectifier
81—Half-wave, high current rectifier
Hmu—High-Mu tube for resistance-coupled audio
20—Power tube (dry cell)
10—Power Tube (Storage battery)
00-A—Special detector
13—Full-wave rectifier tube
26—Low-voltage high-current a. c. tube
27—Heater type a. c. tube

Direct Current Receivers

NO. 424. COLONIAL 26

Six tubes; 2 t. r. f. (01-A), detector (12), 2 transformer audio (01-A and 71). Balanced t. r. f. One to three dials. Volume control: antenna switch and potentiometer across first audio. Watts required: 120. Console size: 34 x 38 x 18 inches. Headphone connections. The filaments are connected in a series parallel arrangement. Price $250 including power unit.

NO. 425. SUPERPOWER

Five tubes: All 01-A tubes. Multiplex circuit. Two dials. Volume control: resistance in r. f. plate. Watts required: 30. Antenna: loop or outside. Cabinet sizes: table, 27 x 10 x 9 inches; console, 28 x 50 x 21. Prices: table, $135 including power unit; console, $390 including power unit and loud speaker.

A. C. Operated Receivers

NO. 508. ALL-AMERICAN 77, 88, AND 99

Six tubes; 3 t. r. f. (26), detector (27), 2 transformer audio (26 and 71). Rice neutralized t. r. f. Single drum tuning. Volume control: potentiometer in r. f. plate. Cabinet sizes: No. 77, 21 x 10 x 8 inches; No. 88 Hiboy, 25 x 38 x 18 inches; No. 99 console, 27¼ x 43 x 20 inches. Shielded. Output device. The filaments are supplied by means of three small transformers. The plate supply employs a gas-filled rectifier tube. Voltmeter in a. c. supply line. Prices: No. 77, $150, including power unit; No. 88, $210 including power unit; No. 99, $285 including power unit and loud speaker.

NO. 509. ALL-AMERICAN "DUET"; "SEXTET"

Six tubes; 2 t. r. f. (99), detector (99), 3 transformer audio (99 and 12). Rice neutralized t.r.f. Two dials. Volume control: resistance in r.f. plate. Cabinet sizes: "Duet," 23 x 56 x 16½ inches; "Sextet," 22½ x 13½ x 15½ inches. Shielded. Output device. The 99 filaments are connected in series and supplied with rectified a.c., while 12 is supplied with raw a.c. The plate and filament supply uses gaseous rectifier tubes. Milliammeter on power unit. Prices: "Duet," $160 including power unit; "Sextet," $220 including power unit and loud speaker.

NO. 511. ALL-AMERICAN 80, 90, AND 115

Five tubes; 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 12). Rice neutralized t.r.f. Two dials. Volume control: resistance in r.f. plate. Cabinet sizes: No. 80, 23¼ x 12½ x 15 inches; No. 90, 37½ x 12 x 12½ inches; No. 115 Hiboy, 24 x 41 x 15 inches. Coils individually shielded. Output device. See No. 509 for power supply. Prices: No. 80, $135 including power unit; No. 90, $145 including power unit and compartment; No. 115, $170 including power unit, compartment, and loud speaker.

NO. 510. ALL-AMERICAN 7

Seven tubes; 3 t.r.f. (26), 1 untuned r.f. (26), detector (27), 2 transformer audio (26 and 71). Rice neutralized t.r.f. One drum. Volume control: resistance in r.f. plate. Cabinet sizes: "Sovereign" console, 30½ x 60½ x 19 inches; "Lorraine" Hiboy, 25½ x 53¾ x 17½ inches; "Forte" cabinet, 25½ x 13½ x 17½ inches. For filament and plate supply: See No. 508. Prices: "Sovereign" $160; "Lorraine" $360; "Forte" $270. All prices include power unit. First two include loud speaker.

NO. 401. AMRAD AC9

Six tubes; 3 t.r.f. (99), detector (99), 2 transformer (99 and 12). Neutrodyne. Two dials. Volume control: resistance across 1st audio. Watts consumed: 50. Cabinet size: 27 x 9 x 11¾ inches. The 99 filaments are connected in series and supplied with rectified a.c., while the 12 is run on raw a.c. The power unit, requiring two 16-B rectifiers, is separate and supplies A, B, and C current. Price $142 including power unit.

NO. 402. AMRAD AC5

Five tubes. Same as No. 401 except one less r.f. stage. Price $125 including power unit.

NO. 536. SOUTH BEND

Six tubes. One control. Sub-panel shielding. Binding Posts. Antenna: outdoor. Prices: table, $130, Baby Grand console, $195.

NO. 537. WALBERT 26

Six tubes; five Kellogg a.c. tubes and one 71. Two controls. Volume control: variable plate resistance. Isofarad circuit. Output device. Battery cable. Semi-shielded. Antenna: 50 to 75 feet. Cabinet size: 10½ x 30¼ x 16½ inches. Prices: $215; with tubes, $250.

NO. 484. BOSWORTH, B5

Five tubes; 2 t.r.f. (26), detector (99), 2 transformer audio (special a.c. tubes). T.r.f. circuit. Two dials. Volume control: potentiometer. Cabinet size: 23 x 7 x 8 inches. Output device included. Price $175.

NO. 406. CLEARTONE 110

Five tubes; 2 t.r.f., detector, 2 transformer audio. All tubes a. c. heater type. One or two dials. Volume control: resistance in r. f. plate. Watts consumed: 40. Cabinet size varies. The plate supply is built in the receiver and requires one rectifier tube. Filament supply through step down transformers. Prices range from $175 to $375 which includes 5 a.c. tubes and one rectifier tube.

NO. 407. COLONIAL 25

Six tubes; 2 t. r. f. (01-A), detector (99), 2 resistance audio (99), 1 transformer audio (10). Balanced t.r.f. circuit. One or three dials. Volume control: Antenna switch and potentiometer on 1st audio. Watts consumed: 100. Console size: 34 x 38 x 18 inches. Output device. All tube filaments are operated on a. c. except the detector which is supplied with rectified a.c. from the plate supply. The rectifier employs two 16-B tubes. Price $250 including built-in plate and filament supply.

NO. 507. CROSLEY 602 BANDBOX

Six tubes; 3 t.r.f. (26), detector (27), 2 transformer audio (26 and 71). Neutrodyne circuit. One dial. Cabinet size: 17¼ x 5¼ x 7¾ inches. The heaters for the a.c. tubes and the 71 filament are supplied by windings in B unit transformers available to operate either on 25 or 60 cycles. The plate current is supplied by means of rectifier tube. Price $65 for set alone, power unit $60.

NO. 408. DAY-FAN "DE LUXE"

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. One dial. Volume control: potentiometer across r.f. tubes. Watts consumed: 300. Console size; 30 x 40 x 20 inches. The filaments are connected in series and supplied with d.c. from a motor-generator set which also supplies B and C current. Output device. Price $350 including power unit.

NO. 409. DAYCRAFT 5

Five tubes; 2 t.r.f., detector, 2 transformer audio. All a. c. heater tubes. Reflexed t.r.f. One dial. Volume control: potentiometers in r.f. plate and 1st audio. Watts consumed: 135. Console size: 34 x 36 x 14 inches. Output device. The heaters are supplied by means of a small transformer. A built-in rectifier supplies B and C voltages. Price $170, less tubes. The following have one more r.f. stage and are not reflexed: Daycraft 6, $195; Dayrole 6, $235; Dayfan 6, $110. All prices less tubes.

NO. 469. FREED-EISEMANN NR11

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. One dial. Volume control: potentiometer. Watts consumed: 150. Cabinet size: 19¾ x 10 x 10½ inches. Shielded. Output device. A special power unit is included employing a rectifier tube. Price $225 including NR-411 power unit.

NO. 487. FRESHMAN 7F-AC

Six tubes; 3 t.r.f. (26), detector (27), 2 transformer audio (26 and 71). Equaphase circuit. One dial. Volume control: potentiometer across 1st audio. Console size: 24½ x 41½ x 15 inches. Output device. The filaments and heaters and B supply are all supplied by one power unit. The plate supply requires one 80 rectifier tube. Price $175 to $350, complete.

NO. 421. SOVEREIGN 238

Seven tubes of the a.c. heater type. Balanced t.r.f. Two dials. Volume control: resistance across 2nd audio. Watts consumed: 45. Console size: 37 x 52 x 15 inches. The heaters are supplied by a small a. c. transformer, while the plate is supplied by means of rectified a.c using a gaseous type rectifier. Price $325, including power unit and tubes.

NO. 517. KELLOGG 510, 511, AND 512

Seven tubes; 4 t.r.f., detector, 2 transformer audio. All Kellogg a.c. tubes. One control and special zone switch. Balanced. Volume control: special. Output device. Shielded. Cable connection between power supply unit and receiver. Antenna: 25 to 100 feet. Panel 7⅛ x 27½ inches. Prices: Model 510 and 512, consoles, $495 complete. Model 511, consolette, $365 without loud speaker.

NO. 496. SLEEPER ELECTRIC

Five tubes; four 99 tubes and one 71. Two controls. Volume control: rheostat on r.f. Neutralized. Cable. Output device. Power supply uses two 16-B tubes. Antenna: 100 feet. Prices: Type 64, table, $160; Type 65, table, with built-in loud speaker, $175; Type 66, table, $175; Type 67, console, $235; Type 78, console, $265.

NO. 538. NEUTROWOUND, MASTER ALLECTRIC

Six tubes; 2 t.r.f. (01-A), detector (01-A), 2 audio (01-A and two 71 in push-pull amplifier). The 01-A tubes are in series, and are supplied from a 400-mA. rectifier. Two drum controls. Volume control: variable plate resistance. Output device. Shielded. Antenna: 50 to 100 feet. Price: $360.

NO. 413. MARTI

Six tubes: 2 t.r.f., detector, 3 resistance audio. All tubes a.c. heater type. Two dials. Volume control resistance in r.f. plate. Watts consumed: 38. Panel size 7 x 21 inches. The built-in plate supply employs one 16-B rectifier. The filaments are supplied by a small transformer. Prices: table, $235 including tubes and rectifier; console, $275 including tubes and rectifier; console, $325 including tubes, rectifier, and loud speaker.

NO. 417 RADIOLA 28

Eight tubes; five type 99 and one type 20. Drum control. Super-heterodyne circuit. C-battery connections. Battery cable. Headphone connection. Antenna: loop. Set may be operated from batteries or from the power mains when used in conjunction with the model 104 loud speaker. Prices: $260 with tubes, battery operation; $570 with model 104 loud speaker, a. c. operation.

NO. 540 RADIOLA 30-A

Receiver characteristics same as No. 417 except that type 71 power tube is used. This model is designed to operate on either a. c. or d. c. from the power mains. The combination rectifier—power—amplifier unit uses two type 81 tubes. Model 100-A loud speaker is contained in lower part of cabinet. Either a short indoor or long outside antenna may be used. Cabinet size: 42½ x 29 x 17¾ inches. Price: $495.

NO. 541 RADIOLA 32

This model combines receiver No. 417 with the model 104 loud speaker. The power unit uses two type 81 tubes and a type 10 power amplifier. Loop is completely enclosed and is revolved by means of a dial on the panel. Models for operation from a. c. or d. c. power mains. Cabinet size: 52 x 72 x 17¾ inches. Price: $895.

NO. 539 RADIOLA 17

Six tubes; 3 t. r. f. (26), detector (27), 2 transformer audio (26 and 27). One control. Illuminated dial. Built-in power supply using type 80 rectifier. Antenna: 100 feet. Cabinet size: 25⅛ x 7⅞ x 8⅛. Price: $130 without accessories.

NO. 545. NEUTROWOUND, SUPER ALLECTRIC

Five tubes; 2 t.r.f. (99), detector (99), 2 audio (99 and 71). The 99 tubes are in series and are supplied from an 85-mA. rectifier. Two drum controls. Volume control: variable plate resistance. Output device. Antenna: 75 to 100 feet. Cabinet size: 9 x 24 x 11 inches. Price: $150.

NO. 490. MOHAWK

Six tubes; 2 t.r.f., detector, 2 transformer audio. All tubes a.c heater type except 71 in last stage. One dial. Volume control: rheostat on r.f. Watts consumed: 40. Panel size: 12½ x 8¾ inches. Output device. The heaters for the a.c tubes and the 71 filament are supplied by small transformers. The plate supply is of the built-in type using a rectifier tube. Prices range from $65 to $245.

NO. 522. CASE, 62 B AND 62 C

McCullough a.c. tubes. Drum control. Volume control; variable high resistance in audio system. C-battery connections. Semi-shielded. Cable. Antenna: 100 feet. Panel size: 7 x 21 inches. Prices: Model 62 B, complete with a.c. equipment, $185; Model 62 C, complete with a.c. equipment, $235.

NO. 523. CASE, 92 A AND 92 C

McCullough a.c. tubes. Drum control. Inductive volume control. Technidyne circuit. Shielded. Cable. C-battery connections. Model 92 C contains output device. Loop operated. Prices: Model 92 A, table, $350; Model 92 C, console, $475.

Battery Operated Receivers

NO. 542. PFANSTIEHL JUNIOR SIX

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio. Pfanstiehl circuit. Volume control: variable resistance in r.f. plate circuit. One dial. Shielded. Battery cable. C-battery connections. Etched bronze panel. Antenna: outdoor. Cabinet size: 9 x 20 x 8 inches. Price: $80, without accessories.

NO. 512. ALL-AMERICAN 44, 45, AND 66

Six tubes; 3 t.r.f. (01-A, detector) 01-A, 2 transformer audio (01-A and 71). Rice neutralized t.r.f. Drum control. Volume control: rheostat in r.f. Cabinet sizes: No. 44, 21 x 10 x 8 inches; No. 55, 25 x 38 x 18 inches; No. 66, 27¼ x 43 x 20 inches. C-battery connections. Battery cable. Antenna: 75 to 125 feet. Prices: No. 44, $70; No. 55, $125 including loud speaker; No. 66, $200 including loud speaker.

NO. 428. AMERICAN C6

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. Semi balanced t.r.f. Three dials. Plate current 15 mA. Volume control: potentiometer. Cabinet sizes: table, 20 x 8½ x 10 inches; console, 36 x 40 x 17 inches. Partially shielded. Battery cable. C-battery connections. Antenna: 125 feet. Prices: table, $30 console, $65 including loud speaker.

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BEFORE YOU BUY

FACTORY PRICES~SAVE 50%
Choice of beautiful cabinets offered

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MAGNIFICENT TONE~SUPER SELECTIVE~POWERFUL DISTANCE GETTER

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Reports from users everywhere leave little for us to add. These are only a few of the many in our files and which we receive daily. Send coupon for plenty of additional proof and testimony of nearby users.

TRIED MANY SETS—MIRACO BEST
Miraco is best set I've ever heard. It's just the set I've always wanted and I've had so many sets I got just a little hard-boiled about believing there were any sets perfect. I sure got my wish. I've had just 104 stations. There's about a station to each number on dial. I get KFI (Cal.) every night. Had PWX last night and got 6KW tonight good and loud.—FRANCIS ARMBRUSTER, Cleveland, Ohio.
P.S. You pack your sets wonderful.

HE KNOWS SETS—READ THIS
I have built radios since they first made their appearance and it has been my pleasure to build, repair and sell them. For quality, selectivity and sensitivity it is my firm belief that the Miraco cannot be excelled. I have proven beyond any shadow of doubt that it will outperform any other radios. I bring in the farthest distance with little or no effort. The Miraco also gives me tone quality.—URBAIN BARIL, Jr., Fall River, Mass.

MIRACO EXCELS EXPENSIVE RADIOS
The Miraco set and loud speaker beat anything around here, regardless of price. Have tried them out against a $200 outfit. Have logged 140 stations, coast to coast.—E. J. CARRIFRE, Bathgate, N. D.

HEARS CUBA, CANADA, MEXICO
A friend visited here that has close to $300 in a radio—but no better tone and no plainer than the Miraco. Have gotten 118 stations. We get Mexico City, Winnipeg, Canada and Havana, Cuba—all of these so plain.—MRS. CLEM CORRELL, Morristown, Ind.

CUTS THRU NEW YORK LOCALS
I can get distance thru the locals when they are all on early in the evening.—J. F. LOGAN, Rockaway Beach, New York.

America's big, old, reliable Radio Corporation* (8th successful year) **guarantees** in its big, powerful, latest 6, 7 and 8 tube Miraco sets "the finest, most enjoyable performance obtainable in **high grade** radios." Unless 30 days' use in your home fully satisfies you a Miraco is unbeatable at any price for beautiful, clear cathedral tone, razor-edge selectivity, powerful distance reception, easy operation, etc.—**don't buy it! Your verdict final.** Save or make lots of money on sets and equipment—write for testimony of nearby users and **Amazing Special Factory Offer.**

Miraco's work equally fine on "AC" electric house current or with batteries. Take your choice. Many thousands of Miraco users—who bought after thorough comparisons—enjoy programs Coast to Coast, Canada to Mexico, loud and clear—with the magnificent cathedral tone quality of costliest sets. Don't confuse Miraco's with cheap, "squawky" radios. Miraco's have finest parts, latest approved shielding, metal chassis, etc.—as used in many $200 sets.

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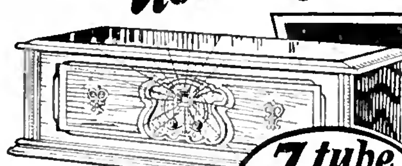
Your Miraco reaches you completely assembled, rigidly tested, fully guaranteed. Easy to connect and operate. **30 days' trial free.** 3 year guarantee if you buy. You take no risk, you insure satisfaction, you enjoy **rock-bottom money-saving prices** by dealing direct with one of radio's oldest, most successful builders of fine sets. 8th successful year in the radio manufacturing business.



MIRACO "Powerpluss" sets—both in 8 and 7 tube models—have magnificently beautiful, clear cathedral tone quality. Turn one dial for stations everywhere. Ultra selective. Miraco multistage distance amplification gives "powerplus" on far-off stations. Latest all-metal shielded chassis. Illuminated dial. Fully guaranteed. *Try one free for 30 days!* Choice of beautiful cabinets.

7 tube one dial METAL SHIELDED CHASSIS $49.75 RETAIL LIST

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"A", "B" and "C" power, direct from light socket, without batteries! Write for Midwest prices and discounts. Midwest Units are highest grade—lastingly dependable, quiet in operation, fully guaranteed.

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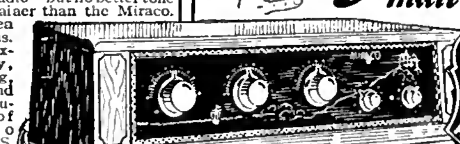

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Another Big Bargain! Famous powerful big Miraco Super 6, 1928 model—ultra selective! Thousands find it outperforms sets of much higher price. **30 Days' Trial Free. Fully Guaranteed.**

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NAME

ADDRESS

NO. 485. BOSWORTH B6

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Two dials. Volume control: variable grid resistances. Battery cable. C-battery connections. Antenna: 25 feet or longer. Cabinet size 15 x 7 x 8 inches. Price $75.

NO. 513. COUNTERPHASE SIX

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). Counterphase t.r.f. Two dials. Plate current: 32 mA. Volume control: rheostat on 2nd and 3rd r.f. Coils shielded. Battery cable. C-battery connections. Antenna: 75 to 100 feet. Console size: 18⅝ x 40½ x 15½ inches. Prices: Model 35, table, $110; Model 37, console, $175.

NO. 514. COUNTERPHASE EIGHT

Eight tubes; 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 12). Counterphase t.r.f. One dial. Plate current: 40 mA. Volume control: rheostat in 1st r.f. Copper stage shielding. Battery cable. C-battery connections. Antenna: 75 to 100 feet. Cabinet size: 30 x 12½ x 16 inches. Prices: Model 12, table, $225; Model 16, console, $335; Model 18, console, $365.

NO. 506. CROSLEY 601 BANDBOX

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. Neutrodyne. One dial. Plate current: 40 mA. Volume control: rheostat in r.f. Shielded. Battery cable. C-battery connections. Antenna: 75 to 150 feet. Cabinet size: 17¼ x 5¼ x 7⅜. Price, $55.

NO. 434. DAY-FAN 6

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). One dial. Plate current: 12 to 15 mA. Volume control: rheostat on r.f. Shielded. Battery cable, C-battery connections. Output device. Antenna: 50 to 120 feet. Cabinet sizes: Daycraft 6, 32 x 30 x 34 inches; Day-Fan Jr., 15 x 7 x 7. Prices: Day-Fan 6, $110; Daycraft 6, $145 including loud speaker; Day-Fan Jr. not available.

NO. 435. DAY-FAN 7

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 1 resistance audio (01-A), 2 transformer audio (01-A and 12 or 71). Plate current: 15 mA. Antenna: outside. Same as No. 434. Price $115.

NO. 503. FADA SPECIAL

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. Two drum control. Plate current: 20 to 24 mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Headphone connection. Antenna: outdoor. Cabinet size: 20¾ x 13¾ x 10¼ inches. Price $95.

NO. 504. FADA 7

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. Two drum control. Plate current: 43mA. Volume control: rheostat on r.f. Completely shielded. Battery cable. C-battery connections. Headphone connections. Output device. Antenna: outdoor or loop. Cabinet sizes: table, 25¼ x 13¼ x 11½ inches; console, 29 x 50 x 17 inches. Prices: table, $185; console, $285.

NO. 436. FEDERAL

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). Balanced t.r.f. One dial. Plate current: 20.7 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: loop. Made in 6 models. Price varies from $250 to $1000 including loop.

NO. 505. FADA 8

Eight tubes. Same as No. 504 except for one extra stage of audio and different cabinet. Prices: table, $300; console, $400.

NO. 437. FERGUSON 10A

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 3 audio (01-A and 12 or 71). One dial. Plate current: 18 to 25 mA. Volume control: rheostat on two r.f. Shielded. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet size: 21½ x 12 x 15 inches. Price $150.

NO. 438. FERGUSON 14

Ten tubes; 3 untuned r.f., 3 t. r.f. (01-A), detector (01-A), 3 audio (01-A and 12 or 71). Special balanced t.r.f. One dial. Plate current: 30 to 35 mA. Volume control: rheostat in three r.f. Shielded. Battery cable, C-battery connections. Antenna: loop. Cabinet size: 24 x 12 x 16 inches. Price $235, including loop.

NO. 439. FERGUSON 12

Six tubes; 2 t.r.f. (01-A), detector (01-A), 1 transformer audio (01-A), 2 resistance audio (01-A and 12 or 71). Two dials. Plate current: 18 to 25 mA. Volume control: rheostat on two r.f. Partially shielded. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet size: 22½ x 10 x 12 inches. Price $85. Consolette $145 including loud speaker.

NO. 440. FREED EISEMANN NR-8 NR-9, AND NR-66

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. NR-8, two dials; others one dial. Plate current: 30 mA. Volume control: rheostat on r.f. NR-8 and 9: chassis type shielding. NR-66, individual stage shielding. Battery cable. C-battery connections. Antenna: 100 feet. Cabinet sizes: NR-8 and 9, 19¾ x 10 x 10½ inches; NR-66 20 x 10½ x 12 inches. Prices: NR-8, $90; NR-9, $100; NR-66, $125.

NO. 501. KING "CHEVALIER"

Six tubes. Same as No. 500. Coils completely shielded. Panel size: 11 x 7 inches. Price, $210 including loud speaker.

NO. 441. FREED-EISEMANN NR-77

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 71). Neutrodyne. One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Shielding. Battery cable. C-battery connections. Antenna: outside or loop. Cabinet size: 23 x 10½ x 13 inches. Price $175.

NO. 442. FREED-EISEMANN 800 AND 850

Eight tubes; 4 t.r.f. (01-A), detector (01-A), 1 transformer (01-A), 1 parallel audio (01-A or 71). Neutrodyne. One dial. Plate current: 35 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Output: two tubes in parallel or one power tube may be used. Antenna: outside or loop. Cabinet sizes: No. 800, 34 x 15½ x 13½ inches; No. 850, 36 x 65½ x 17½. Prices not available.

NO. 444. GREBE MU-1

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 transformer audio (01-A and 12 or 71). Balanced t.r.f. One, two, or three dials (operate singly or together). Plate current: 30mA. Volume control: rheostat on r.f. Binocular coils. Binding posts. C-battery connections. Antenna: 125 feet. Cabinet size: 22¾ x 9¼ x 13 inches. Prices range from $95 to $320.

NO. 426. HOMER

Seven tubes; 4 t.r.f. (01-A); detector (01-A or 00A); 2 audio (01-A and 12 or 71). One knob tuning control. Volume control: rotor control in antenna circuit. Plate current: 22 to 25 mA. "Technidyne" circuit. Completely enclosed in aluminum box. Battery cable. C-battery connections. Cabinet size, 8¾ x 19½ x 9½ inches. Chassis size, 6¾ x 17 x 8 inches. Prices: Chassis only, $80. Table cabinet, $95.

NO. 502. KENNEDY ROYAL 7. CONSOLETTE

Seven tubes; 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). One dial. Plate current: 42 mA. Volume control: rheostat on two r.f. Special r.f. coils. Battery cable. C-battery connections. Headphone connection. Antenna: outside or loop. Consolette size: 36½ x 35½ x 19 inches. Price $220.

NO. 498. KING "CRUSADER"

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 20 mA. Volume control: rheostat on r.f. Coils shielded. Battery cable. C-battery connections. Antenna: outside. Panel: 11 x 7 inches. Price, $115.

NO. 499. KING "COMMANDER"

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 25 mA. Volume control: rheostat on r.f. Completely shielded. Battery cable. C-battery connections. Antenna: loop. Panel size: 12 x 8 inches. Price $220 including loop.

NO. 429. KING COLE VII AND VIII

Seven tubes; 3 t.r.f., detector, 1 resistance audio, 2 transformer audio. All 01-A tubes. Model VIII has one more stage t.r.f. (eight tubes). Model VII, two dials. Model VIII, one dial. Plate current: 15 to 50 mA. Volume control: primary shunt in r.f. Steel shielding. Battery cable and binding posts. C-battery connections. Output devices on some consoles. Antenna: 10 to 100 feet. Cabinet size: varies. Prices: Model VII, $80 to $160; Model VIII, $100 to $300.

NO. 500. KING "BARONET" AND "VIKING"

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 transformer audio (01-A and 71). Balanced t.r.f. One dial. Plate current: 19 mA. Volume control: rheostat in r.f. Battery cable. C-battery connections. Antenna: outside. Panel size: 18 x 7 inches. Prices: "Baronet," $70; "Viking," $140 including loud speaker.

NO. 489. MOHAWK

Six tubes; 2 t.r.f. (01-A), detector (00-A), 3 audio (01-A and 71). One dial. Plate current; 40 mA. Volume control: rheostat on r.f. Battery cable. C-battery connections. Output device. Antenna: 60 feet. Panel size: 12½ x 8¾ inches. Prices range from $65 to $245.

NO. 543. ATWATER KENT, MODEL 33

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71 or 12). One dial. Volume control: r.f. filament rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Steel panel. Cabinet size: 21¼ x 6¾ x 6¼ inches. Price: $75, without accessories.

NO. 544. ATWATER KENT, MODEL 50

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 12 or 71). Volume control: r.f. filament rheostat. C-battery connections. Battery cable. Special band-pass filter circuit with an untuned amplifier. Cabinet size: 20¾ x 13 x 7¾ inches. Price: $120.

NO. 452. ORIOLE 90

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. "Trinum" circuit. Two dials. Plate current: 18 mA. Volume control: rheostat on r. f. Battery cable. C-battery connections. Antenna: 50 to 100 feet. Cabinet size: 25½ x 11½ x 12½ inches. Price $85. Another model has 8 tubes, one dial, and is shielded. Price $185.

NO. 453. PARAGON

Six tubes; 2 t.r.f. (01-A), detector (01-A), 3 double impedance audio (01-A and 71). One dial. Plate current: 40 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Output device. Antenna: 100 feet. Console size: 20 x 46 x 17 inches. Price not determined.

NO. 543 RADIOLA 20

Five tubes; 2 t. r. f. (99), detector (99), two transformer audio (99 and 20). Regenerative detector. Two drum controls. C-battery connections. Battery cable. Antenna: 100 feet. Price: $78 without accessories.

NO. 480. PFANSTIEHL 30 AND 302

Six tubes; 3 t.r.f. (01-A), detector (01- 2A), transformer audio (01-A and 71). One dial. Plate current: 23 to 32 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Antenna: outside. Panel size: 17¾ x 8½ inches. Prices: No. 30 cabinet, $105; No. 302 console, $185 including loud speaker.

NO. 515. BROWNING-DRAKE 7-A

Seven tubes; 2 t.r.f. (01-A), detector (00-A), 3 audio (Hmu, two 01-A, and 71). Illuminated drum control. Volume control: rheostat on 1st r.f. Shielded. Neutralized. C-battery connections. Battery Cable. Metal panel. Output device. Antenna: 50–75 feet. Cabinet, 30 x 11 x 9 inches. Price, $145.

NO. 516. BROWNING-DRAKE 6-A

Six tubes; 1 t.r.f. (99), detector (00-A), 3 audio (Hmu, two 01-A and 71). Drum control with auxiliary adjustment. Volume control: rheostat on r.f. Regenerative detector. Shielded. Neutralized. C-battery connections. Battery cable. Antenna: 50–100 feet. Cabinet, 25 x 11 x 9. Price $105.

NO. 518. KELLOGG "WAVE MASTER," 504, 505, AND 506.

Five tubes; 2 t.r.f., detector, 2 transformer audio. One control and special zone switch. Volume control: rheostat on r.f. C-battery connections. Binding posts. Plate current: 25 to 35 mA. Antenna: 100 feet. Panel: 7¼ x 25½ inches. Prices: Model 504, table, $75, less accessories. Model 505, table, $125 with loud speaker. Model 506, consolette, $135 with loud speaker.

NO. 519. KELLOGG, 507 AND 508.

Six tubes, 3 t.r.f., detector, 2 transformer audio. One control and special zone switch. Volume control: rheostat on r.f. C-battery connections. Balanced. Shielded. Binding posts and battery cable. Antenna: 70 feet. Cabinet size: Model 507, table, 30 x 13½ x 14 inches. Model 508, console, 34 x 18 x 54 inches. Prices: Model 507, $190 less accessories. Model 508, $320 with loud speaker.

NO. 427. MURDOCK 7

Seven tubes; 3 t.r.f. (01-A), detector (01-A), 1 transformer and 2 resistance audio (two 01-A and 12 or 71). One control. Volume control: rheostat on r.f. Coils shielded. Neutralized. Battery cable. C-battery connections. Complete metal case. Antenna: 100 feet. Panel size: 9 x 23 inches. Price, not available.

NO. 520. BOSCH 57

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71). One control calibrated in kc. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Balanced. Output device. Built-in loud speaker. Antenna: built-in loop or outside antenna, 100 feet. Cabinet size: 46 x 16 x 30 inches. Price: $340 including enclosed loop and loud speaker.

NO. 521. BOSCH "CRUISER," 66 AND 76

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71). One control. Volume control: rheostat on r.f. Shielded. C-battery connections. Balanced. Battery cable. Antenna: 20 to 100 feet. Prices: Model 66, table, $99.50. Model 76, console, $175; with loud speaker $195.

NO. 524. CASE, 61 A AND 61 C

T.r.f. Semi-shielded. Battery cable. Drum control. Volume control: variable high resistance in audio system. Plate current: 35 mA. Antenna: 100 feet. Prices: Model 61 A, $85; Model 61 C, console, $135.

NO. 525. CASE, 90 A AND 90 C

Drum control. Inductive volume control. Technidyne circuit. C-battery connections. Battery cable. Loop operated. Model 90-C equipped with output device. Prices: Model 90 A, table, $225; Model 90 C, console, $350.

NO. 526. ARBORPHONE 25

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 71). One control. Volume control: rheostat. Shielded. Battery cable. Output device. C-battery connections. Loftin-White circuit. Antenna: 75 feet. Panel: 7½ x 15 inches, metal. Prices: Model 25, table, $125; Model 252, $185; Model 253, $250; Model 255, combination phonograph and radio, $600.

NO. 527. ARBORPHONE 27

Five tubes; 2 t.r.f. (01-A), detector (01-A), 2 audio (01-A). Two controls. Volume control: rheostat. C-battery connections. Binding posts. Antenna: 75 feet. Prices: Model 27, $65; Model 271, $99.50; Model 272, $125.

NO. 528. THE "CHIEF"

Seven tubes; six 01-A tubes and one power tube. One control. Volume control: rheostat. C-battery connection. Partial shielding. Binding posts. Antenna: outside. Cabinet size: 40 x 22 x 16 inches. Prices: Complete with A power supply, $250; without accessories, $150.

NO. 529. DIAMOND SPECIAL, SUPER SPECIAL, AND BABY GRAND CONSOLE

Six tubes; all 01-A type. One control. Partial shielding. C-battery connections. Volume control: rheostat. Binding posts. Antenna: outdoor. Prices: Diamond Special, $75; Super Special, $65; Baby Grand Console, $110.

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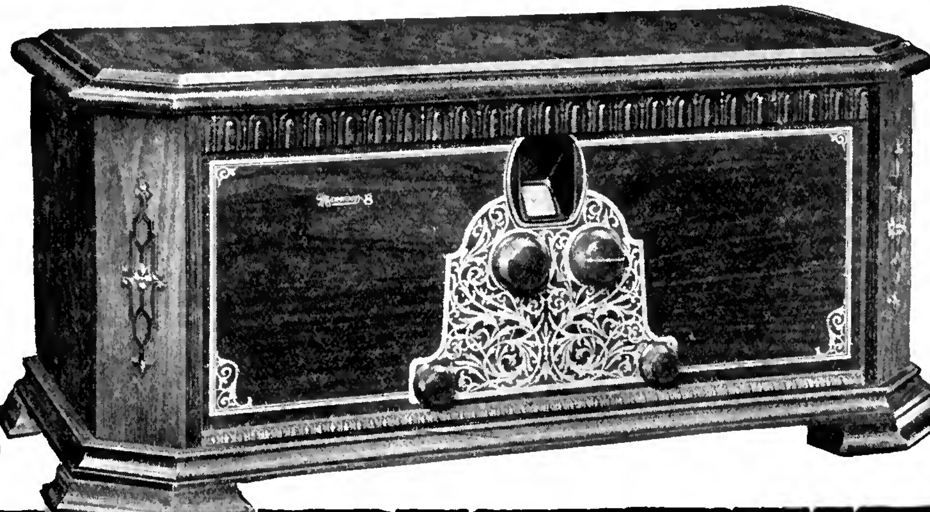

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NO. 531. KOLSTER, 8A, 8B, AND 8C

Eight tubes; 4 t.r.f. (01-A), detector (01-A), 3 audio (two 01-A and one 12). One control. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Model 8A uses 50 to 75 foot antenna; model 8B contains output device and uses antenna or detachable loop; Model 8C contains output device and uses antenna or built-in loop. Prices: 8A, $185; 8B, $235; 8C, $375.

NO. 532. KOLSTER, 6D, 6G, AND 6H

Six tubes; 3 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 12). One control. Volume control: rheostat on r.f. C-battery connections. Battery cable. Antenna: 50 to 75 feet. Model 6G contains output device and built-in loud speaker; Model 6H contains built-in B power unit and loud speaker. Prices: Model 6D, $80; Model 6G, $165; Model 6H, $265.

NO. 533. SIMPLEX, SR 9 AND SR 10

Five tubes; 2 t.r.f. (01-A), detector (00-A), 2 audio (01-A and 12). SR 9, three controls; SR 10, two controls. Volume control: rheostat. C-battery connections. Battery cable. Headphone connection. Prices: SR 9, table, $65; consolette, $95; console, $145. SR 10, table $70; consolette, $95; console, $145.

NO. 534. SIMPLEX, SR 11

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 audio (01-A and 12). One control. Volume control: rheostat. C-battery connections. Battery cable. Antenna: 100 feet. Prices: table, $70; consolette, $95; console, $145.

NO. 535. STANDARDYNE, MODEL S 27

Six tubes; 2 t.r.f. (01-A), detector (01-A), 2 audio (power tubes). One control. Volume control: rheostat on r.f. C-battery connections. Binding posts. Antenna: 75 feet. Cabinet size: 9 x 9 x 19½ inches. Prices: S 27, $49.50; S 950, console, with built-in loud speaker, $99.50; S 600, console with built-in loud speaker, $101.50.

NO. 481. PFANSTIEHL 32 AND 322

Seven tubes: 3 t.r.f. (01-A), detector (01-A), 3 audio (01-A and 71). One dial. Plate current: 23 to 32 mA. Volume control: resistance in r. f. plate. Shielded Battery cable. C-battery connections. Output device. Antenna: outside. Panel: 17¾ x 8½ inches. Prices: No. 32 cabinet, $145; No. 322 console, $245 including loud speaker.

NO 433. ARBORPHONE

Five tubes; 2 t.r.f., detector, 2 transformer audio. All 01-A tubes. Two dials. Plate current: 16 mA. Volume control: rheostat in r.f. and resistance in r.f. plate. C-battery connections. Binding posts. Antenna: taps for various lengths. Cabinet size: 24 x 9 x 10½ inches. Price: $65.

NO. 431. AUDIOLA 6

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Drum control. Plate current: 20 mA. Volume control: resistance in r.f. plate. Stage shielding. Battery cable. C-battery connection. Antenna: 50 to 100 feet. Cabinet size: 28½ x 11 x 14½ inches. Price not established.

NO. 432. AUDIOLA 8

Eight tubes; 4 t.r.f. (01-A), detector (00-A), 1 transformer audio (01-A), push-pull audio (12 or 71). Bridge balanced t.r.f. Drum control. Volume control: resistance in r.f. plate. Stage shielding. Battery cable. C-battery connections. Antenna: 10 to 100 feet. Cabinet size: 28½ x 11 x 14½ inches. Price not established.

NO. 542 RADIOLA 16

Six tubes; 3 t. r. f. (01-A), detector (01 A), 2 transformer audio (01-A and 112). One control. C-battery connections. Battery cable. Antenna: outside. Cabinet size: 16½ x 8¼ x 7½ inches. Price: $69.50 without accessories.

NO. 456. RADIOLA 20

Five tubes: 2 t.r.f. (99), detector (99), 2 transformer audio (99 and 20). Balanced t.r.f. and regenerative detector. Two dials. Volume control: regenerative. Shielded. C-battery connections. Headphone connections. Antenna: 75 to 150 feet. Cabinet size: 19½ x 11¾ x 16 inches. Price $115 including all tubes.

NO. 457 RADIOLA 25

Six tubes; five type 99 and one type 20. Drum control. Super-heterodyne circuit. C-battery connections. Battery cable. Headphone connections. Antenna: loop. Set may be operated from batteries or from power mains when used with model 104 loud speaker. Price; $165 with tubes, for battery operation. Apparatus for operation of set from the power mains can be purchased separately.

NO. 493. SONORA F

Seven tubes, 4 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Special balanced t.r.f. Two dials. Plate current: 45 mA. Volume control: rheostat in r.f. Shielded. Battery cable. C-battery connections. Output device. Antenna: loop. Console size: 32 x 45½ x 17 inches. Prices range from $350 to $450 including loop and loud speaker.

NO. 494. SONORA E

Six tubes; 3 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Special balanced t.r.f. Two dials. Plate current: 35 to 40 mA. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: outside. Cabinet size: varies. Prices: table, $110; semi-console, $140; console, $240 including loud speaker.

NO. 530. KOLSTER, 7A AND 7B

Seven tubes; 4 t.r.f. (01-A), detector (01-A), 2 audio (01-A and 12). One control. Volume control: rheostat on r.f. Shielded. Battery cable. C-battery connections. Antenna: 50 to 75 feet. Prices: Model 7A, $125; Model 7B, with built-in loud speaker, $140.

NO. 495. SONORA D

Same as No. 494 except arrangement of tubes; 2 t.r.f., detector, 3 audio. Prices: table, $125; standard console, $185; "DeLuxe" console, $225.

NO. 482. STEWART-WARNER 705 AND 710

Six tubes; 3 t.r.f., detector, 2 transformer audio. All 01-A tubes. Balanced t.r.f. Two dials. Plate current: 10 to 25 mA. Volume control: resistance in r.f. plate. Shielded. Battery cable. C-battery connections. Antenna: 80 feet. Cabinet sizes: No. 705 table, 26½ x 11¼ x 13⅞ inches; No. 710 console, 29¾ x 42 x 17½ inches. Tentative prices: No. 705, $115; No. 710, $265 including loud speaker.

NO. 483. STEWART-WARNER 525 AND 520

Same as No. 482 except no shielding. Cabinet sizes: No. 525 table, 19¾ x 10 x 11⅜ inches; No. 520 console, 22⅛ x 40 x 14⅞ inches. Tentative prices: No. 525, $75; No. 520, $117.50 including loud speaker.

NO. 459. STROMBERG-CARLSON 501 AND 502

Five tubes; 2 t.r.f. (01-A), detector (00-A), 2 transformer audio (01-A and 71). Neutrodyne. Two dials. Plate current: 25 to 35 mA. Volume control: rheostat on 1st r.f. Shielded. Battery cable. C-battery connections. Headphone connections. Output device. Panel voltmeter. Antenna: 60 to 100 feet. Cabinet sizes: No. 501, 25½ x 13 x 14 inches; No. 502, 28 ⅞ x 50 7/16 x 16¾ inches. Prices: No. 501, $180; No. 502, $290.

NO. 460. STROMBERG-CARLSON 601 AND 602

Six tubes. Same as No. 549 except for extra t.r.f. stage. Cabinet sizes: No. 601, 27 5/16 x 16¾ x 14 7/16 inches; No. 602, 28¾ x 51½ x 19⅝ inches. Prices: No. 601, $225; No. 602, $330.

NO. 472. VOLOTONE VIII

Six tubes. Same as No. 471 with following exceptions; 2 t.r.f. stages. Three dials. Plate current: 2-mA. Cabinet size: 26½ x 8 x 12 inches. Price $140.

NO. 546. PARAGON "CONGRESS"

Six tubes; 2 t.r.f. (01-A), detector (01-A), 3 impedance-coupled audio (two 01-A and 12 or 71). One main control and three auxiliary adjustments. Volume control: resistance in r. f. plate circuit. Plate current: 40 mA. C battery connections. Tuned double-impedance audio amplifier. Output device. R. F. coils are shielded. Cable or binding posts. Cabinet size: 7 x 18 x 9 inches. Price $90.00; without cabinet, $80.00.