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HUGO GERNSBACK Editor

VOLUME I. **September** NUMBER 3

HUGO GERNSBACK, Editor-in-Chief

R. D. Washburne, Technical Editor. **C. P. Mason, Associate Editor**

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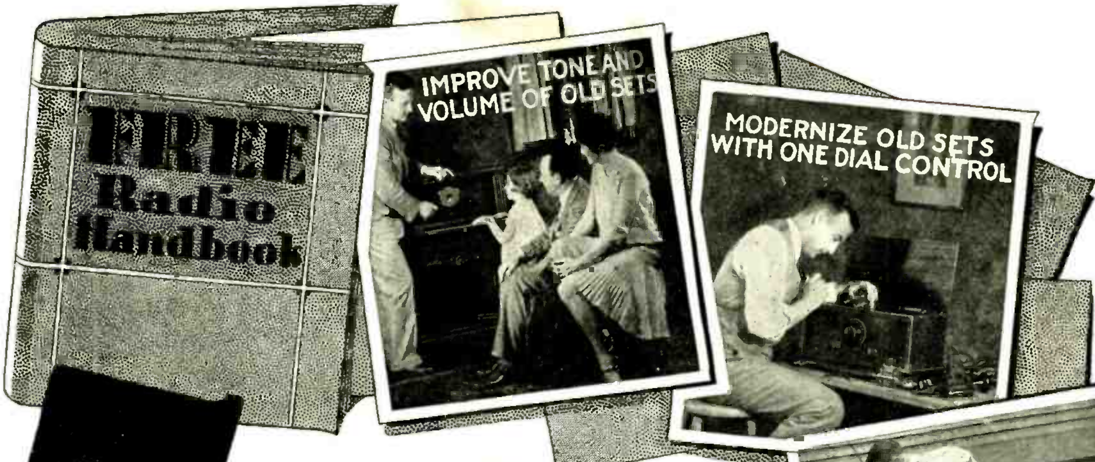

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Volume I. SEPTEMBER, 1929 Number 3

Radio-Craft

HUGO GERNSBACK, - - - - Editor

EDITORIAL AND GENERAL OFFICES, 96-98 PARK PLACE, NEW YORK.

A Special Announcement

By HUGO GERNSBACK

THE radio industry is one of great surprises, and is notable also for its continuous and rapid changes. In an industry that is evolving as rapidly as radio, it is natural that the people engaged in it should also change with it, and continuously modify their ideas as well.

When I started my first radio publication in 1908, it was the day of the "radio amateur" or rather, as he was called, the "wireless amateur." In 1920 the wireless amateur had become a "radio fan" and, instead of sitting at his key and transmitting messages to friends hundreds of miles away, he had constructed a broadcast receiving set to listen to music and other features.

Recently, because of the fact that commercial sets can be bought cheaper than they can be assembled, the radio "fan" is rapidly becoming in the minority. A few years ago there were hundreds of thousands of radio "fans" who constructed sets for their own edification. A little later on, while the factory-made set was still necessarily high in price and limited in production, the radio fan, seeing a good deal of money in the game, undertook to cash in on his experience of constructing sets that could be sold at a profit. Slowly, but surely, we see how he has turned from an amateur into a professional, till now, at last, he has "arrived"—arrived in the business in which he is to stay.

A recent survey, conducted by RADIO-CRAFT among some 10,000 readers of this publication, has brought out the astonishing information that 81% of those circularized are now engaged in radio in a professional manner. They are either service men, repair men, radiotricians, radio engineers or radio-technicians, or builders of occasional sets for special purposes.

An interesting feature, sounding a new note in radio, is brought out by the fact that quite an appreciable percentage of RADIO-CRAFT readers are now interested also in a professional way in "sound pictures." This was to be expected; because every sound picture is dependent upon some radio instrumentality, such as radio amplifiers and radio loud speakers, for its success.

The remaining 19% of the readers are made up of radio experimenters, and those who are interested in radio from a purely theoretical and "hobby" standpoint.

The questionnaire also brought out the point that our readers professed their desire to see in RADIO-CRAFT articles of a technical nature; such as will appeal primarily to the professional man, the service man and the radiotrician, in so far as they will help him to apply his trade and make money from it.

There also is a demand upon RADIO-CRAFT to publish service data on commercial sets; not only those that have recently been put on the market, but those that have been in use for some time. The reason for this is that every service man is often called upon to care for sets which are now obsolete and, without knowing the intricacies of the set or circuit and its constants, it becomes very difficult to service the set properly without great waste of time.

Heeding this demand, and beginning with the October issue, RADIO-CRAFT will publish every month complete data on servicing commercial sets on which there seems to be the greatest demand. We ask the cooperation of our readers in advising us what sort of articles should appear, and, particularly, what existing sets should be described regularly for the benefit of all service men.

This information will be carefully tabulated every month and RADIO-CRAFT pledges itself to give the professional reader only such data as is of interest to the majority.

All the present departments of RADIO-CRAFT will be kept intact. The new policy simply means enlarging the scope of the magazine.

Radio-Craft

FOR

The Professional—
The Service Man—
The Radiotrician

The A. C. Screen-Grid Peridyne

By HUGO GERNSBACK

SINCE the publication of my former articles on the "Interflex" and the "Peridyne" series, I have been overwhelmed with requests for an A.C. screen-grid "Peridyne" set; and the set described in these pages has been designed in response to this demand.

It was realized from the outset that the set builder and constructor require an up-to-date receiver which may be plugged into any A.C. outlet. The set should be as compact as possible; it should be relatively easy to construct, and it should have all the excellent advantages of the previously-described sets.

In presenting, therefore, the five-tube A.C. Screen-Grid "Peridyne", I have no hesitancy in stating that I believe this receiver to be more powerful and more sensitive than any set previously designed by me; and, as a matter of fact, without undue modesty, I will state that I have as yet to see its equal for results.

I could go into all sorts of superlatives as to the really remarkable power this set develops, in spite of its having but five tubes. It certainly equals any 10-tube set in existence today, when use in the home only is required. At no time was it possible for me to use the entire volume of the set; because there is no home-type loud speaker in existence that will handle the full output comfortably. In order to utilize the entire, maximum output from this set, it is necessary to have a loud speaker of the theatrical or auditorium type.

MR. GERNSBACK presents in this article his latest effort—the A.C. Screen-Grid "Peridyne" Five. He makes the claim that, for the number of tubes, this set will outpoint both in volume and sensitivity any other in existence now. The claim is made that this five-tube set will give as much power as any ten-tube set in existence today, so far as house use is concerned. For sensitivity, the set is marvelous. Stations 2,500 miles distant have been received readily and regularly by Mr. Gernsback, in New York City and in the summer time.

This may seem an extravagant claim; but my readers will remember that whatever claims I made for my previous sets were never exaggerated and, in many cases, I deliberately understated the actual performance of such sets.

Sensitivity in Reserve

As to sensitivity, I have had no trouble at all to receive Pacific Coast stations, over an airline distance of some 2,500 miles, in New York City on a hot summer's evening. As a matter of fact, this high sensitivity is sometimes practically objectionable; because the set will receive heterodyne whistles from stations that operate on the same wave length, although thousands of miles apart.

The sensitivity of this set is so great that it becomes impossible to use it with an aerial of the usual length in the city; for, if such an antenna is used, the set has a tendency to become somewhat broad for stations within a 100-mile radius. From this it will be seen why, for those who are located in the country and will operate the receiver over 100 miles away from any strong station, it will perform most satisfactorily for DX work with an aerial about 100 feet long.

For those in the larger cities, where there is an abundance of radio stations, and for those nearer than 50 miles to some powerful station, a very short aerial of 25 feet, and even the 10-foot variety, may be recommended. Such an aerial gives the set the necessary sharpness, yet delivers all the volume necessary for house operation and some to spare.

As a matter of fact, for city use, a few feet of wire placed around the moulding of a room, in the residence or apartment, will be all that is necessary. I have used the metallic screen of a single window with excellent results, in New York City, and even then the full volume of the set was rather uncomfortable.

I appreciate that these statements are difficult to believe, and all I ask is that the set be tried out; I know that first scepticism, and then enthusiasm, has been common with builders of other sets which I have described. Thousands of

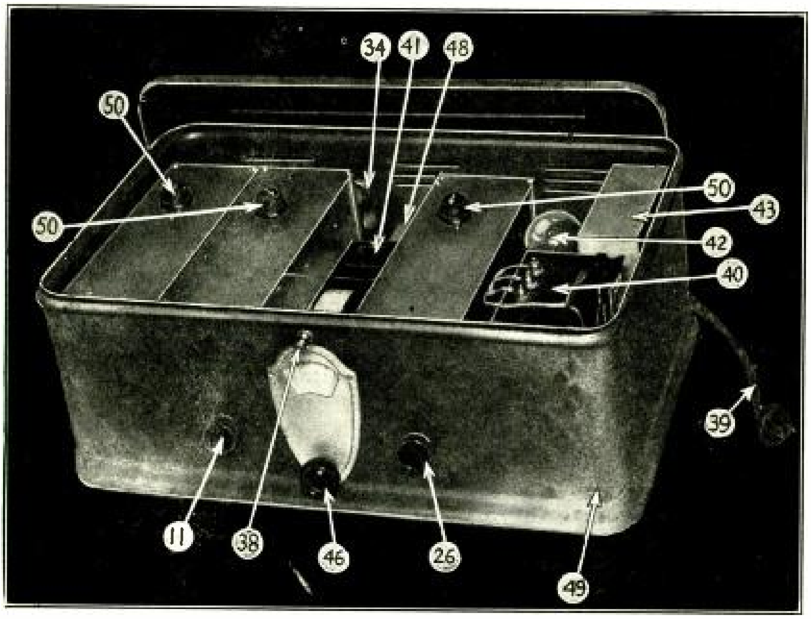


Fig. 5. This is an illustration of the completed A.C. Screen-Grid Peridyne receiver. To put it into operation it is only necessary to connect aerial and ground, and plug the line connection into the A.C. line wall receptacle.

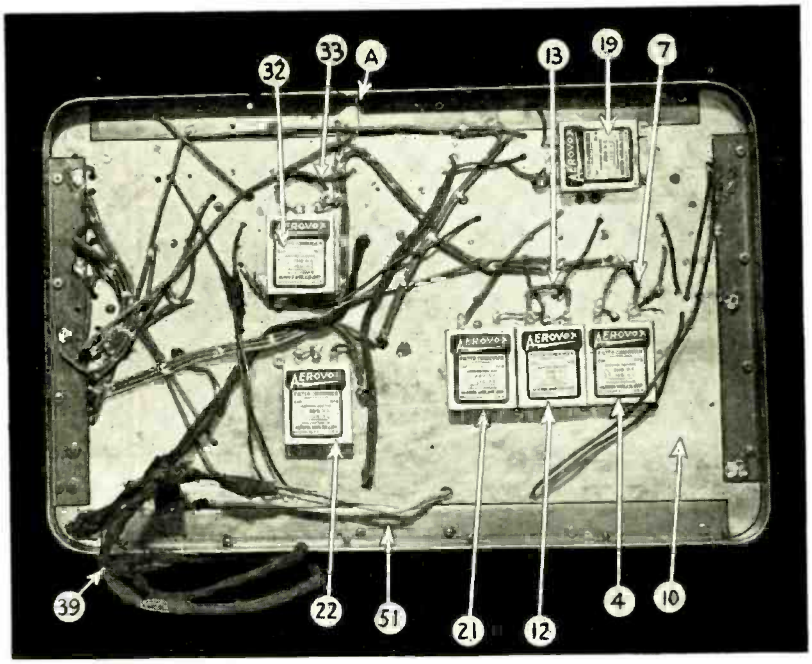


Fig. 4. Lower side of sub-panel. The aluminum sub-panel is raised by means of a brass angle cut and shaped as described in the text.

constructors will back up my findings as to the merits of this remarkable set.

Optional Features

In the present set, the usual "Interflex" system (that is, the crystal detector), has been left out; because the sensitivity and power of the set are so great that the employment of the crystal detector would not add anything to them.

In a later set to be described by me, however, there will be included an entirely new combination wherein fewer tubes are used, and the crystal detector comes in very handy in this design.

While the cover picture on this issue of RADIO-CRAFT shows the set housed in a regulation metallic "can", the latter is, of course, superfluous if the set is to be installed within a cabinet. Any particular model of can, or any wooden cabinet preferred for console purposes, may be used and this option is left to the designer.

We have striven to give in the accompanying photographs and diagrams, enough information to make it possible for anyone to build a set without the need of blue prints or pictorial layouts. It is felt that the average builder will probably wish to make minor changes and, perhaps, substitute certain unessential parts; and for that reason, no additional layouts are given.

The writer will be delighted to hear from those who have built the set and, especially, from those who have obtained unusual results, as to distance, power, etc.

I wish to acknowledge here, with thanks, the invaluable aid given me (in designing this set) by B. B. Bryant, who did the actual work of construction, and a great deal of experimental research in connection with this set.

Circuit Details

The circuit consists of two tuned stages of radio frequency, a detector tube of the '27 type (in contrast to the previous Peridynes, which incorporated the Interflex system of crystal detection), and two stages of A.F. The first R.F. stage employs the standard '27 type A.C. tube; the second employs a screen-grid tube of the new A.C. type. The first A.F. unit employs the '27 tube with 135 volts on its plate and is followed by the power stage in which is used the '71 tube.

Generally speaking, sufficient amplification is obtainable from a single R.F. (within limits) the greater the load in the plate circuit of the screen grid tube, the greater will be the amplification obtainable from the system. The amplification obtainable, therefore, is determined by the "mutual conductance of the tube," which in turn, results in the requirement of a large plate load.

Up to a given point, the greater the "pure impedance" load in the plate circuit of the tube, the greater will be the voltage amplification. There are three ways whereby the plate circuit of a tube may be coupled to the grid of the following tube. These are: (a) direct or conductive coupling; (b) inductive coupling; and (c) capacity coupling.

For all general purposes, the capacity coupling is satisfactory with components of proper values. Since the tube into which the plate circuit is coupled is the detector of the receiver, the type of coupling selected is further justified.

Capacity coupling permits the use of a single coil-and-condenser tuning circuit, arranged in the "rejector" or tuned-impedance system recommended by the tube makers.

The lower the losses of the circuit, the greater will be the effective R.F. impedance; which in turn places a greater load on the plate circuit of the screen-grid tube, resulting in greater amplification. Actual, measured voltage amplification of 75 per stage at 300 meters has been obtained by reducing the losses to almost zero value.

The method of reducing such losses consists, not entirely of the use of low-loss apparatus, but also of the feeding back of energy from the detector plate circuit. This, in effect, tends to neutralize the losses by the introduction of energy in phase with the frequencies in the tuned circuit.

It is now seen that the heart of the receiver is the second R.F. stage and the

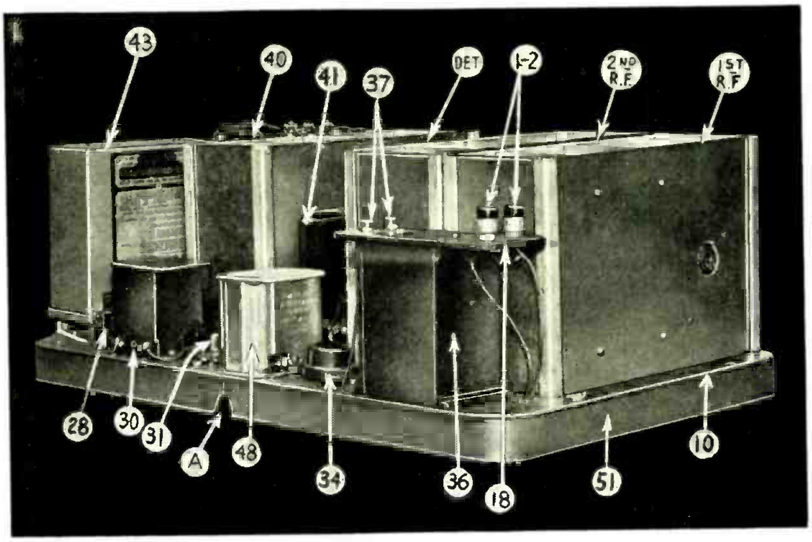


Fig. 3. This is a rear perspective of the new Peridyne, showing the audio equipment and filter block.

stage in which is used the screen-grid tube. This is directly due to the choice of tube and the type of output circuit used for coupling to the next tube. Numerous experiments have indicated that regenerative detector. The regenerative amplification obtainable from the detector is small in comparison to the amplification obtainable from the second R.F. stage.

Selectivity

The selectivity of such a combination is the same as that obtainable with any other R.F. system in which are used the same tuning elements, when the amplification obtainable is of the same degree. Because of the tremendous amplification obtained from this circuit, it is apparent that the tuning will appear to be broad. In effect, the tuning of the second R.F. stage and the regenerative detector would be about the same as that of a four-stage ('01A) R.F. system delivering the same amplification, but with only two tuned circuits.

The necessity of selectivity for radio receivers is paramount, in these days, in order to prevent interference between broadcast stations.

Rather than decreasing the amplification obtainable from the second R.F. stage and regenerative detector, some other means of obtaining the required selectivity is desirable. There are numerous methods, such as band-selector circuits of the many popular types; the addition of another R.F. stage; or the shortening of the antenna system. The first and last methods are objectionable; for either would seriously decrease the DX qualities of the receiver.

The R.F. stage of the type used encounters only one real objection and this is the possible side-band cutoff when it is too closely adjusted near the oscillation point. Amplification from the first R.F. stage is not of prime importance; therefore, considerable amplification may be sacrificed for ordinary use. This is controlled by the resistance (11) in the plate circuit of the tube.

After some consideration, it was decided to build the receiver in a single unit of the A.C. type. This, with the receiver, contains the "B" power unit and the A.C. filament transformer. It is of chassis construction designed to fit into a standard metal cabinet of the "Bandbox" type.

Single Control and Resonance

As there are three tuned circuits, a single tuning control was desirable, which in turn necessitated compensation of the tuned circuits. The "Peridyne" principle of compensation as conceived and developed by Mr. Hugo Gernsback, some two years ago, has been adopted as the most suitable method not needing readjustment. Many compensation systems are objectionable; the use of midget variable condensers, for instance, because of the almost invariable lack of resonance at the opposite end of the broadcast band. When a receiver using such a system is compensated at 200 meters, unless the tuned circuits are high-loss, lack of resonance will be very evident at the longer wavelengths; while the reverse is true when the receiver is compensated at the longer wavelengths.

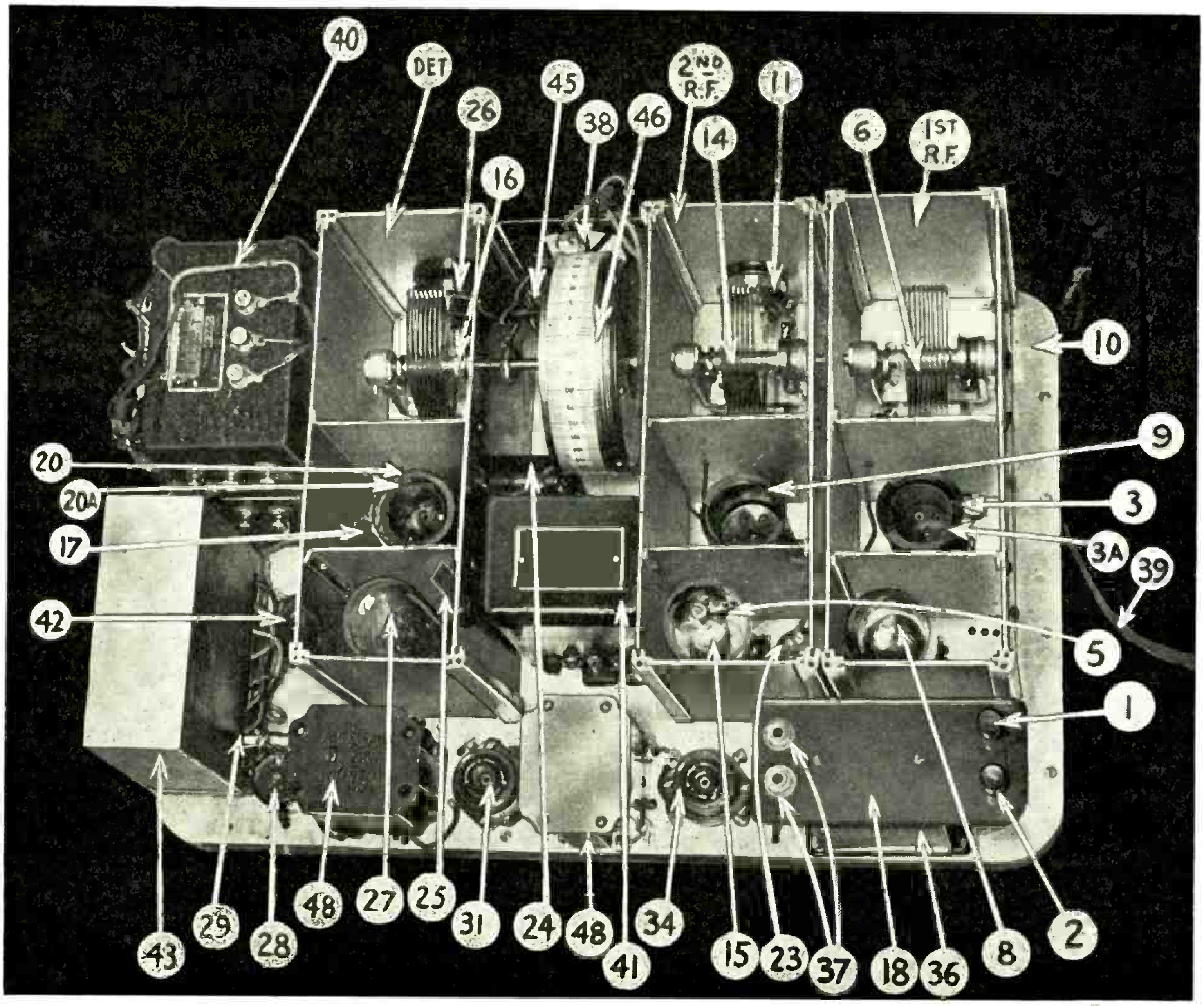


Fig. 1. This perspective view of the Peridyne receiver indicates the positions of the greater portion of the equipment used. Each part of the circuit is adequately shielded and bypassed. Both audio transformers are numbered 48; the one on the left is 30, in the list of parts.

Compensation by midget variable inductances of the variometer type is more satisfactory, but requires greater space as well as elaborate shielding. Effective compensation may be obtained by a combination of these two methods; but it is not convenient because of the requirements of large space and complete shielding.

The "Peridyne" Principle

It has been demonstrated by the performance of previous models of the Peridyne, that complete band compensation is obtainable in a single-control receiver, by the action in each stage of a movable plate upon a coil contained in a shielded compartment. The effect, while partly of a capacitative nature, is different from that of a trimming condenser; as the compensating action is in relation to the coil's capacity, but not to that of the tuning condenser. This gives a compensating effect, in many respects similar to that obtainable with both the midget condensers and variable inductances, but does not require additional space or elaborate shielding. The compensation obtainable by the "Peridyne" principle requires adjustment at the lowest wavelength. As the wavelength is increased, the change in the distributed capacity and distributed inductance of the coil, caused by the relation of the "Peridyne" plate to the coil, keeps the tuned circuits in step, and the result is resonance at all wavelengths of the band.

At this time, it is of importance to mention that, if the "Peridyne" plates are adjusted to a point too close to the coils, absorption of energy and damping of the tuned circuit will result. In general, the greater the distance between the coil and the "Peridyne" plate, the better will be the compensating action and the smaller the losses of damping of the tuned circuits. Under such conditions, it is necessary that the tuned circuits match (and this they do) within at least *three per cent.* over the entire range; which is a condition rarely to be found in receivers compensated by midget condensers, unless they are continually readjusted.

A word of caution regarding the "Peridyne" shields. It was found that, in most cases, the shields are useless on *very powerful signals*. Their highest efficiency is tested only when listening to distant stations and, in order to calibrate the set for the "Peridyne" shields (that is if you are located in a large city), it will be necessary to wait until the locals have signed off, and then compensate the "Peridyne" shields on some station a thousand miles away, or farther. After a number of different stations, of both high and low wavelengths, have been satisfactorily received, leave the shields in the best positions, and do not change them. On loud signals (that is from "locals" within 50 miles), the shields will be found to have little influence; except when using a very short aerial.

Shielding

High-gain amplifier systems, especially those in which the screen-grid tube is used, require shielding as near perfect as possible, to prevent inter-circuit reactions. The need of careful shielding is of prime importance in a compact receiver of this type. This is required to prevent not only reaction between the R.F. and A.F. circuits, but also coupling with the "B" power and A.C. filament supply circuits.

Each tube, coil and tuning condenser is contained in a separate shield compartment of its stage. In addition, shielded hook-up wire is used, for *all* leads in ALL circuits; with the exception of the flexible lead, which runs directly from the coil through the partition shield to the control-grid of the screen-grid tube. When all other leads are shielded, it is not necessary to shield the control-grid lead, nor is it advisable because of the losses that may be introduced by doing so; as the currents in this circuit, especially on DX signals, are of small magnitude.

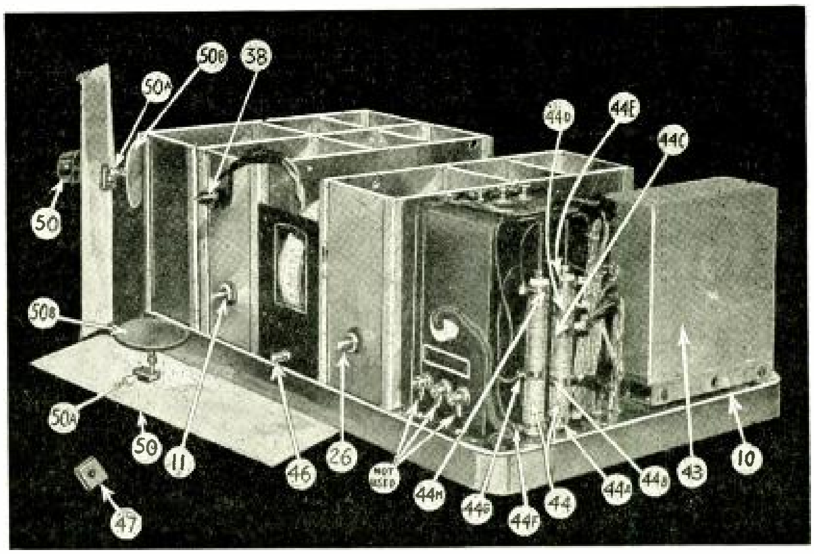


Fig. 2. This view of the Screen-Grid Peridyne shows the placement of the power transformer, voltage divider, Peridyne compensating plates and tuning drum. This drum was conveniently mounted by bending the lower edge of the mounting plate (furnished with the condenser), drilling mounting holes for machine screws, and then clipping off the two little tabs which extended from the sides of this plate. Particular attention is called to resistors 11 and 26 which must be carefully insulated as explained in the text.

Chassis Construction

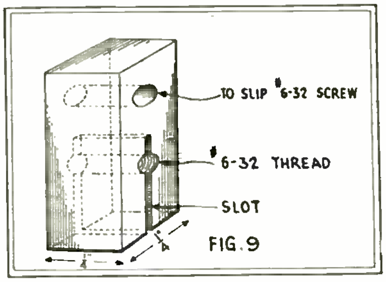
This receiver is built on the "chassis" principle; that is, the receiver is complete and independent of the cabinet.

FIG 13

By marking the brass angle according to the dimensions given above, sawing out the undesired portions, and then bending the brass to shape, a firm support for the aluminum bed-plate is obtained.

With this method of construction, it is possible to use any convenient cabinet for the main part of the receiver. In some forms of chassis construction, the power unit is built as a separate chassis; in this particular set the power unit is included in the single assembly.

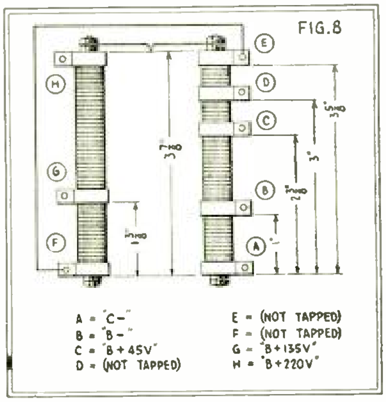
The sub-panel of the Screen Grid "Peridyne" is a single piece of aluminum, 1/16-inch thick. (The dimensions given in the list of parts are oversize,



This little piece of brass, one inch long, is the device for obtaining smooth, firm operation of the Peridyne plates; it thus does away with any need for locking nuts.

to allow for variation in cabinet construction.) The aluminum sub-panel is cut to the exact size determined by a template, made by cutting a piece of cardboard a little larger than the size of the metal cabinet; on this cardboard the cabinet is inverted, a pencil line being then drawn around the outside of the cabinet. This serves as the guiding line for cutting; the template being made by cutting on a line one-eighth-inch inside this pencil line. The completed template should fit into the base of the metal cabinet without binding at any point.

Fig. 10 indicates the exact layout of the sub-panel of this particular receiver,



The voltage divider of this receiver is illustrated, above. The two units are connected in series to form the total resistance required. The lugs must be clamped tightly to the wire to prevent microphonic contact noises.

with drilling holes for the aluminum posts which form the corners of the shield cans. The layout does not include drilling marks for any of the other equipment; as most constructors will want to substitute one or more items they have around the shop, for certain parts used in the original receiver. In addition, the parts layout is obvious from the several photographs and may be determined very closely by noting the arrangement in relation to the shield cans. Letter "*a*" in Fig. 10 indicates the center-mark for the screws which hold the aluminum posts in place; the drill used being the "slip" size for 6-32 machine screws.

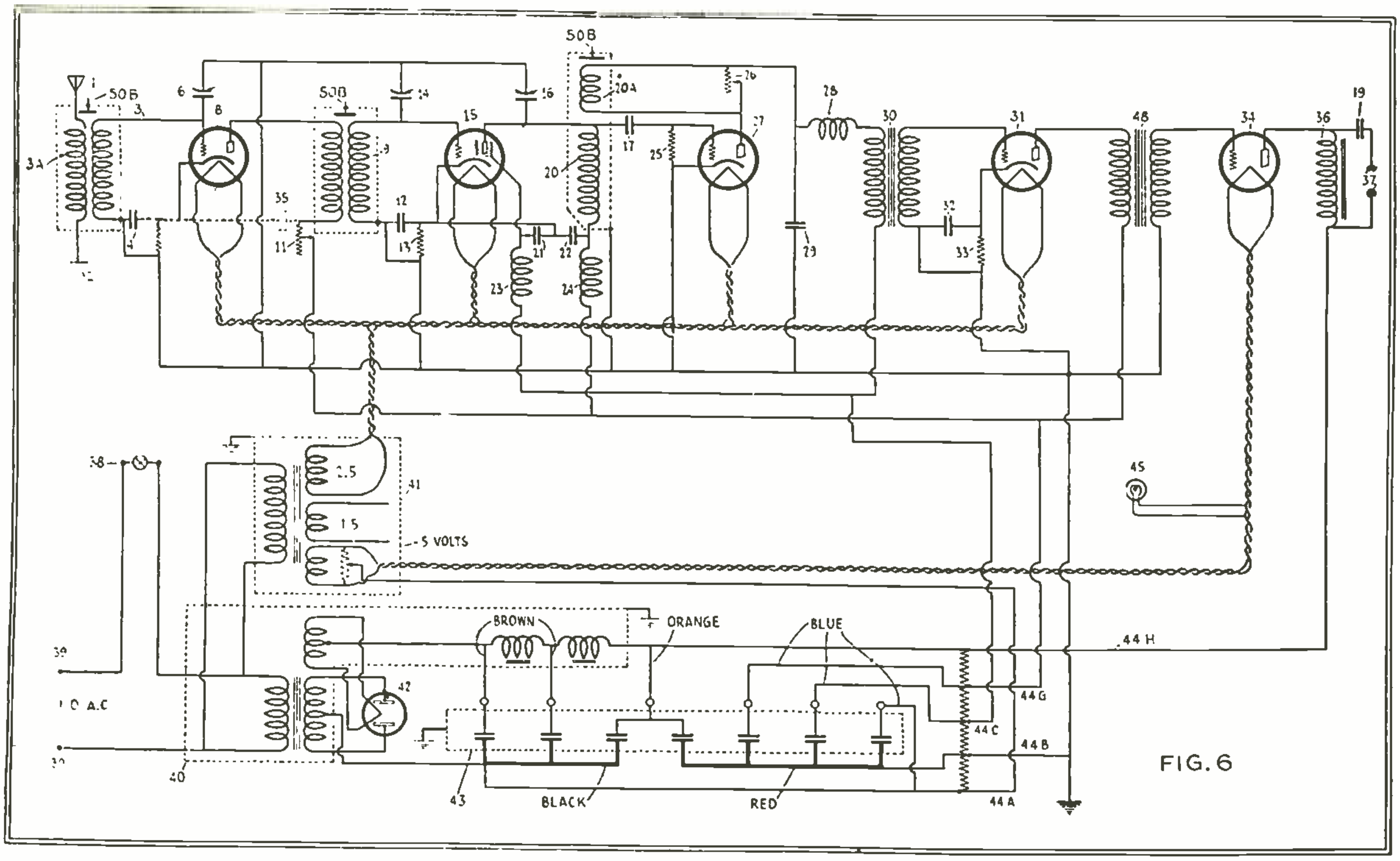
Four aluminum shield-can pillars are

The Shield Cans

With the above completed, we are ready for assembly of the aluminum cans which are to shield the R.F. stages and the regenerative detector circuit.

The construction of the shields is obvious upon checking over the photo-

holes large enough to prevent the shafts or lock nuts of the single-hole-mounting resistors from touching the aluminum cans; they are held securely in place by being locked up with an insulating washer placed on each side of the aluminum plate. It would be wise to prevent



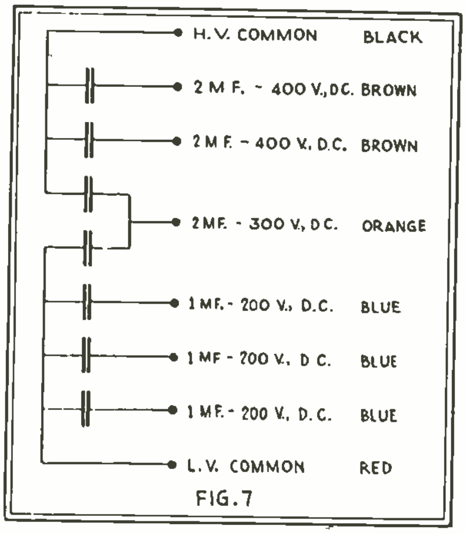
Schematic circuit of the A.C. Screen-Grid Peridyne Receiver. It will be noted that all circuits are fully by-passed by fixed condensers. Where it was considered desirable to supply additional by-pass effect, choke coils have been placed. Due to the terrific gain (amplification) of this set, it was necessary to run all leads direct to their points of connection; and shield every wire in the set, with the single exception mentioned elsewhere. The values of the fixed condensers which comprise the condenser bank are indicated in Fig. 7, below. By use of the Peridyne principle for obtaining balance of the inductances, maximum amplification at all points in the tuning band is obtained, with single dial tuning, without recourse to "trimming" devices which necessitate adjustment at certain points in the tuning range. In the grid return lead of tube 8, is a bias resistor, 7, not numbered.

required, tapped at both ends for 6-32 machine screws. This channeled aluminum is obtainable from the larger hardware stores handling aluminum in any considerable quantity.

Before starting to mount the shield cans, or any of the other items, it will be desirable to make the mounting which will raise the sub-panel one inch from the table.

The six-foot length of angle brass is marked out according to the detail sketch, Fig. 13. The four two-inch sections scribed out are removed to permit bending to form the four corners. This is clearly shown in the photograph, Fig. 4. (The particular brass angle used was one-inch across each of the two faces; it is suggested that a brass angle one inch on one side and one-half-inch on the other, the one-half-inch face forming the "bed" upon which the aluminum sub-panel may rest, could be used with greater ease in working.) The brass angle is bent to fit flush with the edge of the shaped aluminum sub-panel, as the photographs show; the two being held together with machine screws placed around the form about every three inches apart. Where the two edges of the brass angle join (A), a "V" is cut; through this, at the *rear* of the sub-panel, the A.C. line is run. (Fig. 3.)

graphs; dimensions are given in the detail drawings. When mounting the variable resistors *it must be remembered*



The "color code" of the condenser block used, and the capacities of the fixed condensers, together with their voltage ratings are shown herewith.

that both sides of these instruments are at points of high potential and it therefore becomes necessary to insulate them. This is done by drilling the mounting

the resistors from sliding to one side, and causing the metal sleeve to touch the aluminum plate, by fitting a small tubular bakelite or hard-rubber washer to slide over the sleeve and fill the space between it and the edge of the hole in the aluminum plate.

The most difficult part about making the shields is the bending of the aluminum partitions. This was most easily accomplished by clamping the aluminum between two iron bars, in a vise, and hammering the aluminum until it assumes a right angle; only the ¼-inch strip being held by the vise and the remainder being manipulated to position. It will probably be most convenient to mark and drill the supporting screw holes in the partitions before the edge is turned over. These holes are to be tapped for a 6-32 screw. After this preparation, the partitions may be slipped into place and the screw-hole positions scribed on the aluminum side plates; and these in turn are drilled to slip the 6-32 machine screws. (Fig. 11.)

"Peridyne" Compensators

The PERIDYNE compensating plates are now constructed. These consist of discs of sheet copper, 1/16-inch thick and 2¼ inches in diameter (50 B in Fig. 2). The flat head of a 3-inch, 6-32 machine screw is soldered to the center of each disc. The dimensions of the *coil compartment* are scribed in the proper corresponding positions on the three can tops. The exact center of the space marked on each top is drilled and tapped for the 6-32 screw. An additional friction piece of ¼-inch brass rod is provided as shown in Fig. 9 (this is 50 A in Fig. 2). The top plates when thus completed are held for the final assembly. Plug-in coils were selected for use in this set, because of their convenience in properly balancing the circuits as to inductance. This process is greatly simplified by removing the coil from a mounting, rather than going to the trouble of disconnecting all leads from the coil for removal from the shield compartment, in order to increase or decrease its inductance by the removal or addition of one or two turns of wire from the coil. This feature will be appreciated most by the experienced custom-set builder.

Assembly of Parts

The sides and end pieces of each can are now removed, leaving the dimensions of their respective compartments marked on the sub-panel, and the sockets of the plug-in coils are mounted in the coil compartments. These should be placed on pillars 1½ inches high, in order to bring the center of each secondary winding near the center of each compartment. The sockets for the tubes are now placed in their compartments. The R.F. choke in the screen-grid circuit of the screen-grid tube should be placed in the compartment with this tube. The tuning condensers (6) (14), (16) are now carefully and accurately mounted in their compartments.

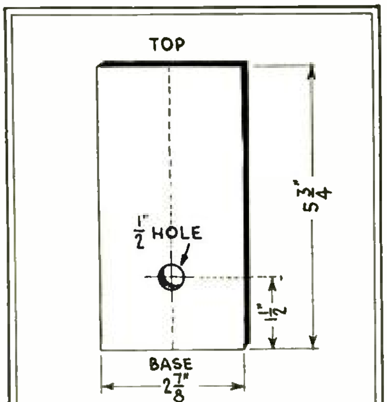


FIG. 12

Two of the three shield cans require front plates which are drilled for resistors. This construction is indicated in the above figure. It may be more convenient to mount the insulating bushings, if the hole is made a little larger than shown.

The drum dial (46) is now placed between the second and third cans, as shown in Figs. 1 and 2, and fastened into position. Just back of this is fastened the filament transformer for the '27, '24 and '71 tubes.

The remaining space behind the shield cans is used for the audio transformers and output choke. No difficulty should be experienced in placing these parts, in addition to the two audio sockets and the detector-plate choke, in the space provided.

The space remaining in the sub-panel is used for the power supply. The power compact is mounted near the front edge of the chassis, leaving sufficient room between the compact and the edge for the mounting of the semivariable voltage divider (44). Near the rear edge and side of the chassis, the condenser block (43) is mounted. This leaves sufficient space for the rectifier tube (42) and socket, as shown in Figs. 1 and 5. All by-pass and output condensers are fastened to the bottom of the chassis (Fig. 4).

The power supply of the receiver makes use of a full-wave (type '80) rectifier, and delivers sufficient current at proper voltages for the receiver, with ample reserve power.

The control (11) of the first R.F. tube is mounted on the end piece of the second can; care should be taken that the resistor does not interfere with the rotation of the tuning condenser. The regeneration control (26), is placed on the end piece of the third can, in the corresponding position. Both units must be insulated as mentioned in the second paragraph under "The Shield Cans."

Coil Construction

Winding forms of the five-prong type (1½ inches in diameter) are used for the coils. Three coils are needed, the first R.F. (antenna), the second R.F., and the third R.F. (regenerative) coil. The secondary of each coil consists of 98½ turns of No. 30 enameled wire wound in the thread cut into the form by the manufacturer; this number will be reduced in the operation of compensating the coils. The antenna-coupler primary (3A) consists of 15 turns of No 26 enameled wire wound on a cardboard or bakelite tube, 1¼ inches in diameter, placed inside of the secondary form (3, Fig. 1). The second R.F. primary coil consists of 40 turns of No. 36 D.S.C. wire, wound in the slot (provided on the base of the coil form), which is 1/16-inch wide and ⅛-inch deep. The third R.F. coil has no primary, as the coupling from the screen grid tube to the detector is of the tuned-impedance type. There is an additional winding (20 A) on this coil, however; this is the tickler or feedback coil and consists of 25 turns of No. 32 D.S.C. wire wound on a tube, like that used for the antenna-coupler primary. To cause proper regeneration it may be necessary to reverse the connections of this winding. The coils used were commercial units rewound as specified above; unwound forms (Type 130T) are obtainable, however

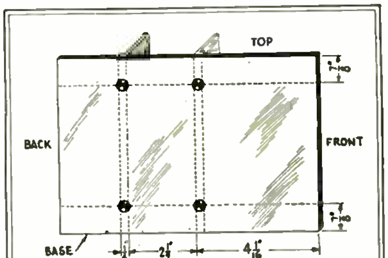


FIG. 11

The way in which the partitions are fastened in place is clearly shown in this figure. Different constructors prefer to follow their own procedure in laying out work of this nature and no effort therefore will be made to put down any hard and fast rules for making these shield cans, as the dimensions should furnish sufficient working basis.

Wiring

While care is required in the wiring, it is not difficult. Shielded wire is used throughout in an attempt to shield all circuits as perfectly as possible. The authors feel that this is directly responsible for the tremendous amplification which is obtained without the circuit oscillation usually resulting.

All wiring should be made as direct as possible, grounding the braided metal-

(*Continued on page* 135)

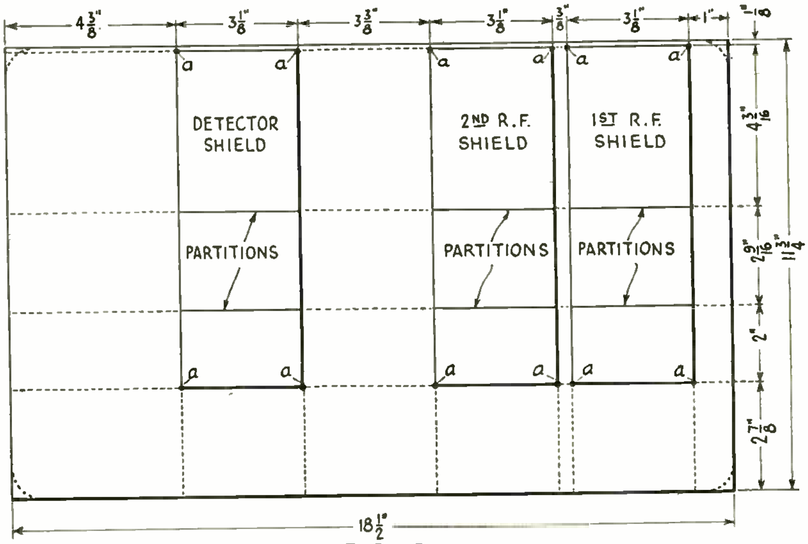


FIG. 10

Placement of the shield can mounting pillar screws is shown in this illustration. Also, the position of the brass angle and therefore the eventual shape of the aluminum sub-panel are indicated.

The Problems of Television

Everyone who wishes to know what is going on, in the world about them, should read this interesting and highly instructive article by the chairman of the Television Committee of the Radio Manufacturers Association, on the subject of television

By D. E. REPLOGLE*

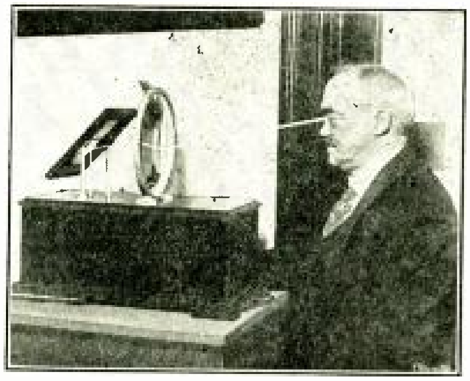
THE radio audience is radio blind. Irrespective of the marvels of radio broadcasting, and without detracting in the slightest degree from the praise due broadcasters for their magnificent service to society in bringing a world of music, entertainment and enlightenment into every home equipped with a radio receiver, the fact remains that the radio audience is blind and must continue to be blind until broadcasting technique includes television to complete the presentation. Today we have only listeners-in for our radio audience; tomorrow, we shall have lookers-in, as well. Television will supply the *visual*, as a supplement to the *aural*, effects in completing the service of broadcasting.

Television Technique

However, as engineers we cannot permit our enthusiasm to run away with our better judgment. Most of us know in a general way the many and the serious problems that stand in the way of television development. In fact, we have received the greatest challenge yet issued to our branch of engineering; for television, we note, calls for doing a lot of things in a fraction of a second; it calls for minute attention to detail; it requires the analysis of images in terms of dots and light values, and the transmission of such an analysis, followed by the reconstruction of the dot elements into a replica of the original image. Electricity, mechanics, gaseous conduction, distortionless amplification, new forms of modulation and demodulation, chemistry, optics and even a new stage technique are among the problems confronting us.

It has been held by some students of television that the greatest problems to be solved are in the direction of presentation. Such views, however, appear unfounded. The same was said of talking motion pictures, yet even at this early date many excellent talking picture plays have been produced. With the entire world to draw upon for visual as well as aural material, there should be no dearth of subjects, although, it is true, much ingenuity will be required to present the world through the tiny window of the television screen. As television develops, the presentation will become increasingly popular, but at first there will be serious but not insurmountable problems by way of staging playlets within the limitations of the close-up picture, which is as much as television can handle for some time to come.

As I see the matter, television presentation may be based on the subject matter of the usual cinematograph screen, except that it has the added advantage of instantaneous reproduction. In other words, the television presentation shows the subject as it is at that particular moment. There is no elapsed time, as with the motion picture. And so the television screen will no doubt be largely devoted to portraits of speakers and artists before the broadcast microphone, with the aural accompaniment entirely optional. Later, there will be playlets, to take the place of the present shadowgraphs which show such simple things as playing ball, dancing, skipping rope, and so on. Today we are not so much concerned with the theme of our television pictures, as we are with the propagation and reception of the images, irrespective of their interest, *per se*.



Mr. Jenkins and a modern version of a television receiver. "The Father of Television," we call him. In England, however, they prefer to think of Mr. Baird as such.

I believe we should, as engineers, be vitally interested in television presentation. For instance, there are already certain television actors, whom, we are told, have the necessary "television faces" and television acting requisites. These considerations are highly important in the early stages of television. Just as early motion pictures, with their frugal amount of detail, called for persons with prominent features, plenty of make-up, and a high degree of expression in their hands and arms, so must we count on these requisites while television is scanty in detail. Later, with more refined image reproduction, we shall come down to the beautiful technique of screen acting with the slight arching of an eyebrow conveying the same thought which the waving of an arm would now convey.

So among our first problems are those of acting and stage setting for our television pictures. We must have the cooperation of those skilled in the histrionic art and stage setting art, if we are to have suitable material to handle with our television systems. Already the General Electric Company has done some excellent work by way of developing a suitable television stage technique, even with a multiplicity of television pick-ups for quick changes of scene, special settings, actors made up for television requirements, and so on.

Channel Selection

The logical problem that follows the production of the television subject is that of detail. In fact, the problem of detail will be a difficult one to solve, since it involves questions of dot elements, time limitations, luminous intensity, accurate synchronizing, and wave band available.

Because of the wide frequency band required for satisfactory television modulation, we are compelled to employ high frequencies or short waves. The broadcast spectrum, which covers from 200 to 550 meters in the United States, and up to several thousand meters in other countries, cannot provide a place for a television channel at least 100 kilocycles in width, which is necessary for satisfactory detail. In the United States the broadcast channels are placed every ten kilocycles apart, which is deemed the narrowest possible channel consistent with good broadcasting results.

With the necessity of employing short waves or high frequencies, then, a number of considerations are immediately introduced into the problem. Short waves, unlike the higher wave lengths, are by no means universal in application. Thus, a single wave length cannot be employed in the short-wave spectrum for a universal television service. An analysis of satisfactory television service discloses the necessity of utilizing three simultaneous short-wave channels, as follows:

1. A channel for urban or city service, under conditions of marked absorption of radio waves. A satisfactory frequency will have to be found by actual experiment, so as to provide television service to those residing in congested metropolitan areas.

2. A channel for suburban or rural audiences, located outside and at varying distances from the metropolitan areas. Since the particular wave length employed for urban or city service may not have the desired carrying power, both this frequency and that for the metropolitan service will have to be determined through long and careful experimentation.

3. A channel for distant service and rebroadcasting purposes, with the skip-distance phenomenon of certain short-wave frequencies utilized to the best possible advantage. It will be this channel which will provide an exchange of television services between nations, and will span the oceans with pictorial and living presentations of important events.

Those who legislate the division of the crowded radio sky or ether may well question the necessity for wide television bands, especially since our present-day broadcasting is handled on relatively narrow channels. Yet the width of the channel determines the dimension of the television image and the amount of pictorial detail. With a radio channel 10

* *Engineering Staff, Raytheon Manufacturing Company.*

kilocycles wide, such as we employ in American broadcasting practice, the television image will be limited to one capable only of handling close-ups of heads or other comparable figures, with crude detail. Such, obviously, is not the ultimate ideal in television.

The Fundamentals

Let us stop for the moment to analyze just what the basic television technique comprises, as we know it today:

At the transmitting end, we really analyze or scan our image by lines. The greater the number of lines into which we break up our image, the greater the detail, as is the case with the dots of the half-tone screen used in making photo-engravings. We obtain our line analysis by utilizing what is known as the scanning disk, comprising a revolving disk with a suitable arrangement of holes. The holes are so spaced from the center of the disk and from each other on the spiral curve as to provide practically straight lines for just that portion of their swing through the field of vision.

An early American television unit incorporating scanning disk, neon lamp, television frequency amplifier and power supply.

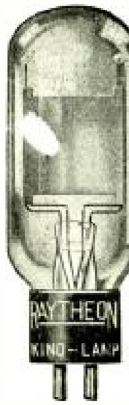
The scanning disk can either throw a beam line by line on the subject, with photo-electric cells picking up the reflected light and translating the varying light intensities into electrical variations; or again, the scanning disk can analyze the focused image line by line and pass the varying light intensities back to a photo-electric cell contained in a camera or light-proof box. The first system is the most commonly employed. The subject, in this case, must be in a studio or indoors, where the light can be controlled. However, it is surprising how powerful the lighting may be, without interfering with the scanning beam action. The second system permits of scanning subjects outdoors, in bright sunlight, since the photo-electric cell, and not the subject, is being subjected to the scanning beam.

At the receiving end, we have just the reverse operation. The signals are amplified and fed to a kino-lamp or neon glow tube, which varies in luminosity according to the modulation of incoming waves. The varying luminosity must now be translated into lines corresponding to those used in analyzing the subject at the transmitting end. A scanning disk, revolving in step with the scanning disk at the transmitting end, is employed. The holes serve to break up the glowing kino-lamp plate into a series of lines of varying intensity; there is only a single point of light on the television receiving

One make of light-sensitive cell. It is used at the transmitting end of the circuit.

screen, and this dot may be bright, medium or dull depending on the radio modulation at that given instant. However, in the short space of less than a fifteenth of a second, the lines for the entire image have been formed by the sweeping dots. The persistence of vision, which causes the eye to retain an image for approximately one-fifteenth of a second, causes all the dots projected for that interval to appear as a complete pattern. By overlapping the lines slightly, the pattern appears fairly solid. In this way, therefore, we convert the moving dot into an apparent line, and the many lines into an apparent solid pattern. Thus we have a continuous illusion, with fresh dots and lines constantly forming to replace those fading out of sight, giving us the living image effect.

Our television image is therefore a pattern of successive lines, so closely packed together that the usual screen fails to suggest successive lines. In some respects it is much the same as the usual half-tone engraving used in printing, made up of dots of varying size. We obtain black when the dots are so large that they meet; gray when the dots are medium sized with a little space between; and white when the dots are very small and surrounded with a preponderance of space. Actually, the varying



A form of conductive-gas lamp. It is similar to the neon-filled lamps, in operation. The square surface becomes intermittently luminous so rapidly the eye cannot possibly follow the fluctuations. It is this "optic fatigue" which makes television possible.

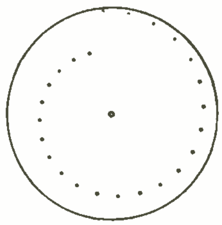
shades of gray are simply an optical illusion, since we are working only with black ink and white paper. Television, likewise, is an illusion. We have dots woven into lines, and lines into a complete image. It is simply a question of how many lines we are using, how much contrast we have between full intensity and minimum intensity, how accurately the lines meet or overlap, and how well we can maintain the synchronism of transmitter and receiver scanning disk.

Now a newspaper half-tone is usually a 65-line engraving, which means 65 horizontal rows and 65 vertical rows to the square inch, or a total of 4,225 dots. Everyone is familiar with the modest amount of detail permissible with such engravings; it leaves much to be desired.

In television practice, however, in order to present an even more crude image, say of 50-line texture, or the equivalent of 2500 dot elements to the square inch, we must transmit these lines in one-sixteenth of a second, or at the rate of 40,000 dot elements per second!

Size Limitations

Our experiments so far lead us to believe that with single side-band transmission, it is necessary that the frequency in kilocycles be one-half times the



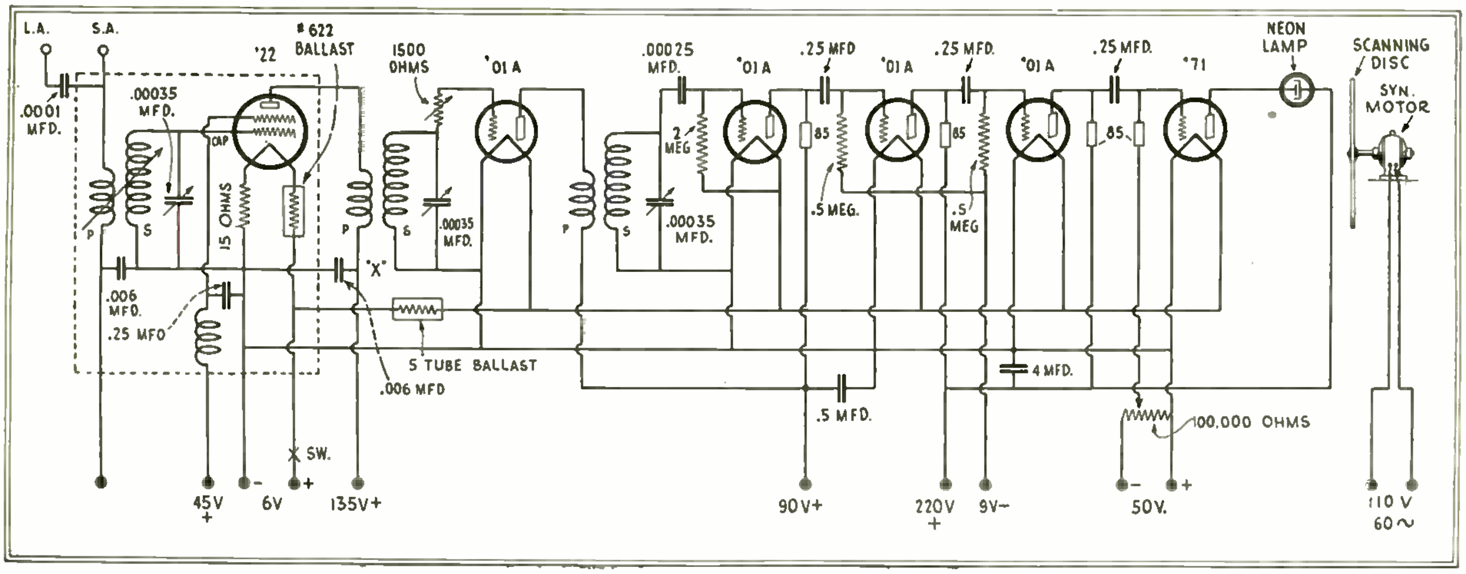
The "scanning disk". It is to television what the "half-tone screen" is to the printer. The distance between two dots (holes) is the width, while the span between the start and finish of the spiral is the height of the picture.

number of dot elements. For a 50-line image, a 20-kilocycle band is required for satisfactory results, and for a 100-line image, an 80-kilocycle band is necessary.

If we refer back to our newspaper half-tone, we will note that an image 3 by 5 is about the minimum for viewing persons and events and entertainment. It would be, in fact, a very small window through which to look out upon the world. Yet such dimensions, with, say, a 50-line texture, would call for an image 150 lines high, and 250 lines wide, or the equivalent of 37,500 dot elements to be transmitted in one-sixteenth of a second!

We have accepted the 100-line image as about the maximum for present-day technique. It permits of presenting two or three persons, full length, with some background, and again with two or three lines of type for caption, if desired, together with sufficient detail considering the nature of the picture.

Even with a 100-kilocycle band, we cannot expect to enjoy anything like the crisp, crystal detail of the motion picture screen. We cannot hope to see the individual bricks in a brick wall. We cannot expect to see individual soldiers in a parade. To provide such detail, an exceptional requisite becomes apparent;



An amplifier designed particularly for television work. Such an amplifier should be capable of amplifying over an unusually wide frequency range extending beyond audio limits, *per se*. The chokes No. 85 have a D.C. resistance of about 100,000 ohms. (One type is the "resisto-choke.") A battery supply with low internal resistance is absolutely essential (to prevent "motor-boating").

a frequency-band thousands of kilocycles wide would be needed.

Unfortunately, there are various systems now being exploited, with 24-line images. While these may be capable of presenting close-ups of faces, with a crudeness of detail and pronounced shades suggestive of an animated poster rather than a living image, they are quite unsuited for the more serious purposes of ultimate television service. Such systems may even be crowded into a wave band 4 or 5 kilocycles wide, so as to be handled in the usual broadcast spectrum, yet the results are only in the nature of a crude experiment. Surely the radio audience will not be satisfied for long to gaze upon decapitated persons, with no promise of something different and better.

Aside from the matter of screen dimensions, a wide radio channel is essential for proper detail. High and low frequencies are imperative. Thus if we cut off the low frequencies, we introduce spurious shadows and also change the tone of the picture. If we cut off the high frequencies, we delete the sharp lines and lose details such as eyebrows

It would require 2,236 dot elements (per one-sixteenth of a second) to reproduce this photograph in the same size by television. Eye fatigue would cause the individual dots to blend harmoniously.

in the case of a close-up portrait. Cutting off the high frequencies also limits us to slow motion, since fast motion is badly blurred. For a comparable pictorial quality, it requires a band at least

The "20-line screen" used to photographically produce the former effect. has here been replaced with an 80-line screen. This view of Jean Arthur, Paramount star, indicates the "detail" which a greater number of dots makes possible.

twenty times the width of that for the finest broadcasting of good music.

Our greatest problem in television development is going to be one of finding the necessary space in the radio sky. With our present technique, we must have a wide channel.

The Scanning Beam

Another problem is that of greater luminosity. It is surprising what we are able to accomplish with the present neon tubes, which have such a low candle-power. Here there appears a genuine opportunity by way of developing new forms of lamps which will be as responsive as neon, yet will give greater light. Again, there is an opportunity by way of developing more efficient methods of utilizing the light that is available. In this connection the four-target or four-plate neon lamp of C. Francis Jenkins, pioneer television experimenter of Washington, D. C., is a step in the right direction, particularly in conjunction with his light-conducting rods. Jenkins has also developed a lens scanning disk, which permits of utilizing the light source to better advantage, particularly in projecting pictures on a screen for a small audience. Alexanderson has also made use of a scanning disk with lenses, instead of the usual plain scanning disk.

For the lens scanning disk, it has become necessary to develop a spot neon light of high luminous intensity and along these lines very considerable progress has been made.

It is now possible to obtain a spot lamp which with a current of about 55 m.a. is so brilliant one suffers pain when looking directly at the light. Other developments are under way in several other experimental laboratories and the greatest progress is being made in those laboratories in which the problems of gaseous conduction have been dealt with most.

The writer has recently had an opportunity to see an extremely brilliant spot source. Even more brilliant than anything hitherto developed. Experimentation is being made on this spot source now to determine its response to high frequencies and the most even way of obtaining the brilliancy.

Another method of obtaining brilliant illumination that can be controlled on television signals, is by means of the Kerr Cell which has been used by Professor Karolus in Germany. The Kerr Cell is merely a means of rotating the axis of polarized light by means of impressing an electrostatic or electro-magnetic field. It then acts as a shutter between a very strong arc lamp and the scanning mechanism.

Another development about which very little is known, is the work of Mr. Farnsworth on the Pacific Coast, in which he has made use of the electron stream in a cathode ray tube, to give quite brilliant illumination.

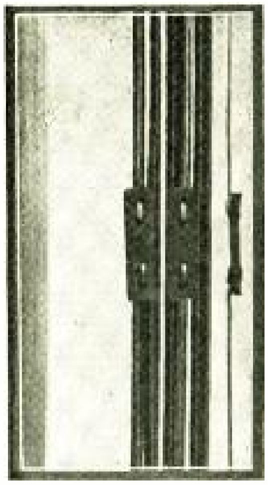
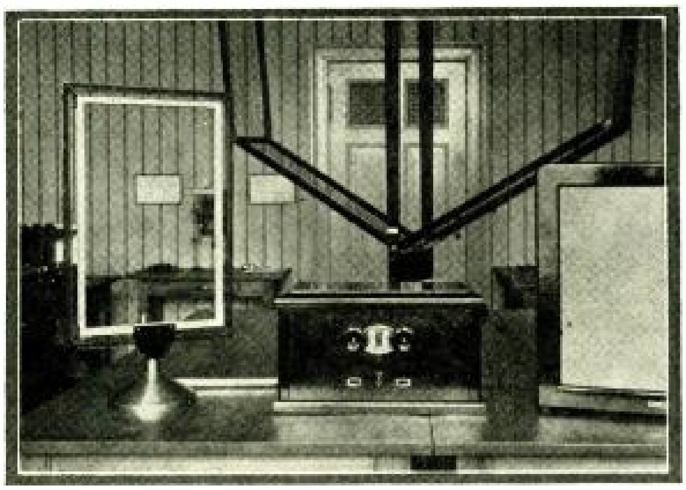
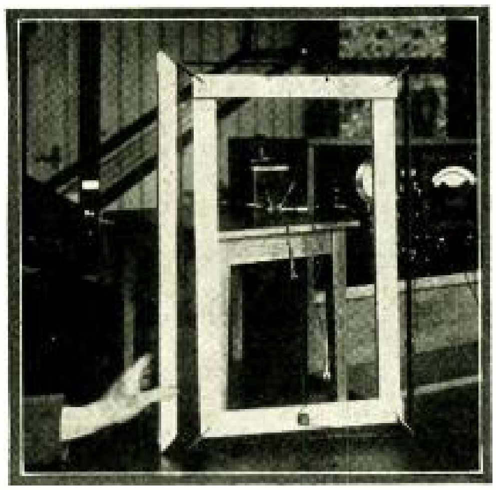
In view of the above experimental work it is believed that the problem of illumination, while yet very difficult, is well on its way to solution and its solution will greatly simplify the matter of reproducing the television image.

(*Concluded on Page* 137)

The Screened Loop Antenna

Many experimenters have worked on the problem of selective reception with a loop aerial but it remained for Baron von Ardenne to adapt to loop aerials the most perfect screen design known to the laboratory, as detailed below.

By BARON MANFRED VON ARDENNE*

At the extreme left is shown the method of anchoring the screening wires to prevent the "shorted turn" effect. The center photo shows the completed loop, shielded receiver, and condenser-type reproducer (Loewe). A delicate laboratory set-up, at right, checks effect of a piece of metal placed in the field of the loop inductance.

A ROTARY loop antenna with good directional action is one of the surest and simplest means of shutting out disturbances due to an especially powerful transmitter located in the vicinity; and such an arrangement affords in many cases the exclusion or lessening of local or distant interference known as static, if the disturbance is directional.

Antenna Effect of the Loop

A presupposition for the complete exclusion of a near-by sender (and especially for the lessening of interference disturbances) by means of a rotable loop antenna is the presence of *a good minimum.* In practice a sharp minimum is seldom attained. Even if the interfering waves come from only one direction, as a rule a sharp interference minimum cannot be attained because the loop acts at the same time as an open antenna.

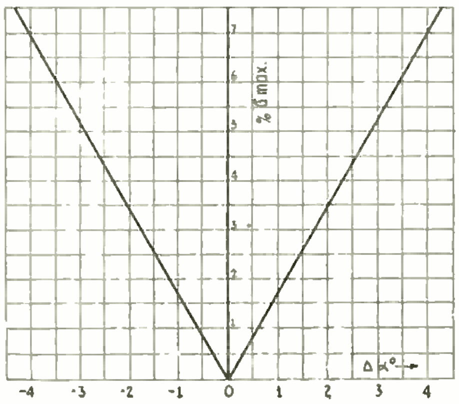
According to the connection of the loop, the *antenna effect* is produced by a capacitative or inductive action at the input side of the receiver. By using special loop connections and receiver connections it is possible to keep the loop from acting simultaneously as an open antenna. Such connections, however, generally complicate the set and occasion considerable changes in existing receivers.

The Screened Loop

Accordingly the use of a screen with the loop antenna appeared very likely to fulfill the presuppositions for a good directional effect. By means of a suitable screen it is possible to eliminate the electric field almost entirely without much influencing the magnetic field. Such a screening of the loop can be accomplished by surrounding the entire loop winding with metal, with a break only at one point. The break at one point is very important, because only this prevents the simultaneous shutting out of the magnetic field. By means of the described screen, which moreover has been used for a number of years on shipboard in taking bearings, the antenna effect is almost wholly removed, if care is taken that the wires leading to the loop take up no kind of energy from space.

Screening Losses

Unfortunately it was shown in the first measurements that the loss, by resistance in the loop, was considerably increased by the use of the screen. To observe the influence of the screen more clearly, the loop was wound with a good high frequency ("Litz") wire. Though the screen



Loop current (in per cent. of the maximum current) obtained by twisting from the position of minimum sound.

was broken at one point and therefore short circuits could not be formed in the screen winding, the loss by resistance of the loop rose about fivefold. The distance of the screen from the loop winding was about 1 to 1½ cm. (about .4 to .6 of an inch). Such an increased loss by resistance through the screen occasions a corresponding increase in damping and causes such a loop to afford only 1/5 to 1/6 of the voltage of a circuit with an unscreened antenna of the same dimensions. The loss occasioned by the screen, which in modern receiving connections cannot be made up without amplification, is so considerable that it appeared practical to seek out special forms of screen in which such great losses do not occur.

Reducing Screen Losses

A certain improvement was noticeable when the screen was arranged at a greater distance from the winding and was made of material with very high conductivity. The exterior of antennas with this sort of screening (which besides are not very simple to construct) appears so ugly that this mode of solution did not seem advantageous. To establish whether the use of special subdivisions could cause improvements, a test was made of the influence of various forms of conductor on the damping.

The arrangement so used is shown in square above. Behind the test loop may be seen a variable condenser and a tube voltmeter. From the deflection of the voltmeter, showing the voltage taken up by a measuring device, corresponding conclusions may be drawn. It appeared that any particles of metal at all which were brought near the winding caused an increase in damping. In the photograph directly above is shown a metal strip brought near the winding.

An increase in damping (even though very slight) could be demonstrated by bringing wooden strips near. A little experiment showed that the weakening of the antenna effect depends on the fact the screen-to-ground ohmic resistance value is less than the loop-to-ground resistance value. Attempts to undertake take screening with a not very good conductor therefore did not appear entirely hopeless. These experiments were carried

(*Continued on page* 139)

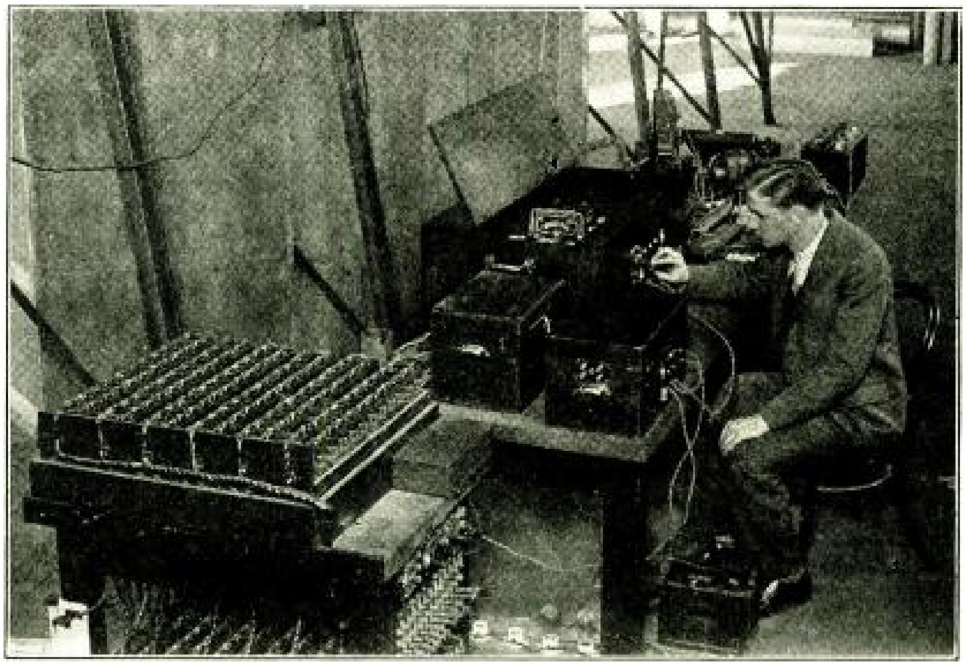
* *Director, Manfred von Ardenne Experimental Laboratory, Berlin.*

A Bureau of Standards Audio Amplifier

The details of how the Bureau of Standards arranges an audio amplifier will interest everyone who considers audio quality an important factor.

By S. R. WINTERS*

Mr. A. M. Kuethe, Aerodynamics Section, Bureau of Standards, is operating the audio unit described by Mr. Winters. There is little to be seen but batteries. Encased and otherwise. The two greatest difficulties encountered in this type of amplifier are "drift" and "overloading". How these difficulties were overcome is a story which will interest many.



This photo shows the unusual number of storage cells required to operate the battery-coupled amplifier in the most efficient manner. By manipulation of the switches, the cells may be connected to deliver the correct voltages to the amplifier, or for charging.

NOVEL experiments involve the use of unusual equipment—and the direct-current, resistance-coupled audio amplifier employed in recent tests by the Aerodynamics Section of the Bureau of Standards is on the borderland of freakish apparatus.

The Battery-Coupled Amplifier

The broadcast listener who prefers a resistance-coupled amplifier to a transformer-coupled in deference to tonal quality and the experimenter in television who uses a resistance-coupled amplifier because of its straight-line amplification will marvel at the oddness of the amplifier employed in measuring the transit speed and variations of air current averaging 40 miles per hour in a wind tunnel. Instead of using fixed coupling condensers, this unusual amplifier resorts to the use of "C" batteries. And while the latter function electrically as such, they are not "C" batteries in accordance with the common definition. but, physically, 180-volt "B" batteries.

The range of frequencies to which this amplifier is responsive, as designed, is from one cycle to two hundred cycles per second. The experimenter will be interested to know that the acoustically flat line response of this amplifier extends considerably beyond 200 cycles, going well into the highest audible portion of the frequency spectrum, but the fidelity curve drawn by the Bureau of Standards, for their specific purpose, was not intended to determine the response characteristics beyond 200 cycles.

This *direct-current, resistance-battery coupled* amplifying unit includes a special circuit which compensates for the lag of the heated wire used in measuring the air speed. This compensating circuit accounts for any lag of the wire over a certain band of frequencies—say, from one to one hundred cycles. In operation, this compensating circuit involves the passing of the plate current of the last stage of the amplifier through a fixed resistance and the voltage drop across the latter is balanced by a potentiometer. This balancing circuit includes a D.C. milliammeter—as an indicating instrument for the potentiometer—as well as an A.C. milliammeter for determining the alternating current produced by the fluctuations.

For the practical purpose of the experiments, the aerodynamic engineers are interested in maximum variations of resistance which do not ordinarily exceed plus or minus 0.25 of an ohm. Result: By employing a 120-volt storage battery line, with 596 ohms in series with the 4-ohm wire (heating current, .2 ampere), the maximum change in the heating current during the fluctuation was one part in 2,400. A voltage fluctuation equal to 0.048, the value of the current, was impressed on the amplifier.

The current is measured precisely. This is accomplished by the insertion of a 6.5-ohm manganin resistance unit in series with the wire, and the potential drop in current across this resistance is determined by an improvised potentiometer. This makeshift indicating instrument consists of a 2-volt storage cell, a 10,000-ohm dial box, a standard 1,000-ohm resistance unit, a portable galvanometer, and a standard cell. The mean voltage drop across the wire is measured by a similar potentiometer, with this exception: A 4-volt storage cell, a 1,000-ohm dial box, and a milliammeter (range zero to 1.5 milliamperes) are employed.

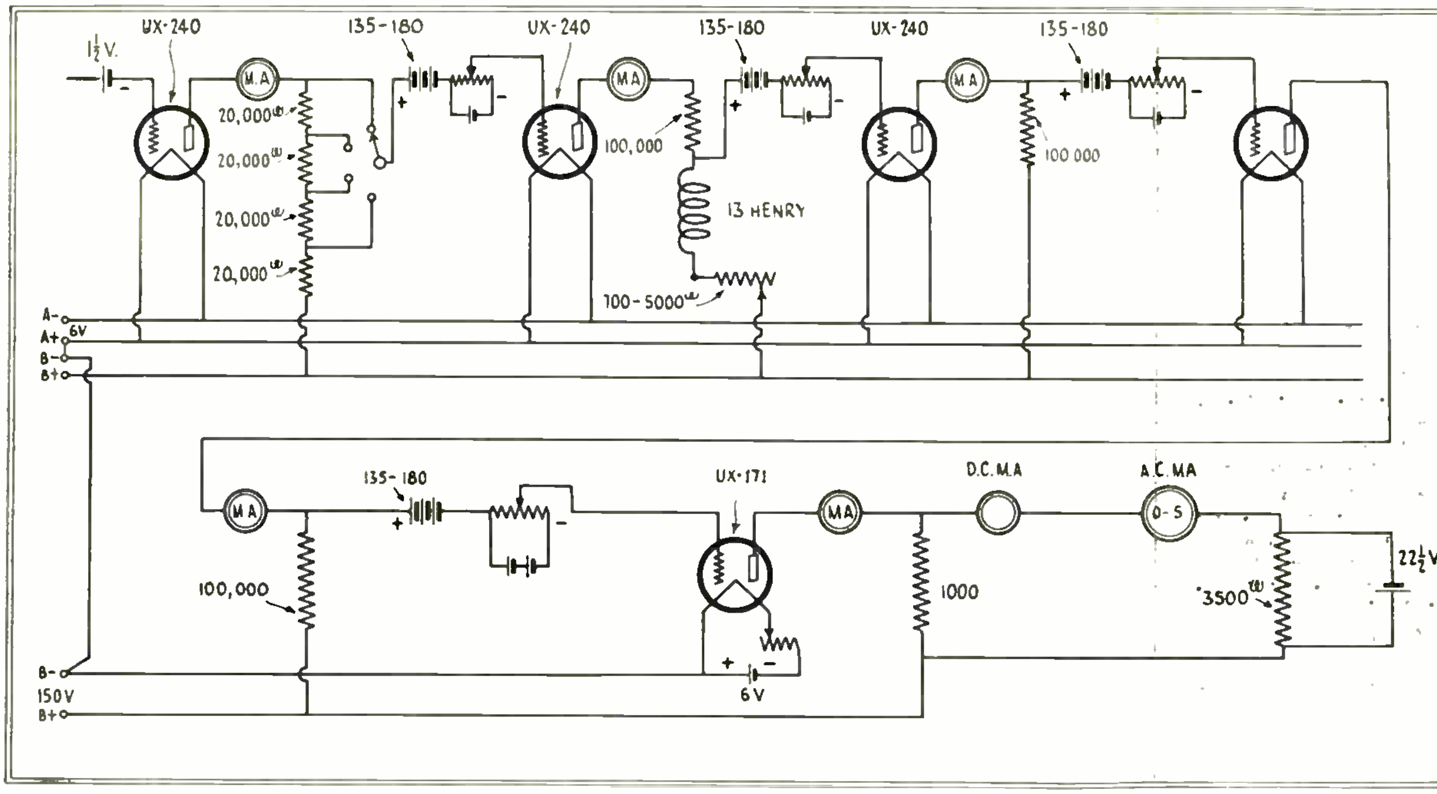
The audio amplifying circuit, as previously indicated, is designed for direct-current amplification. *The amplifier is minus condensers and transformers—and, therefore, minus frequency selective amplification.* Large "C" or "B" batteries—of the order of 180 volts—are placed in series with a potentiometer for fine control of the bias voltage. These "C" bias batteries displace the conventional fixed coupling condensers employed in the ordinary resistance-coupled radio receivers. The application of the audio amplifying circuit—as designed by R. W. King—to a practical working direct-current, resistance-coupled amplifier was not effected without having encountered obstacles. The latter are outlined by H. L. Dryden and A. M. Kuethe, the devisors of this practical circuit.

Engineering Difficulties

"The first difficulty encountered was that due to rapid drifting of the current in the last stage, caused partly by leakage currents from the "C" batteries, which are at high potential, and partly by small changes in voltage of the various batteries. The measures taken to reduce the drift to a workable value of about 1 milliampere in the plate current of the power tube in 5 to 10 seconds, corresponding to a voltage change of about 0.001 of a volt in 5 to 10 seconds at the first grid, were as follows:

"(a). To insulate all "C" batteries by means of paraffin blocks; (b) to use a somewhat smaller plate voltage on the tubes than recommended for ordinary radio use; (c) to use storage cells for "B" batteries; (d) to use 50,000-ohm coupling resistances. In spite of these precautions, it occasionally happens on days of high humidity that the amplifier

*Washington, D. C., correspondent of RADIO-CRAFT.



Schematic circuit of a "battery-coupled amplifier". This form of amplifier will amplify signals at audio or radio frequency. Also, it will do what no other form of tube amplifier can do—it will amplify direct current values. It is difficult to "handle" this type of amplifier but it is worth experimenting with. Each stage amplifies about 12 to 15 times.

is unworkable because of a large drift. Trouble from this source is greatly reduced when the amplification is reduced.

"A second serious difficulty arose in the attempt to use a common "B" battery for all stages. It will be seen that the "B" battery is common to the input circuits in this type of amplifier and forms a coupling between the stages. If the "B" battery remained of constant voltage, this coupling would cause no trouble but, unfortunately, the voltage depends on the current drain. The variation is especially large for the ordinary light-duty dry cells, which we attempted to use at first, and many peculiar effects were found. This difficulty was removed by the use of storage "B" batteries and by using a separate battery for the power tube.

"It is found that the amplification changes with time. It is necessary to run the amplifier about 15 minutes before beginning observations, and to measure the amplification frequently. To insure that the tubes are always worked on the linear portion of the characteristic curve, milliammeters are included in each stage. The characteristics of the amplifier are such that blocking does not occur *if* the limits of the power tube are not exceeded. It is necessary to check occasionally the characteristics of each tube.

"Since in various applications it was desired to measure variations from 0.005 volts to 0.1 volts or even 0.2 volts, it was desirable to be able to vary the amplification in reasonably close steps. Each stage amplifies about 12 to 15 times and to secure finer adjustment than was possible by varying the number of stages, arrangements were made in the first stage to pass on one-fourth, one-half, three-fourths, or all of the drop across the coupling resistance.

"A direct check was made of the non-selectivity of the amplifier (compensating circuit omitted) by observing the amplification of a known alternating current and comparing with the direct-current amplification. Frequencies up to 120 cycles per second were tried and no selectivity was observed."

Balancing the Output

A potentiometer is employed to balance the potential difference across the fixed resistance in the output circuit. The tap on this potentiometer is rigidly fixed to prevent current flowing in the balanced circuit when the plate current of the power tube is at the value corresponding to the mid-point of the linear part of the characteristic curve. Subsequently, balancing is effected by the "C" bias potentiometer of one of the stages of the audio amplifier. With this operating condition insured, the relation between the unbalanced current registered by the milliammeter and the voltage applied to the grid element of the first vacuum tube is linear over an appreciable range—minus or plus 10 milliamperes, to be exact. The alternating current still remaining is determined by an A.C. milliammeter, with a range of zero to 5 milliamperes. If the alternating current is not in excess of 5 milliamperes, and the mean values of the plate currents of the various stages are correct, the tubes may be assumed to be operating within the linear range of the characteristic—and without blocking.

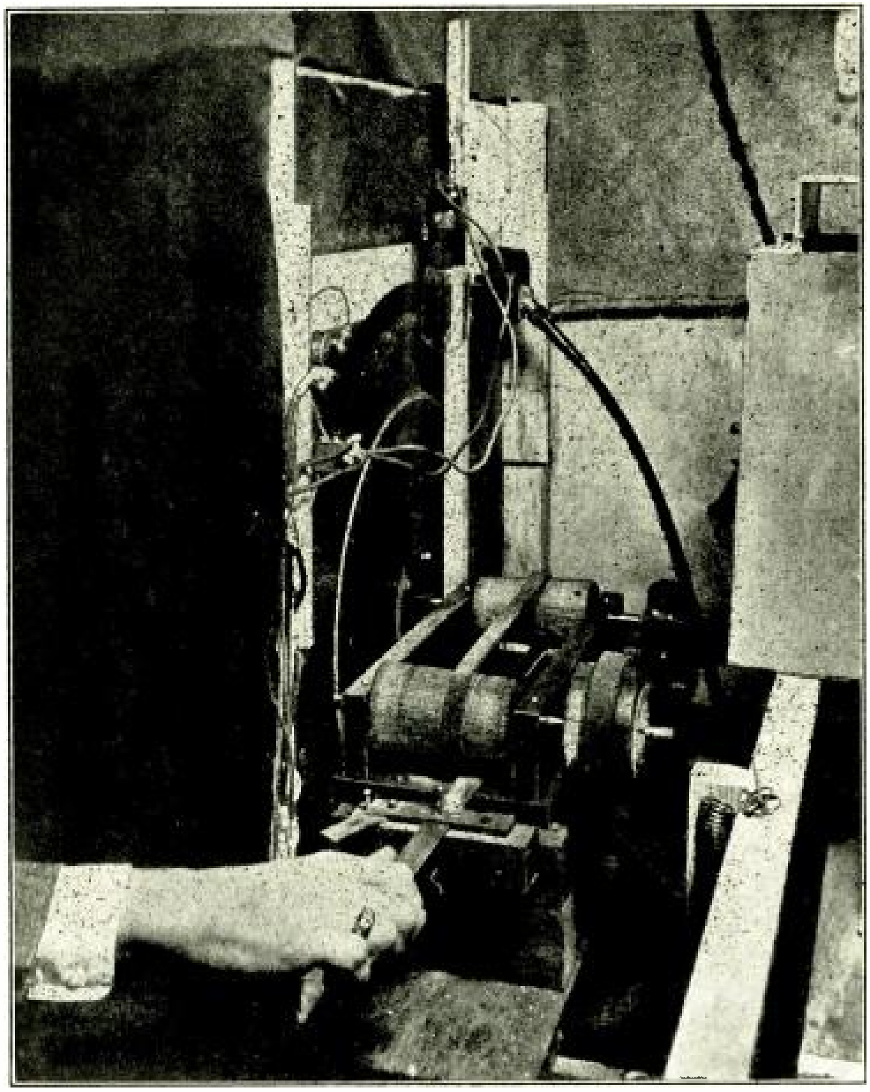
The compensating circuit is defined by the inventors in the following terms: "It has been shown that compensation can be made for the lag of the wire by passing on at some stage the voltage variation in a circuit containing inductance, L, and resistance, R, such that L/R equals the time constant, M, of the wire. We may compute the performance of circuits containing a vacuum tube by assuming that the tube impresses a voltage *ve*, *v* being the amplification factor, and *e* the grid voltage, in a circuit consisting of the external impedance and the plate resistance of the tube, Ro. The distortion term is negligible if the tube is operated in the linear range of the characteristic curve. Since the grid-filament resistance of the succeeding tube is very high and the grid current negligibly small, we need only to compute the voltage variations passed on to the next tube."

(This amplifier may be operated without the 13 henry choke shown in the schematic circuit; in its place a 100,000 ohm resistance may be used. Or a variable resistance with a range up to 500,000 ohms may be used in place of the choke, after the circuit has been almost completely balanced, final test being made with this variable resistance to determine the value that best balances the electrical effects obtained in the circuit.

The result is an amplifier of A.C. and D.C. which operates without the use of inductance or capacity as inter-tube coupling. Therefore the "high frequency pass" effect of condensers and the "low frequency pass" effect of inductance need not be taken into consideration, and frequency distortion due to these factors is eliminated.

The reader is referred to Van der Bijl's book, the "Thermionic Vacuum Tube," pages 253 to 260, and pages 213, 214 and 215 of Scott-Taggart's "Thermionic Vacuum Tubes." Both books are available in many libraries.

Although this type of amplifier is not new, it has not been given much publicity. As pointed out by the designers of this amplifier, there are a number of difficulties which the constructor will encounter; that they may be overcome is clearly shown. We are interested to hear from experimenters building this battery coupled audio amplifier described by Mr. Winters.—Ed.)



Use of the cone pulley in regulating the speed of television scanning disks is advocated by Mr. Gilbert C. Lee, of Los Angeles, California. That such a coupling is sufficiently accurate for television purposes is proved by its use in many industries requiring minute and flexible control. In the paper mills, for example, this type of regulator has been found to meet the very stringent requirements of that industry. The rollers through which paper is passed must run at slightly different speeds because of the stretching of the paper; yet all speeds must be exactly correct and must be maintained constant, since a misadjustment may mean breaking the paper.

Cone Pulleys Solve Television Synchronizing

By C. STERLING GLEASON

THE problem of synchronism in television has been very successfully solved by Gilbert C. Lee, a Los Angeles engineer and experimenter, who has devised a mechanical speed control that overcomes the principal difficulties which heretofore existed.

Mr. Lee's device embodies a steel frame in which are set two conical pulleys, *faced in opposite directions* and connected with a leather belt. A metal guide clasped about the belt can be shifted from side to side by a lever, thus guiding the belt to any desired position on the pulley. It will be seen that when the belt is toward the small end of one pulley, it will encircle the larger circumference of the other; but when it is shifted to the opposite side, the relationship is reversed. When the belt is in the middle, the diameters of the pulleys at that point are equal, providing a 1 : 1 ratio. Thus the speed ratio may be varied at will from 3 : 1 down to 1 : 3. If the driving motor turns 900 r.p.m., the scanning disk may be adjusted to any speed within the range of 300 to 2700 revolutions.

As used by Mr. Lee, the two pulleys, each five inches wide and tapering from three inches in diameter at the base to one inch at the apex, are mounted 12 inches apart (on centers) in a steel frame. The belt is of leather and is one-half inch wide. Special ball-bearing mountings were originally used, but proved too noisy, and phosphor-bronze bushings were substituted.

> THE editor is anxious to receive letters telling of your experiences in anything pertaining to radio. We want to make RADIO-CRAFT as full as possible of human interest; but we cannot do so without your help and support. Let us have your experiences, so far as they pertain to radio, for the benefit of your co-readers. We will publish all for which space can be found.
>
> Tell us why you are interested in radio—tell us why you like the game—tell us what encourages you—tell us what discourages you—and let us have a general get-together. Only by discussing these things through the columns of RADIO-CRAFT can we make this *your very own magazine.*

Practically every known type of speed control was tried before the present method was hit upon. Control through a synchronous motor regulated externally by impulses transmitted simultaneously with the picture frequencies, as employed by the Bell Telephone Laboratories in their famous test of 1927, proved unsatisfactory for transmission over long distances; for, if the synchronizing signal fades, the receiver is thrown out of gear and must be regulated all over again. Friction drives were discarded as too unstable and tricky; gears, as too noisy and not sufficiently flexible. Control by field resistances, Mr. Lee regards as inherently unsatisfactory, as it not only upsets the electrical operating conditions of the motor, but is also slow and inaccurate because sufficient time must be allowed after adjustment for the motor to settle down to a constant speed.

Eventually, he came to the conclusion that mechanical means were the only solution. A control was needed that could be adjusted, preferably continuously, or by very slight steps, over a wide range of speeds, in order to meet the varying requirements of different transmitting stations; one that could be brought up to any desired speed instantly and without hunting; and one independent of external transmission conditions. The result was a drive that is more flexible and stable than any ever tried.

The Radio Craftsman's Own Page

In these columns will be found letters of RADIO-CRAFT readers from every quarter of the globe. Here old friends will renew acquaintances of long standing.

THE letters of encouragement and praise which our readers have been showering on us have been very welcome to the Editors of RADIO-CRAFT, and they take this opportunity of acknowledging the great number to which it has been impossible to reply personally, much as they would have liked to do so. Bouquets, however, are not all they are looking for. This is YOUR magazine, and it will welcome every letter which expresses a definite wish for a certain line of editorial information. It is only in this manner that we can know just what You want and what will be of most use to You. Our readers realize, and so do we, that there is still much room for improvement in RADIO-CRAFT; and, with Your cooperation, it will be forthcoming.

We especially invite letters telling of your experiences with sets, circuits, and practical radio problems, as they come up in your work. We know that our readers like to know what others are doing, as much as to read the more formal articles available from those who are active in industrial development of radio; and we trust to make this Experimenter's page the stamping ground of those who like to follow out their own ideas and do something a little different. What have you found out for yourself that will help along other experimenters? Write to the Editor of RADIO-CRAFT and tell your story in your own words.

A "COMBINATION" YEAR

Mr. Hugo Gernsback, Editor,
RADIO-CRAFT:

I was agreeably surprised and pleased this morning when I opened the mail and found the first edition of RADIO-CRAFT; and I must say that for an opener it could hardly be improved upon. I look forward to the time when this magazine will be crammed full of good, helpful material that the ordinary layman will understand, and pages packed with worthy and square-deal advertisements; as all radio enthusiasts are seeking new devices to make reception better. They want to know of all the new things and particularly where to get them, and your magazine can tell them *where*.

One particular end I am quite interested in, and that is electrical reproduction of phonograph records via radio; as I have demonstrated to many critical music lovers the fact that that kind of reproduction is far superior to what you get from the air—all things considered—and from the advertisements in various magazines, radio and otherwise, I find that it is beginning to come into its own. I feel sure that 1929-30 will be a big "combination" year. I hope that you may be able to feature electrical pick-ups, super-power amplifiers, address systems, etc., and that they will be accompanied with a very generous amount of advertising from pick-up and amplifier manufacturers. I wish I could devote the time to go out and get this one class of advertising; as I am so sold on this end that I believe I would have great success in that particular field.

Wishing unlimited success to you and RADIO-CRAFT, I remain.

Yours truly,
E. D. MACCLAREN,
Onset, Mass.

(Mr. MacClaren, who is an energetic radio dealer, has accurately sensed the trend of the times. While phonograph reproduction alone cannot take the place of radio, the two supplement each other so that no set owner should be without the "combination." The most recent developments along this line are very interesting, and a good deal of space will be devoted to this subject in RADIO-CRAFT during the next few months. They will be of special interest to custom set builders and dealers who specialize in furnishing their patrons with the most up-to-date equipment.—Ed.)

FOR SMALL, COMPACT SETS

Mr. Hugo Gernsback, *Editor,*
RADIO-CRAFT:

On this day of remembering old timers (*July 4*) it came to my mind that I had forgotten to answer your letter of request, which was appreciated, even though laid aside due to a little rush of work. I am very glad to know that you are making a bid for readers for the new magazine you are starting up, and see no reason why you cannot make a go of it. Put the stuff in it; give us some good, honest circuits that will work. As I believe, most of us have about the same likings as to what to expect to find when we open up the magazine—good hook-ups using the latest tubes, such as one, right now, for using one 345 tube in some circuit such as the "Everyman" 4 or 5, and other such hook-ups which tend to bring down the size of the receiver. I believe that in the near future four or five tubes will be the general run. Other writings should include short-wave data and circuits, anything new in radio, and of course the beginner of today should not be forgotten, as he will be the man of tomorrow.

I enclose a money order to cover one year's subscription.

ALBERT B. WILLIS,
Philadelphia, Pa.

(Mr. Willis voices the opinion of many readers, and—though some are interested in bigness—there is no doubt that the set of a few tubes, using the new methods of high amplification, will always serve the need of a majority of set owners. As for short waves, they represent the greatest field for improvement in the service which radio can render. The present broadcast band is being used to its limit; but the possibilities of short waves are very interesting, and will receive increasing space in RADIO-CRAFT.—Ed.)

FROM A SOUTH AMERICAN FRIEND

Mr. Hugo Gernsback, *Editor,*
RADIO-CRAFT:

You will find enclosed a check for a year's subscription to RADIO-CRAFT. I enclose photographs (*unfortunately rather small for reproduction—Ed.*) of your "Peridyne Five" which I have built some months ago, and which I find *wonderful*. It gives reception with extraordinary volume, clarity and selectivity astonishing for its simplicity, of all the concerts of Buenos Aires, Sao Paulo, Montevideo, etc. I have compared it to six-tube receivers of North American manufacture, and it surpasses them all in volume and clarity. I wished to tell you of the great satisfaction it has given, and to ask you to accept my thanks for having created so satisfactory a single-control receiver. I will electrify it when I have alternating current available, and advise you of the results. While I am waiting the pleasure of reading RADIO-CRAFT, I extend my best wishes.

HENRI AVRAND,
Porto Alegre, Brazil.

(We take pleasure in acknowledging this letter, the first from the other side of the Tropic of Capricorn. It will be noted that the seasons in the Southern Hemisphere are reversed; and that reception conditions are usually most exacting so near the tropics. We expect to receive shortly more letters from the distant regions where we have many radio enthusiasts and friends.—Ed.)

JUST WHAT WAS NEEDED

Mr. Hugo Gernsback, *Editor,*
RADIO-CRAFT:

The article on "Reclaiming Sulphated Storage Batteries in the July issue of RADIO-CRAFT, by Mr. C. W. Teck (in "Service Man's Data") was a fine one and came just when I needed it. Now I would like to know how to reclaim the lead in the old batteries—that is, return the oxides back to metallic lead. Thanking you in advance,

DOUGLAS EATON,
Richmond, Va.

(Unfortunately, there is no convenient method of converting the oxides of a storage battery back into metallic lead. Of course, it can be done chemically, but the cost would be entirely prohibitive. In the storage battery the positive plate is converted into peroxide of lead; while the negative plate becomes oxide of lead of the spongy variety. After the battery is discharged and the plates taken out, the two substances become hard and cannot be melted, nor is there any economical use for these substances.—Ed.)

WANTED, A WORLD BEATER

Mr. Hugo Gernsback, *Editor,*
RADIO-CRAFT:

Congratulations on RADIO-CRAFT, which I trust sincerely will meet with every success. Remember from time to time that there is really a very large market for the powerful receiver, and that thousands of radio fans all over the world anxiously scan the radio papers for the latest word on the ten- and twelve-tube set.

A suggestion: why not hold a competition for the most powerful (distance-getting) receiver? Take half a dozen cities in the states and have their radio clubs hold an eliminating contest, the winning set in each trial to be sent to RADIO-CRAFT for final judgment. The question of location would not enter into it, as the final choice of the radio clubs would all be tried out under the same conditions. The audio could be left out of the contest, the actual receiving conditions alone judged.

R. B. TIMBERLAKE,
Montreal, Canada.

(It is rather difficult to make comparisons of the kind suggested. The modern ten- or twelve-tube receivers of good design—especially those which have screen-grid stages—have amplification of a degree so high that there is a reserve of power in the best locations. Add to this the fact that few cities afford the extraordinary locations necessary for consistent reception of extreme distance—New York certainly does not—and the practical drawbacks of this otherwise excellent idea are apparent. The place for such a test would be on some seacoast miles from any city.—Ed.)

SHORT-WAVE EXPERIMENTS

Mr. Hugo Gernsback, *Editor,*
RADIO-CRAFT:

I bought my first month's RADIO-CRAFT from the newsstand, and like it very much. I am interested in short-wave receivers, and have built and experimented with probably all kinds from the junk-box to the latest and greatest—namely the "Super-Wasp." I built this from the diagram with old parts and used a 201A in place of the screen grid, leaving out the "B+45" lead. You should have heard that set work! Plenty of volume, distance and clearness. I am now building the set according to the specifications given in your July issue, except that I am going to use push-pull amplification; and hope to have a better set than any I have ever built. I am going to try an extra stage of R.F. with that 222 screen-grid tube to put it across. Until that time I will be satisfied with the present set as it stands.

(Continued on Page 141)

SHORT WAVE CRAFT

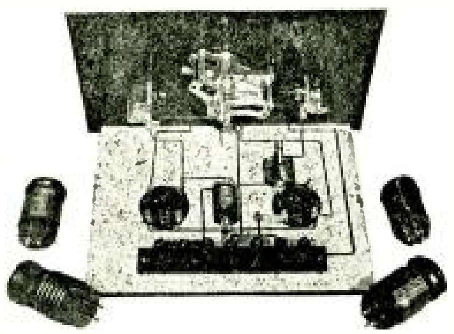
The "Sun" Short-Wave Tuner

The simplicity of an efficient, one-tube short-wave radio set built by the author for code or voice has been accentuated in the construction details of this receiver.

By JACK GRAND

SHORT-WAVE tuners are attracting quite a following among the set builders, experimenters and even owners of factory-built sets. The reports of extreme distance, excellent reception during summer months, and the experimental possibilities offer diversion for those that feel that they cannot find anything new in the present broadcast band.

The author, desiring to build a short-wave tuner, set about getting parts at as low a cost as possible. To speed the



Above is pictured the short wave receiver described in this article. All primary coils may be wound with No. 28 enameled wire; the secondary coils may be wound with Nos. 12, 14, 16 and 28 (green, brown, blue and red units, respectively) wire. The first three are bare and the last is enameled.

construction and assure accuracy of parts, units were to be made of standard make and easily obtainable.

The result was surprising. First, the low cost—less than $11.00. Next the appearance, which can be judged from the photograph. The set is compact and very efficient. By using the base of a tube as a cable plug, the tuner can be used as an adapter.

Building the tuner is very simple as there are only seven parts to wire: (1) The tuning condenser, *C2*; (2) The antenna condenser, *C1*; (3) The regeneration condenser, *C4*; (4) The radio-frequency choke, *L3*; (5) The grid condenser and leak, *C3* and *R1*, respectively; (6) The tube socket, *V1*; (7) The coil socket, *G*, *F—*, *P*, *F+*. The rest of the kit is made up of panel, baseboard, binding-post strip, switch, and dial.

Constructional Details

For convenience of the constructor, in addition to efficiency in design, connections should be direct and as short as possible. The simplest and most satisfactory way of wiring is to start at the filament. Run a wire from the "F—" on the tube socket to the resistor *R2* (4-ohm if a 201A tube is used, or 50-ohm if a '99 type is preferred), and from *R2* to the "A—" battery post. Next, from "F+" on the same socket to one side of battery switch, and from the other terminal on switch to "A+B—." Then from "Ant" post on strip to one side of the antenna condenser *C1*; from the other side of *C1* to "G" on coil socket; to stator of tuning condenser *C2*, and to the grid condenser *C3*; from the other side of the grid condenser to "G" on tube socket. Wire from "F—" on coil socket, to rotor on tuning condenser *C2*, to "Gnd." post, also to one side of switch and to one side of regeneration condenser *C4*. From the other side of regeneration condenser, to "F+" on coil socket; and from "P" on coil socket to one side of the R. F. choke *L3*, and to "P" on tube socket. The other terminal of the R. F. choke leads to one side of the phone binding posts, and the other phone post connects to the "B+45" post. That is all there is, for construction.

To cover the wave band from sixteen to two hundred twenty-five meters, four coils are required (each coil is 1½-in. dia.) as the following table indicates:

Color	Meter Range	No. of Turns, L1	No. of Turns, L 2
Green	16-30	6	6
Brown	29-58	13	13
Blue	54-110	21	15
Red	103-225	54	27

With the Broadcast Receiver

To use this tuner as an adapter, the base of an old tube socket can be utilized. First, obtain three lengths of wire about four feet long, one wire to be soldered to the plate prong of the tube base. This wire is connected to the phone binding post connecting to the R. F. choke. The other two wires are to be soldered to the filament prongs of the tube base and connected to "A+" and "A—" binding posts.

When this is completed the tube base is to be inserted in place of the detector tube in the set. The detector tube in the set is to be placed in the tube socket of the adapter.

As a tuner good results may be obtained with head phones; but much stronger signals will be heard with two stages of audio.

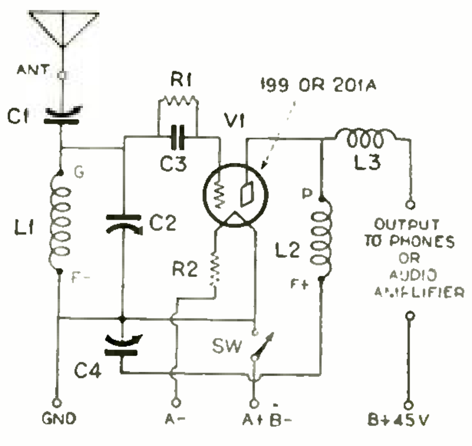
Distance, of course, is a matter of location and at all times the short-wave receiver is superior to a broadcast set in this respect.

When tuning for distance a chart should be obtained, showing at what time stations are broadcasting.

The following is a list of parts used in the "Sun" Short-Wave Tuner:

1—Set of four Octocoils (*L1-L2*)
  Green Coil, 16 to 30 Meters
  Brown Coil, 29 to 58 Meters
  Blue Coil, 54 to 110 Meters
  Red Coil, 103 to 225 Meters
1—R.F. Choke Coil (*L3*) (Pilot, 80 millihenry)
1—.00005-mf. Midget Variable Condenser (*C1*) (Pilot No. J-13)
1—S.L.F. .00015-mf. Variable Condenser (*C2*) (Pilot No. 1608)
1—.00015-mf. Grid Condenser (*C3*) (Aerovox)
1—.0001-mf. Midget Variable Condenser (*C4*) (Pilot J-23)
1—Binding-Post Strip (7 posts) (Eby)
1—7"x12" Panel (I. C. A. "Insuline")
1—8-Megohm Grid Leak (*R1*) (Carborundum)
1—Fixed Resistor (*R2*) (Yaxley) (50-ohm for 199 tube or 4 ohm for 201A tube)
1—Filament Switch (*SW*) (Carter)
2—UX Tube Sockets (Pilot)
1—Pilot Vernier Art Dial; 6 feet of wire
1—8"x11" Wood Baseboard.

(See Parts Layout on following page.)



Schematic circuit of the Short Wave Receiver described in this article by Mr. Grand.

HOME PRACTICE RADIO CODE OUTFIT

TO obtain the best there is in radio, learn the code. Just to listen to broadcast is to miss half the fun.

As the circuit indicates, the hook-up is the Armstrong regenerative arranged in a somewhat unusual fashion; that is, the circuit is permitted to "howl".

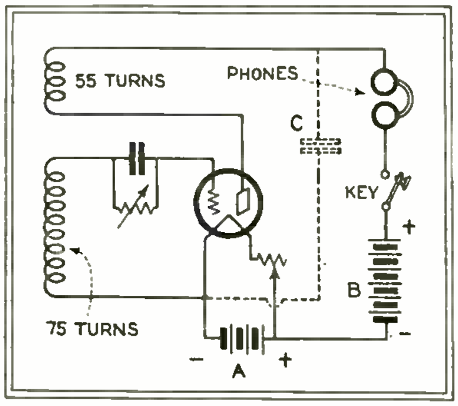
The grid coil is wound on a regular three inch tube, to a total of 75 turns, using number 26 cotton covered wire.

The secondary, or rather, the plate coil, consists of 55 turns of the same size wire wound on a form which will snugly fit inside the grid coil, after the form has been wound with the wire. This tubing may be a piece of cardboard or perhaps better material, of the exact size, or it can be improvised from a piece of the three inch tubing, by cutting a strip from the tube and forcing the two edges together.

It is desirable but not essential that the plate coil snugly fit the grid coil. Both coils are wound in the same direction.

To operate the unit, adjust the plate coil to obtain the desired note, then "pound brass".

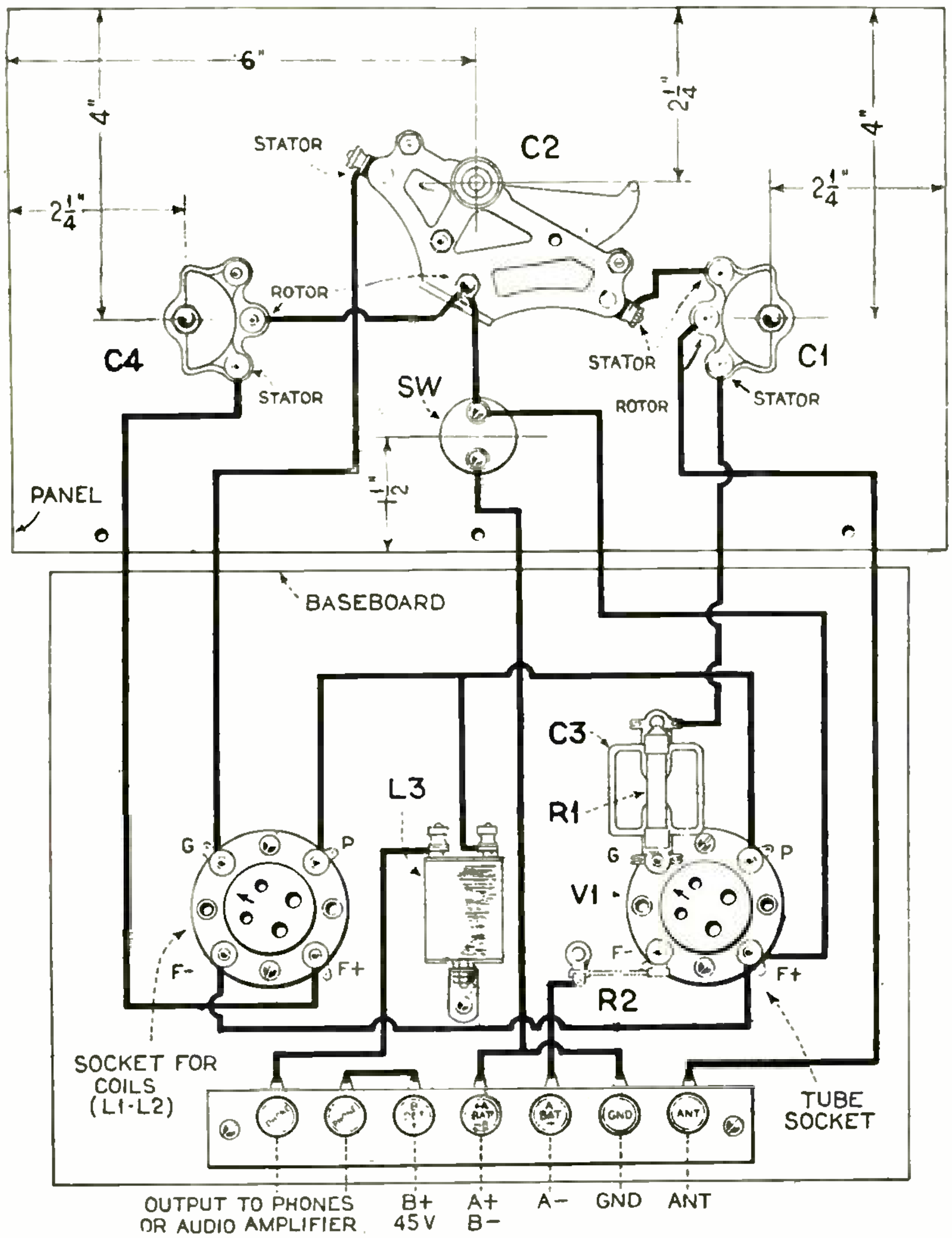
A variable grid leak, indicated in the schematic, is an aid in arriving at a satisfactory tone and volume adjustment.



Schematic circuit of a code practice unit. It sounds like a high-power code station.

Any handy tube can be used with the correct "A" voltage. If the circuit does not oscillate, try reversing the plate leads, changing the tube, and checking the grid return lead to make certain it connects to "A" minus.

M. H. BERRY, Salisbury, N. C.



Layout of parts for the Short Wave Tuner described on preceding page.

TELEVISION AT RADIO STATION W2XCL

PRELIMINARY testing of a short-wave transmitter which will soon be "put on the air" for television broadcasting has already begun. The station is owned by the Pilot Electric Mfg. Co., of Brooklyn, N. Y.

The station, which has been assigned the call letters W2XCL by the Federal Radio Commission, will use 250 watts of power on the bands between 2,000 and 2,100 kilocycles (143-150 meters), and 2,750-2,850 kilocycles (105-109 meters), and for a few weeks will be on the air every Monday, Wednesday and Friday between 9:00 and 11:00 P. M., E.D.S.T.

For the time being the transmissions will consist merely of spoken announcements and of musical notes of different frequencies. The purpose of the tests is to determine the quality of the modulation, the ability of the apparatus to handle the wide frequency bands required for television work, and the field strength of the signals in various parts of the Metropolitan area.

Two highly developed "televisors" are ready to be connected to the transmitter proper, but transmission will not start until most people can receive W2XCL very well. (Reports are requested.)

ARE YOU LISTENING TO ENGLISH AND DUTCH 'PHONE?

THESE two overseas stations are received particularly well on the East Coast. The thrill of hearing the announcer say, "This is G5SW, the short-wave experimental station of the British Broadcasting Corporation, at Chelmsford, England, working on a wave-length of 25.53 meters"; or "Hello, United States and Canada, this is station PCJ, of Philips' Radio, Eindhoven, Holland, working on a wave-length of 31.40 (meters)," may be experienced by anyone (no matter how *blasé*) having a short-wave receiver of average ability, in a fairly good location.

European Short-wave Phone Schedule

Transmission details of G5SW are now available. The antenna power is 15 kw.; and the schedule of broadcasting is: Monday to Friday, inclusive, 7:30 to 8:30 A. M. (The program consists of "luncheon music" during the British lunch hour), and 2 to 7 P. M., E.D.S.T. (Eastern Daylight Saving Time) (London program). In addition, on Monday and Wednesday, 7 to 9 P. M. ("gramophone recital").

The Holland station, PCJ, has a power of 30 kw. They broadcast on three days: Thursday, 2 to 4 P. M., in English; 7 to 8, Spanish; 8 to 9, Portuguese; 9 to 11, Spanish; the Spanish and Portuguese transmissions are directed to Central and South America. On Friday the hours are 2 to 4 P. M., English; 8 to 9, Dutch; 9 to 12, English, French and Spanish; the 8 to 12 programs are directed to Central and South America. Immediately following this (12:01 A. M. to 2 A. M., E.D.S.T.), is the Saturday program, in English, for Australia and the islands of the Pacific. Announcements are always given in four languages.

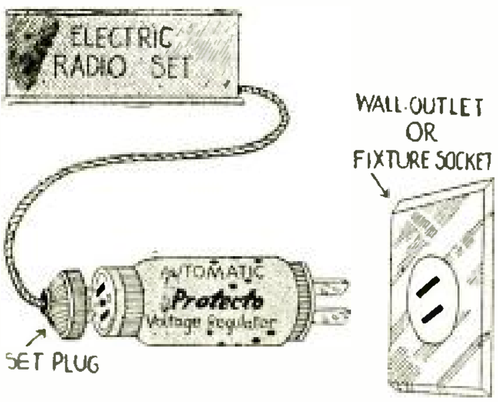
LATEST THINGS IN RADIO

Manufacturers are invited to send to this department photos and descriptions of new apparatus

Line-Voltage Control Unit

By Sidney M. Weisberg*

IF a voltmeter should be connected across the "110-volt" circuit, it will be found that, at various times during the day and night, the reading will fluctuate considerably. This is due to changing "load," as well as to variation in the output of the generator supplying



The method of connecting a fused, line voltage control device is pictured above.

the current. (The variation due to generator output fluctuation is made almost negligible, by the use of modern automatic control devices; but the rise and fall in voltage, due to varying current demands — load variation — at different points along the lines supplied by the "mains" is still a major problem.) The line-voltage varies all the way from 100 to 130 volts.

Laboratory experiments combating this situation resulted in the development of an alloy wire which offers a variable resistance to the flow of current; so that, when the line-voltage becomes too high for safe operation of the radio tubes, its resistance increases; but, when the line-voltage becomes lower, its resistance lessens proportionately.

An example follows: The voltage-control plug at 115 volts causes a drop of 7 volts; if the line-voltage rises to 120, the resistance in the plug becomes still hotter and the additional heat increases the resistance until the drop is 11 volts, thus keeping the line-voltage at a practically constant value below 110 volts. This phenomenon of a conductor having a high "temperature coefficient" is exemplified in the ordinary electric lamp, the tungsten filament of which increases in resistance 1,200% between the extremes of room temperature and incandescence!

*Engineering Staff, Protecto Mfg. Co., N. Y. C.

The records of engineering experiments contain the following table, showing the results obtained with a laboratory set-up which included a Model 37 Atwater Kent 6-tube A.C. radio set (four '26, one '27 and one '71-type tubes), a voltage supply variable between 100 and 130 volts, and the necessary measuring equipment:

Hour	*Set Volts*	*Set Volts*
(*A. M.*)	(*no control*)	(*controlled*)
8	128	110½
10	124	110
12	120	109
(*P. M.*)		
2	122	109½
4	118	109
6	115	108
8	108	107
10	106	105½

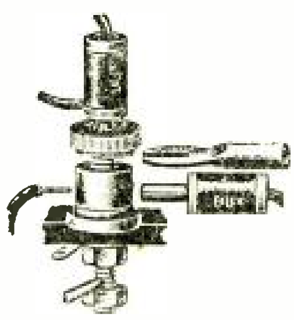
For this test, the Model "A" line-voltage-control unit was used, a 75-watt (max.) instrument internally fused for one ampere.

(There are two other types, designed for heavier service. They are the 300-watt (max.) Model "B," fused for three amperes, and the Model "C," 500-watt (max.) fused for five amperes.)

Upon consideration of the above figures we find the particular Model "A" line-voltage-control unit selected for this test had a 2½ volt plus and minus variation of its optimum output potential (108 volts). This value (108 volts) would result in a considerable increase in the life of the tubes, as compared to 110 volts. During the control unit output plus variation of 2½ volts the input plus variation reached 13 volts, while the input minus variation reached 9 volts.

NEW TERMINAL

EVERY experimenter has wanted, at one time or another, to be able to fasten more than a single "spade" or



A lettered connection post for stranded wire, solid wire, phone and spade tips.

wire conductor to a binding post. Usually it was necessary to juggle with the plurality of wires before they could be securely fastened.

For this reason there will be considerable interest in the (illustrated) new Treble-Duty Terminal, made by J. J. Eastick and Sons, of London, England.

Phone tips can be securely fastened in one portion of the terminal. A locking nut secures a "spade" type of wire tip. A plug of the right size may be put in the top of the item as a third connection point.

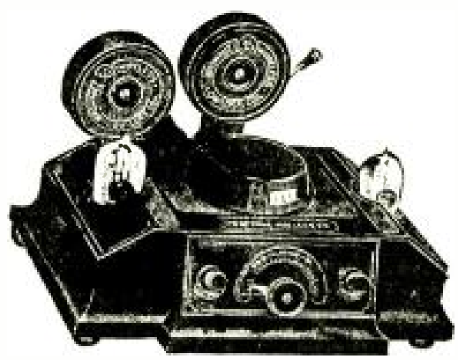
Also, each binding post has an identification on the locking nut.

The binding post may be wired into the permanent part of the equipment by soldering, or, a phone tip or piece of bus bar may be fastened and locked in a hole provided.

There are six colors obtainable in 40 different designations.

2-TUBE SET

THE two-tube receiver pictured is from the Brownie Wireless Company of London, England.



A novel radio set; made in London, England.

It is an excellent example of the moulding art and illustrates the way in which a difficult situation can be handled. It is seldom one finds a receiver with the tubes and coils outside of the cabinet, in the regular sense, presenting the harmonious appearance of this radio set. They only do it in Europe now.

We are not quite certain whether the top control is for coupling and the front one for tuning, or *vice versa*, but we think the former is the case as, otherwise, it would be difficult to read a 180-degree swing of the top, center, dial.

Although this receiver does not use screened grid tubes, these tubes have been in use in Europe for several years.

A LINE-VOLTAGE REGULATOR

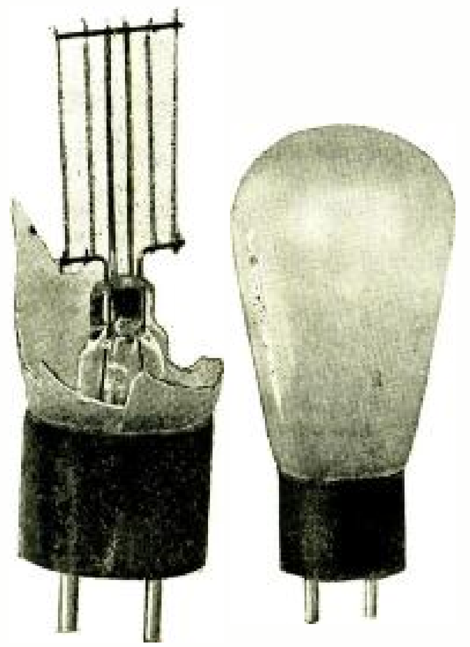
A NEW voltage-regulation device has been developed to alleviate the effects of line-voltage fluctuation.

As generally known, fluctuating line-voltage will result in short tube life and erratic receiver operation. One way of partly compensating for this change in line-current is to tap the primary winding of the power transformer. This results in partial compensation but the results may only be temporary; a change in the current supply being counteracted only by changing the tap connection on the transformer. If automatic balancing of the line voltage could be secured, all the faults of this method would be overcome.

This result has been obtained by the use of a special resistance wire, wound to include sufficient resistance to "drop" approximately 20 volts at low line-voltage and 40 volts at high line-voltage. This resistance is contained in an inert-gas-filled bulb. This device, illustrated in these columns, has an UX-type base but only two terminals are used; the "A—" and the "plate." As these two pins are diametrically opposite each other, the tube base fits squarely on the standard tube socket.

The only requirement for the application of this resistor to any modern receiver is to have the line or power transformer wound or tapped for a primary of 80 volts. The number of turns in each secondary winding remains the same as for the customary 110-115-volt primary. Power transformers with 80-volt primaries for the use of set manufacturers are now available.

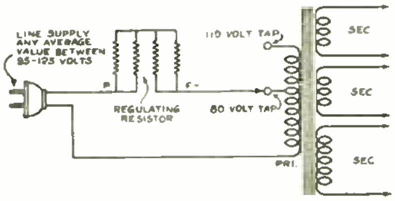
The designating number of the resistor corresponds to the current in the primary of the receiver at 80 volts. For



Interior and exterior of new regulator unit; the latest of such controls.

example, the No. 6-20 unit will pass 0.6 amperes when the voltage across it is 20 volts. With a 10% increase in current, the voltage drop across the resistor will increase 100%, which means that at 0.66 amperes the voltage drop across the resistor is 40 volts. Similarly the No. 8-20 resistor will pass 0.8 amperes at 20 volts and 0.88 amperes at a 40-volt drop. Thus, if it is found that the power in the primary of the power transformer is 0.8 amperes at 80 volts, the set will require resistor No. 8-20. If the current is 1.1 amperes at 80 volts primary the set will require unit No. 11-20.

As the response of this unit to voltage fluctuation is practically instantaneous, it is possible to obtain regulation against surges and rapid line-supply variations impossible with older resistors used for the same general purpose.



Schematic arrangement of the regulator described in these columns.

The method of connecting the resistor into a power line is illustrated in the diagram appearing in these columns.

As it is necessary to determine the current at 80 volts, and as this may not be known, an approximate figure may be arrived at by applying a simple arithmetical formula after finding two factors. The first step is to measure the line-current drawn by the set; then the line-voltage at which the current was measured. Multiply the measured line-current value by 151.25 and divide the product by the actual line-voltage measured. The result is the current which will be required at the 80-volt primary.

The guaranteed life is 2,000 hours. A test-board run of 3,000 hours (15 minutes on, 5 off) on each of the models in the range available, from 0.3 amperes to 1.2 amperes, has not resulted in any sign of deterioration. This test was made at an overload of 20%.

The results of a particular regulation test will be of interest. The line-voltage was varied between the limits of 95 and 130 volts. Without the regulating resistance; the filament-voltage swing at the filament terminals of a type '27 tube measured from 2.1 to 3.0 volts. With the regulator in series with the line, the voltages delivered to the set were 105 to 117 and the filament voltage to the '27 tube was 2.3 to 2.5 volts. At the same time, measurements taken of the plate voltage delivered to the type '50 power tube in the set read 285 to 490 volts, without the regulator, and 350 to 385 with the series resistor. The effect of the high plate voltage obtained in the first instance, on the insulation of the filter condensers (particularly at peak and surge values derived from this potential) may well be imagined. That it is desirable to incorporate a device to overcome such conditions is therefore evident.

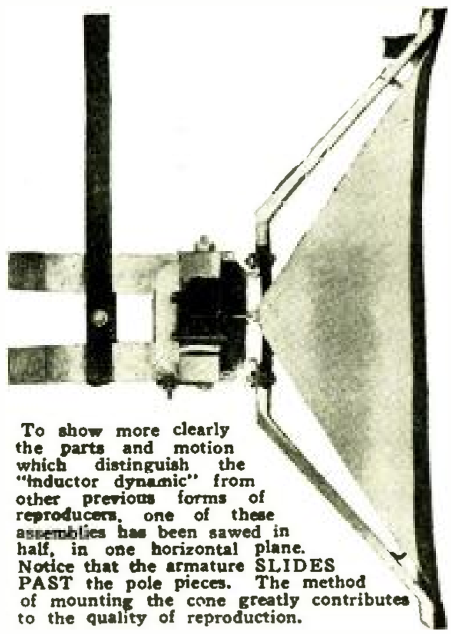
This item, called the "Amperite Self-Adjusting Line Control for A.C. Receivers," is a product of the Radiall Company, New York City. The list price is $3.50.

THE "INDUCTOR DYNAMIC" SPEAKER

TWO types of loud-speakers are in common use today, namely, the "magnetic" and the "dynamic." The former, while inexpensive and simple to apply, is limited in volume and tone range. The latter, while costly and complicated to apply, is capable of remarkable volume and tone range.

However, for some three years past C. L. Farrand, an authority and pioneer in the field of radio acoustics, has been working on a compromise type. As a result of his engineering labors, he has developed an entirely new type of loud-speaker which he has named the *"inductor dynamic"*; because of its resemblance in principle to the conventional induction motor, together with its dynamic power.

To begin with, the "inductor dynamic" speaker is based on the principle of the A.C. induction motor, the rotor of which revolves under the influence of changing magnetic flux in many pole pieces. Here the motion is a rotating one. In the inductor dynamic unit, the changing

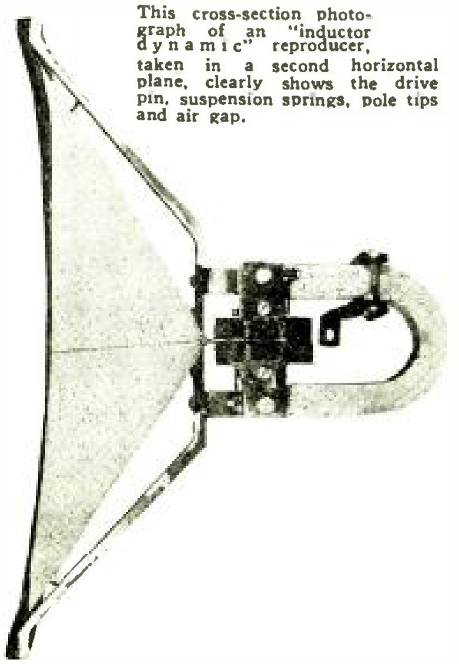


To show more clearly the parts and motion which distinguish the "inductor dynamic" from other previous forms of reproducers, one of these assemblies has been sawed in half, in one horizontal plane. Notice that the armature SLIDES PAST the pole pieces. The method of mounting the cone greatly contributes to the quality of reproduction.

magnetic flux (due to the effect of the current on the fixed magnetic field) actuates a pair of armature bars connected by tie rods, each bar working between its respective pole faces. The gaps between armature and pole faces remain constant, but the area by which the armature and pole face overlap is varied as the armature is set in motion by flux changes. The two light bars, with their tie rods, are supported between the two sets of pole pieces by means of exceedingly light strip springs, whose function is to hold the gaps constant and *not* to supply the restorative force; which duty is left entirely to the magnetic force.

As the new reproducer has been designed to operate efficiently without recourse to an energized field of any kind, the considerations of hum and field-magnet current supply do not concern the owner of an inductor reproducer. Designing this unit to deliver audio energy comparable in quality and volume with the accepted standard, the dynamic reproducer, was accomplished under great technical difficulties.

Referring to the accompanying diagram which tells the story of the inductor dynamic principle, it will be noted



This cross-section photograph of an "inductor dynamic" reproducer, taken in a second horizontal plane, clearly shows the drive pin, suspension springs, pole tips and air gap.

that the armature assembly rides freely between the pole pieces $P1$ and $P2$. The coils $C1$ and $C2$ are connected in series. A current flowing through the windings in the direction indicated will increase the flux through the pole legs $P1$, and decrease the flux through the pole legs $P2$. The flux, seeking the path of least reluctance, exerts a greater force on the armature bar $A1$ than on the armature bar $A2$, thus moving the armature in the direction indicated. On the reverse of the cycle, the armature moves in the opposite direction, in the same manner. The pole legs are cut to the shape indicated to reduce the leakage flux and to bring the greatest flux density to the desired point. The opposite forces on the two armature bars cause the armature to rest at a middle position which may be termed the "magnetic center." The flow of voice current in the coils causes this magnetic center to shift, and the armature moves along with it.

Advantages of Principle

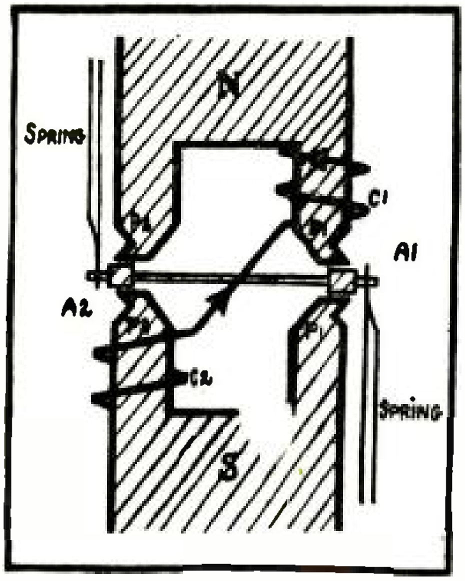
Compared with the magnetic type, the obvious advantage is that the armature in the inductor dynamic is placed sufficiently close to the pole pieces to gain the necessary sensitivity and power; yet, since it moves in the plane of the pole faces, there is no danger of "pole slap" and, again, there is no cramping of swing or amplitude of motion due to limited pole spacings. Also, there is no necessity for the stiff springs which must be employed for the balanced armature of the magnetic type in gaining minimum magnetic gaps for sensitivity and power, yet avoiding pole slap. The stiff spring tension seriously impairs the operation of the usual magnetic type at the lower frequencies. The spring resonances also introduce distortion. The apex of the cone is driven in an arc motion, rather than a straight line, introducing distortion. These limitations have all been eliminated in the inductor dynamic type.

The inductor dynamic requires no separate field-excitation current, but only an output transformer or choke-and-condenser combination, to keep D.C. out of the speaker windings. If the speaker is to be applied to a push-pull amplifier, a third lead may be taken from the windings at the point where the two coils are joined together, and used as the midpoint of the windings. This corresponds to the mid-point in the primary of the usual output transformer or choke, which is thus dispensed with.

The inductor dynamic, which must be carefully matched to the impedance of the amplifier, is made in four different impedance values, distinguished by a disk of one of four colors (green, red, purple and tan) placed on the chassis, to facilitate the matching of impedances.

At 1000 cycles the impedances of the various units are: Green, 7550 ohms; red, 17,500 ohms; purple, 12,500 ohms; tan, 4000 ohms. It is to be noted that the first two values have been found entirely adequate to meet the various conditions which have so far arisen and therefore the remaining two values may be termed experimental and not commercially available.

(For the purposes of the manufacturer only there is a push-pull, center-tapped model available. This form of construction eliminates the need of an output device.) The output transformer or other matching arrangement used with the standard model must be of the very best design in order to realize the maximum in quality reproduction.



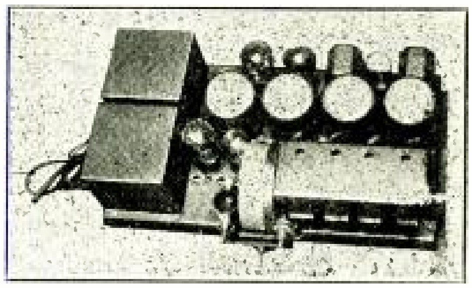
Theoretical connections for producing the "inductor dynamic" motion. Although the small, square armature pieces $A1$ and $A2$ are attracted to the pole tips, the mounting springs prevent motion in this direction (up and down, in this case); consequently, this force is converted into a left-right swinging motion of the armature.

The inductor dynamic is capable of producing all the volume desired for home entertainment. Because of its high electrical efficiency, it will provide as much volume with a given input as the moving-coil dynamic using from ten to fifteen watts in its field. In tone quality, it reproduces the full musical frequency range (we are told). It requires no box resonance for the bass. The entire armature assembly, including springs, weighs 4.5 grams (one-sixth of an ounce) as compared with 8 to 15 grams for the moving-coil dynamic; and it is capable of excellent low-frequency response, in which it exceeds the dynamic. With an input of 15 "transmission units" at 30 cycles, the inductor motor moves a 10-inch cone one-eighth inch.

Two sizes of diaphragm are available. The 7-inch size is found on the $18.00 model and the 10-inch cone is on the $20.00 model. For those who can discriminate between delicate tone shadings, the 10-inch size is recommended; otherwise there is no advantage of one over the other.

THE "MODEL 41" FRESHMAN RECEIVER

THE Charles Freshman Co. is marketing a new apparatus under the name of "C. A. Earl Radio." This receiver, the Models 22, 31, 32 and 41, is available at



Pictured above is the chassis of the new Freshman radio set for the coming "season." An antenna circuit tuning variometer is shown just left of the tuning drum.

prices from $99.50 to $225.00; the last figure being the list price of the Model 41 the chassis of which is illustrated in these columns.

This set incorporates four tuned stages of radio-frequency amplification, detector, and two stages of audio-frequency amplification, the last being push-pull and using type '45 tubes. The radio-frequency circuit is of the neutrodyne type.

Only three types of tubes are required for this set. They are: six type '27 tubes; two type '45 tubes and a single '80 rectifier.

A dynamic reproducer is included in the designs.

Included on the signal-input binding-post strip is a connection post which makes it possible to use the electric-light lines as an aerial.

A variometer tunes the antenna circuit, and this unit is controlled from the front of the panel.

A "High-Low" switch in the power transformer primary makes it possible to obtain an approximate balance whether the line voltage is 110 or 120.

A NEW FIXED CONDENSER

THE Electro - Motive Engineering Corp., New York City, offers a new fixed condenser of the molded-bakelite,

A new fixed condenser which by bending of the soldering tabs may be reduced to the dimensions of 1¼-in. by ⅞-in. by ¼-inch thick.

impregnated type. The list price range is $.35 to $.50, depending on the size.

This fixed condenser is available in ca-

(*Continued on Page* 142)

RADIO CRAFT KINKS

WATCH YOUR JOINTS!

For 100 per cent efficiency sound electrical connections are imperative: hints regarding this neglected side of set construction are given in this article.

By C. A. OLDROYD

HAVE you ever built several sets, all to the same circuit, and perhaps even with the same parts, and found that one of them proved excellent in performance and range, while the others—were just moderate?

You may have suspected the parts; fixed condensers might have aroused your suspicions; the layout may possibly have had something to do with it—but

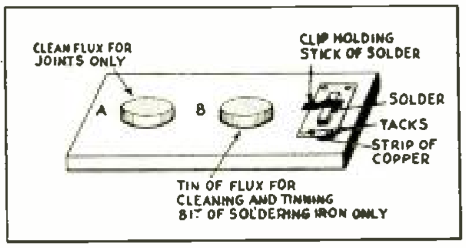


Fig. 1. A handy little block for keeping handy the appurtenances of soldering.

have you ever considered the importance of really sound connections?

They are just as essential as anything else, and yet, in the rush and hurry to get on with the job and to hear the new receiver talk up for the first time, few constructors take enough care with connections.

There is no great trick in soldering, so long as you use a good brand of flux and a hot, well-tinned iron.* The moral is: "Make a friend of your soldering "tackle," treat your iron well, keep the point well tinned, and get as much practice in soldering as you can."

The writer works along the following lines, and the suggestions given may help a beginner, so here goes:

"Tinning"

To "tin" the iron, heat up the copper head until the heating flame shows a faint greenish tinge. Then wipe the head with a rag and dip it into a tin of flux; we'll call this particular flux the tinning flux. Now apply solder, and you'll be surprised how quickly and evenly it flows over the whole tip of the bit. If it should not happen to take to the copper head, then the copper surface wants touching up; for this use a clean file and some emery paper.

* *(The ambiguous use of "tin," "iron," and copper" is occasioned by the fact that they are used "in the trade" without due regard for "Hoyle." A soldering "iron" is made of copper; and, a "tinned" soldering iron has been treated with lead—with tin added, the proportion of tin often being very low!—Ed.)*

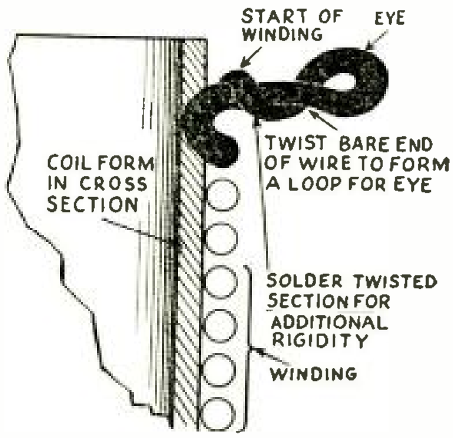
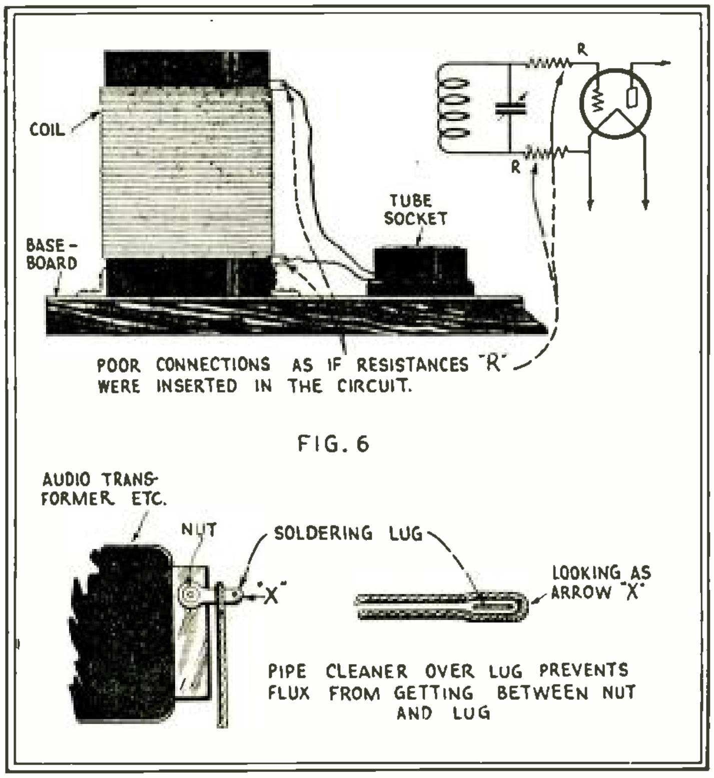


Fig. 3. Making good contact to a coil lead.

The tinning flux referred to above is used solely for keeping the bit in condition, it is never applied to joints. It is the same flux, of course, but the heat from the iron darkens it quickly and lowers its efficiency. (See Fig. 1, where *A* is the clean flux for joints only, and *B* the tinning flux.)

Another point: it is far better to tin soldering lugs and the ends of "flex" (flexible, stranded hook-up wire) or busbar before placing them in position for soldering. If the flux is applied to the joint, say to a lug clamped under a terminal, the application of heat will make th flux run, and it will creep into the joint between the shoulder of the termi-

(*Concluded on page* 143)



At upper left is a schematic circuit and pictorial representation of a poor contact. At lower left is shown a soldering lug on a transformer (Fig. 4A): Figure 4B is slightly to the right of this.

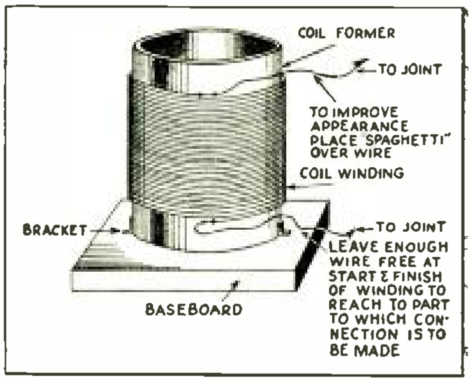
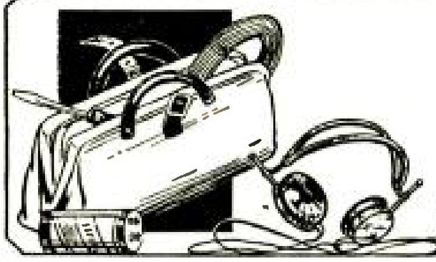


Fig. 2. Recommended method of terminating inductance coil leads.



SERVICE MAN'S DATA

ANTI-MOBO

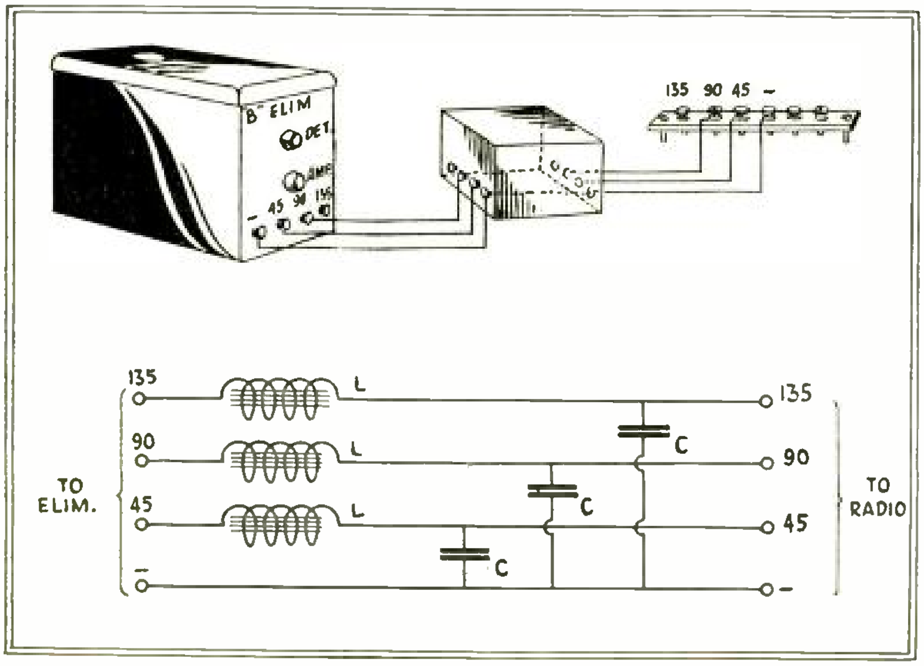
THE service man will find an anti-motorboating unit of the type to be described herein of considerable aid when making radio service calls where the complaint is motorboating. These calls will usually come just after the purchase of a "B" eliminator of a size and type unsuited to the service required.

Chokes *L* may be A.F. transformer primary or secondary windings; if secondaries of better grade transformers are used, the voltage drop through them will probably be too high, with consequent loss of "B" voltage. Also, windings of wire too fine for the current drain will burn out.

Condensers *C* may all be of one size, one mfd., or even less; although, in some cases a high value may be needed. The detector plate is the worst offender in this respect.

This anti-mobo unit supplements the usual filter network of the eliminator. In fact, it may replace this network if care is used in selecting the chokes and condensers.

If the constructor so desires, a complete unit may be built up and the condensers and chokes housed in a small box, placed between the usual "B" eliminator and the radio set, as illustrated. The unit shown has been wired to use only two choke circuits; although the schematic circuit has been drawn to include three. As the power stage (marked "135) seldom causes any trouble due to feed-back, it has not been shown. This filter circuit may be applied to a "C —" bias lead.



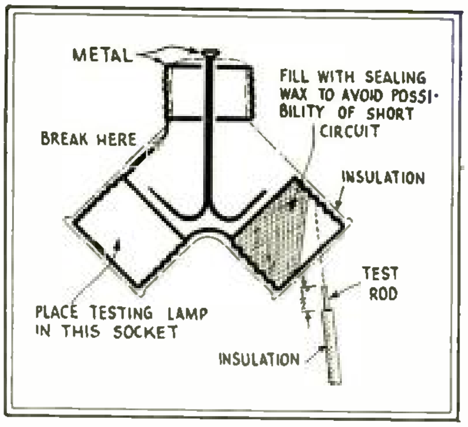
A simple ripple-smoothing ("anti-mobo") device.

"GROUND" DETECTOR

By Louis B. Sklar

HERE is a little device which will enable any radio set-owner to determine at a glance the condition and safety of the "ground" of his radio set. Quite often a radio set-owner does not know which of the two lead-in wires coming from the cellar or other place is the ground and which is the aerial, or whether there is a ground connection at all.

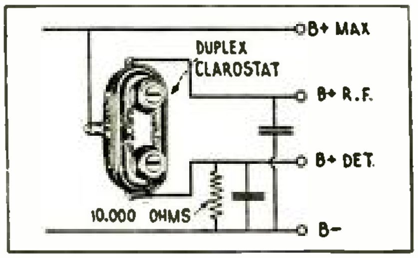
Tracing the two wires is often accompanied with difficulty due to inaccessibility to the ground and aerial wire connections; or when this information is desired during the evening hours.



A test device for checking circuits which may be carrying high voltages; unknown to the set owner or the service man.

The "ground" detector shown in the illustration is made up of a two-way socket. The ground connection of the two lamp receptacles is disconnected from the upper part of the two-way socket which goes to the grounded part of the electric house current. Plugging in the receptacle in the nearest electric outlet and putting in a lamp in socket No. 1, the lamp will not light due to an open circuit. By touching the inner shell of socket No. 2 with the bare end of the ground lead-in, the lamp will light up. The lamp will not light if the aerial lead-in is used instead of the ground lead-in, or if there is an open connection in the ground lead-in. With this scheme, one can also find the condition of the "ground"; whether it is good or poor can be determined by observing the difference in brightness of the lamp when lit with the ground lead-in as illustrated, and when placed in an ordinary lighting outlet.

Caution: If care is not exercised when using this unit, it may result in the purchase of fuses!



The circuit arrangement of a clever emergency repair. (See below.)

AN EMERGENCY REPAIR

WHILE servicing an expensive radio set, located in the furthest suburbs of a certain city, it became necessary to complete a filter resistance circuit which had opened. As the voltage requirements of the set were unusually exacting, the writer had visions of a long trek to town and back again, a matter of about two hours' time.

A sudden recollection that there was in the old "bag of tricks" a variable resistor of the type known as a "duplex, sub-panel-mounting" unit, brought a gleam of hope. Connecting this into the circuit, as shown in the schematic diagram above, effectively solved the problem.

This unit may be mounted on a sub-panel, in any convenient place; final adjustment being obtained by screwdriver manipulation until the voltmeter or set performance indicate that the correct setting has been found.

It is hoped that this idea may be of assistance to other service men; for we are told that forewarned is forearmed.

Putting New Life into Old Supers

In this description of the "capacity bridge," Mr. R. H. Siemens shows an adaptation of the Wheatstone Bridge. The circuit is practical and results in very high gain without circuit oscillation. Every super can be improved by the changes suggested.

By R. H. SIEMENS

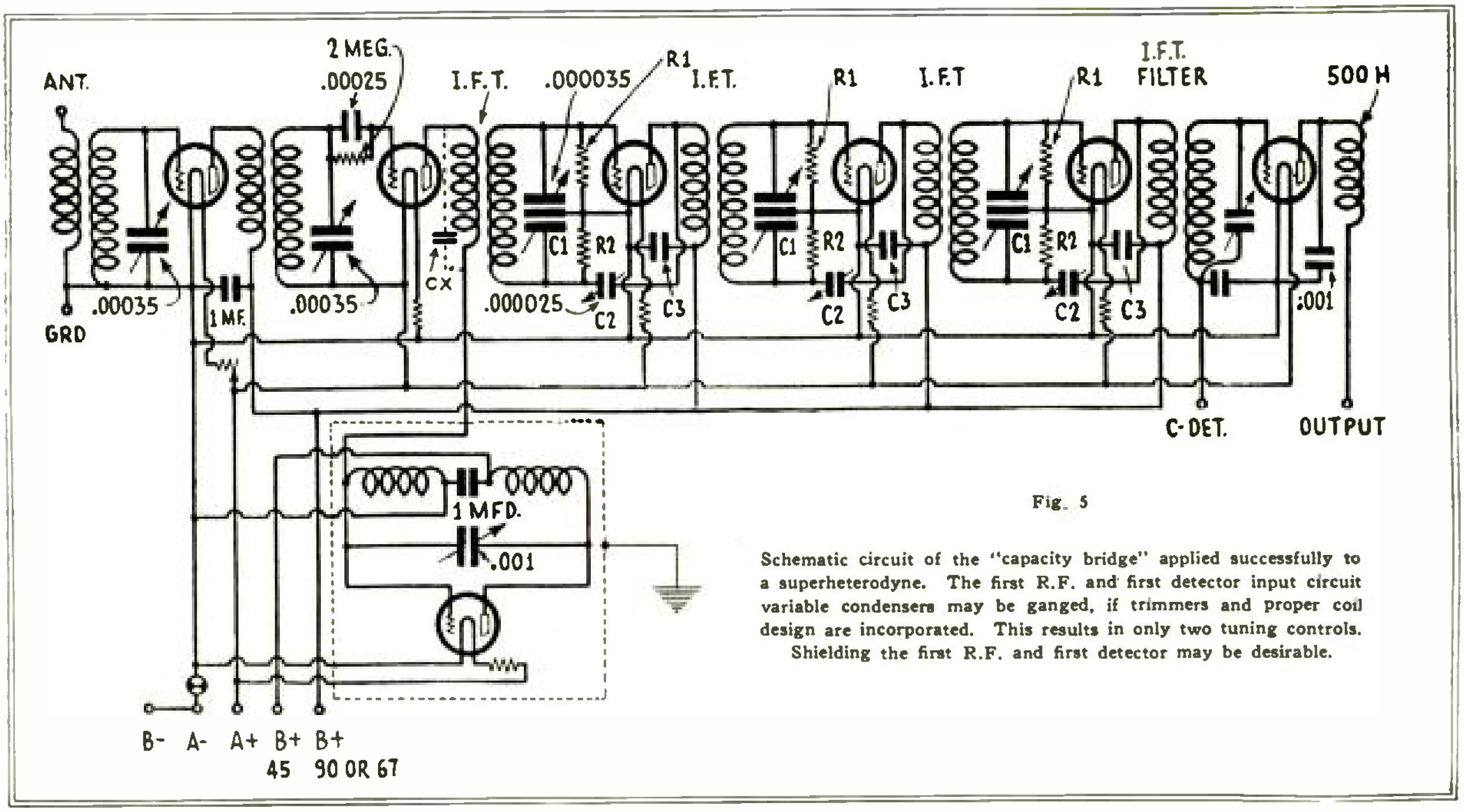


Fig. 5

Schematic circuit of the "capacity bridge" applied successfully to a superheterodyne. The first R.F. and first detector input circuit variable condensers may be ganged, if trimmers and proper coil design are incorporated. This results in only two tuning controls. Shielding the first R.F. and first detector may be desirable.

In this day of super-sensitive and very selective tuned frequency receivers the favorite of the older experimenters, the superheterodyne, has been neglected. Not because of any lack of capability of the superheterodyne principle of radio reception but due to lack of knowing just what to do to cope with the special considerations modern conditions have imposed on receiving equipment.

The service man who knows what is necessary to rejuvenate the older types of superheterodynes, and how to go about it, may reap a good harvest for his efficiency.

Also, the experimenter who always knew the finer technicalities which distinguished the "super" from all other forms of radio receivers; which made it possible, with two-dial tuning, to duplicate and surpass the performance of receivers requiring a multiplicity of tuning units and a circuit balance raised to the *n*th degree, will find new interest in his older set.

The technician will be interested in the intricacies incident to adapting, to various "super" circuits, the principles which, for the past four years, have been tried by the writer and found highly successful in practical service.

As the feature of the schematic circuit shown is the neutralized amplifier, obviously any oscillator and first detector arrangement is permitted.

Experimenters interested in development work incorporating type '26 and '27 (A.C.) tubes in the intermediate stages of superheterodynes, will find the "capacity bridge" equally useful.

Other circuits of course have inherent advantages. In fact, some of these recognized advantages are incorporated in the modernizing method the writer has used for some time and which will be described.

The plan to be outlined is absolutely practical but its principles may be understood better if the reasons for the inception of the original circuit are pointed out.

A War Time Measure

During the war in Europe most of the radio communication was done on wavelengths in excess of 600 meters. This because of the fact that efficient circuits for radio frequency amplifiers had not as yet been developed. The enemy, however, did develop means for communicating on waves as low as 150 meters. Our intelligence service learned of this and the problem of receiving these important messages was placed before our Signal Corps.

Major Edwin H. Armstrong, the inventor of the superheterodyne, was assigned to the job, and this is how it was finally accomplished. The Signal Corps had very efficient amplifiers which functioned best somewhere around 3,000 meters, and he reasoned that if the enemy signal could be transformed from the low wavelength to the wavelength at which these amplifiers were best suited to amplify, the problem would be solved.

The principle of heterodyning was well understood at that time, but had only been used for creating audio frequency tones when pure or unmodulated carrier waves were being received. This was done by placing in the circuit of a receiver that was intercepting continuous wave signals a local oscillator whose frequency of oscillation could be adjusted to differ from the received signal oscillation by the desired tone frequency. Major Armstrong reasoned that if the same principle was applied to the short-wave signal, with the exception that the local oscillator adjustment be made to differ from the short-wave oscillations by the frequency the Signal Corps amplifiers were tuned to, by then amplifying the resultant signal with this amplifier and finally detecting the 3,000 meter output again it would be sure to bring in the enemy communications. This was tried and proved highly successful.

Pure theory had been developed into successful practice.

The Fundamental Circuit

The fundamental phenomena involved will be better understood by reference to Figure 1.

Here the pickup is the usual tuned receiving circuit, loop or otherwise, coupled to a local oscillator and a detector. This is followed by the intermediate amplifier designed to operate at some predetermined super-audible frequency, *i.e.*, above 20,000 cycles. This amplifier is connected on its input side

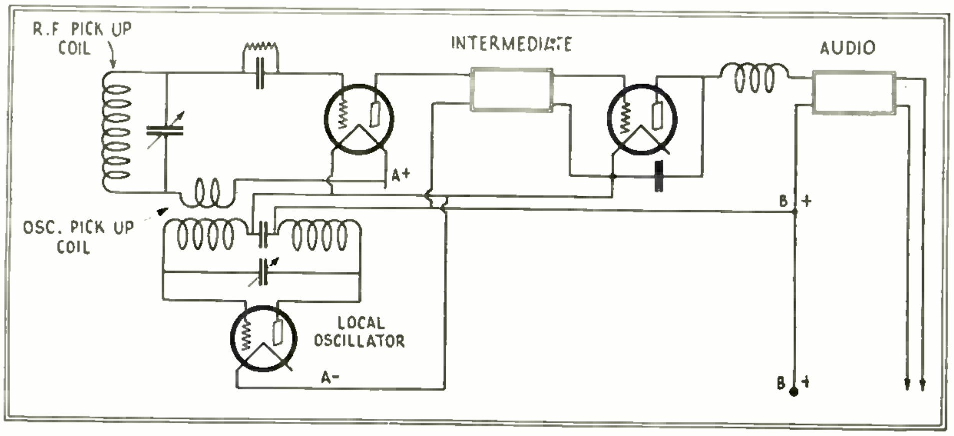


Fig. 1. General plan of the standard superheterodyne. This arrangement is capable of fair results. However, there are many fundamental objections to this design, as pointed out by the author, and such "super" circuits as the General Radio, Remler, Silver-Marshall, Scott, H.F.L. and others have been "serviced," in the manner described, with gratifying results, electrically and financially.

to the first detector and on its output side to the second detector and radio frequency amplifier.

Suppose, now, that the frequency to be received is 1,000,000 cycles a second, corresponding to a wavelength of 300 meters, and for the sake of simplicity the signal is unmodulated. Also assume that the intermediate frequency amplifier is designed for maximum efficiency at 100,000 cycles a second, or 3,000 meters. The first detector is tuned to 1,000,000 cycles and the oscillator is adjusted to either 1,100,000 cycles or 900,000 cycles, either of which will produce a beat frequency of 100,000 cycles. The combined currents of 1,000,000 cycles and 1,100,000 (or 900,000) cycles are then rectified by the first detector and produce in the primary of the input transformer of the intermediate amplifier a direct current with a superimposed 100,000 cycle component. This 100,000 cycle current is then amplified to any desired degree and again detected or rectified by the second detector.

Of course, since the original input signal was not modulated nothing but a series of clicks corresponding to the transmission would be heard unless this output was again heterodyned by an oscillator whose frequency of oscillation differed by the desired tone frequency. This is the method commonly used today when receiving continuous wave signals.

It has been proved that modulated signals or music and speech are handled in precisely the same manner with practically no loss in the modulation itself. The proof of this is quite complicated and will not be gone into here.

To those who might be interested it is suggested that they procure a copy of the Proceedings of the Institute of Radio Engineers for February, 1921, where the original treatise by Major Armstrong and a discussion by A. S. Blatterman appear. This may be obtained from the Institute of Radio Engineers.

Now to get back to the modern application of this principle. It is probably easiest to take up each component unit separately and show wherein faults may lie and give the remedy.

Oscillator Requirements

The purpose of the oscillator is to supply the local heterodyne which when combined with the incoming signal in the detector circuit will create the intermediate frequency. Since it must cover a wide frequency range, provision should be made for maintaining a steady or consistent output over this range. Means for varying the coupling to the detector circuit should be provided to compensate for the variations in output of the oscillator if it is found that a steady output is not maintained.

This is quite important as a correct amount of *mixing* will produce a much cleaner *intermediate frequency* and will prevent overloading of the first detector circuit. Possibly the best method yet advanced is the Lacault system of *modulation* as used in his Ultradyne receiver.

In this arrangement the oscillator furnishes the heterodyne oscillation frequency to the plate of the detector tube in place of the usual plate potential applied from the "B" battery. The incoming signal then modulates this plate current, producing the intermediate frequency.

The plate current of the first detector

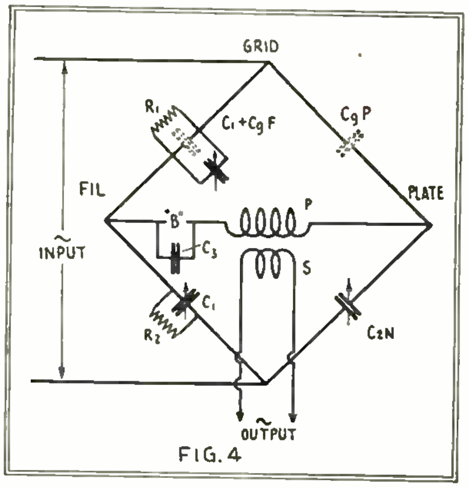


Fig. 4. The "Wheatstone Bridge" effect of the Siemens circuit. Capacity *CgP* and *CgF* are "phantom" capacities. They cause undesired oscillation and are therefore "balanced out".

can be made very steady by proper design of the oscillator, and since the impedance of the detector plate circuit does not vary appreciably over the wavelength range the same mixing proportions result over the entire range.

The easiest way to steady the oscillator output is to maintain a high ratio of capacity to inductance in the oscillator tuned circuit. It is suggested that a capacity of .001 mfd. be used as a tuning condenser, and the coil is so designed that about .0001 mfd. of this capacity is still in the circuit at minimum setting.

It is somewhat difficult to obtain regeneration in the first detector tube when this system of coupling is used, that is, with the usual capacity feedback method. And if regeneration is desired it is necessary to resort to an arrangement as given in Figure 2. Incidentally, the method of connecting the oscillator circuit can be obtained from this diagram also.

The Intermediate Stage

The first thing to consider in designing this amplifier is the frequency best suited for it to function at. There are many things which determine this point, a few of which are given below. The lower the frequency selected the more the amplification which will be attainable, due to greater stability requiring less attention to the neutralization of feedbacks. However, the lower the frequency chosen the more selective must the input detector tuning be made. The reason for this will be readily understood by analyzing a typical case.

Suppose we have selected an intermediate frequency of 51 Kc. Suppose also that we wish to receive station WOR and that both WJZ and WEAF are also operating at the same time. In order to receive WOR, our input *detector* must be tuned to 710 Kc. and our *oscillator* to either 761 Kc., or 659 Kc. to produce the *intermediate frequency* of 51 Kc.

Now, WJZ operates on 760 Kc. and WEAF operates at 660 Kc., and if our input detector circuit will allow just a small bit of energy from either station to come through due to poor selectivity this station carrier energy will also *heterodyne* with our local oscillator, causing a 1,000 cycle "peanut" whistle so commonly heard on most supers, if the receiving set is located where the signal input from WJZ and WEAF is great enough to cause the effect.

Increasing or decreasing the intermediate frequency to 55 Kc. or 45 Kc., just changes the pitch of the heterodyne interference. At 5,000 cycles it may become inaudible to most of us but is still present and sometimes causes *overloading* of both the second detector and audio amplifier.

The solution lies in *input selectivity.* We can increase the selectivity of the input circuits by adding several tuned circuits ahead of them, such as several stages of tuned radio frequency amplification.

The Interference Problem

Tests have been made by the author in a typical location in the heart of New York City with the following number of radio frequency stages found to be necessary to eliminate all trace of interference from this source when used with four of the common types of intermediate amplifiers:

50 Kc.	4 stages
60 Kc.	3 stages
100 Kc.	3 stages
200 Kc.	2 stages

Another type of interference is caused by *direct pickup* of *code interference* by the amplifier and also from *shock excitation* of the pickup circuits caused by commercial spark transmitters, of which there are a large number continually operating around New York City.

Direct pickup of code signals in the amplifier itself can be eliminated by thorough shielding of the intermediate frequency amplifier and its input circuits. Most of this interference is radiated at frequencies between 450 and 540 Kc., and these frequencies should be avoided as intermediate amplifier frequencies unless one is willing to go to considerable expense for shielding.

Even if shielding is fully carried out and the input detector circuits are affected by shock excitation, *i. e.*, pickup of mushy spark signals regardless of where the input circuits are tuned, this energy will also be amplified by the intermediate frequency amplifier, causing disagreeable code reception right through the music reception; which code interference we all agree is quite annoying. Therefore, the best intermediate frequency lies somewhere between 250 and 400 Kc.

The next consideration is *stability* and *frequency selection*. Most of the amplifier systems so far brought out have used one of the so-called losser systems of controlling oscillation or instability, *i. e.*, potentiometer for positive biasing of the amplifier tubes, filament control of one or more tubes of the amplifier, "C" biasing and incorrect plate impedances. It is common knowledge that neutralization of the causes of feedbacks through natural methods offered by several types of neutralizing circuits is much more efficient and is being used almost to exclusion in the better grades of manufactured broadcast frequency amplifiers.

Most of the talk about cutting off side bands in the intermediate amplifier is due more to *near oscillation* of the amplifier when controlled by the losser systems than to sharp tuning. It is practically impossible to get low enough resistance in the tuned circuits of the amplifier when one considers the losses introduced by various forms of bank winding, mounting in shield cans and tuning with mica condensers, *etc.*, as most of the apparatus offered to the public is constructed.

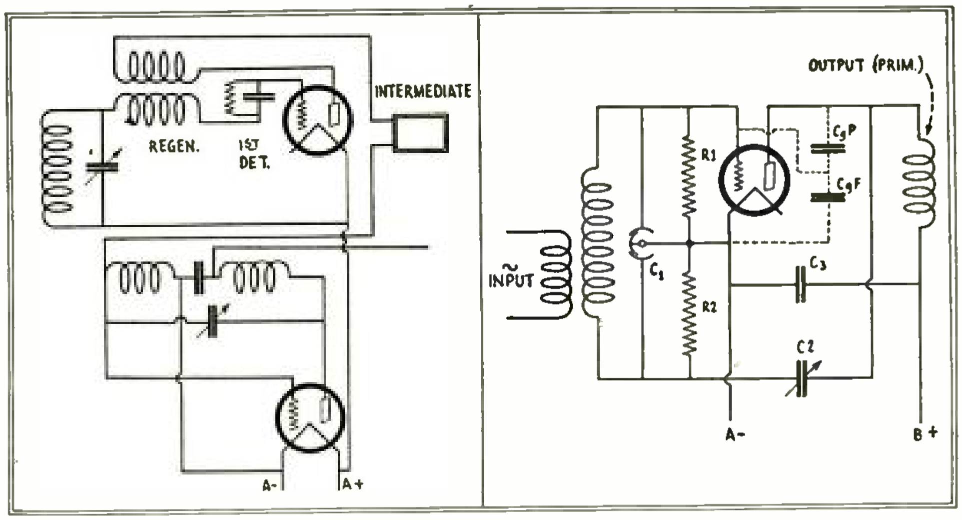
If one will take any of the old amplifiers and properly neutralize and remove all tendency for feedbacks he will readily see the truth of this statement. Fear of poor results from this source can usually be discounted entirely in a properly neutralized amplifier. There are very few neutralizing circuits that can readily be connected to existing apparatus, due to their construction.

The Capacity Bridge

The circuit given in Figure 3, while not very well known, can, however, be readily adapted to any super with complete satisfaction. This circuit comprises a *capacity bridge* which when properly adjusted and balanced gives *complete neutralization* of all causes for feedback.

The electrical equivalent is given in Fig. 4, and one who understands the principle of the Wheatstone bridge so commonly used in electrical testing measurements will immediately see the advantages of this system. It is possible to connect this system to any superheterodyne receiver, and the tremendous advantage gained by its use is distinctly worth while.

In regard to selectivity and gain per stage, transformer coupling will be found better than impedance coupling in both respects. Also tuned air core transformers are usually far superior to the untuned iron core types when properly constructed.



At left. Fig. 2 indicates a successful means for adding regeneration to the first detector circuit of a modulation-system plate-supply superheterodyne. At right. This, Fig. 3, conveys the principle of the "capacity-bridge" neutralizing method. For maximum amplification, each secondary should be accurately tuned to the intermediate frequency. If the coils require balancing, this may be accomplished by shunting *R1* and *R2* (and therefore the coil) by means of two small (additional) variable condensers.

The question of the number of stages necessary to obtain the best results is dependent on the *location* and the *gain per stage*. Some people can get along nicely with only two stages, while others require four. The general average is three stages, and will suffice except under extreme handicaps of poor locations.

It is advisable when using the tuned air core transformer to do the tuning with variable condensers rather than depend on matched fixed condensers. This has two advantages, one being the ability to tune exactly each stage to resonance and be sure of it, and the other is the allowance to shift the tuning of the intermediate frequency if it is found to be necessary to get around some peculiar type of heterodyne interference.

Thorough shielding of the entire receiver is advisable if the set is to be used in congested radio sections, and will also help to keep the noise level caused by man-made interference, such as elevator motors, contactors, *etc.*, out of the receiver.

It is also advisable to use at least one stage of radio frequency amplification before detection to prevent overloading of the first detector when receiving distant stations right alongside of powerful local stations, as a large percentage of the local signal is probably present in the detector circuit; even though the selectivity of your intermediate amplifier is such as to prevent you from hearing the local signal its presence can cause overloading, and consequently poor reception of the distant station.

If extreme sensitivity is wanted a conventional grid leak and grid condenser may be used in the second detector circuit. However, this system too readily allows overloading of the second detector, and it is recommended that a "C" battery type of detector circuit be used. The tone quality will be slightly better and the loss in sensitivity can usually be discounted as the amplification from the intermediate amplifier is usually great enough to overcome this loss.

It is also advisable to provide some means of preventing the intermediate frequency from entering the audio amplifier. This is best accomplished by placing a suitable radio frequency choke and bypass condenser in the plate circuit of the second detector. It usually takes a larger choke than those found sufficient in the ordinary radio frequency amplifier, due to the lower frequency coming from the intermediate amplifier. From 250 to 500 millihenries will be sufficient when used with a .001 bypass condenser from the detector plate to the negative filament.

Complete details for the revision of any superheterodyne receiver, except impedance coupled types, may be readily had from the complete circuit incorporating the above ideas in Fig. 5. In this circuit *C1* is a dual balanced condenser, midget size, having two separate 2-plate stators and one 3-plate rotor. Each half has a capacity of about 35 mmfd. The value is not critical. As the condenser is adjusted the capacity increases on one side and decreases on the other.

Neutralizing

Reference to the schematic circuit of Fig. 3 will explain its purpose, which is, briefly, to provide an *electrical center tap* on the secondary of the transformer and to compensate on one side of the bridge for the capacity which normally exists between the grid and filament of the tube. *C2* is the neutralizing condenser (of five plates), which duplicates the capacity existing between grid and plate of the tube. *C3* is the "B" circuit by-pass condenser and prevents coupling between the various tubes through the medium of the

(*Concluded on Page* 142)

Servicing the Broadcast Receiver

At a meeting of the Radio Club of America, held at Columbia University, the writer, a radio research engineer, read a paper, which described in detail the most common troubles in radio sets, and gave practical methods for discovering these troubles and suggestions for their remedy. Some of the important points discovered by Mr. Aceves are briefly outlined in this article.

By JULIUS G. ACEVES

THE tasks in servicing sets fall under the headings of installation, maintenance and repair. Frequently, simple inspection is sufficient to locate the troubles, which in many cases, originate from the misuse of the set for lack of ability to operate it—in fact, for lack of ordinary common sense.

Leaving aside the installation of sets, which is not the main purpose of our text, let us examine the problems that the service man may be confronted with, and then suggest some general methods that will guide him to a solution in the majority of the cases. Then we will exemplify some special treatments in exceptional and involved cases.

A radio set comprises:

I. Several sources of electrical energy.
II. An R.F. Amplifying System.
III. One or more frequency converters.
IV. An A.F. Amplifying System.
V. An electrically operated sound reproducer.

I. The sources of electrical energy are:

1. From the radio waves collected by an antenna or loop.
2. From the "A," "B" and "C" voltages furnished by batteries or house current tap.

The troubles from the first source may be ascribed to—

(*a*) Insufficient aerial, and
(*b*) Defective aerial and ground system.

Under (*a*) there may be—open or short circuits, and loose connections in the pickup system. A continuity test will reveal the defects under heading (*b*). However, for the present, no remedies will be suggested until we list the most common troubles.

2. The sources of power for the operation of the tubes are manifold, and the troubles may come from—

(*a*) Insufficient voltages
(*b*) Excessive voltages
(*c*) From the presence of other than continuous currents in the supply leads.

These currents are, in most cases, harmonics of the frequency of the power supply line; at times, the fundamental may be present and, frequently, currents originating from other electrical devices connected to the same lines. Of the latter, the transients are the most objectionable and difficult to eliminate, especially in sets for D.C. These interferences may come, nay, they actually do come at all times *via* the radio pickup system, particularly by antennas that happen to run near radiating electrical apparatus such as sparking motors, X-ray machines and high tension sparking devices for ignition capable of producing shock excitation. In this case there is little hope for remedy as the interfering E.M.F.'s contain practically a continuous spectrum of frequencies, consequently including the signal frequency.

II. In the R.F. system, as in the rest of the vacuum tube networks in the radio set, troubles may be due to—

1. Poor amplification.
2. Poor tuning.

In the former case, most troubles come from (*a*) defective or wornout tubes, (*b*) by their operation at improper "A," "B" or "C" potential. However, the R.F. system has troubles of its own, mostly due to (*c*) regeneration and oscillation, and (*d*) excessively sharp or broad tuning, or no tuning at all.

It has been found that certain radio frequency transformers were made with coil forms which absorbed moisture to a very appreciable extent; cotton covered wire has this faculty to a high degree unless special precautions are taken. When moisture thus affects the operation of a radio set, it is observable as a considerable loss in volume and occasionally broad tuning. The remedy is to change the coils or to treat them with a protective covering.

The superheterodynes involve considerations which are taken up in the following paragraph. The places for trouble are more numerous in this type of receiver, but these receivers are relatively few in number.

III. The frequency converters have for their function to re-create either directly or by means of an auxiliary R.F. system, the original modulating wave at the broadcast station. They are called detectors and in most instances tubes with or without a condenser-and-leak accomplish the desired result. In the superhets, there is a conversion of frequency at the first detector, which does not recreate at once the modulating wave, and here the troubles multiply themselves "*ad infinitum*" in home-made sets, as well as in some commercial sets. The difficulties experienced in these frequency trans-

Most General Troubles In Tabular Form

I. IN THE SOURCES OF ENERGY

1. Pick-up System	(a) Insufficient Input to set	(a) Aerial too short
		(b) Aerial shielded
		(c) Loop in wrong direction
		(d) Set in bad location
	(b) Opens and shorts	
	(c) Loose connections	
2. "A," "B" and "C" source	(a) Insufficient Voltages	(a) Bad tubes
		(b) Opens and shorts
	(b) Excessive Voltages	(a) Poor design
		(b) Wrong connections
		(c) Opens and shorts
	(c) Extraneous currents	(a) A.C. hum due to defective filtering
		(b) A.C. by induction or conduction or capacitance
		(c) Transients

II. IN THE R.F. SYSTEM

1. Poor amplification	(a) Bad tubes	
	(b) Improper voltages	(a) Opens and shorts
2. Poor tuning	(a) Broad	(a) Condensers not tuning all alike
		(b) Opens or shorts
		(c) Too long an aerial
	(b) Sharp	(a) Regeneration due to defective design or operation or wrong tubes
		(b) Neutralization incomplete
		(c) Excessive "B" voltage

formations are caused by the presence of harmonics in the local oscillator, giving rise to a multitude of radio-frequency currents interfering with each other and thereby distorting the signal very badly. In some of the latest models of high gain R.F. sets, the detection occurs where the modulating frequency is recreated (second detector in superhets) and the tendency is to eliminate the condenser and leak and use the curvature of the plate current characteristic. This system will reduce the detector troubles to a minimum. In the detector that brings back the original modulating wave, the troubles may come from—

1. Operation of tube at improper voltages.
2. Open, short circuited, or defective condenser-and-leak.

IV. The A.F. system is responsible for most, but not all the troubles from distortion in a radio set. It rarely fails to work entirely and when it does it is due, as a rule, to defective tubes or to lack of proper "A," "B" or "C" voltages. Open and short circuits in this system usually weaken the signal to an almost inaudible strength, but poor tone quality may come as a result of several factors, of which the most common and important are:

1. Bad tubes.
2. Poor transformers.
3. Bad plate resistors and leaks.
4. Short circuited turns in the transformers.
5. Saturation of iron cores.
6. Coupling between stages, particularly between power stage and detector grid or plate returns.
7. Impedances not properly matched in the system.
8. Power stage of insufficient undistorted power capacity for the volume of sound required.
9. Periodic fluctuations in the "B" and "C" voltages commonly known as "motor-boating."
10. Loose connections.

Of all these items, Nos. 1, 6 and 8 are the most common in the modern radio receiver, because all the latest sets have been designed with high-grade transformers where care has been taken to match the impedances of the tubes with the transformer windings, and the cores are so designed that when the tubes have the proper "C" voltage the steady component of the plate current will not saturate the iron cores. As to resistance-coupled sets, there are so few in existence that little trouble is to be expected from items 3 and 7; however, the greatest malady of such sets is in the periodic fluctuations of "B" voltage which produce a sound in the loud speaker similar to the chug-chug of a motor engine; hence the popular term attached to this sort of trouble. It comes from the operation of resistance-coupled sets from filters that are not suitably designed for them, and the action is so well-known that it will not be discussed at length. (Battery operated sets rarely, if ever, "motor-boat".) The most effective remedy is effected by the use of smaller coupling condensers or grid-leaks, or both. If a high-capacity condenser is available, it usually stops motor-boating when connected across the "B" voltage supply leads.

V. The reproducer is the ultimate terminus of the audio frequency and it is here a considerable portion of the distortion results in many sets. Reversed leads are a frequent source of trouble. These may be the terminals which connect directly to the output of the set, or they may be leads, inside the unit, which join the voice coils to each other or to the cord. To properly check and correct this fault will require a delicate magnetic system capable of indicating and differentiating between degrees of magnetism. However, a knowledge of the unit and an appreciation of audio volumes will occasionally suffice. A compass is an aid to locating reversed magnetic polarity. Filings in the gap often cause distortion.

A source of distortion which may escape casual investigation is that due to sub-audible, or nearly sub-audible frequencies either generated or induced into the output audio system. When dynamic type reproducers are used the most general cause is imperfect filtration. A capacity of 2,000 mf. in shunt to the field winding usually suffices to reduce this low frequency oscillation to a negligible amplitude.

"Permanent magnets" are not permanent, and distorted reproduction from magnetic type reproducers may indicate a need for remagnetizing.

Having listed the most common difficulties experienced in connection with the whole receiving plant, let us now suggest methods to discover the faults without wasting unnecessary time and worry. For the purpose of refreshing our recollections, we give in tabular form a list of the troubles and their sources, so that by inspection of the table the remedies will become obvious in many cases.

III. IN THE DETECTOR		
1. Single detection	(a) Lack of sensitivity	(a) Improper voltages
		(b) Open or short circuits
		(c) Low resistance leak
		(d) Short circuited grid con-condenser
	(b) Distortion	(a) Improper voltages
		(b) Open leak
		(c) Improper capacity of condenser
		(d) Open circuits
2. Double detection	(a) and (b) same as above	
	(c) Harmonics from the oscillator	
	(d) Unsteady oscillator frequency	(a) Poor design
		(b) Excessive feed back
IV. IN THE A.F. SYSTEM		
1. Feeble or no response	(a) Bad tubes	
	(b) Open and shorts	
	(c) Wrong connections	
2. Distorted output	(a) Poor design	(a) Poor transformers
		(b) Saturated cores
		(c) Regeneration, Positive and Negative
		(d) Power stage of insufficient output wattage
	(b) Poor construction, assembly or operation	(a) Coupling through eliminator
		(b) Impedances not properly matched
		(c) Motor-boating
V. IN THE LOUD SPEAKER		
1. Feeble or no response	(a) Opens and Shorts	(a) In the leads
		(b) In the "motor"
		(c) In the power supply in dynamics
	(b) Poor adjustments	(a) In the air gap
		(b) In the diaphragm or cone
2. Distorted reproduction	(a) Same as above	
	(b) Impedances not matched	
	(c) D.C. through "motor"	(a) Shorted coupling condenser
		(b) Absence of coupling circuit to power tube
	(d) Loose parts	(a) Loose Wiring
		(b) Sympathetic vibrations on surrounding objects
	(e) Insufficient air column	(a) Short horn
		(b) Short baffle board
	(f) Regeneration	(a) Electric Feed-back
		(b) Acoustic resonance
		(c) Acoustic-electric back-couplings to tubes in set

The Cooperative Radio Laboratory

Where all experimenters may meet on a common ground to discuss and develop radio technicalities.

DAVID GRIMES, Director

IN our last article, we went to some length to point out that grid-leak detection is more sensitive on weak signals than the "C"-bias method. The operation of the two methods was discussed, and it was shown that the grid-leak detector, while more sensitive on weak signals, is easily choked up on medium and loud reception. This choking ruins the tone quality and makes it quite difficult to obtain satisfactory reception of the bass notes on local and medium-range programs. The "hybrid crystal" was presented as a solution of this grid choking, as it operates, apparently, on a "grid-dumping" principle. It actually detects best when so connected in the grid of the tube that it allows the electrons thereon to flow freely to the filament; while the grid-leak system operates on just the opposite principle.

Now, no attempt was made to explain why the grid-leak is more sensitive. This we will try to do, as it is rather necessary for a proper comprehension of the hybrid-crystal circuit. A great many circuit combinations are just pure nonsense, because they are merely different ways of doing the same thing. Such circuits must sooner or later fall by the wayside, as they constitute no improvement in the art and accomplish no real purpose. The hybrid-crystal combination, however, is not "just another one of those circuit contraptions"—but a knowledge of the grid-leak detector is required to fully appreciate it.

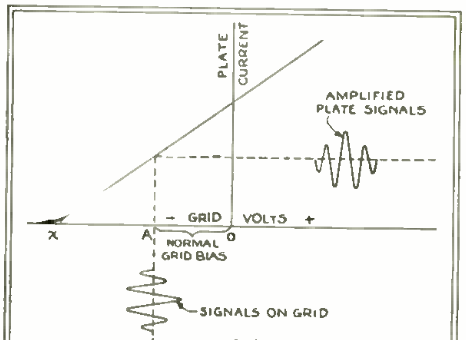


FIG. 1

In this figure is shown the effect at point A of grid voltage swing on plate current. Compare this figure with figure 2.

Why "Plate Rectification"?

The "C"-battery (or plate-rectification) circuit operates *by reason of deliberately-distorted radio-frequency amplification.* Reference should here be made to Fig. 1, which shows the operation of a standard radio-frequency amplifying tube employing normal "C" bias. The incoming signals vary the potential on the grid, back and forth, about the normal bias as shown at "A". This causes the plate current to vary in a similar fashion about the point representing the normal value caused by the normal "C" bias. As long as the "C" bias is kept at a value about half-way between the point "X" (where the plate current is entirely cut off by the excessive negative "C" bias) and the point "O", the plate current will increase and decrease equally for each increase and decrease of the grid voltage. We then have undistorted *amplification.*

But, if the "C" bias on the grid is increased to the point "X" (where the plate current is entirely cut off) there will obviously be no action in the plate circuit as the grid swings still further negative (from the normal) upon receiving an incoming signal. When, however, the grid voltage increases so as to result in a potential less negative than the point "X", some plate current will flow. This results in *unequal amplification,* as shown in Fig. 2. Such an action causes the plate current gradually to increase and decrease, as the incoming wave increases and decreases under the influence of the controlling microphone at the transmitting station. Detection has occurred as a natural result of the *unequal amplification.*

While all of this seems a bit technical and complicated, we hope you will bear with us, as it is quite illuminating when you have grasped it. We are now coming to the main point in "C"-battery detection. The audio currents created by the detector action originate in the plate of the detector; hence the name "plate rectification".

Grid Rectification

The action is entirely different in the grid-leak detector; in this case, amplification of R. F. currents is not a factor. The grid is kept at a normal potential, about that of the positive end of the filament. Then, each time the grid swings positive, as the signal is received, it attracts electrons to it. The electrons, not having a ready path to filament, tend to accumulate—thus building up a negative potential on the grid. This accumulation increases and decreases as the incoming signal increases and decreases under the influence of the transmitted program. It is thus clearly seen that the audio signal originates, in a grid-leak system, in the grid—by virtue of grid choking! Fig. 3 shows the operation of a grid-leak detector and Fig. 4 shows the actual detecting circuit—the grid only!

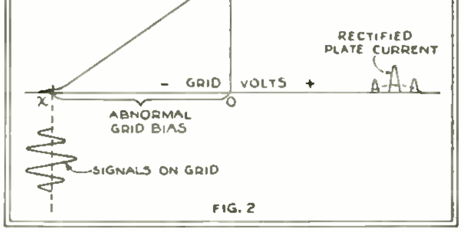


FIG. 2

In this figure the plate current is shown with the grid swing at X. In figures 1 and 2 a "C" battery has been indicated.

Now, obviously, the plate circuit serves no purpose for detection. Yet we know that any audio-frequency voltage placed on the grid will result in amplified currents in the plate. The plate of a grid-leak detector *must* act as an audio amplifier. It does! This is shown in Fig. 5. Thus, any radio set which uses grid-leak detection really has one more audio stage of amplification than appears on the surface. The grid-leak detector is that audio stage; no wonder that this system of detection is more sensitive on weak signals. (As previously stated, it is not satisfactory on signals strong enough to choke up the grid completely.)

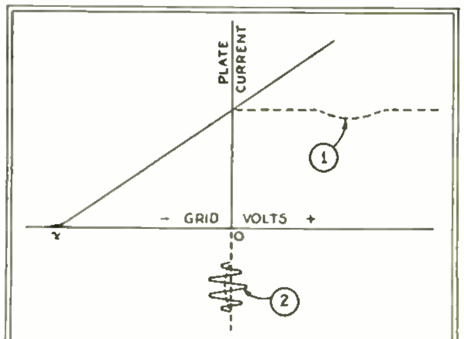


FIG. 3

Here we see the effect on the plate circuit when the "grid-leak-and-condenser" type of rectification is used. This is the arrangement generally conceded to be the most sensitive.

It should be apparent from this that the grid-leak detector functions simultaneously as a detector and an amplifier. So any other system that would compete with the sensitivity of the grid-leak must not only detect, but also act as one stage of audio amplification.

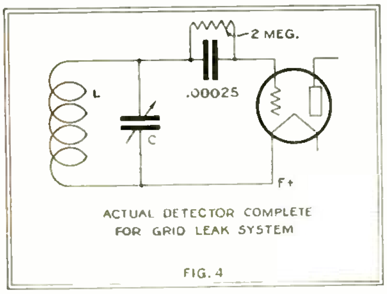
At this late day in radio design, we would indeed be foolish to advocate the use of a crystal detector, if it were not better than present methods. Let us get this little thought clearly in mind before going further. *A plain, simple crystal detector, as such, is not as good as either "C" bias or a grid-leak tube.* A crystal detector is about as efficient as a two-element tube rectifier. But the reason that the "C"-bias detector is superior is that in detecting, it amplifies the *radio frequency;* and the reason the grid-leak is still more sensitive, is that it efficiently amplifies the *audio energy.* The tube is better than the crystal only so far as the amplification of the tube is added to the rectifying properties.

Separate Detector Action

It is but a short step from the above conclusion to the hybrid-crystal arrangement shown in Fig. 6. (The Gernsback *Interflex* circuit.) Here we propose to employ the crystal expressly for rectification or detection and the tube, with which it is associated, for amplification. Under these circumstances, there is nothing we have yet found (with the exception of the regenerative detector tube) that will compare in sensitivity to the hybrid-crystal circuit—and, of course, the tone quality of the crystal is much to be preferred to that given by a regenerative detector.

We had become so accustomed to expecting only local reception from a crystal detector that we received a real thrill when the crystal-hybrid was first put on the air. *Without any sort of radio-frequency amplification or regeneration,* all average stations up to 200 miles, and many of the more powerful ones as far away as 500 miles, came in with satisfactory volume. Now, think that over; that beats even the famous super UX-200A soft detector. Do you wonder we are enthusiastic over its possibilities?

Another problem must be considered at this point. A stage or two of radio frequency adds amplification and permits increased selectivity. So, when dispensing with radio frequency for our crystal tests, we must supply some circuit which will still give some selectivity. For this purpose, we are submitting the "Tandem Tuner", shown in Fig. 7. Tuning circuits designed for selectivity have existed from the earliest days of radio. In fact, tuned consecutive circuits were in use several years before the three-ele-



Schematic circuit of the usual grid leak-and-condenser combination, which the "hybrid tube" development supplants.

ment vacuum tube was invented. So, fundamentally, the "Tandem-Tuner" idea is not new; but we dare say that few of you have ever tried it. The results are well worth the effort.

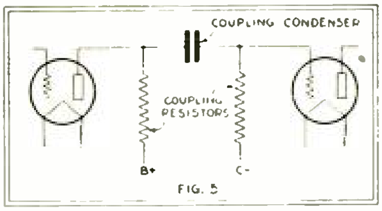
Again referring to Fig. 7, the dial of condenser *B* tunes exactly like the second dial of any tuned-radio-frequency set. In fact, the actual operation of both dials *A* and *B* appears to be the same as would be experienced were the two separated by a radio-frequency tube. Of course, the amount of coupling between the two coils largely governs their behavior. If the number of coupling turns is too great, both circuits become broad. If the coupling turns are too few, considerable volume will be sacrificed. This coupling primary should have about six per cent as many turns as the secondary; this means about 5 or 6 turns in a coil having 90 to 100 in the secondary.

It was a tandem-tuner that helped more than anything else in permitting our hybrid-crystal circuit to pick up distance reception through locals. But can you imagine the extreme sensitivity of the crystal-tube combination that would still pick up weak signals even after some signal strength had been sacrificed through a tuning filter?

Advantage of Tandem Tuning

This tandem-tuner idea is worth watching; we believe that it is the coming system, even if two or more stages of radio frequency are employed. At the present time, most of the commercial broadcast receivers employ a stage of untuned radio frequency between the antenna and the tuned stages. This serves to remove the antenna variations from the tuning dials. The only difficulty is that such a circuit gives a lot of trouble near any powerful broadcast station. Being untuned, this tube amplifies everything brought in by the aerial—the near-by local as well as the desired "DX".

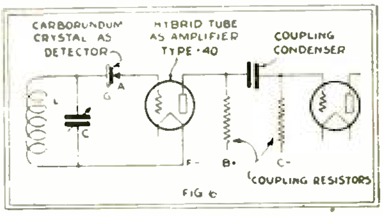
Herein is the difficulty. The local sta-



Grid swing in the detector acts in a similar manner to that in any audio tube, resulting in audio amplification in plate. Grid condenser and leak do not enter into the problem.

tion is so strong that the first tube is generally overloaded; this causes *detection of that station and the presence, in the plate of the first tube, of audio currents representing the local program.* These audio currents impress themselves on all other radio carrier waves passing through this untuned coupling tube. So, no matter what wave is subsequently tuned in, one immediately hears the local program in the background—riding through on the new wavelength as a cross-modulation from the first tube. This annoyance is bound to kill eventually, the untuned-coupling-tube idea.

But, with the tandem-tuner, the opposite effect is utilized. Instead of the antenna currents reaching the first tube without tuning, only the wave of the station desired ever gets as far as the first tube, because of the two tuned selective circuits in the tandem. Interference and cross-modulation never occur with this



An experimental circuit which incorporates a crystal detector coupled to a tube having a high output impedance is illustrated.

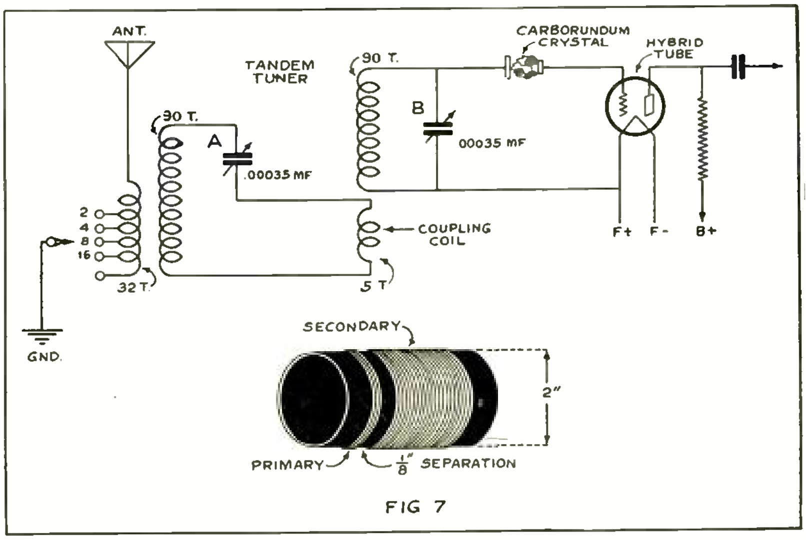
scheme. Of course, the arrangement adds another tuning condenser; but, fortunately, the tuning of the tandem is sufficiently broad to permit ganging the controls without any serious difficulty.

Special Audio Arrangement

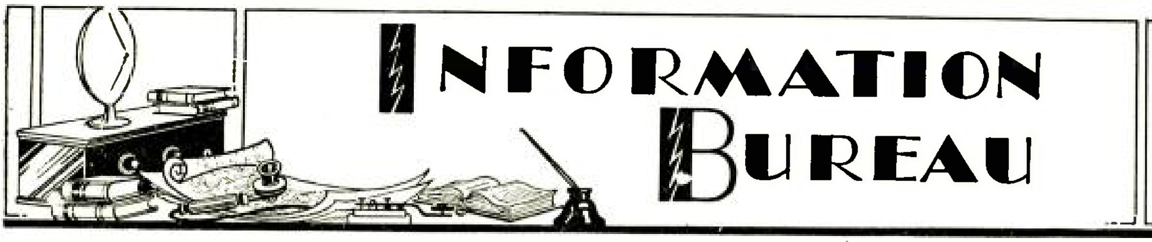
Before closing the Cooperative Radio Laboratory for this month, we must give a little more information on the audio circuit; in our Cooperative Laboratory last month this was just touched upon. With this circuit angle more fully explained, we will then be ready for the complete battery-operated hybrid-crystal receiver. Then, if sufficient interest is shown in this engineering, we will discuss the complete A. C. design for the circuit; so that you will be able to operate the set directly from the 60-cycle, 110-volt, electric mains. The circuit also lends itself admirably to D. C. design—that is, electrified operation from 110-volt direct-current mains; this will appeal to many readers who live in the D. C. districts of large cities. Satisfactory electric circuits for such conditions are very rare; but the hybrid-crystal seems to turn the trick. Let's hear from you on this if you are interested.

Fig. 5 in the August issue of RADIO-CRAFT showed an audio circuit composed of one stage of resistance coupling and

(*Continued on Page* 142)



Complete schematic circuit for an unusual coupling arrangement designed to result in a very high degree of selectivity without a great number of controls, even though a crystal detector is shown.



SPECIAL NOTICE

When writing to the Information Bureau, correspondents are requested to observe the following rules:

(1) Ask as many questions as desired, but furnish sufficient information to permit a proper diagnosis. Carefully drawn schematic diagrams are often desirable.

(2) Inquiries (not too involved) to be answered by mail must be accompanied by 25c in stamps, per single question. Blueprints are not available.

(3) Use only one side of paper and LIST each question.

(4) We cannot furnish comparisons between commercial instruments.

(The reader with the greatest number of interesting questions each month, although they may not all appear in the same issue, will find his name heading this department.)

Highest for the Month: N. E. LILLEY with 6 Interesting Questions

PLEASE BE SPECIFIC!

AT the head of our department this month we nearly had the name of Mr. Herbert Johnson. He submitted four very interesting questions; but two of them were too vague and did not contain sufficient information to enable us to diagnose the situations.

If Mr. W. H. Poulk (Oil Hill, Kan.) will explain what he means by the words "work successfully," and will send a diagram of the exact connections used, his troubles can be diagnosed.

As Mr. Ellis G. Glover (LaPorte, Ind.) does not furnish the make and type of his untuned radio-frequency transformers, or the schematic circuit of the set he wants to improve, we advise that no assistance can be given until more complete details are furnished.

As it is always necessary to know the "load" under which a power transformer is to work, before such transformer can be designed, and until we know the load demands of his radio set, we cannot furnish the design required by Mr. Oswald Robert (Laval, Que., Canada).

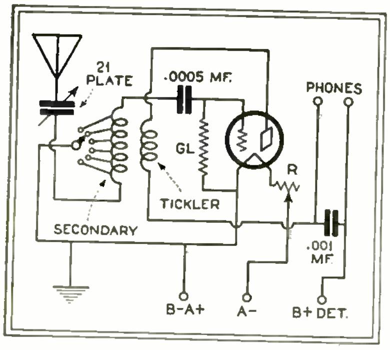
We are requested to "——print a sixteen-tube set (electric) for D. C. with pick-up, screen-grid in the last stage, and all tubes in series so as to use the five amperes in each tube (or more, according to the type of tube called for), good for DX." As the request of Mr. Felix A. Lopez, New York City, is contradictory we find it impossible to comply.

ACE TYPE "TRU" SET—EDISON "DISTANCE" SWITCH

(13) Mr. Louis Holmes, Beallsville, Ohio.

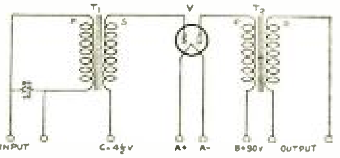
(Q.) Please publish the schematic circuit of the regenerative receiver called the "Ace, Type TRU" set. The diagram is desired, to enable the writer to replace certain leads which were unintentionally removed by him.

(A.) The circuit requested appears in these columns.



(Q. 13.) Schematic circuit of the "Ace" Type TRU receiver. Regeneration is controlled through the variable coil indicated as "tickler."

It is not essential that the grid condenser have a greater capacity than .00025-mf. Changing the value of the grid leak (G.L.) will result in a great change in the operation of the set; the effect being dependent mostly on the battery voltages and particular tube used.



(Q. 14.) Fig. A. A single-stage audio frequency amplifier unit. This may be used with any hookup requiring such an amplifier. The vacuum tube V may be any tube designed for the service intended. The transformer and voltage constants will be guided accordingly.

An audio-frequency amplifier may be added (it is recommended), the primary being connected to the two binding posts marked "phones." The circuit for such an amplifier is quite standard.

This is a particularly sensitive circuit but it must be operated with care to prevent excessive radiation of energy which would cause interference with other reception.

The 21-plate condenser has a capacity of about .0005-mf.

(Q.) How does the "Distance" switch on an Edison radio set work?

(A.) It controls regeneration in the detector tube circuit.

AUDIO AMPLIFIERS

(14) Mr. E. C. Heidenreich, Indianapolis, Ind.

(Q.) Please print several diagrams of amplifiers that can be used as separate units, apart from the radio set; and to operate on dry cells.

(A.) We are showing two circuits which may be what you desire.

In A, transformers T1 and T2 are of the standard type. If high-ratio ones are used, high volume will result at the expense of quality; using relatively low-ratio units will result in relatively better quality. The voltages are as indicated. This is the arrangement for a single stage of audio amplification. It may be desirable to shunt the input, or primary winding, of the first audio-frequency transformer with a fixed condenser of .001-mf. capacity, as indicated in dotted lines; the output of the tube may connect to a pair of headphones or to the primary of a matching transformer, the latter arrangement being shown.

A two-tube circuit is illustrated in Fig. B. A power tube in the last stage is recommended and illustrated. It is of the dry-cell type. Resistors are ballasts designed for the particular tubes in the filament circuits of which they are shown.

S.G. TUBES—RECTIFIER—CROSLEY SET

(15) Mr. N. E. Lilley, Montreal, Que., Can.

(Q.) Is it best to shield all screen-grid tubes in a set; and, what does the "G" post on the tube socket connect to when a screen-grid tube is used?

(A.) If care is taken in the placement of parts, location of leads, and instruments used, it is not necessary to shield the screen-grid tube. In general, it will be desirable to shield the tube, and thus obviate the necessity of taking particular precautions to prevent circuit interaction.

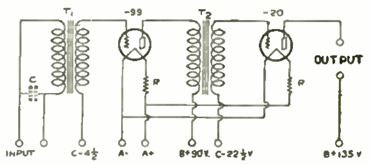
The socket binding post referred to connects to that part of the circuit indicated in the diagram being followed. In most instances, it will be a lead to the 45-volt "B+" tap on the "B" battery.

(Q.) If a lead-aluminum-borax solution type of rectifier is connected to the 110-volt A.C. circuit, will it operate satisfactorily as a "B" eliminator, series resistances being used to limit the output to two voltages, 90 and 45 volts?

(A.) This arrangement is quite satisfactory and it is only necessary to connect a 25-watt lamp in one of the A.C. leads as a safety measure. Filter chokes and condensers are necessary to smooth the ripple.

(Q.) In my set, which is a Crosley, are two fixed condensers, .01-mf. each. One is in the detector grid lead and the other is in the last audio grid lead. Removing them from the set results in a 10% increase in volume; why is this?

(A.) The capacities mentioned are unusually



(Q. 14.) Fig. B. Schematic circuit of a two-stage audio frequency unit. This circuit permits of greater amplification than the one shown as Figure A; either circuit, however, may be used, depending upon the amplification desired.

large. If they are removed and the circuit closed through, the grids will be operating "at a different point on the characteristic curve." As this point may be the most sensitive adjustment for the particular tubes you are using, increased volume will result, on weak signals; however, it is quite possible that this connection would not result in as good volume on strong signals, as with the original circuit.

MICROPHONIC NOISES — DISTORTION—PARALLEL PLATE FEED

(16) Mr. John Patrick, Toledo, Ohio.

(Q.) What is the test for microphonic noises in a five tube set?

(A.) You may check by the localizing method as follows:

1. Remove last audio tube. If crackles continue, check "A", "B" and "C", loud speaker unit and cord, and everything associated with that tube. If noises stop:
2. Try another tube in the same socket.
3. Remove next to last audio tube. If crackles continue, check all parts connected to that tube. If crackles stop:
4. Try another tube. Continue this elimination process to localize and then locate the fault.

Another method is to use a pair of headphones to check reproduction of the detector circuit and continue this progression until last stage of audio has been reached.

We had the peculiar experience related below.

Crackles with tube in socket; no crackles otherwise. Tube exchange was no remedy. Changing a leaky condenser, however, cleared the trouble.

(Q.) I have a neutrodyne receiver, the reproduction of which seems to have a high note "fuzz." Can this be due to the neutralization not being as exact as it was?

(A.) It can be. Also:

1. The insulation of the neutralizing condensers may be leaky, causing detection in one of the R. F. stages, due to the positive potential impressed on the grid.
2. The detector grid leak value may have changed.
3. Defective tubes often cause this trouble.
4. The audio transformers may need to be replaced. (This is an unusual source of distortion.)
5. The reproducer may need repair. (Probably re-magnetizing.)
6. Defective by-pass condensers may cause the trouble.

(Q.) What is a "parallel plate feed" amplifier?

(A.) When a circuit is connected in parallel plate feed fashion, the A.C. is isolated from the D.C. which supplies the plates of the tubes.

The principle of parallel plate feed has been applied to both a single tube circuit and to a push-pull circuit to eliminate direct current from the iron-core inductance.

This is being done by using an inductance or a resistance to develop a drop for the A.C. potential and a feed for the D.C. By means of a condenser, the A.C. (which may be at radio frequency or at audio frequency) is "drained" to the succeeding tube or tubes.

A little study of the schematic diagram that accompanies this answer, will make the point plain.

A very clear and concise explanation of the theory and application of plate feed appears in the February, 1929, issue of *Radio Broadcast Magazine*. The article is by Mr. Kendall Clough, originator of the circuit.

PERMALLOY—REACTIVATING TRANSFORMERS

(17) Mr. L. K. Leighton, Oakland, Cal.

(Q.) What is Permalloy?

(A.) Permalloy is an alloy consisting of 73½% nickel and 21½% iron. It is annealed and heat treated in such a way that the resultant material in addition to being magnetic has a permeability greater than any other grade of iron known. It loses its magnetism more quickly and more completely than any other iron.

It is used mostly by the Western Electric Company and certain cable companies.

When used in cables it is a ribbon wrapped around the bundle of wires. This ribbon measures one-half inch in width and is one-six-thousandth of an inch thick.

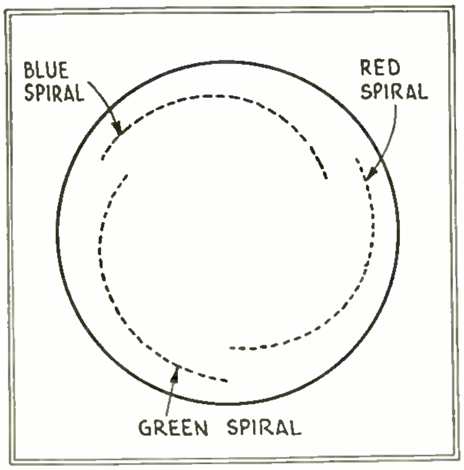
In radio, its application is different. It forms the core of audio frequency transformers working over the entire audio frequency band. More "brilliant" reproduction results.

(Q.) I have an Amertran first stage DeLuxe audio transformer which has a Permalloy core, I understand. The quality did not sound good so I changed it for another of the same type and immediately the beautiful tones I had originally were duplicated. Is it possible for transformers to change with age?

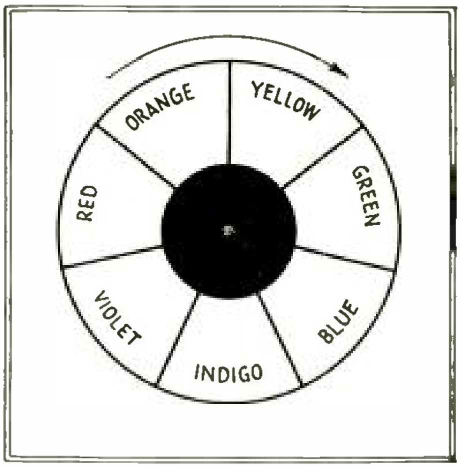
(A.) Yes, it is possible and occurs more often than is realized. Age, tube plate current and mechanical shocks can cause it. Particularly, transformers having a special nickel-iron core material are the only ones subject to this condition, so far as we know. It is our guess that, perhaps unknown to you, the primary of the transformer was shunted across the direct current plate supply.

If, due to a fault in the tube, or to an accidental contact of some tool, the plate contact of the audio tube should be momentarily connected to the "A" circuit, this would result.

To reactivate your DeLuxe transformer, connect only the primary winding to the 110 volt A.C. lighting circuit for one minute, with the secondary entirely disconnected. This will rearrange the molecular structure of the special iron which, incidentally, is not Permalloy.



(Q. 19.) Three rotating spirals of holes, arranged as shown, made television in colors a possibility in the Baird system.



(Q. 19.) Newton's Disk. By rotation of the proper combination of the primary colors of the visual frequency spectrum, it is possible to produce the sensation of "white".

RECEPTION—CELOTEX

(18) Mr. Frank L. Lanning, Upper Montclair, N. J.

(Q.) Is it possible to forecast radio reception conditions?

(A.) Within practical limits it is possible to anticipate very closely, reception conditions in a certain area, by noting the barometer reading. A rising barometer indicates probable good reception conditions and a falling barometer, poor reception.

(Q.) What is Celotex made of?

(A.) "Celotex," the material of which thousands of dynamic and magnetic speaker baffles are made, is constituted of sugar cane stalks compressed to four times the former density, resulting in a solid board with almost negligible acoustic resonance. The boards average one and one-half inch in thickness.

NEWTON'S DISK—TELEVISION—RESISTOR

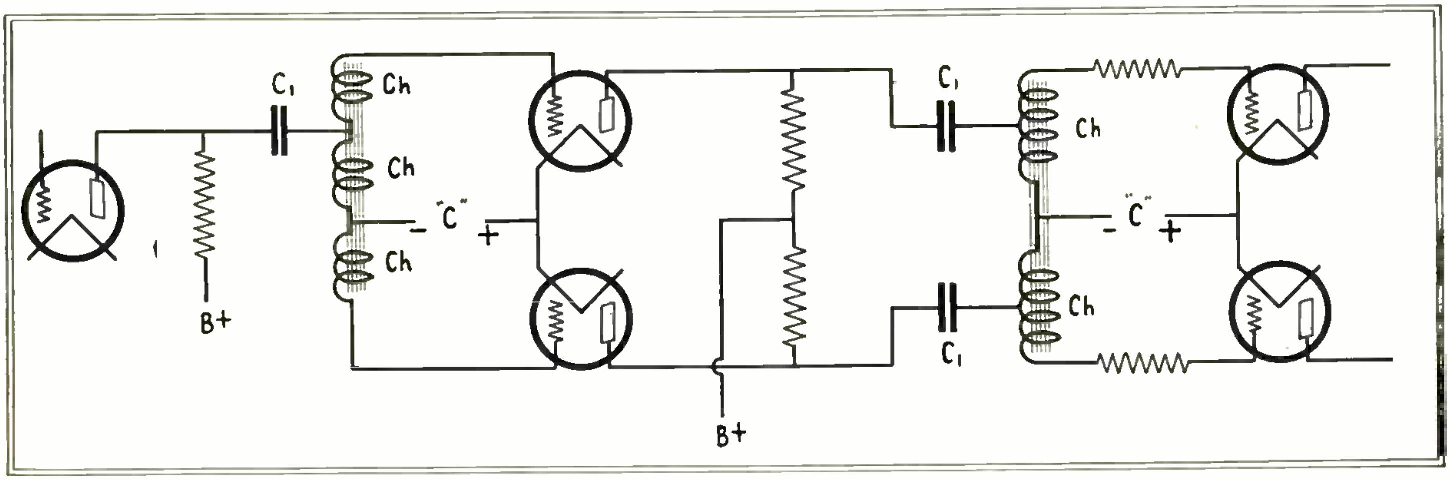
(19) Mr. Michael Delehanty, Terre Haute, Ind.

(Q.) Where can a 5,000-ohm grid leak be obtained?

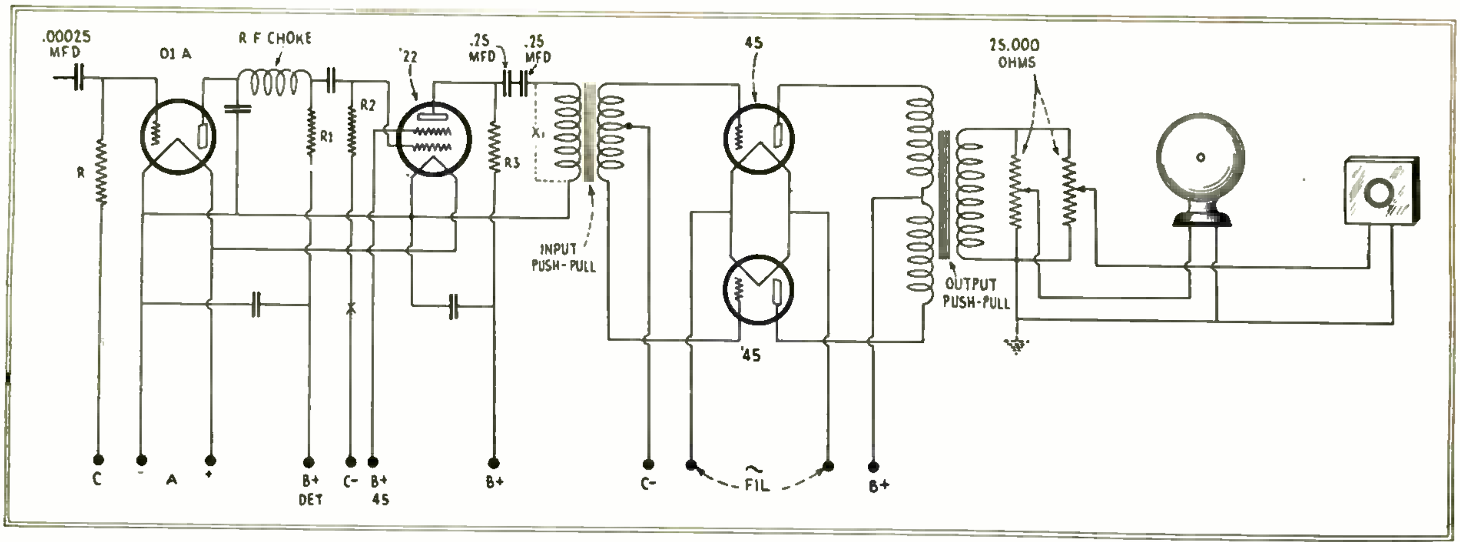
(A.) This is used in transmitters. Ask for a 5,000-ohm resistance, wire wound, at any good supply house.

(Q.) I am conducting some experiments in television and would like to duplicate the physics experiment known as "Newton's Disk." By mounting on a rotable shaft and twirling the card, all the colors of the rainbow painted on it merge into almost a clean white. Can you assist me?

(A.) You will find elsewhere in these columns a sketch of the card you refer to. We suggest you try the following water colors



(Q. 16.) "Parallel Plate Feed" is the circuit connection shown above. Due to the use of plate circuit resistances, a high "B" potential is essential. An average value for these resistances is 25.000 ohms; a value of 50.000 ohms will result in increased volume, if proper "C" bias and "B" potential are used. If type '12 tubes are used for the second push-pull stage, apply about 250 to 300 volts when using 25,000-ohm resistances. If '01A tubes are used for the first push-pull stage, about 180 volts may be applied if the plate circuit resistances have about 75,000 to 100,000 ohms. Condensers *C1* may be about 0.25 mf. capacity (high voltage test) and chokes *Ch* may have any convenient value, for experimentation.



(Q. 21.) This is a rather unusual arrangement of parts. It is necessary to use input and output audio transformers of the correct design for the '45 tubes, if maximum amplification is to be obtained, with the requisite tonal efficiency. The combined reproduction of the two "speakers" may be adjusted to satisfy the electrical conditions of the completed amplifier.

or oils to get approximately the right effect, which may be close enough for your work.

For red, use vermilion with a little permanent violet; orange, orange cadmium; yellow, chrome yellow; green, prussian blue and cerulean; blue green, veridian plus a small amount of cobalt blue; blue, ultramarine; violet, permanent violet and a little blue. Due to optic nerve fatigue the colors will, when rapidly rotated, resolve into the sensation of white.

(Q.) In the latter part of 1928 I read about a scheme for transmitting instantaneous pictures in colors. Red, blue and green were used, but I do not recall the details. Can you tell me in a general way the method Mr. Baird used?

(A.) The sketch which you will find in these columns pictures the Baird method of color television.

By having *three* scanning spirals instead of one, it was found possible to assign a particular color pickup and reproduction to each one and present a very creditable example of television in colors—the eventual arrangement we may expect.

Of course, there was only one-third the usual light effect to be obtained, per spiral, theoretically. Practically, it was discovered that persistance of vision aided the experiments greatly and the requisite brilliancy resulted.

A bigger problem was to be able to reproduce in three primary or primary-secondary colors. Merely applying a color screen, as is done in some forms of "still" color photography, did not solve the problem, as there was not sufficient blue and green in the rich red neon lamps which until that time were the only type in regular use.

The solution was to use two separate lamps. One, the usual pink or red neon; the other, a special mercury vapor, helium vapor lamp. The latter radiations could be readily filtered into blue and green.

It should be mentioned that although these experiments were strictly experimental the results were quite a success.

LINE VOLTAGE—VOLTAGE CONTROL

(20) Mr. Ernest K. Walling, Butte, Mont.

(Q.) What is the average voltage of lighting mains?

(A.) The range of potential is 90 to 135 volts. The average is about 112 volts.

(Q.) How could the range in voltage effect the practicability of design of an electric receiver?

(A.) By "electric receiver" it is presumed that what is meant is a radio receiver using A.C. tubes. Such a set would work well in the majority of cases if it was designed for a line supply of 112 volts.

However, the voltage range is so great in many instances it would be wise to incorporate some compensation arrangement.

First, there is the situation of a fairly steady supply at potentials other than 112 volts.

Then, we have the condition of a swinging potential with a mean value that is probably about 112 volts.

The remedy for the first condition is a limiting device which will prevent the supply exceeding 112 volts; we know of no unit to increase the voltage should it be low, other than the device mentioned below, which is of entirely different character to the fixed limit unit mentioned above.

In the case of a swinging potential, it is necessary to introduce a boosting voltage at one time and remove it at another.

Or, to express it more simply, the swinging voltage applied to a "balancing box" must have become a relatively steady 112-volt potential upon leaving the "box." The box's steady output becomes the steady 112 volt supply for the electric receiver. All this voltage equalizing depends upon the supply being A.C.

Such balancing units are obtainable and as they appear on the market will be described in the columns devoted to new apparatus.

A few more words may complete this answer. It is probably obvious that the entire electric machine will work best at some steady voltage for which it is designed. Therefore, change of the line supply potential will cause an unbalance of the receiver voltages and in consequence affect the receiver performance. Insufficient line potential usually results in distorted, weak reception, as the units comprising the voltage supply are not able to deliver the potential for which the set was designed. Also, the tubes will operate on an entirely different part of the "characteristic curve" of these tubes. These two foremost effects are sufficient to cause entirely different operation of the circuit. When it is realized that, in addition, the electrical circuit of the tubes, the coupling circuits, will react very differently to these changed characteristics, it becomes evident that a low line potential is not desirable.

Too great a line voltage carries its disadvantages, which are usually broad tuning, short tube life, condenser breakdowns, and perhaps transformer burnouts; circuit oscillation may also result and whether tuning is broad or sharp with such a condition will depend upon the couplings which result between the radio frequency tube input and output circuits (broad tuning may be caused by inductive feed-back, although circuit oscillation may result at the same time; tube-element capacitative feed-back can also cause circuit oscillation but it is not likely to cause broad tuning.)

For many reasons it is desirable to incorporate some device for equalizing A.C. line voltages to a standard value.

VOLTAGE DROP—VARIABLE CONDENSERS—AUDIO AMPLIFIER

(21) Mr. Frank Halsey, Whippany, N. J.

(Q.) What is the "IR drop" occasionally referred to in articles?

(A.) This is the more familiar "voltage drop," or, the potential difference between two points in a circuit, the value being determined by multiplying R (the resistance in the circuit) by I (the current in the circuit).

(Q.) Is it necessary to make any additional changes when substituting a straight line frequency condenser for a midline of the same capacity?

(A.) It may be desirable to balance the associated coil. The maximum capacity may be identical but the minimum capacity will probably be different. For this reason it may be desirable to add or subtract a few of the coil turns to properly cover the desired frequency spectrum.

(Q.) Isn't it carrying things to extremes, to dust between the plates of variable condensers?

(A.) Not at all. During dry weather the dust may not cause much trouble but as soon as the air becomes damp, the dust absorbs moisture and becomes very conductive. These hundreds of conductive paths from rotor to stator form a resistance network of very low value. The observable results are broad tuning, crackling sounds and loss of sensitivity.

(Q.) I am going to make a audio amplifier using the new '45 type tubes. What would be the schematic arrangement of a circuit using: one, '01A tube as a detector; one, '22 type tube for first stage audio amplification, and; two, type '45 tubes as second stage audio amplifiers, arranged in push-pull?

(A.) The circuit you request appears in these columns.

Note that the '22 type tube is resistance-capacity coupled with the detector; its output is resistance-capacity-transformer coupled to the push-pull tubes by use of the Clough audio system. This method is used with particular advantage when high impedance primary audio frequency transformers are incorporated in the unit.

The detector tube derives its plate supply through a resistance and for that reason it is necessary to apply a relatively high voltage to the resistance, in order to have the desired voltage at the detector tube plate. It may be desirable to apply about 150 volts to the resistor in the plate circuit of the '22 type tube. In fact, we suggest making the value of *R3* about one megohm and increasing the plate potential sufficiently to compensate for the change.

It will be noticed that the fixed condensers coupling the '22 tube plate and the A.F. transformer primary are two in number, connected in series. There are several reasons for suggesting this. In the first place the condensers will stand considerably greater voltage without leakage or rupture; in the second place the required capacity is obtained in a more convenient form. The resultant capacity in this instance is .125 mfd. This is not an unalterable value and just what it should be will depend upon the constants of the primary of the particular A.F. transformer used.

The '45 type tube filaments are supplied with A.C. The "B" and "C" voltages will be those determined upon as being most convenient, one being matched against the other.

The values of the resistances follow: *R* is about two megs.; *R1*, 50,000 ohms; *R2*, three megs.; *R3*, 250,000 ohms.

As indicated, the detector "B" potential should be well by-passed by at least two mfds. and preferably six mfds. Unless such circuits are well by-passed motor-boating will result.


PILOT
FILAMENT
SUPER WASP

Screen-Grid "Peridyne"

(*Continued from page* 107)

lic covering to the chassis wherever it can be done, by soldering to the brass hardware and to parallel leads. In wiring, it is recommended, the grid, plate, "B+" returns, "B—" returns, "B" power and filament circuits should be wired in the order given.

The "antenna" and "ground" binding posts are mounted on a small bakelite panel which is fastened with machine screws to the top of the output choke, as shown in Figs. 1 and 3. As the last stage of audio terminates at the same part of receiver, it is convenient to use the same panel to mount the tip-jacks for the reproducer cord.

One of the "secrets" of successful operation of circuits incorporating screen-grid tubes is adequate circuit isolation. This has been accomplished by the use of choke coils and fixed condensers. These compel the alternating and pulsating potentials to follow correct paths. Although the main volume control resistor (11) shown in Fig. 6 has a high inherent or self-capacity which tends to by-pass a large portion of the R.F. current within the operating range of frequencies, it is recommended that a shunt capacity (35) be connected from the variable resistor to the cathode, as indicated by the dotted lines; its value may be one mf. and working potential (rating) 200 volts.

The "C" bias is obtained without recourse to batteries, through well by-passed resistors of the proper values, placed in the "B—" or returns of the R.F. tubes and the first A.F. Ordinary grid-suppressor resistances of the wire type are satisfactory, providing they are of the values indicated in the parts list. The "C" bias of the power tube is obtained from the first section of the voltage divider (44).

Testing

After the receiver has been completely wired, it should be thoroughly checked and tested with the schematic wiring diagram (Fig. 6). When the builder is assured of its correctness, the various tubes are inserted in their sockets. The antenna, ground, speaker and 110-volt A.C. power leads are connected. Allowing sufficient time for the tubes to heat to their emitting point, the condensers are rotated individually by hand until a station having a wavelength between 400 and 550 meters is heard. The condensers are now carefully adjusted until the station is as loud as possible. Do not rush this part of the work. The set screws provided for fastening the rotors of the condensers to the shaft are now tightened.

The condensers are now set at their position of maximum capacity. The loose drum is rotated until the maximum, or 100-degree, division is opposite the indicator of the escutcheon-plate window and is then locked in place by tightening its set screw.

Final Assembly

The tubes are now removed and the antenna, ground, speaker and 110-volt A.C. leads are disconnected. The metal cabinet is now drilled to allow the protrusion of the regeneration and R.F. controls, as shown in Fig. 5. A wedge-shaped aperture, as shown, is cut out of the can; which should allow for the protrusion of the drum control shaft and which is later covered by the escutcheon plate. Immediately above the escutcheon plate a hole is drilled for the power switch. Leads of sufficient length are soldered to the switch and connected in one side of the 110-volt line as shown in the schematic diagram.

The complete chassis is now placed into the cabinet. The front should be first inserted until the various shafts are through the apertures previously made in the front of the cabinet. (*The resistors, insulated from the shield cans by washers, as described, have previously been insulated from the cabinet by means of bakelite plates* (47); *these plates, slipped over the shafts of the resistors, only need be about* 1½ *inches square and of scrap material not more than* 1/16-*inch thick.*) When the shafts are through, slight force will cause the chassis to clear the rear edge of the cabinet. The chassis is now screwed to the cabinet; the escutcheon, switch and knobs are placed in position and fastened.

Final Adjustments

After the chassis has been fastened into the cabinet, with the escutcheon plate and knobs in position, the tops of the cans are placed in position and fastened down by screws which are turned into the ends of the corner posts. If the top plates are given a slight curvature, they will hold the vertical plates more securely in position. The antenna, ground, speaker and power leads are again connected; the tubes are put in their sockets and the power is turned on.

After a few minutes, rotate the drum to near its minimum position, until a low-wave station is tuned in. Adjust the R.F. control and the regeneration control to best value for volume and quality. At this time the "Peridyne" plates are adjusted by screwing in; these should previously have been left near the top of their respective cans. Five turns or less should suffice for proper adjustment. After the final adjustments the builder will experience remarkable power, quality and DX reception.

List of Parts for the A.C. Screen Grid Peridyne

2—"XL" Binding Posts (marked "Ant." and "Gnd.") (1, 2)
3—Silver-Marshall Coils, type 132A, 1½" dia. (3, 9, 20)
7—Aerovox Fixed Condensers, 1-mf., 200-volt D.C. (working voltage) (4, 12, 19, 21, 22, 32, 35)
1—Small Clip for Screen-Grid Tube (5)
3—Hammarlund "Midline" Variable Condensers, .00035-mf. (6, 14, 16)
2—Electrad Grid Suppressors, 1,900 ohms each (used as bias resistors for 1st R.F. and 1st A.F.) (7, 33)
7—Pilot Tube Sockets, Type UY (for tubes 8, 15, 27, 31 and coils 3, 9, 20)
2—Pilot Tube Sockets, Type UX (for tubes 34 and 42)
1—Electrad Variable Resistance, 0-200,-000-ohm. (11)

1—Electrad Grid Suppressor, 1,000-ohm. (used as bias resistor for screen-grid tube) (13)
1—Pilot Fixed Condenser, .00025-mf. (17)
1—Bakelite Plate, 2¼"x5"x3/16" (18)
3—Silver-Marshall R.F. Chokes, Type 276 (23, 24, 28)
1—"Carborundum" Grid Leak, 1½-meg. (25)
1—Electrad "Royalty" Variable Resistance, Type F., 0-2,000-ohms. (26)
1—Dubilier Fixed Condenser, .0005-mf. (29)
1—Amertran "DeLuxe" First-Stage A. F. Transformer (30)
1—Pilot Output Choke, 20-henry (36)
2—Frost Cord-Tip Jacks (37)
1—Hart-Hegeman Snap Switch (38)
1—Cord and Plug (for connection to the A.C. line) (39)
1—Thordarson Power Compact, Type R280 (40)
1—Pilot Filament Transformer, Type 386 (41)
1—Aerovox Filter Condenser, Type BC280 (43)
1—Electrad "Truvolt" Voltage Divider, 14,000-ohm. (total), with five taps (44)
1—Mazda Pilot Lamp, 6-volt (45)
1—National Drum Dial (Illum.) (46)
1—Amertran DeLuxe Second-Stage A. F. Transformer (48)
1—Aero Metal Cabinet, 19"x8"x12" deep (49)
3—Kurz-Kasch Bakelite Knobs, 1¼" dia. (50)
3—Type '27 A.C. Tubes (1st R.F.; Det.; 1st A.F.) (8, 27, 31)
1—Type '24 A.C. Tube (Screen Grid, 2nd R.F.) (15)
1—Type '71 Tube (2nd A.F.) (34)
1—Type '80 Tube (Full-wave Rectifier) (42)
2—Pieces of 1/16" Bakelite, 1½" square (and insulating washers) for resistors 11 and 26 (47)
1—Roll Corwico Flexible, Rubber-covered Wire
16 ft. Belden Shielded (woven-mesh covered) "Colorubber" wire
6 ft. Radio Specialty Co. 1-inch Brass Angle (51)
1—Radio Specialty Co. Aluminum Plate, 12"x18¾"x1/16" thick (Subpanel) (10)
12—Hammarlund or Radio Specialty Co. Aluminum Channel Posts (Corners), 5¾" long, channeled for 1/16" material
6—Hammarlund or Radio Specialty Co. Aluminum Plates (Ends), 2⅞"x 5-13/16"x1/16")
6—Hammarlund or Radio Specialty Co. Aluminum Plates (Partitions), 3⅜"x 5-13/16"x1/16"
6—Hammarlund or Radio Specialty Co. Aluminum Plates (Tops), 3½"x 5-13/16"x1/16"
6—Hammarlund or Radio Specialty Co. Aluminum Plates (Sides), 8-9/16"x 5-13/16"x1/16"
6—Brass Pillars (Coil Socket Supports), ⅜"x1½"
1—Radio Specialty Copper Strip (for "Peridyne" Plates), 7½"x2½"x1/32" (50B)
3—Machine Screws (for Coil Socket supports), 8/32"x2" long
Misc.: Screws, nuts, washers and solder-ing lugs

Television Problems

(*Concluded from page* 110)

The Synchronism Problem

Synchronization is a problem which calls for the efforts of inventive minds. In metropolitan areas where the same alternating current system is available, it becomes a relatively simple matter to keep transmitting and receiving disks in step by means of synchronous motors. That system is the simplest and safest, of course.

However, television service is bound to extend over a considerable territory, where the same current is not universally available. Hence an independent means of obtaining and maintaining synchronous operation must be employed. Ingenious automatic speed controls have been developed, with centrifugal governors making and breaking contacts across speed-control resistances, for maintaining steady speed of the scanning disk irrespective of the fluctuations in line voltage or other causes.

To my mind, the problem will probably be solved more in the direction of ingenious braking devices, which will regulate the scanning disk by means of a definite frequency impressed on the television carrier wave along with the television signals. Again, there may be a synchronizing signal sent out for each revolution of the scanning disk, tending to start the scanning disk out in step with the transmitting disk, at each revolution. There are many ways in which synchronous operation may be obtained.

One very ingenious system of synchronization makes use of the group frequency which accompanies television signals. This frequency can be separated from the television signals and utilized in a synchronized braking arrangement to maintain the same speed at the receiving mechanism as at the transmitter.

One of the simplest devices that has yet come out of a laboratory, is a gear arrangement which permits adjustment of the phase relation between a synchronous motor and the position of the disk when the disk is in motion.

With this arrangement a synchronous motor can be used to drive the transmitting scanning mechanism and the receiving scanning mechanism can be controlled by this very ingenious device so that it will make up for differences in phase between the transmitter and receiver as both are on the same power supply and can be used quite satisfactorily to make up for variation in frequencies between separate power systems.

In this connection it might be interesting to note that transmission in Washington from a synchronous motor run on the Washington power system was followed very easily in Boston on a receiver run on a synchronous motor on the Boston Edison system. It was only necessary to make an adjustment every ten or fifteen minutes.

For the immediate future this holds out the most satisfactory method of solving the synchronizing problem.

The problem of obtaining a nation-wide television broadcasting service is a serious one. In fact, the production of television receivers is largely handicapped until television service is available in various parts of the country. Here it is my belief that the film or radio movies method of broadcasting is going to meet with the greatest favor at first, until such time as broadcasters are prepared to give the necessary time, space, care and money involved in broadcasting television subjects themselves.

Jenkins of Washington, D. C., Frank Conrad of Westinghouse and others, have worked out systems whereby the television pictures are first recorded on film, the positive of which is placed in a machine which scans each frame line by line. The advantage of the film is that the subjects may be posed under ideal conditions in the motion picture studio, with all the talent desired; secondly, that the films can be widely distributed and broadcast by small or large stations without special skill or equipment; thirdly, that a nation-wide hook-up can be effected by the radio movies method, even though no wire lines are required; fourthly, that the uniform service over a large part of the country will permit of selling television service to large advertisers, who can sponsor television in much the same manner that broadcast programs are now patronized. Of course, broadcast radio movies, will lack the news value which is available when the subject is picked up direct and televised. However, in time the direct pick-up will come into more extensive use, and network operation will be necessary.

There has been considerable technical difficulty in picking up an outdoor or indoor scene of large dimensions and transmitting it to the scanning mechanism with sufficient elemental light to readily actuate the photo electric mechanism of the transmitter. While it has been done in the past it has involved the use of very elaborate and sensitive mechanism.

A new method has been proposed and is now in the process of test, that will provide for the photographing of a scene directly on a film. This film will then be developed in a matter of three seconds and the developed film run through the transmitter scanning mechanism thus causing a lag of only three seconds before the transmitting of the picture.

As the scanning mechanism for scanning film is comparatively simple and fairly well developed, it seems obvious that this method will probably be the first satisfactory means of broadcasting current events, assuming, of course, that the difficulties in the quick developing film can be readily overcome.

It is my belief that while television will continue for some time as a separate service, without much attempt to combine sight and sound broadcasting, the eventual outcome is a single carrier wave with double modulation to include sight and sound presentations. This will be an interesting problem in modulation and demodulation for the radio engineer.

Laboratory activity is progressing along these lines as fast as finances and facilities will permit.

We conclude with the announcement that the Bell Telephone Laboratories have demonstrated the reproduction of a waving American flag in its colors. (It reminded one of looking at a motion picture in colors.)

BOOK REVIEW

Experimental Radio. By Rolla Ramsey (Professor of Physics, Indiana University), published by Ramsey Publishing Co., Bloomington, Ind.; third edition (copyright, 1929), 5" x 7", 255 text pages, 168 line drawings, cloth cover. Price, $2.75.

This is a very interesting book, written in rather sketchy form. Many portions of the book will not be clear to the average experimenter, requiring a few explanatory words from an instructor. All the mathematical formulas necessary to convey the principle of a given condition are printed and, in many instances, these will be beyond the comprehension of some students of radio. *Experimental Radio* should be termed a text book for these reasons. The book pre-supposes a knowledge of elementary mathematics and radio theory.

It is the only work of its kind available and fills a distinct need. The treatment of the subject is about as good as it could be; for to simplify the explanations would introduce the possibility of error if the same amount of text were used; and the book would need to be several times as large if the only other alternative — sufficient explanation to eliminate the desirability of personal interpretation—were followed. Hence, the makeup keeps in mind the premise mentioned in the first paragraph.

There are 128 "experiments," and each is accompanied by an explanatory line drawing. As the title may not quite define the contents of the book, we abstract one of its smallest units. "Experiment 12. To Measure the Capacity of a Condenser. Take a large condenser, about 10 microfarads, place it in an alternating (current) circuit and measure *E* around the condenser and the current through the condenser. Calculate the capacity from the formula: $C=I/E\omega$. ($\omega=6.283 f$.) Care must be taken in this experiment to correct for the current through the voltmeter. The A.C. generator must be one in which the E.M.F. varies as the sine of the angle. Any harmonic will be emphasized by the condenser, and the results will not check with theory."

We feel that a full index should have closed this book. As it is, we hope every reader of RADIO-CRAFT magazine will find it convenient to add *Experimental Radio* to his radio reference library. (R.D.W.)

The Screened Loop

(*Continued from page* 111)

out practically by placing a uniform coat of graphite on a wooden frame which surrounded the loop winding. It appeared from practical trials that, although the screen was somewhat effective, nevertheless a comparatively strong and therefore undesirable damping took place.

Efficient Screening

In these measurements copper wire proved very favorable with regard to damping. In fact, loop antennas in which the screening was effected by wires (as proposed by Dr. S. Loewe and the writer) showed approximately the slight losses of unscreened antennas. In practice, very efficient screening was secured by winding with wire, using the same points of support as for the actual winding of the loop. Naturally, however, the impairing of the magnetic field was again hindered by breaking the screen. (The high damping by the "shorted turn" effect of the screen was eliminated by breaking the screen circuit.)

The view at the left shows part of a loop with a screen in which insulated intermediate pieces are inserted to break the continuity of the screen windings.

In the center photograph is apparatus used in the tests with loop screened in the manner illustrated which has good mechanical proportions and is comparatively easy to make. Between the loop and the sensitive receiver (which has a number of tubes and an aperiodic high frequency amplifier) is visible a wire which is also screened. In the background may be recognized a large loop antenna such as was formerly necessary for receiving long distance transmissions.

A very attractive screening of the electric field may be secured in practice, if the number of unclosed screen turns amounts to about 50% of the actual loop turns. The increase in natural capacity due to the wire screen amounts to merely about 20 to 30 cm. and is therefore harmless. (One centimeter of capacity equals 1.1124 mmf.—Ed.)

To secure the desired ideal directional characteristics, the described loop screen when in use must be connected with the screening of the receiver and also grounded, and at the same time every point of the loop must be insulated from the screen.

Sensitivity vs. Interference

With the screened loop antenna, which can be combined with any existing set, by careful design, the freedom from interference or disturbance from a near-by station is limited almost solely by the fact that the interfering waves do not come from a single direction only but from several somewhat different ones. Especially at sunset irregularities may often be determined in this respect.

Still in such cases the minimum remains almost always sufficiently sharp to reduce the volume of the unwelcome sender to about 2 to 5% of the volume using a non-directional antenna instead.

In practice the degree of exclusion of local interference is further dependent

(*Concluded on page* 141)

Screened Loop

(*Concluded from Page* 139)

on the mechanical adjustability for the minimum. As a rule an easily turnable loop antenna may be adjusted to within approximately ½% of exactness. It is then possible, with the aid of the screened loop antenna just described, to lessen the amplitude of the disturbing sender to about 1%, as shown in the diagram.

A Reception Phenomenon

With the proper arrangement of the loop and with the loop circuit ungrounded the directional effect is so good that sometimes the carrier is indeed shut out entirely, but not the side waves coming from a somewhat different direction. The result of these interesting phenomena is a distorted reproduction, if the receiver is adjusted to the wave of the local sender which is nearly shut out. This distortion is very like that which can often be observed during the minima of the fading periods with distant reception.

Diffusion effects do not always allow the attaining of an absolutely sharp minimum possible with a loop of ideal characteristics. Practical experiments demonstrated, however, that except in the interior of large buildings or under exceptional conditions we can attain at most hours of day or night an almost ideal minimum within the wave lengths of about 200 to 600 meters.

NOTICE

We wish to advise our readers that the article in the August issue describing a home-made three-circuit tuner appeared under the name of Mr. Sklar in error. This article was submitted by Mr. Coleman Sutton of Alhambra, California, who designed the tuner described in that issue.

WHAT RADIO CRAFTSMEN SAY

(*Concluded from page* 115)

You can submit this letter to anyone who has doubts about the "Super-Wasp."

CLINTON ZIMMERMAN,
Penbrooke, Pa.

(It is doubtful whether the designers of the receiver would be willing to acknowledge it with so radical an alteration. The purpose of using a screen-grid tube in the first stage is to obtain a high amplification of the signal which is not possible with a '01A-type; the latter merely serves as a coupling, which may be useful with certain aerials, but will be unsatisfactory with others. Good results may be obtained by one constructor who departs from the rules, but will not be duplicated by others—consequently, disappointment and a tendency to doubt the story.—Ed.)

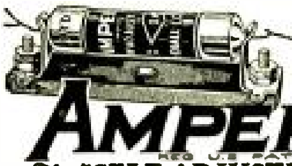
FIRST COPY WORTH THE SUBSCRIPTION

Mr. Hugo Gernsback, *Editor*,
RADIO-CRAFT:

Many thanks to RADIO-CRAFT from a blundering cut-and-try coil-winder. The first copy has saved me already what my two-years' subscription cost me. May I hope that your staff will give us a screen-grid "Regenerative Interflex" later? To our minds, that was the ideal fool-proof family set.

F. N. BEMIS,
Saugus, Mass.

(We hope that many more of our readers will have equally satisfactory returns for their money. In the meantime, "If you don't see what you want, ask for it." Our "Interflex" fan readers will find Mr. Grimes' articles in "The Co-operative Radio Laboratory" of the greatest interest.—Ed.)



Servicing "Supers"

(*Concluded from page* 125)

common "B" supply. This capacity is quite important if stability is wanted and should be quite large for low intermediate frequencies, *i. e.*, at least 2 mfd. for intermediate frequencies from 20 to 100 Kc., and may be reduced to 1 mfd. if frequencies higher than 100 Kc. are used.

It is also important that these by-pass condensers be connected directly between the *negative filament and the "B" terminal of the output transformer of the particular tube with which it is associated.* *R*1 and *R*2 are one-half megohm grid leaks, which provide a grid return to the filament.

The adjustment of *C*1 and *C*2 is quite easy if the following procedure is carried out: Tune in a loud signal from a local station. Remove the first intermediate amplifier tube from its socket. Insert a small piece of paper or other insulating material under the positive filament prong of the tube and replace the tube in its socket. Most likely when this is done the signal will again be heard although not quite as loud. Adjust *C*1 and *C*2 until no signal (or, minimum signal) is heard. This is then the correct adjustment. Remove the piece of paper and replace the tube in its socket again. The same procedure is then carried out with the rest of the intermediate amplifier tubes in succession. The amplifier is then properly neutralized and will stay thus.

LATEST IN RADIO

(*Concluded from page* 120)

pacity ranges from .0004-mf. to .02-mf. Mica of a high grade is used as the dielectric, and the plates are of tinfoil. Eyelet-type connections are made in the condenser, and a single mounting hole is molded on one side of the condenser. Thus the unit may be screwed or bolted in position, or it may be held in place by soldering or eyeletting (riveting).

RADIO LABORATORY

(*Concluded from page* 129)

one of transformer coupling. This circuit is the result of reasoning and not an attempt to be "different." The insertion of the crystal in the grid lead of the hybrid tube requires a grid return to "A—". This, combined with the fact that a high-mu tube gives best results, practically demands resistance coupling. A transformer in the first stage will result in loss of volume, *particularly on the bass notes.*

A transformer in the second stage is quite necessary. The first audio tube should be a standard '01A type; this works better into a transformer primary than into resistance coupling. And last, but not least, the use of a transformer coupling in the second stage permits the reversal of the primary windings ("Phaseing") to stop motorboating, howling, etc. Resistance coupling precludes this—as there is no way to reverse the connections on the input to a resistance stage.

Radio Kinks

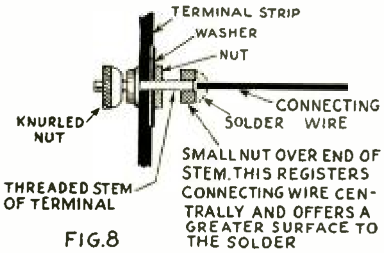
(*Concluded from page* 121)

nal and the underside of the lug. When the flux sets, it acts almost as an insulating layer, and there is no longer a clean metal-to-metal connection.

Coil connections, too, must be given attention; for the coils are the heart of the set.

Effect of Bad Connections

A poor joint will act like a resistance in the circuit (Fig. 6); it will "damp" it; and the set will lack "pep." Leave the ends of the coil winding long enough

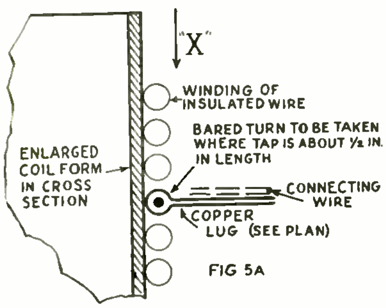


The recess formed with the small nut centers the bus bar.

to reach to the part to which connection is to be made; then winding and connecting wires will be all in one piece.

Refer to Fig. 2. Leave the winding leads long enough to reach the part to which connection is to be made; then winding and connecting wires will be all in one piece.

If a separate wire or busbar is to make the connection, then follow Fig. 3.



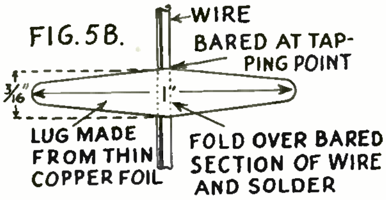
Making good coil connections.

Strip the insulation from the short projecting end of the wire and make an "eye" to take the busbar, and solder. (This kink may prove useful: Bend a pipe cleaner around the wire just back of the eye, as shown in Figs. 4A and 4B. When the flux melts, the pipe cleaner will absorb it and prevent its spreading.)

Taps on a coil can be made in a similar fashion; by baring the wire for half-an-inch or so when winding the coil, and twisting the wire into a small loop. A different method is shown in Figs. 5A and 5B. Here the wire is again bared for a short distance and a strip of thin copper foil bent around it.

A Good Connection

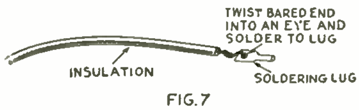
Fig. 7 is the writer's favorite way of making a connection to a flex lead.



Computing the tapping of the coil.

There remain only terminal connections; the best way is illustrated in Fig. 8, where a small nut is partly threaded over the end of the binding post stem, leaving a thread or two of the nut clear of the end of the stem. The connecting wire or busbar is placed in the slight recess thus formed, and the whole soldered up.

The testing layout is illustrated in Fig. 9A. The actual joint is shown at "T." Two slotted terminals (*A* and *B*) are placed close to this joint; *A* is connected to a thirty-ohm rheostat *R* and the latter to a two-volt storage battery (or a dry cell). The other terminal of

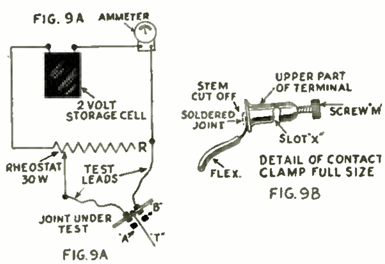


The "soldering lug." Tinned ones solder easiest.

the battery goes to an ammeter reading, say, up to one ampere. Finally, the second lead from the ammeter goes back to terminal *B* and the joint.

After setting up this test gear, first clamp a piece of clean busbar between the terminals *A* and *B*, now adjust the rheostat so that the ammeter reads a certain even value, say a quarter of an ampere. Leave the rheostat adjusted in this r anner throughout all further tests; and note, after connecting to the joint *T* (which is to be tested for resistance), if the reading of the ammeter is as before. If it is, then your joint is above suspicion.

After our little discussion, perhaps some reader will regard connections in receivers with a new respect, and in future, watch his joints!



Testing joints without cutting wires, by using the clamp shown.