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RADIO NEWS

October
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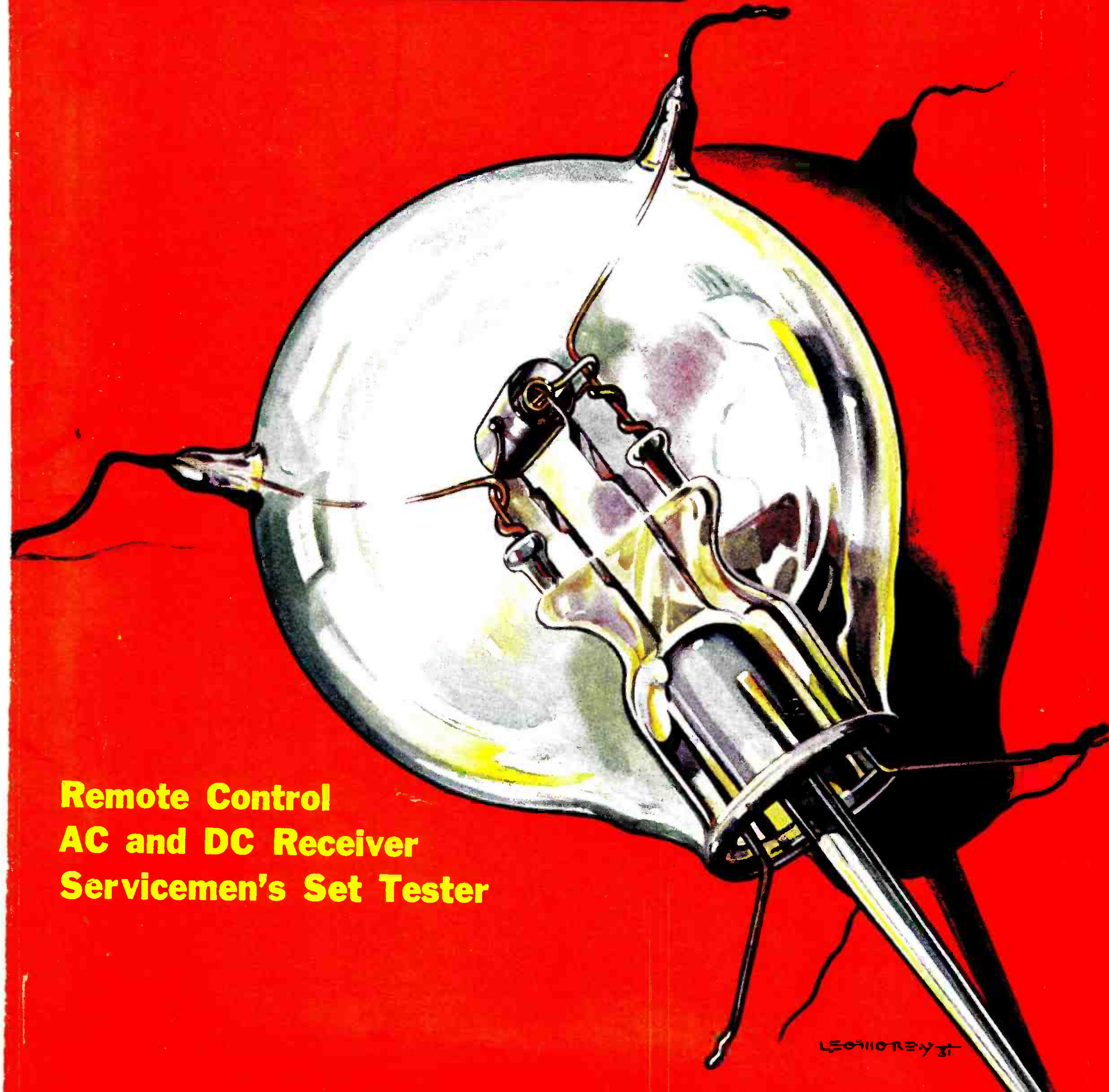

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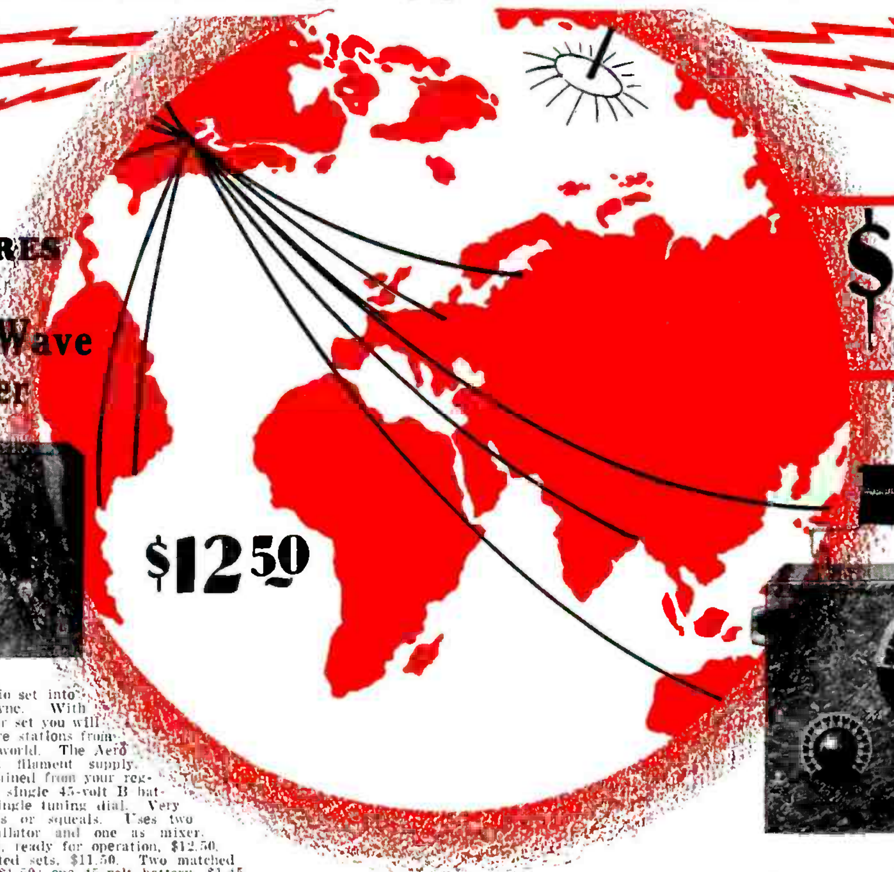

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Convert your AC or DC radio set into a short-wave Superheterodyne. With this converter on your regular set you will be able to tune in short-wave stations from many different parts of the world. The Aero Converter contains its own filament supply. B voltage can easily be obtained from your regular set, or you may use a single 45-volt B battery. No plug-in coils. Single tuning dial. Very easy to tune. No whistles or squeals. Uses two UX227 tubes, one as oscillator and one as mixer. Price, AC model, less tubes, ready for operation, $12.50. DC model for battery-operated sets, $11.50. Two matched UX227 tubes at 75c each, $1.50; one 45-volt battery, $1.45.

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A new radio thrill for you. Span the world with this set. Enjoy unique foreign programs from strange lands. Hear broadcasting stations from all over the world, via short waves. Your ordinary receiver cannot tune in these low-wave stations. World-wide receiver gets 14 to 550-meter stations with surprising clarity. Price of set, including 6 coils, $6.45; price in foreign countries $7.75, postpaid.

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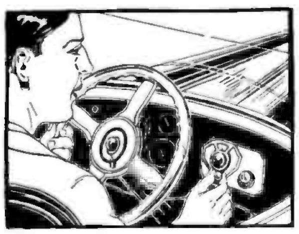

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As a member of the Radio Training Association, you receive personal instruction from skilled Radio Engineers. Upon completion of the training, they will advise you personally on any problems which arise in your work. The Association will help you make money in your spare time, increase your pay, or start you in business. The easiest, quickest, best-paying way for you to get into Radio is by joining the Radio Training Association.

This amazing Radio Set Analyzer plus the instructions given you by the Association will transform you into an expert quickly. With it, you can locate troubles in all types of sets, test circuits, measure resistance and condenser capacities, detect defective tubes. Knowing how to make repairs is easy; knowing what the trouble is requires expert knowledge and a Radio Set Analyzer. With this Radio Set Analyzer, you will be able to give expert service and make big money. Possessing this set analyzer and knowing how to use it will be but one of the benefits that will be yours as a member of the R. T. A.

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RADIO NEWS

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Edited by LAURENCE M. COCKADAY

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CONTENTS

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DEPARTMENTS

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The Editor—to *You*

HERE we are, installed in our new quarters in a modern eight-story building at 350 Hudson Street, New York City. Large airy offices of approximately 6,000 square feet, in the heart of the Manhattan radio manufacturing center, give our staff new facilities and conveniences for turning out the finest radio magazine that can be published.

* * *

THERE are probably many of our readers, clients and friends who have not as yet heard that RADIO NEWS has been acquired by the Macfadden interests and is now being published by the newly formed Teck Publishing Corporation, a Macfadden subsidiary. The editor considers this new affiliation, right at the time we are celebrating the 12th Anniversary of RADIO NEWS, a significant one to our readers, for it insures, with the enormous resources, increased distributing capacity and long executive and editorial experience of this great organization, an even more brilliant future for the oldest established radio magazine. The staff of editors who have been making the magazine for you remain intact and they are indeed spurred on in their work by the generous cooperation of the executives of the parent organization.

* * *

RADIO NEWS' editorial policy will continue to be devoted to a progressive program of improvement and development in the radio science, art and industry. It will continue to present impartially and authoritatively. through its pages, news of every important development in the radio field. RADIO NEWS will also continue to be the Forum, the informing friend and ready reference of engineers and technicians, servicemen, experimenters and set builders, radio amateurs and commercial operators, dealers and manufacturers, scientists, teachers and students.

* * *

WORK is now practically completed on the construction of the partition walls for our new and up-to-date shielded radio laboratory and our engineer-editors are now busy with aggressive plans for developing new sets. testing and measuring devices and working on solutions of the problems of our readers.

* * *

THE *Service Bench* department is to be expanded to give added helpfulness to the service-salesman, to help him to increase his business, to work more efficiently so that his every motion will bring real service to the customer and substantial profit to himself, in making sales and acting as the good-will emissary of the radio dealer and manufacturer.

For engineers, a new department, *Radio Science Abstracts*, is bringing in high praise and comment. It is helping engineers to keep up to date on contemporary advances in the science and to review quickly and conveniently the world's worth-while technical papers, books and periodical literature.

What's New in Radio will continue to bring to dealers and ultimate consumers news of all the latest products placed on the market for radio users.

Experimenters will find the new department, *With the Experimenters*, contains a wealth of helpful information on a large variety of subjects, with exact data, presented authoritatively.

* * *

ONE of the most popular and newest of our departments is the *Radio Physics Course*, of which Lesson Three is to be found in this issue. It is a complete course in radio and contains a teachers' question box available to physics instructors and students alike, for current class-assignment work. It is now being used by many schools and colleges.

Latest Radio Patents is also useful to technicians, designers and inventors. This is keeping them advised of new inventions in the art, and at the same time is making RADIO NEWS invaluable as a radio reference.

* * *

AND still other new departments are to be added as our program of development is further rounded out. One of them will be announced in the November issue.

* * *

RADIO NEWS will still continue to be placed on the newsstands on the 10th of each month preceding the date of publication. Be sure that you do not miss a single copy, for it will be invaluable to you alike in your work or hobby.

* * *

ELEVEN days after this issue of RADIO NEWS is placed on the newsstands the 8th Annual Radio and Electrical World's Fair will be in progress in New York at the Madison Square Garden. Radio enthusiasts will see there in brilliant display all the newest radio developments for the 1931-1932 season.

* * *

TWENTY-SEVEN days later at Chicago will be held the 10th Annual Radio and Electrical Show, where enthusiasts of the Middle West may congregate for the same purpose. These are the two greatest radio and electrical centers of the United States and it is said that 25% of the total annual radio sales are made in these areas.

On page 316 of this issue there appears a description of some of the latest radio apparatus that will be exhibited at these shows. These include the latest receivers, apparatus and television equipment.

* * *

EVEN royalty finds great interest in listening in on the short-waves, according to Robert Hertzberg of Lawrence, Massachusetts. King Prajadhipok of Siam, who is now returning to his native country after a four months' sojourn in the United States, is an ardent radio fan and user of American radio apparatus. He is familiar with most of the short-wave stations of the world, having listened in to most of them in his famous palace at Bangkok. Mr. Hertzberg demonstrated a new short-wave set of a well-known American manufacturer at Ophir Hall, Purchase, New York, at the King's request, recently. His Majesty is enough of a radio experimenter to specify certain technical changes he wanted in a new set to meet reception conditions in Siam.

* * *

UNCLE SAM himself as well as the individual citizens of the United States seem to be appreciative of the news and information contained in "our own" magazine. Recently he sent a request for 44 subscriptions to RADIO NEWS to be distributed to the various government airports of the War Department Air Corps. He also requested subscription copies for the Bureau of Standards library. This is the finest kind of acceptance.

Nearly every reader who writes to the editor begins his letter with statements like the few that follow: *"I have enjoyed* RADIO NEWS *for years; you certainly are putting out a great magazine."* Edward Dejak, Cleveland, Ohio.

* * *

"I enjoy your magazine very much and want to congratulate you on your steady improvement of it, especially of late. The department 'Latest Radio Patents' has real value in it for most any reader of the magazine. It puts light on phases of research which are unpublished in any other way. I hope you will continue it." Murray A. Crosby, Riverhead, New York.

* * *

"As a constant reader of RADIO NEWS, *may I express my feelings and sentiments regarding the 'Latest Patent' department? It is one of the best departments in your magazine and I am looking forward to many more articles."* Norbert J. Richard, Milwaukee, Wisconsin.

* * *

"Just a line to tell you that the 'Radio Science Abstracts' department is well received by me. Please continue it as a regular feature and give more book reviews." L. Carini, Wetherfield, Conn.

* * *

THIS is true also of letters from foreign subscribers, as evidenced by the following excerpt:

"I must say that the latest issues of RADIO NEWS *are more interesting to the experimenter and technician than those previous to the change in editorship. The articles on home recording and concerning radio and music generally are excellent."* Leslie Jones, Maxwell, New Zealand.

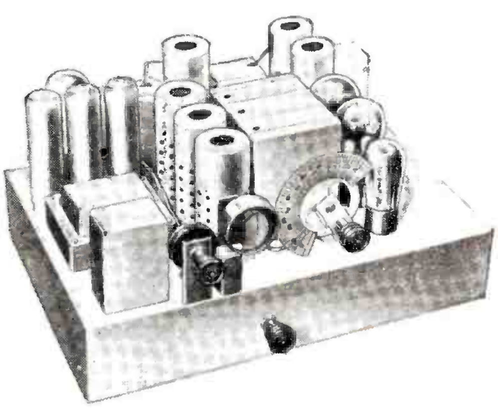
* * *

THE Editors appreciate this recognition.

NEW SPECIALS *from* RADIO'S *Bargain Book*

It's here! The new 1932 WHOLESALE RADIO SERVICE COMPANY 10th Anniversary Catalog! Bargain book of the radio industry! The greatest, finest catalog ever issued. Chock full of the newest and latest in radio. Brand new, guaranteed merchandise. Wholesale prices—lowest in our history. Send for your copy of the new WHOLESALE 10th Anniversary Catalog TODAY. Absolutely free. Just mail the coupon below.

LAFAYETTE *10 tube* Super-Heterodyne



The new Lafayette Duo-Symphonic—America's most modern receiver—the most powerful radio receiver ever developed. A 10-tube Super-Heterodyne, completely shielded to eliminate interference. Here are a few outstanding features of this great new receiver. FOUR VARIABLE-MU TUBES AND TWO PENTODE TUBES IN PUSH-PULL. VISUAL METER TUNING (one of the greatest improvements in perfect reception). AUTOMATIC VOLUME CONTROL (eliminates unpleasant blasts and distortion). LAFAYETTE PERFECTED TONE CONTROL (suit your own taste as to tonal quality). LOCAL-DISTANCE SWITCH (removes interference between stations). STADIUM DYNAMIC SPEAKER (assurance of perfect reproduction), 1¼ MICRO-VOLTS PER METER SENSITIVITY and HAIR-LINE 10 K.C. SELECTIVITY.

Listen to this set perform! Try it for 30 DAYS FREE TRIAL IN YOUR OWN HOME. Convince yourself that at the sensationally low price it is the finest value in the radio field. THE ONLY RADIO BONDED BY A $10,000,000.00 BONDING CONCERN. Write for complete information!

GOOD NEWS *for* RADIO SERVICE MEN

Wholesale Radio is "Replacement Parts" Headquarters. We maintain a huge stock of Replacement Parts for all model sets. Prices are consistently LOW. Buy with perfect confidence and safety from the largest institution of its kind in the country. *All merchandise guaranteed.* Prompt, efficient service. Full Replacement Parts Section in new 10th Anniversary Catalog.

Lowest Price-*fine Quality* MIDGET SET *ever developed*

The radio sensation of the year! A five-tube mantel receiver, capable of amazing performance, with every modern feature, for only $16.50. And what a set! TWO SCREEN GRID—VARIABLE-MU—PENTODE OUTPUT—no wonder this little dandy is such a powerful performer. Other features are GENUINE ROLA DYNAMIC SPEAKER—LOFTIN-WHITE AMPLIFIER—3-GANG CONDENSER—BUILT-IN ANTENNA—RCA LICENSED—LOFTIN-WHITE LICENSED.

This mighty atom is encased in a mantel cabinet of surprising beauty. Clean-cut and good looking. 13¾ inches high, 11¼ inches wide.

It's the buy of the year! Try it in your own home under our liberal guarantee and 30-DAY FREE TRIAL OFFER and convince yourself. The sensationally low price, less tubes, is only

16.50

LESS TUBES

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Please rush copy of your new 1932 Tenth Anniversary Catalog, *absolutely free.* I am particularly interested in the ☐ New Lafayette 10-Tube Super-Heterodyne ☐ $16.50 Mantel Receiver.

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Address..

Town...State..............................

Accurately Predicts Future Trends

The final measure of progress in any art is the scope of its application.

Radio broadcasting, talking movies, television, all of the many developments of recording, transmission and reproduction of light and sound have grown from a common root—the labors of early experimenters with wireless telegraphy.

The end is not yet in sight. Present results have inspired technical workers throughout the world with a degree of confidence in their capabilities, which promises even greater marvels in the years to come.

May RADIO NEWS, *which is the pioneer publication and long ago predicted present-day realizations, continue its good work.*

O. B. Hanson.

Manager of Plant Operating and Engineering
National Broadcasting Company

Explains Quasi-Optical Wave Phenomena

Dr. Saxl (right) in the RADIO NEWS *Laboratory pointing out to the Technical Editor some of the design features of the new tube which enable it to generate radio signals at wavelengths of less than one inch. These ultra-short waves, approaching light wavelengths, have been used in actual transmission and reception—but follow optical laws rather than the more familiar laws of radio*

The World's HIGHEST FREQUENCY Oscillator Tube

Here is presented for the first time a complete and comprehensive description of the new oscillator tube which has made possible radio transmission on wavelengths measured in inches rather than in meters

By Dr. Irving J. Saxl

BY means of an entirely new type of vacuum tube working on different principles than the usual feed-back oscillator, frequencies as high as one to six billion cycles are now being used to produce the world's shortest radio waves. Although there have been a number of descriptions of the general system used recently between Dover, England, and Calais, France, for transmission on the wavelength of 18 centimeters, the complete data on the tubes used have been so far kept secret. The purpose of this article is to explain what these tubes are, how they operate and the circuits with which they are used.

One of the illustrations shows the physical characteristics of the unique tube as used in the actual communication work. It has an output of .5 watt power.

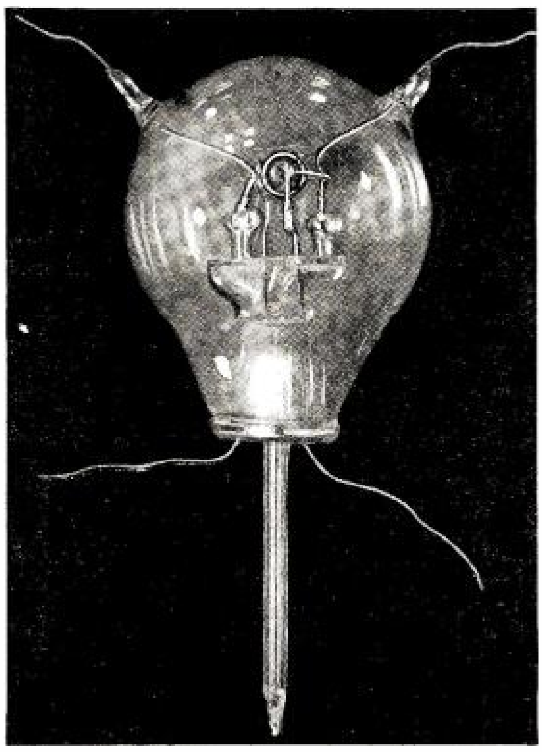
Unique Tube Construction

As shown in drawing 5 the grid is not supported except at the terminal, as every connection between the windings of the grid would mean a partial short-circuiting of the grid. Special care has been taken in the design to choose the different parts of the lead-in wires and supports in a way so that they represent just fractions of one wavelength; the special wavelength for which the tube has been designed. Between the lead-in wires a shield of copper is attached to protect the lower parts of the tube from the influence of the electric oscillations. The entire shield has a size of only 2.5 inches by 2.5 inches.

The distance between the actual oscillator (the space between grid and plate) and the shielding is exactly one-half wavelength. The other parts of the tube, the plate, the grid and the filament, have also been designed to represent exact fractions (or harmonics) of the wavelength. This is also extremely important for the distance *between* the lead-in wires. Special care has been taken to build the tube absolutely symmetrical.

In the oscillator, the grid is charged to a potential, say between 250 and 300 volts positive. The plate, however, has not only a lower potential than the grid but is kept even lower than the filament (about 40 volts negative).

In a transmitter or oscillator tube like this the oscillations, as Kurz and Barkhausen have shown, are not controlled by a direct coupling between the exterior circuits of the grid and the plate (not as in the audion, for instance). These oscillations or frequencies in the order of 1,600,000,000 to 6,000,000,000 cycles per second are created and generated by periodical movements of electrons within the space between grid and plate in such a way that they impress a harmonic of their frequency upon the oscillating circuit. The wavelength itself is determined by the electrode-size and the voltages applied, a higher voltage being used for shorter wavelengths. A special tuning system has proven unnecessary.



The micro-ray tube is designed with its elements geometrically concentric. The base is eliminated and plate and grid leads isolated to keep inherent capacity to an absolute minimum

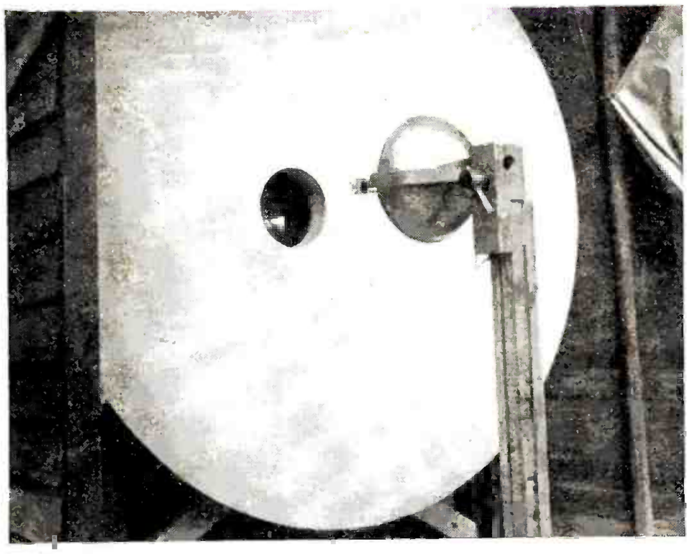
The electrode size and also the distances between the lead-in wires determine, to a very marked extent, the characteristic wavelength at which the tube will radiate. In the two pictures in which we are showing two types of micro-ray tubes this effect may be clearly seen. The one with the standard European socket has a wavelength of about eighteen centimeters. The lead-in wires for the filament, the grid and the plate are all parallel, thus being coupled to each other to a considerable extent by their respective capacitance. In the other tube, however, the grid and plate are carried out at opposite points of the tube to make possible the use of still shorter waves. Under favorable conditions wavelengths have been handled with this type of tube as low as 2.5 centimeters.

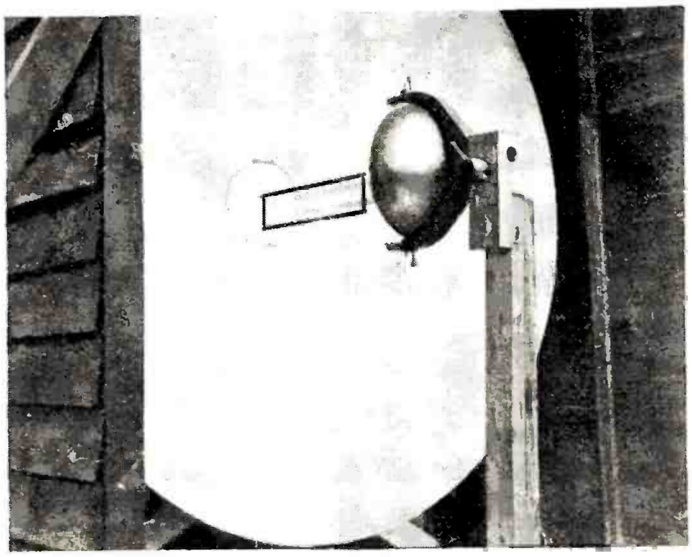
Antenna Design

Ultra-frequency apparatus of this type naturally does not work on an antenna system of high impedance. For these quasi-optical waves use has been made of the old Hertz and Lecher-type installation, the bipoles being carried out directly from the tube into the focus point of the reflectors.

By using reflectors, a gain of energy of about 160,000 times is made in comparison with a system without reflectors. With this ultra short-wave reflector system communication over the English Channel has already been maintained with an energy of only 0.5 watt . . . scarcely enough energy to give sufficient current to an electric pocket searchlight.

There is no fading effect for these ultra short-waves as they are not reflected by the Heaviside-Layer. Like light, which on its way from the sun passes the outer circles of the earth's





Antenna - reflector systems used in transmitter and receiver systems both of which employ the micro-ray tube. The receiving installation at the right shows the antenna doublet, larger than that in the transmitter, mounted in the small rectangular frame

atmosphere, they travel apparently with ease through these layers.

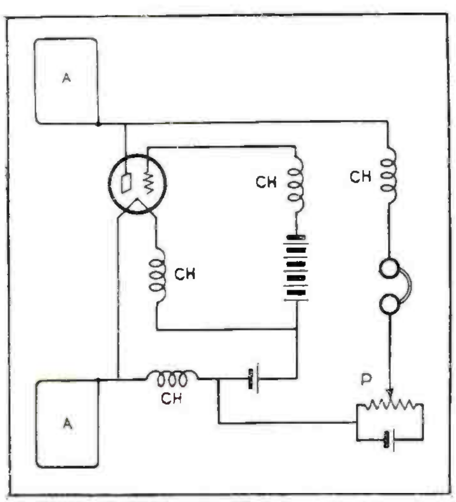
The resemblance of these quasi-optical waves to light waves becomes still more significant if we regard the fact that they can be collected in a lens system like light rays. The only difference is that we use, instead of glass, a medium of more suitable dielectric properties. With lenses of bakelite, amber and similar materials, quasi-optical waves can be focussed and in many other ways controlled like light rays.

Metallic lenses have also been used for concentrating the beam of electromagnetic waves. These investigations have been carried on by Cockaday of New York University, the results being very satisfactory. There is, however, this one point; that the metallic lens is to be regarded as a source of radiation for itself. In combining a lens with a reflecting antenna, that part has to be taken into consideration. By using proper forms and observing the electrical data of the chemical materials used for building the lens system, the frequency of this system can be readily controlled. Dispersion and refraction of these waves can be maintained on bakelite prisms or metal grids.

Polarized Waves

These quasi-optical waves, as generated in the way mentioned above, are highly polarized. They travel easily through a grid with parallel wires all in one direction. But they are held up if we turn the grid around 90 degrees, this phenomena repeating itself after each 90 degree turn. It is like turning a polarizing Nicol crystal in a polarization apparatus.

For wartime use these transmitting stations would have the considerable advantage of not sending out any visible light that could be recognized by the enemy. They are strictly directional and therefore highly secret. This secrecy could also be increased by having receiver and transmitter both revolving synchronously on a horizontal axis, thus changing the plane of polarization constantly. Transmitters such as this are more easily transportable than the heavy longer-wave transmitting outfits. They are less expensive and need less energy. Although these waves travel like light and with all advantages of light they are not absorbed by fog and rain and are not subjected to changes in atmospheric conditions.



A receiver circuit for the micro waves. Notice the simplicity of the circuit, due to the frequency being determined within the tube which is completely isolated from associated apparatus by chokes

By going down to the order of quasi-optical wavelength the channel of communication is thus greatly enlarged. For means which require a broad spectrum of wavelengths, as for instance is necessary for television, a proper medium is hereby given.

Long and careful research work preceded the instalment of the first station to work across the English Channel on wavelengths shorter than ever before used for communication over a distance of 20 miles.

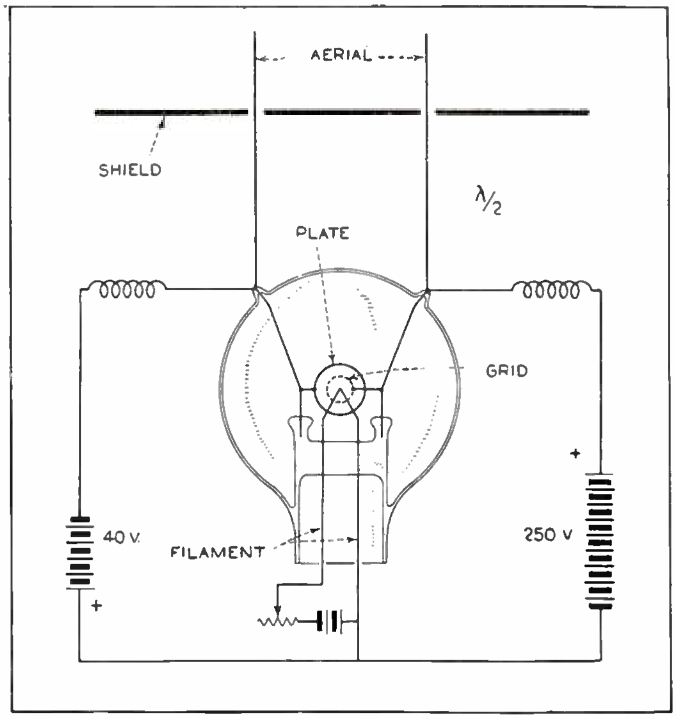
Relating to wavelengths of only a few centimeters, the laws valid for communication on the broadcast or even the short-wave channels down to 10 meters, are not valid any longer. These waves, although purely electromagnetic waves, only of a tremendous higher frequency than the usual radio waves, are not reflected from the Heaviside layer like the so-called short-waves and therefore have not been used between points so far distant that the curvature of the earth would interfere with transmission. If larger than about three meters, electromagnetic waves will bend around obstacles, such as mountains or buildings or pass through them. These slightly longer waves are reflected from the Heaviside layer, remaining on the earth. In the dimension of the ultra-short waves, however, a fair sized building is an obstacle sufficient to prevent the rays from penetrating through it. This is likewise true of hills and even of large trees.

Thus communication has only been tried between points on a straight line connection. These ultra-short waves travel like light; they are different from light, however, inasmuch as they are not absorbed by the dust, moisture and CO_2 content of the atmosphere, also that they are not acted upon by the heat-vibrations of the air, which are a heavy obstacle for long-distance communication along a path of modulated light in the ultra-violet, visible or infra-red region.

As mentioned above, these ultra-short waves travel like light, but have the agreeable distinction from light in not being influenced by the atmospheric conditions of rain, fog, day and night. Therefore, receivers and transmitters can be built which resemble the huge searchlights for visible light.

By bringing these ultra-short waves into the focus point of a reflector, they can be concentrated to almost a single line. Of course, there have been other methods for producing a directional effect for the longer waves. This has been accomplished by cutting out side radiation by interference and a partial loss of energy. For real reflection, the dimension of the wavelength has to be short in comparison to the dimension of the reflector. The size of the reflector is limited by practical size considerations. Thus reflection is to be expected only from those wavelengths which are small in comparison to the size of the reflector. In our particular case the wavelength, with which communication across the English Channel was maintained, is only about 7 inches. This is small enough to be handled properly by a reflector about 10 feet in diameter.

Naturally there is a chance for further development of this new field of transmission. We might increase the size of the present reflectors. With increasing the size of the reflector several advantages are procured. First, it would get larger in comparison to the order of the wavelength; thus better concentration of the beam of electromagnetic radiation would be accomplished. Second, irregularities in the shape of the reflector become smaller, in percentage, to the total size of the reflector. Thus the approximation to the ideal shape for the reflector may be made to a larger extent than in a relatively smaller reflector where a tiny deviation from the geometrically correct structure would throw a large percentage of electromagnetic waves in an undesired direction.

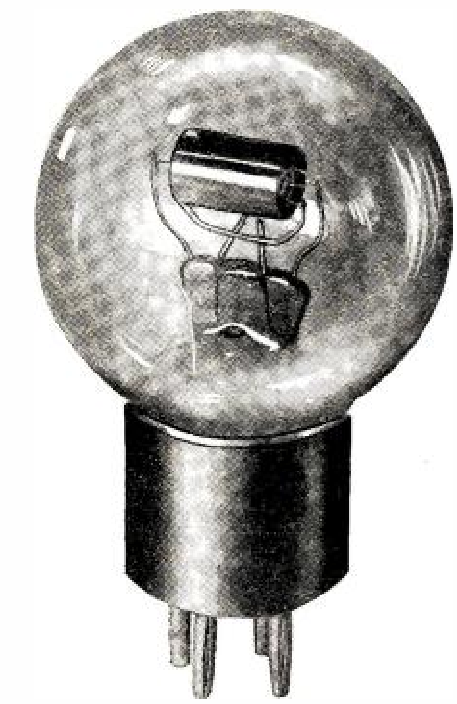


Picturization of the complete transmitter circuit. Note the high voltage on the grid and low voltage on the plate. This voltage relationship is essential to the operation of the tube

Reflector to Wavelength Ratio

The second way of making the size of the wavelength a small fraction of the size of the reflector is to decrease the wavelength. Although the technical difficulties in that direction of development are perhaps great, wavelengths have been produced as low as 2.5 c.m. (about one inch) and smaller in the physical laboratories. There is, therefore, a good chance of approaching the problem of improved reflection from this angle.

Work along the lines of ultra-short wave communication has been done independently in France and in Germany. All these developments go back to the fundamental investigations of Heinrich Hertz and the work of Barkhausen and Kurz and later by the research work done by Harms. In Germany, Esau has been working along these lines with special regard to its therapeutical application, and in France work has been done by A. G. Clavier, I. H. Fournier, R. H. Darbord and E. M. Deloraine, director of I. T. and T. A. G. Clavier, who came with his collaborators Fournier and Darbord to the United States recently on a visit, is chief of the French Signaling Department, which concerns itself with the development of the quasi-light-wave communication.



Modified form of the new tube. This is capable of oscillation only on wavelengths down to 18 centimeters, due to capacity added by the base arrangement.

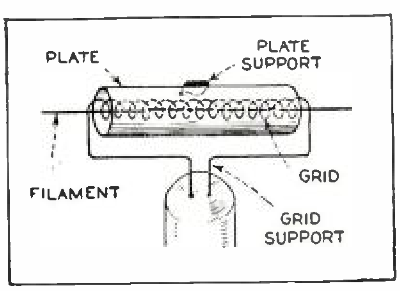
The important new feature of the Dover-Calais tests is primarily how the actual energy was generated. The wavelength on which these experiments have been carried on is not more than 18 centimeters (about 7 inches). That means the tremendous frequency of 1,600,000,000 cycles per second. Although the generation of these and even shorter wavelengths than that had been known in the physical laboratories for quite some time, the energy output of this apparatus has always been so minute that practical communication over a reasonable distance was earlier considered impossible. This ultra-short wave energy had previously been created in the experiments of Lampa, Hertz and others, by various kinds of spark-gap oscillators. Heinrich Hertz first used the cylinder-parabolic reflectors in the focussing line of which he had his high-frequency spark and a little bipolar antenna. In the geometrically balanced receiver the detector was placed directly in the focussing line.

Earlier Oscillators Lacked Power

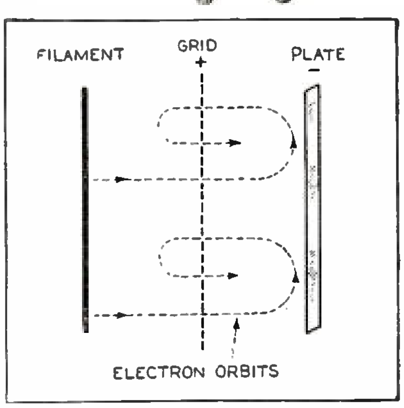
Other interesting types of spark gap oscillators already had been used by Russian experimenters. Special containers were filled with metal filings which were moved constantly by a stirring wheel. In the cup with these moving filings (all smaller than a certain size) a second electrode protruded, coming in contact with new filings. Thus the necessary small electrodes were provided by the filings for producing very small electromagnetic waves. As these electrodes burn off, if used continuously, by moving the grains new electrodes were continuously provided.

Now the use of vacuum tubes and ultra-frequency generation has made possible the output of one-half watt of energy at frequencies up to 6,000,000,000 or more.

As compared with the power ordinarily employed in radio transmission work this power of half a watt seems insignificant. It should be borne in mind, however, that American amateurs have established many long-distance transmission records, operating with one watt and less, on wavelengths of twenty and forty meters. There are authentic records of transmission tests in which a span of several thousand miles has been covered using a single peanut receiving tube in a forty-meter transmitter.



Internal construction, showing concentric arrangement of plate and grid around the straight filament



Illustrating graphically the Barkhausen Effect. Electrons from the filament are enormously speeded up by the high grid potential. They pass through the interstices of the grid and are turned back by the negative plate, describing an orbit, as shown

REMOTE CONTROL
in Custom-Built Radio Installations

This custom-built unit in a fine home offers a striking illustration of what one enterprising serviceman accomplishes with standard parts and equipment in producing a really modern installation

By Sterling Stevens

NOW is the time for all good radio men to get together in order to discover some way that the family may eat until business picks up, or until television is with us. One way to accomplish this result is to sell something to somebody who has the money to pay for it, so let's go after the man who is insulted when you suggest anything but the best; and don't think that there aren't plenty of them right in your neighborhood.

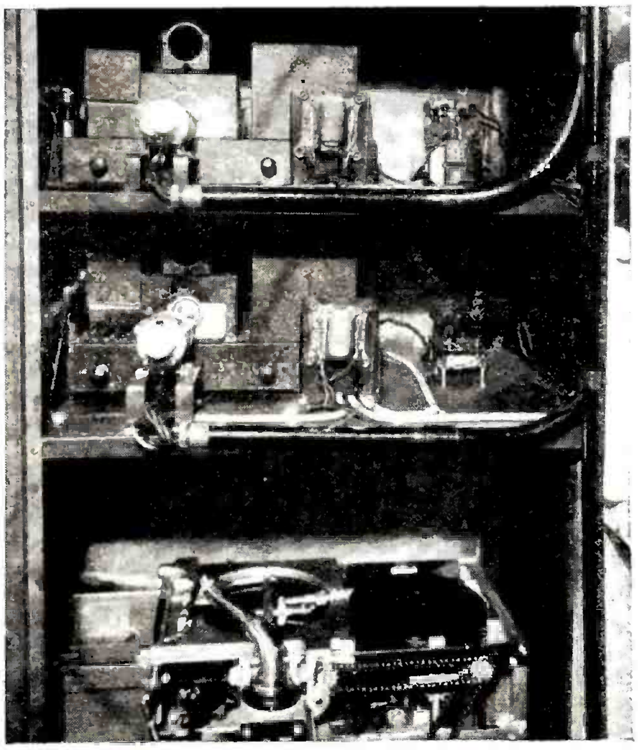
Here is a remote control system that will give real one hundred per cent. satisfaction to the customer, and no experimenter work on the part of the radio man. Work like this can be charged for and the job will show a profit that no similar amount of labor in any other branch of the radio business can ring up on the cash register. You won't need to lay awake nights wondering how long the system will work, since it is the simplest of all, and being the simplest is the most efficient.

Here is the author's idea of what a radio system for remote control should include in order to appeal and be salable to the wealthy home owner:

1. Every room in the house should have the possibility of:
   (a) Tuning in any station on the dial.
   (b) Controlling the volume individually at each position.
   (c) Cutting out the speaker entirely if desired.
   (d) Playing phonograph music and rejecting undesired records.
2. It must be possible to turn the system off and on from any position, not just the one where it was turned on.
3. Changing the volume at one position must not change it at another.
4. If one of the dials is moved with the radio turned off, some means must be supplied to correct the reading so that the stations will come in at the proper numbers when the system is used again.
5. All dials must follow and show the correct reading at all positions regardless of whether or not the positions are all in use.
6. The phonograph must play continuously and require no reloading.
7. All components must be of standard manufactured brand with a national reputation, easily obtainable on the open market.

Suppose there are eight rooms to be supplied with radio reception, four on the main floor and four upstairs. In order that the operators of the system have a greater opportunity of tuning in the radio at will, let us install two radios, each supplying four speakers, two on the main floor and two upstairs. These speakers may be so divided that the rooms most likely to be used at the same time will be on opposing systems. A system that will select either of the two radios at any position can be worked out, providing the customer has too much money instead of just plenty of money. But let's be reason-

A remote control box located on a bedside table. It is portable to provide maximum convenience and is enclosed in an appropriate cabinet



The radio set and phonograph equipment in the installation described in this article. This equipment is mounted in a steel cabinet in the basement

The Home Beautiful Calls for "Invisible" Radio Sets and Wall Type Loud Speakers

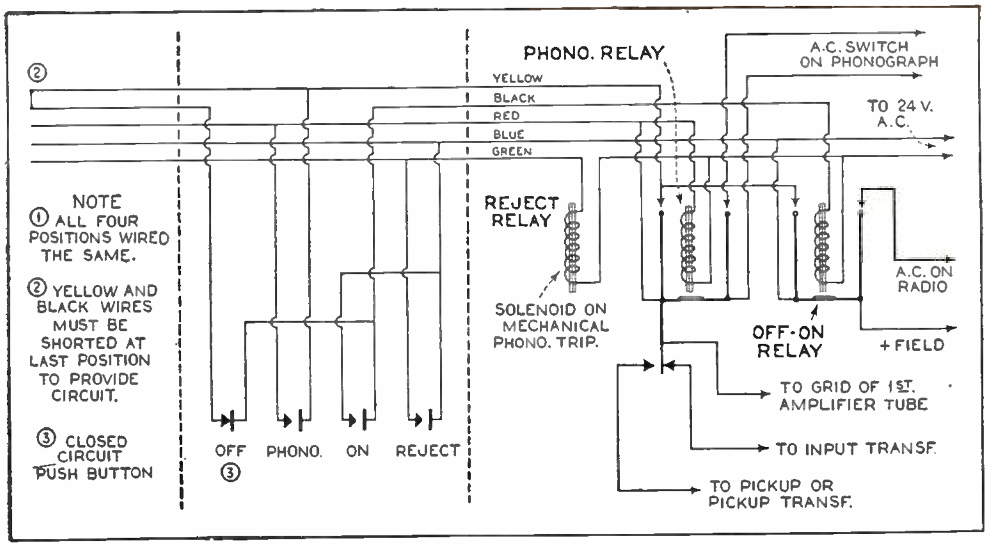


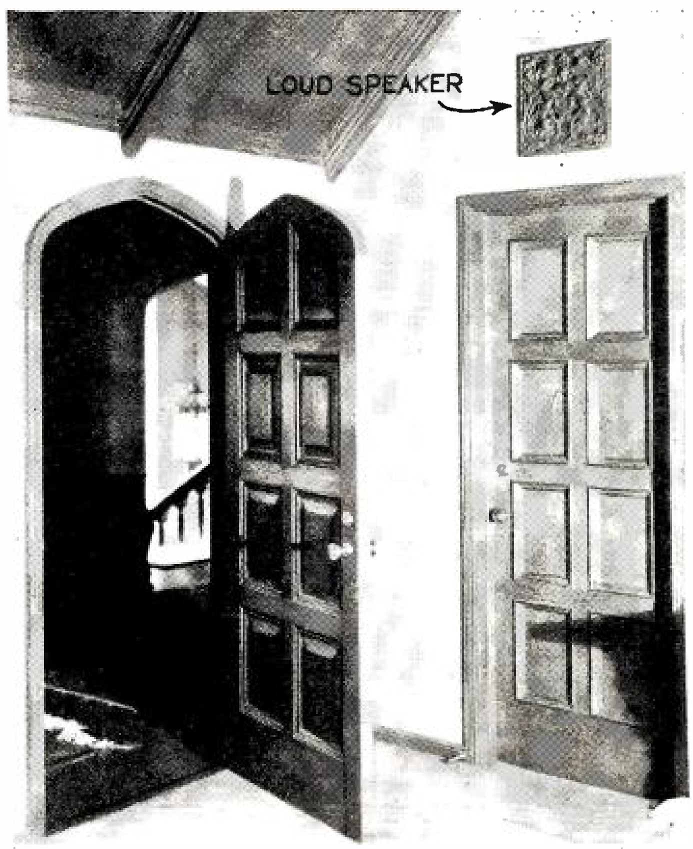
Figure 2. The relay system, operated from remote control boxes and providing complete control of radio and phonograph operation. For simplicity only the switch circuits of one remote control box are shown

able with the present layout and make it so that it can be sold and not just dreamed about.

One practical way to satisfy the above noted requirements is to use the General Electric Selsyn motors (meaning self-synchronous). The Selsyn is an interesting little device, six inches long and about three inches in diameter. If five of them are connected, as shown in Figure 1, and the rotor of one is moved, the rotor of all the others move a corresponding distance. They can be used as remote signal indicating devices in a number of different requirements. Standard Selsyns have their rotors wound with a single-phase winding, the leads to which are brought out and tagged with small metal markers labeled R1 and R2. The stators have a three-element Y-connected winding, leads to which are brought out and tagged S1, S2 and S3. Excitation is single phase and is connected to the rotor winding, and all rotors must be connected to a single source of energy. The motors are designed to a particular frequency and it is preferable that this frequency be used. Up to fifty-five volts is induced in the stator windings, according to the angle of rotation, and so with the 110 volts a.c. applied to the rotor, all wiring to the motors can best be in conduit, although not specifically required by all wiring codes.

Adjustment of Selsyn Motors

If the motors show a tendency to buzz at certain positions of the dial, a series resistance may be inserted in the rotor circuit which will cut the voltage and reduce the noise. If



Here the loud speaker grill over the door lends a decorative touch to the room—a decidedly important feature in high-grade home installations

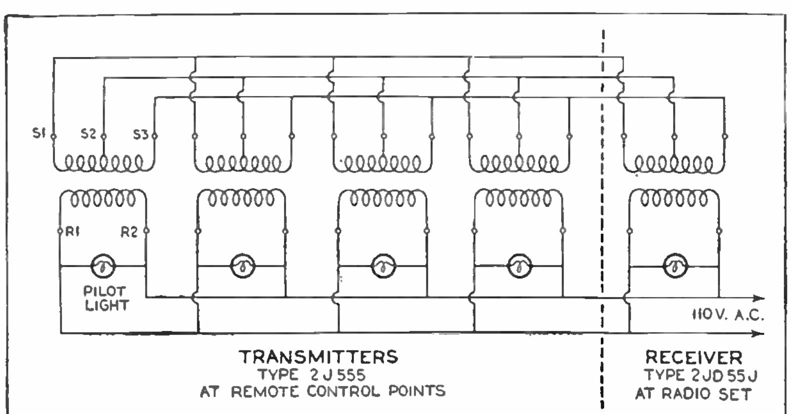


Figure 1. Schematic circuit of Selsyn motor system for tuning radio set from any one of four remote locations. The motor at the right is the one mounted on the tuning condenser shaft of the radio set

they do not seem to have enough energy, a step-up transformer may be inserted in the rotor circuit in order to take care of the 1R voltage drop in the supply lines. A Selsyn in synchronizing with its sister Selsyns will always travel through the smallest angle to its satisfied position; and so in connecting a Selsyn "receiver" to a radio set this fact must be kept in mind.

The Selsyn receiver is different from the Selsyn "generator" in that it has a special pressure device inserted in it which prevents "hunting" on that particular motor and so forces all other dials and motors to line up with it. The receiver Selsyn should be connected to the radio set tuning shaft by means of not more than a two-to-one gear. The remote control dial may then

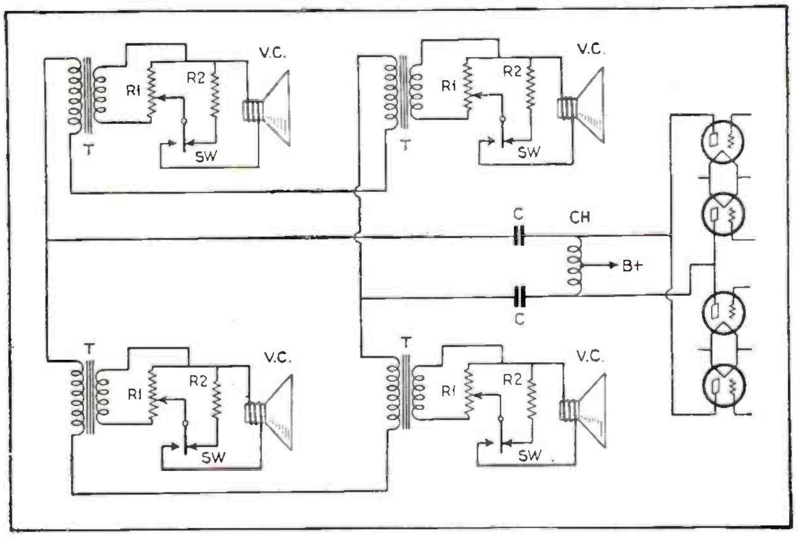


Figure 3. Output circuit. Four type -45 tubes are used in parallel push-pull arrangement. The parts employed are: Ch—output choke, 4,000 ohms impedance; T—output matching transformers; R1—60-ohm volume control potentiometers; R2—15-ohm compensating resistors; C—2 mfd. blocking condensers; Sw—antenna type switches; Vc—speaker voice coils

be calibrated in a 360 degree —0 to 100 marking. Gearing at the remote control dial is not necessary and with the suggested arrangement, very excellent dialing may be obtained. Any extra torque exerted against a Selsyn naturally limits its effectiveness; and so all rotors must be free to move with no binding.

Checking Motor Connections

If a Selsyn receiver does not follow its transmitter exactly, look first for binding of parts. If mechanically free, check the electrical connections for open or incorrect circuits. Be sure the rotor brushes are making contact. If one rotor circuit is open there will be very little synchronous torque between the transmitter and receiver and there will be two synchronizing points each 190 degrees apart. If a stator lead is open, it will be found that the receiving Selsyn will follow the transmitter, but it will follow through a limited angle and then reverse its direction, giving very erratic action. If one of the Selsyns runs in the wrong direction the S1 and S3 leads are not connected properly.

Remote control boxes may be let into the wall, as shown here beside a hand-carved speaker grill

Excessive heating in Selsyns may be caused by one or more of the following reasons:

1. Excessive excitation voltage.
2. Incorrect excitation frequency.
3. Pairing of transmitter and receiver of different stator voltage ratings.
4. Open rotor circuit on one Selsyn.

Selsyns should be installed so as to have plenty of ventilation. Equipped as they are with ball-bearings, they do not require lubrication under normal usage, such as for remote control indication. They should be mounted on rubber in order to prevent mechanical vibration.

So much for the Selsyns for the time being; so let us turn our attention to the relay circuit for turning on and off the radio, starting the phonograph, and operating the reject circuit. The relays should be of the 24-volt a.c. type in order to get away from conduit on the one hand and the unreliable d.c. on the other. a.c. from a transformer floating on the line is always there waiting to be used and so appears to be the most practical for our particular use.

Each system requires two relays, one to start the radio and the other to start the phonograph and transfer the amplifier input from the radio, where it normally stands, over to the pick-up for phonograph operation. The relays used are standard signal relays, wired and built over to accommodate the requirements of the circuit. It is well to buy the best relay available and with heavy points, since any sputtering at the contacts of an a.c. relay is not to be tolerated.

The Relay System

The diagram in Figure 2 shows the layout of the relay circuit. The pressing of the "on" button operates the off-on relay, closing two circuits. One is the 110 a.c. on the radio and field supply, and the other locks up the relay applying the 24 volts across the relay coil until the series circuit controlled by the normally closed "off" button is pushed, thereby removing the current from the winding of this coil and allowing the relay to open. The phonograph relay is operated in a similar manner, except that it is connected in series with the contacts of the "off-on" relay. One arm locks up the relay while the other applies a.c. to the phonograph. A double-pole, single-throw switch is built into this relay to transfer the grid from the first amplifier tube from its input transformer to one side of the pick-up. The other side of the pick-up goes to ground, since a -27 heater type tube is used.

The Radio and Amplifier

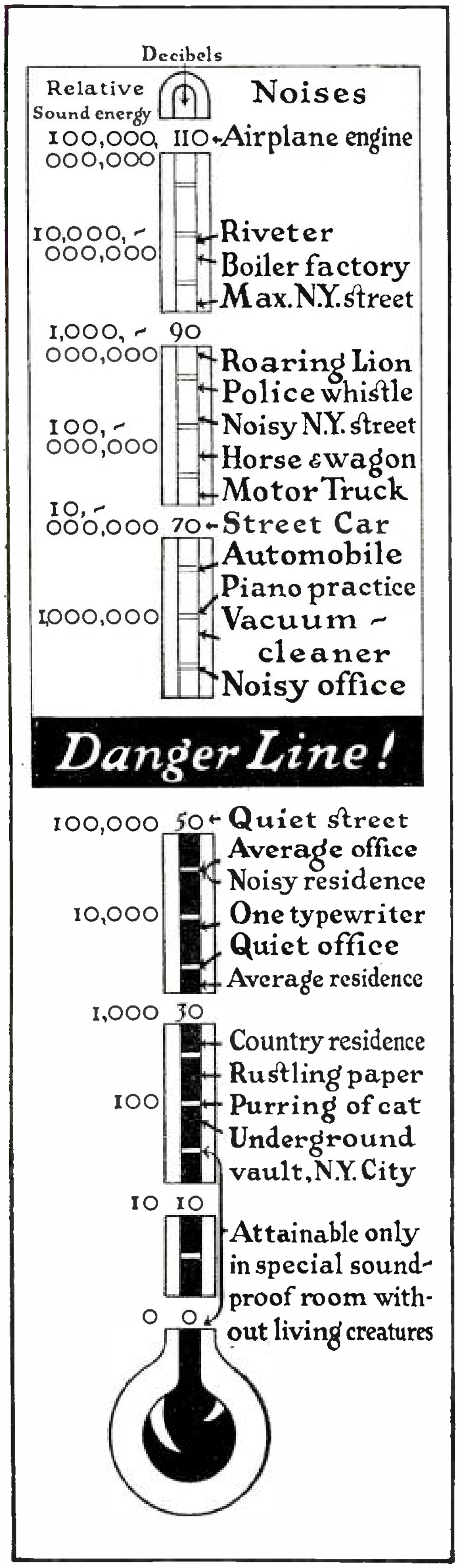
Two type 12 Stromberg-Carlson radio sets are used in the equipment illustrated. The rotor assembly lends itself admirably to remote control, being self-balanced and easily connected to the receiving Selsyn.

The operation of four dynamics is a bit too much of a load on any pair of -45's, and so you will find it desirable to parallel off another pair and double the output. The Stromberg mentioned has an extra -80 tube for supplying the field voltage to its dynamic speaker. Since we will have no use for this extra current, it should be directed over through the -45 output circuit and put to work to take care of the added -45's. Since the two extra -45's are operated from the same filament source, it will of course be necessary to change the bias resistor. One half the resistance normally used is required. Remove the normal output transformer and replace it by a choke of proper characteristics and with a 4000-ohm output. This output choke feeds directly four impedance matching transformers arranged in series parallel, as shown in Figure 3, and located at their respective remote positions. The Model 12 Stromberg is equipped with automatic volume control, therefore no attention need be given to changing volume at the radio itself. Once this is set it will deliver a constant signal to each remote position where it can be controlled as will be shown later.

It will be found necessary to free up the rotor of the tuning condenser gang so that the rotation will be smooth. A pressure device is furnished at the end of the rotor shaft which should be adjusted to give as free an (*Continued on page 324*)

Radio Lends a Hand in Fingerprinting "NOISE"

The noise "thermometer," showing how some common noises rate in the scale of decibels in which the new radio noise meters read. Continuous noises louder than 50 decibels are deemed likely to be dangerous to health and efficiency



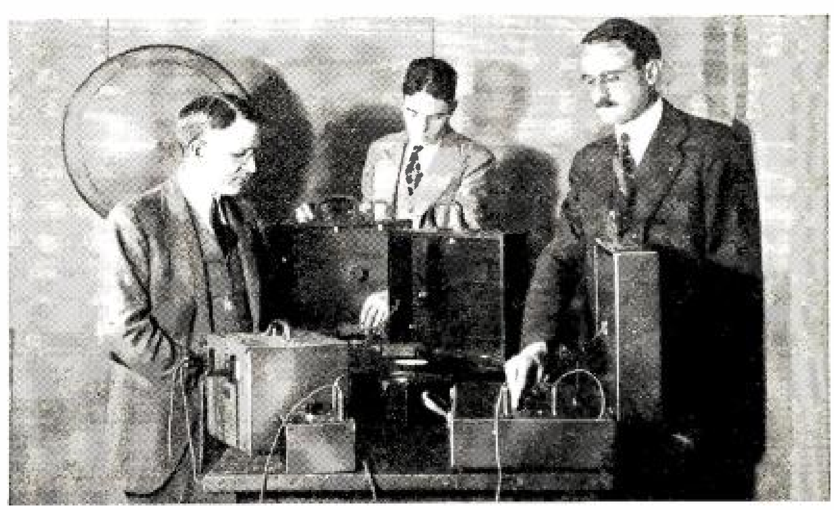
The public demands that something be done about noise. The first step in stopping noise is to measure and analyze it. Thus originates the new profession of noise engineer, open to radio men because radio apparatus is used in most of the noise measurements

By E. E. Free, Ph.D.

SHOULD this ever become a noiseless world, radio will have made it so. Radio often is accused, it is quite true, of being a contributor to the noises of today, instead of a reducer of these noises. There is much truth in this, indeed, when one thinks of the innumerable loudspeakers allowed to blare raucously on city streets, but even this unfortunate activity is outweighed by radio's important contributions to noise reduction.

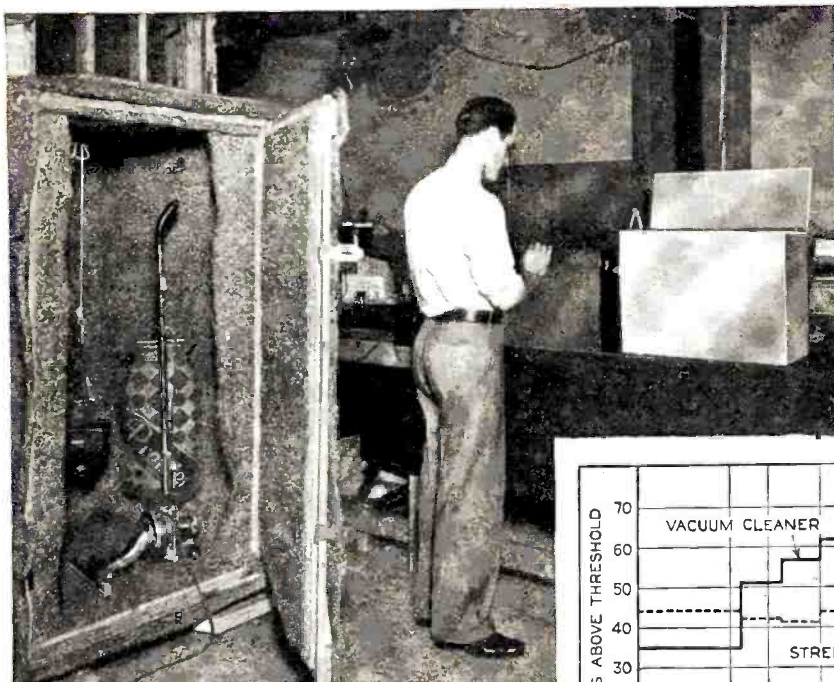
Every day the public demand for quiet increases. Quiet offices and residences rent better than those that are noisy and at higher rates. Quiet refrigerators, vacuum cleaners and other household machines sell better and at higher prices. Quiet automobiles take what remnant of the automobile market has survived the business depression. Railway and street-car companies face the same demand for quiet-running vehicles. Prices of property in suburban developments, recommendations of city planning engineers for civic improvements all turn, as one of their major factors, on the possibility of decreasing noise.

Like any other phase of engineering, noise reduction has measurement for its first essential. Like all human activities, ear judgments are affected by prejudices and individual desires. First of all, the noise engineer must know, in definite physical terms, independent of human ears, just what noises he deals with, just how these are produced, just what are their constituents, like the constituents of a chemical compound which the chemist analyzes before he undertakes to change it.



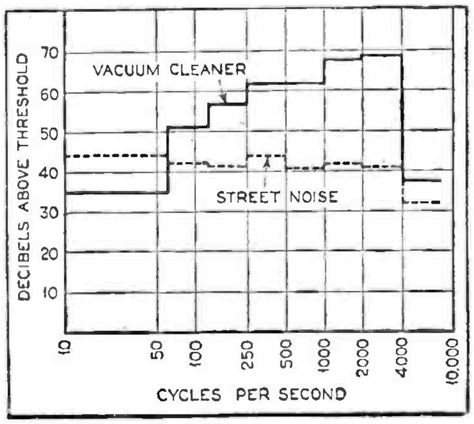
Bell Telephone Laboratories

Dr. Harvey Fletcher (left), distinguished sound expert of the Bell Telephone Laboratories, and Dr. R. H. Galt (right), with some of the noise measuring instruments developed by that institution. Dr. Galt was in charge of the majority of the noise measurements made recently on the streets of New York City for the Noise Abatement Commission



Photos Courtesy E. E. Free Laboratories

How frequency analyses of noises are made. Above are the frequency analyzer and a modern form of acoustimeter in use to measure the pitches of the noises from the vacuum cleaner in the sound-proof box at the left. At the right is a frequency analysis thus obtained, showing the composition of the cleaner noise. For comparison, a similar analysis of New York City street noise is added



The great contribution of radio to the new science of noise reduction is that radio apparatus provides the best way, one might almost say the only way, in which these noise measurements can be made.

Modern apparatus for measuring noise is really no more than the first part of a broadcasting station. First of all there is a microphone to pick up the noises. Then comes an amplifier to increase the electric equivalent of the noise energy to a measurable point. Finally, instead of modulating these sounds on a carrier wave as the broadcaster does, the noise engineer measures the energy concerned on some suitable variety of electric meter.

These instruments are very recent developments, still not well understood either by laboratory physicists or by radio engineers. Much more will be heard of them in the next ten years than has been heard in the past.

Even a decade ago, when my own organization first began to study the problems of noise measurement, the modern radio devices were not available. Our first survey of street noise in New York City, the first such survey ever made anywhere, was done with a device called the audiometer, developed by the Bell Telephone Laboratories, the principle of which is to match the noise to be measured against a standard noise produced by the instrument. The ear of the observer determines the match. In skilled hands this instrument and method have proved extremely valuable. It even has proved possible to measure noises with some reasonable approximation to accuracy merely by listening to the sound of a standardized tuning fork and comparing that sound with the noise to be measured.

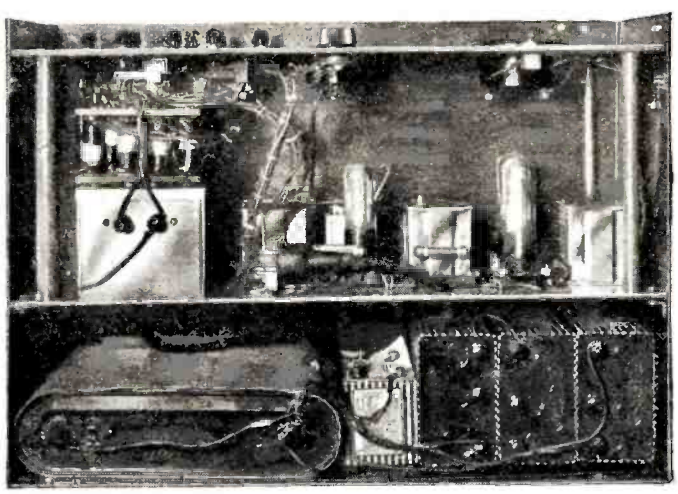
The Ear an Inaccurate Gauge

All such methods involve, however, a dependence on the observer's ear, and this has been found to be a highly dangerous procedure. No two observers agree perfectly in ear sensitivity. Even the same observer may vary notably on different days. Methods have been devised, of course, to overcome these difficulties more or less completely, fooling the ear, so to speak, into giving the right result. However, the best modern technique of noise measurement abandons the ear altogether as an instrument or an indicator and adopts the microphone, the amplifier and the meter, which are the gifts of radio.

One noise meter recently developed in our own laboratories consists, for example, of a small case less than the size of an ordinary suitcase. At one end of this case there is a microphone protected by a metal screen. The output of this microphone goes to a three-stage, vacuum-tube amplifier, especially designed for extreme stability in operation, so that the output of the amplifier always will correspond exactly with the sound input to the microphone. This amplifier output then is measured on a meter approximately logarithmic in character, so that the meter scale will cover a substantial range of noise intensities. Dry batteries for the operation of the amplifier are included in the instrument's case, so that the whole device is perfectly portable, may be taken anywhere and may be used to measure noises on streets, in factories, from machines, in offices or anywhere else.

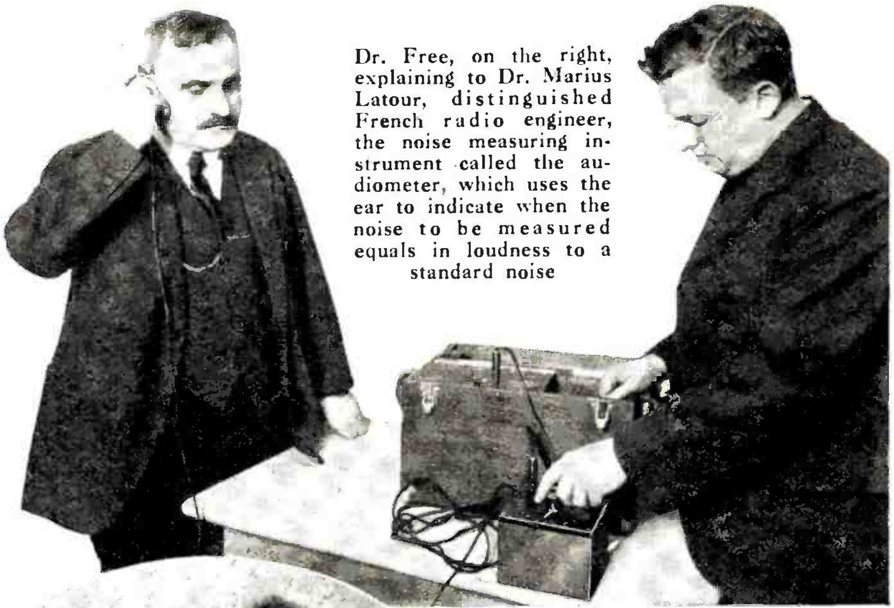
For more complete noise analyses and more accurate noise measurements, especially of faint noises or of those which are very high or low in pitch, more flexible and complicated equipment is necessary. There is now available, for example, acoustimeter equipments marketed by the C. F. Burgess Laboratories, Inc., of Madison, Wisconsin, which will measure noises so faint that the human ear can barely hear them. This same instrument responds accurately to deep base noises like the tones of the deepest organ pipes or to extremely high treble noises like the chirps of insects. The microphone may be detached and set in any convenient position to pick up, for example, the noise from a special part of a machine. The loudest of noises like those from the three motors of an airplane, all operating together a few feet from the microphone, also can be measured quite as accurately as the faint noise of the purring of a cat.

The development of these instruments has not been a simple matter of fastening together any microphone that happened to be about, any cheap form of amplifier and any convenient meter. Like the problems of first-class reproduction in radio, adequate and accurate noise measurement requires unusual skill in the design, adjustment and operation of the apparatus. The slightest degree of self-oscillation in the amplifier is fatal. Any feed-back from one portion of the outfit to another will produce erroneous results. The operation of the microphone



Inside a portable noise measuring instrument. The amplifier is above at the right. To its left are the attenuators and the filters which may be used to make the response of the instrument the same as that of the average ear. The batteries are in the compartment below, including "A" battery supply. The meter is mounted, facing upward. The entire instrument is cased in aluminum

must be exceptionally stable so that the same noise always will produce the same meter reading. In addition, attention must be paid to the constancy of response of the entire outfit to different frequencies; otherwise the readings will be inaccurate when noises vary in frequency composition between, for example, the relatively high-pitched noise of a vacuum cleaner and the relatively low-pitched hum of an electric transformer.



Dr. Free, on the right, explaining to Dr. Marius Latour, distinguished French radio engineer, the noise measuring instrument called the audiometer, which uses the ear to indicate when the noise to be measured equals in loudness to a standard noise

New Scale of Sound Intensity

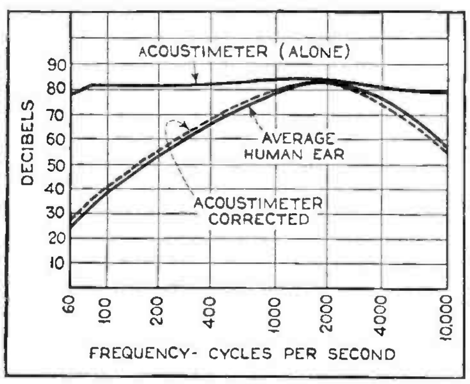
Not only has the new science of noise engineering required the development of these novel pieces of apparatus, but it has necessitated also the devising of a new scale of units. Fortunately, a suitable scale already was available in the telephone art, the scale of decibels used to measure the attenuation of speech energy in telephone lines or its magnification by telephone amplifiers. This decibel scale has been taken over bodily into noise engineering.

The scale is a logarithmic one. The fundamental unit is the bel, ordinarily divided into 10 decibels. The bel represents the logarithm to the base 10 of the ratio of sound energies concerned. That is, an increase of 1 bel or 10 decibels corresponds to a multiplication of the energy by 10. An increase of 20 decibels means a multiplication by 100; 30 decibels means multiplication by 1000, and so on. Not only is this logarithmic scale an advantage because of the large range of sound energies encountered in ordinary noises, but it has the additional convenience of corresponding, at least approximately, with the behavior of the human ear. Accordingly the difference of two noises in decibels corresponds roughly with the apparent difference of the same noises in loudness.

Recently evidence has begun to develop that this agreement of the decibel scale with loudness judgments is not sufficiently accurate for many purposes. Accordingly there is now a movement to introduce some other scale of noise units, perhaps based on the decibel scale but agreeing more exactly with average ear judgments. One difficulty, however, is that two people seldom judge the loudness of sounds exactly alike. Accordingly a true scale of loudness units probably would vary for each individual and perhaps the decibel scale, while it may not agree exactly with the judgments of any single individual, is a good enough compromise for ordinary use.

General Electric

Above, measuring the noise of an electric motor in the laboratories of the General Electric Company at Schenectady. The microphone on the tripod feeds into the amplifiers and meters at the right.



Sounds of different pitch differ in loudness in the ear even at the same energy. Accordingly, modern acoustimeters frequently have electric filters to make their readings correspond with ear judgments of loudness, as is shown by the curves at the left

It is necessary always to remember, however, that the decibel scale is not a scale of absolute values of anything. It is a scale of amplification or reduction. So many decibels means a specified ratio, lower or greater, than some definite figure. Accordingly, if noises are to be compared with each other under different conditions, the decibel scale must be further defined by the adoption of some arbitrary zero noise, above which all decibel figures are to be computed.

Several such zeros have been in use. Probably the commonest one is that corresponding to what is believed to be the maximum sensitivity of the human ear at the frequency to which the ear is most sensitive. This frequency is approximately 2500 cycles per second, and the faintest sound which the average ear can hear at that frequency is approximately .46 millibar, the millibar being the conventional physical unit of sound pressure.

Recently, however, a number of noise engineers have suggested abandoning this figure of .46 millibar in favor of the round figure of 1 millibar as the zero of the decibel scale. The practical difference is slight and the round figure facilitates computations. Presumably this will be adopted universally.

On this basis, therefore, a sound of zero decibels corresponds to a sound pressure of 1 millibar. This sound will carry a certain energy, measurable in ergs, watts or any other suitable unit. A sound carrying 10 times this energy will be rated as 10 decibels, one carrying 100 times this zero energy will rate as 20 decibels, one carrying a billion times the zero energy will be 90 decibels, and so on, on the usual exponential scale of 10.

In computing from decibel figures the sound pressure, that is, the actual physical pressure which the sound waves will produce on a surface against which they strike, it is necessary to divide the decibel figures by two. This is for the reason that the sound pressure corresponds to the square of the sound energy. Accordingly a sound 20 decibels above the assumed zero of 1 millibar sound pressure is not 100 times the sound pressure but only 10 times, or 10 millibars. Similarly a sound 100 decibels above the assumed (*Continued on page* 328)

Audio System Design Charts

The author presents here data taken from his laboratory notes covering the design of audio and transmission systems. Included are three charts which will save engineers and experimenters much time and calculation

By Kendall Clough

BECAUSE they have been so useful in reducing the tedium of extensive calculations in connection with design or selection of units for use in amplifiers and other transmission systems, I am presenting from my notes three design charts giving the solutions to three of the basic problems. These charts give solutions in terms of simple parameters of the circuits and are capable of accurate results when judiciously used. In order that the results may be intelligently applied, I am presenting the solutions of the problems rather than presenting the graphs per se. It is hoped that these topics may serve not only as a foundation for a more definite view of transmission problems on the part of the uninitiated, but also as a concise review for those practiced in the art.

The first problem we will consider is that of the effect of a mismatch in a circuit transmitting power from a generator, e, having an internal resistance, r, and delivering its power to a resistance R. The circuit is given in Figure 1. By Ohm's law—the current, i, is

$$i = \frac{e}{R + r} \qquad (1)$$

The power in the load R is given by

$$P = i^2R \qquad (2)$$

or by substituting (1) in (2)

$$P = \frac{e^2R}{(r + R)^2}$$

For design purposes it is more convenient to introduce a parameter

$$a = \frac{R}{r} \qquad (3)$$

into (3) giving

$$P = \frac{e^2a}{(a + 1)^2r} \qquad (4)$$

By differentiating, P, with respect to, a. and equating to zero, we find that the power is a maximum when a = 1. This is the usual conclusion that a generator delivers the maximum energy to a load having the same resistance as its own. If we let P_m be the maximum power in the matched condition, we have

$$P_m = \frac{e^2}{4r} \qquad (5)$$

If P_o is the power for any other condition we may find the loss in decibels due to any ratio of load to internal resistance, a, by

$$\text{Loss (DB)} = 10 \log \frac{P_m}{P_o}$$

or

$$\frac{\frac{e^2}{4r}}{\frac{e^2a}{(a + 1)^2r}} = 10 \log \frac{(a + 1)^2}{4a} \qquad (6)$$

This function has been plotted in Chart 1. It is interesting to note that the curve when plotted logarithmically in "a" is symmetrical about the value a = 1. In other words the loss is the same whether the load is "a times" too large for best power transfer or $\frac{1}{a}$ too small.

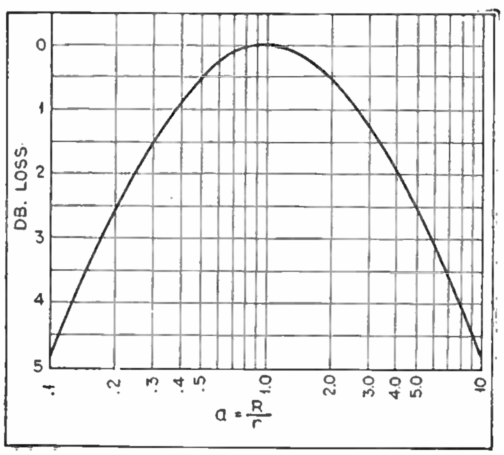


Chart 1. Attenuation curve for different ratios of internal and external impedance

An example of the use of this chart may be helpful. Let us suppose that the output of a 112-A tube is to be operated into a 500 ohm line pad. A transformer having a 4.5 to 1 turns ratio is available. Such a transformer when connected to the line will present a load R to the tube of 4.5^2 times 500 = 10150 ohms. The plate resistance of a 112-A tube is about 5000 ohms. Hence $a = \frac{10,150}{5000} = 2.03$. Referring this value to Chart 1, we see that a loss of 0.5 DB will be sustained due to this mismatch.

A second chart deals with the losses sustained due to the departure of an actual transformer from the ideal in matter of primary inductance. An ideal transformer is defined as one which neither stores nor dissipates energy. This requires that the primary reactance be very large (infinite) compared with the resistance of the generator. It is because the primary reactance approaches the resistance of the source at low frequencies that the response is impaired.

Let us consider Figure 2, in which the generator, e, with its internal impedance, r, is operating through an ideal transformer into a load resistance, R. The transformer has a ratio of primary to secondary turns N. Because it is an ideal transformer we can transform the circuit for analytical purposes as shown in Figure 3, in which the transformer has been eliminated and the generator operates a load R′, whose value is defined as

$$R' = N^2R$$

It should be noted here parenthetically, that the ideal transformer has no leakage reactance. That is, all the flux generated

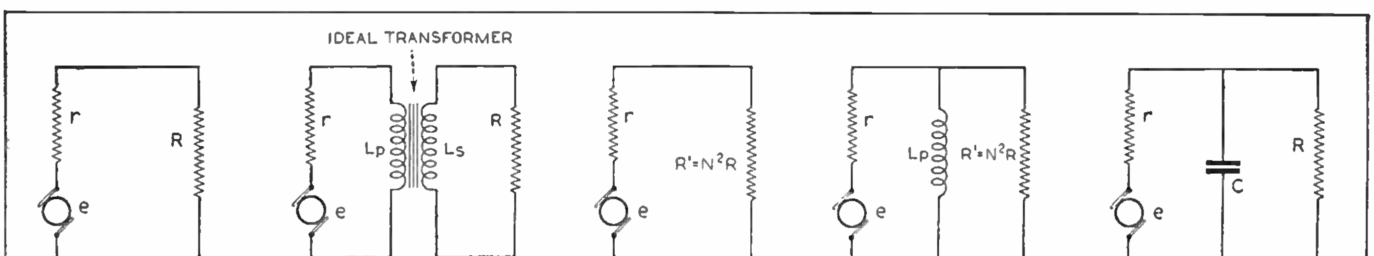


FIG. 1 FIG. 2 FIG. 3 FIG. 4 FIG. 5

in the magnetic circuit by the primary turns is linked by all the turns of the secondary. We will assume this to be true of the actual transformer because we are dealing with low frequencies where the leakage reactance is negligible in well designed transformers.

Now, actual transformers are not ideal with respect to primary inductance and for this reason we are interested in finding the transmission loss due to a finite primary reactance, for this will determine the ability of the device to pass low frequencies. We proceed by introducing the primary inductance L_p of the device across the circuit as shown in Figure 4. The reactance of the primary is $\omega L_p = 2\pi f L_p$ or in vector notation; $j\omega L_p$. Then, the load on the generator is the parallel combination of $j\omega L_p$ and R' given by

$$\text{Load} = \frac{j\omega L_p R'}{j\omega L_p + R'} \quad (7)$$

Then, the total impedance of the circuit to, e, is

$$Z = \text{Load} + r = \frac{j\omega L_p R' + j\omega L_p r + R'r}{j\omega L_p + R'} \quad (8)$$

The current, i, is

$$i = \frac{e}{Z} \quad (9)$$

The voltage across the load is given by

$$e_2 = i \cdot \text{load} = \frac{e \cdot \text{load}}{Z} \quad (10)$$

Substituting (7) and (8) in (10) we see that

$$e_2 = e\frac{j\omega L_p + R'}{j\omega L_p R' + j\omega L_p r + R'r}$$

and

$$\frac{e_2}{e} = \frac{1}{\left(1 + \frac{r}{R'}\right) + \frac{r}{j\omega L_p}} \quad (11)$$

Rationalizing the above we have

$$\frac{e_2}{e} = \frac{1}{\sqrt{\left(1 + \frac{r}{R'}\right)^2 + \left(\frac{r}{\omega L_p}\right)^2}} \quad (12)$$

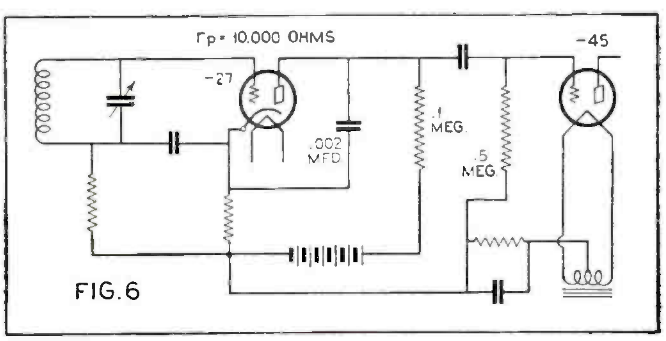
To make this result useful for charting we will introduce two parameters. The first

$a = \frac{R'}{r}$ is the ratio of the effective load impedance to the generator impedance and the second

$b = \frac{\omega L_p}{r}$ is the ratio of the primary reactance to the generator resistance. Introducing these into (12) we have

$$\frac{e_2}{e} = \frac{1}{\sqrt{\left(1 + \frac{1}{a}\right)^2 + \left(\frac{1}{b}\right)^2}} \quad (13)$$

In the absence of the primary reactance (ωL_p = infinite) b is infinite and (13) reduces to



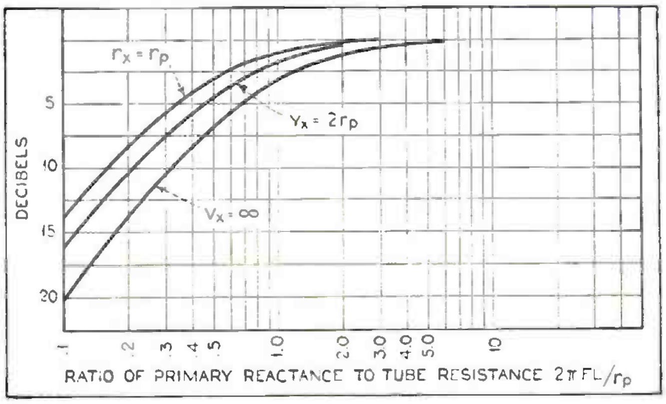


Chart 2. Curve showing attenuation of transformer due to primary inductance as compared to ideal transformer

$$\left(\frac{e_2}{e}\right)_m = \frac{1}{1 + \frac{1}{a}} = \frac{a}{a + 1} \quad (14)$$

The power ratio in the load is then

$$\frac{P_2}{P_1} = \left(\frac{e_{2m}}{e_2}\right) = \frac{a^2}{(a+1)^2}\left[\left(1 + \frac{1}{a}\right)^2 + \left(\frac{1}{b}\right)^2\right] = \left[1 + \left(\frac{a}{(a+1)b}\right)^2\right] \quad (15)$$

And the transmission loss due to a definite value of primary reactance is given by

$$\text{Loss (DB)} = 10 \log \left[1 + \left(\frac{a}{(a+1)b}\right)^2\right] \quad (16)$$

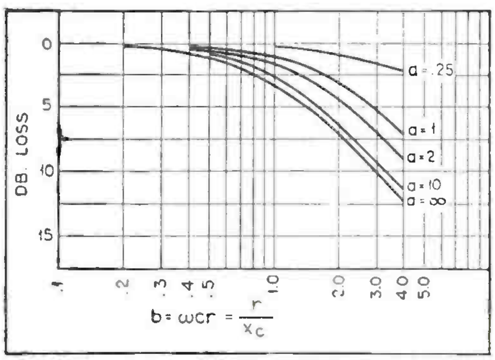


Chart 3. Curves showing DB losses in output circuits, for various degrees of impedance mismatching

Because there are two parameters involved, we must assign specific values to one and vary the other in order to obtain a graph of the expression. Graphs will be of value for several magnitudes of a. The first, a = 1, corresponds to equality between the load and generator impedance for maximum power transfer. This would correspond to the operation of a transformer out of a push-pull amplifier, for example, into a perfectly matched load. In the case of a single tube (triode), however, the best undistorted output is obtained by making the load resistance about twice the plate resistance. Hence, we are interested in the function when a = 2. When operating a pentode the load is usually about $\frac{1}{5}$ of the plate resistance. This calls for a curve for a = .2. Curves of this type are plotted in Chart 2.

In addition to these three values a fourth is of singular interest, when a is infinite. This corresponds to operation of a transformer or choke, as an interstage device where the load impedance, (for low and moderate frequencies) is very high compared to the plate resistance. In this case, since $\frac{1}{a} = 0$, equation (16) becomes

$$\text{Loss (DB)} = 10 \log \left[1 + \left(\frac{1}{b}\right)^2\right]$$

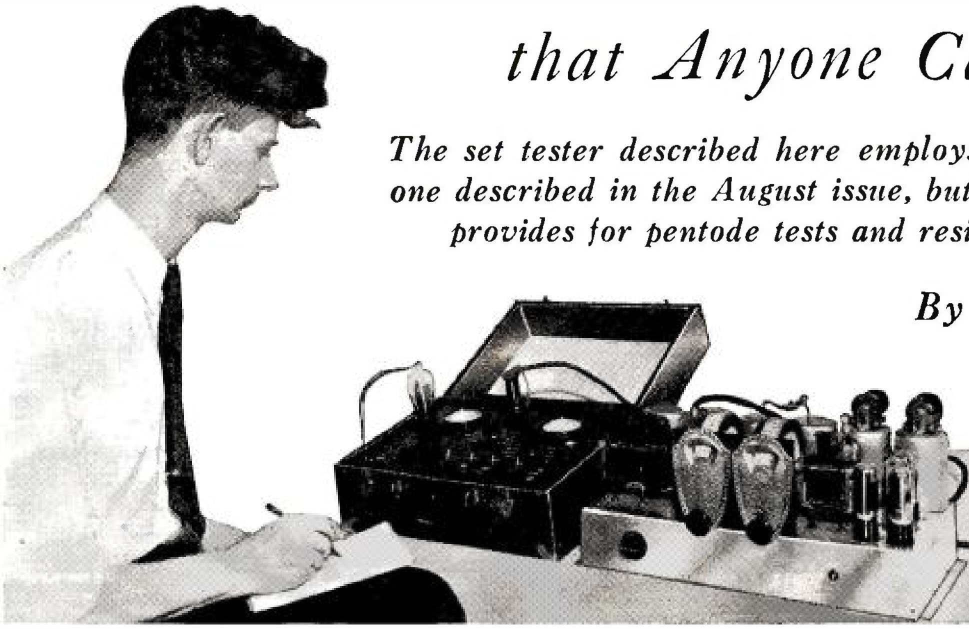
As an example of the application of this chart let us suppose that the requirement is for an output transformer for operation into some specific load and that the frequency characteristics shall not suffer more than one decibel at 60 cycles due to the primary reactance. What value of primary inductance is required and how much will the gain be down, at 30 cycles. The tube resistance for a -45 tube is about 1800 ohms. For operation of a single tube the turns ratio will be chosen such that the tubes see twice its own impedance, so we refer to the curve a = 2 and find *(Continued on page 332)*

A Set Tester De Luxe

that Anyone Can Build

The set tester described here employs the same circuit as the one described in the August issue, but uses precision parts and provides for pentode tests and resistance measurements

By John M. Borst



In the August issue of RADIO NEWS, Mr. Bill Stella described a set tester of his design which could be made by the serviceman at a small expense. We liked the simplicity and all around usefulness of this instrument so much that it was decided to build up and present a revised model for the consideration of our readers.

As the reader will remember, Mr. Stella used variable resistors which he had picked up on a bargain counter and adjusted to approximate resistance values. We wanted an instrument of somewhat greater accuracy and since some of those who built the tester described in the August issue will undoubtedly wish to improve on the accuracy of their measurements, when their pocketbooks permit, we are here describing this revamped analyzer.

The Revamped Tester

So far as practical the original parts have been used. The differences are the following: all multiplier resistors have been replaced by precision resistors guaranteed to be within 1% of their rated value. The switch S2 has been replaced by a Best switch for no other reason than to have both switches the same. The a.c. voltmeter used has a range of 0-5 volts instead of the 0-10 because most voltages read are of the order of 2.5 volts and it was felt that at the lower end of the 10 volt scale the divisions were too crowded for the accurate reading of the low voltages. Both the switch and the meter, however, can be left as before if the constructor desires.

Since the previous tester had been added to from time to time the various switches had to be put where there was room. We thought the serviceman might wish a neater, professional looking instrument so that a new panel and a larger case were added to the new parts. The new panel is engraved, the switches are mounted in a row and the pin jacks in another.

The case is a stock item at a local radio store and was selected because it provides space for spare tubes, small tools or other servicemen's equipment.

The old hook-up is used except for a slight change in the continuity circuit. There is a milliammeter having a 0-1 milliampere range. With the necessary multipliers and switches there are eight voltmeter ranges and five millammeter ranges available. All voltmeter ranges have a resistance of 1000 ohms per volt. The voltmeter ranges are: 0-1 volt, 0-2.5 volts, 0-5 volts, 0-10 volts. 0-50 volts, 0-250 volts, 0-500 volts and 0-1000 volts. The milliammeter has ranges of 0-10 ma., 0-25 ma., 0-50 ma., 0-100 ma., and 0-500 ma. The circuit diagram is shown in Figure 1.

The selector switch S1 enables the user to read all voltages and currents of the tube under test. All kinds of tubes have been provided for, including a.c., d.c., screen grid, pentode and half wave rectifier tubes, also the measurement of both sides of full wave rectifiers. All meter ranges are available externally and a battery has been incorporated in the hookup to supply a continuity testing circuit.

Pentode Tests Provided For

All the preceding features, except the pentode adapters, were provided by the design of the previous tester. In addition we have added calibration curves which permit the use of the instrument as an ohmmeter with a range from 100 to 60,000 ohms.

Let us examine the circuit used to provide the eight voltmeter ranges. As we know, the voltmeter consists of a milliammeter in series with a resistor of known value. When we read the current flowing through the meter, the potential

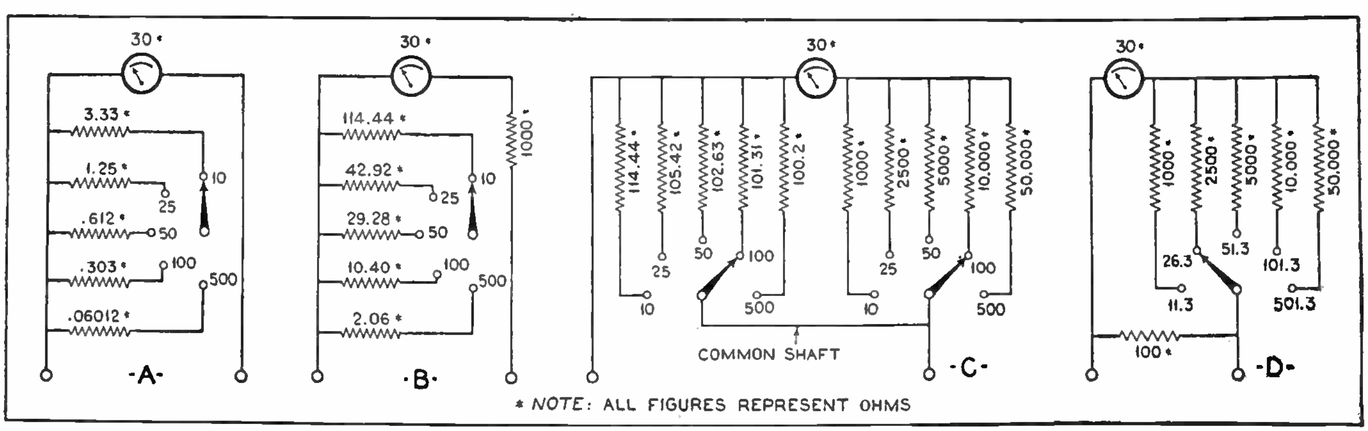


Figure 2

difference at the terminals can be calculated by means of Ohm's Law. When the resistor has a properly chosen value the scale of the milliammeter can be considered direct reading as we only have to multiply by 10, 25, 50, etc.

It is plain that the entire accuracy of this arrangement hinges on the accuracy of the series resistors. Therefore we have replaced the cheap resistors of the preceding tester by quality resistors rated by the manufacturer to be accurate to within 1%. These were checked in the RADIO NEWS Laboratory and found to be well within the 1% limit.

In the arrangement used here the resistance of the milliammeter has been neglected. To be sure, this gives a reading which is a trifle low on the lowest scales but on the higher ranges the error becomes so small that it is insignificant. It is quite customary in home-built apparatus to neglect the meter resistance as resistors of the odd value otherwise required are not available. However, for those who wish to take this small error into consideration we give the following list of corrections:

On 1 volt scale add 3% and on the 2.5 volt scale add 1.2%. The higher scales need no corrections.

The theoretically correct way to extend the current range of a 0-1 milliammeter is to shunt it with resistors of 1/9, 1/24, 1/49, 1/99 and 1/499 of the resistance of the meter to obtain ranges of 10, 25, 50, 100 and 500 milliamperes, respectively. This circuit is shown in Figure 2A together with the value of the needed resistors. Shunts of such small resistance values are not easy to get and are very expensive if we want them accurate. Therefore it will be necsary to try another scheme.

The completed job. A conversion chart is attached inside the cover to facilitate quick readings. In front of the tester are all of the accessories except the two adapters employed in pentode measurements

Current Dividing Shunts

When we add a resistor in series with the meter the shunt does not have to be so small. This circuit is shown in Figure 2B. Here again we show the values of the resistors needed. However, this also calls for resistors of an odd value.

Now suppose we keep the shunt resistor the same, then we could vary the series resistor for the different ranges. If we use for these series resistors the voltmeter multipliers already provided, we can save on resistors.

When calculating the correct shunt value for use with this scheme (see Figure 2C), we find that the values approach 100 ohms as the range increases. Suppose we select a single shunt of 100 ohms, which is easily obtainable, then let us see what ranges we get.

Let us look at Figure 2D. When the selector switch is set at the first point for what we will call the 10 ma. range, there will flow in the shunt circuit a current of 1030/100 or 10.3 times the current the meter indicates, according to the law of parallel resistances. Therefore the total current in the circuit under measurement is now 10.3 plus 1 (in the meter series circuit) or 11.3 times the current indicated by the meter. In other words the range of the meter has actually been multiplied by 11.3. But for the sake of convenience we consider it as being multipled by 10.

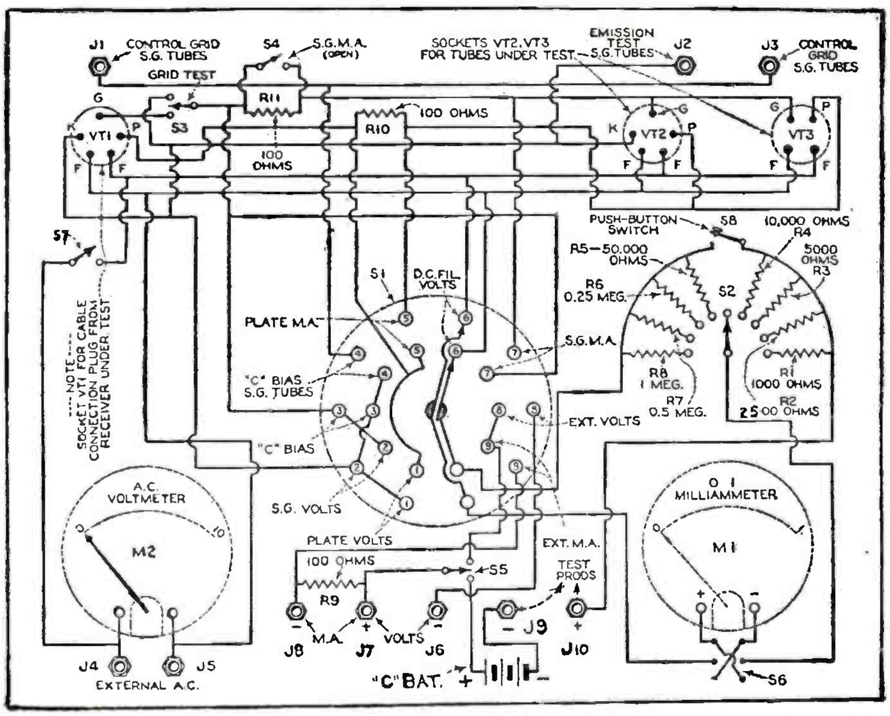


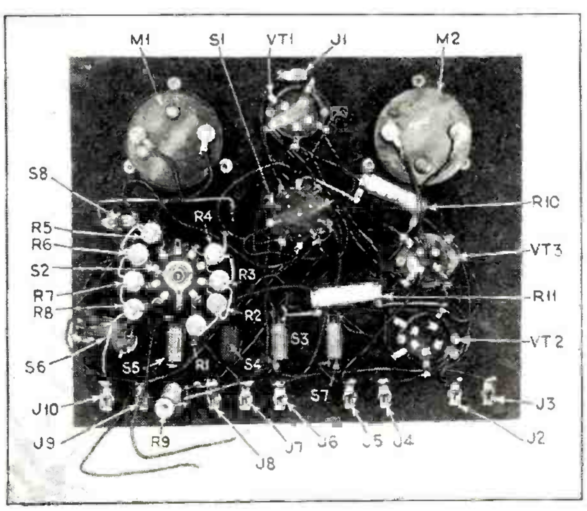
Figure 1. Schematic diagram of the tester. The switches S2 and S1 are shown reversed, as they look from the back of the panel

With the same calculation, the multiplication factor for the other ranges are 26.3, 51.3, 101.3, 501.3 instead of 25, 50, 100 and 500. These differences seem large, but for the ordinary run of measurements a serviceman makes they are not important, especially when one considers the saving in the cost of the expensive low resistance shunts.

For those who desire greater accuracy the following is a list of correction factors to be applied to the 10, 25, 50, 100 and 500 ma. ranges:

On the 10 ma. range add 13%; on the 25 ma. range add 5.2%; on the 50 ma. range add 2.6%; and on the 100 ma. range add 1.3%.

When we wish to measure the current (*Continued on page* 346)



Underside of the panel, showing layout of all parts and method of mounting resistors

What Goes On In Your Vacuum Tubes

Last month Mr. Reisman explained how the vacuum tube works. This month he continues the explanation and also describes a number of the uses to which vacuum tubes are now being put

By Emil Reisman

PART TWO

IN radio broadcasting use is made of the vacuum tube for generating radio waves. This is usually accomplished by so designing the circuits in which the tube is connected that a part of the output of the tube is brought back to the grid to again influence the output. Under such conditions any variation in the grid voltage produces a similar change in the plate current. A small portion of the energy in the plate circuit is then directed to the grid of the tube so that it may produce further changes in the plate current. Once this action begins a steady alternating current is generated by the tube. This alternating current is of exactly the same nature as the 60-cycle, alternating current supplied in your home by the power company. When a tube is so operating that it generates an alternating current it is said to be "oscillating."

At first sight it may seem strange to many and contrary to the laws of nature that a source of continuous current power supply can be changed to an alternating current power supply by means of a simple vacuum tube. By observation we will find numerous phenomena—many occurring in our everyday lives—in which directly applied energy is converted into alternating energy, just as in our oscillating vacuum tube.

A continuous stream of air rushing into an organ pipe comes out of the pipe in very rapid puffs, thereby creating that atmospheric disturbance that we know as sound. How can the violinist's arm, which evidently exerts a direct pull on the bow, produce a musical sound which we know to consist of alternate compression and rarefaction of the air? Certainly the man's muscles are not causing that phenomenon directly.

A Rusty Hinge Squeaks When the Door is Pushed Open
BUT
What Relation Has This To Oscillating Tubes?

The rusty hinge on a door squeaks when the door is pushed open. The balance wheel of your watch continually oscillates back and forth when the main spring is trying always to push it in the same direction. Why does a flag flutter in the breeze?

Just as the pitch of a violin string can be changed by varying the length, mass or tightness of the string, so can the frequency of the alternating current from the oscillating vacuum tube be controlled by simple changes in the resonant circuit to which the tube is connected. By varying the conditions in the apparatus of the oscillating vacuum-tube circuit, the swings or oscillations of the electric current from the plate of the tube may be made to alter any number of times from lower than one oscillation per second to over three hundred million per second. A very remarkable range!

When these oscillating electric currents are properly fed into an antenna system, the silent and invisible disturbances are set up that we call radio waves. The radio waves used in broadcasting, and which your set receives, may oscillate from five hundred and fifty thousand to one million five hundred thousand times each second, depending on the wavelength upon which the station is operating.

Radio Broadcasting — And How We Receive It

To use the radio wave as a "carrier" for the radio program, its strength or intensity must be varied in exact accordance to the variations in sound produced in the broadcast studio by the speaker, singer, or orchestra. We use, therefore, a microphone which translates the air vibrations caused by the music or speech into weak electrical vibrations exactly similar to those in the air. We

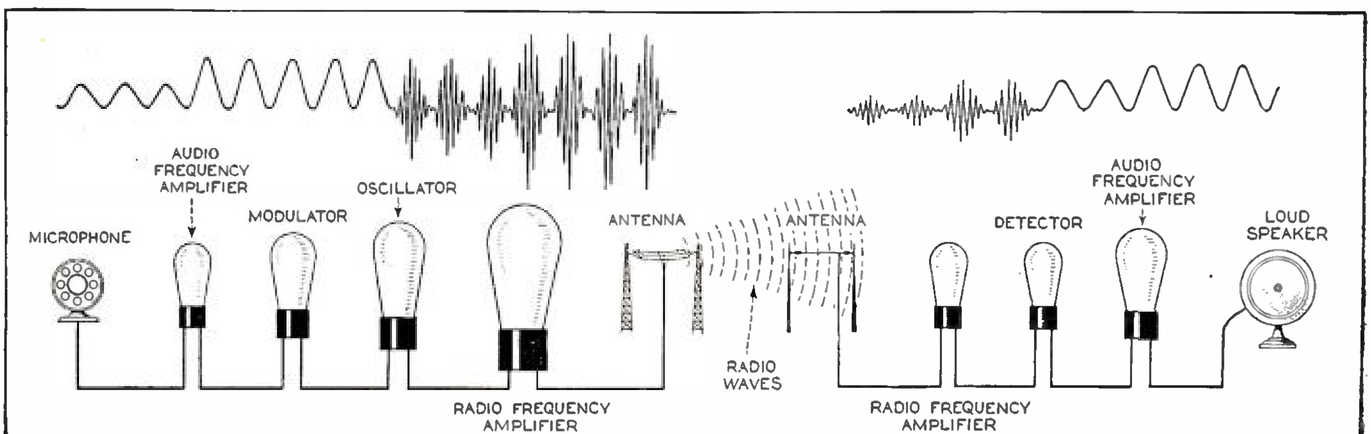


Figure 1. The rôle of the vacuum tube in radio broadcasting and receiving. This diagram shows the sequence and the purpose of all the tubes used from the microphone of the transmitting station to the loudspeaker in the receiving set. The changes in the form of the electrical waves are also shown

must now use several amplifying tubes to strengthen these weak electrical voice currents. The output of one tube is connected to the input of another, through suitable apparatus for linking the tubes, so that the tiny electric vibrations from the microphone are finally amplified to a very considerable degree.

Now, this voice-current or electrical vibration is made to do a wonderful thing. It is so fed into the circuit in which the radio oscillations are generated, that it varies the strength or intensity of the oscillating current in exact accordance with the air vibrations which were picked up by the microphone. The radio waves, therefore, are made to vary in strength according to the variation in strength of the oscillating current which generates them. It is this intricate combination of radio wave and audio vibration which is hurled from the antennas of our broadcasting stations to span the earth in every direction of the compass.

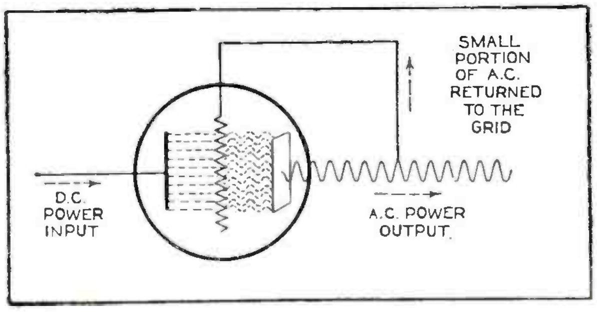


Figure 2. How the vacuum tube oscillates. When the circuits in which a tube is connected are so designed that a part of the output energy of the tube is brought back to the grid to again influence the output a steady alternating current is generated by the tube

When the radio waves, traveling at the speed of light in all directions from the antenna of the broadcasting station, pass the wire of a receiving antenna the electrons in the material of the wire are given a push, and we have a current of electricity flowing down the wire and into the radio set. These little electrical impulses follow in amplitude the variations in the radio waves emanating from the broadcast station.

The tiny electrical currents generated in the antenna by the passing radio waves, are used to charge the grid of the first amplifying tube. The amplified current, produced by the radio wave, is thus successively amplified by one tube after another in the radio-frequency amplifier, until a comparatively strong signal is obtained.

Our broadcast current, though much more powerful now after being amplified, still consists of a reproduction of the carrier wave modulated by the electrical equivalent of the sound wave picked up by the studio microphone. The detector tube in the radio set separates the high-frequency "carrier", which has already done its work, from the low-frequency current representing sound waves.

The audio currents, which have been picked out by the detector tube from the high-frequency carrier wave, are now further amplified by one or more vacuum tubes in the audio frequency amplifier in order to produce a current of sufficient strength to satisfactorily operate the loudspeaker. Considering the many transitions these energies must go through, it is remarkable with what fidelity the sound produced by the loudspeaker of a good modern radio set follows that which is originally produced in the broadcast studio.

The powerful vibration of your loudspeaker diaphragm originates from the merest "whiff" of electrical energy that the radio antenna delivers to the set. The total energy amplification of your radio set, between the infinitesimal current from the antenna to the powerful current which operates the loudspeaker, may be well over a million times! Without the aid of the amplifying vacuum tube such tremendous step-up of electrical energy would be utterly impossible.

Increasing the Range of the Nation's Communication Systems

Nowadays, when it is so easy to make a long-distance telephone call and to converse with a person across a continent, we little realize that before the application of the vacuum tube to telephony, engineers had almost considered a telephone conversation between New York and Chicago impossible. Besides radio transmission and reception hundreds of other applications for vacuum tubes have been developed. It is only through the use of the vacuum tube that long-distance telephony has been developed.

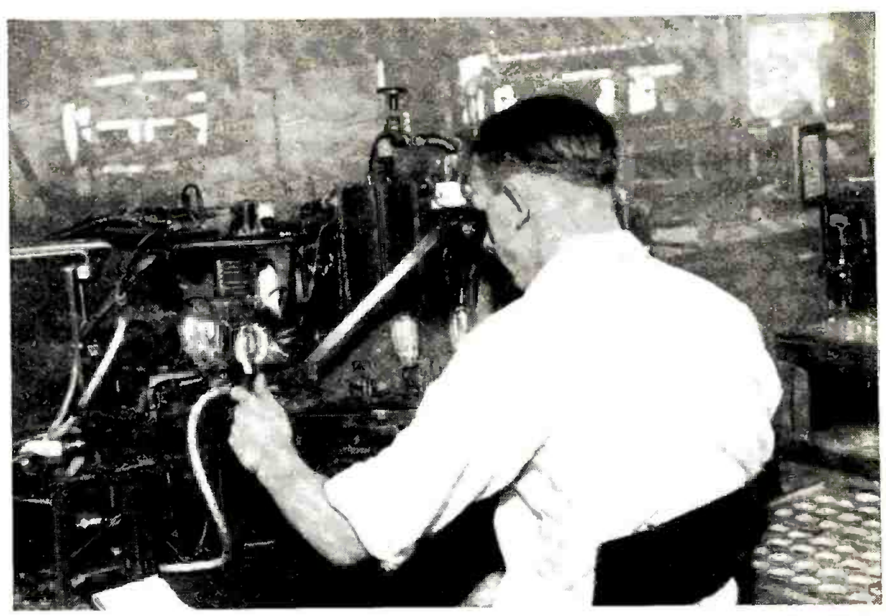
In every telephone circuit there is always a considerable loss of sound energy. In long distance lines this loss is great and can only be made up by the use of a device which would return more energy into the transmission line than that which was received at any point in the line. The vacuum-tube amplifier is ideally suited for such a purpose.

In the transcontinental telephone circuit extending about three thousand five hundred miles, the delicate voice-currents are reinforced at about thirteen points along the transmission line. In order to receive the required three hundred and fifty millionths of a watt of telephone energy to actuate the telephone receiver at San Francisco without the use of these amplifiers, several million kilowatts (equivalent to millions of horsepower of energy) would have to be delivered into the line at New York! Telephone lines are also being hooked up with radio transmitting stations to provide us with chain broadcasting and international telephone service.

The Versatile Vacuum Tube in Industry

Modern industry has been quick to grasp the vacuum tube, so widely used in radio transmission and reception, for its own particular uses. Since vacuum tubes have come into common use they have been given many new tasks. Industries that have never before given the vacuum tube a thought have now suddenly found that it can play an important part in their manufacturing processes.

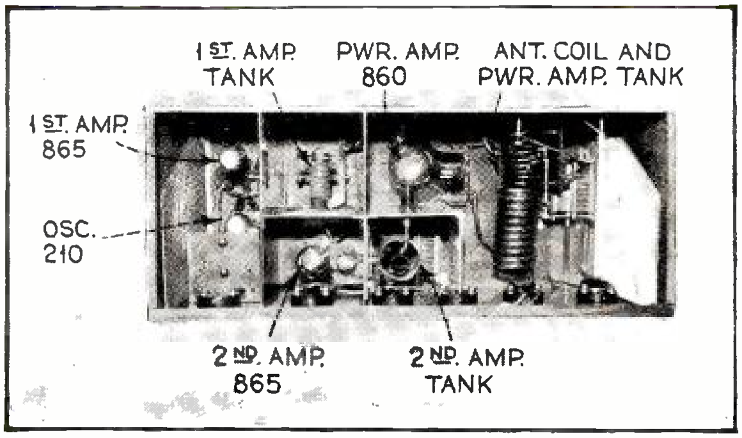
Many paper manufacturers are now using vacuum-tube equipment for constantly measuring and controlling the thickness of the paper as it comes out of the rolls. A micrometer gauge, through which the paper passes, controls the constants of the circuit of an oscillating vacuum tube so that a change in the thickness of the paper produces a corresponding change in vacuum-tube current. This change in current is used to give a continuous indication, in any desired part of the plant, of the thickness of the paper as it is (*Continued on page 338*)


A high-frequency furnace in which the high-frequency currents are produced by vacuum tubes in operation. The coil of heavy wire encloses an intense field which will bring to a white heat any metal placed within it. Thus, in vacuum tube manufacture the tube elements are subjected to intense heat during the "flashing" process, without damage to the glass bulb or stem

Radio News Prize

A detailed description of a multi-tube many of the features ordinarily looked installations. Provision is included for frequency

By Paul B.

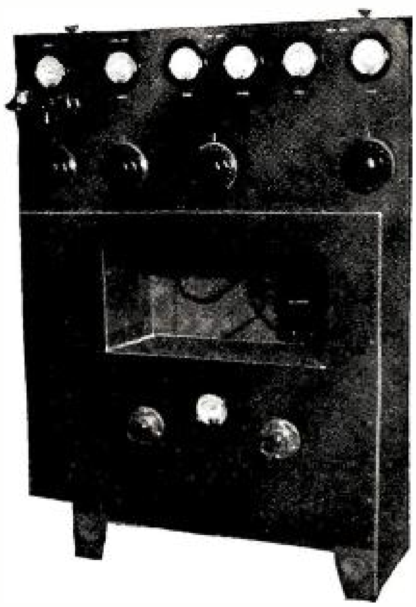


Top view of transmitter with main shield cover removed

IN the design of a truly modern transmitter there are many factors that cannot be overlooked. These may be considered in three groups: (a) The emitted signal must comply with the Federal Radio Regulations. (b) The transmitter must be of sufficient power and stability to permit reliable communication. Three-band operation is also desirable. (c) The cost of the component parts must not be unreasonably high.

In order to fulfill the first requirement, the emitted signal must be within the allotted frequency bands and must be of single frequency. That is, the unmodulated carrier must be "pure d.c." in quality and have little or no drift. The keying should be reduced to a minimum for the benefit of the neighbors. From the above specifications it is obvious that some type of master oscillator must be used.

For reliable communication at least fifty watts in the antenna should be used. Of course, two or even one type 210 can be urged to give this output, but this is far from good practice. Stable operation can be obtained only when the component parts of the transmitter are run below, or very near, their rated power. If operation in several bands is desired, more than one stage of amplification will have to be used.



Front view of transmitter and below it the cabinet containing the relays (behind window), filament transformers and low-voltage plate supply. The filament rheostats and filament voltmeter are seen on the lower panel

Cost an Important Factor

Unfortunately, when we set about designing such a piece of apparatus, the cost problem always rears its ugly head. However, during the last year or so, prices of standard makes of apparatus have been greatly reduced and it is now possible to build a real 1931 screen-grid-crystal-controlled-multi-band model for close to the price of a half-baked 1928 job with raw a.c. on the plate.

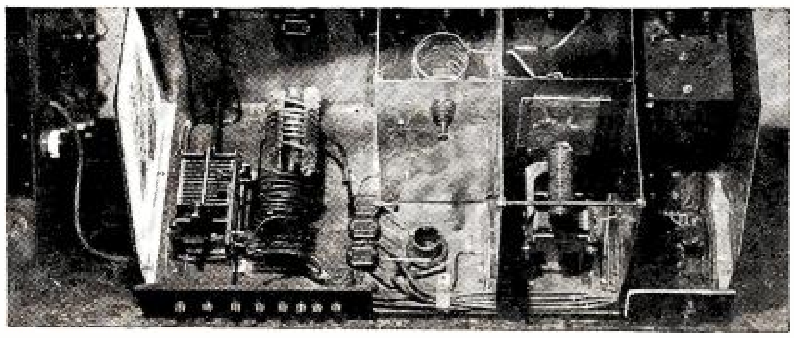
Now that we have the requirements, we can go about fulfilling them. First, it was stated that the outfit must be a master oscillator affair. There is a very wide choice of tubes and circuits that will make an excellent M.O. However, before choosing a layout at random, let us see what combination will do the best job.

Since this transmitter is to be a multi-staged outfit with an output of seventy-five watts, the cost will probably run quite high unless good judgment be exercised in its design. If an oscillator tube of low power rating is used, it will be necessary to use one or two extra intermediate stages in order to raise the excitation voltage of the power amplifier to the level required for efficient operation. In order to cut the intermediate stages to a minimum, we shall use a type 210 tube and run it well under rating. In this way we can obtain sufficient output and still maintain excellent stability. The tuned-plate-non-tuned-grid circuit seems to be as good as any from the stability point of view and a good deal better in respect to convenience and flexibility. By means of a simple switching arrangement in the grid circuit, non-tuned, choke, crystal or external excitation may be employed. Another point in favor of this circuit is that if series feed is used no r.f. choke need be used in the plate circuit. For multi-band operation the oscillator can be arranged with plug-in coils or it can be operated in a low-frequency band and a series of doublers used to secure the high-frequency excitation for the power amplifier. If the crystal control is to be used, it is advisable to run the oscillator in the 3500 kc. band and not to attempt to use 7 or 14 megacycle crystals.

Screen-Grid Tubes

The intermediate stages must be arranged so that plug-in coils can be used to facilitate rapid changing from one band to another. When amplifying straight through, either neutralization or screen-grid tubes must be used. 865 type screen-grid tubes are now on the market for only a few dollars more than the *good* type 210's. Their excellent operation more than balances the slight additional expense. Another feature of these tubes is that they require a relatively low bias voltage. This makes possible a more or less novel method of keying, which will be described later.

Convenience, efficiency and economy all seem to point toward the screen-grid tube for the amplifiers. Convenience, because rapid changing from band to band, or from one frequency to another requires only one simple adjustment of the tank condenser. Efficiency, because of the excellent characteristics of the tube and its



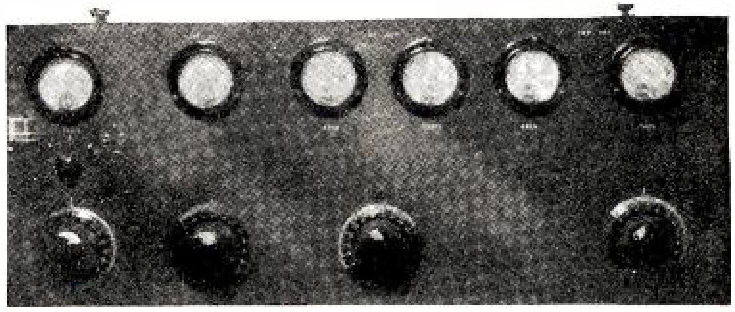
Rear view of transmitter with metal cabinet removed

*Amateur station, W2BWF, Troy, N. Y.

"Ham" Transmitter

amateur transmitter which includes for only in the best of commercial multi-band operation, with or without doubling

King, Jr.*



View of transmitter showing location of meters and controls

ease of excitation. Economy, not because of the low initial cost of the tube, but because of the saving in apparatus (namely, neutralizing inductance, condenser and grid bias battery) and upkeep. If properly used, all modern tubes have remarkably long lives. Since no fifty-watt screen-grid tube is on the market, the 860, young screen-grid brother of the well-known 852, is the best choice.

The Plate Voltage Supply

For best operation, three separate plate supplies will be necessary. Nearly every ham will throw up his hands in holy horror at this suggestion, but will probably agree with me before I finish.

The 150-volt supply for the crystal stage can be had from an old "B" eliminator (procurable anywhere from two dollars down at any second-hand store—mine cost 50 cents). The 550-volt supply can be very easily assembled at low cost from components sold by any of the wholesale or mail-order houses that have been sending us catalogs for years. High-voltage is never cheap, but by a careful selection of parts, the cost can be brought to a minimum.

The filaments are supplied from two transformers, one with a ten-volt secondary and one with an eight-volt winding. Each of these is equipped with a separate primary rheostat. The filament voltmeter is arranged to switch from one transformer to the other.

The antenna tuning apparatus is not included in the transmitter because of the constant changes always going on at the station.

With the foregoing paragraphs in mind, the transmitter now at W2BWF was constructed. The following layout was adopted only after several months of more or less constant experimentation.

The crystal oscillator uses a type 210 and is arranged so that one of three quartz crystals or resonant chokes may be selected. The first amplifier employs a type 865 tube, and is capacitively coupled to the oscillator. The second amplifier is similar to the first. The power stage employs a type 860, seventy-five-watt tube. Unlike the other stages, it is inductively coupled to its exciting amplifier. The antenna is inductively coupled, but may be capacitively coupled if so desired.

The foregoing is a general outline of the transmitter proper. Each stage will be dealt with in detail.

The oscillator employs the simplest possible circuit, with no frills or unnecessary trimmings. It was found advisable to arrange the apparatus so that the crystals could be mounted outside the cabinet, as the heat of the (*Continued on page 351*)

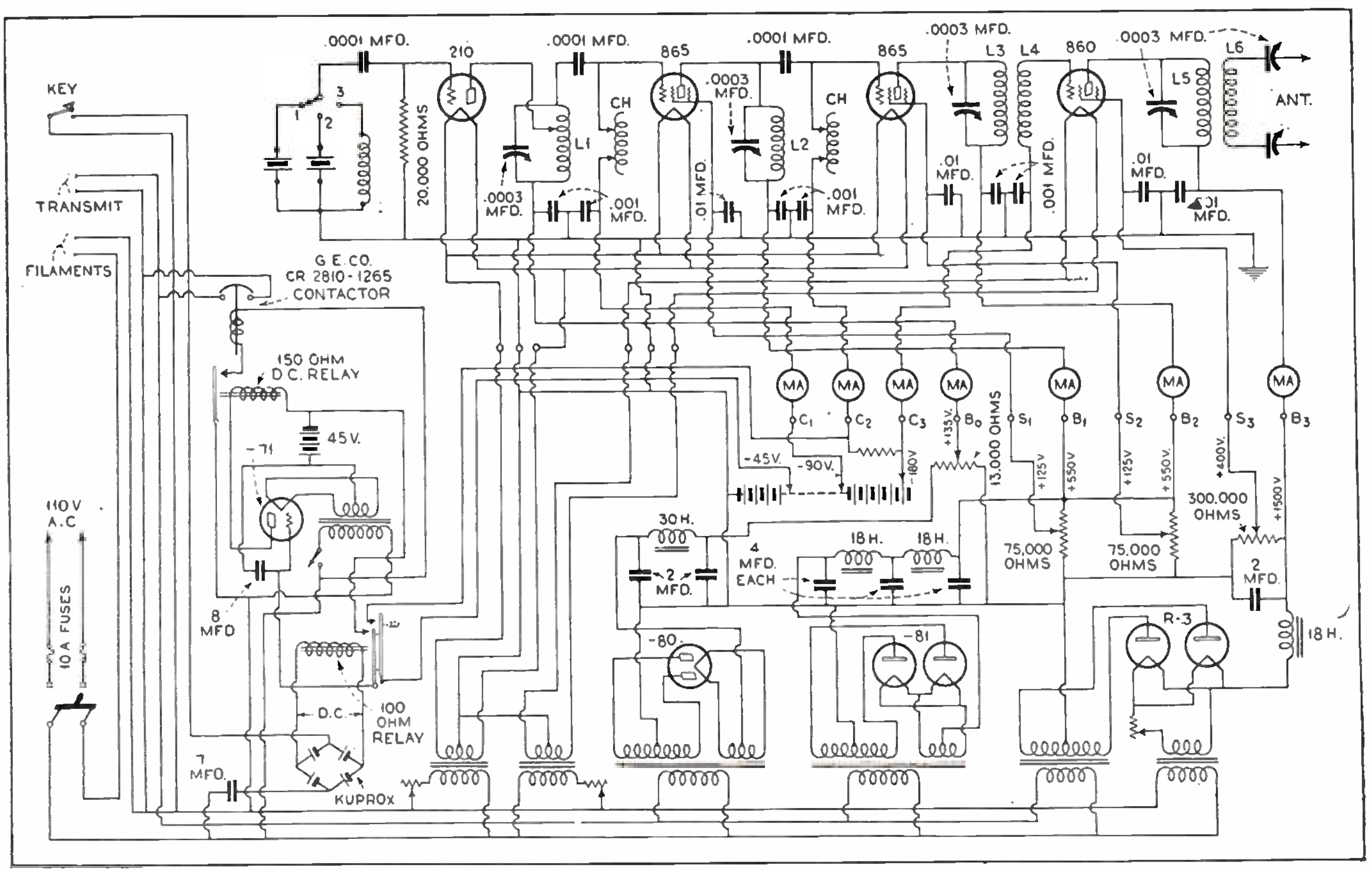


Figure 1. The schematic diagram. At the left is the automatic power-switching circuit. Pressing the key turns on the plate power, but the -71 tube circuits act as a lag to keep power on for short interval after keying stops

What Will Be Our Future Broadcast Fare?

There can be no question that radio broadcasting is with us to stay and that it has reached a level of high entertainment and economic value—yet there is still room for improvement, as Mr. Bouck points out

By Zeh Bouck

RADIO broadcasting, no longer in its infancy, is emerging from the anesthesia accompanying the minor operations of adolescence. Radio today is in its formative stage, and by an analytical consideration of its past and present we can form a good idea as to where it is logically progressing and what directive efforts should be made to paint a more roseate future than is indicated by its unassisted and haphazard evolution. Radio may either be permitted to flourish like a weed, or be cultivated like a rose. A system of eugenics may be applied, or radio may continue to evolve by natural selection and like the whale with its vestigal legs carry on for a hundred million years useless encumbrances of the past.

We are in the unique position of being able to consider the past in a contemporary light rather than in a historical sense. Most of us old timers can look back and recall, even vividly, the old days of broadcasting, but few of us can resurrect our reactions at the time, and it is only in this light that we can make a true comparison with conditions existing today and prophetically look into the future. That is the reason why people either keep diaries, don't keep diaries, or burn diaries.

Radio is today third among our legitimate industries; in absolute figures it is fourth. It would appear that radio is firmly entrenched in the hearts and habits of the American people. Almost without regard to the manner and direction in which radio progresses, it is bound to last. Even if it is never any better than it is today, our grandchildren, aye and theirs, will listen just as they would be satisfied to ride in an automobile even if no improvements over the 1931 models were ever developed. The movies once predicted (hopefully) an ephemeral existence for radio. Radio then gave the movies the talkies, and they are both going strong. The phonograph manufacturers predicted a short life for radio (hopefully) and radio gave the talking machine its electric reproduction in exchange for a share in its best artists.

Doug and Mary before the mike at old WJZ—among the very first of famous personalities on the air

Harking Back With the Author

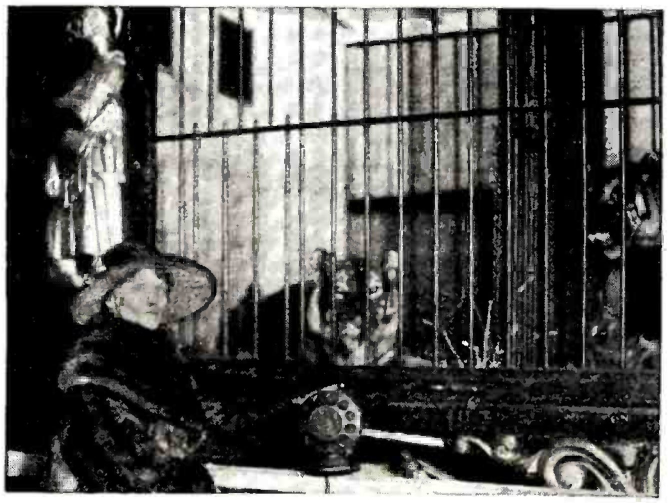
But even as late as 1926, Efrem Zimbalist, in explaining his consistent refusal to broadcast, prophesied a short life for radio. In the New York *Sun*, on January 16th of that year, we wrote: "Efrem Zimbalist, the eminent fiddler, takes hope (so it would seem) in the declaration that broadcasting is passing through an ephemeral existence, into an oblivion not more than two years distant. Radio cannot live because, declares Mr. Zimbalist, 'it certainly has no artistic value. One of the reasons for this is the vast amount of rubbish broadcast'!"

But on April 27th, 1929, a bit more than two years later, and plenty of time for radio to have passed into oblivion, we wrote in the Cincinnati *Enquirer:* "The inadequacy of the average violinist was demonstrated last Sunday evening by Zimbalist in the Atwater Kent Hour. Zimbalist played as we had long forgotten a violin could be played. In his hands the instrument became something more than a fiddle to be sawed upon by the Evil One in the Danse Macabre and consigned to his headquarters generally anyway. We enjoyed the program immensely. It would be silly and pedantic to pass further comment on Zimbalist's playing."

Though radio itself may be a permanent institution, its influence and effects may be variable. Two fundamental factors enter into the equation—its technical progress and the appeal of the programs offered. The latter is perhaps the more important consideration, if only because, ultimately, it is the most insistent stimulus to technical perfection. It might be said, without undue exaggeration, that the fate of the entire industry—engineering, manufacturing, servicing, the fan aspect, etc., is dependent upon the excellence of radio programs. So, in our analysis of broadcasting, the program will be our first matter of condemnation and of praise.

The Trials of 1926 Are Still With Us

At least a part of Zimbalist's prediction, his forward-looking



The first of the "stunt" programs. At the zoo declaration has stood the test of time—his reference to the "vast amount of rubbish broadcast." "Rubbish," to Zimbalist, referred to the trash broadcast by unpaid artists before radio was established on a commercial basis as an advertising medium. With Zimbalist himself upon the air, rubbish necessarily takes on another meaning, and refers to the contamination of really good material by a plethora of advertising drivel.

The program overloaded with such rot is recognized as a genuine problem in broadcasting, but it is by no means a matter of recent vintage as many of its critics would assume. A comparson of today's programs with those of some years ago will indicate the progress in this direction and the extent to which efforts should be made curtailing this nauseating "plugging" in programs of the future.

Whatever were the inadequacies of the early days of broadcasting, they were happily free from the offensive ballyhoo that still ruins some of our best programs, causing a million listeners every night vainly to search the dials for something palatable to an intelligent taste, or eventually to turn off the radio in disgust. Advertisers were slow to accept the new medium, and it was not until the spring of 1925 that we find our first rebellion against rank practice, but apparently things progressed rapidly in those days, and we find ourself, a year later, in a more critical spirit.

Above, J. Andrew White goes over a few details before his broadcast of the Dempsey-Firpo fight

Left, "The Waters of Minnetonka" was worn to shreds 'way back in '26, as indicated by this cartoon which headed one of the columns of the author, who was probably the world's first radio columnist and broadcast critic

One Advertising Man Offers His Viewpoint

On the other side of the question, however, a prominent advertising man once complained to us. "Our client," he said, "pays good money, over $75,000.00 a year, to give the radio audience some enjoyable music. In return for this twenty-five minutes of good music, furnished to the listener free of charge, but at a big cost to our client, I don't think that you or anyone else has a right to kick if we use five minutes to say something about the product. Am I right or am I wrong?"

A most naive and logical argument! His client, for $75,000.00 a year, has a right to broadcast anything he feels like, from "The Waters of Minnetonka" to the Sears, Roebuck catalog. But five minutes means about 750 words of advertising. Considering the average of the best full-page advertisements in large circulation present-day magazines, that is equivalent to five pages, a pretty good size dose that would just about use up his seventy-five grand in two issues!

It takes the average reader about three hours to go through the fiction and articles in such a magazine. He spends much less than that time on the advertisements. Moreover, he scans the ads when he feels like it. They are not forced upon him and he rarely interrupts himself in the middle of a story to investigate the merits of a manufactured product.

The ratio of about thirty to one seems to be the palatable limit—less than one minute of advertising in a half hour broadcast. And even this must be handled deftly, or, in its very incongruity, it will stand out like a sore thumb and defeat its own purpose. To most listeners, the radio is psychologically akin to the theater. It is no place for a sales talk, and to be harangued on the virtues of any product between classic orchestral renditions is on a par with having Toscannini take orders for a pet brand of violin between the Andante and Allegro of Tschaikowsky's Fifth Symphony.

Roxy—and the original gang. First and foremost, and perhaps the finest, among institutional programs, and the one that started a billion-dollar industry

As a warning to broadcast advertisers it may be well to note that already at least one man of imagination has designed a device which will automatically cut off the loudspeaker during announcements. It is the inventor's idea that silence is vastly preferable to much of the advertising matter now being broadcast. This plan has its drawbacks—particularly in that it cuts out desirable announcements along with the bad. It does, however, indicate a measure which eventually may be adopted.

In the vast majority of instances the value of a radio program to its sponsors depends directly upon the degree to which it *pleases the audience*—its entertainment value, and this varies, perhaps, inversely with the amount of advertising it contains.

Explorers *of the* Ether

The "amateur," "experimental" and "special service" designations used by the Federal Radio Commission in licensing transmitters are among the most interesting from the standpoint of the short-wave fan. The author here tells something of the purposes of transmitters licensed under these classifications, and the regulations covering their use

By Carl H. Butman*

THE special services of radio, according to present classifications, comprise amateur, experimental —including television work—police and fire, geophysical, agricultural, emergency, motion picture and private services. This group constitutes what is likely the most interesting and appealing group of radio activities. Each service has great future possibilities in that extensive developments of special radio communication and "television" lie ahead of us.

The entrance into radio of many of today's successful engineers and inventors was brought about by their early amateur interest in communication without wires. Even before broadcasting's advent, many enterprising and venturesome young men were attracted to the possibilities of exploring the ether waves and communicating with associates in different parts of this country and the world, with the result that what first appeared to be a sport soon became a practical hobby and then a vocation.

Reviewing the Department of Commerce's list of radio amateurs back in the days prior to 1915, we find the names of three of the high officials of the American Radio Relay League: Hiram Percy Maxim, President; Charles H. Stewart, Vice-President, and Kenneth B. Warner, Secretary.

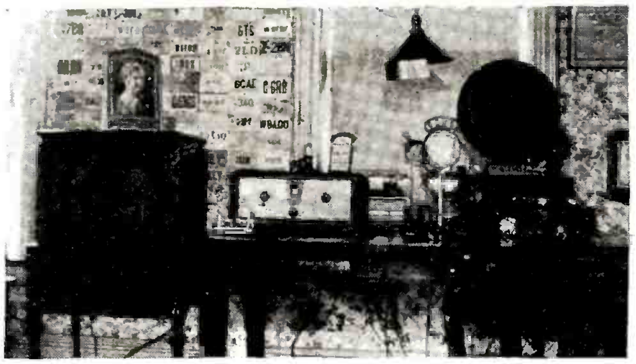
Among the other "old-timers," although we are speaking of a period only sixteen years ago, are such well-known radio men as Alfred H. Grebe, Dr. A. Hoyt Taylor, U. S. N.; John L. Reinartz, C. W. Horn, Arthur Batchelor, Traveling Supervisor, and E. Downey and H. D. Hayes, Supervisors of Radio; Gerald C. Gross, Federal Radio Commission; J. E. Smith, National Radio Institute, and many others who are now following professional radio careers.

Those interested in amateur work should secure a copy of the Federal Radio Commission's General Order No. 84 as amended from any local supervisor or from headquarters in the National Press Building at Washington. Further information may be secured from the American Radio Relay League, familiarly known among "hams" as the "ARRL," Hartford, Connecticut.

The American amateurs are responsible for much of the efficiency and broadness of scope of radio communication today. They are credited for their experiments, hard work and accomplishments, especially in developing the practicability of short waves for long-distance communication with low power.

Once these intrepid radio explorers ranged freely and unsupervised over practically the whole radio spectrum. Today they are restricted to a few narrow bands of frequencies, due to the ever-increasing demands for more and more channels for commercial, governmental and other essential services. The radio spectrum, broad as it may seem to some, is actually very limited.

*Radio Consultant. Formerly Secretary, Federal Radio Commission.



In spite of the terrific demand for wavelengths by commercial broadcasting and other interests, the amateur still has a number of short-wave bands set aside by the Federal Radio Commission for his exclusive use. Here is the operating table of 9DUD, amateur station of Wells Chapin, St. Louis, Mo., typical of the many amateur stations that have made names for themselves in radio experimental circles and in emergency communication in times of catastrophe

The amateur channels assigned for exclusive use are from 1,715 to 2,000 kc. (175 to 150 meters), used for short distance; 3,500 to 4,000 kc. (85.7 to 75 meters), used for medium distances; 7,000 to 7,300 kc. (42.9 to 41.1 meters), available for longer distances; 14,000 to 14,400 kc. (21.4 to 20.8 meters), for international communication; 28,000 to 30,000 kc. (10.7 to 10.0 meters), for long-distance international communication, and 56,000 to 60,000 kc. (5.3 to 4.9 meters), and the last band, still of experimental value only, reaches from 400,000 to 401,000 kc. (.74 to .73 meters).

All these channels may be used for continuous-wave telegraphy, but only the first, second and sixth bands are available for radio telephony, except by special authority. The first and sixth bands may be employed for amateur television, facsimile and picture transmission. The maximum output power is limited to one kilowatt.

A little over a year ago, when serving as Secretary of the Federal Radio Commission, the writer called together all the amateur interests in an effort to revise the Federal operating regulations and aided somewhat in bringing about the issuance of General Order 84, which, as later amended, recites exactly and specifically what amateurs may and may not do.

They must not transmit messages for pay or engage in communication for material compensation, either directly or indirectly. The use of damped waves is forbidden to amateurs, but this is also generally debarred from any use except in emergencies. Other regulations require the use of efficient, non-harmonic producing apparatus, the keeping of logs and the procuring of an operator's license, etc.

Up until last fall the licensing of amateurs reposed in the hands of the Chief Supervisor of Radio of the Department of Commerce, who delegated his authority to the several supervisors. This practice was revised in September, 1930, when the Commission recalled its delegated power, deciding to administer this field as it does other types of service. The supervisors of the Department of Commerce, however, still give the amateurs' examination for operator' licenses and make inspections of the installations just as they do for commercial services.

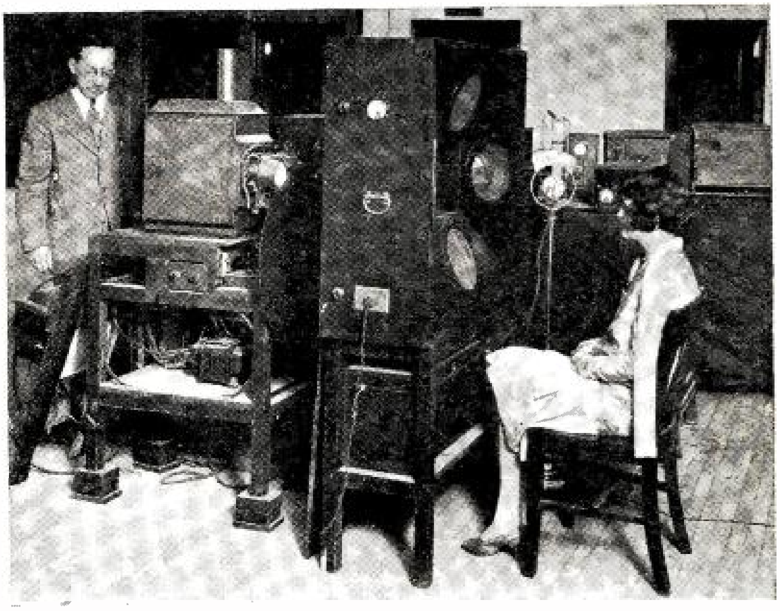
There has been an increase of 2,165 amateur stations during the past fiscal year, believed to be the largest increase since 1922. The total on June 30, 1931, was over 20,000 amateur stations.

Radio in Emergencies

The essential value of radio as a reliable means of communication, especially over long distance, is revealed by the fact that in nearly every disaster and in many emergencies radio has continued to function when, in many instances, other means of rapid communication have failed. I have in mind, for example, the severe blizzard in February, 1916, when amateur radio circuits were used extensively in train dispatching. Again in January, 1924, during a blizzard in the Great Lakes region, radio served a great public need in train dispatching. When the New England and Mississippi floods paralyzed wire communication in 1927 amateurs again rendered excellent temporary services to their respective communities. Amateurs and commercial stations handled thousands of imperative distress and emergency messages between the States and Porto Rico during and following the Florida and Porto Rico storms in September, 1928. The Bull Insular Line provided such commendable service between its experimental stations, W2XAP, New York, and W3XA, Baltimore, and W4XK in San Juan, that the Governor of Porto Rico wrote the company, expressing his thanks, as did also the American Red Cross.

General Experimental Work

Unfortunately many of the early radio records of the Commerce Department were destroyed by fire, so it is not possible to list the first licensed experimenters in radio, although it is known that many began as amateurs. All were explorers in this new field. In a list of experimental stations on the air in 1915 we find a few names well known today in radio circles. Among them are John Hays Hammond, Jr., Prof. John H. Morecroft, Frank Conrad, Robert F. Gowen, J. Harris Rogers, Alfred N. Goldsmith and Peter Cooper Hewitt, but there were many others who were qualified operators.



AN EXPERIMENTAL TELEVISION STATION

There are a number of television transmitting stations now working on regular published schedules, but the majority, such as the one shown here, are still in the experimental stage. The Radio Commission has assigned certain frequency bands for this type of transmission, which is one of the special services mentioned in this article

General Orders 64, 68 and 88 cover experimental requirements, but it is necessary to file applications for construction permits specifying the available frequencies, site and purposes for which the facilities are sought just as in applying for commercial or broadcast licenses. In experimental work, however, licenses are only issued to bona fide experimenters who are striving to improve radio communication, develop new methods of transmission or are exploring some of the various phenomena of radio. For the use of such applicants as survive the rigorous requirements fifteen specific channels are available; that is, to be shared among the experimenters in the way that ship channels are assigned to licensed watercraft. In addition to these fifteen channels a band of frequencies between 60.000 and 400.000 kc. is available for research work.

Today there are listed in the records of the Commission 157 general experimental stations and thirty special experimental stations, licensed to conduct tests on certain other frequencies. This latter class of work includes field intensity tests, special experiments in connection with the development of transmitters, trans-oceanic telephonic research work, etc.

Recently several temporary licenses were issued to the broadcast chains and other stations for use in short-wave pickups. Six special channels are now reserved for this type of service.

Some of the difficulties encountered by unqualified experimental applicants are revealed in the reports of the Commission examiners who did not find that the granting of construction permits and licenses would be in the public interest. One examiner recommended a denial because the applicant failed to show that the proposed experiment would warrant a belief that contributions to the radio art would result or that he was qualified as a radio engineer or even an operator. This applicant's ignorance of the radio situation was disclosed when it was shown that the frequencies for which he applied were assigned to other services and unavailable for experimental use. Another applicant, a manufacturer of radio apparatus, also failed to convince the examiner of his technical and financial ability to undertake experiments or improve on apparatus now in use. He, like the first mentioned applicant, was denied the privilege of experimenting in the already congested channels allocated to this use as are many of those desirous of enjoying this privilege.

Relaying Programs to Foreign Countries

Although originally relay broadcasting included the transmission of programs on short waves from one American station to another, this privilege is not accorded to applicants in this country, due to lack of channels, such privileges being granted only for use in transmitting broadcast material abroad for rebroadcasting by foreign stations.

Data and regulations for the relatively small group of relay broadcasters are available in General Orders No. 64 and 68, which clearly show that relay broadcasting is still classified as an experimental service and only authorized for qualified applicants. The Commission requires detailed technical reports quarterly when a showing of service made available to foreign stations must be made. There are only twenty channels available for the joint use of the twenty-four stations licensed to engage in this type of work. The licensees comprise chiefly the larger broadcasting and radio manufacturing interests, equipped financially and technically to carry out this type of work under the direction of skilled engineers. In the list of stations so licensed are found the names of the National Broadcasting Company, the Atlantic Broadcasting Corporation, the Westinghouse, General Electric and Crosley companies, the Federation of (*Continued on page* 333)

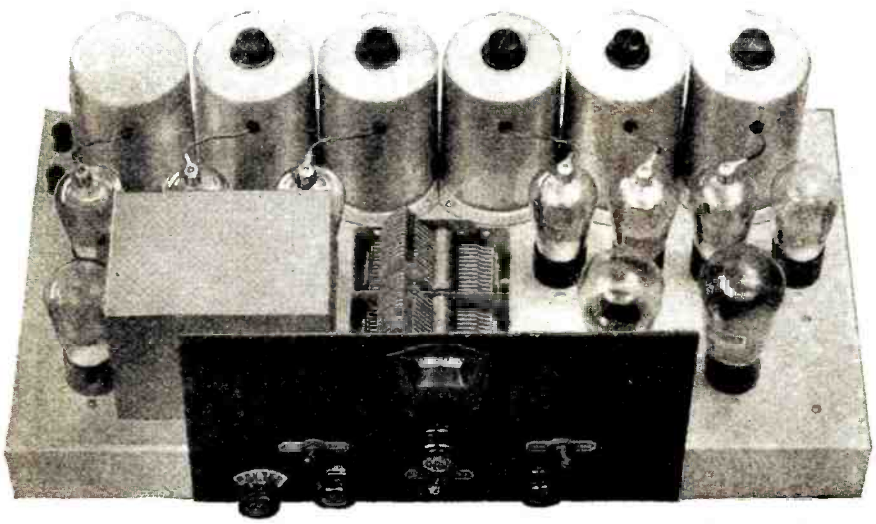
De Forest Radio Photo

One of the Michigan State Police cars which, because of its radio receiver equipment, is in constant touch with headquarters and can sometimes be at the scene of a crime in time to catch the criminals red handed

The Latest All-Wave

A laboratory-built receiver 15 meters to 550 meters. Band means of a switch on the front coil

By W. H.



The ten-tube chassis. The lower left-hand knob on the panel is the wave-band changing control which permits instantaneous wavelength changeover

SIMPLICITY has been the key to success of every great invention. Probably in no field of endeavor has the above fact been more apparent than in the development of radio. Looking back over the last few years of rapid design change, every new principle, every new improvement in performance in radio receivers has gone through a cycle of refinement and boiling down, accomplishing even better results with fewer parts, lower cost and added eye value.

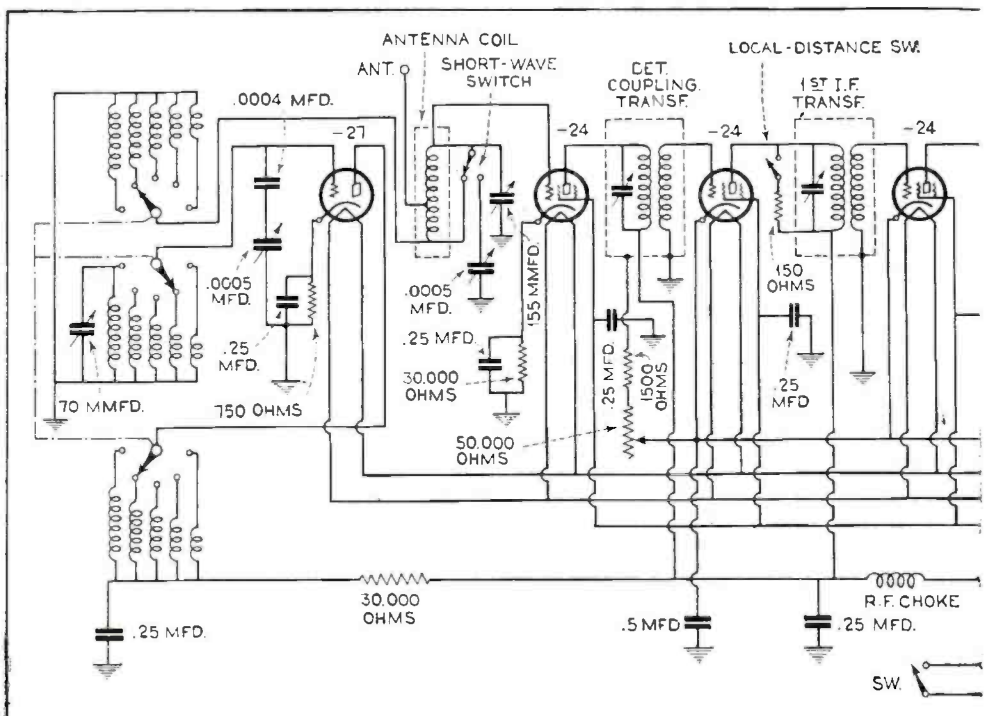
Just a few years ago when the romance of radio was first fully grasped by the public many homes were literally converted into radio laboratories, and father, the staid business man, took a new lease on life in working out many interesting phenomena in the early radio science. This romantic period is fast dying out and radio today has passed from the "den-and-cellar" workshop into the "drawing room." This cycle of evolution is now complete in the broadest receiver and another improvement is taking place in a new type of equipment, the all-wave type, capable of extending the horizon of radio reception to unlimited distances, realizing the dreams of every radio loving fan. With these facts in view, much thought was given the design of the Lincoln De Luxe SW-32 receiver to eliminate, in one fell swoop, the inconveniences and defects which have in the past been apparent. In the design of a combination short-wave and broadcast receiver, it is a well-known fact that far more careful thought is necessary for the successful reception of the high-frequency signals than for signal frequencies of the broadcast band, from 200 to 550 meters.

Special precautions must be taken to eliminate losses in dielectrics, especially where receivers are operated in foreign tropical countries where humidity is high, and many other features, to be described later, must be worked out, not overlooking simplicity of design and ease in operation. Let us itemize a few of the outstanding features:

Capitalizing on the advanced design of the Lincoln De Luxe SW-31, which had only one plug-in coil to change for each group of frequencies, the new SW-32 has its coils mounted permanently in a group and thoroughly shielded, selection being made by a rotary non-capacitative switch, operated from the front panel. With this improvement instantaneous change may be made from any group of short-wave bands to another or to the broadcast band, eliminating all inconveniences and simplifying operation to a degree whereby any inexperienced operator can tune from 15 to 550 meters with ease.

Through valuable experience in designing special equipment for the MacMillan Polar Expedition, where extreme weather conditions affect the performance, each coil is thoroughly impregnated in an effective insulating compound, assuring uniform efficiency and reliable performance. The writer was forcibly struck with the performance in this design at a demonstration given before a representative group in western Illinois under conditions ordinarily unsuitable for anything but near-by reception. The temperature was 105 degrees, immediately succeeding a heavy cloudburst, yet European stations were brought in with perfect clarity and at almost any loud speaker volume desired. In the broadcast band, WOR, WEAF and other stations 10 kilocycles away from the Chicago locals could be brought in without interference, even when the volume control was advanced to the maximum.

The general arrangement of the receiver is identical with its previous model; in fact, the fundamental features are identical throughout with the well-known Lincoln design. It may be of interest to know that owners of the De Luxe SW-31 or



The circuit diagram. The power supply, not shown here, is a

*President, Lincoln Radio Corporation.

Receiver Design

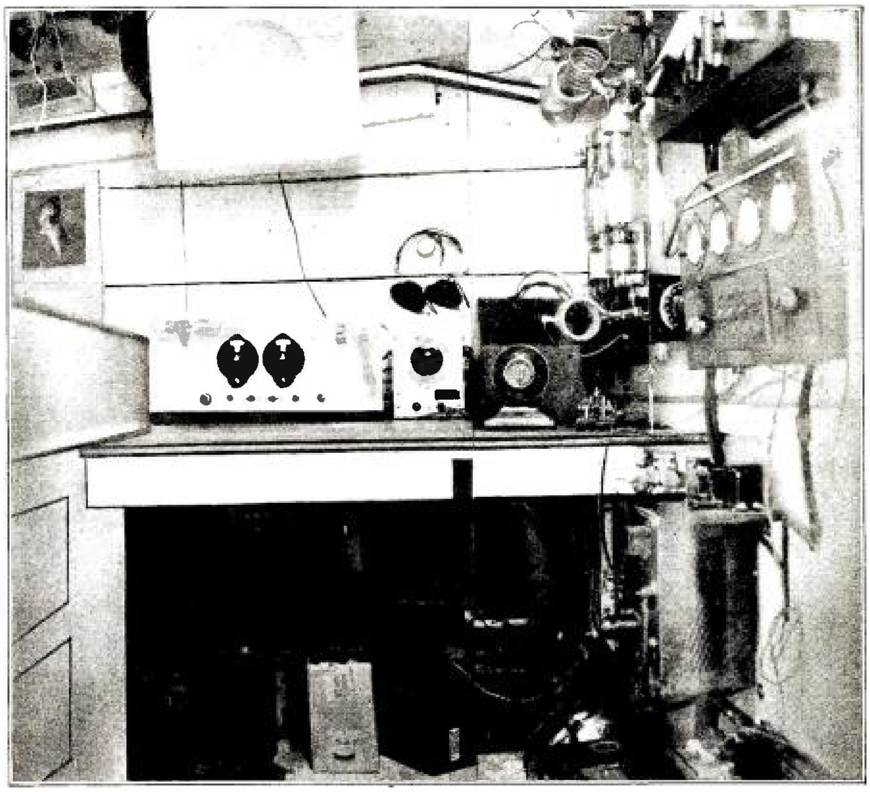
which covers all waves from changing is accomplished by panel, eliminating the plug-in nuisance

Hollister*

De Luxe "31" can have all the De Luxe SW-32 improvements incorporated in their present receivers.

Chassis Description

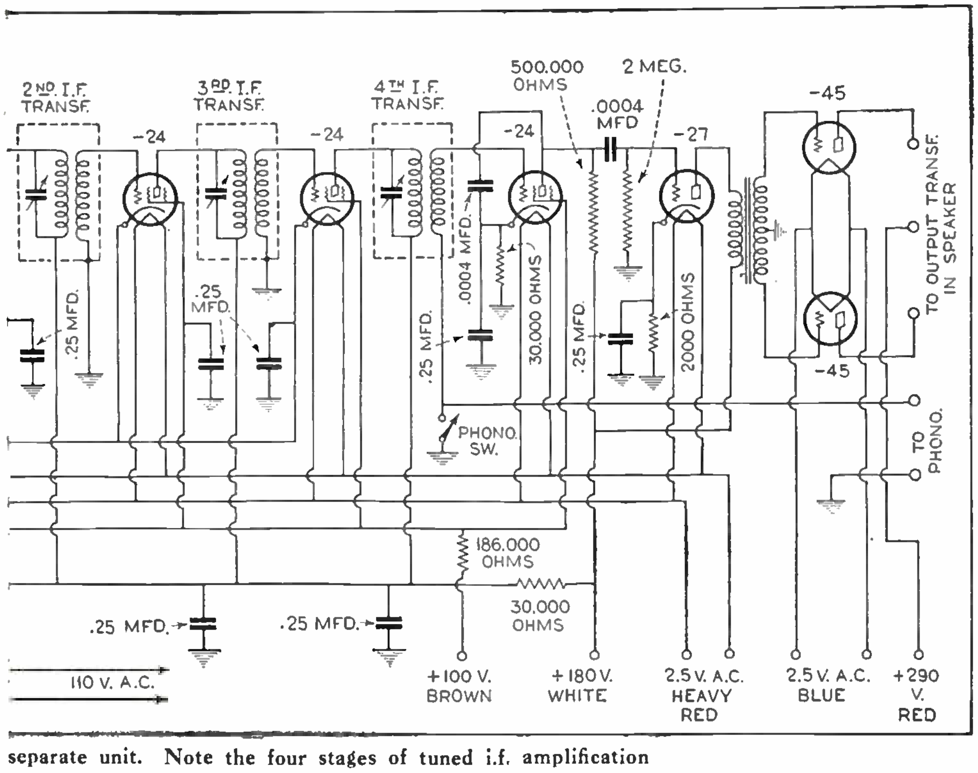
Mounted in a straight line on a heavy, satin-finished cadmium-plated base are the high amplification i.f. transformers, so essential for extreme distance with high volume. In straight cascade are located the -27 type oscillator, -24 type first detector, four stages of -24 type i.f., -24 type second detector, -27 type first audio and -45 type push-pull second audio stage. In this circuit no advantage was found in the use of multi-mu tubes, and due to the tremendous amplification, of which only a fraction is used for average reception, the Pentode tube was quite unnecessary. The Pentode tube was also found to depreciate the quality of tone. The front panel controls are simplified, utilizing one dial control with antenna trimmer, low and high power switch, short-wave and broadcast switch, phono-radio switch and volume control.



Specially designed Lincoln receiver installed as part of the equipment on the MacMillan Polar Expedition schooner "Bowdoin", used in maintaining two-way communication between the "Bowdoin" and Chicago

The underside of the chassis is wired with rigid bus bar. This not only exemplifies precision laboratory methods, but a decided advantage was found in arranging every wire to allow for the high amplification without regenerative feed backs. Twelve .25 mfd. condensers give excellent by-passing at all points desired.

Power equipment is in a separate unit and is composed of condenser bank with a wide margin of safety against voltage breakdown and a substantial choke and power transformer. The heater supply winding of the power transformer is of large stranded cable, capable of handling 30 amperes and actually handling 11 amperes. The field of the special auditorium dynamic speaker is excited by the power supply unit, necessitating a field of 2,250 ohms.



separate unit. Note the four stages of tuned i.f. amplification

Intermediate Frequency Transformers

The i.f. transformers are of the tuned plate, high impedance type, tuned to 480 kc., a frequency found to be perfect for short-wave reception. Plate and grid windings are of the solenoid type, universally recognized for highest efficiency. The plate coil is tuned by highly insulated 100 mmfd. stator and rotor type low-loss condensers. Five of these tuning units produce a total rejectivity sufficient to permit the oscillator to be rotated slowly from a station to its adjacent 10 kc. station without interference between the two.

Oscillator Assembly

Mounted on left side of the chassis are five coils—the broadcast oscillator and four combination antenna and oscillator

(*Continued on page* 334)

Mathematics in Radio

Trigonometry and Its Application in Radio

By J. E. Smith*

PART TEN

TRIGONOMETRY teaches us the relation of lines and angles and we learn from the study of this subject that it has many useful and practical applications to engineering problems.

It has been shown that the study of algebra is essential to the understanding of changing expressions from one form to another, for in various discussions it is necessary to alter the factors in order to obtain a certain result. It has been shown that geometry is essential in order to appreciate the dimensions of space and we have learned some of the factors governing geometrical figures.

The factors governing trigonometric relations are based primarily on the ratios of the sides of a triangle to an included angle and the complete theory of trigonometry is built up from this very simple relation. From these relations the phase of currents and voltages in an electric circuit are more readily understood, power in alternating-current systems is better appreciated, losses in radio apparatus such as coils and condensers are more easily explained, and several other designs are dependent upon the theory and understanding of trigonometry.

Let us consider the right angle triangle of Figure 1, and express the relation: the ratio of the side opposite the acute angle x to the hypotenuse h is to be called the sine of x. This begins the theory of trigonometry, and it is a mathematical assumption that the sine of an acute angle in a right angle triangle is the ratio of the side apposite the acute angle to the hypotenuse of the triangle.

We can go a step further and show that this will have a definite numerical value. Let us suppose that the angle x is equal to 45°, then since the angle C is 90°, angle B must also be equal to 45°, for we know from geometry that the sum of the angles of any triangle is equal to 180 degrees. Therefore, side AC must equal side BC. Now we know that the square of the hypotenuse is equal to the sum of the squares of the other two sides. Referring to Figure 2, we see that the sine of an angle of 45° has a numerical value of .707. It will be found that this ratio will be constant for any one angle, for if the sides of the triangle in Figure 2 be extended any definite amount the ratio of the side opposite the hypotenuse will still have the value .707.

Cosine

Let us express the relation: the ratio of the side adjacent to the acute angle x, to the hypotenuse h, is to be called the cosine of x. It can be readily appreciated from Figure 2 that the numerical value of the cosine of an angle of 45° will have the same value as the sine of that angle.

Referring to Figure 3, let us determine the sine of an angle equal to 30 degrees. Let the triangle ABC be an equilateral triangle and draw BD perpendicular to AC which will bisect AC. If side AB is equal to "a," we find that AD will be half this value, and since the triangle is equilateral it is also equiangular and the angles of ABC are each equal to 60 degrees. The angle x is thus equal to 30 degrees and we find by reference to Figure 3 that the sine of x is equal to .50.

In order to find the numerical value of the sine of 60 degrees, we can apply the algebra we have already learned, and remembering that the square of the hypotenuse is equal to the sum of the squares of the other two sides, we can find that the sine of angle y of Figure 3 is equal to the value .866.

Tangent

Let us express the relationship in a right angle triangle: the ratio of the side opposite the acute angle, to the side adjacent, is to be called the tangent of the angle.

These three relations, the sine, cosine and tangent of an angle are the three fundamental considerations of trigonometry which are applied continuously to radio circuits and systems, and to apparatus design. Other relations will be shown later and it is interesting to note that the sine of an angle of 30 degrees has a value of .50, the sine of an angle of 45 degrees has a value of .707 and the sine of an angle of 60 degrees has a value of .866.

Extending the theory a little further, we find in considering Figure 4 that if we take the sine of x in triangle ABC and compare it to the sine of x′ of triangle AB′C′ that the numerical value is rapidly approaching the limit 1. For we see that side BC is at some one time going to be equal to side AB, the hypotenuse. It is obvious that as the angle is generated by the line AB moving in a counter-clockwise direction, the angle will appear in different parts of the circle. For convenience, the circle is divided into four parts called quadrants, as in Figure 5. An angle is in the first quadrant when its value lies between 0 and 90 degrees, in the second between 90 and 180 degrees, in the third between 180 and 270 degrees, and in the fourth between 270 and 360 degrees.

The distance from a point to the vertical line is called the "abscissa" of that point. If positive, this is measured from YY (Figure 6) toward the right. When the point is at the left, the abscissa is negative. The distance from a point to the line XX is called the "ordinate." When above the line XX the ordinate is positive, when below XX it is negative.

In considering the angle generated by a line moving in a counter-clockwise direction in a circle of radius equal to unity or 1, we find by referring to Figure 6 that the sine of an angle x in the first and second quadrants is positive, for it is above the reference line xx. The sine of an angle in the third or fourth quadrant is negative, since it is below the reference line. (*Continued on page* 336)

HEREWITH is presented the tenth of a series of instruction articles on mathematics, emphasizing especially its application to radio. The articles which have appeared thus far are:

WHAT HAS GONE BEFORE

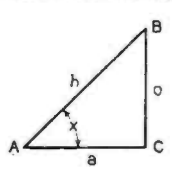
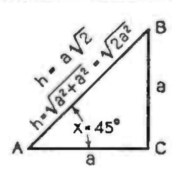


FIG. 1

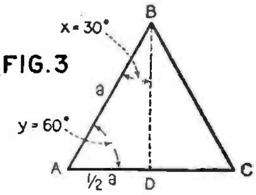


$\sin x = \frac{a}{a\sqrt{2}} = \frac{1}{\sqrt{2}} = \frac{1}{1.41} = .707$

$\cos x = .707$

FIG. 2

FIG. 3



$\sin x = \frac{1}{2}a \div a = \frac{1}{2} = .50$

$BD = \sqrt{a^2 - \frac{1}{4}a^2} = \sqrt{\frac{3}{4}a^2} = \frac{a}{2}\sqrt{3}$

$\sin y = \frac{a\sqrt{3}}{2} \div a = \frac{\sqrt{3}}{2} = \frac{1.733}{2} = .866$

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*President, National Radio Institute.

Plug-in Coils BANNED

In New Short-Wave Superheterodyne Converter

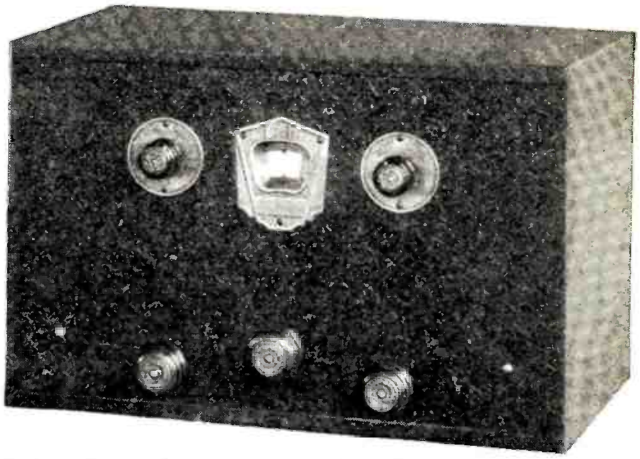


Figure 1. A short-wave superheterodyne converter without plug-in coils—just hook it to your broadcasting set and thus extend your tuning range down to 10 meters

Last month Mr. Silver described a revolutionary short-wave superheterodyne receiver in which a simple switching arrangement eliminated the nuisance of plug-in coils. Now he describes an S-W converter employing the same scheme

By McMurdo Silver*

THE large number of short-wave superheterodyne converters which have gone into service since last fall and the extremely satisfactory results they have given offer proof of the advantages of the superheterodyne principle in short-wave receiver design. The only practical disadvantage of these converters was found in the fact that they were converters and were not an integral part of the standard broadcast receivers which would be used in the home for entertainment purposes. On the other hand, a converter represented a small additional investment to provide complete coverage of the short-wave bands, with their good reception possibilities of both distant domestic and foreign programs.

A second disadvantage of the converter was in its use of plug-in coils, with the inconvenience attendant upon the removing of the cover of the converter and pulling out and plugging in a couple of coils for each change in the wave band to be covered. Both of these drawbacks had been given very serious consideration during the winter and spring of 1930-31 and had been completely overcome in the combination short-wave and broadcast band superheterodyne described by the author in the August, 1931, issue of RADIO NEWS. As, however, many broadcast listeners desiring short-wave reception already have reasonably satisfactory broadcast receivers which in these hard times they do not wish to junk in order to buy an entirely new combination short-wave and broadcast band receiver, the short-wave portion of the receiver described in the August, 1931, issue has been made available as a short-wave converter which may be employed with any standard broadcast receiver, be it of the superheterodyne or t.r.f. types.

Used with any good broadcast receiver, this short-wave converter will provide a sensitivity on short waves slightly in excess of that of the broadcast receiver alone, together with exactly the same tone quality as is provided by the broadcast set itself, plus, if anything, a slight gain in selectivity due to the arithmetical selectivity improvement obtained in any superheterodyne (see October, 1930, issue of RADIO NEWS for explanation of arithmetical selectivity factor of superheterodynes).

*President, Silver-Marshall, Inc.

The Operating Controls

The new Silver-Marshall 739 short-wave superheterodyne converter is illustrated in Figures 1, 2 and 3, while its circuit diagram appears in Figure 4. Considering Figure 1, the entire unit is seen to be contained in a black crystalline shielding cabinet 12 inches long, 7 inches deep and 8 inches high. A single high-ratio vernier tuning dial tunes both the first detector and oscillator circuits, while a vernier adjustment for the first detector circuit is controlled by the lower left-hand knob. The lower right-hand knob is the on-off switch.

The upper left-hand knob is the wave-change switch which, without the use of any plug-in coils whatsoever and by an extremely simple and reliable switch arrangement, permits selection of the coils to cover any one of the four wave bands of 10 to 20 meters, 20 to 40 meters, 40 to 80 meters, and 80 to 200 meters, all by the turn of a single knob. The upper right-hand knob is to permit of selection between the short-wave converter and the broadcast band receiver without disconnecting one from the other or in any way disturbing the connections. This switch also cuts off power to the short-wave

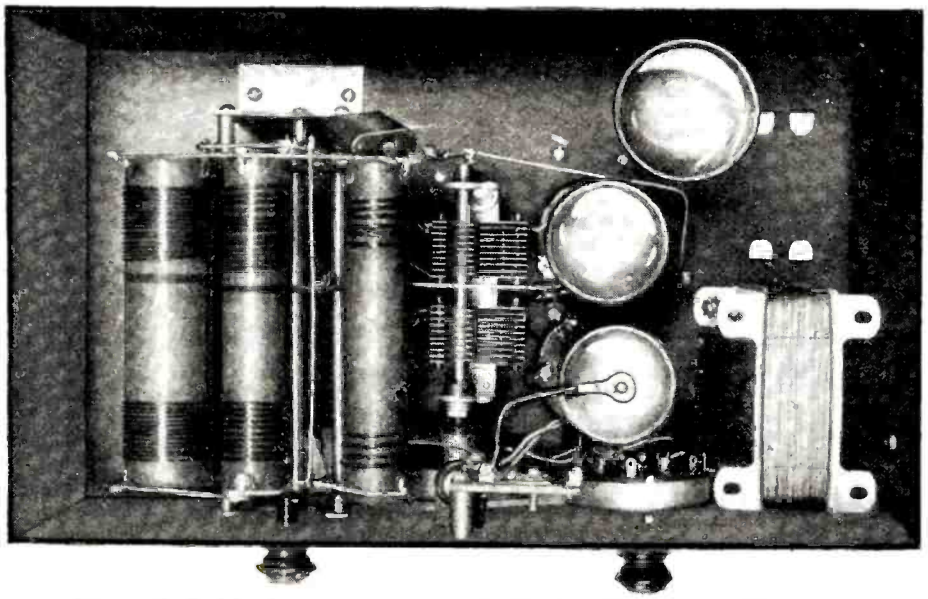


Figure 2. Inside view, showing the coil and coil switching assembly at left. Note the compactness obtained in spite of the large coils.

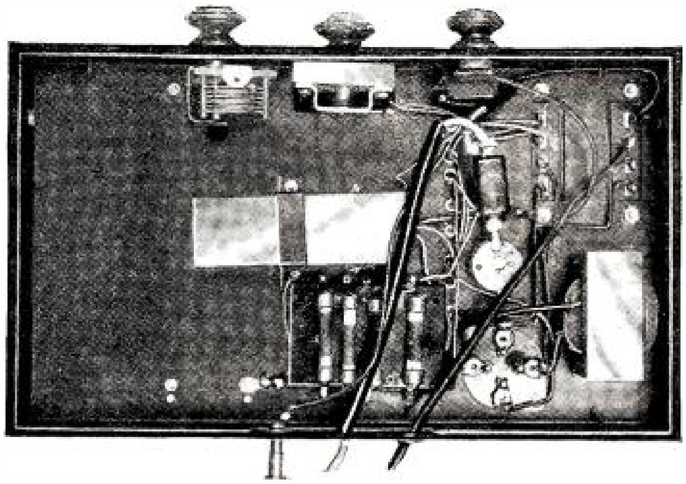


Figure 3. Not much under the chassis—mainly the power supply filter system and auxiliary panel controls

oscillator so that even though the converter is left turned on, with its tubes kept hot and ready for immediate service, this selector switch permits dropping the converter and shifting to the broadcast receiver, or vice versa, instantaneously and at will.

Examining Figure 2, the construction of the converter is seen to be quite simple. At the left is the coil and switch assembly. The right-hand coil form carries the lowest wave first detector and oscillator coils, the central coil form carries the 20 to 40-meter oscillator and detector coils, and the left-hand coil form carries the 40 to 80-meter first detector and oscillator coils. Directly below this coil form and not visible is the pair of 80 to 200-meter coils on their form.

The first detector and oscillator coil for each band are wound upon the same form, being carefully spaced to provide optimum coupling for most efficient heterodyning action. The selection between the various coils is made by means of the three-bladed, four-position switch, which is split into three sections in order to provide the shortest possible leads for each circuit. The first section is just behind the front panel, the second is about half-way back beneath the coils and the third section is at the rear end of the coils. The three individual switch assemblies are controlled by a single continuous shaft. The contacts have been designed for positive, uniform contact to avoid any variation of resistance due to age or excessive use.

Employs Regular Broadcast Antenna

Directly to the right of the coil assembly, which is a single rigidly assembled unit, is seen the two-gang tuning condenser consisting of two 140 mmfd. sections. Directly above this condenser assembly and mounted upon a pillar attached to the front panel is a small compression mica condenser shown as C4 in the circuit diagram. This is an antenna series condenser, which, it is contemplated, will be adjusted once with a screw driver when the converter is first installed, to best adapt it to the type of antenna employed. Incidentally, the converter can be operated on even the largest broadcast antenna with entirely satisfactory results.

To the right of the gang condenser at the front is a –24 type first detector tube mounted upon a socket elevated above the steel chassis to avoid any deleterious capacity effects. Directly to its rear is the –27 oscillator tube, with its biasing condenser and leak standing vertically between the –24 and –27 tubes. To the rear is the –80 rectifier and in the right front corner is the power transformer furnishing all "A," "B" and "C" power for the converter. The multi-contact switch directly in front of the –24 first detector tube is the selector switch for converter or broadcast receiver operation. One set of contacts throws the antenna (which is connected to the converter) either to the broadcast receiver or the converter, the second set of contacts, shown as S5 in the diagram, serving to cut off plate current to the oscillator when it is not in use.

Examining Figure 3, the underside view of the converter, the detector vernier condenser is seen at the upper left, the on-off switch at the upper right, the power transformer lugs in the upper right-hand corner, the filter choke in the lower right-hand corner and the filter condensers, of semi-self-healing dry electrolytic type, at the center of the chassis. The balance of the parts are self-explanatory, but it should be noticed that a shielded lead projects from the rear of the chassis. This is the antenna lead to the broadcast receiver, the actual antenna being connected to the binding post at the rear of the converter. An effective ground connection is obtained through the shielding on the antenna lead.

Examining the circuit diagram of Figure 4, the –24 detector is seen to have the antenna coupled directly to its grid through the semi-variable compensating condenser C4 and to have its grid circuit tuned by the gang condenser C1 and the vernier condenser C3. Selection of the tuning coils for the detector is made by switch S1, which is mechanically interconnected with switches S2 and S3, which select the proper grid and plate coils in the oscillator circuit. The oscillator, for purposes of stability and constant output, employs a tuned plate rather than a tuned grid circuit, the grid coil actually being the tickler, and visible as the small narrow winding upon the coil forms seen in Figure 2. The oscillator is tuned by the gang condenser C2.

The Power Supply

The first detector is semi-automatically biased by the resistance R2 which is by-passed by condenser C7. A certain fixed and desirable value of first detector bias is obtained by bleeding a portion of the power supply current through this resistor, which is seen to be in series with R4 and R5, voltage dividing resistors providing screen potential for the detector tube, R3 being an additional voltage (*Continued on page* 340)

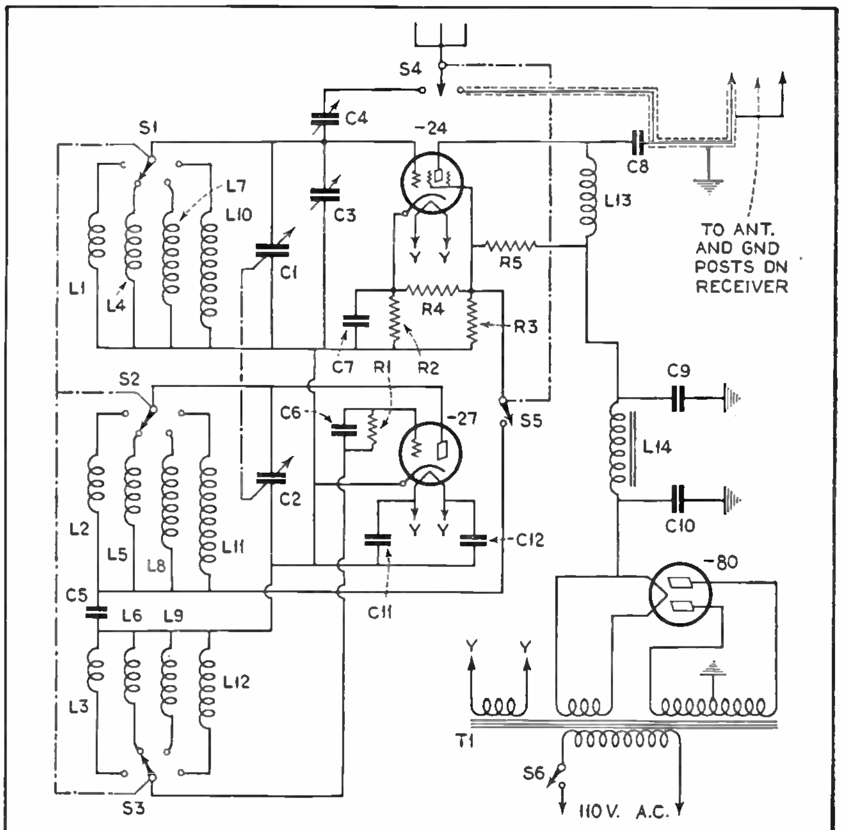


Figure 4. Schematic diagram of the superheterodyne converter, with its ganged coil-selector and cut-out switches

Here is the author tuning in a program, with a televisor similar to the one he described how to build in his article last month

Useful Hints on Tuning In TELEVISION PROGRAMS

The television receiver is tuned in the same way as a radio, but the televisor adjustments introduce a new technique. This article explains just how to obtain and hold the best images

By D. E. Replogle*

THE public prints comment in their news columns on the programs and the artists appearing in television as per the daily program announcements. Everywhere we hear that television is the coming thing, not only coming, but already arrived after a fashion. RADIO NEWS has published several articles on the assembling of television equipment in kit form. The questions now arise, "How can I get the programs, what will they look like, how will I know when my radiovisor is working perfectly?" It is the purpose of this article to answer these questions.

Let us presume that the television enthusiast has ordered the radiovisor and receiver kit from his radio dealer or the manufacturer. He has assembled them as per the RADIO NEWS articles which have appeared for the past few months. On his table, next to his broadcast receiver, he places his television equipment. Fortunately he has kept his radio receiver. for it will be required to pick up the sound portion of the sight and sound television programs. While his radio receiver and attendant loud speaker operate on the broadcast band, his television receiver and radiovisor operate on the television band, in the 100-150 meter channel.

This is the fourth of the series of articles by Mr. Replogle on the construction and operation of home television equipment. The first article, in the July issue, described a modern television transmission station, W2XCR, and the methods employed in putting combination sight and sound programs on the air. This was followed, in the August issue, by an article giving a detailed description of a television receiver for home construction. The September article told how to build a simple televisor to use with this receiver and now, in the present issue, the author tells how to operate television receiving equipment. These instructions apply equally well to both home-built and factory-built equipment.

Connecting Up

Just as the loudspeaker of his radio set is attached to the output of the receiver, so the radiovisor, which might be called the loudspeaker of sight, changing the electricity to sight as the loudspeaker changes the electricity to sound, is attached to the output of his television receiver. This receiver, by the way, is more broadly tuned than is the radio receiver, because a wide frequency band is essential to television if half tone pictures are to be procured. And just as the radio receiver is plugged into a 60 cycle 110 volt a.c. light socket, so too is the television receiver. Moreover, while the two wires from the neon lamp of the radiovisor are fastened to the output of the receiver, the cord of the radiovisor eddy-current motor which turns the radiovisor scanning disc is fastened to another light socket outlet. The television and the radio equipment, however, are in no other way connected.

The next step is to pick up the evening paper and choose the program to which you want to listen. Television broadcast stations are located along the Atlantic Seaboard in Boston, Long Island City, New York, Passaic, New Jersey, and Wheaton, Maryland. Others may be found in Schnectady, Chicago and the West. Let us suppose that the television enthusiast has decided to listen in on W2XCR-WGBS of New York, jointly owned and operated by the Jenkins Television Corporation and the General Broadcasting System. The first call letter is that of the television station, the second that of the radio station, which broadcasts the accompanying sound. The paper will give the WGBS wavelength as 254 meters or 1180 k.c. and the W2XCR wavelength as 147 meters or 2035 k.c.

Well and good. We look at our watch. 8:30 P.M. We turn on the radio receiver and tune it to WGBS. Then we turn on the television receiver and dial to 147 meters. As soon as the television receiver tubes warm up the neon lamp of the radiovisor begins to glow. Through the radio loudspeaker we hear the station announcement. The neon lamp of the radiovisor glows bright and dim as we look at it through a tiny hole in the scanning disc. Now we snap on the radiovisor switch. The eddy-current motor starts revolving the scanning disc clockwise. The hole of the light moves across the field of vision as we view it through the magnifying lens. Then another line right below where the first one passed. Then a third and fourth. The lines come faster and faster. When the bottom one has passed, the top one starts again. The disc gains speed, the lines come in rapid succession, it looks as though all the lines were there at once; the single dot of light has taken on the aspect of a solid mass of light about four inches square. As the scanning disc approaches the correct speed the lights and shadows take form. Through the loudspeaker we hear the announcer present Dr. Sigmund Spaeth, authority on music. Dr. Spaeth appears, attired as

*Vice President, Jenkins Television Corporation.

we see in the costume of the Mauve Decade, the 1880's. He smiles at us, then sits at an old-fashioned square piano. Through the loudspeaker we hear a few introductory bars as we see Dr. Spaeth play several opening chords, then, as we see him open his mouth, we hear the dulcet tones of a song of long ago through the loudspeaker. The show is on.

Now that we are getting the program, let us see if we cannot improve the reception. WGBS is tuned in perfectly. We adjust the tuning knob of the television receiver, keeping our eyes on the picture. Finally we have it as sharp as possible. But what's that? The picture slips over to the right, seems to slant over and almost go off the screen entirely. There, it does go off to the right and reappears again on the left. That is a sign that the scanning disc of the receiver is not in perfect synchronism with that of the transmitter. The receiving disc is going too fast, it is gaining on the image. We turn the little rheostat on the radiovisor, the disc slows down, the picture no longer moves across the screen. But now something else is happening. The top of the picture is swinging back and forth while the bottom part stays still. We let the radiovisor run a minute or two without further adjustments. It is hunting. Soon the picture stops wobbling. Good.

Framing the Picture

But now, though the picture is not moving across the screen and is not wobbling, it is not in the center of the screen. That means it is not framed properly. Without touching the scanning disc we reach in back of the radiovisor, and, grasping the neon lamp housing, turn it slightly around. For through the square hole in the housing we see the neon lamp. And this hole must be directly in back of the disc and centered with the lens. So by turning it a little bit we frame the picture horizontally. Now we lift it up a little bit and the picture is right in the center of the frame.

Dr. Spaeth has risen from the piano and now, standing before us in the regalia of a past generation, is explaining the original significance of the song he is about to sing. He twists his waxed mustachios, adjusts the brilliant stickpin in his huge cravat, lifts up the tails of his coat and seats himself once more at the piano. The cameraman at the studio must have changed the shot to a close-up, for now we see only his face and shoulders, but in greater detail than before. We make out his hair, his raised eyebrows, his teeth. Then a splotch of black across the picture indicates static, which we can also hear marring the vocal performance.

Importance of Synchronization

Every once in a while the picture begins to wobble, disintegrate, break down into indiscernible black and white splotches. The reason for this is that the receiver is in New Jersey, let us say, while the transmitter is in New York City, at the W2XCR-WGBS studio at 655 Fifth Avenue. The scanning disc of the transmitter is motivated by the New York Edison Company's power system while the scanner of the receiver is being motivated by our house current, furnished by Public Service of New Jersey. Since the receiver is operated on a power system foreign to that of the transmitter the scanner gets out of step once in a while. A slight adjustment of the radiovisor rheostat, slowing or hastening the speed of the disc brings the picture back. Perhaps, in order not to have to make any adjustments, we will get a Jenkins automatic synchronizer, a little ingenious device which, fastened on the motor shaft on the front of the radiovisor, will automatically synchronize the receiving scanner with the transmitting one. Of course, if the receiver operated on the same power system as the transmitter the scanners would be automatically synchronized by the power system itself.

It is now 9 o'clock and W2XCR-WGBS signs off. However, the DeForest station, W2XCD of Passaic, New Jersey, goes on the air at this moment. We retune the radiovisor, bringing it up to 2050 k.c., on which the Passaic transmitter broadcasts the sight. The sound from W2XCD is broadcast on 1604 k.c., a bit below the broadcast band, but obtainable on our radio receiver at the bottom of the dial. We have no job synchronizing the scanner with that of the transmitter, for both are working on Jersey power.

The first portion of the program consists of a motion picture film accompanied by phonograph records. We can make out some cowboys riding over a plain. They come to a house. We see a group of people and can make out a child, a man and a woman, but no facial detail. Then a close-up, showing a woman's face. We see she has dark hair, parted in the middle. The picture is an old silent one. The subtitle appears, quite clear, but too small to read readily. The picture finished, we see the announcer and hear him present the first direct pick-up feature, a dancer. The direct pick-up camera shows the dancer in close-up, then moves back, we with it, until it takes in a small stage. The dancer is in ballet costume. We hear the piano accompaniment and see her go into her toe dance. Her gestures, steps, costume, all are visible, but the face lacks detail at this distance.

A somewhat more elaborate televisor which is factory-built and provides a more finished appearance in keeping with a modern living room setting

Non-Standard Transmitters

The W2XCD program at an end, someone suggests W2XBU. But no, that station's scanning disc has 48 holes and revolves slower, making a 48 line, 15 frames per second picture. Our disc is standard, 60 lines at 20 frames per second. The off-standard signal may be tuned in provided we get a 48 hole disc, which may readily be purchased for a small sum and put in place of our present one. Then, by slowing down the speed of the disc we could get the signal. But not with our 60 hole disc revolving at 20 frames per second. So we tune in the Jenkins W3XK of Wheaton, Maryland, instead.

We have presumed that the television receiver and radiovisor have been properly assembled and attached, and that conditions generally were good. But it is quite easy for the amateur to make a few mistakes in the assembly of his apparatus. These mistakes will manifest themselves in several ways. Some we will discuss, so that from the symptoms corrections can be made and peculiarities in reception overcome at once.

Supposing, on switching on the radiovisor the back side of the neon lamp glows instead of the side facing the scanner. That means the rubber covered leads from the neon lamp to the output of the receiver have been reversed. By reversing the leads the right side of the lamp will glow. If the neon lamp fails to glow at all the chances are that the receiver is not furnishing enough voltage. We can but stress the necessity of following instructions concerning the construction of the Jenkins receiver precisely, or, if another receiver is being used in conjunction with the radiovisor make sure that at least a -45 type power tube is being used, or preferably a -50 type tube.

Or again, when the motor which revolves the scanner is turned on the disc may refuse to move. Twirling the disc in a clockwise direction with the hand will set it in motion, after which the motor will keep it running. We have already spoken about synchronizing and framing the picture.

If the image is very bright and lacks shadows too much voltage is being supplied the neon lamp and may be lessened by inserting a high variable resistance in the plate circuit of the power tube, or in series with the lamp. Perhaps good silhouettes or black and white pictures are obtainable but not half-tones or shadow effects, (*Continued on page 331*)

Short-Wave Reception *with* Broadcast Superhets

Not only does this simple converter eliminate the undesirable harmonics obtained when using some converters with superheterodyne broadcast receivers—it actually provides an added stage of i.f. amplification

By William C. Dorf

At this time, when so many manufacturers are producing superheterodyne receivers, short-wave fans are wondering whether a receiver of this type can be used successfully with a converter for short-wave reception. This question arises because some converters have not been successful even with a.c. tuned r.f. receivers, probably due to the method of attaching these units to the receiver.

In the past one arrangement was to insert the connecting plug of the converter into the first detector socket of the superheterodyne. As some new sets employ only two intermediate-frequency stages, this method was not satisfactory because the first tuned intermediate transformer is thus thrown completely out of alignment with the other two transformers.

The new adapter, described here, is designed to operate with a.c. screen-grid superheterodyne receivers, working on an intermediate frequency of 175 kc. It one of sixteen different models of this unit that are available for us with any type of a.c. or d.c. operated radio receiver.

The adapter, known as a "Submariner," employs the new "J" feature incorporated within the instrument itself; a coupling device for 175 kc., which with the special connecting plug (shown in Figure 2) inserted in the oscillator socket of the receiver, provides an arrangement whereby the first detector tube of the set is not discarded as in other short-wave converters, but is utilized in the receiver to function as an additional stage of intermediate-frequency amplification. This method also insures the proper operating voltages for the type -27 tube in the converter, which is employed as a combination oscillator and a first detector. It may be well to state here, since the oscillator tube of the receiver is removed, no troublesome harmonics are encountered from it when tuning the adapter to short-wave stations.

It is a known fact that the screen-grid tube is capable of much higher amplification at low frequencies than at high frequencies. For instance, this tube can produce a gain of 70 per stage at 175 kc. (1725 meters) whereas it will give a gain of only about 5 per stage on 9530 kc. (31.48 meters). This is one of the reasons why short waves are not received as well with tuned-radio-frequency circuits preceding a short-wave detection, without regeneration, as this not only gives a small gain per stage, but adds complexity to the receiving arrangement by employing additional tuning condensers.

In comparative tests it was noted that the new converter, combined with a screen-grid broadcast superheterodyne, compared favorably with a specially constructed short-wave superheterodyne receiver.

The interchangeable coils in the converter are of the plug-in type and are equipped with five prongs for insertion in a standard UY type socket mounted at the rear and close to the top of the device. This order of construction does away with long leads and is instrumental in adding to the efficiency of the unit. The coils are space-wound and each coil form contains all three inductances, L1, L2 and L3. Therefore, in changing from one wave-band to another, it only means changing one coil instead of two or three. The wave ranges of the three coils are as follows: Coil No. 1 (purple), 13 to 30 meters; coil No. 2 (green), 29 to 60 meters; coil No. 3 (blue), 59 to 145 meters.

All parts except the vacuum tube and plug-in coils are enclosed in a small sloping metal cabinet which provides adequate shielding for the circuit.

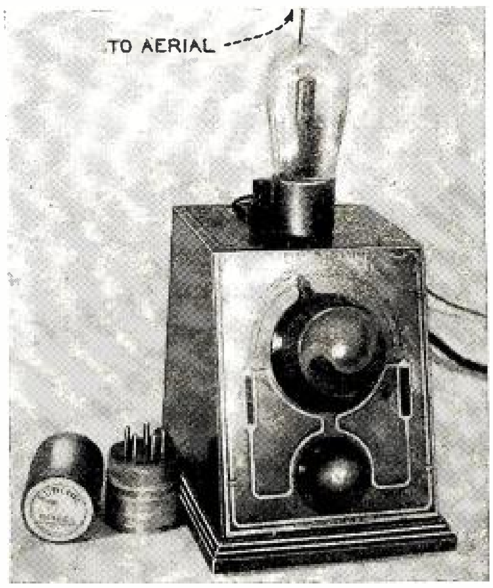


Figure 1. This simple and inexpensive adapter employs only one tube and draws all of its operating power through a plug inserted in the oscillator socket of the broadcast receiver

Installing the Converter

Attaching the Submariner to the receiver is a simple matter. First, remove the oscillator tube from the receiver and place it in the socket provided for it on top of the converter. Then insert the connecting cable-plug in the oscillator socket of the set. The control-grid cap of the first detector tube is then removed and in its place is attached the cap on the single wire from the converter. Care should be taken to see that the unused grid cap of the first detector tube does not make accidental contact with any metal part of the chassis.

Next proceed to disconnect the antenna wire from the set and reconnect it to the antenna binding post on top of the converter. A jumper or connecting wire should be brought over from the ground binding post of the receiver

(*Continued on page 336*)

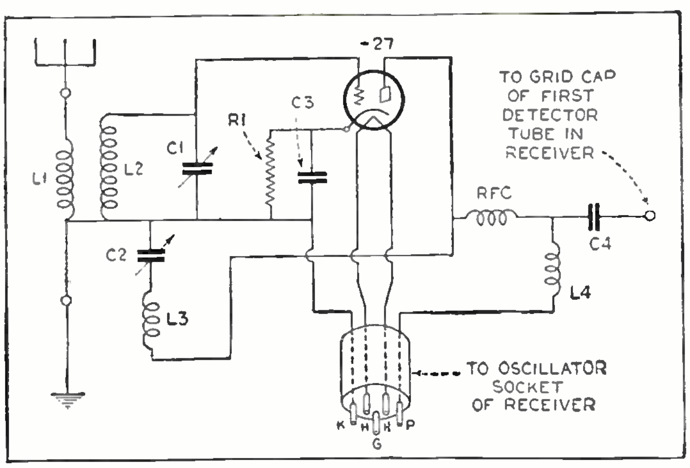


Figure 2. The diagram shows the extreme simplicity of the adapter

A Universal Receiver

Which Operates from Either A.C. or D.C. Lines

Metropolitan areas where some neighborhoods have a.c. and others d.c. provide a real problem for radio fans. Here's one receiver which solves the problem, as it will operate with either type of current supply

By H. G. Cisin, M.E.

Part One

EVER since "all electric" radio sets became popular, residents of New York and the other large cities supplied with both alternating and direct current have had to worry about which current was flowing in the electric lines in their apartments. Ordinarily this makes no difference to the apartment dweller. Lamps, heating devices of all kinds and most vacuum cleaners and fans work equally well on either type of current supply. But radio sets are different. At first it was said that "radios wouldn't work on d.c." This difficulty was soon overcome and a number of satisfactory direct-current sets are now on the market.

This situation, which is only a nuisance from the radio owner's viewpoint, is not without reason so far as the power companies are concerned. Originally direct current (d.c.) was the only kind in common use. Alternating current was considered a laboratory experiment and not suitable for commercial purposes. The big disadvantage of the d.c. is the loss in transmitting it for any considerable distance, since it is not practical to "step up" the voltage, which is easily done with a.c. The d.c. is still preferred for the operation of power motors used in factories and apartment houses, though some of the d.c. districts are gradually being changed to a.c. by the power companies.

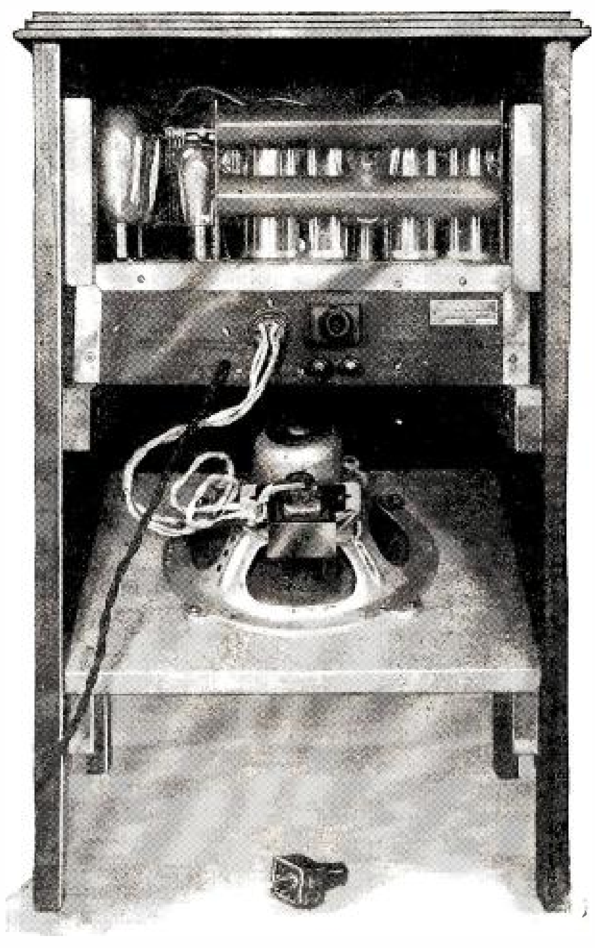
Truly Universal

A person who moves from one apartment to another, even in the same block, will sometimes find that his electric supply is of a different type and his radio set consequently useless. Usually rewiring the set is too expensive to be practical and the only alternative is to trade it in for a fraction of its real value on the purchase of another.

The answer to this condition is found in a new receiver designed by Arthur C. Ansley, director of the Ansley Radio Laboratory. This set works on either d.c. or a.c., the change from one current to the other being made by simply shifting a plug on the back of the receiver. Two developments make this universal operation possible without sacrificing the efficiency of the set in either case. One is a series filament arrangement which is an adaptation of the circuit used in the usual type of d.c. set. The other is an ingenious switching arrangement, operated by the circuit-changing plug on the back of the chassis. Those circuits in the set which need to be changed are brought out to the ten terminals of this plug. Two caps are furnished, one for a.c. and one for d.c. These caps complete the connections between the terminals of the plug in such a way as to adapt the set to either current.

This design is the result of experimental work extending over a period of several years. In the early days, when only battery-type tubes were available, attempts were made to use them with duplicate power units for the two currents. In this case it was necessary to filter the filament current as well as that for the plates of the tubes, and the resulting sets were cumbersome and expensive as well as lacking in power output and quietness of operation.

The new receiver is very compact. The complete chassis measures fourteen inches long, twelve inches deep and nine inches high. It uses the standard type of a.c. tubes. Three type -24 screen-grid tubes are used in the radio-frequency amplifier and one as a power detector. The first audio-frequency tube is a -27 and feeds into two -45's in a push-pull output stage which gives ample undistorted volume. A type -80 rectifier tube is used on a.c., but is automatically disconnected by the d.c. circuit-changing plug.



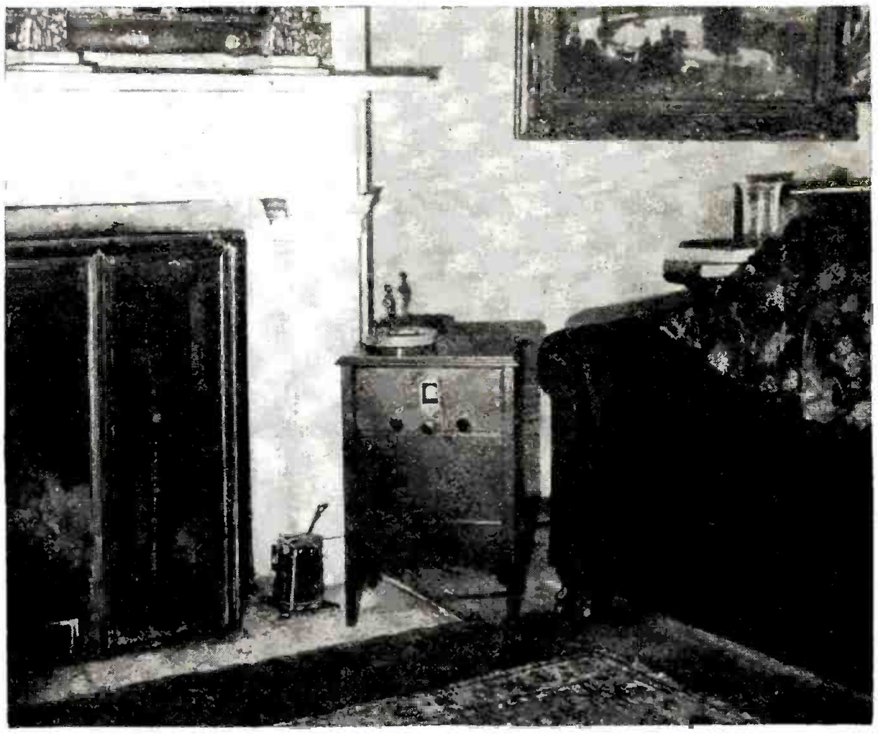
Rear view of the receiver, showing the a.c. cap in position on the rear panel. To use the receiver on d.c. supply this cap is replaced by the d.c. cap, which may be seen on the floor below the cabinet

Those who are interested in the technical details will find a number of unusual features in the schematic diagram. Although the tubes are of the standard 2.5-volt heater type, the filaments are in series instead of in parallel, as in the usual a.c. set. In series with the tube filaments are the two heavy resistors, R17 and R18. These are mounted on top of the chassis and in the rear, so that the heat developed is dissipated through an opening in the back of the cabinet. Since this circuit consists entirely of resistances, the voltage drop through it is very nearly the same on either a.c. or d.c. In other words, the tubes receive approximately the same voltage on either current.

Same Tubes for A.C. or D.C.

With the exception of the -45's, the tubes are of the heater type wherein the cathode is separate from the filament circuit so that this series arrangement of the filaments does not affect the usual amplifying circuit. The grid bias for each tube is obtained, as usual, from the voltage drop across a resistor connected between the cathode and the metal base of the set. While this is usually referred to as "ground" and is so indicated in the diagram, it is not actually connected either to the ground binding post or to the extreme negative side of the filter circuit. The filaments of the power tubes are grounded and the grid return for these tubes is brought out to the extreme negative end of the filter circuit. This is so arranged that on a.c. it is about 50 volts negative from the "ground" because of the drop through the section of the voltage divided (R16) between (c) and (d). On d.c. the filaments of the tubes are in parallel with this grid bias resistor and the drop through them is 15 volts, the correct grid bias for the −45's with the d.c. line voltage.

The circuit changing plug 10 is another original feature of the set. This is virtually a ten pole, double throw switch with the plug as the center set of terminals and one of the two caps for each end. When the a.c. cap, 11, is in place the primary of the power transformer, 9, is connected across the line and the 280 rectifier tube receives its filament and plate voltage from the secondaries. The speaker field is inserted across the condenser, C21, and forms the second choke in the filter. When the d.c. cap, 12, is in place the primary of the transformer, 9, is open and the 280 tube is consequently dead. The speaker field is no longer needed as a choke and so is connected across the 110 volt line. The d.c. line is connected, with due regard to polarity, to the input of the filter circuit so that choke, 14, and condensers, C17, C18, and C19, filter the plate current just as they do with the rectified a.c.



The Universal receiver in a small console, installed in a New York City apartment where only direct current supply is available. In the summer the owners can take it with them to their summer place, where the supply is a.c. Thus the cost of an extra receiver is eliminated

The push-pull output transformer, 4, is located on the speaker and its center tap or "B+" lead is connected directly to one side of the speaker field. On a.c. this draws the plate current for the power tubes through the first section of the filter, while on d.c. it is drawn directly from the line. This gives the maximum possible voltage from the d.c. without any noticeable hum in the output.

If we follow the circuit through from the aerial, we find a number of interesting features. The ground binding post, 2, is not connected to the chassis either directly or through a condenser. The use of a ground which is separate from the electric line, such as a water-pipe or radiator, has been found to give a considerable reduction in the pickup of "man-made static", especially on d. c. L1, L2, L3, and L4 are the radio-frequency coils which are completely shielded and located underneath the chassis. They are space-wound on threaded bakelite tubing with a diameter of 1½ inches. The primary is wound in two sections—a low inductance section wound over the lower end of the secondary, and a high inductance section wound on a small wooden bobbin inside the main form. This section is tuned to a frequency slightly lower than the broadcast band, and makes possible a much more even response without trouble from oscillation. (*Conitnued on page* 339)

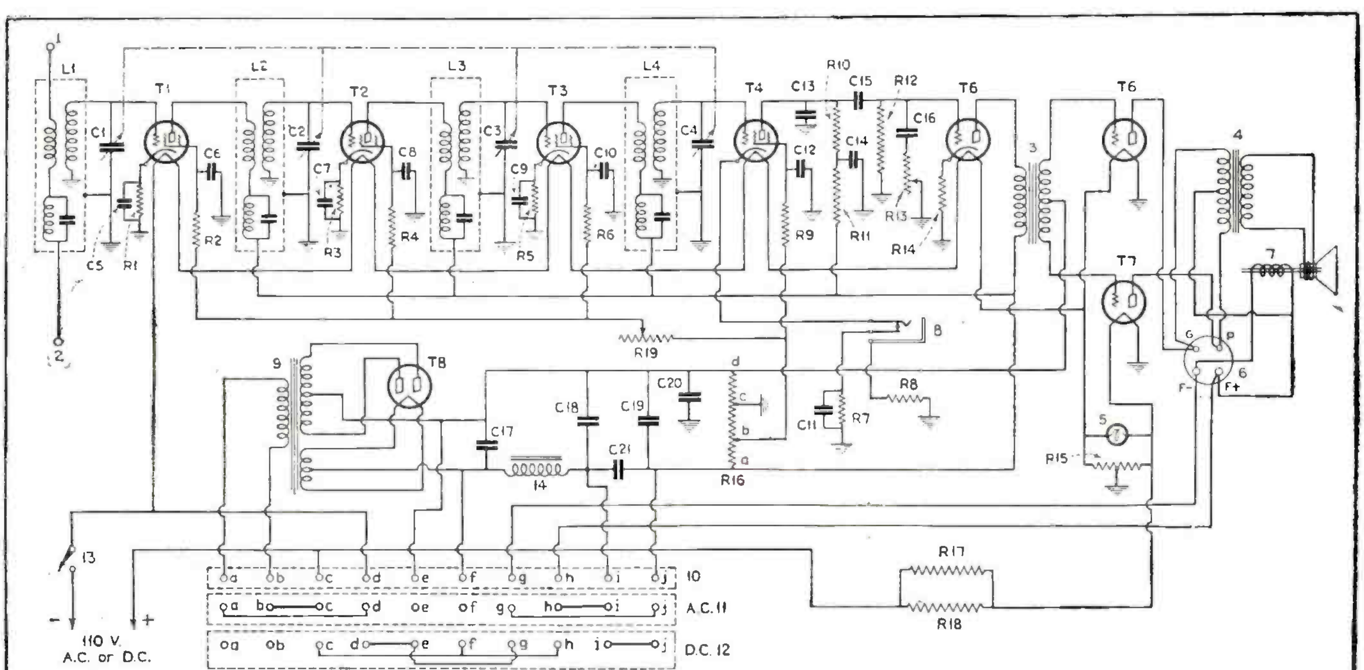


Figure 1. The circuit diagram. At the bottom is shown, schematically, the terminal plug, 10, and below it the a.c. cap, 11, and the d.c. cap, 12, which instantly adapt the set to either type of supply

Ten Meters *for* Ten Dollars

An Ultra Short-Wave Transmitter

Many transmitting amateurs do not appreciate the advantages offered by the 10-meter band. Here is a practical transmitter which provides a low-cost medium for trying out this band. It will work on the 20 and 40-meter bands as well

By Don Bennett

PARDON me! I didn't mean you to understand that we meant ten instruments at a dollar each. Perhaps I should have said 30 kilocycles for a cent!

The transmitter to be described here can be built in a few hours at a cost of ten dollars or less, depending on the state of your supply of excess parts. The ten-dollar figure includes the purchase of all parts except the tubes and baseboard, so that any parts you have on hand will reduce that figure somewhat. Later on in the article we will list the parts and their cost at prevailing prices.

While occupancy of the ten-meter band is by no means new, until lately there have not been many hams down there, because they did not understand its usefulness. It is good for short hauls, local traffic and rag-chewing and for extreme distances. It also lends itself admirably to beam transmission experiments. The short antenna used can be erected inside most rooms and reflectors can likewise be set up easily. The writer has his ten-meter antenna running across his bedroom about a foot from the ceiling. It is Zepp fed with feeders about four feet long. The top is exactly sixteen feet between insulators. You need not restrict yourself to feeders of this length, but try to keep them in multiples of quarter wave-lengths (units of eight feet).

This antenna system, shown in Figure 2, erected inside the house, offers to the beginner an invaluable opportunity to learn the workings of an antenna system. A neon lamp, held in the hand and run along the feeders and antenna will show the distribution of r.f. voltage in the antenna and feeders. When the system is properly tuned the lamp will light brightly at the two ends and gradually diminish as you work toward the center of the antenna and as you go down the feeders toward the set. (If you were to insert flashlight lamps every foot or so along the antenna and neon lamps between them, the flashlights would show the current distribution and the neon lamps the voltage distribution.) Of course, with a full-wave antenna (32 feet long) you would find two nodes (where the neon does not light). We recommend that beginners build this set in order that they may learn more about the way their antenna system works. The same rules hold true for the lower frequencies but are not as easily demonstrated.

The transmitter, the circuit of which appears in Figure 1, is a conventional tuned-grid-tuned-plate, push-pull rig. In building it you must be careful to use rigid assembly methods and rigid wiring. The high frequencies are very susceptible to small changes in capacity that would be caused by loose, sloppy wiring. The r.f. leads should be kept wide apart to minimize the capacity between them. In the set which is shown in Figure 3 you will notice that r.f. leads, except those from the antenna coil to the antenna binding posts, are of bus bar, run as straight as possible.

A wooden baseboard 7" × 14" × ½" thick is covered with a sheet of thin copper (34 gauge). This tacked down in several places and turned over at the ends to give a neat appearance. At either end a small panel is erected on a piece of corner bracket to support the condensers. The two coils are mounted on plug-in bases adjacent to their respective condensers. The tube sockets are mounted between the coil supports with the grid leak and grid condenser between the tube sockets. All connections are brought out to a bakelite strip at the rear of the set. The filament voltmeter and plate milliammeter are supported by adjustable brackets on their respective binding posts. The r.f. choke is mounted vertically and fastened by a screw that comes up through the baseboard.

The grid coil is of the plug-in type, wound on a one-inch tube with three jacks to furnish the proper connections. The plate coil is wound on an REL form, with the antenna pick-up coil wound on the same form. The grid coil is wound in two sections of three turns each. The plate coil is also wound in two sections, one and one-half turns each. This coil is wound in the center of the form with the turns so spaced that there is one blank notch between adjacent turns. The small numerals shown on the plate coil in the circuit diagram refer to the numbers of the ribs, and, likewise, the socket terminal to which connection is to be made. These numbers will be found on the coil socket. Incidentally, the coils are wound in the same direction that the terminal

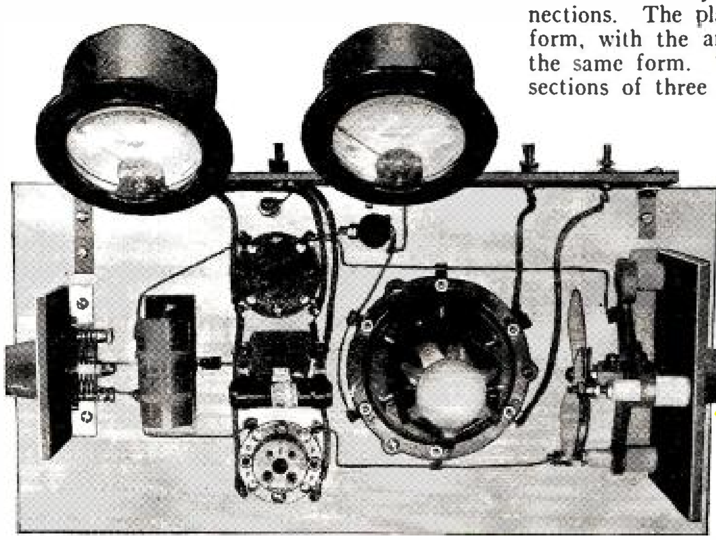


Figure 3. Close-up of the transmitter, showing all parts and wiring. Note the use of bus-bar for rigidity

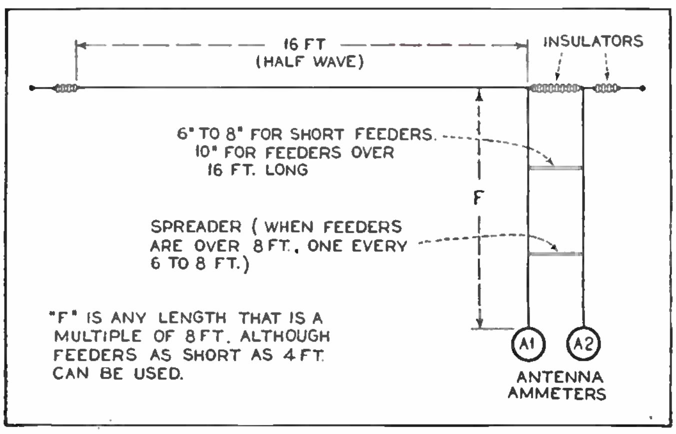


Figure 2. The aerial used by the author. This may be either indoors or out

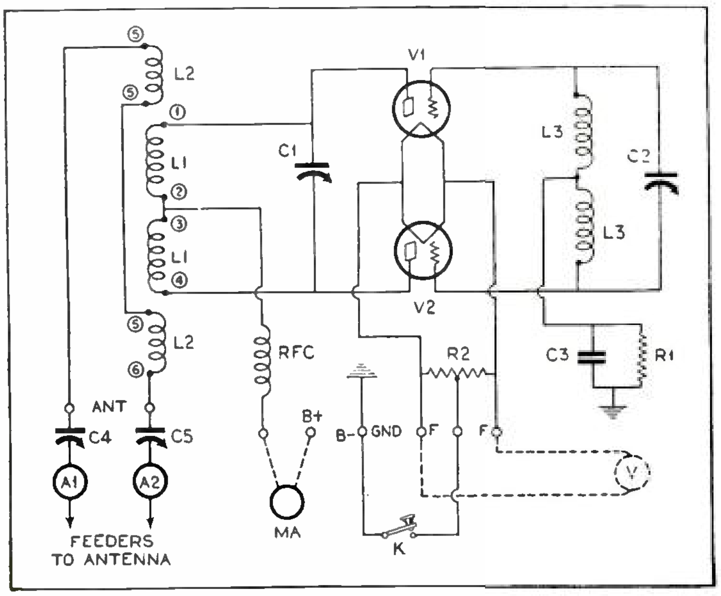
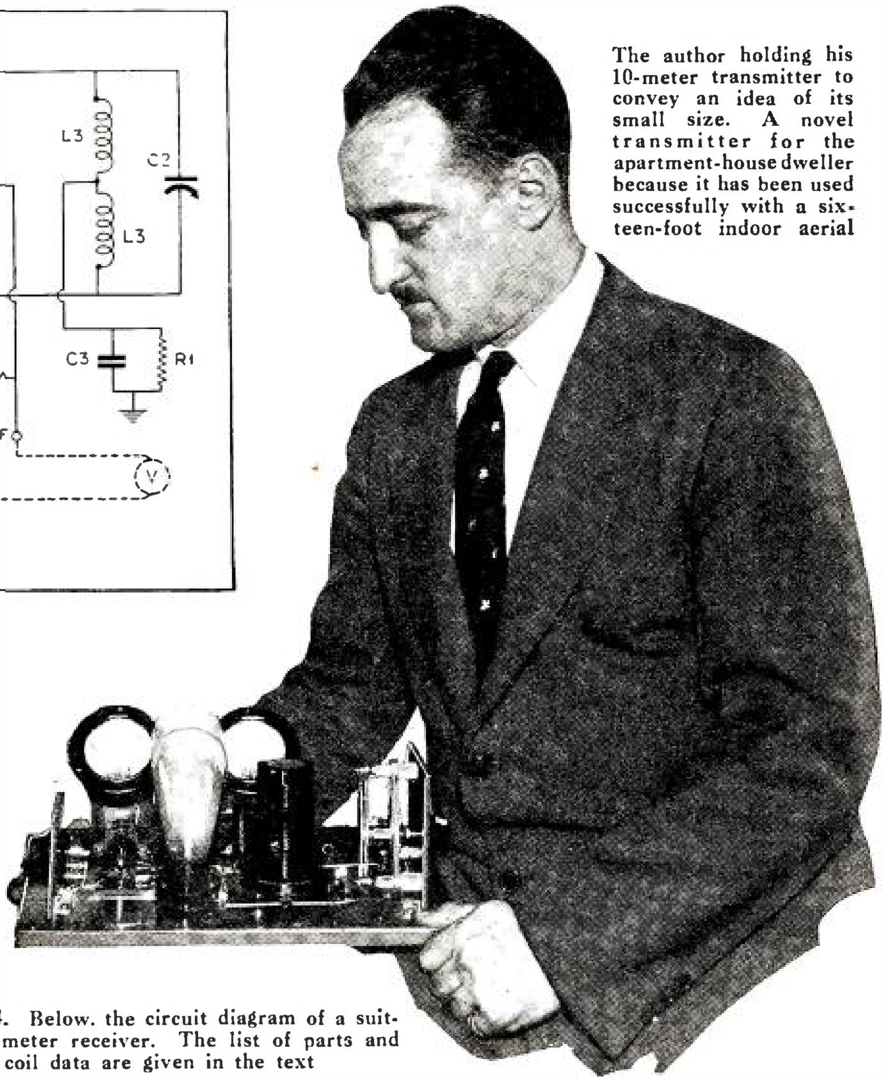


Figure 1. The circuit of the 10-meter transmitter. Detailed coil specifications are given in the text



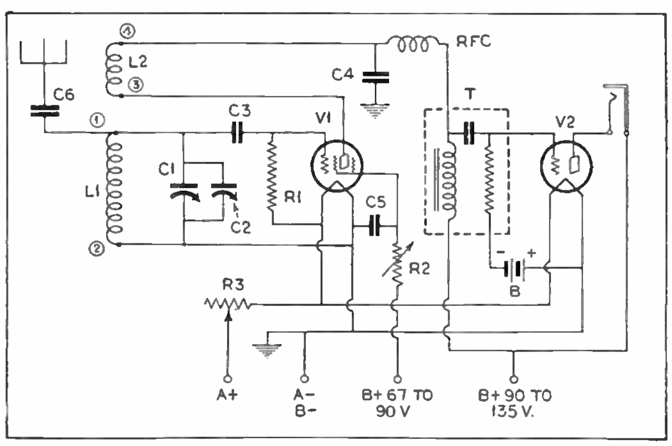
The author holding his 10-meter transmitter to convey an idea of its small size. A novel transmitter for the apartment-house dweller because it has been used successfully with a sixteen-foot indoor aerial

numbers progress; looking at the top of the form, winding is done in a counter-clockwise direction. This is because of the pitch of the threads which are cut on a spiral. Perhaps in order to simplify your winding these coils, it will be best to give you the specifications for locating the turns exactly. Number eighteen wire is used and a drill around No. 50 will be found satisfactory for passing the wire freely and without difficulty. Drill holes as follows:

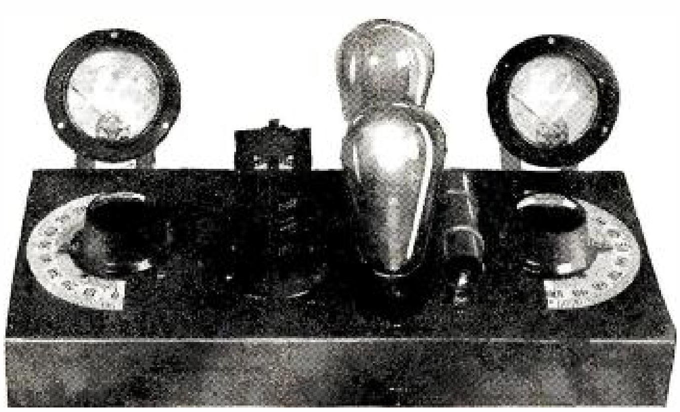
Rib	*Thread*
1	18 down
2	21 down
3	21 down
4	18 up
5	9 up
5	13 up
5	14 down
6	10 down

This means that you start with rib 1, count 18 threads down from the top of the rib and drill a hole in that notch. Proceed with the rest, drilling three holes in No. 5 rib. This takes care of one end and the jumper of the antenna coil. To wind, pass the end of your wire through the hole in No. 4 rib, pull through enough slack to reach the terminal at the bottom of the coil and start winding in a counter-clockwise direction as you look at the top of the coil. Let the wire fall naturally into the groove until you come to rib 2, where you go up one thread. When you get around to rib 4 again you will find you have one thread between turns. Wind until you get to rib 2 the second time (1½ turns) and pass the wire through the hole you have drilled there. Now start winding again from rib three, one and a half turns will bring you to rib one. In winding the antenna coil it is better to measure off the amount you will need for each part of the coil (two turns each side) and wind from the center toward the ends. Put the two ends of your wire through the upper holes on rib 5 and wind the top section counter-clockwise, the lower clockwise. The lower section terminates on rib five and the upper section on rib six. This detailed description is given you because on these high frequencies a small change in inductance or capacity materially affects the frequency range. If you find that after winding the coils as described you cannot get into the amateur band, the stator plates of the condenser can be (*Continued on page* 343)

Figure 4. Below, the circuit diagram of a suitable 10-meter receiver. The list of parts and coil data are given in the text



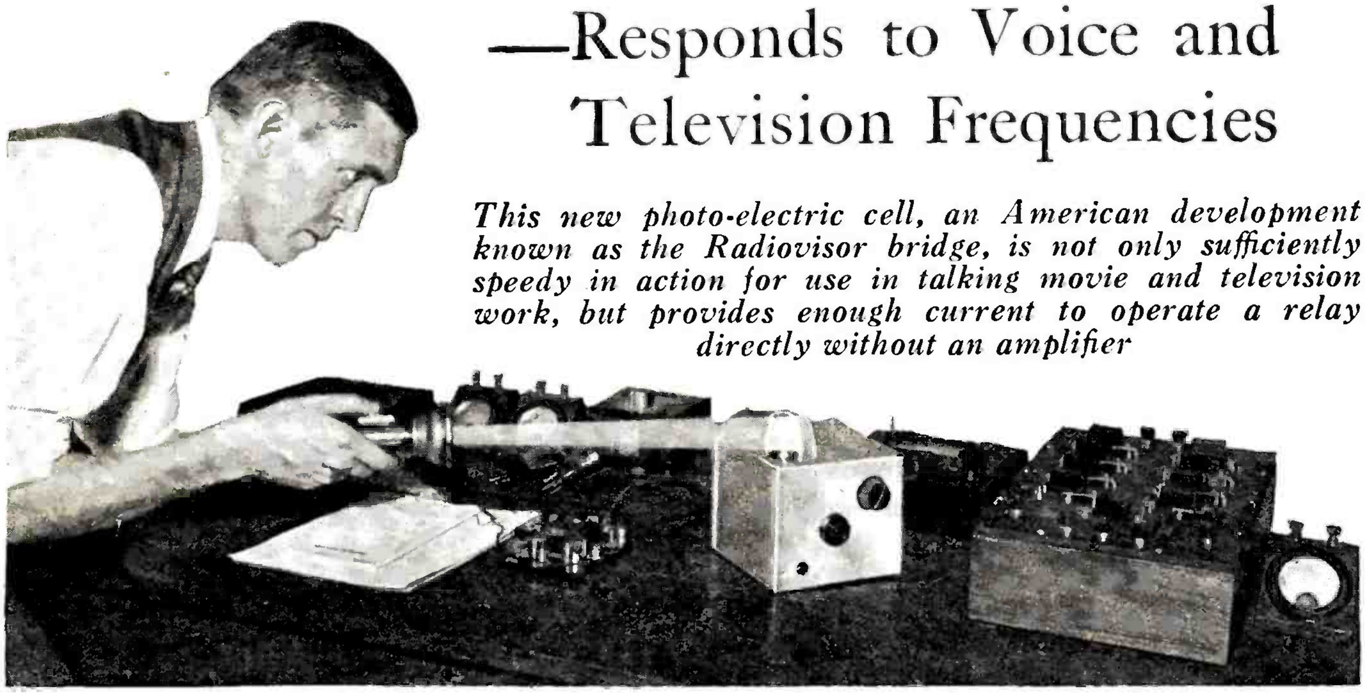
Below—A ready-made transmitter based on the design of Mr. Bennett's transmitter, for those who prefer not to build their own. This is intended for 10-meter work, but ready-made coils are also available for the 20, 40 and 80-meter amateur bands



SELENIUM AWAKES!

—Responds to Voice and Television Frequencies

This new photo-electric cell, an American development known as the Radiovisor bridge, is not only sufficiently speedy in action for use in talking movie and television work, but provides enough current to operate a relay directly without an amplifier



A set-up in the RADIO NEWS Laboratory employing the new selenium bridge. This unique cell provides sufficient current to operate a relay directly, when controlled with a beam of light

By Laurence M. Cockaday

PART ONE

DURING the last decade practical application of light-sensitive electric devices has been increasing rapidly both in electrical research and industrial work. Fire and burglar alarms, talking pictures, control of railway trains and signaling, sorting and counting of industrial products, control of street lighting, physical and chemical measurement and analysis are among these applications. And only recently the development of an actual artificial electric "eye" for persons with defective vision or total blindness, invented by Pierre Auger and Georges Fournier, was reported to the French Academy of Science by Jean Perrin, well-known physicist. A blinded French soldier, who has been using this device, is now able to distinguish the direction of an open door or window, a light burning in a dark room at night, light-colored or dark-colored furniture and to distinguish between persons dressed in light or dark clothes in a room. The device uses a photo-electric cell equipped with a lens system and working in conjunction with audio reproducing earphones which are worn over the ears. By learning the various sound intensities produced by different light intensities as the "eye" is focused in various directions, the wearer is soon able to pick out objects of light or dark shades.

Low Output; a Photo-Cell Problem

It has long been recognized that one of the drawbacks of the present-day potassium-hydride and the calcium types of photo-electric cells, used in a large number of these applications, is the tiny amount of electric current derived as a function of the light falling on the cell. The earliest type of light-sensitive cell was the well-known "selenium" cell (or bridge) as developed by Neale, an early English experimenter. It should be noted by the reader that the selenium cell changes its resistance under the influence of incident light; it is therefore often called a photo-conductive cell. The potassium-hydride and the calcium type cells depend for their action on the emission of electrons by a sensitive film of this compound. These electrons are then attracted by a positively charged plate. The selenium cell, it is true, produced a large change in electrical energy as a function of light, but it had other serious drawbacks, such as fatigue, leakage and slow-speed response, that have held it back in modern application. This slow speed was, however, due to the way it was applied rather than to the inherent qualities of the selenium. Further research has now enabled physicists to better understand the action of this metal and to overcome the above-mentioned disadvantages.

A new development of the selenium bridge takes the form of a tall tubular glass bulb, inside of which is mounted a flat glass plate. Upon the front side of this plate are two interlocking grids of gold fused onto the glass. These grids are covered with an extremely thin layer of selenium enamel.

Some idea of the large size of the light-sensitive surface may be obtained from this close-up of the new selenium bridge

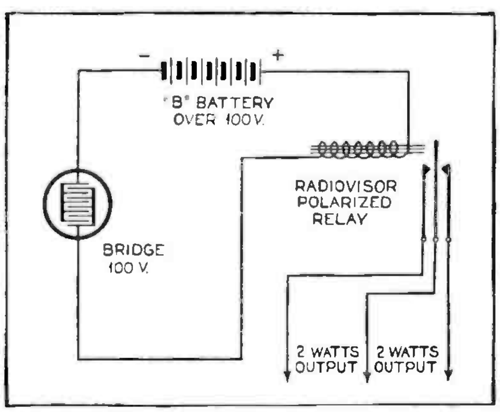


Figure 1. Direct-coupled circuit to polarized relay for controlling circuit by light variation. This is the simplest battery-operated circuit for the application of the bridge

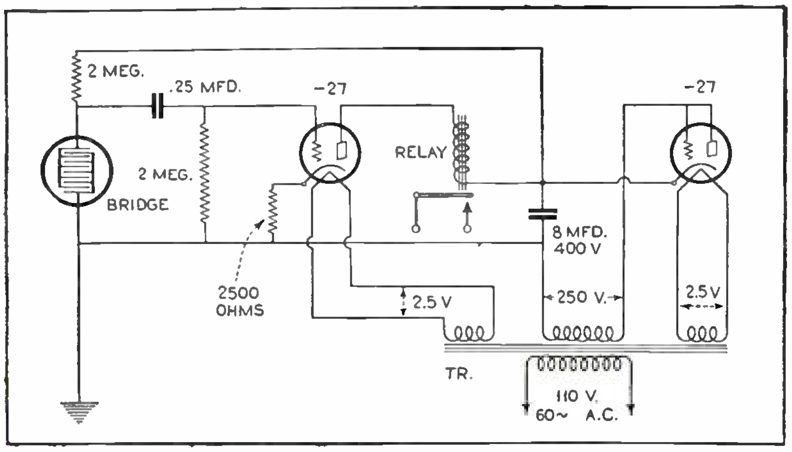


Figure 4. Impulse circuit for a.c. operation, with bridge feeding heater type tube actuating power relay

A new French device, using a photo-electric cell, has been successfully used by a blinded French soldier in place of the orthodox cane, to guide him in safety

The whole grid is subjected to a carefully controlled thermal-heating process during which the enamel is converted into a crystalline light-sensitive form of the metal. The glass plate which contains the sensitive surface is held in german-silver clips, making good electrical contact with the gold electrodes of the grid. It is enclosed in a glass bulb which is exhausted of air and carefully filled with a specially prepared chemically inert gas. The bulb is mounted on a new type of three-prong base which fits a special bridge socket. The third prong on the socket is there to prevent it from being inserted in the socket the wrong way.

The new bridge furnishes enough current to operate electrical relays, directly, for controlling a number of watts of electrical energy. The speed of this new bridge or cell has also been increased so that it is able to handle frequencies of sufficiently high orders for even talking moving-picture work. The new device, originally developed by German and English research physicists, has been the subject of still further development by the Burgess Battery Company. The American tube, known as a "radiovisor bridge," has an average ratio of dark-to-light resistance of not less than four-to-one when the incident light is varied from absolute darkness to 10 foot candles. It is practically independent of voltage. These new bridges are available in types for 100 volts, 220 volts and other special values up to 800 volts.

New Cell Has Large Light-Sensitive Surface

The glass plate and gold grid are coated with the active material spread as an almost infinitesimal thickness of the order of 2.5×10^{-3} cms., in order to make the utmost quantity of the light-sensitive material accessible to the illumination and to leave as small an amount as possible to act as an inert shunt to the active portion. The bridge contains an active surface measuring ¾ of an inch by 2 inches.

The new gold grid arrangement on the glass plate contributes to an extremely low internal capacity and enables the bridge to function on light frequencies as high as 10.000 cycles per second. The bridges are aged under test to allow the dark resistance to attain a steady value before the bridge is placed in service.

A standard bridge, with a dark resistance of the order of one to ten megohms, may be connected to a suitable d.c. supply in series with a sensitive relay which is ordinarily adjusted so that the normal current passing through it when the bridge is not illuminated is slightly less than that which would be required to close its contacts. Upon illumination of the sensitive plate in the bridge, the current increases to over four times the original dark amount and the relay closes immediately without resorting to the use of an amplifier. This primary relay can then be employed to control another more powerful relay circuit including a secondary relay. This secondary relay may be of a telephone relay type or a vacuum contact type specially developed for use with the bridge. Figure 1 shows a circuit for using the bridge in this manner, for dry-battery operation. It is possibly the most sensitive and (*Continued on page* 341)

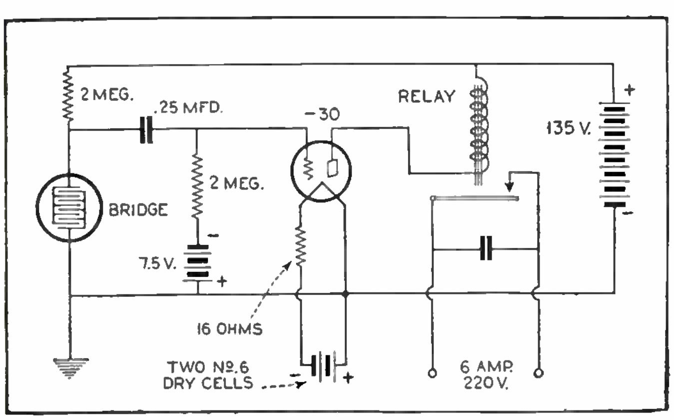


Figure 2. Impulse circuit for dry-battery operation, with power relay fitted with vacuum contact. Across relay is a 400-volt condenser, its capacity for d.c. non-inductive load, .0025 mfd.; for d.c. inductive load or a.c. non-inductive load, .005 mfd.; for a.c. inductive load, .01 mfd.

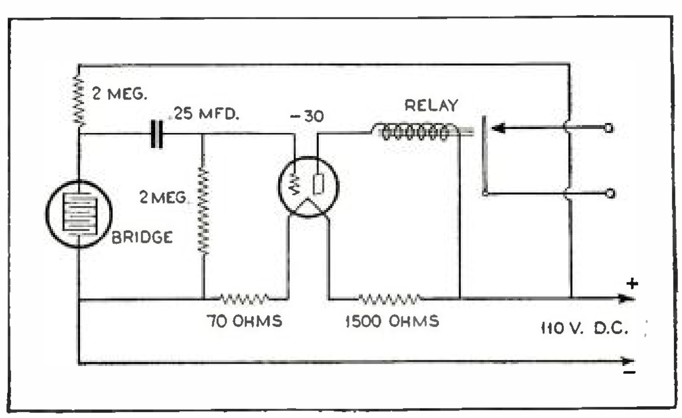
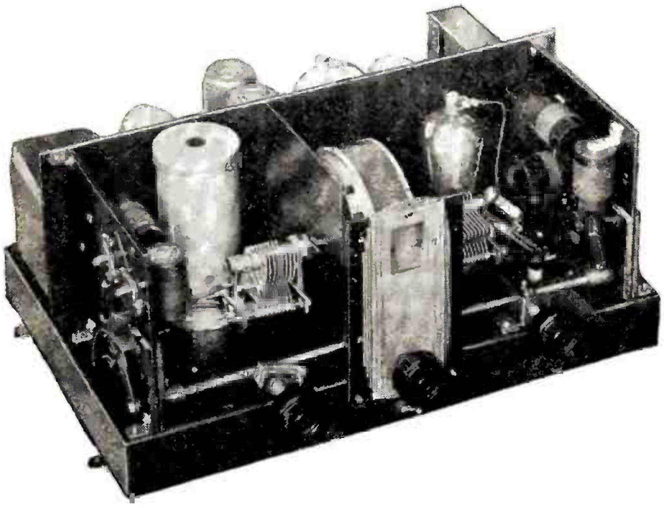


Figure 3. Impulse circuit for 110-volt d.c. operation, employing vacuum tube and power relay. If the circuit is to be operated on 220-volt current, the 1,500-ohm resistance is changed to 3,000 ohms

A "Rolls Royce"

A new idea in short-wave superheterodyne job which includes an r.f. stage, detector, and works into the antenna circuit

By James



The band shifting mechanism shown in this view has several unique features. The switches themselves are ganged by a shaft and controlled from the front panel. The same shaft manipulates a color screen in front of the main tuning dial illuminator. Thus the color of the dial illumination indicates the frequency range for which the converter is set. Additional contacts are provided on the band shifting switches so that an unused or experimental range is available to extend the range of the converter to frequencies not covered by the standard coils

SHORT-WAVE converters are by no means new. During the past few years a great many have been described in RADIO NEWS and kindred periodicals. In the light of present-day performance standards, some of the early ones were pretty poor, but each succeeding one has, as a rule, had some new feature of sufficient merit to warrant it being classed as a step ahead of its immediate predecessor.

The general design, at present, seems to be along the lines of the Lafayette, described in the August issue of RADIO NEWS, which comprises a screen-grid detector, -27 type oscillator and self-contained power pack. A series of plug-in coils provide a wavelength range of from approximately 15 to 115 meters. Such a converter, when used with certain types of broadcast receivers, gives amazingly fine results, but unfortunately its excellence of performance is apparently dependent, to quite an extent, upon the type of broadcast receiver with which it is used.

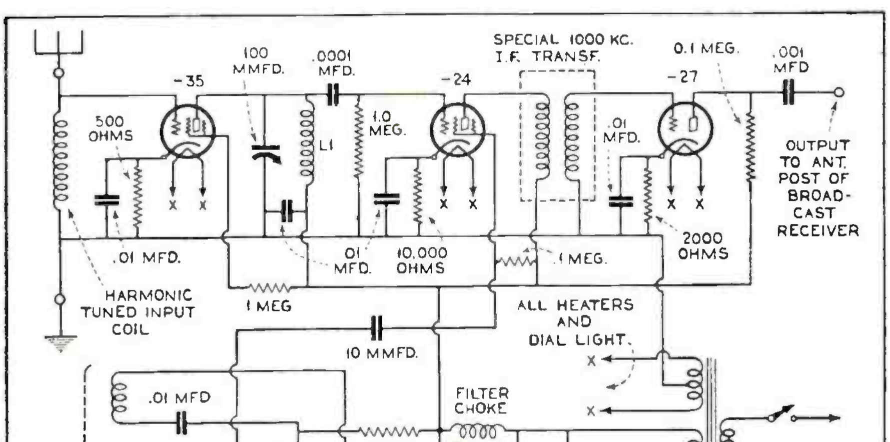
Such is also bound to be true of any converter which is merely a "frequency changer" and does not appreciably amplify the incoming signals. Thus it was evident that if a converter was to be designed that would give uniformly good performance regardless of the type of receiver with which it was used, such a converter would of necessity contain an appreciable amount of amplification both at signal frequency and intermediate frequency. Furthermore, it must overcome two other weaknesses inherent in all so-called three-tube type converters; namely, inefficient antenna coupling, so as to insure a strong signal on the first detector grid; and inefficient coupling between the output of the converter and the broadcast receiver with which it was being used, in order to insure some signal actually from the converter into the broadcast receiver regardless of whether the broadcast receiver used a low-turn input primary, a high-turn input, a coupling tube, an antenna-coupling condenser, or any one of the various other types of input systems resorted to by different manufacturers during the past few years.

It is this latter matter of coupling between the converter and the set that has caused so much difficulty with the varying performance of converters in the past.

Formerly it was thought that some sort of a tapped coupling transformer, for matching the output impedance of the detector plate circuit in the converter to the input of the broadcast receiver, would take care of this difficulty, but such practice was soon found to be a doubtful panacea.

It was then that L. W. Hatry, known to readers of RADIO NEWS as the designer of the HY-7 superheterodynes, hit upon the idea of using an additional (coupling) tube. Laboratory work during the past year has proven the wisdom of Hatry's suggestion, and, in fact, we have been able to go quite a step further in the design of the converter, in making the extra tube do double duty. In other words, in addition to being a coupling tube, it is also used as a high-gain i.f. stage so that the converter will give excellent results with some of the rather insensitive broadcast receivers, as manufactured prior to the advent of the screen-grid tube and the consequent high-gain tuned r.f.

From the foregoing it would seem that if cost were not of too much importance, there would be no reason, in the light of present engineering knowledge, why a really fine short-wave converter, universally applicable to any kind of broadcast receiver, could not be designed. As a result, we now have the design illustrated in the accompanying photographs. Including the rectifier, it employs five tubes, is the same size as a high-grade, short-wave receiver and uses about as many parts. Due to the use of the superheterodyne principle, it is, of course, much more selective than any of the standard type short-wave receivers, and when used with the average type of broadcast receiver will be found more sensitive and capable of greater volume, through the use of the broadcast receiver audio system and dynamic speaker. Of course, as with all "double detection" or superheterodyne receivers, the signal-to-



The circuit diagram, details of which are provided in the text. Coils L1 and L2 are shown here as single coils, the range selector switch being omitted for the sake of simplicity

*National Company, Inc.

# of Converters

converters is represented in this five-tube oscillator, one i.f. stage and power supply, of any type of broadcast receiver

Millen*

noise ratio on weak signals is far from being as favorable as with a "single-detection" or tuned r.f. receiver, such as the SW5 Thrill Box.

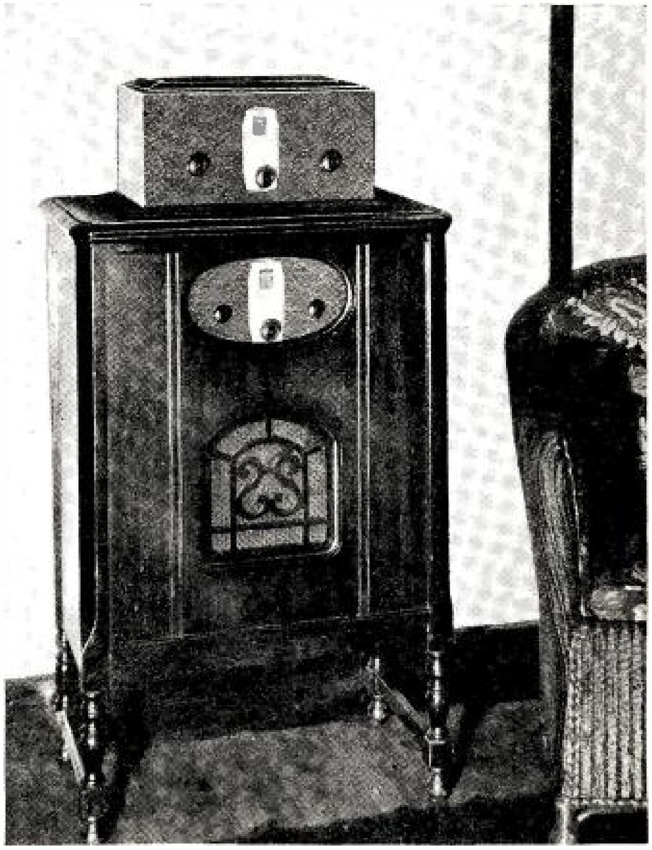
As short-waves come more and more into common use by the general public, the converter must be sufficiently attractive in appearance so that it may be placed in the living-room alongside the radio set with which it is to be operated. The new type converter is pleasing to the eye, has single-dial control and no plug-in coils. Furthermore, it is connected permanently in place and either the broadcast receiver or the short-wave combination is made available by merely turning a small switch on the panel of the converter.

The Circuit

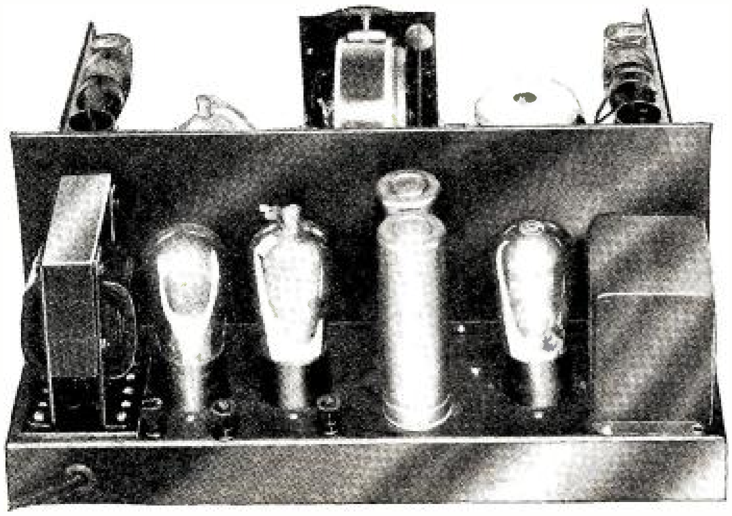
The circuit comprises a stage of "harmonic-tuned," signal-frequency amplification feeding into a screen-grid detector gang-tuned with the –27 oscillator. The beat-frequency output of the detector plate-circuit is fed through a special coupling transformer, peaked at 1000 kc., into the combination i.f. amplifier tube coupling circuit which is in turn connected to the input of the broadcast receiver. A type –26 tube is used as the rectifier which supplies the plate current to the four tubes in the converter, thus making battery or difficult connections to the power pack of the broadcast receiver, with the consequent danger of overloading, entirely unnecessary.

The "harmonic-tuned," signal-frequency amplifier is an outgrowth of the system developed in the laboratory of the National Company several years ago, in connection with its original short-wave receiver, in that the antenna is hooked directly to the grid of the screen-grid amplifier tube and the grid-to-filament circuit is completed by means of a high-decrement choke coil having a natural period of around 100 meters. Harmonics of this natural period will then fall on all the principal short-wave reception bands. During its early use several years ago trouble was encountered with this self-tuning amplifier system due to cross-modulation from strong local stations, but the recent introduction of the type –35 variable-mu tube eliminates this difficulty and makes the use of this input system practical and efficient.

The tuning condensers in both the oscillator and detector grid circuit are of the straight-frequency-line type. The two condensers are mounted on either side of the type "HS" projection drum dial, to form the single tuning control.



The new converter mounted atop a regular broadcast set and extending its range down to 15 meters when the switch on the converter is thrown to the short-wave position. Reversing this switch connects the antenna direct to the broadcast receiver



The power transformer and filter are along the rear, shielded from the detector and oscillator circuits by the long metal center partition

Although at first glance it may seem as if "grid-leak-condenser" detector is employed, such is not the case. In fact, such practice on the part of overzealous designers in a futile attempt to put "sensitivity" in their converters has perhaps been more responsible than anything else for poor converter performance in the past, as has been pointed out by S. Ballantine in the *I. R. E. Proceedings* for May, 1928, and H. A. Chinn in *QST* for June, 1931.

In the circuit diagram, Figure 2, the screen-grid detector works as a "plate circuit rectifier" due to the biasing furnished by the resistor in the cathode circuit. The grid condenser and leak shown are for the purpose of coupling the detector to the tuned plate-circuit of the initial r.f. amplifier tube.

Contrary to general opinion on the part of those who have not made extensive investigation in the field, plate detection that is as sensitive as the usual triode grid detection can be obtained with a type –24 tube when used with the proper circuit constants. Such a detector circuit is a feature of the new National converter described herewith.

The Coil Assemblies

To cover the range from 15 to 185 meters, one set of oscillator and one set of detector grid coils are required, and a switching arrangement, as shown in the photograph, is employed to bring the proper pair of coils into the circuit. In order to simplify switch construction and eliminate unnecessary losses, the circuit and coils have been so designed as to have a minimum number of connections that must be interchanged.

While the losses in the coils of a converter are not of the same importance as in a (*Continued on page 344*)

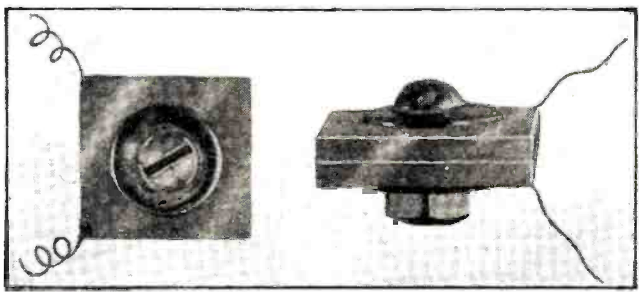
The Crystal Detector Again

Every so often the crystal detector comes up again for consideration as a means for improving tone quality. Here it is once more—with data for making a novel crystal unit which is permanent in adjustment

By E. A. Davis

WHILE the tonal qualities of a crystal detector have always been recognized, its neglect or lack of use has been due probably to its instability when constructed along conventional lines. This difficulty has been overcome by the construction of an efficient fixed detector, as described in this article, which comprises a pair of metallic plates having a thin dielectric sheet, such as tracing cloth, clamped between the plates, and having small grains of unilateral conductive material embedded in and extending through the sheet and in contact with the and forming a restricted unilaterally conductive connection between the plates and through the nonconductive sheet, which device is patented but the construction of which is substantially as follows:

Two plates one inch square of any metal sufficiently thick (about 3-32), having parallel smooth faces, are drilled in the center to accommodate a No. 8-32 machine screw, one plate being insulated from the screw by a small fiber washer and the other, the bottom plate, holding the machine screw.



Top and side views of the fixed crystal detector described in this article

Upon this plate, and permitting the machine screw to extend through, is placed a piece of linen tracing cloth slightly larger in area than the plate. Tracing cloth is used because it was found to be more uniform as to thickness and density and is more easily punctured than ordinary paper or other dielectrics. If the top plate is now placed in position and the nut of the screw tightened, the device would resemble an ordinary condenser. Before placing the top leaf of the holder, sprinkle lightly over the cloth dielectric fine particles of galena, iron pyrites or other such material having unilateral conductivity. The size of these particles must be uniform and no larger than the thickness of the dielectric. By passing the particles through a 100-mesh screen, the exact size may be obtained. Now the top leaf may be put in place. Previous to assembling the plates, there should be soldered to each metal plate a small wire about three inches long, forming a lead to accommodate the attaching of the crystal holder to the circuit.

After the top plate is put in place, having previously placed an insulating washer under the nut, screw down the nut, but not so tight as to puncture the dielectric. Place the device across a bridge circuit that will measure the unilateral conductivity; tighten the nut until a deflection is obtained, reverse the current flow and note the deflection. Adjust the nut until a ratio of current in one direction to that in the other is at least six to one, keeping the lowest side down to the minimum amount of current. The smaller the current flow of the low side, the better the detector. The plates will be found held tightly together.

In the absence of a bridge, the crystal may be mounted directly in series across the aerial and ground, having the phones in parallel with the first circuit; and tune the crystal holder by tightening the nut until the loudest signal is obtained.

A microscopic examination of the dielectric shows several irregularly shaped punctures and the fact that the minerals have point-to-point contact with either or both plates. The plate holder has some capacity but is quickly drained out, due to the approximate contacts of the minerals to the plates.

By constructing a crystal holder as outlined, a sensitive detector can be made, having many points of contact instead of the single, flimsy "cat whisker" type, and lends itself to a permanence and stability not obtained otherwise. After adjusting the plates to resonance, dip the assembled crystal holder in paraffin or coil dope, which prevents the elements from oxidizing. The assembled crystal plate holder shown in Figure 2 has the ability to handle tube currents without changing its characteristics and to maintain its permanence over long periods of time.

To further illustrate the idea of unilateral conductivity of the crystal detector plate, a graph is plotted in Figure 1 to show the current values at different voltages and with opposite polarity. When positive voltage exists, the crystal allows a current to flow, the value of which is determined by the characteristic curve, but no appreciable current flows when negative voltage exists.

In experimenting with the crystal plate in the grid circuit, in place of the conventional leak and condenser, the results obtained showed a striking increase in tone qualities and power output. The crystal plate is hooked up similar to the conventional grid condenser, with the low resistance side directly to the tube and the high side to the coil; but the grid return of the coil must be to the negative side of the filament. In the case of an a.c. tube, a negative potential must be supplied. (*Continued on page* 335)

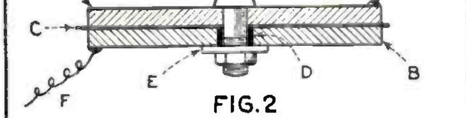


Figure 2. Section of assembled crystal unit. "A" is a machine screw and nut; "B," the metal plates; "C," tracing cloth bearing crystal particles; "D," insulating bushing; "E," insulating washer; "F," wire terminals

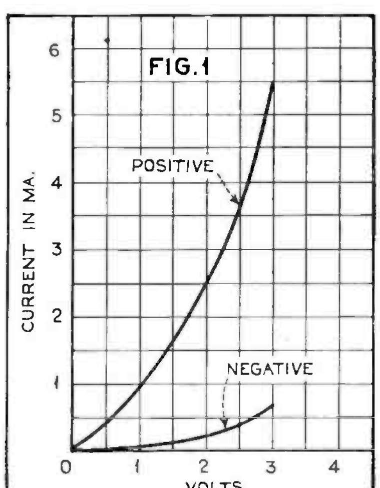


Figure 1. Curves demonstrating the unilateral conductivity of the crystal unit described in the text

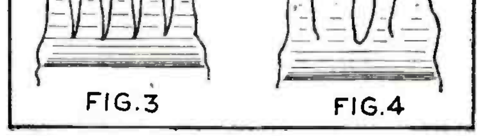
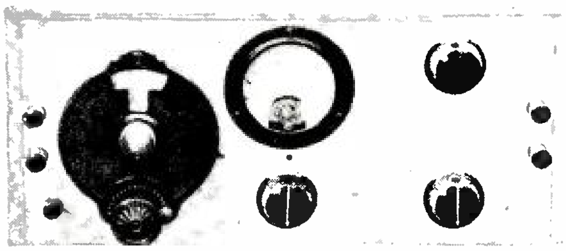


Figure 3. Manometric flame form of voice sound of "ah." Figure 3 illustrates form, using crystal detection, while Figure 4 was obtained using grid leak and condenser detection


The oscillator is extremely neat in appearance and is compact in size, as will be seen from this illustration

An All-Purpose Oscillator

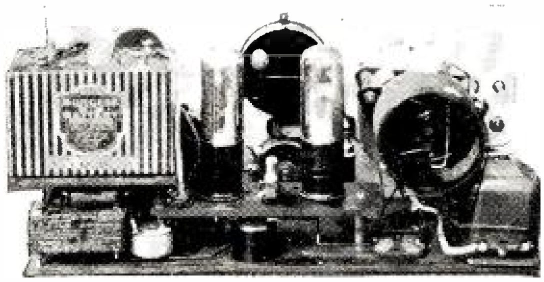
We have come to look on modulated r.f. oscillators as complicated and unstable devices, difficult to construct and oftentimes balky in operation. Here is one exception to the rule—and it is relatively inexpensive

By C. K. Krause

ONE of the most essential pieces of testing apparatus for the present-day laboratory or service shop is a modulated r.f. oscillator. From all indications and predictions it is nigh impossible to perform a 100% test job without some method of signal generation.

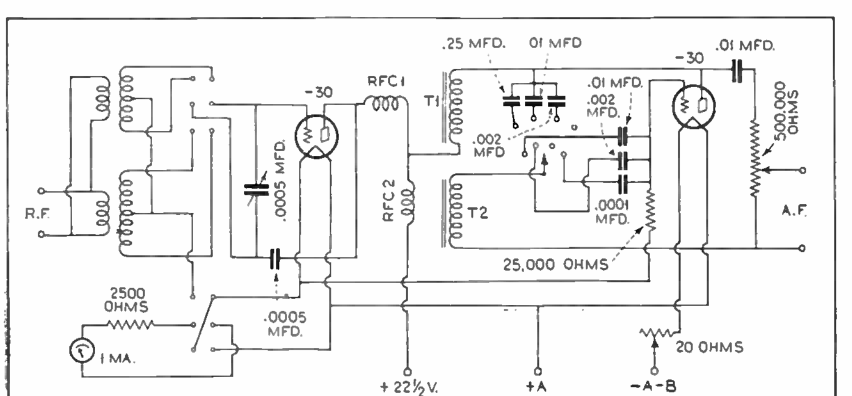
The oscillator described here was designed only after several months of careful work and has been in use for general testing purposes and experimental work. The following are some of the uses to which it may be put: separate r.f. oscillator; a.f. output may be used separately on an a.c. Wheatstone bridge circuit to align receivers and i.f. amplifiers, and to measure inductance or capacitance; a heterodyne wave meter; and when employed with an attenuator, known resistance and thermocouple ammeter, an ideal signal generator can be incorporated to make overall tests on receivers.

The range of the r.f. oscillator covers the broadcast band and in addition, by a simple switching arrangement, the intermediate range from 200 k.c. down below 100 k.c. This means that, should manufacturers start placing superheterodynes on the market using many different values of i.f., the oscillator will be capable of covering the range.


Detailed view of the oscillator with sides and back of "can" removed. The use of type -30 tubes permits employment of flashlight batteries for the filament supply, thus doing away with external batteries

The construction of the unit is quite simple and the total cost will be approximately $20.00 (including meter), contingent upon the equipment already on hand, such as condensers, coils, etc. The accuracy of the instrument depends a great deal on the care used in construction and calibration and the parts employed. It can be made accurate to the order of plus or minus one percent.

With the aid of the photographs and the circuit diagram, no particular difficulty should be experienced in duplicating this unit. Furthermore, it is not absolutely necessary to keep the same arrangement of apparatus. However, the placing of the parts as shown is quite satisfactory and because space is a factor in the design care must be exerted. One diversion if the constructor so desires would be to mount the r.f. coil on the top of the case and use the plug-in type of coils to cover many ranges.



The circuit of the modulated r.f. oscillator

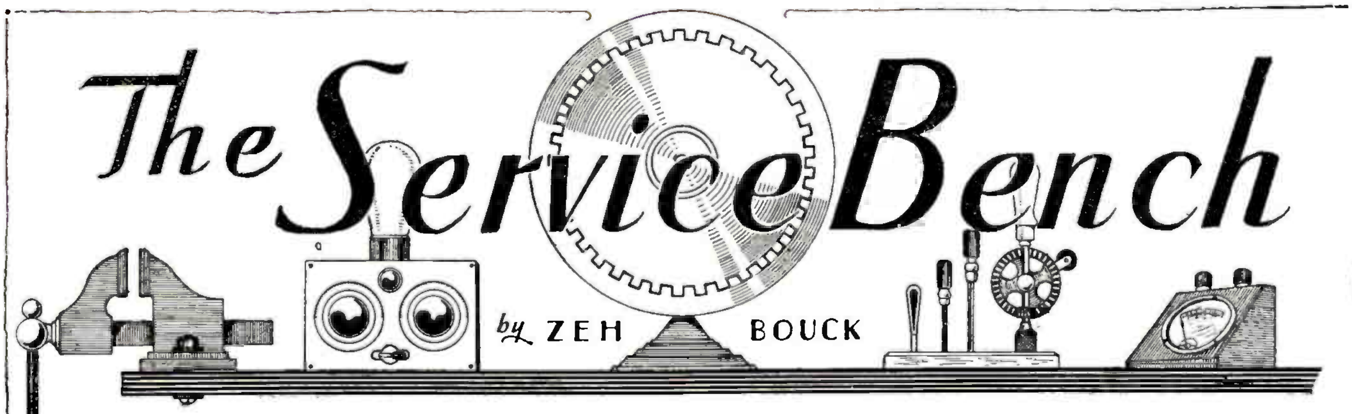
The entire unit including all batteries is housed in a can 5 inches by 6 inches by 14 inches. External leads are not necessary and troublesome radiation is done away with, thus tending to add to the accuracy. Also, with the addition of a handle, the unit is quite portable. Since the new two-volt tubes are used, the power requirements are simple, with the plate supply consisting of a small 22½ volt battery and the filament supply of a two-unit flashlight cell.

Details of Design

As can be seen from the diagram, an 0–1 milliammeter is used in the grid circuit to indicate oscillation and resonance. To further increase the accuracy, the meter in conjunction with a multiplier resistance is used to set and maintain the proper filament voltage. The change-over is performed with the aid of a double pole, double throw push button switch.

The broadcast r.f. coil consists of 51 turns center tapped, wound on a 2½-inch bakelite form and tuned with a .0005 mfd. variable condenser. To cover the intermediate frequencies a switch is used to throw over the long wave coil which is an i.f. transformer taken from a Radiola 60. Before this transformer is used the condenser across the transformer primary should be removed, the condenser across the secondary unscrewed for minimum capacity, and the neutralizing condenser shunted out. Since the variable condenser is kept in the circuit with the long wave coil, the range of intermediate frequencies covered will include a reasonably wide band.

In taking the r.f. energy from the unit it must be borne in mind that the method used should exert as little influence on the oscillator as possible. After trying many schemes it was concluded that the best method was to use a pick-up coil which had a very small diameter in comparison to the oscillator inductance. This coil consists of a random winding on a spool approximately ⅜ inch in diameter, ¼ inch deep and 1.4 inch wide, with about 150 turns of number (*Cont. on page 342*)



Money in Pick-ups—The Serviceman's V.T. Voltmeter—Pepping Up Indoor Antennas—Crosley—Majestic—Shop Notes—Radiolas—Servicing Rural Radios—Test Record Forms

Picking Up Cash With Pick-Ups

THE Service Bench has suggested the remunerative possibilities in the installation of phonograph pick-ups, and a few months back we demonstrated pictorially a simple and logical process of salesmanship. The general response to these suggestions has been such as to justify a more elaborate treatment of the subject, and the following paragraphs, culled from an investigation of the field and from many servicemen letters, are dedicated to a few extra rings on the cash register.

Harvey Forbes, a serviceman-dealer of Butte, Montana, makes an offer of an attractive allowance on old phonographs to every purchaser of a combination Radiola and Victrola. In addition to this, he devotes a few lines of his regular advertising space to announcing the fact that he is in the market for antique record scratchers. These he buys at ridiculously low prices (from fifty cents to five dollars), since the Y.M.C.A., overflooded with old machines, refuses to accept them as a gift! The larger models he equips with a good chassis—such as a Silver-Marshall—a high-grade pick-up and electric turntable. The smaller machines are rejuvenated merely by the installation of the motor and pick-up. A skillful brush and an oil rag efface the more serious marks of time, and Mr. Forbes sells the small reproducers for fifty-five dollars—a profit of about twenty-five dollars! Some of these are sold back to the original owners.

As we have had occasion to intimate in the past, the best prospects for phonograph pick-ups are your regular clients with old-type machines to which they hold on for reasons more or less sentimental. The phonographs are never played, because the comparison with the radio, all too eloquently, displays their inadequacies. A sale can generally be made by demonstrating the perfection made possible by the electric pick-up and the modern electrically recorded disc.

Any service call provides the opportunity for such a demonstration, and a good pick-up in the service kit makes the most of it. Carry three records—jazz, semi-classical and classical—selecting for the first demonstration that which you consider most in accord with your client's taste.

Figure 6. Your customers sometimes visit your shop. A small display is always attractive, and this one brings up the subject of tubes—and sells them!

A heavy weight on the base of the pick-up makes possible a temporary installation without the use of screws. Some servicemen find the portable electric phonograph, such as the Audak Musichrome, more convenient and satisfactory for a quick demonstration.

The serviceman should never find it justifiable to sacrifice a quality installation for price. Insist on selling your customer the best pick-up you can buy, and be satisfied yourself with the product. Under no circumstances sell other than the more recent models of pick-ups. They have been improved upon greatly, within the last year, and many of the models offered by mail-order houses, at cut prices, have been supplanted by a superior design.

Inspect the old cabinet and phonograph motor before deciding upon the type of installation. Several good motors and pick-ups are better adapted to different cabinet and motor-board requirements. A convenient and economical installation can be effected with a Pacent Electrovox chassis. This includes the motor, motor-board and pick-up, a single-unit arrangement which facilitates its incorporation in almost any type of cabinet.

Some pick-ups include a switch for changing from radio to record; in all other cases a switch should be provided for this purpose, preferably mounted on the radio cabinet and arranged to break one of the r.f. circuits when thrown to the phonograph side. Such a double switch makes it unnecessary to turn down the radio volume control when playing a record.

Many servicemen make no charge for the installation, merely charging the customer the list price for the necessary parts, making their profit on the discount. The customer is shown the list price on literature accompanying the pick-up. He is satisfied to pay this, and the "free installation" is a good sales argument.

Other servicemen prefer to give the customer a little better price on the pick-up and motor (always showing him that he is being favored with a special discount) and charging him the regular service fee of $1.50 an hour.

Liberal discounts are allowed servicemen by the manufacturer.

Some servicemen write that (*Continued on page* 352)

A SIMPLE CALIBRATED V. T. VOLTMETER

By G. F. Lampkin

OUT of a number of vacuum-tube voltmeters the one to be described was born. This meter is small enough to be portable, is sufficiently responsive not to require an overly sensitive indicator, and is rugged and reliable enough for hard, every-day usage. It is particularly useful in volume-level monitoring and audio-gain measurements, because of the calibrated dial.

Since the vacuum tube is always operated so as not to take grid current, it consumes no power from the input potentiometer. Therefore the latter can be calibrated directly in decibels. The dial is turned to hold a constant reading on the vacuum tube plate meter for various input voltages. The voltmeter may be calibrated to read the absolute values of input voltages. If this is done with the potentiometer dial set at zero decibels, then higher ranges may be measured. The actual voltage will be that read from the plate-meter calibration times a factor determined by the dial setting (see the chart in Figure 3).

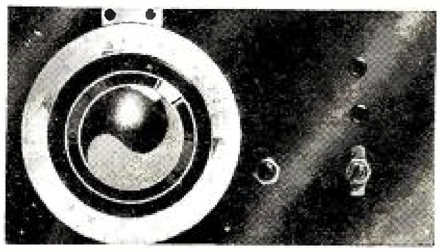


Figure 4. Front view of the serviceman's vacuum tube voltmeter. A direct reading calibration contributes much to the speed, accuracy and general utility of the instrument

However, the real usefulness of the meter is not so much in measuring absolute values of voltages as in determining relative values. The calibrated dial makes this possible without resort to curves. Dependence upon the constancy of tubes and batteries is not necessary when obtaining relative values.

The serviceman, when checking a radio receiver, has usually employed an output indicator—his own ear. For speedy and accurate neutralization, or for alignment, an indicating output meter is, however, really indispensable. Also, in measuring the gain of an audio amplifier at a single or several frequencies, the instrument to be described is ideal. The variation in gain, directly in decibels, can be read and plotted as quickly as a new frequency can be set. The overall gain can be computed by measuring the input and output at a given frequency.

There is little novelty in the circuit of the instrument shown in Figure 1, save, perhaps, in the absence of the grid bias potentiometer. The novelty is rather in the directly calibrated dial and in the choice and layout of the components. The apparatus is assembled on a 5½-inch by 9-inch formica panel, and a 5½-inch by 9-inch wooden baseboard. Three Burgess No. 5156 tapped 22.5-volt batteries are mounted on the rear of the baseboard, and supply "B" and "C" potentials. Figure 2 shows the general layout with details on the battery retainer.

In making the dial, an old 4-inch bakelite dial is turned down to below the etched lines and figures. Then a 4½-inch disk of aluminum is marked out, sheared and filed as nearly round as possible, fastened to the back of the bakelite dial with three screws and the whole dial given a final turning and polishing.

Figure 3 is a table for calibrating the dial. With a tube, put the grid bias at —4.5 volts, and select a plate voltage that will give an initial plate current of .05 milliamperes. Apply a 2-volt, 60-cycle alternating current to the input of the instrument. Turn the dial completely clockwise for maximum plate current, around 0.2 to 0.3 milliamperes. Read the value closely and make a slight scratch on the dial opposite the line on the indicator. Then apply 2.12 volts a.c. Turn the dial to retain exactly the same plate current as before, and lightly mark the dial for 0.5 db. Increase the voltage to 2.25, mark the dial setting for 1 decibel. Continue the calibration according to the chart in Figure 3. A "B" eliminator transformer with 2.5, 5, 7.5, 110 and 300-volt windings, with a rheostat for voltage control, can be used as the 60-cycle source.

Remove the dial, and with a sharp wood chisel and a hammer make a radial indentation at each scratch, just to a circle ¼ inch inside the edge. With a set of ⅛-inch steel figures, mark the graduations with the corresponding values in decibels. Line the figures to a 7/16-inch inner circle. A little advance practice with the figures on scrap aluminum will aid in doing a nice job on the dial. Finally put the dial in a chuck, and give the aluminum face an emery-cloth finish. Reset it on the Tonatrol shaft, with the shaft turned completely clockwise and the dial at zero.

If an input-voltage plate-current calibration for the zero db. setting is made, then for any other dial setting the input voltages are larger by the factor shown in the third column of Figure 3.

DIAL CALIBRATION DECIBELS	INPUT VOLTAGE	FACTOR
0	2.00	1.00
.5	2.12	1.05
1	2.25	1.12
2	2.52	1.26
3	2.82	1.41
4	3.17	1.58
5	3.56	1.78
6	4.00	2.00
7	4.48	2.24
8	5.02	2.51
9	5.63	2.82
10	6.33	3.16
12	7.96	3.98
14	10.03	5.01
16	12.62	6.31
18	15.90	7.94
20	20.00	10.00
22	25.2	12.59
24	31.7	15.85
26	39.9	19.95
28	50.2	25.12
30	63.4	31.63
32	79.6	39.81
34	100.2	50.12
36	126.2	63.10
38	158.9	79.43
40	200.0	100.00

Figure 3. Calibration chart for the V.T. meter, showing the variation in decibels for different voltage ratio—dbs. equaling 20 × the $\log_{10}$ of the voltage factor

The Parts List

Weston milliammeter, 0-1 ma.
Electrad Super Tonatrol, 100,000-ohm.
Frost hum balancer, 20 ohms.
Yaxley toggle type battery switch.
Yaxley tip jacks (2 required).
Polymet filter condenser, 1 mfd., 1000 volts.
Burgess No. 5156 "B" batteries, 22½ volts each (3 required).
UX type tube socket.
4-inch bakelite dial (see text).

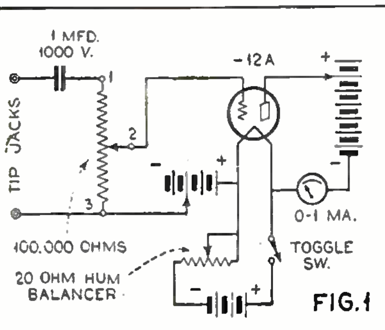


Figure 1. Circuit diagram and component values for a rugged serviceman's vacuum tube voltmeter

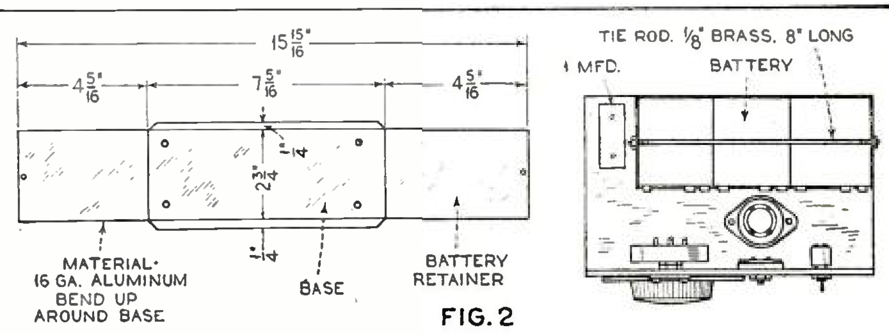
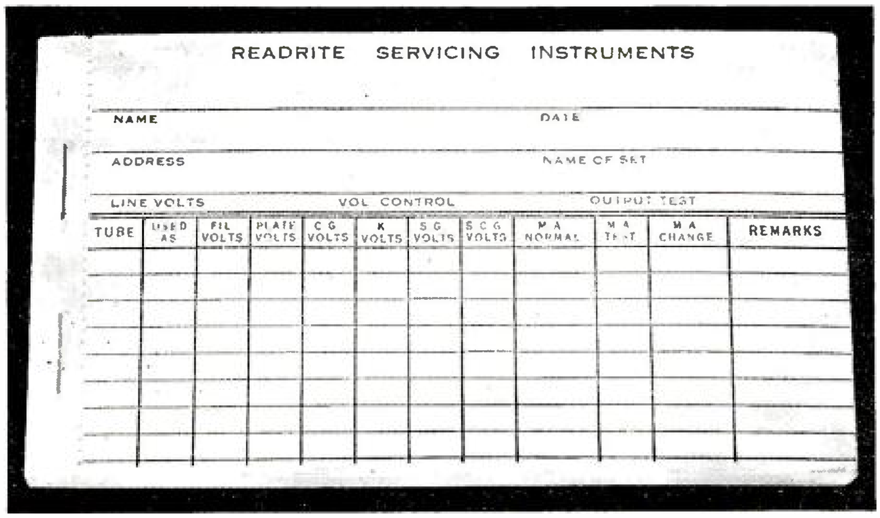


Figure 2. Layout and constructional details of the portable vacuum tube voltmeter

Free to Servicemen


READRITE SERVICING INSTRUMENTS

NAME DATE

ADDRESS NAME OF SET

LINE VOLTS VOL CONTROL OUTPUT TEST

TUBE	USED AS	FIL VOLTS	PLATE VOLTS	C G VOLTS	K VOLTS	S G VOLTS	S C G VOLTS	M A NORMAL	M A TEST	M A CHANGE	REMARKS

THE serviceman, if he is wide awake, is not satisfied to do a service job and then forget about it. Instead he will keep a record of the name of the customer and of the customer's receiver. This record, if properly kept, provides a lead for follow-up service sales and in case of another service call later provides useful data on the receiver to be serviced.

As an aid to servicemen the Readrite Meter Works has printed up a test record form of convenient size, and bound in pads of 75 forms each. One of these pads is shown full size in the accompanying photograph. These forms provide space for the customer's name and address, the date, type of receiver and test readings for all tubes in the set. RADIO NEWS *has been authorized to offer these pads to readers who may have use for them. There is no charge. The only requirement is that the request be written on the serviceman's letterhead or that of his employer if he is employed by a radio company or service organization. Or the request may be accompanied by his business card or billhead—anything to indicate that the writer is a bona fide serviceman. Address all requests to* RADIO NEWS, *Department R, 350 Hudson Street, New York City.*

ALL IN A DAY'S WORK

SIGNAL pick-up on the lower floors of steel apartment houses is notoriously poor when the receiver is operated from an indoor antenna—as is more or less an invariable rule in these days of high-sensitivity receivers and particular landlords. In such instances the pick-up can often be improved by grounding the open end of the antenna to a near-by radiator—or any convenient source of ground, providing it is not the same ground connected to the ground post on the receiver. While offhand it may seem that one ground is the same as another ground, and that the effectiveness of the aerial should be reduced by such a procedure, this is not the case. What really happens is that many more feet of antenna are available for pick-up purposes and the response of the receiver is often doubled, bringing in, satisfactorily, stations impossible to receive before. Using a radiator ground as an aerial and the water-pipe ground as "ground" is occasionally an excellent combination.

Haywire Possibilities on Crosley and Majestic

Harry Hooton, of the Radio Service Company, Beach Hill, West Va., sends along the following items from his service notebook:

"Three new Crosley receivers arrived here a short time ago, and all were as dead as the proverbial door nail. One of our servicemen happened to touch the grid terminal of a first radio-frequency tube, and the room was flooded with music. An examination showed that the wires leading from the antenna binding posts were broken. These were repaired and the sets performed well. We have also serviced quite a few Crosleys in which the antennas were grounded to the shielding at the posts. It is a good idea to check a Crosley at this point.

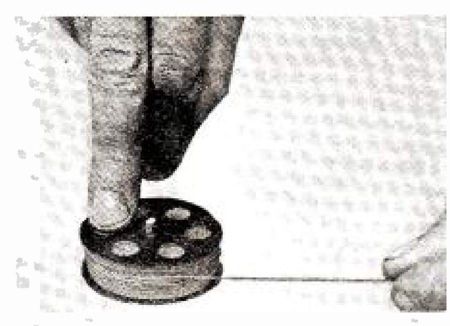


Figure 5. Winding discarded magnet wire on a typewriter spool—a neat and economical way of disposing of it until it is needed again, as it will be!

"Another 'queer' case was a Majestic model 52. This set would work okay for about ten minutes, and then the volume would slowly drop until, finally, the set was dead. After the set had become silent, the plates of the rectifier tube were red-hot. Examination proved the trouble to be a defective filter condenser. The cause was probably a slow leak through the dielectric which required some time to build up to a genuine short circuit."

A Service Shop Kink

Occasionally an observing nature is impressed with the waste that seems more or less characteristic of the average service shop. We are probably most profligate with the wire from discarded coils, and Frank Bentley, of Missouri Valley, Iowa, suggests a neat way of temporarily disposing of this surplus.

"Buying magnet wire to replace a good many pounds I have thrown away in the course of radio servicing, has finally cured me of a wasteful habit. Old typewriter spools make an excellent and handy means of keeping wire—and every bit you save is bound to be useful sometime in the future. The metal spools are easy to wind it on. Drive a nail through the hub of the spool into the bench, and turn the spool with the forefinger, feeding the wire with the other hand as shown in Figure 5. Twist the end of the wire around a rubber band, and slip the band over the spool. These spools take up next to no room, will not roll, and accommodate a surprising amount of wire."

Checking Up on Radiolas

Mr. J. A. Robinson, proprietor of Robinson's Radio Service, Methuen, Mass., specializes in Radiolas. In reference to models 44 and 46, he writes:

"When these receivers persist in oscillating (and when we say oscillating, we mean oscillating!), the trouble will generally be found associated with the two 'cans' covering the second r.f. tube and its related circuit. Remove the cans and clean, very thoroughly, the half inch of bare metal at the bottom of each can. Use sandpaper or a file, and bend so as to fit snugly in position. With the cans removed, bend the small lugs that are provided to make contact with the shaft of the ganged tuning condenser.

"On a Radiola 66, a customer complained of excessive static, accompanied with unusual fading. After checking their reception with that of a neighbor, I entered the complaint with my service department. Disconnecting both antenna and ground indicated the probability of external trouble in no way associated with this particular make of set. Examination of the antenna revealed no defect, but the ground gave us the solution to the trouble.

"The ground had been attached to the cold-water pipe where it entered the heater. The cold water pipe became quite warm as the heat crept along the pipe, and the constant contraction and expansion had helped the ground clamp to do its stuff—that is, to loosen up. Changed to a different location on the pipe, the ground clamp has remained tight for some months."

Interference in Rural Districts

The fact that radio servicing is by no means a strictly urban proposition is indicated in the contribution from Ronald A. McNeill, of Atwater, Sask., Canada, who writes:

"I have, on (*Continued on page* 352)

Backstage in Broadcasting

Chatty bits of news on what is happening before the microphone. Personal interviews with broadcast artists and executives. Trends and developments in studio technique

By

Samuel Kaufman

MAJOR EDWARD BOWES, director of the weekly Capitol Family programs over the NBC, recently celebrated his sixth anniversary as impresario of the Capitol Theatre programs. As on many occasions in past years, we were his studio guests. The studio where the Capitol programs originate is a large, low-ceilinged basement room just beneath the stage. It is the most peculiar studio in New York and if you ever witnessed other studio presentations you will notice the many different methods used here. Inasmuch as visitors are not regularly admitted, Yasha Bunchuk, conductor of the orchestra, is coatless. Between orchestral numbers he smokes. The door to the studio is left open throughout the presentation, in order to permit the quick entrance of performers from the stage above. Major Bowes sits in an easy chair in a distant corner of the room and makes his announcements into a table microphone. Kelvin Keech, the network announcer, sits alongside for station announcements. Although many guest artists are heard on the Capitol feature from time to time, the basic personnel has remained unchanged. Hannah Klein, pianist; Waldo Mayo, violinist, and three vocalists—Louise Bave, Westell Gordon and Dudley Wilkinson—are among the older members of the Family who appear on the feature regularly.

Major Bowes

WHEN Wiley Post and Harold Gatty reached Germany on the first leg of their record aerial circumnavigation of the globe, the NBC surprised American listeners by broadcasting the reception of the fliers on German soil. Thence, around the world to Canada, and the same chain presented a description of the completion of another leg of the great flight. And finally in New York a corps of NBC announcers, including Floyd Gibbons, did a splendid job in reporting the conclusion of the Winnie Mae's dash around the world. The NBC was not yet through with the fliers. George Engles, vice-president of the chain and managing director of the NBC Artists' Service, caused considerable astonishment in radio circles when he announced that his network would manage the subsequent national tour of Post and Gatty. The tour was to last six weeks or longer and was to cover the East, South, Middle West and the Pacific Coast. The tie-up with the radio network in this instance was rather unusual, and Mr. Engles partially explained it by the statement: "We hope in this way to assist in promoting greater public interest in this country in aviation." Bruce Quisenberry, of Engles' staff, accompanied the two fliers in their city-to-city tour.

ON the occasion of Roxy's birthday, we paid a visit to the noted showman-broadcaster in his temporary office in the Palace Theatre Building. Mr. Rothafel's quarters, in the suite reserved for the RKO Board of Directors, was filled with flowers and his secretary was busily engaged in opening batches of congratulatory telegrams and messages arriving in a continuous stream. We asked Roxy about several new radio and amusement features we heard he was contemplating for Radio City. He would not disclose any of his plans for the huge amusement center, but did state that many sensational features will be introduced. He regretted that he could not reveal the program plans before the actual completion of the first Radio City units in the Fall of 1932.

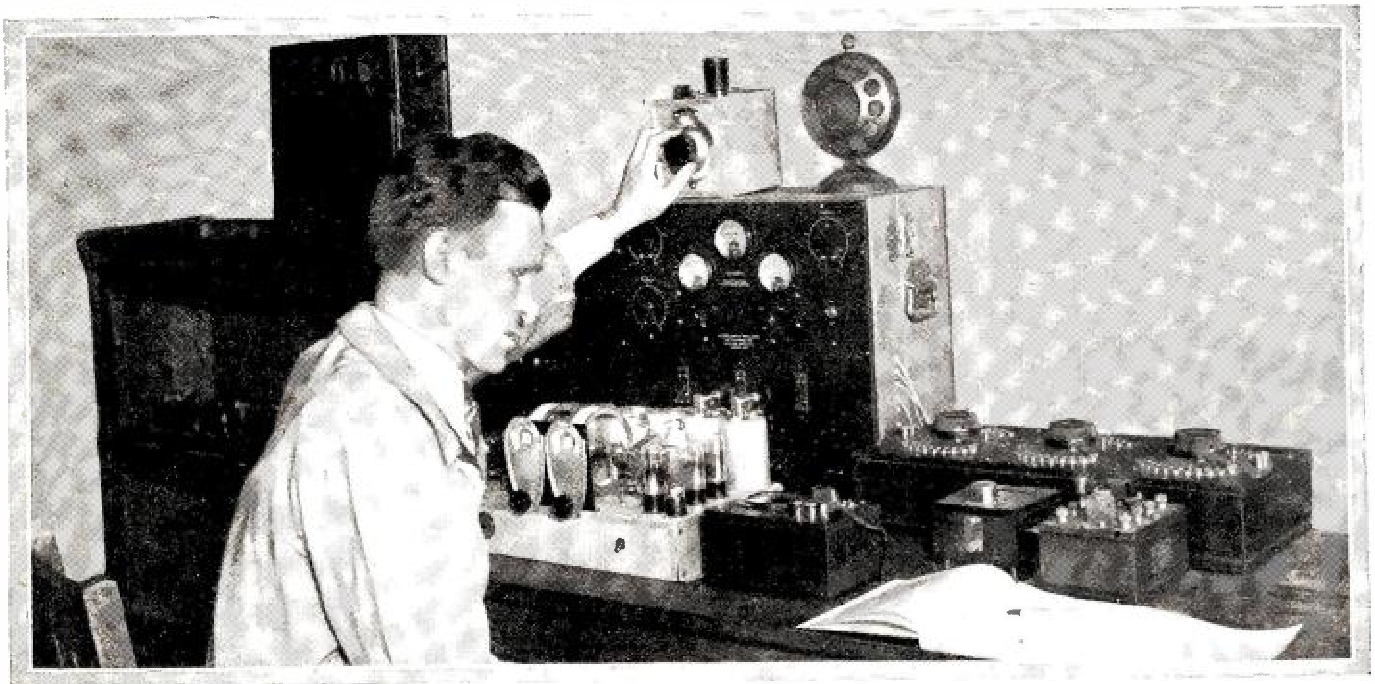
Wiley Post and Harold Gatty

MARY AND BOB, the radio team who for several seasons enacted stories from real life on the True Story Hour of the CBS, recently shifted over to NBC waves when the program was transferred to that network. The New York studios, where the program originates, have always been crowded to capacity by visitors anxious to witness the actual production of the feature. Mary and Bob, the rôles filled by Nora Sterling and Cecil Secrest, are assisted by a large cast of actors, Graham Harris' orchestra and Fred Vittell, tenor, in the presentations now heard Monday nights over the NBC. The vacated Friday period on the CBS was filled by the Liberty Radio Hour, a variety period containing dramatic sketches, talks by writers, musical interlude and characterizations based on features and stories in *Liberty*.

Nora Sterling

MAURICE BARON, the new conductor of the Roxy Symphony Orchestra heard over the NBC, is the composer of over 200 selections for orchestra, piano, violin and voice. While serving as assistant to his predecessor, Erno Rapee, his concert arrangements were frequently presented. He composed numerous music scores for motion pictures.

Baron was born in Lille, France, the son of an army bandmaster. He began his music studies in childhood. Not yet twenty, his family moved to Canada. Music was far removed from the Baron household and Maurice became a cowboy. Several years later he abandoned the ranch to become a clarinet player in a visiting circus band. When the season ended he was engaged by the Boston Opera Company as assistant conductor and chorus master of one of its road troupes. Reaching Seattle, he joined the local symphony as a violinist and remained for an entire season. The following season he joined the San Francisco Symphony Orchestra as a viola player. Coming East, he met S. L. Rothafel (Roxy), who hired Baron as a musical arranger for the Rialto and Rivoli theatres.



With the Experimenters

Two-Tube Pentode S.W. Receiver; Measuring A.C. Voltages; An Aerial Mast; Direct-Coupled Photocell Amplifier; Parts List for the Wood S.W. Adapter; Novel Aerial Hints; Constant Frequency Without a Crystal

Conducted by S. Gordon Taylor

A Two-tube, Pentode, S.W. Receiver

Now that we've heard so many vague rumors about a radio tube called "pentode," let's see what pentode is and *how* it can help us short-wave fans.

In the first place a pentode is a screen-grid power tube, called "pentode" because of an additional screen on the filament. But don't let that extra screen bother you, because it is connected direct to the filament inside the tube. Being colder than the filament, it collects any electrons coming toward the filament and grounds them, but allows free passage to electrons going toward the plate. As far as short-wave fans are concerned, it's easier to think of the pentode as a screen-grid power tube.

Its chief advantage is its immense gain; in fact, the gain of a pentode is so great that it can be fed by the detector, regardless of whether it be a grid leak and condenser or a bias type. Thus the first audio stage of our short-wave set can be done away with, and good riddance to it and its howls, hums and line noises. So much for *why* to use, now for *how* to use it.

Here are the current requirements:

Filament voltage..........2.5 volts a.c.
Filament current............1.5 amps.
Plate and screen-grid voltage...250 volts
Plate current..................32 mils.
Screen-grid current...........6.5 mils.
Control grid bias.......... —16.5 volts

It uses a UY base. The plate and control grid and filament connections are the same as on the type -27 tube. The screen-grid connection is to the point where the cathode connection is on a -27 tube. The pentode -47 *has no cathode.*

The grid bias required is —16.5 volts. The combined plate and screen grid mils is 38.5.

428.57 ohms
By Ohm's law. .0385 amps)16.5 volts,

so if the filament transformer winding is center-tapped, just put a 429-ohm resistance between the center tap and the ground. A 500-ohm Electrad resistor can easily be made 429 ohms by loosening one end clamp and sliding it toward the center, then tightening it again. If the filament winding on the transformer is not center-tapped, a center-tapped resistor on the tube socket will suit just as well.

In the circuit, Figure 1, a type -24 screen-grid tube is used with a condenser and grid leak and both "C" bias and

(*Continued on page* 345)

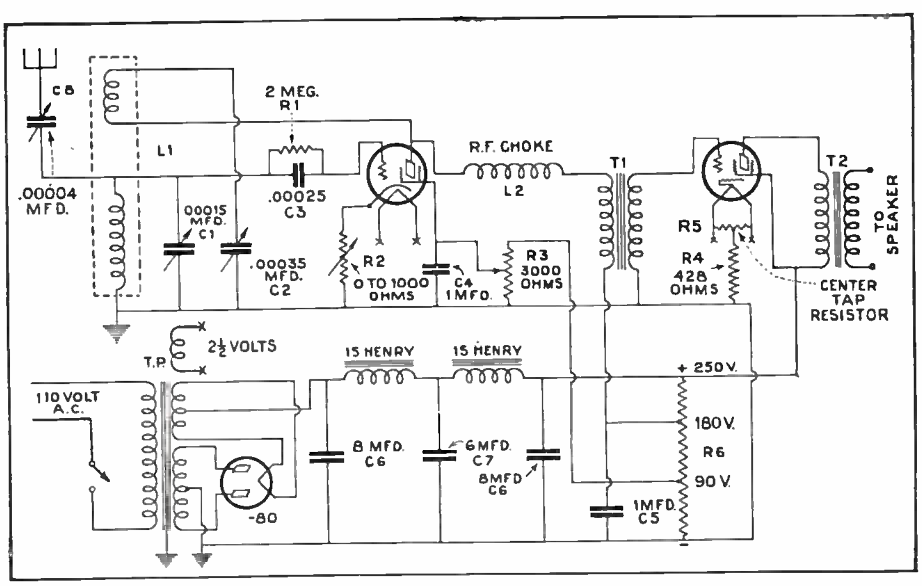


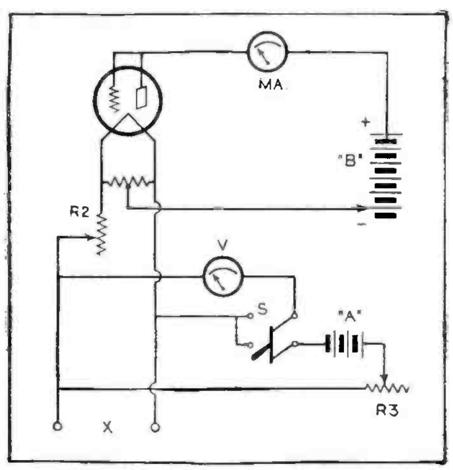
Figure 1. Circuit diagram of Mr. Smith's receiver

Measuring A.C. Voltages

I suppose a great many amateurs and experimenters with limited means have had occasion to measure a.c. voltages but, having only d.c. meters available, have been unable to do so. Here is a method of measuring a.c. voltages with a d.c. milliammeter and a d.c. voltmeter. This method should only be used to measure low-frequency sources where a current drain of 60 milliamperes will not cause an appreciable voltage drop.

The tube employed is a type -99 with plate and grid connected together to cause it to serve as a rectifier. The meter MA used is a d.c. instrument with a range of 1 milliampere, although a meter with a somewhat higher range will be satisfactory. The circuit for the connections is shown in this column. The plate battery voltage is adjusted to a value that will give a fairly high reading on the milliammeter when the filament voltage is adjusted to three volts by means of the filament rheostat R3, and the resistance R2 is not in the circuit.

With the resistance R2 set at maximum and the switch S open, the a.c. voltage to be measured is connected at the terminals marked X. Then the resistance at R2 is decreased until a fairly high reading is shown by the milliammeter. After this



reading is noted the a.c. voltage is disconnected from the terminals X and the switch S is closed. The rheostat R3 is then adjusted until the milliammeter reading is again the same as when the a.c. was connected. The voltage reading shown on the voltmeter will then be equal to the a.c. voltage under measurement.

If desired this measuring device can be calibrated by running a series of test measurements of various a.c. voltages and noting the exact setting of the resistance R2 for each different voltage. A given volt applied at X will always require the same amount of resistance at R2 to cause a given plate current to flow, providing the plate voltage remains constant. After the calibration has been completed the "A" battery, voltmeter, switch and the resistance R3 will no longer be needed.

In making a.c. measurements with this device it will, of course, always be necessary to have the "A" battery voltage equal to or higher than the a.c. voltage to be measured.

HARRY KENYON,
Berlin Heights, Ohio.

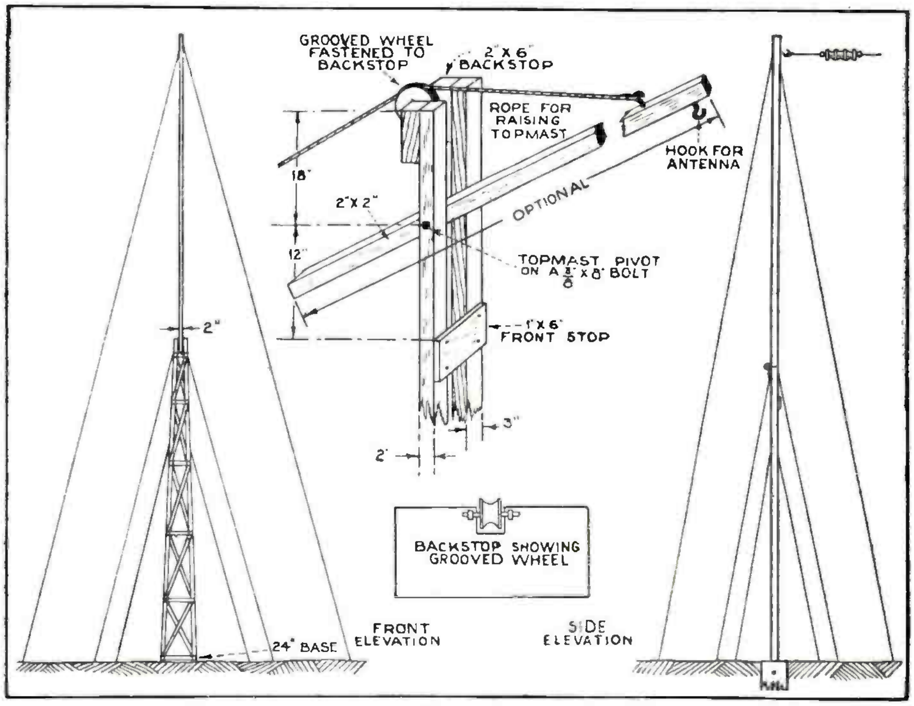


Figure 2

An Aerial Mast

The illustrations are of an aerial mast that has many advantages over those generally erected, in that the aerial wire and its attachments can be fixed at any time from the ground without lowering the main mast. It is light, but strong, and is pleasing in appearance. These points, coupled with simplicity and cheapness, make it worthy of the attention of the radio fan.

There are two sections; the lower one is a light latticed affair and the top one pivoted to the lower.

The lower mast can be built from a piece of 2 by 6, straight-grained and fairly clear. Rip this down the center and spread at the bottom to 24 inches, inside, and a little less than 2 inches at the other end. Lattice this up to suit your fancy, to within 30 inches of the narrow end. Here nail or screw a piece of 1 by 6, hereafter called the front stop, and on the other side, at the extreme top, nail or bolt a piece of 2 by 6 with a grooved pulley set in it. This is the back stop. How this pulley is inserted can be seen in Figure 2. When completed the lower mast should have sufficient guys attached on each side at the top, and two-thirds of the way down, to make it secure when erected.

Next prepare the top mast. This is made from 2 by 2 banister stock or other straight-grained stuff and should be free of all but the smallest imperfections. This is pivoted between the legs at the narrow end of the lower mast, about 18 inches from its top end. A 3/8-inch by 8-inch bolt is useful for this purpose. This pivot is then equi-distant between the front and back stop. A rope is fastened about two feet from the top end of the top mast and passed over the pulley. Now raise the lower mast by pushing it up with the top one, using the latter as a sort of pike pole. The lower ends of the lower mast can be pivoted between two pieces of 2 by 4 set in the ground or they may be set right in a hole. The use of cement is suggested here, bearing in mind, though, that this may make it a landlord's fixture. The lower mast is now erect, but the guy wires are dangling around and must next be fixed, being sure that the mast is perpendicular and straight with the world.

Next attach the insulators, antenna and guy wires to the top mast, which still has its high end within reach of the ground; go around to the other side of the lower mast and pull on the rope that was placed over the pulley. Up goes the top mast, carrying with it the aerial, etc. When this is nearly erect the rope will leave the pulley of itself and then is used as a guy. The top mast rests against the front and back stop. The side guys are finally drawn tight.

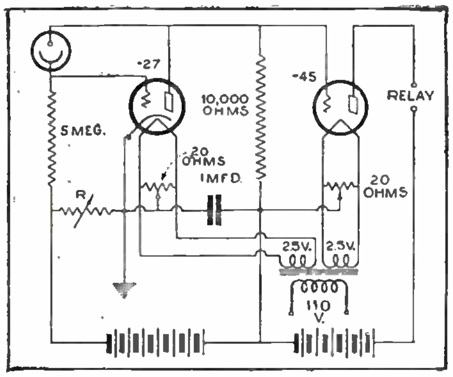
Whenever the aerial requires adjustment, simply loosen the rope. The weight of the aerial will start it down. Guide the rope back on to the pulley as it goes down and do your fixing from the ground.

WILLIAM S. PINCHIN,
Seemans, Sask., Canada.

Two-stage, Direct-coupled, Photo-cell Amplifier

While operating a photo-cell relay, the author ran across a common occurrence with this type of equipment. The current available from a single stage of amplification was only about 7 milliamperes. In order to operate the only relay on hand with sufficiently large contacts to handle the current which was to be broken, it was necessary to have a current of about 30 milliamperes. In order to operate this relay, a "power" amplifier was developed. The hook-up of this amplifier is shown on next page. Although this amplifier uses the Loftin-White principle, it is much simpler in operation. All of the voltage dividing equipment has been abandoned and "hum-balancing" resistors have been eliminated. The only condenser shown in the diagram is not really essential, but seems to eliminate any tendency on the part of the relay to chatter when acting at high speeds.

A "B" power unit capable of supplying 300 volts was used in place of the batteries shown in the diagram. The filament return from the –45 and lower end of the 10,000-ohm resistor in the –27 plate circuit were returned to the 180-volt tap. This is not a very critical adjustment, as any voltage from 150 to 200 will give good results. The only control necessary for the operation of this amplifier is the resistance, R, which controls



the grid bias on the first tube and hence the current through this tube. This in turn controls the grid bias of the second stage and the current through the –45.

In operation, a value of light slightly below the maximum is allowed to fall on the photo-cell. This increases the current through the first tube and increases the grid bias of the second stage until the current through the relay becomes a minimum. The resistance, R, is adjusted until the relay almost trips. The light source is then cut off and the effect noted on the relay. This should allow the relay current to return to normal and close the relay. If it does not, the adjustment should be repeated with a stronger light.

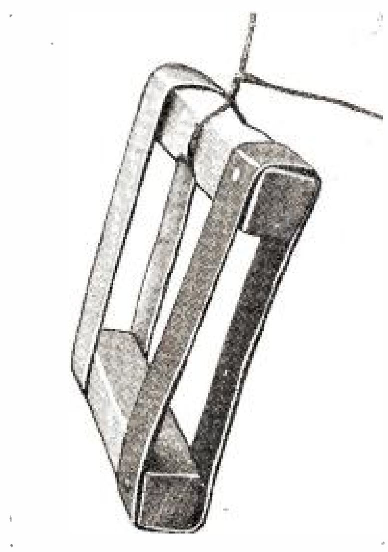
A resistance of 200 ohms for R will generally be sufficient to allow for any adjustments which may have to be made. It is to be understood that this amplifier was intended to produce large currents in the power stage.

C. BRADNER BROWN,
Kansas City, Missouri.

Parts List for the Wood S-W Adapter

In response to numerous requests from readers the parts list for the Wood converter, constructional details of which appeared in the September issue, page 212, is given herewith:

C1, C2—Hammarlund 60 mmfd. special Wood type midget condensers
C3, C4—Midget by-pass condensers, .1 mfd.
C5—Aerovox .0001 fixed condenser
C6—.005 mfd. fixed condenser
C7—.003 mfd. fixed condenser
C8, C9—Tobe 2 mfd. filter condensers
L1, L2, L3, L4—Wood coil set
R1—Durham 800-ohm resistor
R2, R4, R5, R6—Durham 4-gang resistors
R3—Durham 3 megohm grid leak
R7—Durham 200.000 ohm resistor
SW1—Yaxley No. 33 TB inductance switch
SW2—Yaxley No. 33 inductance switch
SW3—A.C. switch
VT1, VT2, VT3—Hammarlund flush UY sockets
VT4—Hammarlund flush type UX socket
National dial, type No. E-VED
Wood chassis base
Wood chassis frame, one set
Wood 30 henry filter choke
Wood power transformer
Wood power pack shield
Wood mahogany cabinet



Novel Aerial Hints

These are the days of the camp and the open road, with their difficulties. Temporary radio installations bring forth some ingenious methods of "getting by" as things which should be taken care of are only too often forgotten. The above photo shows a novel insulator and aerial connection found attached to the side of a summer cottage. Just two small inch-square sticks around which were tacked two rubber bands cut from an old tire inner tube. Easily made, easily put up and quite satisfactory in performance.

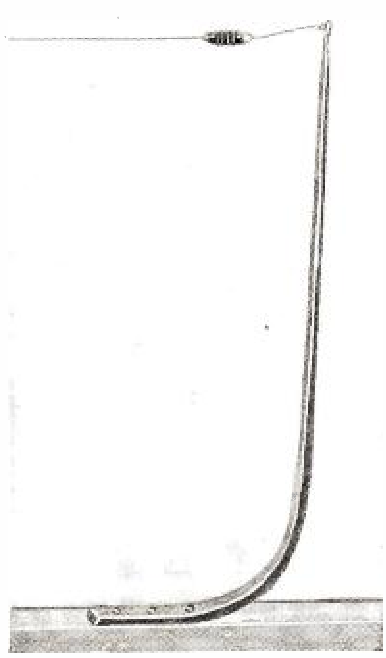


Figure 3

Aerial wires are often run along the ridge of a building, frequently with clumsy and unsightly pieces of 2″ x 4″ nailed up at each end to hold the wire. More work and material are made use of to keep these "lumber piles" up in the air than to hold the wire. If the wire along the building is not too long, a very neat and practical arrangement can be made as shown in Figure 3. Simply an old rib and socket from a discarded auto top. A number of small lag screws can be nicely used to secure it firmly to the capping, as the piece is light, but very strong with a bit of spring. Such fastenings or holders present a neat and workmanlike appearance. You can get them of any length you wish from a junked car dealer just for the asking, at most for the work of tearing them from an old car yourself.

FRANK W. BENTLEY,
Missouri Valley, Iowa.

Constant Frequency Without a Crystal

For some time amateurs have felt a need for an inexpensive way of keeping their transmitters constantly on one wavelength. The only means of getting constant frequency is with a crystal with a temperature control. In cases where a master oscillator with an amplifier or two between the master and power amplifier, the circuit is all the more useful, as a slight shift of the master throws every circuit out of tune.

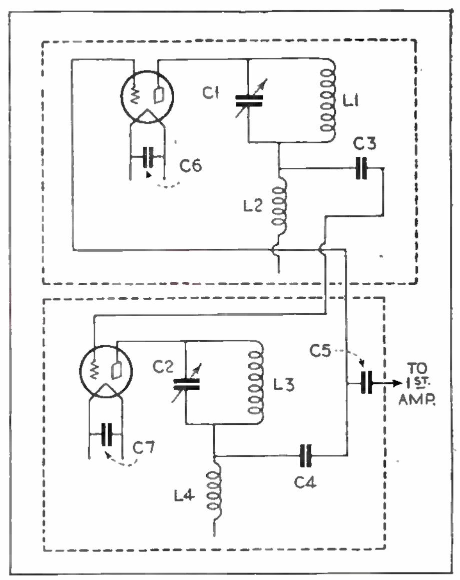
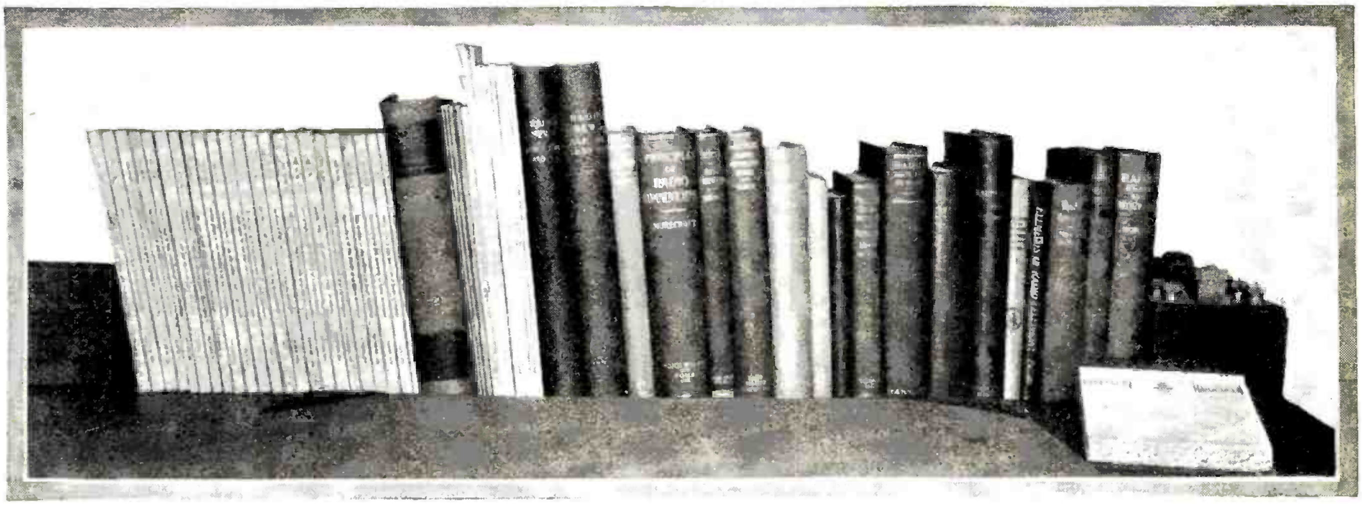


Figure 4

The accompanying diagram shows the circuit of a master oscillator that will cost little and give frequency stability comparable with that of a crystal. The proof of the last statement is borne out by the fact that we have been using the circuit described here on a 50-watt push-pull transmitter without a choke or by-pass condenser in the plate supply to the two 50-watters. Any amateur knows that the slightest frequency shift would burn our plate supply in no time. One of the greatest advantages of this arrangement is that the frequency can be varied to suit one's requirements while still the same constancy of frequency is obtained. This gives the transmitter a flexibility which offsets any possible superior steadiness of the crystal.

The diagram, Figure 4, needs very little explanation. Coils L1 and L3 are coils wound to your frequency. Condensers

(*Continued on page 348*)



Radio Science Abstracts

Radio engineers, laboratory and research workers will find this department helpful in reviewing important current radio literature, technical books and Institute and Club proceedings

Conducted by
Howard Rhodes

Experimental Radio Engineering, by John H. Morecroft. John Wiley and Sons, Inc.

This book, by the distinguished author of "Principles of Radio Communication", which since its publication in 1921 has been considered by most engineers the best text on radio phenomena, serves the important purpose of supplying the student of radio with a comprehensive text to be used as a guide in performing experiments in the radio laboratory. While some books have been published outlining various tests on radio apparatus, they are books that appeal only to the casual student and have little value to the keen observer. Experimental Radio Engineering, on the other hand, aims to give the student a thorough grounding in radio frequency phenomena and the experiments are arranged to show clearly the operation of various units and the factors which influence their characteristics.

The book contains a total of fifty-one experiments. The first few experiments are devoted to the measurement of inductance, capacity, resistance, mutual inductance and resonance. The following experiments include studies of meters, resonance indicators and antennas. The student is then led to experiments with the vacuum tube in which he studies their a.c. and d.c. characteristics, the vacuum tube voltmeter, detectors and power tubes. Other experiments are concerned with the permeability of iron, shielding, filters, the effect of taps on a coil, radio frequency amplification and similar subjects. We feel that the choice of material to be found in these fifty-one experiments is excellent and that the book will prove a very useful aid in connection with laboratory studies of radio frequency circuits and apparatus. The author follows the very commendable practice of including a large amount of quantitative material to indicate the characteristics of various units.

Experimental Radio Engineering is a book we can thoroughly recommend to all readers.

Radio Encyclopedia, Second Edition, by S. Gernsback. Published by S. Gernsback Corporation.

We have here the second edition of a book which proved quite popular among many radio fans. The entire book is arranged alphabetically so that under A we find information on all those radio terms and radio units whose names begin with A. In scope the text is very elementary and much of the information is in the form of definitions of the various units. To the man whose knowledge of radio terms is limited and who is not familiar with the uses of various units used in a radio set, this book will prove useful since the arrangement is such as to provide ready reference. It includes chapters on sound picture apparatus and television.

Note on Radio-Frequency Transformer Coupled Circuit Theory, by J. R. Nelson, Proceedings of the Institute of Radio Engineers, July, 1931.

Equations considering the effects of output and distributed capacities and primary resistance are developed for radio-frequency transformer-coupled amplifiers using either a tuned or an untuned primary. These equations are transformed to such a form that they may be compared with the well-known equations derived for an untuned primary neglecting the output and distributed capacities. The equations for an untuned primary are verified experimentally.

It is shown that the amplification obtainable with a tube and a transformer having an untuned primary may be made nearly uniform over a frequency range such as that covered by the broadcast band by adding resistance to the primary to reduce the high-frequency amplification. It is also shown that the addition of primary resistance reduces the selectivity approximately the same percentage as it reduces the amplification. The selectivity of a stage with a tuned primary is found to be approximately the square of the selectivity of a stage with an untuned primary.

Small-Signal Detection, by E. L. Chaffee, Electronics, May, 1931.

Much of the material published during the past on the theory of detection has been highly technical and mathematical. In this article the author endeavors to reduce detection theory to its simplest form. Much of the discussion in this article centers around graphical analyses which are of considerable aid for a clear understanding of how detectors operate.

Theory of Radio Communication, by John T. Filgate. Published by Radio Design Publishing Company.

Between the radio engineer and the man who knows little or nothing about radio circuits there is a large group of experimenters and service men whose knowledge of mathematics is limited but who have obtained a very useful and worthwhile practical knowledge of radio apparatus and the manner in which it operates.

To the man whose present knowledge of radio is very limited this book will prove useful.

The Variable-Mu Tube and Distortion in Radio Receivers, by A. G. Campbell, Radio Engineering, June, 1931.

This article goes into considerable detail in analyzing mathematically the performance of the variable-mu tube under actual operating conditions. The article covers the calculation of voltage gain and distortion.

Amplitude Modulation vs. Frequency Modulation, by Verne V. Gunsolley, Radio Engineering, June, 1931.

An article on the old problem—are there or are there not sidebands? Mr. Gunsolley discusses with considerable ability the relation of the sideband theory to frequency modulation and amplitude modulation. The author was evidently led to a discussion of the subject because of the Stenode circuit and the question as to whether or not this circuit operates on pure amplitude modulation. The author concludes the article with the following interesting comments: "Nothing could be clearer than the proposition that frequency modulation and amplitude modulation are radically different and entirely unrelated phenomena. . . The Stenode demonstrates the truth of the foregoing conclusion. It does receive without interference and yet it does suppress the high frequencies. If it were not true that reception on the Stenode is independent of sidebands up to the crystal, then the compensation in the audio amplifier would also compensate the interference, and in the same manner as it restores the suppressed frequencies it would also restore the interference. This it does not do, thereby demonstrating the truth of the analyses made in this article."

We recommend the article to those who have been intrigued by the discussion centering around the characteristics of the Stenode circuit.

Undesired Responses in Superheterodynes, by Ralph H. Langley, Electronics, May, 1931.

An article that discusses in considerable detail the problem of superheterodyne design with particular reference to the choice of the intermediate frequency to give minimum undesired responses. It also indicates the undesirability of depending entirely upon the intermediate frequency amplifier for selectivity due to the fact that, unless the carrier is also tuned, strong local signals may overload the tube, thereby producing harmonics and causing interference.

Notes on Public Address Installation and Operation, by Gordon S. Mitchell, Projection Engineering, June, 1931.

A good discussion of the practical problems encountered in designing and operating public address equipment. It covers problems of microphone placement, acoustics, frequency range, elimination of acoustic feedback and reflection, etc.

A Dynatron Vacuum Tube Voltmeter, by Rinaldo de Cola, Electronics, May, 1931.

The vacuum tube voltmeter described by the author has the advantage of considerably greater sensitivity than other types of voltmeters. Whereas the ordinary vacuum tube voltmeter using a three-element tube cannot ordinarily be used with any great accuracy to measure voltages less than about one-half a volt (unless very sensitive meters are used) the dynatron voltmeter readily measures as low as five-hundredths of a volt. For the voltmeter a standard type 224 tube is used with the meter connected in the screen grid circuit. The voltage on the screen grid is about 90 and the plate voltage is variable by means of a potentiometer from zero up to about 45 volts; the potentiometer permits the plate voltage to be accurately adjusted to the proper operating point. In the grid circuit is a grid leak and condenser and the unknown voltage to be measured is applied to the grid circuit. An a.c. input voltage of 0.05 gives a plate current change of approximately 0.2 milliamperes. By placing the indicating meter in the plate circuit instead of the screen circuit the sensitivity is almost exactly halved.

The Design and Construction of Standard Signal Generators, by C. J. Franks and Malcolm Ferris, Radio Engineering, June, 1931.

This article, a reprint of a paper delivered by the authors before the Radio Club of America, discusses in considerable detail the essential properties and requirements of a standard signal generator, its construction and use. Several photographs and circuits are given of typical generators. Considerable information is given on the matter of shielding, output and attenuating systems and sources of error therein, modulation, filtering, etc.

Performance of Piezo-Oscillators and the Influence of the Decrement of Quartz on the Frequency Oscillations, by M. Boella, Proceedings of the Institute of Radio Engineers, July, 1931.

In Part I of this paper, the performance of piezo-oscillators of the usual Pierce circuits is treated on the basis of the resonance curves of the quartz (taken experimentally) and with the help of vector diagrams.

In Part II, the influence of the decrement of the quartz resonator on the oscillation frequency is examined. This study has led to the development of an arrangement which permits the quartz to oscillate in proximity to its frequency of resonance and to reduce thereby the influence of the decrement on frequency to about 1/10 of that usually found.

Preview of Some of the Papers to Be Published in the September, 1931, Issue of the Proceedings of the Institute of Radio Engineers

A Simple Method of Harmonic Analysis for Use in Radio Engineering Practice, by Hans Roder.

A simple method of harmonic analysis is applied for a.c. waves with certain properties. Curves having such properties often occur in audio and radio-frequency applications in the form of so-called "characteristics." This paper presents a graphical method of finding the amplitudes of the harmonics by working directly from the "characteristic." For obtaining the results, a polar planimeter is used. The design of a new mechanical harmonic analyzer is based on this method.

Performance of Output Pentodes, by J. M. Glessner.

The comparison of power output, distortion, power sensitivity, and a.c./d.c. power economy of a group of experimental pentodes is made with corresponding triodes. The apparatus and method of measuring are described.

The pentodes' a.c./d.c. economy and power sensitivity are considerably higher than that of the corresponding triodes. The harmonic distortion is found to be generally worse with the pentodes. The variation in power output with changes in load resistance, arbitrarily called "output distortion", is shown to be about the same for both classes of tubes.

The need of a large capacity shunting the bias resistor in a self-biased pentode amplifier is shown. Its effect on power output and power sensitivity is discussed.

In the conclusion, five types of distortion occurring in triode and pentode operation are compared. The principal use for the pentode appears to be with battery and 110-volt d.c. types of receivers.

Some Developments in Common Frequency Broadcasting, by G. D. Gillett.

This paper describes the results of the simultaneous operation of radio stations WHO and WOC on a common frequency using independent crystal controlled oscillators. These stations had previously been compelled to share time on 1000 k.c. and each is now able to render full time service.

The exceptional stability of the crystal controlled oscillators used at each station is described. Since even these oscillators require occasional readjustment to maintain them in isochronism, a monitoring receiver was established midway between the stations and the resultant program is sent back by wire line to WOC to provide an indication for readjusting its frequency to exact isochronism with WHO. An audio oscillator used to modulate the carriers in the monitoring receiver provides a tone independent of the program for the guidance of the operator. Curves are presented showing the quality impairment caused by different degrees of isochronism and signal strength ratios.

The improvement in distance reception with simultaneous operation is reported and an explanation given. The impaired reception in the area midway between the stations and outside their normal service range is shown to be a function of the degree of modulation of each transmitter, of the field strength ratio and of the audio phase angle and independent of the carrier phase at the transmitters. It is pointed out that reception equal to that from either station alone may still be obtained in this area by the use of a simple directive antenna.

The marked increase in the service rendered by these stations through simultaneous operation is indicative of the improved service that can be rendered to urban areas by common frequency broadcasting. Although it is probable that the high powered station on a cleared channel will remain the best means of affording a high-grade service to a metropolitan area while also rendering an acceptable service to large rural areas, common frequency broadcasting now appears to offer definite means by which to provide an improved coverage to a number of noncontiguous communities.

A Thermionic Type Frequency Meter for Use Up to 15 KC, by F. T. McNamara.

A new type of frequency meter is described which is adapted to the measurement of low and intermediate frequencies. The instrument absorbs a negligible amount of power from the circuit being tested, has a linear calibration curve and a sensitivity of about eight microamperes for one per cent change in frequency. An experimental model is described in detail. The input to this model is between five and ten volts. The method makes use of a bridge system and two tubes operating as balanced detectors. The meter reading is directly proportional to change in frequency for small changes.

Developments in Short-Wave Directive Antennas, by E. Bruce.

Part I of this paper discusses the relative importance of the factors which limit the intelligibility of short-wave radio telephone communication. The more important of these factors are inherent set noise, external noise (static, etc.) and signal fading. The possibility of counteracting these limitations through antenna directivity is indicated.

Part II describes an antenna system which maintains a desirable degree of directivity throughout a broad continuous range of frequencies. The cost of this antenna is more favorable than that of many types of fixed frequency antennas of equal effectiveness.

Automatic Color Organ Producing Color by Music, by Edward B. Patterson.

The automatic color organ, a by-product of radio, produces color by means of music and synchronizes colors with music. Acoustic power on the order of microwatts controls lighting power of hundreds to millions of watts, which is varied in accordance with rapid fluctuations of the input.

The circuits are controlled by means of thyratrons, which has the advantage that only a small input power is required to release very large amounts of power in the plate circuit. (*Continued on page 326*)

Radio Physics Course

This series deals with the study of the physical aspects of radio phenomena. It contains information of particular value to physics teachers and students in high schools and colleges. The Question Box aids teachers in laying out current class assignments

Lesson Three

Sound, Musical Instruments, Tone Quality, Frequency Range as Related to Broadcasting

By Alfred A. Ghirardi

MUSICAL sounds are sustained at definite pitches for comparatively long times and the change in pitch takes place in definite steps called the musical interval—thirds, fifths, octaves, etc. The musical sounds are all agreeable to the ear. However, we can very easily distinguish the sound of one musical instrument from that of another. For instance, middle C, which is defined as producing 256 air waves per second, may be struck on the piano, blown on a trumpet, or played on a violin, yet the sound in each case will be characteristically different, and easily recognized, despite the fact that the pitch or frequency of the fundamental sound waves thus produced is exactly the same in all three cases. We have no difficulty in recognizing the particular instrument which produced it. The voices of different persons can also easily be distinguished and recognized. The characteristic which enables one to recognize the tones of the different instruments, or to assign a sound to its source, is called the *quality* or *timbre*.

Quality and Timbre

The physical explanation of quality or timbre is that most sounding bodies vibrate not only as a whole but also in various parts as well. When the string of a musical instrument is plucked so as to make it vibrate as a whole as in (A) of Figure 1, the production of the musical note is easily understood. When a bow is drawn across it or the string is plucked at the proper point, it may not only vibrate as a whole, but in parts as well. This may easily be seen by plucking the long strings on a piano. Thus at (B) a string is vibrating as a whole between points A and C and is also vibrating in halves between A B and B C. At (C) a string is vibrating as a whole and in five segments. The same action occurs in vibrating air columns. When a string or an air column vibrates as a whole (A), it produces its lowest tone or *fundamental*. When it vibrates in two segments (B) it produces its first *overtone* or second harmonic. This harmonic is double the frequency of the fundamental. A *harmonic* is a simple multiple of the fundamental frequency. Thus the second harmonic of middle C (256) is $256 \times 2 = 512$. The fourth harmonic is $256 \times 4 = 1024$ cycles, etc. When the string vibrates in fifths, as at C, the fourth overtone or fifth harmonic results, etc. A string or air column of a musical instrument can be vibrating as a whole and at the same time be vibrating in segments. It will then give out its fundamental frequency and a number of harmonic frequencies at the same time. The harmonics are usually weaker than the fundamental, but in some musical instruments they may be stronger.

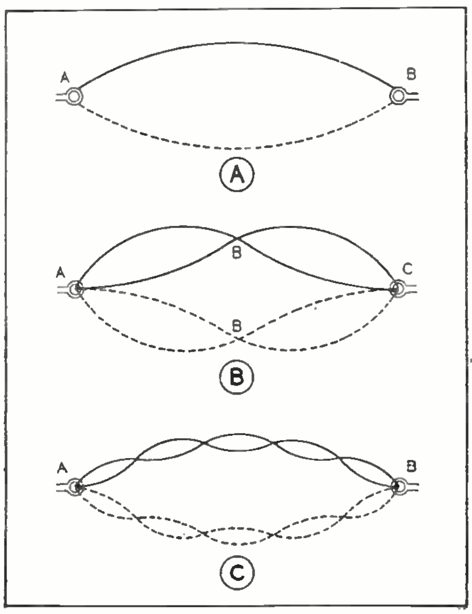


Figure 1. Showing the action of musical strings plucked or bowed at different positions. A represents the action when the string vibrates as a whole, producing a single fundamental frequency. At B and C the string vibrates as a whole and also in parts to produce overtones or harmonics

The fundamental and harmonic sound waves do not exist separately in the air, but combine to form a resultant wave which is different from any of its components. This is the wave which affects the ears of the listener. The combination is responsible for the "quality," "timbre" or "tone color" of the tone and gives each musical instrument its individual characteristic sound. The general "wave form" of a musical note of a given frequency maintains a similarity easily recognized as being of a certain fundamental frequency regardless of the instrument which produced it. Figure 2 shows the actual wave forms of the sound waves produced by sounding the note middle C on the piano, 'cello organ pipe, and trombone organ pipe. These curves were determined by Dr. Harvey Fletcher of the Bell Telephone Laboratories. At the top is the wave form of a "pure" fundamental or sine wave sound of the same frequency. Note the differences in the little zigzag lines of the sound wave curve of note C originating on the piano and the same note originated on the 'cello organ pipe and trombone organ pipe. These little zigzag lines or ripples are caused by, and represent the number, position and loudness of the harmonics in the sound waves produced by these particular instruments. The height or amplitude of these lines indicates the loudness of each harmonic. Note that the general form or shape of the wave is similar in all three cases. A low-pitched piano tone has a large number of harmonics; the third harmonic of the 'cello organ pipe has about five times the amplitude of the fundamental; the trombone organ pipe is also very rich in harmonics.

Pure tones (tones without harmonics) are very rare and lack individuality. They seem very flat when heard by the ear and have little musical value. Higher harmonics than the fourth are seldom encountered in ordinary practice. Harmonics higher than the third are not important. It is the abundance of strong harmonics that produces the "quality," "tone color," or richness of musical sounds, but the pitch depends entirely on the fundamental frequency. Those musical instruments which have a deep rich tone are the ones which produce strong harmonic frequency air vibrations as well as the fundamental. Musical tones are quite complex because of these harmonics.

The harmonics are influenced greatly by the difference in

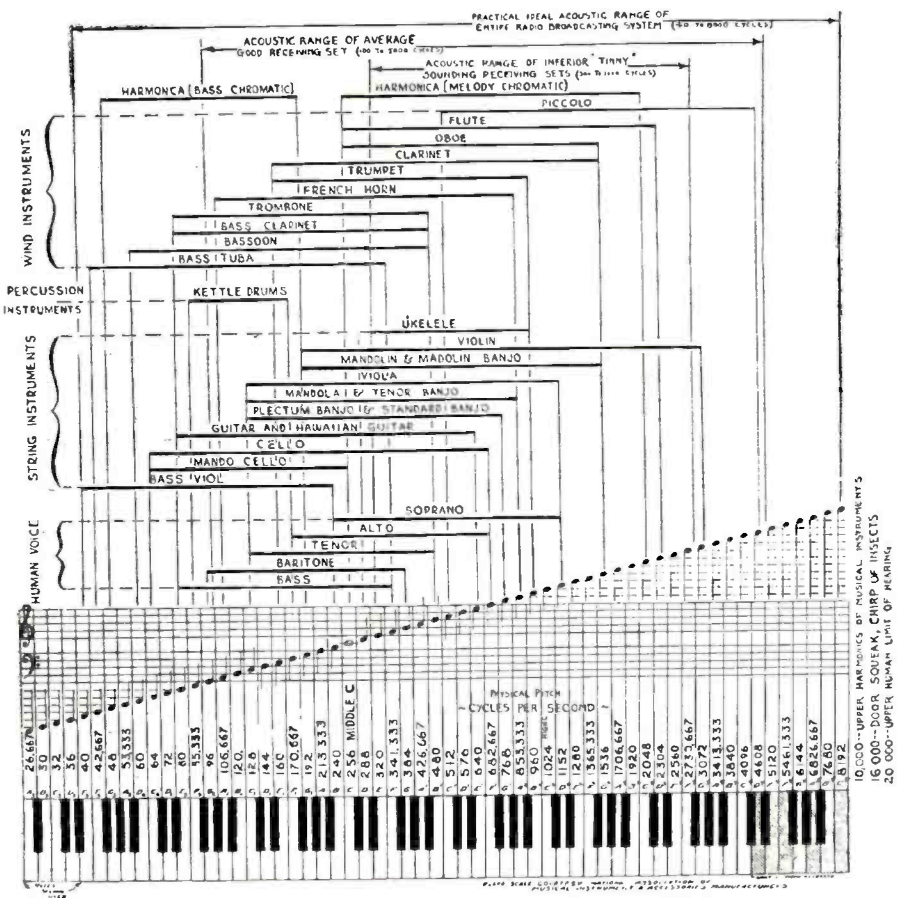


CHART SHOWING FREQUENCIES OF VARIOUS NOTES ON A PIANO KEYBOARD AND THE FREQUENCY RANGES OF VARIOUS MUSICAL INSTRUMENTS

Figure 3. Chart showing the fundamental frequency ranges of various musical instruments and the human voice

pends upon how violently the air is set in motion. The loudness is determined by the intensity of the sound sensation as produced in the brain by the ear. Loudness of sounds can usually be controlled greatly by the sound-producing body. Thus the human speech organs can control the sound of the voice from a very low whisper (barely audible) to a loud shout. Musicians refer to the loudness of musical sounds by special terms such as "pianissimo" for very soft; "piano" for soft; "forte" for loud and "fortissimo" for very loud.

It must be remembered that the actual air pressure variations due to sound waves are very small. The variations due to the weakest sound which a person with average hearing can hear is in the order of .000000015 pounds per square inch. A painfully loud sound would produce a pressure variation of about .015 pounds per square inch, or 1,000,000 times as great. The average power of normal speech is about 10 microwatts (0.00001 watts). In music the variation of sound power between a "fortissimo" passage and a "pianissimo" passage may be as great as 100,000 to one. The intensity just sufficient to be heard is called the "threshold of audibility." The intensity which stimulates the sensation of feeling is called the "threshold of feeling." Both the threshold of feeling and the threshold of audibility vary greatly with the frequency of the sound. A consideration of these figures shows that the human ear is an extremely sensitive and delicate instrument and will operate over a wide range of frequencies (about 10 octaves) and a large range of intensity of sound.

the physical make-up, characteristics of the material, etc., of the musical instruments. Thus a violin made of wood has a pleasing, mellow sound and certain harmonics. If it were made of sheet metal it would sound metallic because the intensity of the individual harmonics produced would be quite different. A cornet made of wood would sound like a clarinet, etc. "Muting" of a saxophone, cornet, trumpet or clarinet is a familiar procedure, especially in dance orchestras. These instruments are muted simply by inserting a plug in the opening of the horn. The resulting tone has a decided wheeze because the mute damps out certain of the overtones of the instrumental notes. This changes the character of the tone because the wave form of the sound is changed. In speech, cavities in the head and upper part of the chest resonate to affect the timbre or quality of the tone. The roof of the mouth and the lips also affect this by varying the size and shape of the resonance cavity of the mouth. Interference with the free passage of this vibrating air (such as stopping of the nasal passages or irritation of the throat when suffering from a cold) causes a harsh, rasping sound or hoarseness due to the suppression of the harmonics and overtones.

"Loudness" of Sound

The harder we strike a bell or a drum, the louder will be the sound, because the body vibrates over a greater amplitude. The "loudness" of a sound de-

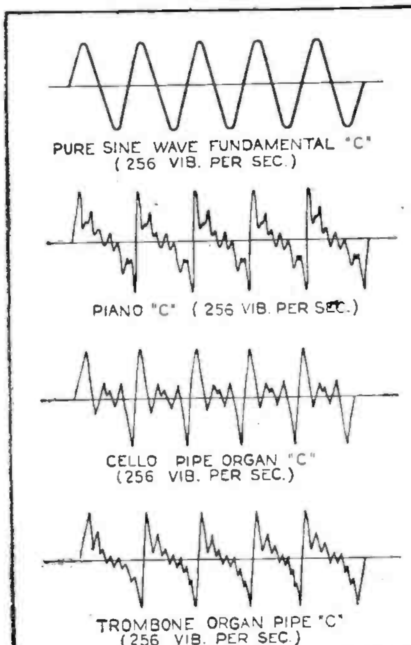


Figure 2. The wave forms of a musical note of identical pitch as produced by different instruments. The difference in wave forms represents the difference in overtones produced

Perception of Sound by the Human Ear

The sensation of sound as relayed to the human brain by the auditory nerves presents an interesting and important study. Dr. Harvey Fletcher has covered this subject thoroughly in his excellent book "Speech and Hearing." He explains the uneven response of the human ear to sounds of various pitch ranges of audibility. Two sounds having the same physical amplitude but differing in frequency do not sound equally loud. It requires a much greater amplitude in low frequency than in high frequency sounds to produce equal loudness sensation because the human ear hears sounds of high frequency better than those of low frequency, and sounds around 2000 cycles better than any others. Thus it is evident that a radio loud speaker emitting the low sounds of an organ selection is really handling a greater amount of energy, and is vibrating over a greater amplitude, than when emitting the high notes of a violin selection so as to produce equal loudness sensation in the ear. Other characteristics of the ear will be studied later at appropriate places.

In radio broadcasting we are interested in transmitting and reproducing as naturally as possible, both speech and music. We have seen that the sound waves are first changed into electric currents and then into radio waves at the transmitter. At the receiver the electric waves are transformed into electric currents and finally back into sound. It is essential that all of these changes be so made that the final sound issuing from the loudspeaker will be an exact counterpart (in so far as the human ear can judge) of the original program. From the foregoing studies of the characteristics of speech and musical sounds we can see that true reproduction of music and speech in the home depends on maintaining with exactness the frequency loudness, pitch and quality or waveform of the sounds. When we realize the complexity of the sounds occurring in music and speech it seems almost impossible that they could undergo so many transformations in the radio broadcasting system and still reach our homes in almost perfect condition. It is true that some changes may occur without being noticed by the average ear.

Frequency Characteristics

The average fundamental frequency of the male voice is around 120 cycles per second, while the female voice is about 240 cycles (an octave higher). However, harmonics exist in some speech sounds up to about 8000 per second, and while female speech has less overtones than male, they extend up to 8000 and the richest overtone area of the male voice is between 3000 and 5000 cycles. Cutting off the frequencies above 5000 eliminates the characterizing features of the unvoiced sounds such as s, f, sh, th, z, etc. These are absolutely necessary for the clear and distinct rendition of speech. Most of the energy of the voice occurs in the frequencies below 1000 cycles, most of the intelligibility above that frequency. The frequencies transmitted over the ordinary telephone lines range only from about 250 to 2700 cycles. That is the reason why it is difficult or impossible to understand sounds like th, z, sh, etc., in telephone conversation.

The playing of a musical selection by an orchestra, an organ or a piano involves the production of a large number of fundamental sound frequencies and accompanying higher harmonic frequencies. The musical tones are more or less complex. Speech does not involve as large a range of frequencies as does music, so that a system designed to satisfactorily transmit and produce the entire useful musical scale will generally be satisfactory for speech also.

The range of "fundamental" frequencies which must be transmitted in the reproduction of music from an entire orchestra will ordinarily extend from about 40 up to 4000 cycles per second. The orchestra is composed of four choirs, the strings, the wood-wind, the brass and percussion. The lower and higher strings or keys on the harp or piano are seldom used. However, satisfactory transmission requires that the important "harmonics" of these frequencies also be transmitted and reproduced, otherwise the reproduction will not possess the characteristics of the original sound.

Old Sets Tire Listeners

A certain amount of low-frequency suppression is possible without serious effects, due to the fact that the ear has the power of supplying to our consciousness many of the fundamental frequencies, provided the harmonics are reproduced. However, it is much better if these missing fundamental frequencies are transmitted and reproduced, for the ear soon grows tired of performing this function and the listener becomes mentally fatigued. This tiring action is very marked when listening to old radio receivers which do not reproduce either the low or the high frequencies correctly. When the harmonics are not reproduced the personal element in either the (Continued on page 352)

Question Box

PHYSICS and science instructors will find these review questions and the "quiz" questions below useful as reading assignments for their classes. For other readers the questions provide an interesting pastime and permit a check on the reader's grasp of the material presented in the various articles in this issue.

The "Review Questions" cover material in this month's installment of the Radio Physics Course. The "General Quiz" questions are based on other articles in this issue, as follows: A Universal Receiver, Radio Lends a Hand in Fingerprinting Noise, The Crystal Detector Again, What Goes On in Your Vacuum Tubes, Plug-in Coils Banned, Remote Control, A Set Tester De Luxe.

Review Questions

1. *Distinguish between (a) fundamental (b) overtone or harmonic (c) octave.*
2. *What is the second octave of a 200-cycle note? The fourth octave?*
3. *What is the second harmonic of a 200-cycle note? The fourth harmonic?*
4. *Upon what does the quality or timbre of a sound depend?*
5. *Why does a 200-cycle note sounded on a piano sound differently than a 200-cycle note sounded on a violin?*
6. *What would be the effect on the sound wave produced by a loudspeaker diaphragm whose amplitude of vibration was not proportional to the current through its winding?*
7. *What determines the loudness of a sound?*
8. *Since the complete range of important fundamental sound frequencies occurring in speech and music is only from about 40 to 4,000 cycles, why is it necessary to transmit a range of 40 to 8,000 cycles for real good reproduction of speech and orchestral music?*
9. *What musical instruments would not be heard in their entirety if the loudspeaker or some other part of the transmitting and receiving equipment cut off at 3,000 cycles?*
10. *A symphony orchestra composed of over 100 instruments is performing in a broadcasting studio. What determines the actual movement of the microphone diaphragm, the resultant sound pressure wave produced by the combination of the sound waves of each individual instrument, or does each individual sound wave act on the diaphragm separately?*
11. *Why is the rattling of paper, squeak of a door, chirp of an insect difficult to transmit and reproduce over the radio?*
12. *Why are ordinary telephone lines unsuited for the transmission of sound pick-ups for broadcast programs of symphonic music?*
13. *In what direction do sound waves normally travel? How may they be directed in some particular direction?*
14. *Why does the sound from a radio loudspeaker diminish in strength as you move farther away from it?*

General Quiz on This Issue

1. *Is it entirely practical to design a receiver that will work off either a.c. or d.c. lines without use of a complicated relay system?*
2. *From the standpoint of relative noise in what order would you rate the following: motor truck, purring cat, typewriter, rustling paper, vacuum cleaner, roaring lion, street car?*
3. *What is manometric flame apparatus used for?*
4. *How much energy would be required at the New York end of a telephone line to make a speaker's voice heard at the West Coast end, without using amplifiers?*
5. *Why is it advisable to shield the lead connecting a short-wave superheterodyne converter to the antenna post of a broadcast receiver?*
6. *What unit is used by engineers as a measure of sound intensity?*
7. *For what radio purpose are Selsyn motors being extensively used?*
8. *Why is it impossible to accurately measure grid bias voltage obtained from the drop across a resistor in the cathode circuit of a tube, even with the finest 1,000-ohm-per-volt meters?*
9. *What is wrong when the image, viewed in a televisor, "drifts" to right or left?*
10. *If a crystal detector passes six times as much current in one direction as in the other, is it likely to be a good detector?*

Madison Square Garden, N. Y.

The 8th Radio and Electrical World's Fair, September 21st to 26th inclusive

What's New at the

As a service to radio enthusiasts in the East and Middle who expect to attend these exhibitions, these pages are

Midget Receiver

Description—A new line of receivers by the same manufacturer, comprising three U. S. Apex and two Gloritone models, all of which utilize the new type -47 pentode tube. The model 8A shown here is an eight-tube

superheterodyne and is equipped with an electro-dynamic speaker and automatic volume control. The vacuum tubes employed are as follows: Three -35 type tubes, three -27 type tubes, one -47 pentode tube and one -80 type rectifier tube. This set measures 17⅜ inches high by 16 inches wide by 11⅝ inches deep and weighs 24½ pounds.

Maker—United States Radio and Television Corp., 360 N. Michigan Ave., Chicago, Illinois.

All-Wave Receiver

Description—The new line of Pilot radio receivers includes a seven tube superheterodyne, midget and consolette models; two full-size ten tube superheterodyne console models; and a table and console model of the Universal all-wave set. The accompanying illustration shows the Universal console model. This combination short-wave and broadcast set has a wave-length range of 15 to 650 meters without the use of plug-in coils. All-wave changing is accomplished by a switching arrangement, which is controlled by a knob on the front panel.

Maker—Pilot Radio and Tube Corp., Lawrence, Massachusetts.

All-Wave Mantel Receiving Set

Description—Here is an all-wave a.c. midget receiver with a wavelength range of 15 to 550 meters. Reception on the short-wave

or broadcast band is controlled by a single knob mounted on the front panel. The new -47 type pentode tube is used in the output power stage. The receiver chassis and speaker are enclosed in a cabinet of Gothic design.

Maker—Polo Engineering Laboratories, 125 W. 45th Street, New York City.

A Compact Receiver

Description—A semi-portable eight tube superheterodyne receiver, enclosed in an attractive walnut cabinet of novel design. It is equipped with a special flat extension cord for plugging into any a.c. house supply outlet to provide the antenna and ground system as well as the power. All tuning controls are mounted on top of the receiver.

The tubes employed are three -24 type screen-grid tubes, two -27 type tubes, two -45 power tubes and one -80 type rectifier tube. This is one of the new series of Sentinel receivers, made by the same company, which also include a table model seven tube superheterodyne, a four tube midget receiver employing one -47 pentode tube and two console type superheterodyne receivers, models Nos. 108A and 109.

Maker—United Air Cleaner Corp., 9705 Cottage Grove Ave., Chicago, Ill.

Superheterodyne Receiver

Description—The console model S-8 Lyric superheterodyne receiver shown here is encased in a butt walnut finished cabinet measuring 38½ inches high by 20½ inches wide by 13 inches deep. The following tubes are employed, one -24 type, two -27 type, two -35 type, two -47 pentodes and one -80

1931 Radio Shows

West, as well as to dealers, jobbers and servicemen devoted to descriptions of new 1931-1932 radio apparatus

The Coliseum Chicago

The 10th Radio and Electrical Show, October 19th to 25th inclusive

rectifier. This manufacturer's new line of receivers also includes two midget sets and two additional console receivers. The –47 type pentode tube is utilized in all receivers.

Maker—All-American Mohawk Corp., No. Tonawanda, N. Y.

Portable Receiver

Description—A new portable five tube receiver employing two –51 type screen-grid tubes, one –27 type tube, one –80 type rectifier tube and a –47 pentode tube in the power output stage. The receiver chassis

and the new model 6 inch Utah dynamic speaker are enclosed in a leatherette covered case with a convenient carrying handle. The receiver works on a.c. lines without antenna.

Maker—Dubilier Clock Corp., 40 West 17th Street, New York City.

An Attractive Lowboy Receiver

Description—The new model eleven tube superheterodyne lowboy receiver illustrated

here is but one of a new series of Philco receivers. The new line includes two mantel type superheterodyne sets and six console superheterodynes. All models are equipped with tone control, illuminated station recording dial with glowing arrow for precise tuning and a new type electro-dynamic speaker.

Maker—Philadelphia Storage Battery Co., Philadelphia, Pa.

Transmitting Condenser

Description—The No. 704 toothpick-type transmitting condenser is designed for low-powered transmitting circuits and general laboratory use. This condenser is of the mica dielectric type and is rigidly and permanently held by a brass clamp casing. It is capable of handling 2 amperes at 140 meters and has an effective a.c. voltage rating of 2000 volts. The unit measures 2½ inches long by 17/32 inch wide by 21/64 inch thick. These new units will be found exceptionally well suited for amateur and laboratory set-ups.

Maker—Dubilier Condenser Corp., 4377 Bronx Blvd., New York City.

Midget Receiver

Description—A new series of receivers, consisting of three console models and one midget type. All models are superheterodynes and employ the new multi-mu tubes. The console sets use two –47 pentode tubes

in the push-pull output stage. The seven tube midget set, model 51, illustrated here, utilizes one pentode tube in the power output stage. This set measures 17¾ inches high by 15½ inches wide by 12 inches deep.

Maker—Fada Radio Co., Long Island City, N. Y.

Universal Test Prods and Plug Connectors

Description—This kit consisting of twelve pieces can be used in numerous combinations for many forms of radio connections and testing, and will therefore prove of great assistance to the service man and radio experimenter. The kit is available in seven different colors; all parts are highly finished and polished. The following is a summary of the parts employed in this kit.

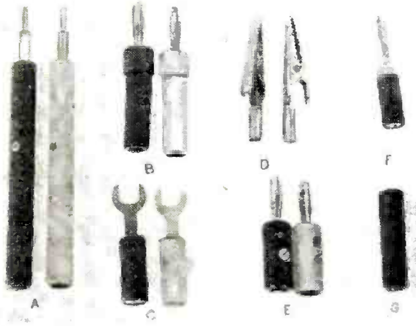
A—Test prods with phone tips at one end and wire connection at other end. Wires are held securely by set screws.

B—Plug at one end, wire connection other end. Set screw for fastening wire is under threaded cap.

C—Spade terminal one end, other end fits phone tip or plug.

D—Crocodile jaw clip, other end fits phone tip or plug.

E—Plug at one end, with hole at side to accommodate plug.



F—Plug at one end, chuck at other end to take phonograph needle for making contact through insulation.

G—Coupling unit will fit phone tip or plug.

Maker—International Air Research Laboratories, 3936 Queens Boulevard, Long Island City, New York.

Midget Receiver

Description—A mantel-type, tuned radio-frequency receiver, measuring only 15¼ inches in height. The set makes use of the new pentode tube. The dynamic speaker

is concealed behind an attractive screen grille. The receiver chassis and power supply is one complete unit and is carefully shielded.

Maker — General Electric Company, Bridgeport, Connecticut.

Miniature Pentode Receiver

Description—A four tube midget receiver utilizing one -35 type tube, one -24 type tube, one -47 pentode tube and one type

-80 tube. The cabinet is only 13 inches high by 13 inches wide by 9 inches deep. The model No. 22P illustrated here contains an electrically operated Telechron clock. This receiver is also available in a d.c. model, employing two -36 type tubes and two -38 type tubes, and in both a.c. and d.c. models, without the clock feature.

Maker—The Electrical Research Laboratories, Inc., Chicago, Illinois.

An Attractive Receiver

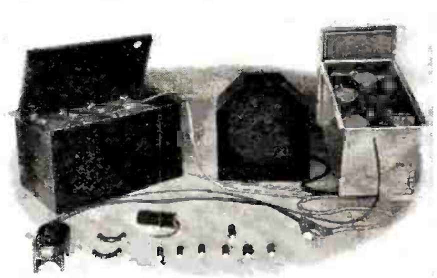
Description—The clock model radio receiver illustrated here is a tuned radio-frequency circuit, employing the new multi-mu -35 tube and a -47 pentode in the output stage. The dimensions are 61½ inches high by 14 inches wide by 9¾ inches deep. This

receiver is but one of a new line of superheterodyne and tuned radio-frequency consoles and midget receivers made by the same manufacturer.

Maker—The Crosley Radio Corp., Cincinnati, Ohio.

Automobile Radio Receiver

Description—The Motor Majestic receiver, specially designed for installation on automobiles, makes use of the newly developed automobile type -36, -37 and -38 tubes. Tuning is accomplished from a small remote control unit, which is clamped to the steer-



ing column just below the wheel. A dynamic type speaker is employed and the tubes are lighted from the car storage battery while the plate current is obtained from four large "B" batteries which are contained in a metal case.

Maker—Grigsby-Grunow Co., Chicago, Illinois.

Superheterodyne Receiver

Description—A new eight-tube superheterodyne receiver which employs two -47 pentode tubes in the power output stage. Multi-mu -51 screen grid tubes are utilized in the radio-frequency stage, first detector, and an intermediate-frequency stage. There are three cabinet models, all employing similar chassis.

Maker—The United American Bosch Corporation, Springfield, Massachusetts.

Television Kit

Description—The accompanying illustration shows a complete outfit for building the new "See All" television scanner. Special care has been given to the design of the scanning disc. The double spiral of holes simplifies the framing of the image and as the holes are square and not round, greater illumination is attained. The kit is complete with special instruction book and blueprints which shows just how to assemble the scanner.

Maker—Television Products of America, 5 Union Square, New York City.

Console Receiver

Description—The superheterodyne receiver, model 19, is enclosed in an open-front mahogany cabinet, measuring 42 inches high by 25 inches wide by 15¼ inches deep. This set features a new automatic clarifier, to re-

duce the noise level on distant reception. The vacuum tubes utilized are: Four of -35 type, two of the -27 type, two -45 power tubes, and one -80 rectifier.

Maker—Stromberg-Carlson Telephone Mfg. Co., Rochester, N. Y.

Latest Radio Patents

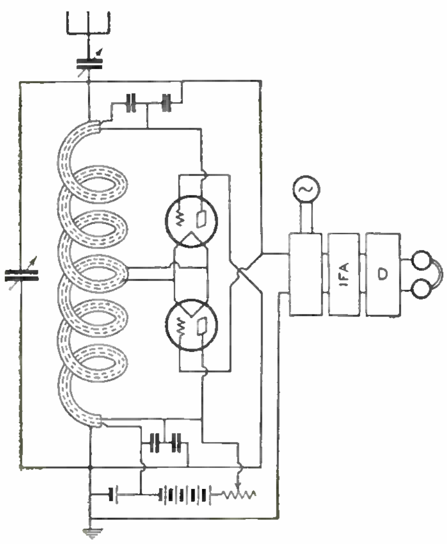
A description of the outstanding patented inventions on radio, television, acoustics and electronics as they are granted by the United States Patent office. This information will be found a handy radio reference for inventors, engineers, set designers and production men in establishing the dates of record, as well as describing the important radio inventions

Conducted by

Ben J. Chromy*

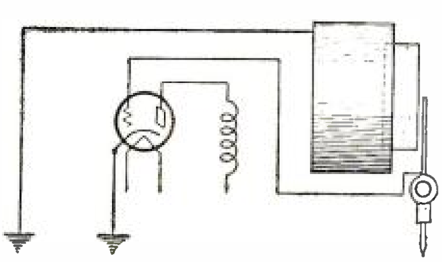
1,804,087. WAVE AMPLIFYING SYSTEM. EDMOND BRUCE and HARALD T. FRIIS, Red Bank, N. J., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a Corporation of New York. Filed Dec. 31, 1926. Serial No. 158,170. 8 Claims.

1. An amplifier comprising a plurality of electric space discharge devices connected in balanced relation to operate without fre-



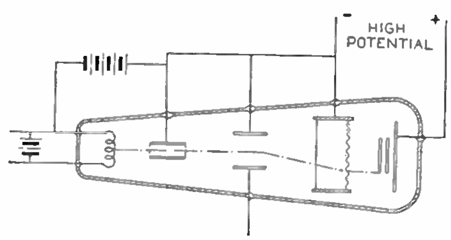
quency translation, each of said devices having a cathode, an anode and a grid, a common input circuit and a common output circuit for said devices, said common input circuit being connected to ground, means for impressing signal variations upon said common input circuit, and means for connecting said cathodes to a point on said input circuit electrically remote from said ground connection.

1,804,364. PICKUP. OLIVER B. PARKER, Brooklyn, N. Y., assignor to Pacent Electric Company, Inc., New York, N. Y., a Corporation of New York. Filed July 12, 1930. Serial No. 467,453. 18 Claims.



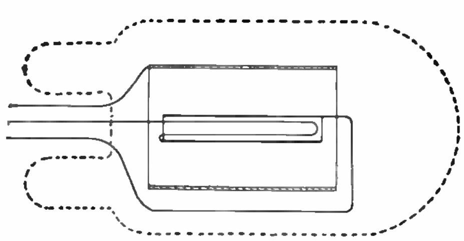
18. An electrical device of the general character disclosed comprising a member of a material capable of permanently retaining an electrostatic charge and having an electrostatic charge permanently incorporated therein, a companion member associated in electrically coupled relation with the first member, means for supporting said members in relatively movable relation and circuit establishing connections for said members.

1,810,018. CATHODE RAY OSCILLOGRAPH. DOUGLAS E. HOWES, Northfield, Vt., assignor to Westinghouse Electric & Manufacturing Company, a Corporation of Pennsylvania. Filed May 28, 1924. Serial No. 716,294. 8 Claims.



4. In a cathode-ray tube, a source of electrons, a tube confining the electrons into a stream, and a foraminate plate at the same potential as said tube, the axes of the foramina being parallel to said tube, means between said tube and said plate for deflecting the stream, and means for increasing the speed of said electrons after leaving said plate.

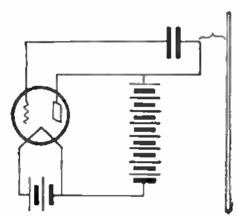
1,806,108. HOT CATHODE DEVICE. FREDERICK S. MCCULLOUGH, Edgewood, Pa. Filed Jan. 5, 1926. Serial No. 79,352. 1 Claim.



An electron tube having a tubular cathode member, a heater wire having a loop inside the cathode member and extending longitudinally of said cathode tube, both ends of said wire being at the same end of the cathode, one end of said wire being connected to one end of the cathode, a heater current supply wire connected to the other end of the heater wire, and a second current supply wire connected to the cathode only at that end of the cathode opposite the end to which the heater wire is connected

1,806,245. SHORT WAVE OSCILLATOR. ABRAHAM ESAU, Jena, Germany. Filed Feb. 12, 1927, Serial No. 167,650, and in Germany Feb. 18, 1926. 5 Claims.

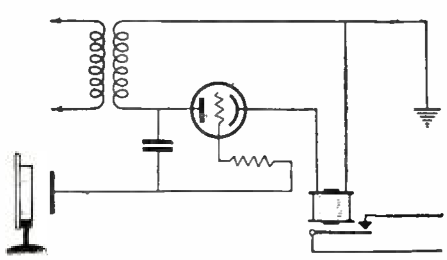
4. The method of generating and transmitting ultra-short waves, which consists in



generating a fundamental short wave, splitting said fundamental wave into a plurality of waves, one at least of which is shorter than the fundamental wave, and transmitting the ultrashort wave so produced.

1,806,093. APPARATUS RESPONSIVE TO THE PASSAGE OF RAILWAY VEHICLES. ANDREW J. SORENSEN, Pittsburgh, Pa., assignor to The Union Switch & Signal Company, Swissvale, Pa., a Corporation of Pennsylvania. Filed June 7, 1930. Serial No. 459,713. 5 Claims.

1. Apparatus responsive to the passage of a railway vehicle, comprising a plate mount-



ed in the trackway in such position that when a vehicle passes it the plate and a portion of the vehicle form a condenser, a source of alternating current one terminal of which is connected with said plate through a fixed condenser and the other terminal of which is connected with ground, a grid glow tube the grid of which is connected with said plate, a relay, and a circuit for said relay including said source and the two electrodes of said tube in series, the parts being so proportioned that in the absence of a vehicle the tube is in conducting condition so that the relay is energized, whereas when a vehicle coacts with said plate, the relative potentials of the grid and one of the electrodes of said tube are changed so that the tube becomes non-conducting and the relay becomes deenergized.

1,803,850. ELECTRON DISCHARGE DEVICE. FREDERICK W. HOCHSTETTER, Pittsburgh, Pa. Filed Mar. 27, 1930. Serial No. 439,280. 5 Claims.

1. An electron discharge device comprising an evacuated envelope, a plate and fila-

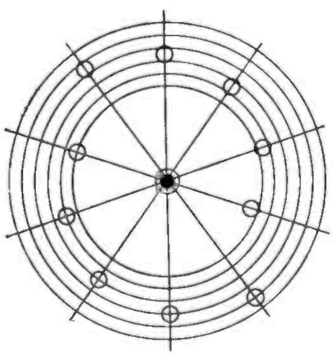
*Patent Attorney, National Press Building, Washington, D. C.

ment therein, a grid between said plate and filament, a dielectric stem within said filament and a second grid within said stem.

1,804,344. BALLAST RESISTOR. HOWARD A. JONES, Schenectady, N. Y., assignor to General Electric Company, a Corporation of New York. Filed Apr. 20, 1927. Serial No. 185,316. 4 Claims.

2. In combination, a receptacle filled with an inert gas at a relatively low pressure, and a ballast device mounted therein, said ballast device comprising a pair of series connected nickel and iron resistors.

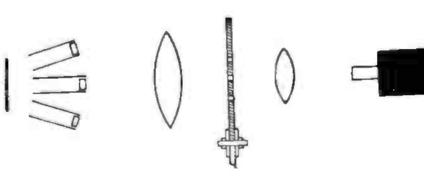
1,806,638. TELEVISION. PIERRE MERTZ, Bellerose Manor, N. Y., assignor to American Telephone and Telegraph Company, a Corporation of New York. Filed July 24, 1928. Serial No. 295,098. 12 Claims.



1. The method of scanning to produce image currents which comprises repeatedly scanning the entire area of a field of view and causing each scanning line of the entire path of one complete scanning to partially overlap two scanning lines of a preceding one.

1,807,465. TELEVISION AND LIKE APPARATUS. JOHN LOGIE BAIRD, London, England, assignor to Television Limited, London, England, a British Company. Filed Oct. 7, 1929, Serial No. 397,985, and in Great Britain Oct. 12, 1928. 1 Claim.

A scanning device for use in television apparatus comprising a source of light, a rotating screen interposed between said source of light and an object to be scanned,

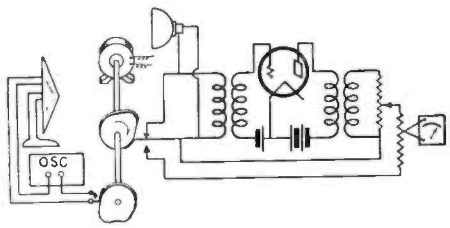


said screen having a plurality of series of spirally arranged apertures therein, the apertures in the different series being spaced radially of said screen whereby light rays will be passed from said source across different sections of the object simultaneously, and a plurality of light sensitive devices each positioned to receive light from one of said sections of the object only.

1,809,967. RADIANT ENERGY RECEIVING SYSTEM. HENRY C. FORBES, Springfield, Mass., assignor to Westinghouse Electric & Manufacturing Company, a Corporation of Pennsylvania. Filed Feb. 15, 1929. Serial No. 340,256. 9 Claims.

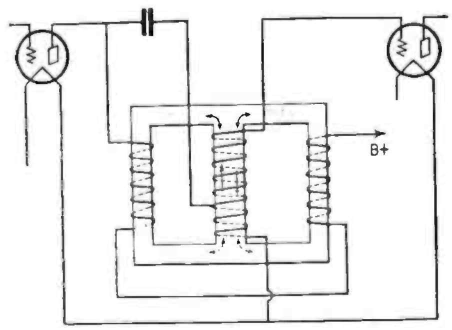
1. In combination, a directional energy-receiving device, and means for continuously indicating the direction from which energy is being received and the average amplitude of said energy.

1,812,030. ACOUSTIMETER. CLARENCE A. ANDREE, Madison, Wis., assignor to C. F. Burgess Laboratories, Inc., Madison, Wis., a Corporation of Delaware. Filed Sept. 13, 1929. Serial No. 392,350. 22 Claims.



1. The step in the method of determining the period of reverberation of a room which comprises causing the average intensity of sound to be suitably indicated during a predetermined period of time when the sound is varying logarithmically.

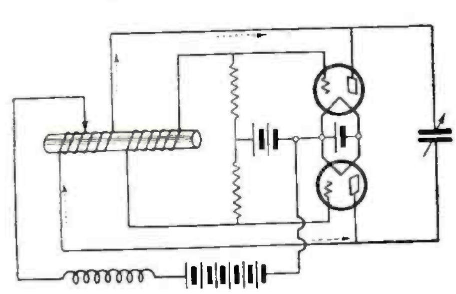
1,808,726. AUDIO FREQUENCY COUPLING. HAROLD P. DONLE, Meriden, Conn., assignor, by mesne assignments, to Radio Inventions, Inc., a Corporation of New York. Filed May 9, 1928. Serial No. 276,346. 7 Claims.



1. An audio frequency coupling device having capacitative and inductive elements for a vacuum tube amplifier, the latter consisting of a closed iron core having a central leg and two outer legs, windings upon said outer legs connected in series, said windings being so directioned as to cause their magnetic paths to include substantially only the periphery of the core and serving to feed plate potential to the plate of the previous tube and a step-up auto transformer having windings carried by said central leg the input to said auto transformer being through said capacity element and having its output connected to the succeeding vacuum tube.

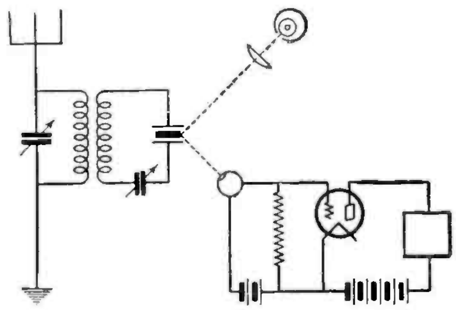
1,811,127. BALANCED MAGNETOSTRICTIVE OSCILLATOR. JAMISON R. HARRISON, Middletown, Conn., assignor to Wired Radio, Inc., New York, N. Y., a Corporation of Delaware. Filed Dec. 11, 1928. Serial No. 325,368. 6 Claims.

1. An electrically balanced circuit arrangement comprising in combination a plurality



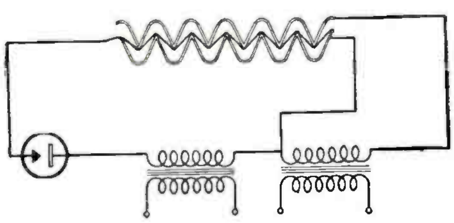
of thermionic tubes having cathodes, an input circuit connected between said control electrodes and said cathodes, anodes and control electrodes, an inductance included in said input circuit, an output circuit connected between said anodes and cathodes, an inductance connected in said output circuit, the windings of said inductances having the turns thereof extending in the same directions, a rod of metal coincident with the axes of said inductances and means for tuning said output circuit.

1,810,475. RECEIVER. CLARENCE W. HANSELL, Rocky Point, Long Island, N. Y., assignor to Radio Corporation of America, a Corporation of Delaware. Filed May 2, 1927. Serial No. 188,155. 12 Claims.



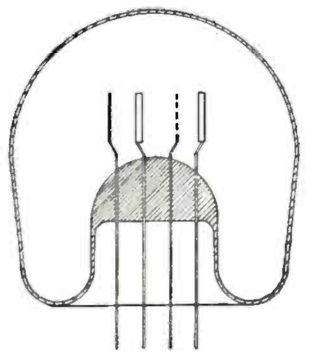
1. Means to detect signal energy comprising a photo-electric cell, a source of light, and a piezo-electric crystal responsive to the signal energy cooperating with the source and the cell to cause a change in the light energization of the cell which is dependent upon vibration of the crystal at its own natural frequency.

1,809,754. ELECTROSTATIC REPRODUCER. JOSEPH J. STEEDLE, Scranton, Pa. Filed May 13, 1929. Serial No. 362,681. 23 Claims.



1. An electrostatic speaker, including a plurality of angular plates, and a diaphragm angularly disposed there-between, whereby a plurality of angularly related propagating areas are formed by said diaphragm.

1,807,177. GAS DISCHARGE TUBE. JOHANNES MICHAEL SCHMIERER, Lichterfelde, near Berlin, Germany, assignor to Radio



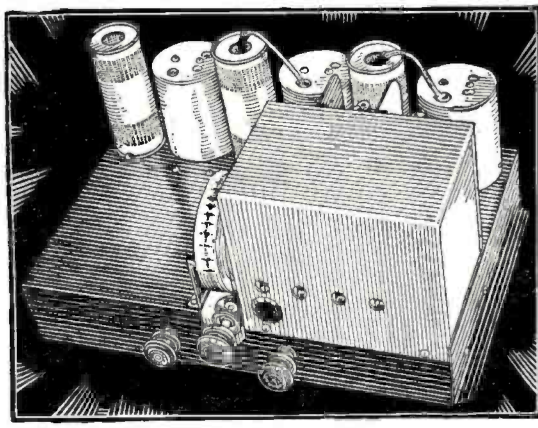
Patents Corporation, New York, N. Y., a Corporation of New York. Filed Nov. 10, 1924, Serial No. 749,037, and in Germany Dec. 31, 1923. 1 Claim.

An ionic glow discharge tube containing gas and comprising a non-thermionic cold operating cathode, an anode, a grid elec-

(Continued on page 337)

SM

THE GREATEST SUPERHETS SILVER-MARSHALL HAS EVER BUILT



716 Superhet Tuner
(683 Amplifier Not Shown)

716 Tuner Brings Them In

The 716 is the great-grandson of the famous Sargent-Rayment 710; and just as it was unbeatable in its day, the 716 cannot be out-performed today.

It is a six-tube vario-mu superheterodyne tuner that has brought in ninety-seven stations on the ninety-five channels—and brought them in beautifully. It is intended to operate with the S-M 683 amplifier and the 855B speaker although it will operate satisfactorily with any high quality amplifier and speaker. However, amplifiers other than the SM 683 do not incorporate the high-frequency compensation to off-set the loss of highs in the extremely selective I. F. Amplifier of the 716 Tuner.

The 683 Amplifier has a totally new dual tone control system by means of which the treble or base can be raised at will, leveled off, or lowered, independently of each other. This, with the 716 results in a clarity of speech and music at high or low volumes never before attained in any radio.

Tubes required in tuner: 3—'51's, 2—'27's, 1—'24. Size: 16½" long, 10½" deep, 7¾" high.

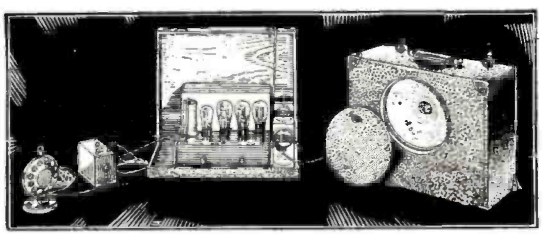
Price of 716 Tuner, wired, less speaker..........$69.50 LIST

Tubes required in 683 Amplifier: 1—'27, 2—'47's, 1—'80. Size: 12" long, 9½" deep, 9" high.

Price of 683 Amplifier: wired, less tubes.........$69.50 LIST

Price of 855B Electro-Dynamic Speaker..........$20.00 LIST

686 Portable Amplifier



686 Complete Portable P. A. Unit

The latest addition to the Silver-Marshall amplifier line is the 686 Portable. It contains a push-pull pentode amplifier similar to the 684 described in the S-M catalog.

The 686 is absolutely complete: three-stage push-pull pentode amplifier, dynamic speaker with baffle, extension speaker cable, control box (for record pick-up, P. E. cell, or microphone input), microphone, microphone cord. It is all a.c., supplying P. E. cell voltage and microphone current. All material fits into one carrying case and weighs less than seventy-five pounds. Microphone and P. E. cell voltage supplies are variable, jacks supplied for reading microphone current with milliameter. Has a gain of better than 90 DB, and an output of 7 to 8 watts.

By renting a 686 Portable for speeches, dances, etc., you can easily make it pay for itself in a short time. A steady, profitable business can be developed in almost any city.

Price, absolutely complete, including tubes .....$199.50 LIST

A Money-Making Offer

Six thousand Authorized Silver-Marshall Service Stations are making money either full-time or part-time as S-M agents. They receive special discounts, have an exclusive superheterodyne midget receiver of their own, receive special offers on certain S-M equipment from time to time. They receive every data sheet as it comes from the presses and are made free subscribers to the "Radiobuilder".

If you can use some extra money, fill out the coupon on this page.

Get the New S-M Catalog

MARSHALL, Inc.

Canadian Division: SILVER-MARSHALL of CANADA, Ltd.
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6405 W. 65th Street, Chicago, U. S. A.

☐ Please tell me how I can become an Authorized S-M Service Station.

☐ Enclosed find $1.00 for the next 25 issues of "The Radiobuilder".

Name ....

Address......................................

Remote Control

(Continued from page 270)

action as possible. The balance weight should be so adjusted that the rotor will stay in any position without any external force exerted against it. Proper care at this point will insure action at the remote control positions very favorable to the regular three-to-one action on the radio normally.

A Capehart 28-record continuous playing phonograph can be used with excellent results. A radio man with an imagination can easily find a place in the accompanying circuits for another Capehart playing only dance music while we relegate the classical music to the first mentioned. The circuit shows a rejector circuit in which any unwanted record may be interrupted in favor of another. This is a solenoid, operated by a button, and tripping a mechanically operated switch which does the business. All of the "Reject" buttons are paralleled throughout all remote positions, and while the phonograph will play out over both systems, it is impossible to do so unless all relays are up. The method of connecting the relays is shown in Figure 2.

The eight six-volt dynamics should be arranged with their respective transformers in series parallel. This is done to maintain as near as possible the proper impedance relations, but necessitates an approximately equal load on the secondaries at all times. This is accomplished without much loss by including a double-pole-single-throw switch which floats a 15-ohm resistance across the secondary when the loud speaker in the particular remote position is not in use as shown in one position, Figure 3. A constant impedance volume control might be used with success, but this would require more power, since the volume control in question would have to be equal to the output impedance of the transformer.

The use of six volts on the field eliminates the necessity of conduit or BX, thus making a considerable saving. The six volts can be supplied either by Kuprox units or Tungar tubes. In the relay circuit very little current is used and, as the voltage is but twenty-four, no conduit is required. This wire can be number 18. In fact, regular battery cable is just the thing, since it is color-coded.

In a large home, appearance is everything. Therefore the loudspeakers must be installed in the wall and the openings dressed up to conform with the other furnishings. The photographs show grills that fit in with the modern English type of home. You will note that one is a coat-of-arms and the other a lyre. These grills are finished to match the woodwork in their respective rooms, and are all hand-carved and backed with silk. You will find that a grill of this type will cost from fifteen to one hundred and fifty dollars apiece, according to what wood-carver you go to and in what section of town he is located.

The operating plates are of great importance from an appearance standpoint. From a standpoint of efficiency, be sure that the push-buttons are of the highest grade—heavy contacts and good springs. In the case of the "off" button, the contacts are, of course, of paramount importance, since it is a closed circuit and a bad contact at any position renders the entire system inoperative. The remote control plate itself is a bronze casting with the engraving on the back bringing out bronze lettering on an oxidized finish. This finish can be made to conform with that of the metal work on the lighting system and iron work in the rooms. In order to pass the electrical inspection in Los Angeles, as well as in many other localities, it is necessary to separate the high voltages from the low. The box illustrated therefore was divided into three parts, one on the left for the relay circuit; the center one for the Selsyn motor; and the one on the right for the voice coil circuit. This box is grounded by means of the conduit for the Selsyn motor wiring. In the bedrooms the plate and its box may be placed in a special wood cabinet, as shown in the photograph, instead of being installed in the wall. This makes for maximum comfort.

In the particular installation illustrated, the two radio sets, the phonograph and the relay system are installed in a special "radio room" and operated by remote control exclusively. The entire apparatus is installed in a metal cabinet and is so arranged that easy access may be had for maintenance. Each level is well lighted so that visitors can see the "works" and watch the operation of the phonograph. No opportunity of showmanship has been neglected and yet no unnecessary money spent to accomplish this result. The radio room in many cases will serve to establish the degree of excellence in workmanship and become the determining factor in the selling of new jobs.

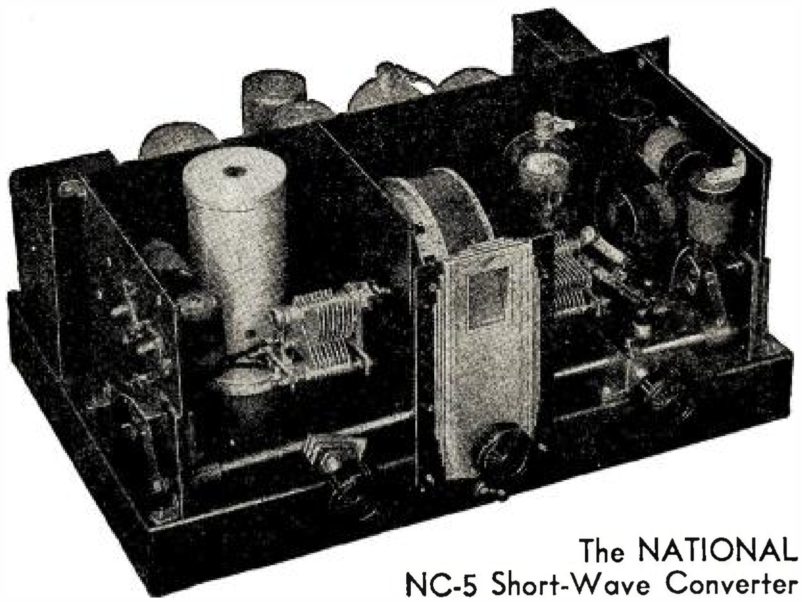
There are many varying factors in an installation of this kind and the inexperienced radio contractor might find himself on the short end of the contract unless he is very careful in his figuring. The wiring should not be attempted by the radio man; in fact, in most cities it is necessary to employ a licensed electrician to do this work. Besides, the electrician is ordinarily more accustomed to this kind of work and can do it in much less time than it would take any radio department. The electrical contract then may be sublet at a certain figure and the radio man may do the supervising. The castings for the plates should not run more than five dollars apiece, and the engravings about six dollars each.

The a.c. relays cost $14 each, net. The reject relay can easily be built up in the shop, being a simple solenoid designed for momentary use only. The type of phonograph used is the 28-record continuous playing Capehart which reproduces both sides, thereby giving 56 selections before repeating a selection, and sells at $290. The Selsyn motors cost $32 each and the one on the radio set itself, being special, costs $25. An installation such as the one illustrated in the photographs should retail at around $2700.

Many interesting variations may be made in an installation of this kind, there being no limit if your customer can spend

Receive SHORT-WAVES on ANY RADIO with this NEW NATIONAL NC-5 SHORT-WAVE CONVERTER

RANGE 15 TO 185 METERS



The NATIONAL
NC-5 Short-Wave Converter

NOT just another converter, but an entirely new type of radio instrument; the NC-5 brings in short-wave broadcasts and code, with *any* broadcast receiver. National Company set out to do a *real* job, and did, putting in an exclusive HARMONIC TUNED INPUT CIRCUIT which automatically resonates a stage of high-frequency amplification, *plus* an additional stage of high gain amplification, which also serves as a low impedance coupling with the radio set. Results: a converter with a wallop, with a new standard of performance. It is a fitting companion in quality and fineness to the well known NATIONAL SW-5 THRILL BOX.

SINGLE CONTROL TUNING

Tuning is reduced to its easiest form, with one knob. Built-in "padding" condensers make the circuits "track" each other accurately.

EASY TO CONNECT AND USE

Simply connect the antenna to the NC-5, and the NC-5 by its lead to the antenna post on your set. The NC-5 has its own built-in power supply. Plug its power cable into the baseboard receptacle alongside the one from your set and it is ready. Turn the switch when you want to receive broadcasts in the usual way. It is unnecessary to disconnect in any way.

EXTRA SET OF COIL-FORMS STANDARD EQUIPMENT

An extra experimental pair of coil-forms are included to permit covering any new stations or special ranges not within scope of regular coils, and provides the flexibility of the plug-in system, without its inconveniences.

DESIGN ELIMINATES INTER-LOCKING AND DEAD-SPOTS

Especially complete shielding and separation of critical circuits has done away with any tendency to interlock. Operation is extremely stable over the whole range. There are no dead spots in the tuning range.

NO PLUGGING-IN COILS

The NATIONAL NC-5 converter has all the flexibility of the plug-in-coil type without any of its inconveniences. Coil switching by a new system gives positive coil connection. Coils and coil switches are mounted on panels of R-39, the special non-hygroscopic low-loss coil material developed by the Radio Frequency Laboratories for use in NATIONAL Short-Wave Equipment. Coils themselves are wound on forms of R-39, and are arranged so that there is NO INTER-COUPLING.

ATTRACTIVE—COMPACT

The NATIONAL NC-5 Converter comes housed in an attractive cabinet that harmonizes with any set. The size is compact, 8" x 17½" x 12". R.C.A. license.

COLOR OF DIAL ILLUMINATION INDICATES WHICH COILS ARE IN CIRCUIT

By an exclusive and novel patented device the color of the main dial illumination changes as the different pairs of coils are thrown in with the wave-changing switch: red for the red coils, green for the green coils, and so on.

TUBES USED

Tubes used are one UY-235, two UY-224's, one UY-227 and one UX-226.

STANDARD MODEL

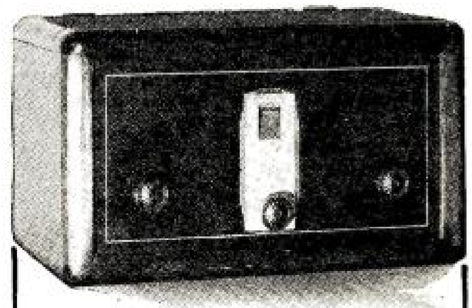
With beautifully finished metal cabinet. Operates on 110 volts, 50-60 cycle A.C. Also made for 220 volts, 50-60 cycles; and 110 volts, 25-40 cycles.

DE LUXE MODEL

In hand-rubbed solid mahogany case with genuine inlay on front panel. A fitting companion for the most beautiful radio set. Chassis identical with standard model.

WRITE US TODAY FOR PARTICULARS AND PRICES

Send the coupon in today for full information on the NATIONAL NC-5 Short-Wave Converter.



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Remote Control

the money. A switching arrangement that would allow for a double speaker circuit in which any remote position could make its choice of a radio channel would naturally be an improvement on the system described. A switching circuit could be wired so as to select the unbusy channel. The switch at the remote position which does the selecting could be made to also turn on the proper output circuit to the loudspeaker at this position. Any number of Selsyns can be connected together if you have the right-size Selsyn. The thoughtful radio man can work out his own remote control problem with the use of this Selsyn motor.

Now for the actual operation of the system. Mr. "A" enters the library and wants to hear the latest stock reports from KFI. He presses the "on" button. In the radio room relay A, located on the right-hand side, closes by virtue of the 24 volts applied across its terminals. The arm on the left-hand side takes the place of the "on" button holding the relay up. The arm on the right-hand side applies 110 volts a.c. to the radio and its field supply. When this happens the red pilot light at the library lights, as will the other three pilots at the other three positions in this particular circuit, showing that this channel is in operation. If the speaker switch is off in the library, Mr. "A" turns it to the "on" position, substituting the voice coil for the resistance used to maintain the primary impedance. The music of some station comes in at this point and Mr. "A" turns the center knob to the proper number for KFI and in comes KFI and the stock reports. By and by, the stock reports are finished and Mr. "A," after dialing around for a while and finding nothing but advertising, an excess of which we are cursed with out here, decides that he would like some phonograph music. Therefore he presses the "phonograph" button, which in turn operates relay B in the radio room, which is "locked up" in the same manner as relay A was, with the difference, of course, that the right-hand contact starts the phonograph mechanism. The double-pole, double-throw switch added to this relay transfers the grid of the first amplifier tube from its input transformer, where it normally stands to one side of the pick-up, the other being grounded. Mr. "A" now hears his phonograph music.

However, this particular selection being reproduced does not appeal to him and so he returns to the remote control box and presses the "Reject" button. This operates the reject relay which trips the mercury switch on the phonograph. In exactly 22 seconds a new record is playing. The phonograph plays along for a while and soon it is time for dinner. Mr. "A" goes to the dining room and remembers that he has failed to turn off the phonograph and he presses the "off" button in the dining room, which happens to be on the same circuit as the library. Immediately the series circuit is broken, removing the current connected to each of the two relays through the left-hand arm on each relay. This cuts off the phonograph. However, the turntable continues to revolve until it is in position to start a new record, at which time it too shuts off.

Radio Science Abstracts

(*Continued from page* 312)

Notes on Loudspeaker Response Measurements and Some Typical Response Curves, by Benjamin Olney, Proceedings of the Institute of Radio Engineers, July, 1931.

The difficulties encountered in loudspeaker measurements are briefly reviewed and a description of the acoustic features of a particular indoor measuring system is given. Outdoor testing arrangements are described whereby double as well as single radiating loudspeakers are measured with negligible ground reflection error. It is pointed out that the over-all electrical fidelity curve of a radio receiver is an inadequate performance index; the electro-acoustic fidelity embracing the frequency response of the loudspeaker is suggested as more informative. The interpretation of loudspeaker response curves in terms of what one may expect to hear is discussed.

Response curves shown and discussed include the following:

1. Effect of type of cone corrugation.
2. Comparison of radio receiver cabinet with flat baffle.
3. Curves showing that the face dimensions of a box baffle are of equal importance with the path length from front to rear of cone in determining low-frequency response.
4. The effect of extreme length in a box baffle.
5. Measurements of the same loudspeaker in cabinets of different size.
6. Over-all electro-acoustic response curves of radio receivers.
7. Loudspeakers with improved high-frequency response.
8. Some examples of outdoor measurements.

Talking Pictures and Acoustics, by C. M. R. Balbi. Published by The Electrical Review, England.

This book by Mr. Balbi, an English consulting engineer, discusses the underlying principles of various systems, the apparatus and the design and arrangement of studios used in making talking pictures. The book aims to indicate the problems involved, not so much with the idea of aiding the sound engineers or the studio architecture, but rather with the idea of bringing together the problems of these two groups and showing how they interlock. In its treatment the book might be termed mildly technical. Many of the curves are qualitative rather than quantitative. Several excellent pictures are given showing dissected views of various pieces of apparatus. Mr. Balbi's book should appeal to the professional and also to those who wish to know more of the general systems involved in the production of talking pictures.

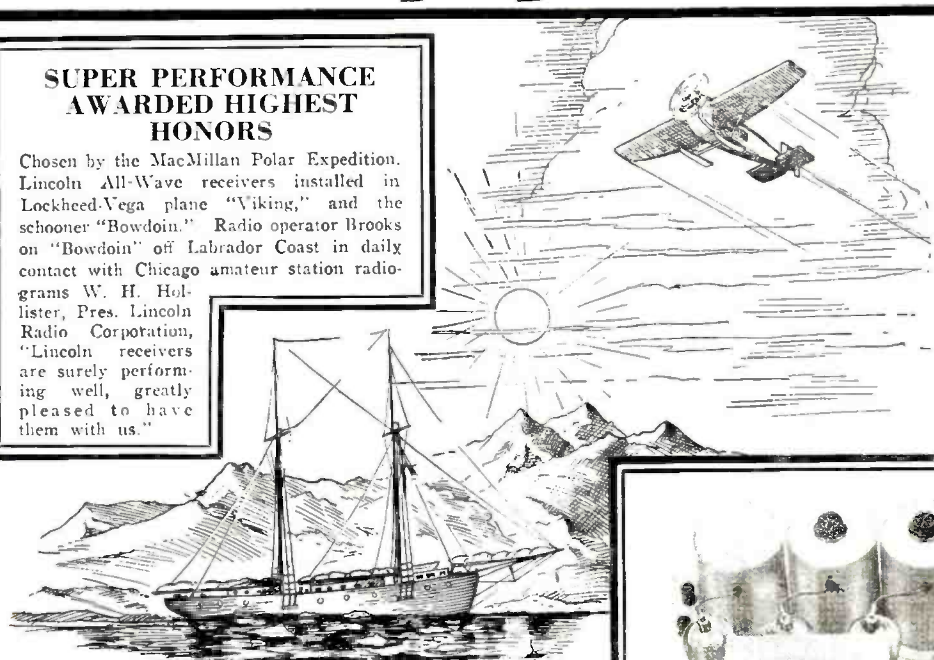
Lincoln Equipment in the Arctic!

SUPER PERFORMANCE AWARDED HIGHEST HONORS

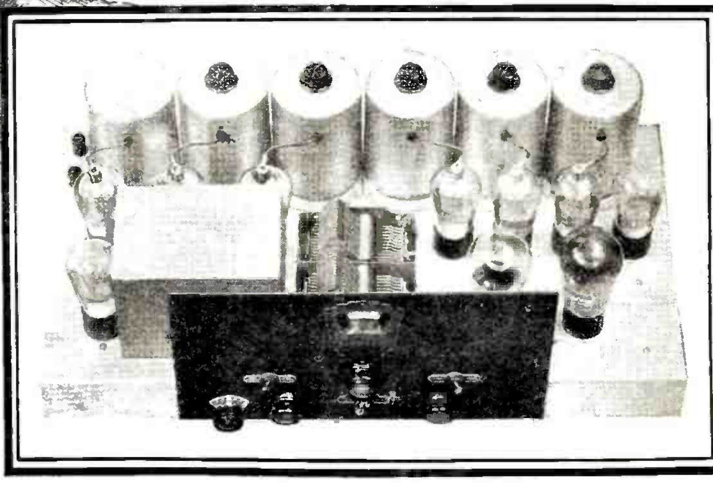
Chosen by the MacMillan Polar Expedition. Lincoln All-Wave receivers installed in Lockheed-Vega plane "Viking," and the schooner "Bowdoin." Radio operator Brooks on "Bowdoin" off Labrador Coast in daily contact with Chicago amateur station radiograms W. H. Hollister, Pres. Lincoln Radio Corporation, "Lincoln receivers are surely performing well, greatly pleased to have them with us."

SUPER POWERFUL LINCOLN EQUIPMENT

used for all communication between "Viking" plane and "Bowdoin," also contact direct with Chicago; handling all expedition matter and personal messages, coming from coast of Greenland thru all interference of Aurora Borealis and magnetic disturbances.



World-Wide Reception -15 to 550 Meters- No Plug-In Coils with the Lincoln De Luxe S.W.-32



NOW you can sit comfortably in your easy chair and switch instantly from your local station to London, Paris, Rome, Nauen, Morocco, Saigon, Wellington—over 100 phone stations throughout the world.

NO PLUG-IN COILS
SIX SCREEN-GRID TUBES

in the highest amplifying system known WITH PERFECT 10 KC REJECTIVITY famous in Lincoln equipment for the last four years.

Turn the indicator to the desired band of frequencies and apply the full tremendous power of the DeLuxe SW-32 to short-wave or Broadcast signals. Utilizing the tremendous amplification and rejectivity of the famous Lincoln tuned intermediate transformers, originated four years ago and perfected to a high degree, the DeLuxe SW-32 brings in distant signals with tremendous volume with perfect rejectivity. A Lincoln owner in Tennessee listens to NINETY-TWO FOREIGN SHORT WAVE STATIONS out of a total of 128 foreign phone stations. Old time "Hams" and radio fans marvel at the tremendous volume available on signals thousands of miles away. Even in the Broadcast band owners of Lincoln equipment located in the Central West are actually listening to stations 7,000 miles away with loud speaker volume. A report from Cushing, Oklahoma states: "Seven Stations received from Japan in one morning, all in the broadcast band." While another report reads: "Listening to 2YA Wellington, New Zealand, Osaka, Sendai, and Kumamoto, (750, 770 and 790 KC) in Japan, KGMC Honolulu, 2BL Sydney, Australia, all in the Broadcast Band. Do you wonder that Lincoln receivers are classed as the most powerful equipment in the world?

Do you wonder why Lincoln equipment outperforms any known receiver and is chosen by the Polar Expedition, Broadcasting Station, and Individual who want the best?

A.C. AND BATTERY MODELS

The LINCOLN DC-SW-10 is identical in design with the Lincoln DeLuxe SW-32 using the new low drain 2-volt tubes, push-pull output.

You can have this equipment in your home, in a beautiful console at a nominal price. The only equipment strictly laboratory built by competent engineers actually doing the work.

Lincoln receivers are not sold through the regular channels, are not on sale in any store. You can distribute these receivers in your own community.

LINCOLN RADIO CORPORATION

329 South Wood St., Chicago, Dept. N-10

Write today for full information

Name ....

Address ....

....

Fingerprinting "Noise"

(*Continued from page 273*)

zero is 10 billion times the *sound energy* of that zero but is only 100,000 times the *sound pressure*, corresponding to 100,000 millibars or 100 bars.

Further complexities of the units for noise measurement enter, when one considers loudness as well as physical energy. Not only does the average human ear vary slightly from the true logarithmic scale when the ear is used to judge sound intensities, but that organ also varies greatly in its ability to perceive different sound frequencies. Very low-pitched sounds, for example, require thousands of times more sound energy to be audible than do sounds in the intermediate frequencies to which the ear is more sensitive. There is a similar decrease of ear sensitivity in the very high frequencies. The highest frequencies, above some 20,000 or 30,000 cycles per second, are totally inaudible.

Accordingly, in order to measure the loudness of a noise in the average ear, what might be called the "noiseness" of the sound, it is necessary to take into account the frequencies present as well as the sound intensities. This can be done by making a complete acoustic analysis of the noise concerned, specifying the exact amount of energy present in each of all possible frequencies. This constitutes what is called a sound "spectrogram," analogous to the optical spectrogram yielded by a spectroscope. In most practical circumstances, however, the measurement of the loudness or noisiness of a noise can be accomplished much more simply by the use of a network of electric filters adjusting the response of the noise meter to be the same as that of the average ear.

On the complete types of acoustimeter now in use, for example, two measurements are possible in quick succession. One of these is the total physical energy of the noise to be measured, in terms of decibels above the assumed zero of one millibar sound pressure. The other measurement is made by passing the output of the microphone through an electric filter, the characteristics of which are the same as those of the average ear. When this is done, the meter reading indicates the loudness of the sound rather than its physical energy. This is measured also in decibels, but the decibels in this instance are automatically "weighted" so that the effect of each frequency present on the average ear is taken into account.

A large number of noises of many kinds now have been measured in this way, so that it becomes possible to construct a kind of "noise thermometer," in which, for example, it appears that the average noise of a quiet city street is about 50 decibels above the zero of the scale. A noisy street, like some of the streets of New York City, may rise to 80 decibels of noise. A riveting machine or a boiler factory may provide 100 decibels. A country residence, on the other hand, may be as quiet as 25 or 30 decibels. Even in an underground vault, with every precaution taken to exclude noise, there is likely still to be a small amount of noise energy which seeps in, usually amounting to 10 or 15 decibels above the zero of the standard scale.

The data embodied in this noise thermometer has practical importance also in evaluating the probable annoyance which a noise will create. A certain type of household refrigerator, for example, creates, in an ordinary room, about 35 decibels of noise. In a noisy city residence or office this noise will be entirely unnoticeable, being drowned out entirely by the substantially greater noise present under these conditions from the average city noise sources. In a country residence the same refrigerator may seem ex-

Johns Manville

Testing noise in an office by an acoustimeter, to determine just how much the noise would be reduced by one type or another of sound-absorbing material on walls, floors or ceiling. Many office managers now have "noise surveys" made of their offices at intervals, to determine which offices are too noisy and how it can be cured

Fingerprinting "Noise"

tremely noisy because the surrounding noise is less. In practical noise problems, therefore, the engineer must take into account not only the actual noise produced but the circumstances, quiet or noisy, with which this noise is likely to be compared.

We frequently are called in, for example, to decide whether or not a certain factory or machine or other noise producer constitutes a legal nuisance. For this purpose the measurement of the noise is not enough. In addition it is necessary to determine what the surrounding noise probably would be were the objectionable noise producer absent. It is necessary also to determine what average noise might be expected in the locality concerned, for example, in the average suburb of similar character to one from which there is noise complaint.

For the vast majority of practical noise measurements either the total energy, measured in decibels, or the loudness, measured in terms of the response of the average ear, will provide all of the scientific evidence that is necessary. In some instances, however, it is desirable to have specific information as to the different frequencies present in the noise. In the case of machine noises, for example, this may be useful in determining the particular part of the machine which is seriously noisy.

Again the complete provision of this information requires the frequency spectrogram, and several forms of apparatus now exist with which this spectrogram can be measured. Often, however, it is sufficient to analyze the noise into a series of frequency bands, conveniently corresponding to the octaves on a piano. In the work of our laboratories, for example, we make large use of such a frequency analyzer, arranged to measure separately the frequency band between 64 cycles and 128 cycles, that between 128 cycles and 256 cycles, and so on up to approximately 10,000 cycles. Analysis of noises in this fashion corresponds to a rough chemical analysis of an unknown compound. Frequently this is sufficient, both in chemistry and in noise engineering, for a practical conclusion.

Again this frequency analyzer borrows radio technique. It consists, as the radio engineer immediately will understand, of a series of electric filter-circuits arranged to pass only the particular bands concerned. By a convenient switching arrangement the sound energy in the different bands is segregated from energy in other frequencies, is amplified and is measured on the meter in the usual fashion.

The reasonably complete specification of a noise usually involves, therefore, the measurement of total energy, the measurement of loudness and the separation of the noise into frequency bands corresponding to this octave system or to some simple equivalent of it. The necessary apparatus for this is the microphone, the special amplifier, the meter for the measurement of the amplified energy and the

(*Continued on page* 330)

Radio News Technical Information Service

The Technical Information Service has been carried on for many years by the technical staff of RADIO NEWS. Its primary purpose is to give helpful information to those readers who run across technical problems in their work or hobby which they are not able to solve without assistance. The service has grown to such large proportions that it is now advisable to outline and regulate activities so that information desired may come to our readers accurately, adequately and promptly.

Requests for Information

Long, rambling letters containing requests that are vague or on a subject that is unanswerable take up so large a portion of the staff's working time that legitimate questions may pile up in such quantities as to cause a delay that seriously hinders the promptness of reply. To eliminate this waste of time and the period of waiting, that sometimes occurs to our readers as a consequence, the following list of simple rules *must* be observed in making requests for information. Readers will help themselves by abiding by these rules.

Preparation of Requests

1. Limit each request for information to a single subject.
2. In a request for information, include any data that will aid us in assisting in answering. If the request relates to apparatus described in RADIO NEWS, state the issue, page number, title of article and the name of the device or apparatus.
3. Write only on one side of your paper.
4. Pin the coupon to your request.

The service is directed specifically at the problems of the radio serviceman, engineer, mechanic, experimenter, set builder, student and amateur, but is open to all classes of readers as well.

All questions from subscribers to RADIO NEWS will be answered free of charge, provided they comply with the regulations here set forth. Non-subscribers to RADIO NEWS will be charged a nominal fee of $1.00 for this service. All questions will be answered by mail and not through the editorial columns of the magazine, or by telephone. When possible, requests for information will be answered by referring to articles in past issues of the magazine that contain the desired information. For this reason it is advisable to keep RADIO NEWS as a radio reference.

Barred Queries

Complete information about sets described in other publications cannot be given, although readers will be referred to other sources of information whenever possible. The staff cannot undertake to design special circuits, receivers, equipment or installations. The staff cannot service receivers or test any radio apparatus. Wiring diagrams of commercial receivers cannot be supplied, but where we have published them in RADIO NEWS, a reference will be given to past issues. Comparisons between various kinds of receivers or manufactured apparatus cannot be made.

Only those requests will be given consideration that are accompanied by the current month's coupon below, accurately filled out.

OCTOBER, 1931
Technical Information Coupon
RADIO NEWS Laboratory
350 Hudson Street
New York, N. Y.
Gentlemen:

Kindly supply me with complete information on the attached question:

☐ I am a regular subscriber to RADIO NEWS and I understand this information will be sent me free of charge.

☐ I am not yet a subscriber to RADIO NEWS and enclose $1.00 to cover costs of the service.

☐ I wish to become a subscriber to RADIO NEWS and enclose $2.50 to receive the magazine regularly for one year, and to receive this valuable technical information service free of charge.

Name ....

Address ....

Fingerprinting "Noise"

(*Continued from page 329*)

set of electric filters constituting the frequency analyzer.

All of these devices are simple enough in principle, involving nothing not well known to experienced radio engineers. Details of construction, use and interpretation of results may be more complicated and difficult, although even these are being more and more simplified as the noise engineers continue the development of their science.

Beyond the art of noise measurement there stands also the equally difficult one of getting rid of the noises after they have been measured. In this part of the noise engineer's activities there is no substitute for experience. Noise-proof cases may be used, less noisy mechanical devices may be substituted, noise frequencies may be altered so that they move into frequency ranges in which the ear is less sensitive, many other practical expedients may be employed. Some day all this will be reduced doubtless to simple rules and principles. At present, however, the assets of the successful noise reducer are merely experience, good engineering and, most of all, common sense.

It always will be true, however, that the first step in noise reduction is to know precisely what are the noises with which one deals. This is the realm of noise measurement and this is the part of noise engineering to which radio methods and radio instruments have made such outstanding contributions.

Television Programs

(*Continued from page 292*)

which give depth and life to the images. This indicates a faulty receiver or amplifier. Probably you are using a regenerative short wave set instead of the special television receiver. Regeneration cuts detail and increases distortion. The wide side bands are essential for half-tone effects. The amplifier must be resistance coupled, not transformer coupled.

Tuning Hints

If you tune your television receiver without reference to a station chart you may get a muddled pattern, think you have a television station and wonder why the pictures are not clear. Perhaps you are picking up short wave sound signals from a short wave station. These signals, though visible on the radiovisor, naturally form no recognizable picture. Or perhaps you have a television station, but one operating on an off-standard number of lines or scanning disc speed, such as the 48 line, 15 frames per second picture of which we spoke before. Other off standard stations operate on 45 lines, the disc revolving counter-clockwise instead of clockwise. These, of course, cannot be tuned in properly with a standard 60 line 20 frames per second set, but may be caught by changing the disc as mentioned above. Again, indistinguishable patterns of black and white might mean a station too far distant or too weak to properly motivate the neon lamp. Finally, it might mean that the scanner is not in step. By snapping the radiovisor motor switch on and off several times the disc may be placed in step, and held there at the right speed by means of the rheostat.

Heavy black horizontal lines in the picture usually indicate that one or more of the tiny holes in the disc are clogged, preventing light from coming through. Dirt or dust may be removed from the holes with a thin sliver of wood. Care should be taken not to rub dirt into the holes by keeping the hand away from the perforated portion of the disc.

Following Instructions

Otherwise there should be no trouble with television reception, provided instructions have been followed in assembling the receiver and radiovisor. Be sure the station is standard, and that it is properly tuned in. Sometimes this can be facilitated by attaching a loud speaker instead of the neon lamp to the receiver while tuning. For the ear can tune in to maximum clarity and volume better than the eye. The television station will be recognized by its high buzz saw note. This note having been tuned in, detach the loud speaker, replace the neon lamp leads, start the radiovisor motor, and the picture will be received.

Do not expect perfect detail in the pictures. They are still crude. But progress is so rapid that week to week improvement will be discernible and the thrill of snatching pictures out of the air will outweigh any lack of detail.

Audio Design Charts

(Continued from page 275)

the value of "b" corresponding to one decibel. This is found to be 1.38, hence

$$b = 1.38 = \frac{2\pi fL}{r} \text{ and } L = \frac{1.38\,r}{2\pi f}$$

substituting the frequency we have

$$L = \frac{1.38 \times 1800}{2\pi 60} = 6.59 \text{ henries}$$

To find the loss at 30 cycles we note that b is obviously one half the value at 60 cycles or $\frac{1.38}{2} = .69$. Referring to Chart 2, we see the loss is 2.9 DB.

It will be apparent from the above that the shape of the functions given in Chart 2 is the shaping of the normal frequency characteristics of the amplification with respect to frequency when all regenerative and degenerative contributions have been eliminated. Thus when the loss at any specified frequency has been evaluated the frequency characteristic has been determined.

The third condition we will ascertain is the loss in amplification incurred by shunt capacities in a transmission system such as an amplifier or a line which is short relative to the wavelengths being transmitted. The equivalent circuit for this case is shown in Figure 5, in which the impedance of the load as seen by the tube is made up of the load R and the capacity C in shunt is stated as

$$Z_L = \frac{\dfrac{R}{j\omega C}}{R + \dfrac{1}{j\omega C}} = \frac{R}{j\omega CR + 1} \quad (17)$$

The total impedance to the generator is

$$Z = \frac{R}{j\omega CR + 1} + r = \frac{R + j\omega CRr + r}{j\omega CR + 1} \quad (18)$$

the voltage across the load, e_2, is

$$e_2 = iZ_L = \frac{eZ_L}{Z} \quad (19)$$

$$\therefore \frac{e_2}{e} = \frac{R}{R + j\omega CRr + r} = \frac{1}{\left(1 + j\omega Cr + \dfrac{r}{R}\right)} \quad (20)$$

In order to make this useful for design purposes we introduce parameters $a = \frac{R}{r}$ and $b = \omega Cr = \frac{r}{X_c}$ giving from (20)

$$\left(\frac{e_2}{e}\right) = \frac{1}{1 + jb + \dfrac{1}{a}}$$

or rationalized

$$\frac{1}{\sqrt{\left(1 + \dfrac{1}{a}\right)^2 + b^2}} \quad (21)$$

Obviously, the most power will be dissipated in the load when the shunt capacity, C, is zero, hence $b = 0$ in which case (21) becomes

$$\left(\frac{e_2}{e}\right)_{max} = \frac{1}{1 + \dfrac{1}{a}} = \frac{a}{a + 1} \quad (22)$$

The ratio of the load power without the presence of C and with it is given by the ratio of (22) to (21) and is

$$\frac{e_{2m}}{e_2} = \frac{a}{a + 1}\sqrt{\left(1 + \frac{1}{a}\right)^2 + b^2} \quad (23)$$

and since the power ratio is the square of (23) the transmission loss is

$$\text{Loss (DB)} = 10 \log \left[1 + \left(\frac{ab}{a + 1}\right)^2\right] \quad (24)$$

The function has been plotted for the values $a = .25$, $a = 1$, $a = 2$, $a = 10$ in Chart 3. Here again another case is interesting in which a is infinite. This is the case in which the load is entirely that of the capacity of the circuit and applies when the shunt capacity is large and the frequency is high, such as would be the case in operating a resistance coupled amplifier at radio frequencies, using commercial tubes. Let us apply this chart to two exemplary problems.

First let us suppose that an amplifier is to be connected to a speaker in a remote part of a building by means of a cable having a capacity of 0.2 mfd. The conductors of the cable are not large, so it is desirable to keep the current as low as possible to avoid transmission losses. At the same time it is desirable to keep the transmission constant to within 2 decibels at 6000 cycles. For what line impedance should the line transformers be designed? Maximum power is to be taken from the amplifier, hence $a = 1$. The value of b for 2 DB loss is (from Chart 3) 1.5 hence,

$$\omega Cr = 1.5$$

$$r = \frac{1.5}{2\pi \times 6000 \times .2 \times 10^{-6}} = 199 \text{ ohms}$$

and we see that 200 ohm line transformers would suffice.

As a second example let us consider Figure 6 showing a detector and power stage. It has been found that for stability the detector plate circuit must be shunted with a .002 mfd. condenser. How much will the reproduction suffer at 5000 cycles due to this cause? To the 2000 mmfd. condenser we will add 50 mmfd. representing the effective input capacity of the power tube, distributed capacity of resistors, etc., so that the total C is 2050×10^{-12}. The 227 tube under detecting conditions has a plate resistance $r = 20.000$ ohms. This gives

$$b = 2\pi fCr =$$

Audio Design Charts

$2\pi \times 5000 \times 2050 \times 10^{-12} \times 20.000 = 1.29$

R is the effective resistance of the grid and plate resistor in parallel or

$$R = \frac{.5 \times .1}{.5 + .1} = .0834 \times 10^6 \text{ ohms}$$

and

$$a = \frac{.0834 \times 10^6}{20,000} = 4.17$$

Running down the ordinate b = 1.29 and interpolating between the curves a = 2 and a = 10 we see that the loss at 5000 cycles due to the capacity is approximately 3 DB—. Again, in this case, the functions give the shape of the frequency characteristics (regenerative effects excluded).

Thus these three charts represent the effects respectively of the three electrical quantities in shunt to transmission system. Chart 1 resistance. Chart 2 inductive reactance, Chart 3 capacity reactance.

Ether Explorers

(*Continued from page 285*)

Labor and a few other organizations, including quite a number of companies manufacturing television equipment.

One of the most interesting services in the radio field is television, which is still retained in the experimental class although it is probable that this service has great future commercial possibilities. The present regulations of the Commisson are set forth in General Orders 50, 64, 74 and 88. All licenses are issued for limited periods only and those accorded the privilege are required to report the results of their experiments.

For the joint use of visual broadcasting licensees the following bands of frequencies are authorized: 2000 to 2100 kc, 2100 to 2200 kc, 2750 to 2850 kc. and 2850 to 2950 kc. Recently the Commission opened up four additional television bands in the ultra-high-frequency range, making available the following bands: 43,000 to 46,000 kc. 48.500 to 50,300 kc, and 60,000 to 80,000 kc.

In issuing television licenses to deserving applicants the Commission is disposed to grant the applications of those engaged in experimentation to improve the technic and then to those who employ methods which give maximum definition with the minimum radio-frequency band widths. Therefore, only legitimate and experimental research work is authorized and necessarily few licenses are granted. As a matter of fact there are only nineteen licensees, although two or three of them are permitted to operate more than one station.

Police!! Police!!

If, when listening on a short wave receiver some night, you pick up messages comparable to the following, you will realize that you have tuned in a state or municipal police station communicating with its radio-equipped scout and cruiser cars. (*Continued on page 334*)

Explorers of the Ether

"Scout car No. 100, cruiser No. 8, 211 Main Street—scout car No. 100, cruiser No. 8, 211 Main Street—burglary."

"Cruiser No. 47, Sub-station No. 2, watch for yellow touring car Michigan Avenue, four men, hold-up."

Testimony in the files of the Radio Commission recorded in connection with the application of Detroit Police Department, reveals that Station WCK is on the air twenty-four hours a day. This station, which is the successor to the original police radio broadcasting station, appropriately designated as KOP in 1922, is dispatching messages of this type at the rate of over twenty-two thousand a year. These messages started over 8,000 runs by police cars and resulted in the capture or arrest of over 1,300 individuals. Such arrests as were made took place within an average of one minute and forty-two seconds. The messages from police headquarters to the radio-equipped scout cars, cruisers and sub-stations go on the air every two or three minutes and have done much to aid the police in clearing up a threatened crime wave.

Through police radio services, missing persons are located, hit-and-run drivers apprehended, lost cars recovered, attempted burglaries and holdups thwarted and escaping criminals captured. The man at headquarters is sometimes at a loss to know what has happened possibly for a few minutes, but it is never more than ten minutes after a broadcast before a report is filed. Within that period some member of the cruiser or scout car has dropped off at a police telephone box and called up headquarters to report.

Some of the other large municipalities boasting of modern police radio systems are: Dallas, Minneapolis, Miami, Chicago, Cincinnati, Cleveland, Indianapolis, New York, St. Paul, Louisville, Philadelphia, Seattle, St. Louis, Richmond, Buffalo, Los Angeles and Washington, D. C.

The States of Massachusetts, Michigan and Pennsylvania have also organized state-wide radio nets, on frequencies set aside for that purpose by General Order 74. The cities of Seattle, Chicago, Detroit, and New York operate marine and radio fire alarm, as well as police, systems.

There are about forty police radio stations now in operation in eighteen states, and twenty or more outstanding construction permits to erect stations, indicating that an increased number of stations will soon be on the air co-operating in curtailing criminal activities and running down criminals.

The Federal police radio regulations are set forth in General Order 85, wherein eight specific short wave channels are allocated for municipal use. The chief requirement exacted is that the service be confined to the broadcasting of emergency communications from police headquarters to squad cars or other mobile units equipped with receiving sets.

Radio Explorers for Oil and Minerals

Another of the newer radio services which is developing great commercial potentialities is that known as geophysical research. For this use the Commission has assigned five channels between 1600 and 1704 kc. as set forth in General Order 74. Requirements are that portable stations of from ten to fifty watts may be licensed for use in geophysical exploration work for locating oil and mineral deposits. The old day of the divining rod is practically gone and in its place comes the radio explorer who, after certain investigations, can advise his principal whether or not it is worthwhile to tunnel or drill in a hitherto unproductive or unopened territory.

It is reported that more than one hundred million dollars' worth of new oil deposits have been located by means of radio. Approximately one hundred and twenty-five portable geophysical stations are operating in different parts of the United States; some owned by engineers and others by oil development organizations.

It was not until spring of last year that the Commission adopted the policy which would permit the use of such radio stations, by responsible applicants, for what might be termed prospecting purposes.

Radio for the Movies

Having provided for practically every class of radio service which it would seem would be either necessary or desirable, the Commission not wishing to neglect the moving-picture industry and in accord with demands for such radio facilities, amended General Order 74, last fall, to provide three channels for the use of the moving-picture interests. Licenses are only issued for temporary and emergency radio service for moving-picture producers on location where other forms of communication are lacking.

These three channels are available on proper presentation of needs by qualified applicants and are being assigned for limited periods of ninety days with a power limitation of 250 watts.

Study the General Orders

Reiterating my previous advice to those interested in any type of radio communication system, either as owners or operators of stations, permit me to urge a careful study of the radio laws and the Commission's regulations. New general orders are being promulgated and existing orders are being modified, so that a close contact with the Commission, through some agency, is almost essential if one is to keep properly posted.

All Wave Receiver

(Continued from page 287)

short-wave coils, completely inclosed in a satin-finished zinc shield. Immediately below and mounted in front riser of chassis is the selector switch, operated from front panel. When tuning stations in the broadcast band, indicator should be pointed at "200-500" meters and a

All-Wave Receiver

small switch thrown to position marked "Broadcast." In this position the broadcast oscillator coil is used and a shielded antenna coil is tuned by a .0005 mfd. condenser. The oscillator coil is tuned with a .0005 mfd. variable condenser, with a fixed .0004 condenser in series, giving a resultant low variable capacity, adaptable for both broadcast and short wave.

Throwing the broadcast short-wave switch to short-wave position, opens up the .0005 antenna tuning condenser, shorts out the large broadcast antenna coil and leaves the small broadcast antenna trimmer condenser across the pick-up coil on the oscillator which is used as a main antenna coil in the short-wave position. By then turning indicator to any desired band of short-wave frequencies any short-wave station from 15 to 200 meters may be received, utilizing the full power of the receiver on short-wave reception without eliminating or changing the stages of the receiver in any way.

Installation and Operation

Installation of the receiver is very simple. Connections to power equipment and the 14-inch Jensen auditorium speaker are all plainly marked. From 15 to 20 feet of antenna are all that is necessary in view of high amplification of this receiver. This antenna, which may be hidden behind the moulding of the room, eliminates the complications of an outside antenna with its many drawbacks. Without moving from his chair, the operator can select any desired band by turning the indicator on the front panel to the marked position. For instance, if you are listening to stations in the broadcast band, with your indicator pointing to broadcast, and wish to listen to G5SW, Chelmsford, England, on 25.53 meters, all that is necessary is to change indicator to point marked 15-30 meters, snap the "short-wave broadcast" switch, then tune the receiver in the identical way you would for broadcast reception. No changes in the receiver are made from short-wave to broadcast which would eliminate or add stages as full amplification is used on all bands.

Crystal Detector

(*Continued from page 302*)

An analysis of the flame contour projected by a Manometric flame apparatus justifies the assumption that the crystal tends to suppress the harmonics introduced by the detector tube.

A low-wattage transmitter was constructed and the sound of the letter "A" voiced into the mike and picked up by a simple non-regenerative receiving set, consisting of a detector tube and two stages of audio, the output being projected on a revolving mirror through the gas apparatus.

Figure 3 is of the crystal flame and illustrates the regularity of the simple tone. Figure 4 is of the grid leak condenser action.

S.W. Reception with Superhets

(*Continued from page 293*)

to the ground terminal on the unit, thus grounding them both.

This device was designed to operate with practically any type of antenna. However, thirty to fifty feet of aerial will give a satisfactory signal.

The large dial mounted on the face of the front panel controls the condenser C1. The knurled disc to the right of this dial is part of a mechanism associated with this tuning dial to provide a vernier adjustment with a ratio of 64 to 1. The condenser C2, which is controlled by the small knob is adjusted so that the tube is oscillating properly and is not unduly critical. The condenser C1 will be the only control necessary to touch to tune in the signal. Volume is controlled at the receiver, as when using the receiver alone on higher waves. If the set employs a local-distance switch, set this control for distant reception.

The schematic diagram of the adapter in Figure 2 shows the three inductance coils, L1, L2 and L3, the radio-frequency choke coil, model No. 322, the tuning condenser C1 and the regeneration control condenser C2. The output of the converter is passed through an impedance coupling device designed for 175 kc. The leads to the cable connecting plug are also shown in this diagram.

The following dial settings for a few short-wave stations may vary somewhat on different instruments and for different vacuum tubes but will be of general assistance to the reader in locating the dial settings for his particular instrument.

Call Letters	*Location*	*Wavelength in Meters*	*Dial Setting*	*Coil Number*
WGY	Schenectady, N. Y.	19.8	39	1
KGO	Oakland, California	23.35	59	1
G5SW	Chelmsford, England	25.53	72	1
KDKA	Pittsburgh, Pa	25.4	71	1
CJRX	Winnipeg, Canada	25.6	73	1
DHC	Nauen, Germany	26.225	74	1
2ME	Sydney, Australia	28.8	90	1
WRNY	New York, N. Y.	30.9	13	2
PCJ	Hilversum, Holland	31.4	15	2
WGY	Schenectady, N. Y.	31.48	16	2
KOIL	Council Bluffs, Iowa	49.5	60	2
WLW	Cincinnati, Ohio	49.5	60	2
WENR	Chicago, Illinois	49.8	61	2
G5SW	Chelmsford, England	53	71	2
KDKA	Pittsburgh, Pa	63.5	7	3
W3XK	Jenkins Television, Washington, D. C.	105	46	3

Mathematics in Radio

(*Continued from page 288*)

In like manner, we find that the cosine of an angle x in the first and fourth quadrants is positive, for it is to the right of the reference line yy, and the cosine of an angle in the second and third quadrants is negative since it is to the left of the reference line. That the cosine of an angle is the ratio of the side adjacent to the hypotenuse, it will have a value of 1 to 0. Thus, for an angle of zero degrees the sine will have a numerical value of 0 while the cosine will have a value of 1, but for an angle of 90 degrees the cosine will have a numeri-

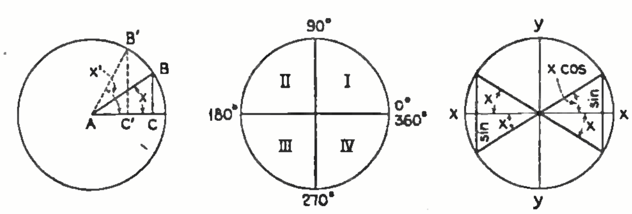


FIG.4 FIG.5 FIG.6

It is important to notice the magnitude of the trigonometric functions and it is readily apparent, from considering Figure 7, that the sine of an angle (remembering that the sine is always the ratio of the side opposite to the hypotenuse) will have a value from 0 to 1. Also, remembering cal value of 0 while the sine will have a value of 1. See Figure 7.

Now, the tangent of angle is the ratio of the side opposite to the side adjacent and for zero degrees we can appreciate that it is the ratio of 0 to 1, which is, of course, 0. The tangent of an angle

Mathematics in Radio

for 90 degrees is the ratio of 1 to 0, which is infinite. Thus we say that the numerical value of the tangent of any angle can have any value between 0 and infinity.

Examples

1. We have seen that the sine of 30 degrees is equal to .50. Show that the cosine of 30 degrees has a value equal to .866.

2. The tangent of an angle is the ratio of the side opposite to the side adjacent. In considering the hypotenuse as equal to unity, we can state that the tangent is the ratio of the sine to the cosine. What is the numerical value of the tangent of 30 degrees?

3. We have seen that the sine of 60 degrees is equal to .866. Show that the cosine of 60 degrees has a value equal to .50.

4. What is the numerical value of the tangent of 60 degrees?

5. What is the numerical value of the tangent of 45 degrees?

6. The co-tangent of an angle is expressed as the ratio of the side adjacent to the side opposite. Show that the co-tangent of 45 degrees is equal to 1.

a. What is the co-tangent of 30 degrees?

b. Show that the co-tangent of 60 degrees has a approximate value equal to .577.

7. The secant of an angle is expressed as the ratio of the hypotenuse to the side adjacent. Show that the secant of 45 degrees has an approximate value equal to 1.41.

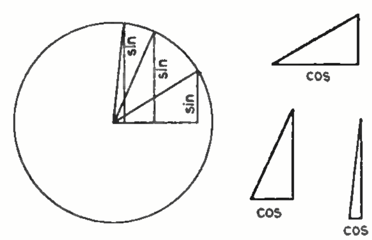


FIG. 7

a. What is the secant of 30 degrees?

b. Show that the secant of 60 degrees has a value equal to 2.0.

8. The co-secant of an angle is expressed as the ratio of the hypotenuse to the side opposite. Show that the co-secant of 45 degrees has an approximate value equal to 1.41.

a. What is the co-secant of 60 degrees?

b. Show that the co-secant of 60 degrees has an approximate value equal to 1.16.

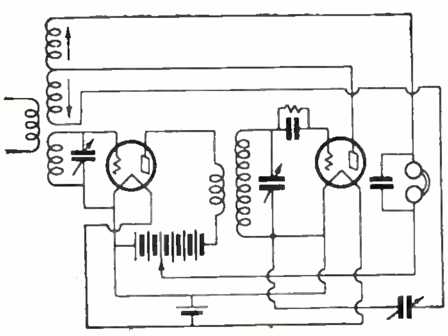
Latest Radio Patents

(*Continued from page* 320)

trode for controlling a glow discharge between said cathode and anode and a control electrode positioned outside the discharge space between said cathode and anode and on the opposite side of said cathode from said anode to maintain the electric glow discharge between said cathode and anode.

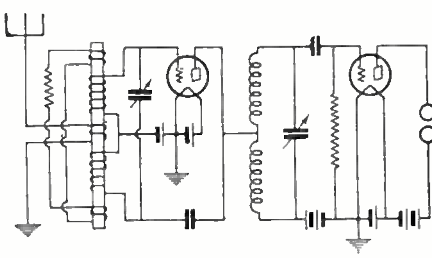
1,808,150. HIGH FREQUENCY AMPLIFIER. Percival J. Townsend, Los Angeles, Calif. Filed Nov. 1, 1927. Serial No. 230,311. 5 Claims.

1. In combination, one or more electronic emission devices having a plurality of electrodes, an input circuit connected to some of the electrodes, an output circuit connected to some of the electrodes, and means for feeding back energy from the output cir-



cuit to the input circuit, comprising a pair of inductances and a capacity connected in series and between the input and output circuits, the inductances being inductively coupled to the input circuit, said output circuit including a translating device in series with one only of said inductances.

1,807,759. PEVENTION OF PARASITIC OSCILLATIONS. Harold C. Silent, Los Angeles, Calif., assignor to American Telephone and Telegraph Company, a Corporation of New York. Original application filed Nov. 9, 1928, Serial No. 318,194. Patent No. 1,785,819, dated Dec. 23, 1930. Divided and this application filed Mar. 27, 1930. Serial No. 439,389. 4 Claims.



1. A translating device comprising in combination, a balanced bridge having a secondary transformer winding in each balancing arm, a primary circuit inductively coupling said secondary windings, an auxiliary transformer individual to each said balancing arm with a primary winding in series therewith, a series connection for the secondaries of said auxiliary transformers such that a voltage active in said primary circuit first mentioned induces opposed voltages in said auxiliary secondary windings, whereas a voltage active in the bridging arm of said bridge induces additive voltages in the auxiliary secondary windings.

Your Vacuum Tubes

(*Continued from page 279*)

being made. Any deviation from the required thickness can therefore be quickly corrected. The moisture content of the paper as it leaves the rolls is also an important factor and must be carefully controlled. An oscillating vacuum tube is the heart of a new device for automatically controling this moisture content. The paper, as it is being made, passes beneath a small ribbon of cellulose acetate. Cellulose acetate is a material which readily absorbs moisture, and whose dimensions change rather considerably with the moisture content. As the paper passes close to the cellulose-actetate ribbon, the ribbon absorbs moisture from the paper and increases in length. Any change in moisture content of the paper produces a change in moisture content of the ribbon. A part of the circuit of the vacuum tube is mechanically connected to the cellulose-acetate ribbon. Any change, therefore, in the ribbon dimensions produces a change in oscillating current which can be used to indicate directly the relative moisture content of the paper, or to control apparatus for correcting the moisture content.

It is rather a long step from paper manufacture to mining, but we find that vacuum-tube equipment is being used nowadays in prospecting for ores. Electrical prospecting depends on the fact that ore is a better electrical conductor than the surrounding material. By receiving and studying the reflected characteristics of radio waves from a special transmitter nearby deposits of ore may be located.

Airplanes are now guided from the ground and kept on their proper course by specially-transmitted radio signals, by which the pilot can ascertain whether he is keeping on his course or not. It is mainly by means of such a system that the air-mail service has been able to operate successfully through rain, snow and fog.

We now turn to the use of vacuum tubes in a different type of non-horizontal traffic. This time we find them used to start, stop and level passenger elevators in the modern skyscraper. In many of the new office buildings the elevators are entirely operated by push buttons. As the passengers enter the elevator they tell the operator the number of the floor they want to get off at. The operator pushes the corresponding button on the panel. When the car is full the operator pushes the "start" button, the doors automatically close, and the car goes up. As soon as the car reaches a floor corresponding to one of the pushed buttons the car stops, levels itself accurately with the floor and the door opens to let passengers off. When the car is ready to go up again the operator pushes the "start" button, and the elevator car continues up until it reaches another floor at which a passenger desires to leave. The car again stops, levels itself and the doors open.

People on the various floors wishing to go up or down, by pushing the "up" or the "down" button near the door of the elevator shaft, automatically stop the first car passing that floor in the proper direction. The car stops and the doors open to take on passengers without the slightest mental or physical effort on the part of the elevator operator.

Of course, the electrical wiring on one of these automatic elevators is intricate and quite a few vacuum tubes are used, but in general it may be said that the automatic control is based on the change of plate current when a tube changes from an oscillating to a non-oscillating condition. Coils are mounted in the elevator shaft along the various floors. Other coils mounted in the elevator car react electrically with the fixed coils as they pass them, and thus produce the necessary changes in the operating condition of the vacuum tubes to control the elevator. These quiet, efficient elevators are almost uncanny in their operation, and are a triumph of engineering science.

The marvelous vacuum tube has many practical uses other than the ones mentioned above. The tube, in combination with electrical circuits, through its oscillating properties can produce music of exquisite purity of tone. The Theremin is a musical instrument of that type.

From music to train control is a long gap to bridge, and yet the same little tube is used to transmit railway block-signals into the locomotive cab of the train, so that the engineer at any time or in any weather can tell at a glance whether the road before him is cleared for his thundering locomotive.

Use is made of the high-frequency current which the oscillating vacuum tube can generate in many other ways. In a special vacuum furnace, heated entirely by current of high frequency, certain special steels and pure metals are made. The current heats the metal by inductive effects, and no electrical connections need be made to the interior of the furnace. By such means of heating the temperature which can be attained is limited only by the melting point of the vessel which contains the molten metal. It was only by means of a furnace such as this that science has recently been able to produce some of the new solid hard metals. A similar process is used in vacuum tube manufacture where it is necessary to subject the grid and plate elements to intense heat without damaging the glass bulb. This method is shown in the accompanying photograph.

The simple looking vacuum tube is so truly universal that we find it used even in surgery. The radio knife, as it is popularly called, utilizes high-frequency current, generated by an oscillating vacuum tube, to perform bloodless surgical operations. In operations with this modern instrument the capillaries are sealed as the knife cuts—hence no bleeding. As the knife cuts through the tissues it sterilizes, and healing has been found in many cases to be rapid. By means of the electronic knife, exceedingly delicate brain operations, which formerly were considered almost impossible, have been successfully performed. In the field of medicine the vacuum tube not only helps to perform operations but can also induce fevers!

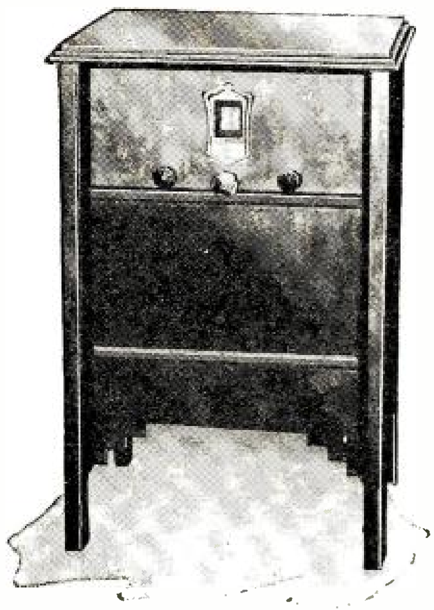
A Universal Receiver

(*Continued from page 295*)

The four-gang condenser, C1, C2, C3, and C4 with a single dial, tunes all the secondaries. Compensators on each section permit an accurate line-up.

The radio-frequency amplifier consists of three type –24 screen-grid tubes. Grid bias on these tubes is secured by the 1000 ohm resistors, R1, R3, and R5, in the cathode circuits. All of the circuits are thoroughly by-passed. Volume is controlled by the potentiometer, R19, which varies the voltage on the screen grids of the radio-frequency tubes. This potentiometer is designed with a special resistance curve to provide smooth control of volume at all times.

The radio-frequency amplifier feeds into another –24 tube which is used as a power detector. The high grid bias for this tube is secured by the drop through the 10,000 ohm resistor, R7. A phonograph jack, 8, is provided. When this is used the detector acts as an audio amplifier and it is necessary to reduce the grid bias to avoid distortion. The phonograph



A front view of the receiver in the cabinet

jack accomplishes this automatically by disconnecting the 10,000 ohm resistor, R7, and its by-pass condenser, C11, from the cathode and grounds the cathode through the phonograph pick-up and the 1000 ohm resistor, R8. This gives ample volume and excellent tone quality from any of the modern electric recordings. The three r.f. tubes and the detector are inclosed in aluminum shields to prevent any coupling between the stages.

In order to furnish the high impedance necessary in the plate circuit of the power detector, the first audio stage is resistance coupled. The tube in this stage is a –27, T5, with its grid bias furnished by the 1500 ohm resistor, R14. The grid of this tube is connected with a tone control which consists of condenser, C16, and the variable resistor, R13. This provides for continuous variations in tone, from base to treble.

Two –45 tubes, T7 and T8, in push-pull, comprise the last stage. Since the filaments of these tubes draw only 1.5 amperes and are in series with the –24s and –27s which draw 1.75 amperes, a means must be provided for shunting the extra .25 ampere around them. This is accomplished by the 20 ohm resistor, R15. The center tap on this resistor is grounded, as is the end of each of the two filaments, therefore each tube has 10 ohms directly across its filament. The dial light, 5, is also connected across this resistor.

The plates of the power tubes are brought out to the speaker plug, 6, which is a standard UX socket. The grid bias on these two tubes is secured in a rather interesting manner. The filaments are grounded to the chassis and the grid return is brought out to the extreme negative side of the filter circuit. On a.c., the plates of these tubes are supplied with their full rated voltage of 250 volts, and the necessary 50 volts of grid-bias is provided by the drop through the section of the voltage divider between (c) and (d). On d.c. the plate voltage is limited by the voltage of the line, usually about 115 volts. The grid-bias in this case comes from the drop in the filaments of the preceding tubes. This is 15 volts and leaves about 100 volts on the plates. While this seems very low, it is an inevitable limitation of d.c.; the tone quality at ordinary room volume is surprisingly good, though naturally the output is greater on a.c.

With the exception of the filament circuit and the switching arrangement previously described, the power unit is conventional. A dry electrolytic condenser of 4 mfd. capacity, C17, in the first section, 8 mfd., C18, in the second and 2 mfd., C19, in the third, is used. The filtering by this arrangement proved better than the more frequently used 2-4-8 connection. When the speaker field is used as a choke a .25 mfd. condenser, C21, is shunted across it in order to make it resonant to approximately the frequency of the ripple.

For those who are interested in building the Ansley Universal a.c.-d.c. radio a second installment of this article will describe, in detail, the assembly and wiring.

Parts List

C1, C2, C3, C4—Four-section gang condenser, .00035 mfd. each section, with dial and dial light (5)

C5, C6, C7, C8, C9, C10, C11, C12, C14, C20, C21—By-pass condenser block (15) including the following capacities, respectively, .1 mfd., .1 mfd., .1 mfd., .1 mfd., .1 mfd., .1 mfd., .1 mfd., .25 mfd., 1 mfd., 1 mfd., .25 mfd.

C17, C18, C19—Dry electrolytic condenser block with capacities, respectively, of 4 mfd., 8 mfd. and 2 mfd.

L1, L2, L3, L4—R.F. coil assembly, mounted in shields on a common base

R1, R3, R5, R8—Flexible wire-wound resistors, 1000 ohms each

R2, R4, R6, R7, R11, R12, C13, C15, C16—Resistor-condenser assembly with resistance and capacity values of, respectively, 20,000 ohms, 20,000 ohms, 20,000 ohms, 10,000 ohms, 50,000 ohms, 500,000 ohms and .001 mfd., .006 mfd. and .006 mfd.

A Universal Receiver

R 13—Tone control resistor. 200,000 ohms.
R14—Flexible resistor, 1500 ohms.
R15—Wire-wound resistor, 20 ohms, center-tapped
R16—Tapped voltage divider, 8000 ohms
R17, R18—Enameled resistors, 110 ohms, 200-watt rating.
R19—Volume control resistor, 25,000 ohms, with switch (13)
T1, T2, T3, T4—Tube sockets marked "224"
T5—Tube socket marked "227"
T6, T7—Tube sockets marked "245"
T8—Tube socket marked "280"
Metal chassis, shaped and drilled
Tube socket marked "speaker" (6)
4 tube shields for tubes T1, T2, T3, T4
Phonograph jack (8)
Push-pull audio input transformer (3)
Power transformer (9)
Filter choke (14)
Dynamic speaker, 2500-ohm field, with built-in push-pull output transformer (4)
Circuit changing plug (10)
A.C. and d.c. caps for plug (11) (12)
Binding post strip, Ant. (1), Gnd. (2)
Bakelite back strip for chassis
Escutcheon plate for condenser dial
Knobs for three controls
Electric cord and plug
Lugs, screws, brackets, hook-up wire, etc.

Plug-in Coils Banned

(*Continued from page 290*)

resistor employed in order to provide desirable operating voltages for the –24 detector. The plate of the detector is fed through the r.f. choke L3 and its output goes through the small condenser C8 directly to the antenna binding post of the broadcast receiver.

It will be noticed that in addition to the grid condenser C6 and leak resistor R1 in the oscillator circuit (which tend to maintain a constant and desirable output voltage, and more even heterodyning action), two by-pass condensers, C11 and C12, are connected across the oscillator heater circuit. These condensers have been found particularly desirable in preventing interaction between the short-wave oscillator and harmonics of the broadcast receiver oscillator if the broadcast receiver employed is a superheterodyne. They are actually mounted very close to the oscillator tube socket terminals and are just visible in Figure 2.

The power supply is extremely simple, consisting of a power transformer furnishing "A," "B" and "C" voltage to the two tubes and having a very low drain. It is employed with the –80 rectifier, which delivers a full 250 volts for most efficient operation of the detector and is filtered by a single high inductance choke L14 and the two 4 mfd. dry electrolytic condensers C9 and C10.

In operation the converter is simply placed on top of or near the broadcast receiver, with its power supply plug inserted in a nearby 105- to 125-volt, 50-60 cycle a.c. power outlet. The broadcast receiver antenna is connected to the binding post on the rear of the converter cabinet and the shielded lead projecting from the converter connected to the antenna post of the broadcast receiver with the shielding connected to the receiver ground post. With the short-wave-broadcast selector switch of the converter thrown to the broadcast position and the broadcast receiver volume turned well up, the broadcast receiver is tuned to a clear channel at about 650 kilocycles, or somewhere between 600 and 700 kilocycles. The short-wave-broadcast switch is then thrown to the short-wave position and the converter tuned by means of its single tuning dial with the small vernier antenna trimmer (lower left knob) adjusted from time to time for maximum noise level in order to keep the first detector and oscillator circuits in exact alignment at all times. Volume is, of course, controlled by the broadcast receiver volume control and tone quality by the tone control in the broadcaster receiver, if it has one.

Compensating for Critical Tuning

Due to the very wide frequency band covered in each range of the converter, it will often be found that the tuning of the converter dials, like that of any short-wave tuning dial, is extremely critical and it may be a little difficult to adjust, particularly on the very low wave stations. This is very easily compensated for, as the broadcast receiver dial provides a beautiful vernier action, since one of its dial divisions represents only one channel or 10 kc. as against many times this for each dial division of the short-wave converter dial. The converter may be definitely logged and stations once tuned in, returned to or re-tuned without any difficulty if the broadcast receiver dial is always set at the same point when the converter is operated. This, however, is not at all difficult and as a matter of fact, several degrees variation on the broadcast receiver dial will have very little effect in changing the setting of the converter dial.

All in all, the short-wave superheterodyne converter offers for those experimenters and broadcast listeners who have a good broadcast receiver the finest and least expensive method of short-wave reception. All matters of inconvenience such as have been found in previous short-wave converters have been done away with in the new 739 model, and its operation is so simple, reliable and certain that the most inexperienced broadcast listener can now have the full benefits of short-wave reception.

Selenium Awakes!

(*Continued from page* 299)

quickest-acting light-sensitive relay circuit yet developed along these lines, without an amplifier.

The bridge may also be used with a vacuum-tube amplifier. directly, with a vacuum contact for controlling currents up to 6 amperes at 220 volts maximum, or over 1½ horsepower.

Figure 2 shows this circuit as it is used with dry cells and "B" batteries. The diagram includes the electrical constants for the various resistances, voltages and capacities.

The circuit shown in Figure 3 is one for operating the bridge with a vacuum tube, on 110-volt lighting circuits, in connection with a power relay. All that is necessary to utilize this circuit on 220 volts d.c. lighting lines is to change the 1500-ohm resistance to 3000 ohms.

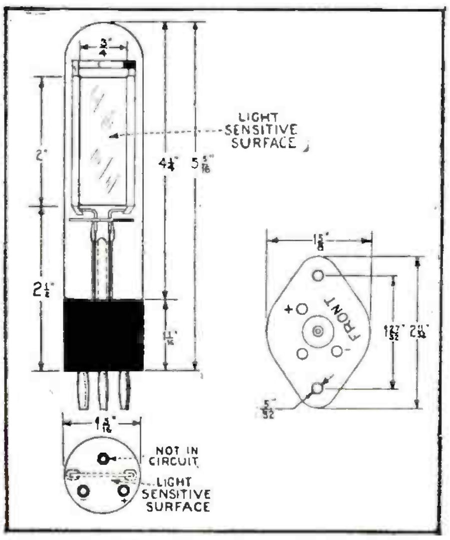


Figure 5. The dimensions of the bridge. Figure 6. The special socket employed for mounting the bridge

Still another circuit for employing the bridge on 110-volt, 60-cycle lighting lines is given in Figure 4. In this application a type -27 heater tube is used as a rectifier in connection with a special power transformer. This transformer is equipped with a main secondary winding of 250 volts and two 2.5-volt windings for activating the type -27 amplifier tube as well as the rectifier. All of the constants for this circuit are clearly shown in the diagram.

Figures 5 and 6 give dimensions of the tube, bridge and socket, respectively.

Selenium, the element used in these new cells, was isolated in 1870 by Berzelins. He found it as an impurity in sulphuric acid. Selenium was studied by the chemists for over sixty years before its light-sensitive properties were observed. The chemists found it belonged in the sixth group of the periodical chart of the elements, sandwiched in between sulphur tellurium. It lies just between the metals and non-metals and shows a tendency to form allotropic modifications. Selenium exists in three well-defined forms: as amorphous selenium; as crystalline, red selenium and as crystalline, gray metallic selenium. The last-mentioned form is a very stable one and is the only form that is conductive like a metal as well as light-sensitive.

The ability of selenium to change its resistance when subjected to illumination was first observed by Willoughby Smith at 1872 when he was working in a cable station on the Island of Valencia. Here, crystalline selenium in strips, was employed as high resistances, and Smith noticed that the resistances of these strips decreased when light coming in the window fell on them. Since that time selenium has been developed into various types of cells for light-sensitive use.

The usual method for constructing a selenium cell for reasonably low resistance is to apply the selenium on an insulator in the form of a flat covering and to separate it into two portions connected by a long narrow strip. This is done by cutting away a portion of the selenium covering. Later the practice of winding two fine conducting wires on an insulated block and spreading selenium over the surface, to produce a long path, came into use. Such arrangements are commonly known as selenium cells, but the term "bridge," as proposed by Minchin, is considered preferable.

As stated before, the sensitivity of the new type of American bridge described in this article is considerably higher than in other light-sensitive devices of the type. This sensitivity is ordinarily termed "current sensitivity."

The theory of selenium's sensitivity to light is generally based on the idea of splitting up of the atoms of selenium into oppositely charged ions. This is called "ionization." Negative ions, in the case of selenium, might be free electrons moving back and forth within the metal in accordance with electric forces imposed thereon. The conductivity, therefore, of the selenium depends upon the number of electrons set free by light and not yet reabsorbed by positively charged atoms. According to D'Albe, the number of electrons freed at any given moment is proportional to the light absorbed by the surface of the selenium cell. The number of ions which can recombine is proportional to the square of the number of freed electrons in the cell. This is expressed by the equation

$$\frac{dN}{dt} = C - BN^2$$

where N is the number of free electrons
t is the time
C is the measure of the light energy
and B is a constant (the coefficient of recombination).

Equilibrium in a cell will be reached when the production of ions, caused by light falling on the cell, equals the number of ions reabsorbed during this same time period, when

$$C = BN^2$$

(*Continued on page* 342)

An All-Purpose Oscillator

(*Continued from page* 303)

32 wire. This is mounted inside the oscillator coil about one inch from the end of the winding. However, the best point of coupling will have to be determined by trial, keeping in mind that a fair dip in the grid meter is essential at resonance, while the looser the coupling the better. It was found that the primary of the i.f. transformer was suitable for pick-up on the high waves and the coupling was loose enough to materially influence the accuracy.

Since the rotor plates of the condenser are at r.f. potential, care should be used in mounting it on the metal panel and if a metal tuning dial is used, it should have an insulated bushing.

The construction of the a.f. oscillator is not complicated and the use of a switching arrangement whereby the grid condenser is changed every time a tuning condenser is varied will produce audible frequencies which are quite pure in tone. Above all it will cover the entire musical range with the necessity of only one switching operation. Although the values of the condensers are as indicated, others of about the same size can be substituted. If it is desired to obtain other frequencies it is only necessary to use various condenser combinations.

The transformer coils, T1 and T2 are simply an output transformer as used with a magnetic speaker, usually referred to as a one to one. Any a.f. transformer can be used as can a center tapped output choke in which case the grid and plate return will have to be the center tap connected to the plus B.

It is quite important that good r.f. chokes be employed, and of high enough inductance that when using the i.f. oscillator the calibration will not be affected by the audio oscillator. The choke RFC2 is used mainly in order to secure sufficient a.f. potential drop to modulate the radio frequencies.

The audio frequency output can be used externally by taking energy from the plate circuit through a .01 mfd. condenser and an attenuator of 500,000 ohms which is used to control the output. This feature is quite desirable in order to run tests on audio equipment and be able to quickly cover various representative points between 100 and 5000 cycles.

By using the instrument as an oscillating wavemeter, it is possible to obtain an accurate calibration by the beat note method. The output terminals of the oscillator are attached to the antenna and ground posts of a receiver or by using a coupling coil and hinging it near the receiver (leads from the oscillator should be shielded). The oscillator dial is varied until zero beat is obtained between the signal and the current from the oscillator, also, the milliammeter will show a dip depending upon the coupling. Under these conditions the oscillator's frequency is the same as that of the signal. This same procedure is carried out for various frequencies until a sufficient number of points are secured to plot the necessary calibration curve.

To calibrate the intermediate frequency range it is necessary to use a broadcast signal which is a harmonic of the desired i.f. For example, to obtain the resonant point for 175 kc. the oscillator should beat with the fourth harmonic or 700 kc. Unless care is used the results are apt to be untrue and it is best to check against several harmonic points in the broadcast band. The next point

(*Continued on page* 343)

Selenium Awakes!

(*Continued from page* 341)

or where

$$N = \sqrt{\frac{C}{B}}$$

The conductivity of a selenium cell is then proportional to the square root of the illumination. The new selenium radiovisor bridge handles many times more current than the usual photo-electric cell and therefore calls for a minimum of amplification in even complicated applications. The device is independent of applied voltage, within wide limits, and is relatively inexpensive even when used with its associated apparatus. It is simple to apply to new applications, many of which are being found from day to day Possibly some of our readers may discover important new uses for this device

A CORRECTION

On page 133 of the August issue, in Mr. Bouck's article entitled "Oscillator Condenser Design for Single Control Superheterodynes" the formula (1) should read as follows:

$$R = \sqrt{\frac{1}{\pi^2 Lnk \left(\frac{df}{d\theta}\right)^2 \left\{\frac{1}{2\pi \frac{df}{d\theta}\sqrt{LCo}} - \theta\right\}^3} + r^2} \qquad (1)$$

Ten Meters for Ten Dollars

(*Continued from page 297*)

altered to increase the spacing and therefore the capacity. Coils purchased already wound will be correct and this adjustment should not be necessary.

The plate tuning condenser is an REL 181-A special and consists of three plates. Its capacity is about 40 mmfd. The grid tuning condenser is a Pilot seven-plate midget. The grid tuning leak is a Hardwick-Hindle, 10,000 ohms, and the grid condenser an Illini .002 mfd.

The binding post strip is of bakelite, ½ inch by 12 inches, and the connections are spaced along it at 1½-inch intervals. 8/32 by ¾-inch machine screws and nuts provide the connections, and binding posts are not used because it would then prove difficult to mount the meters. Meter mounting brackets are shown in Figure 5.

Power Supply

The power supply depends entirely on the type of tube you wish to use. This set is adaptable to any receiving tube, including the following types: -99, -30, -01, -12, -71, -45, -10 and type 510, which was used in testing this set. For the first five named, "B" batteries or a "B" eliminator can be used very nicely. If you have a high-voltage "B" eliminator it can also be used for type -45's. We used the power supply described in the last issue of RADIO NEWS for the Junior Transmitter. The one described in the February issue is also adaptable. For the fellow who can afford only the cost of the parts and whose family owns a broadcast receiver with a push-pull -45 output stage, the tubes can be removed from the broadcast set and used in the transmitter and the power supply of the broadcast set can be used by making an adapter from an old tube base.

The key can be inserted between the —B connection and the filament center tap or a center-tap resistor across the filament terminals. Key click filters should be used the same as with any other set. (See past issues of RADIO NEWS for circuits.)

This set can also be used for the 20, 40 and 80-meter bands by purchasing coils to cover those bands.

Receiver

Most short-wave receivers can be made to work on ten meters unless they have peculiarities of construction that prevent the set from oscillating in that band. If this proves to be the case, a rearrangement of the parts to provide shorter leads will sometimes remedy the trouble. The circuit given in Figure 4 is also adaptable to different tubes, although we used a -32 as detector and a -31 in the audio. High screen voltages may prove necessary to make the set oscillate. All we can suggest is that you experiment. We used an REL coil form with one turn on the grid coil and three turns on the plate. Wound with No. 22 enameled wire and the coil drilled as follows, using the same system described for the transmitter coils. Rib 1, 4 up; 2, 3 up; 3, 14 up; 4, 17 up. A 20-meter coil was also wound for listening to the harmonics and placing the transmitter right into the 28-megacycle band. This coil was as follows: Rib 1, 16 down; 2, 9 down (seven turns); rib 3, 5 down; rib 4, top notch. four turns. Socket connections are marked in the circuit. The other parts used in the receiver are listed at the end of this article.

General Information

The antenna tuning condensers can be of almost any capacity as long as it is sufficient to tune properly. 250 mmfd. condensers being used for testing by the writer.

Do not use excessive voltages. With the two type 510's used here, 600 volts on the plate and 105 ma. with antenna connected permitted the tubes to run cool, give good output (an arc over ¼" long could be drawn on the plate condenser) up to one ampere radiation being recorded.

The price of ten dollars does not, of course, include tubes, meters or power supply. The parts for the transmitter can actually be purchased for less with judicious shopping. Here they are:

Parts for the Transmitter

L1—REL coil form (wound), No. 262-D special, and base	
L2—(Wound on same form)	
L3—REL grid coil, No. 262-D special, and base	$ 3.50
C1—REL variable condenser, No. 181-A special	4.00
C2—Pilot seven-plate midget	.45
C3—Illini .002 fixed condenser (1000-volt)	.20

All-Purpose Oscillator

(*Continued from page 342*)

for 175 kc. would be 1050 kc. and if a zero beat note is obtained the point is correct. Because harmonics are used it is possible that the resonance meter indication will not be discernible. In like manner, other points are obtained and a suitable curve plotted.

When using the oscillator to align circuits or as a wavemeter to measure inductance or capacity, it is important to remember that the output should be introduced to circuit under examination in such a manner that the results will not be in error. This can usually be accomplished with the aid of a pick-up coil attached to the r.f. output through shielded leads, this coil is then used to transfer energy to the circuit. In cases of shielded coils and i.f. amplifiers energy should be introduced by attaching the oscillator output to the primary winding of the preceding plate circuit.

An output meter can be used for aligning purposes, in addition to the oscillator resonance meter.

Ten Meters for Ten Dollars

R1—10,000-ohm resistor	.50
RFC—REL No. 132 r.f. choke	1.00
2 sockets, UX type	.40
1 piece bakelite 3 inches square	
1 piece bakelite 4½ inches square	
1 piece bakelite 1½ inches by 12 inches (cut from scrap panel)	
Wood screws, machine screws, washers, copper, etc.	.15
Total approx.	$10.00

Keyed parts not included in costs:
C4, C5—250-mmfd. National condensers
K—Key
V1, V2—Tubes as described in text.
A1, A2—Jewell 0-2.5 r.f. ammeters
MA—Jewell 0-50 or 0-200 milliammeter (depends on type and power of tubes used)
V—Filament voltmeter (optional)
R2—Center-tap resistor if no tap available on filament transformer.

Note—The above prices are not the list prices of the manufacturers, but the prices which can be obtained by judicious shopping.

Parts for the Receiver

L1, L2—See text
C1, C2—REL 187-E combined tank and vernier condenser
C3—.00001 mfd. fixed condenser
C4—.002 fixed condenser
C5—1 or 2 mfd. by-pass Flechtheim condenser
C6—Antenna coupling condenser made of two small angles with ½ inch by ½ inch faces, one firmly fastened and the other adjustable, average spacing 1/16th to ⅛th inch
R1—2-5 megohm grid leak
R2—500,000 ohm Centralab radiohm
R3—Filament rheostat (value depends on type of tube used) usually 30 ohm
RFC—r.f. choke, receiving type, National
T—National impedaformer
B—"C" battery (can be conveniently incorporated in set)
V1—Type -22, -24 or -32 tube
V2—Type -01A, -71, -27, -30 or -31 tube

A "Rolls Royce" of Converters

(*Continued from page* 301)

tuned r.f. short-wave receiver, nevertheless they should be kept within reason, consequently the forms used are molded of the R-39 material developed especially for the short-wave coil-transformer work by the Radio Frequency Laboratories. Ordinary bakelite is much less effective as a dielectric at short wave-lengths due to its tremendous losses.

The oscillator and detector tuning condensers are of such values as to properly track on the 45-to-85 meter range when the natural circuit and tube capacities serve as the "pads." On the shorter waves, the detector grid coils must be padded and on the longer wavelength range the oscillator requires the padding condenser. This latter condenser, due to the small difference in frequency between the signal and the intermediate frequencies, must of necessity be quite large in order to restrict the oscillator range to that of the detector input circuit. Mechanically, the padding condensers are small flexible brass tubes over the grid leads running from the coils to the band-shifting switch.

By properly adjusting the padding condensers at the factory, true single control, without the use of a trimmer, is obtained over the entire range of from 15 to 185 meters.

In order to have the oscillator coil-switching mechanism at ground potential, the oscillator circuit is of the shunt-feed, rather than the more usual series-feed, variety.

Two of the common faults of practically all converters in the past have been so-called "dead spots" and "interlocking." Both of these troubles are due to the design and construction of the coils more than to anything else. To prevent interlocking, the two groups of coils, namely, the oscillator and detector grid sets, must be shielded from each other. This is accomplished in the present design by locating them at opposite ends of the chassis and placing between them the steel partition shield shown next to the drum dial in the illustration. This separating of the two groups of coils, in conjunction with the special type of oscillator-detector coupling (a 10-mmfd. condenser between the grid of the oscillator tube and the screen of the screen-grid detector), results in complete elimination of interlocking tendencies.

Dead spots in the tuning range, it was found, were caused by unused coils coupling with the coil in the circuit. When it is considered how many different coils there are, including ticklers, primaries, etc., and the number of multiples of the fundamental period of each coil that is effective in producing a dead spot, the extreme importance of locating these coils relative to each other in such a manner as to eliminate undesired interaction is readily seen. Figure 6 shows the ingenious scheme worked out for eliminating this undesired coupling. In this adapter all coils in each group have their axes at right angles to those of adjacent coils.

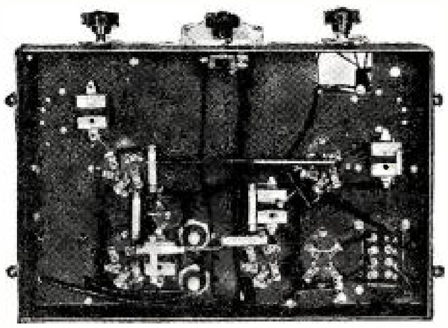
The Power Supply

In order to reduce the internal impedance of the type -26 tube when used as a rectifier, the grid and plate are tied together.

In addition to the plate supply windings, the power transformer has the nec-

A "Rolls Royce" of Converters

essary 2½-volt heater windings. The filter comprises a small choke coil which, due to the low value of current drawn through it, can have an exceedingly small air gap and consequently high inductance without danger of saturation. On both sides of the choke are located 8-mfd. electrolytic filter condensers. The power pack is entirely shielded from the detector and the oscillator circuits by means of the welded-steel partition, running lengthwise along the chassis.



Below deck, where practically all except the coil connections are made

The Intermediate Frequency

Before starting on the design of a converter embodying single-dial control and a tuned-coupling tube circuit, it is essential to know the intermediate frequency at which it is to be operated. It is a well-known fact that all of the more recent types of broadcast receivers are most sensitive in the middle of their tuning range, and that all of the earlier types of receivers are of considerably higher than average sensitivity at this same frequency, whereas they may have practically no sensitivity or gain at either one end or the other of the band. Furthermore, the fact that 1000 kc. is sufficiently removed from 1500 kc. so that its use will permit tuning in signals fairly close to the end of the broadcast band where such procedure would be impossible if 1500 kc. were used as the i.f., also had some effect in influencing the selection of 1000 kc. as the optimum frequency at which to set the broadcast receiver when used with the converter.

Knowing this frequency, it was then possible to design the fixed 1000 kc. r.f. transformer coupling between the first detector plate circuit and the grid circuit of the combination i.f. amplifier and coupling tube. It also permitted the selection of the proper values of the "padding" condensers in the r.f. oscillator circuit to insure single-dial control.

In order to prevent pick-up of local broadcast stations operating on or near 1000 kc. from interfering with short-wave operation, the lead between the antenna post on the broadcast receiver and the switching device in the converter is thoroughly shielded. The switch connects the end of this shielded lead either to the antenna or to the output of the converter, depending upon whether short-wave or broadcast reception is desired, and eliminates the necessity of manually changing the antenna from the antenna terminal post of the converter to the similar post on the broadcast receiver.

With the Experimenters

A Two Tube, Pentode, S.W. Receiver

(*Continued from page* 308)

screen-grid voltage variable. The filament supply is from the same winding as the pentode. This, of course, makes the heater in the -24 about 15 volts positive to the cathode. But I have used it this way and have experienced no difficulty. It is obvious of course that as the grids of both tubes are at ground potential, if the grid of the -24 has a —1.5-volt bias, the cathode is at +1.5 to the ground. The Pentode has a bias of —16.5 volts, thus the filaments of both pentode and -24 are +16.5 from ground or +15 from the cathode of the -24.

The coils may be of any standard make or homemade. I use Silver-Marshall type 131 plug-in coils, but any other well made coil will suit as well, as Pilot or Nationals.

Here is a list of the necessary parts:

C1—Any good .00015 vernier condenser
C2—Any good .00035 vernier condenser
C3—Any good .00025 grid condenser
C4—Any good .1 mfd. by-pass condenser
C5—Any good 1 mfd. by-pass condenser
C6. C7—Electrolytic filter condensers recommended
CP—Any good midget condenser
R1—2 meg. grid leak
R2—0 to 1000 ohm wire-wound resistance
R3—3000 ohm wire-wound potentiometer
R4—429 ohm bias resistor (must be able to stand 40 mils without undue heating)
R5—Center-tapped filament resistor
R6—Voltage divider with taps at 90 and 180 volts
L1—Any good plug-in coil set with tickler windings
L2—Samson r.f. choke
T1—Amertran 3-to-1 audio transformer
T2—Output transformer. Must be able to stand 32 mils on the primary. Bear in mind that the output impedance of the -47 is 35,000 ohms. Try to get an adequately high impedance primary in the output transformer. A low impedance will work, but greater efficiency may be expected if the primary of the output transformer has an impedance about equal to ¼ of the plate impedance of the -47.
VT1—Type -24 tube

(*Continued on page* 346)

A Set Tester De Luxe

(*Continued from page 277*)

in a circuit we have to break it and insert our shunt with the meter across it. Now we have to break many different circuits in this tester and in order to use the same shunt we would have to have another switch and complicated wiring. It is more convenient and cheaper in the end to provide three separate shunts in the different circuits so that all we have to do is to connect the voltmeter across them with switch S1.

the milliammeter assumes that all resistors are within 1% of their rated values; in that case all measurements will be accurate to within 1% if the correction factors are applied. Thus it is necessary to adjust these 25 watt resistors by means of the movable clips, checking the resistance with the Wheatstone bridge.

Since a continuity testing circuit was already provided it was thought that this

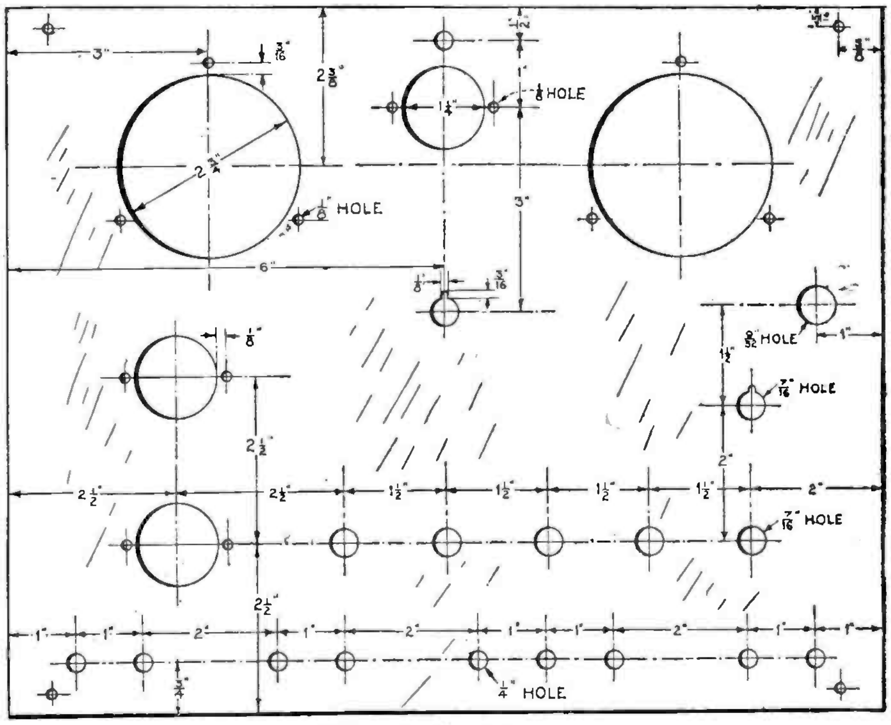


Figure 5. Panel layout

The highest current we are going to measure is 500 ma. Therefore we must select for the shunts, resistors which are rated for this high current. The maximum wattage is to be $I^2R = (\frac{1}{2})^2 \times 100$ or 25 watts. It is for this reason that we had to use resistors rated at 25 watts for which we chose the Electrad type B-1. These are guaranteed to be accurate to within 5%.

But our discussion of the accuracy of

test could be made far more useful to the serviceman if we went one step further and calibrated the voltmeter for resistance measurement from 100 to 60,000 ohms.

If we trace the continuity testing circuit, we find that the milliammeter is in series with the 100-ohm resistors as well as with the multiplier resistor and the test prods. Any external resistor connected in this circuit (between the test prods) will result in decreased current flow through the meter. When using a 4.5 volt battery the value of any unknown resistance added to the circuit is given by the following equations:

$$R_x = \frac{E}{I} - R_1,$$ where R_x represents the unknown resistance to be measured, R_1 = known resistance including the meter and two series resistances

E = battery voltage

I = actual meter reading.

Examples: If the meter, set for the 50 ma. scale, reads .5 ma., this formula is applied as follows:

$$R_x = \frac{4.5}{.0005} - 5100 = 9000 - 5100 = 3900 \text{ ohms}$$

The same reading, with S2 set for the

A Two-Tube Pentode S.W. Receiver

(*Continued from page* 345)

VT2—Type -47 pentode tube

TP—A good solid power transformer

A glance at the above list will show that most fans have most of the stuff on hand from which the receiver can be easily made.

As for performance, I play W3XAL, W8XAL, W9XF, code and amateur stations all over the world on the loud speaker regularly, and I feel sure fans will get just as big a thrill as I do out of playing the loud speaker on a *two-tube set.*

GEORGE LEANDER SMITH,
Los Angeles, California.

A Set Tester De Luxe

25 ma. scale, would give:

$$R_x = \frac{4.5}{.0005} - 2600 = 6400 \text{ ohms.}$$

On the 10 ma. scale:

$$R_x = \frac{4.5}{.0005} - 1100 \text{ ohms} = 7900 \text{ ohms.}$$

A curve giving the value of the unknown resistance for all meter indications can now be calculated or it can be determined empirically by substituting standard resistors in the circuit and noting the current.

The making of such a curve is an arduous task and therefore, to save the reader this trouble, a set of curves is provided in Figure 4. These curves were made using both methods mentioned above so as to provide a double check on their accuracy.

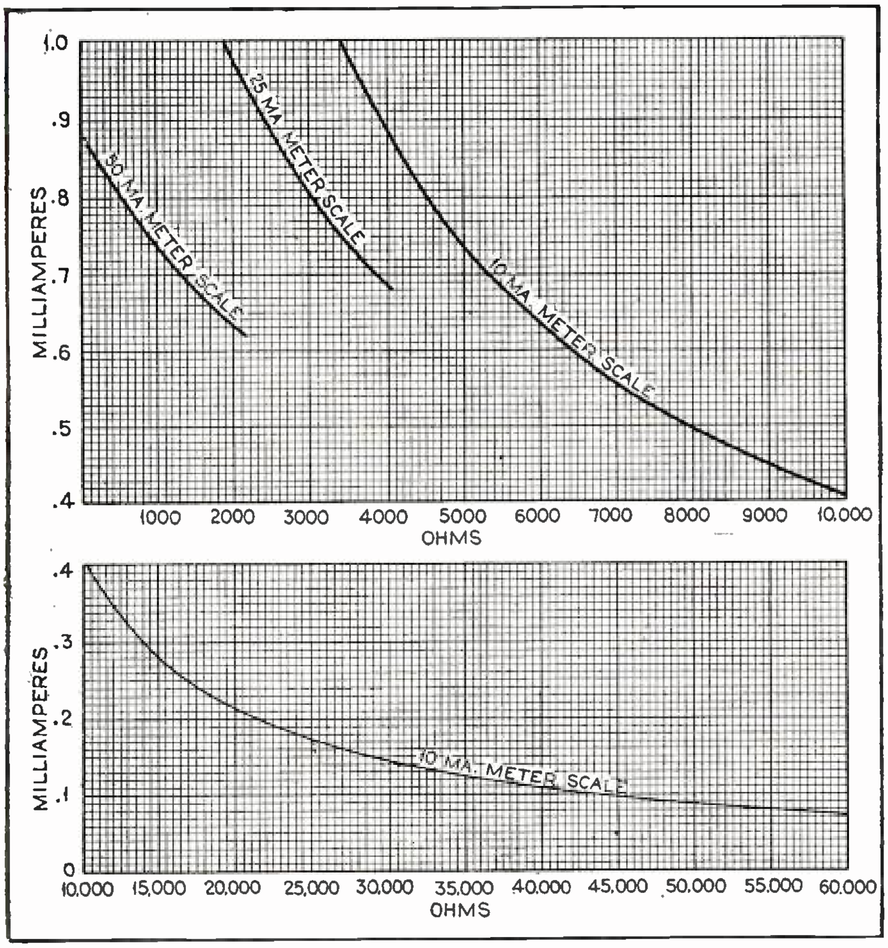


Figure 4. Calibration curves for resistance measurements, using the continuity circuits of the tester

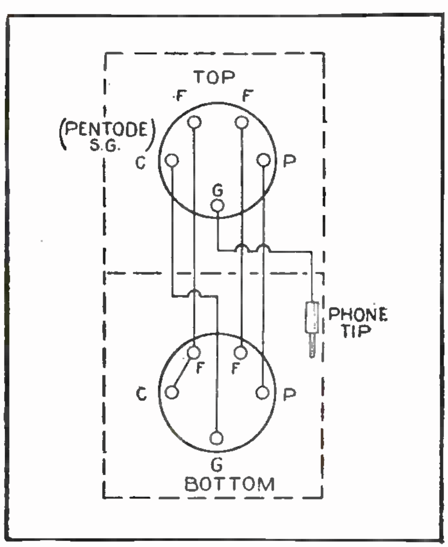


Figure 3. Internal wiring of pentode tube adapter (two required), showing top and bottom sections as viewed from underneath. Method of using these adapters in testing pentodes is described in the text

The upper left curve is for resistances of less than 2000 ohms; the middle curve for resistance values between 1900 and 3400 and the curve to the right will serve for resistances from 3400 to 10,000 ohms. The bottom curve is to be used for the higher resistance values up to 60,000 ohms.

The accuracy of the curve, or rather the accuracy of the result, is best in the middle. An accuracy of better than 5% can be expected between 1000 and 20,000 ohms and within plus or minus 10% for resistances above or below this range.

We should like to point out that neither the curve nor the meter circuit contribute to these inaccuracies. They are due solely to the crowded scale which makes it impossible for the operator to read to better than the mentioned limits.

In the calculation it has been assumed that the battery-voltage is exactly 4.5. As we never draw more than one milliam-

Set Tester

pere from it, we should be able to use the battery for six months or more. It goes without saying that as soon as the voltage has dropped more than, say 2%, resistance measurements will suffer in accuracy and it would be better to replace the battery.

To provide a neat and professional appearance, the metal panel was drilled and engraved in a shop especially equipped for this work. However, for readers who prefer to prepare their own panels, the drilling layout is shown in Figure 5.

When the panel is ready, the switches, sockets and tip jacks can be mounted and wired. Then the resistors are mounted in the manner shown in the photograph of the underside of the panel. The multiplier resistors R1, R2, R3, R4, R5, R6, R7, R8 are mounted in a vertical position, supported by the busbar wiring. Resistors R9, R10 and R11 are also supported by their busbar connections.

Just one word of advice regarding the switches S1 and S2. Be sure the notches at the edge of the mounting holes are in the position shown in Figure 5.

Finally the 4.5 volts "C" battery is mounted on the bottom of the carrying case, by means of a metal strip securely screwed to the case. Flexible leads from panel to battery should be left about one foot long.

After the construction and wiring are completed, meter multiplier and shunt circuits should be tested. The voltmeter ranges may be tested by connecting a 45 volt "B" battery across the jack terminals J6 and J7. With the switch S1 set for "ext. volts," the battery voltage is checked on the 50, 250, 500 and 1000 volts scales. A low voltage battery is next connected in the same manner to

(Continued on page 349)

With the Experimeters

(Continued from page 310)

C1 and 2 match the coils to produce the correct frequency. Condensers C3 and 4 can range from .005 to .0005. Chokes L2 and L4 should be very good or two chokes should be used with a by-pass to ground from a point between them. C5 should be about .0005. Each stage should be completely shielded. The leads to the grids should be shielded or placed as far apart as possible. A—, B— and shields should be connected to a good ground. C6 and C7 by-pass any r.f. on the positive filament side to ground as A— is ground.

To tune this circuit shift the tuning condensers till both circuits are tuned on the desired frequency. Only when both circuits are perfectly in tune will it oscillate.

We have used tubes in this circuit from the –99 to –10 and have varied the plate voltages widely on each tube and have never experienced frequency shift.

I am sure that every ham that uses this circuit in his master oscillator will be more than pleased with the results.

L. H. STANTZ
Brooklyn, N. Y.

INDEX TO ADVERTISERS

Set Tester

(*Continued from page 348*)

check the 1, 2.5, 5 and 10 volts scales. The continuity circuit is tested by plugging test prods into Jacks J9 and J10, throwing the switch S5 to the "continuity" side and then touching the tips of the prods together to complete the circuit.

A check up of the current measuring portions of the circuit is made by connecting a variable resistor, 0-1000 ohms, in series with a 4.5 volt "C" battery and connecting this combination between J7 and J8. The switch S1 set in the "ext. ma." and switch S2 set for the 10 ma. range, the variable resistors are adjusted to provide full scale reflection (10 milliamperes). Then the switch S2 is thrown to the other points to check other milliammeter ranges.

This finishes the analyzer proper and the accessories may now be made ready. The cable plug which is used to connect the tester into a socket in the receiver under test consists of a six wire cable terminating in a UY type plug at each end. The sixth wire terminates in a 'phone tip at one end and a regular battery clip at the other end. A 5-4 adapter (having four prongs at the bottom and five holes at the top) is required to permit the UY type plug on the receiver end of the cable to be connected in a four terminal socket. Finally a six inch wire is equipped with a control grid clip at one end and a phone tip jack at the other end to make connections between the control grid of the screen grid tube under test and the jacks J2 or J3 in the tester.

For measuring pentode tubes a pair of simple adapters is required. These two adapters are exactly alike and the internal connections for one shown in Figure 3. This figure represents the bottom views of the upper and lower sections of the adapter.

The original tester did not provide for pentode measurements. In the present model this is taken care of by means of the pair of adapters which have already been mentioned—at least this is true so far as the types –33 and –47 pentodes are concerned. The type –38 pentode does not require the use of the adapters but is measured in the same manner as the –24 tube.

In measuring the type –33 and type –47 pentode, one of the adapters is plugged into socket VT1 and the plug of the cable coming from the receiver is inserted in the top of this adapter. The other adapter plugs into socket VT2 and the pentode tube is then plugged into the adapter. The phone tips coming from the adapters are then plugged into jacks J1 and J3. Then all measurements of the pentode tube are made in exactly the same manner as those for screen grid tubes.

The measurement of rectifier tubes was possible with the original tester, as well as the present one, but was not touched on in the descriptive article in the August issue. Half wave rectifiers of the –81 type are measured in the same manner as plate current and plate voltage and other tubes. Current measurements may

Set Tester

be made on both plates of -80 type full wave rectifiers. One side is measured in exactly the same manner as the plate current for the -81 or any other type of tube. The other plate is measured in the same manner as the screen grid current of a -24 tube. The voltage of both plates can likewise be measured in the same manner as the plate and screen grid voltage of other tubes.

The final use of the set tester—for measuring unknown resistors—is an extremely valuable feature. This is accomplished, as explained before, by employing the continuity test circuit. The unknown resistor is connected between the tips of the test prods and the current flow measured. After noting the reading of the milliammeter, the current value is checked against the curves shown in Figure 4 from which the value of the unknown resistor is read directly.

With this tester completed, the serviceman has a unit of inestimable value to him in his work. Its usefulness is not limited to the serviceman however. Custom set builders, experimenters and in fact anyone who plays around with radio has frequent occasion to make tests of receivers and tubes, to measure the value of unknown resistors, etc. The usefulness of the tester will be found well worth its price when used for these purposes.

List of Parts

J1 to J10—insulated tip jacks.

M1—Jewell d.c. milliammeter, type 88, range O-1 ma.

M2—Jewell a.c. voltmeter, type 78, range O-5 volts.

R1—1000 ohm resistor.

R2—2500 ohm resistor.

R3—5000 ohm resistor.

R4—10,000 ohm resistor.

R5—50,000 ohm resistor.

R6—250,000 ohm resistor.

R7—500,000 ohm resistor.

R8—1 megohm resistor.

Shallcross Super Akra-ohm type 6-M (accurate ± 1%)

R9, R10, R11—Electrad type B-1, 100 ohm resistors (25 watt).

S1—Best Mfg. Co.'s 9 tap, non-shorting bi-polar switch.

S2—Best Mfg. Co.'s 9-tap inductance switch.

S3, S5—Toggle switches, s.p.d.t.

S4, S7—Toggle switches, s.p.s.t.

S6—Toggle switch d.p.d.t.

S8—Push button type switch.

VT1, VT2—Pilot five prong, sub-panel tube sockets.

VT3—Pilot four-prong sub-panel tube socket.

Blan special carrying case, 14 3/16 inches by 11 5/16 inches by 7¼ inches high outside.

One pair of Blan "Buddy" type test prods, with phone tips.

2 Blan cable plugs, 5 prong, spool type.

Tube adapter, 5-4 type.

Blan special pentode test tube adapters, 2 required (see Figure 3).

General Fabricating Company special drilled and engraved Testolite panel, 10 7-16 inches by 13 inches by 3-16 inch.

6 wire battery cable, four feet long.

Read Classified Advertising—It Pays

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Radio News Prize "Ham" Transmitter

(*Continued from page 281*)

tubes had a slight tendency to change the frequency of the quartz.

The antenna at W2BWF is the popular Zeppelin type, 66 feet long with 60-foot feeders. This arrangement may be used either as a single-wire voltage-fed system in the 3.5-4.0 mc. band or as a "zep" in the 7.0 and 14.0 mc. bands. The two tuning condensers are mounted on a bakelite panel fastened to the wall above the transmitter.

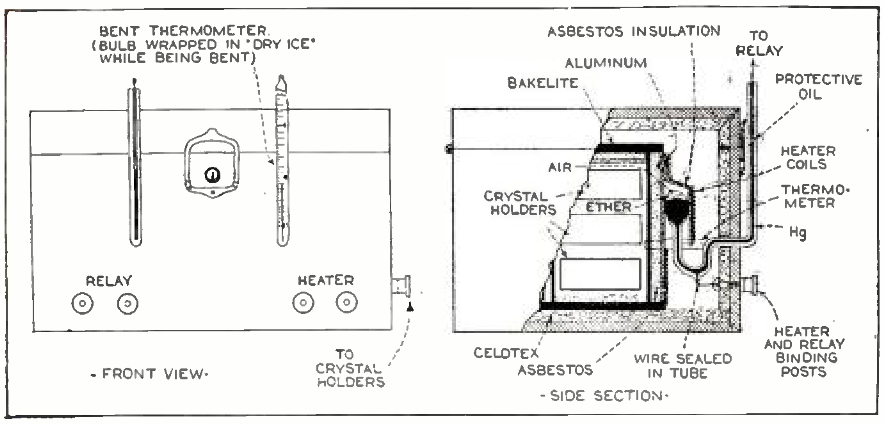
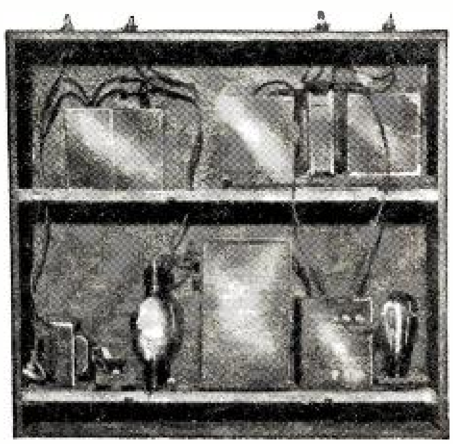


Figure 2. Details of the "oven" which maintains crystals at constant temperature

The construction of the temperature-controlled box, as shown in Figure 2, is very simple.

The control element is of the mercury type and was made over the kitchen gas range one evening. It is made of small bore barometer tube as shown in Figure 2, blown into a three-quarter inch spheroid at one end. This bulb contains a drop of ether and a small bubble of air, the rest of the tube being filled with mercury. The ether volatilizes and is extremely sensitive to temperature changes at about 40 degrees Centigrade.



The high voltage and intermediate voltage supplies are mounted in this metal cabinet, which is fastened to the rear of the main cabinet

After the transmitter is all set up it should be adjusted in the following steps:

(1) With all tubes out and all meters shunted, turn all power on full. This will subject all parts to much higher d.c. voltages than will ever be used in actual operation. If nothing blows it is sure that the transmitter will be safe from high voltage breakdowns.

(2) Place all tubes in their sockets and see that they light to proper brilliance (plate supplies turned off, of course).

(3) Insert a crystal in the grid circuit, being sure that the quartz and plates are free from dirt and grease, also that the selector switch is connecting to the right crystal. Take the shunts off the meters and turn the oscillator plate current on. Tune the oscillator tank until the plate current takes a sudden dip. The oscillator will then be furnishing maximum output.

(4) Now apply proper plate, screen and bias voltages to the first amplifier. Tune the tank of this circuit also for minimum plate current.

(5) The same procedure is followed in the other two stages.

(6) A lamp bank or some other sort of dummy antenna should be coupled to the tank of the last stage. With an ammeter in this circuit, start at the oscillator and make any slight adjustments to *increase the plate current in the following stages*. Tune the last tank for maximum current in the dummy antenna.

(7) Touch the grid terminal of the crystal holder. If the plate currents throughout the transmitter (except the oscillator) drop to zero, the set is acting as it should and there is no oscillation in the amplifiers.

(8) The grid meters indicate excitation and the set should be tuned so that they read maximum.

(9) Replace dummy with real antenna. Tune for maximum antenna current.

The transmitter at W2WBF has been in operation for some months and has proven entirely satisfactory. It has never developed bugs and has always been stable in operation. The signal has been reported "pure d.c. vy stedi," "xtal pdc," etc. I have never been reported as having a rough or raw a.c. note.

Radio Physics Course

(*Continued from page* 315)

human voice or musical instrument is lost. A violin tune may sound like a whistle, the high-pitched tones of the piccolo may not be heard at all. The *ideal* frequency range for perfect speech, music, important harmonics and most noises such as tapping, hissing, etc., is about 30 to 10,000 cycles. However, it has been definitely established experimentally, by progressively eliminating high and low frequencies by means of electrical filters, that exceedingly good reproduction is possible if the range extends from about 40 to 8000 cycles.

Examination of the chart of Figure 4 shows that only four major instruments produce fundamental sound frequencies above about 2500 cycles. These are the pipe organ, piano, piccolo and the flute. Fundamental notes of higher frequency than this are rarely played in ordinary music excepting on the piccolo and flute. It would appear then that a radio transmitting and receiving system designed to handle sound vibrations up to about 8000 cycles would satisfactorily handle the fundamental and first three harmonics of all notes up to about 2500 cycles. (The third harmonic of 2500 cycles is $2500 \times 3 = 7500$ cycles.) Only the very high notes of the flute, piccolo, piano and organ would be eliminated.

At the lower end of the musical range we find that only the pipe organ and piano can produce notes lower than 40 cycles per second. These lower notes are seldom played, and even if they are, their harmonics are reproduced and the ear unconsciously tends to supply the missing fundamental frequencies.

At the present time most of the powerful broadcasting stations in the United States transmit all sound frequencies from slightly below 100 cycles to about 5000 cycles per second, due to the present 10-kilocycle band basis for assigning broadcast station carrier frequencies, as we shall see later. Broadcast engineers have been pushing into the higher frequencies, however, and many of the latest transmitters are capable of transmitting a complete range of sound frequencies from 30 cycles in the bass to 8000 cycles in the high notes in order to obtain better transmission of the low notes and harmonics. It is interesting to note that the telephone wire circuits which link radio stations into chains or networks for programs of common origin are capable of only the range from 75 cycles to 4800 cycles at present.

It is almost certain that the next few years will witness great improvements in loud speakers and receiving equipment with the complete important sound frequency range reproduced for full tone quality and realism.

It is true that some persons have a distinct aversion to really faithful low-note or high-note reproduction. Very high notes cause the sensation of feeling rather than hearing. Loud high notes may cause severe irritation or pain. Also static and many other electrical interfering noises are most prevalent on the high frequencies. The latter consideration has been a very important factor in the question of high note reproduction.

When one fully realizes and understands the task of the radio broadcasting transmitter and receiver, one must really marvel at its simple design and almost perfect accomplishment. The complex audio-frequency sound waves must be faithfully transformed into audio-frequency electric currents and waves varying in intensity at these audio frequencies. These waves are in turn radiated into space. The transmitter as a whole must be capable of responding to a whisper or a pianissimo as well as to a shout or a fortissimo. It must be impartial in its transmission of all the complex sound waves of all the different instruments.

Cash With Pick-ups

(*Continued from page* 304)

they find it easy to sell the pick-up alone, for use with the old spring motor, where a sale of both pick-up and a new electric motor represent, to the customer, a somewhat discouraging outlay. At the next service call, when they have had time to tire of cranking up the machine (and the price for the motor alone is not formidable), they are generally ready to complete the electrification.

Richard Horle, of Schenectady, N. Y., says that he gets around those customers of his who balk at the idea of any kind of a demonstration by playing records through the radio, ostensibly to test the audio amplifier and speaker. Once having listened to electrical reproduction, the sale is usually a simple matter.

Rural Interference

(*Continued from page* 306)

quite a number of occasions, run across complaints of interference on radios operated either from or close to 32-volt farm-lighting plants. The interference may be from several sources—either the ignition system of the gas engine, the starting contacts or the commutator. The simplest way of eliminating ignition noise is by putting a 25,000-ohm resistor in series with the spark-plug—as close to the plug as possible. Commutation interference can often be cleared up by cleaning the brushes and commutator. Radio-frequency choke coils in both sides of the line, and by-passed to ground on each side of the chokes with 2 to 4-mfd. condensers, are also most effective. Wind the choke coils with about 150 turns of the same size wire used for the lines on a 2-inch diameter tube. The frame of the generator and engine should also be grounded. On automatic plants, noise from the starting contacts can be reduced by connecting a 1-mfd. condenser across them."

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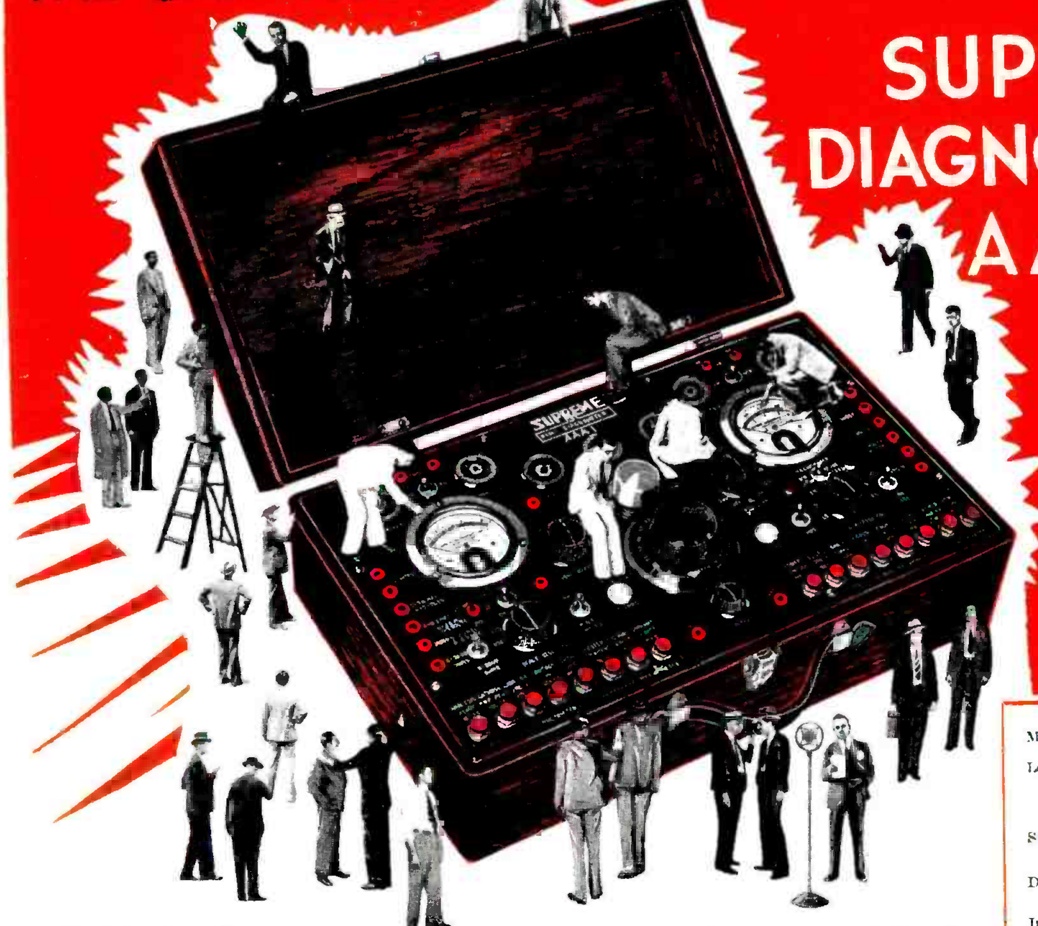

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