RADIO'S LIVEST MAGAZINE

A GERNSBACK PUBLICATION

Radio-Craft

September
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HUGO GERNSBACK Editor

Describing the New

RADIO GARAGE DOOR OPENER

See Page 138

A New Triple-Twin Tube—Direct Coupled Amplifiers—A "1-Tube" Super
A Quality Audio Amplifier—Design of Test Instruments—Adapters

Radio-Craft

FOR THE SERVICE MAN · DEALER · RADIOTRICIAN

CONTENTS OF THE SEPTEMBER, 1933, ISSUE

VOLUME V NUMBER 3

IN OUR NEXT FEW ISSUES:

WHAT EVERY YOUNG SERVICE MAN SHOULD KNOW ABOUT THE INSTALLATION OF PLAYHOUSE SOUND SYSTEMS. How much does it cost to install an efficient sound system in a theatre? What apparatus will be required for a house with a capacity of 1,000 people; of 5,000? What are the probable difficulties one would encounter in installing the system and how could these faults be overcome? These and many more questions of a similar nature are answered in a practical manner in this multi-article by an authority on the subject. This series alone will be worth the price of many subscriptions to RADIO-CRAFT.

HOW TO MAKE A UNIVERSAL A.C.-D.C. AUTO RADIO RECEIVER. A feature of this ultra midget set design is the high gain attained through the use of modern tubes; including the type 6C6. Other considerations of interest to everyone are its low cost of construction and simplicity of design. Provisions are made for phonograph pickup or microphone input.

THE MAINTENANCE OF CARBON MICROPHONES. Nearly every radio technician has viewed the carbon microphone with a sense of awe, presuming that, since the instrument was one of the most expensive, small-size units in his equipment, only a gifted few could successfully service it. In this article the author clearly discloses the foibles of the device and the correct repair procedure to be followed by a technician having average ability and good judgment.

RADIO-CRAFT is published monthly, on the fifth of the month preceding that of date; its subscription price is $2.50 per year. (In Canada and foreign countries, $3.00 a year to cover additional postage.) Entered at the post office at Mt. Morris, Ill., as second-class matter under the act of March 3, 1879. Trademark and copyright by permission of Gernsback Publications, Inc., 98 Park Place, N. Y. C.

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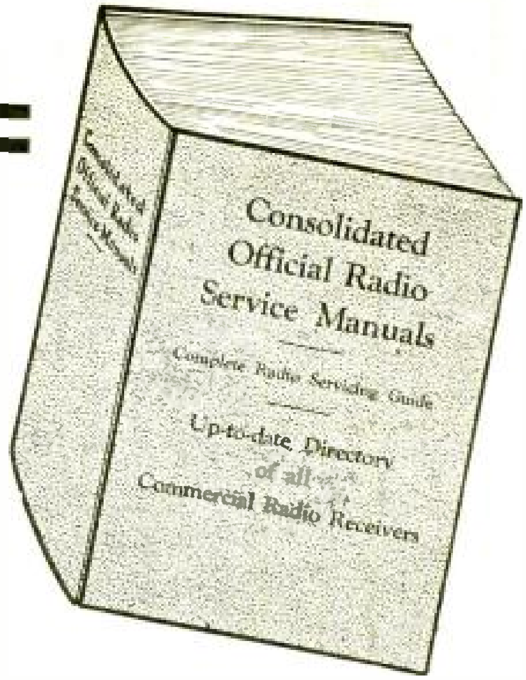
This  +  +  = 

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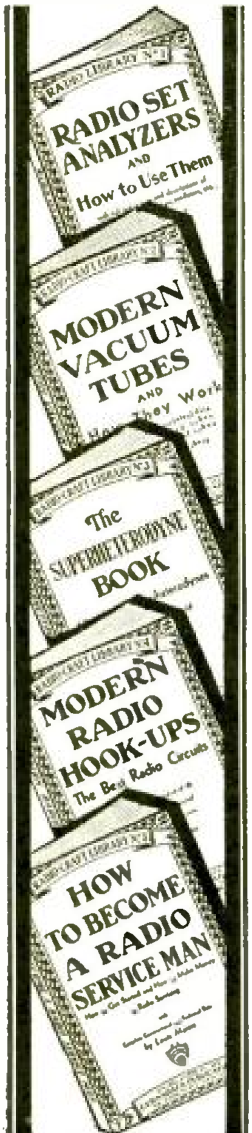

Book No. 1

Radio Set Analyzers

And How To Use Them

With Full Instructions and Descriptions of Set Analyzers, Tube Checkers, Oscillators, Etc.

By L. VAN DER MEL

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Book No. 2

Modern Vacuum Tubes

And How They Work

With complete Technical Data on All Standard and Many Special Tubes

By ROBERT HERTZBERG

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All About Superheterodynes

How They Work, How to Build and How to Service Them

By CLYDE FITCH

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Book No. 4

Modern Radio Hook-Ups

The Best Radio Circuits

A Complete Compendium of the Most Important Experimental and Custombuilt Receivers

By R. D. WASHBURNE

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Book No. 5

How to Become a Radio Service Man

How to Get Started and How to Make Money in Radio Servicing

By LOUIS MARTIN

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Book No. 6

Bringing Electric Sets Up to Date

With Pentodes, Multi-Mus, Dynamic Speakers—Complete Information How to Modernize A. C., D. C. and Battery Operated Receivers

By CLIFFORD E. DENTON

In this country there are over ten million electrically operated receivers that could be modernized—by placing in them new type tubes, new speaker equipment and other modern improvements. This business of improving old sets can go to the experimenters and Service Men if they will quickly jump into action.

Book No. 7

Radio Kinks and Wrinkles

For Service Men and Experimenters

A Complete Compendium on the Latest Radio Short-Cuts and Money-Savers

By C. W. PALMER

It often becomes necessary for experimenters and Service Men to call upon their memory for some short cut or radio wrinkle that will solve a problem quickly. In business, "short cuts" mean time and money saved, and to the Service Man "time saved" means money earned.

Book No. 8

Radio Questions and Answers

A Selection of the Most Important of 5,000 Questions Submitted by Radio Men During the Course of One Year

By R. D. WASHBURNE

There have been collected a wide variety of questions which have come into our editorial offices during the past two years, and only those whose answers would benefit the majority of men engaged in radio have been incorporated in this amazing question and answer book. A tremendously long list of topics is treated.

Book No. 9

Automobile Radio and Servicing

A Complete Treatise on the Subject Covering All Phases from Installing to Servicing and Maintenance

By LOUIS MARTIN

Automobile radios are up and coming, and someone has to service them properly. It therefore behooves you to read this immensely important new book on the art of Automobile Radio. The book is concise, and full of illustrations, photographs, diagrams and hookups.

A few of the really interesting chapters: Introduction; Automotive Radio Installations; Complete Descriptions of Commercial Automotive Receivers; Servicing Automotive Receivers; The Ignition System; General Service Considerations; Effects of Temperature on Power Supply; Conclusion.

Book No. 10

Home Recording and All About It

A Complete Treatise on Instantaneous Recordings, Microphones, Recorders, Amplifiers, Commercial Machines, Servicing, etc.

By GEORGE J. SALIBA

If there is one subject that is fascinating to every radio man, it is that of Home Recording. Of course, this volume is not all on "Home" recording, but the information contained therein is important to commercial radio men, studio operators, engineers and others interested in this phase of radio.

The art of recording and reproducing broadcast selections is becoming more important every day to radio men, experimenters and Service Men. Equipping dance halls, auditoriums, churches, restaurants and homes with public address systems and amplifiers brings many extra dollars and often an excellent income.

Book No. 11

Point-to-Point Resistance Measurements

The Modern Method of Servicing Radio Receivers

By CLIFFORD E. DENTON

Of the difficult problems which Service Men face today when repairing receivers, the greatest is that of replacing proper resistance values in sets. This task becomes even more difficult when the values of resistors are unknown; and manufacturers of many standard sets do not pass this information on to Service Men. In this new book radio men will find the information needed to quickly place a receiver in normal operating condition. This book cuts in half the time usually required to adjust the average set.

Sufficient space has been devoted to the elementary problems and the theory of electricity as it is applied to resistance measurements so that the Service Man will have a comprehensive idea as to how to overcome this problem.

Below you will find a partial list of the contents which will appear in this new book.

INTRODUCTION. Advantages of Resistance Measurement Method of Servicing for Radio Work; Basic Principles; Methods of Resistance Measurement; Resistors in Radio Receivers and Amplifiers; Point-to-Point Resistance-Measurements in Typical Radio Set using Ohmmeter; Resistance Measurements using Modern Tester; Routine Testing where Circuit Diagram is Available and where Resistances are Known; Routine Testing where Circuit Diagram is Not Available and where Resistances are Unknown; the Relation of Voltage Testing Methods to Resistance Measurement; APPENDIX. Resistance Charts etc.

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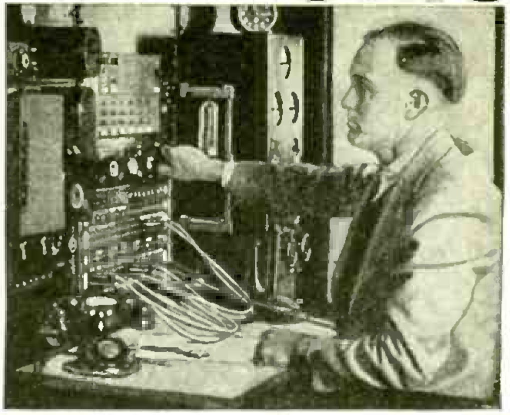

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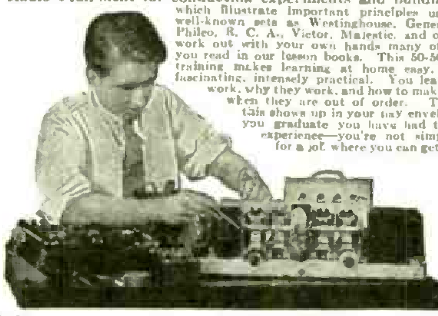

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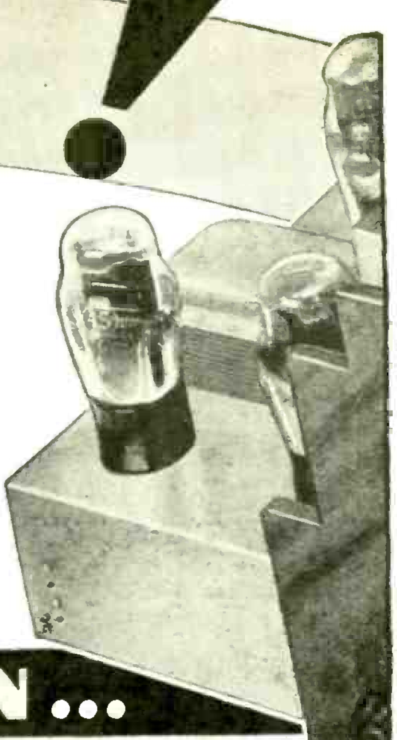

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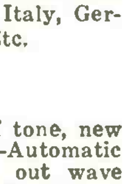

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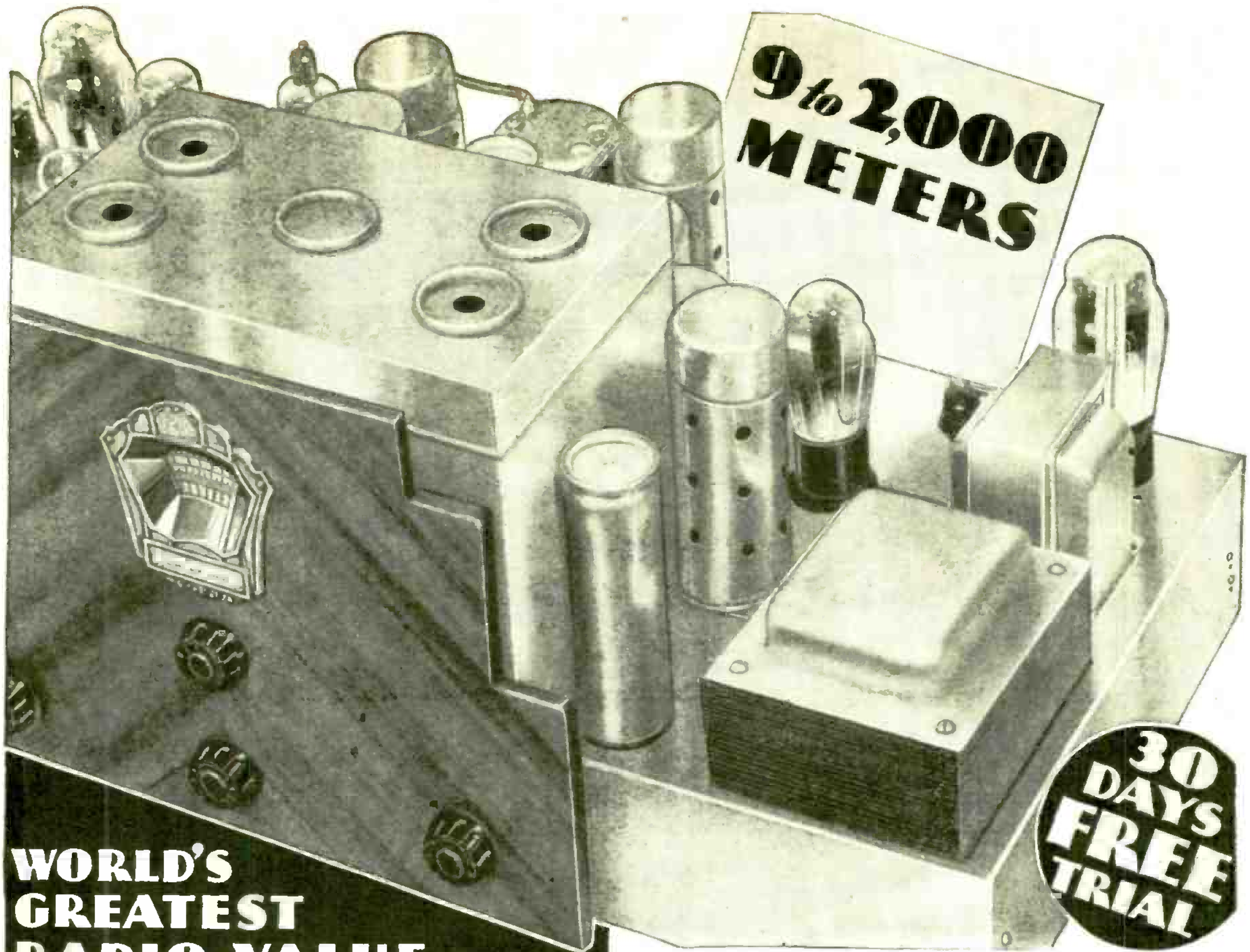

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"Takes the Resistance Out of Radio"

Editorial Offices: 96-98 Park Place, New York, N. Y. HUGO GERNSBACK, Editor Vol. V, No. 3, September, 1933

OUR CHANGING RADIO

An Editorial by HUGO GERNSBACK

THERE is probably no industry in the whole world that changes so abruptly and so radically as the American radio industry. It is always a source of surprise to radio men from foreign countries who visit the United States and find most of their radio ideas thrown overboard. The American radio industry has long been accused of having little or no stability; because one manufacturer, in his efforts to beat the next one, seemingly stops at nothing to gain his goal, provided there are a few dollars for him in the offing. We have seen it time and again in the past: first when the $60.00 radio killed all those selling for $200.00 or more; then when the first midget killed the legitimate sets; and again last year when the cigarbox models promptly smothered what business there was left with the regulation midgets.

That there will be a stop to all this, and that the radio industry will settle down into an unexciting butter-and-egg-type of business, no one believes for a minute. Progress, as spelled in radio, simply does not work that way. Too many radio engineers are lying awake nights figuring out how they can steal a march on their competitors. While this sort of thing lasts, no one can tell what 1934 will mean in terms of radio.

In our May issue we published, purely as an April Fool joke, our now famous (or infamous) Seven-Tube Vest Pocket Set. The "tubes" in this set were made from ordinary pilot lamps. This, at the time, looked like a good joke. However, the joke is now on us, because already one of the largest tube manufacturers has announced a real radio vacuum tube even smaller than a pilot lamp! We now have the *shoe button* type of tube, a number of which have already been manufactured and demonstrated at the Century of Progress in Chicago. Whether we will actually have vest pocket sets which, in turn, will do away with the cigarbox models, no one can foretell at this time.

Of course, the radio industry did not wax rich on the cigarbox type of set, and the dollar volume for 1933 will be found to have fallen considerably. When you have to run a factory on $7.00 or $8.00 units (some sets sold even lower) in comparison with the midget sets which averaged about $30.00 or thereabouts, it needs no mathematician to predict the result. And, while the actual sales volume of these cigarbox sets was fairly large, it was not large enough during the depression to make up for the reduction in price.

As far as these cigarbox sets are concerned, they perform a useful function because they give the man who wants a cheap set a radio, which, perhaps, he could not afford otherwise. But, everyone also knows that the sound quality from these cigarbox sets is poor; in some sets so poor that voice reproduction becomes almost unintelligible at times. This is not the fault of the sets themselves, but lies in the loudspeaker. So far, because of the exceedingly small dimensions of the little sets, no satisfactory loudspeaker that gives good reproduction has been designed. It is conceivable that such a loudspeaker will be made in due time, but as yet it is non-existent. Perhaps this is a good thing, because after all, radio is too big an art to rely entirely upon cigarbox sets.

For better results and for ease in servicing, it is necessary to have adequate space, and this you can only have in a standard console model. Even the old type midgets were too crowded. One of the foremost radio set manufacturers never manufactured a midget because their engineers claimed that it was impossible to get correct sound value in small cabinets.

In due time, it is believed that radio manufacturers will return to sanity and manufacture regulation sets that will be a credit to the industry. While we are on that subject, let me mention one point which has been neglected by most set manufacturers. In Europe, the appearance of the average American radio set brings forth smiles and guffaws of laughter. The European as well as the American artist sneers at a radio set housed in the American "Period" style cabinet. The artist will say, "Why should an ultra-modern article like a radio set be housed in a *Louis Quatorze* wooden cabinet?" The idea, he says, is incongruous, and he insists you might as well walk the streets today wearing a powdered wig and knee breeches. The effect would be identical.

To me, the Century of Progress in Chicago, translated into radio terms, proved an eye-opener. When you look at these strikingly, and at first appearance, bizarre buildings, you wonder why such an architecture was used. The reason is very simple. Science, electricity, radio, etc., have transformed the world. We live today in a world entirely different from that of our parents and grand-parents, and we should think and act accordingly. To hitch up Egyptian art or the art of the French kings with modern progress is a step backward, not forward. If radio is new, as it is, then it should be new and modern in appearance.

This idea first made itself felt in the cigarbox models, where we already have strictly modern art, and where the "period" abortions have been left far behind. There are some very striking cigarbox models which have caught on to the new idea; but so far, there have been hardly any new-art radio sets in the larger models. These are still preposterous stilted-leg monstrosities, and they still look like old-fashioned cabinets instead of expressing themselves in new terms.

Here is a thought that the radio industry should embrace, and the quicker it does so, the quicker will it put radio across to the public. There are many new materials which lend themselves to the working out of these ideas. We have new plastic materials which, in combination with metals, will make strikingly new and modern receivers. Wood should not be used, or only sparingly, and the quicker we get away from the cabinet-looking sets, and take the modern Chicago architecture as a basis, the quicker the public will approve the idea and buy.

Many homes in the United States are undergoing revolution, and modern furniture is being installed rapidly. The "period" cabinet does not fit into this atmosphere, and should be replaced by modern designs.

Fig. A
A view from the inside of a garage showing the location of the equipment.

THE NEW RADIO GARAGE DOOR OPENER

A commercial system for the remote control of garage doors, etc. A 100-meter signal radiated by a transmitter located in, for example, an automobile is picked up by a receiver and, in turn, actuates a door-opening or closing motor... A "code" prevents tampering or accidental operation of the system.

R. D. WASHBURNE

"PRESTO!" is the "open Sesame" which controls the door of the really modern garage. Press a button and, lo, the portals of your garage swing wide before you, lock open while you majestically continue your ride; and then, at a second press of the button, close and lock, whether you are leaving your garage or returning to it. We will now (with due apologies to the ads) disclose the "trick."

A radio transmitter mounted in the automobile transmits a short-wave signal of "coded" or pre-determined dot-dash characteristics, when a knob on the instrument board is pressed. This signal is radiated by a one-wire antenna underneath the car chassis, and is picked up by a one-wire antenna buried in the driveway. The latter antenna is connected to a receiving set which "de-codes" the signal, and then operates motors which control the opening, closing and locking of the garage doors. Literally, the system is a "radio key."

A display at A Century of Progress illustrates this procedure. An idea of the relative parts arrangement may be obtained by reference to the cover illustration and Fig. A. A schematic circuit of the radio transmitter located in the car is shown in Fig. 1. The receiver connections are shown in Fig. 2. The door motor, which operates only when a particular set of signals is received, connects to the receiver as shown in Fig. 3.

As shown in Fig. 1, a simple spark coil arrangement is sufficient for the transmitter requirements of this installation. The transmission is rather broad, on a wavelength of 100 meters. However, the field of radiation is confined by the body of the car almost entirely to an area immediately underneath the car, thus preventing interference on nearby receiving sets. Such slight interference as may be introduced on extremely sensitive receivers, or those operating on short waves, is of little consequence as the units operate ordinarily at considerable intervals, and then only for about three seconds. The spark coil unit is contained in a water-tight case and is bolted to the underside of the car chassis.

The transmitter timer, shown only in schematic form in Fig. 1, clamps to the instrument board, and consists of a rack-and-pinion arrangement incorporating a balance wheel, escapement wheel, hairspring, pallet lever, and a contact plate and contact springs. The rack-and-pinion mechanism is controlled by a plunger.

The timer action is set at the factory with a combination which is different for every installation. It is put into operation by a thrust on the plunger which extends from the lower edge of the instrument board of the automobile. Since a similarly-coded action is installed at the receiver, it is not possible for static, or the radiations of a transmitter not equipped with the same code, to actuate the door motor.

In reference to the diagram of the transmitter, the car wiring is shown in dotted lines; external wiring is shown in heavy lines; and, internal wiring is shown in light lines.

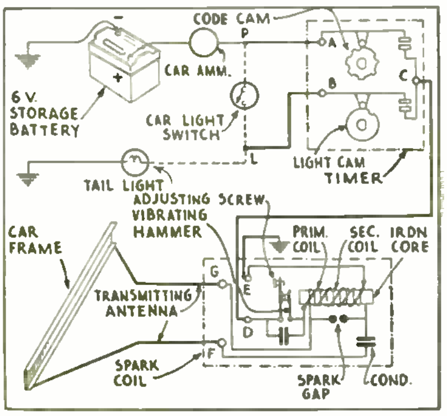


Fig. 1
A diagram of the transmitter used in the radio-controlled door opener. Note that the car frame is used as the radiating system.

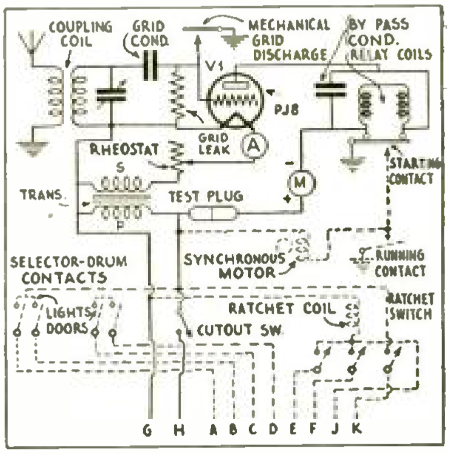
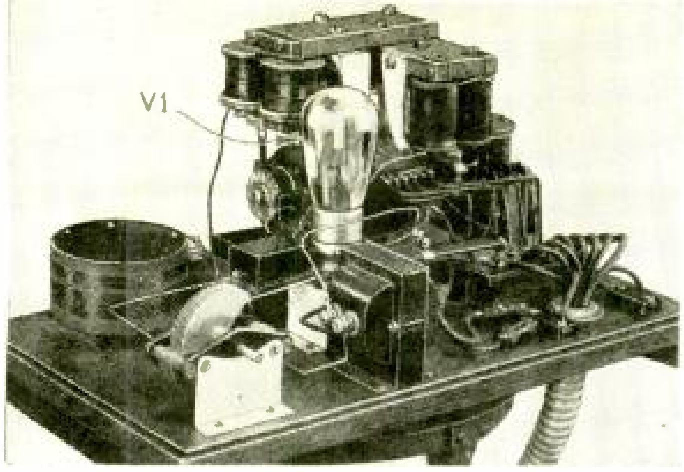


Fig. 2
Diagram of the receiver pictured in Fig. C.

Radio-Controlled Garage Lights!

It is of considerable interest to note that *the lights inside the garage may be automatically turned on and off* by radio. This is accomplished by an added impulse in the code, which is transmitted only when the lights of the car are turned on (thus completing a section of the car lighting circuit which is



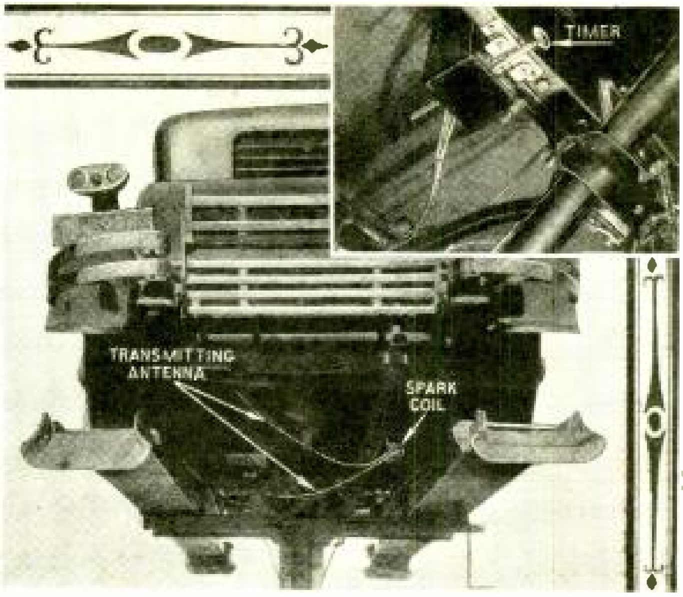


Fig. B, right
The illustration at the upper right shows the location of the timer while the larger photograph shows the location of the spark-coil transmitter.

Fig. C, above
A close-up of the receiver, usually mounted on one of the walls of the garage.

wired to the radio control system).

The antenna which connects to the transmitter is strung diagonally underneath the chassis. The receiving antenna, about 150 ft. long, is buried a few inches deep in the driveway.

The receiver must be in continuous operation; consequently, the amplifier tube, V1, shown in Fig. 2, is specially designed for *continuous* operation over a minimum period of 2½ years. For testing this tube a D.C. milliammeter of 0 to 15 ma. range is connected into circuit at M; for the same purpose an A.C. ammeter of 0 to 2 A. range is connected at A. (This tube is of the type developed for use in automatic train control equipment.) The output of V1 actuates the de-coding mechanism, a set of relays and electromagnets operating a pawl-and-ratchet system that rotates worm gears and a number of discs which close contacts. One receiver can control, at will, either side of a 2-car garage. The stock receiver and door operating units are designed to operate on 110 V., 60 cycles, A.C. The components are protected by a metal shield-can; the assembly is mounted inside the garage, fairly close to the door-operating motor.

A split-phase motor is used in the door-opening and closing system, the circuit of which is shown in Fig. 3. In this figure, heavy lines indicate external wiring. Any number of the manual control switches may be placed in convenient locations. Although our major interest lies in the radio components, the action of the door control also is described.

Power is transferred from the motor unit, when starting contact is made, to a latch magnet, by means of an armature and spring-operated lever, releasing a brake and closing the main motor switch at the lever end. As soon as the electric motor reaches normal speed, in about one-half second, a centrifugal clutch engages and passes the motion on to a planetary differential which forms the main part of the release mechanism. A pawl holds the ring gear fixed until the load exceeds a set amount, and then trips. This permits the ring gear to run free and the motor, which continues to run, is disconnected from the driving pinion. The driving pinion causes the door to open or close.

At the end of the door travel a cam shaft is automatically operated. It opens the main motor switch and applies a brake which stops the door. At the same time the release mechanism is locked by a locking lever so that any attempt to force the door will not trip the release mechanism. Also, the motor control switch is shifted and the motor prepared to operate in the reverse direction on the next signal; an additional switch for controlling the lights also is shifted.

Radio control of the garage door permits the motorist to enter or leave his car under shelter, a boon when it's "raining pitchforks," or in blizzard weather. Incidentally, the same principles may be applied to the operation of doors within the home.

The radio light control feature of this installation has several points of particular interest to the car owner. As the car is driven up the driveway and the door-control plunger is operated, the garage, driveway and yard are suddenly flooded with light, provided the headlights of the car are turned on—as for night driving. A conveniently located switch inside the house makes it easy to extinguish the garage and yard lights in case it is desired to leave them turned on until the owner is inside his home. This provision minimizes the possibility of a marauder lurking about, since all local areas become flooded with light. Thus, for a few hundred dollars the provident person may possess a useful "magic wand."

Installations throughout the country have proved that this "unseen servant" is an absolutely practical mechanism—another effective member of the radio "robot" family. Whether the Service Man will be able to obtain this equipment for private installation cannot be definitely stated at the present time. To date, all "radio door" installations have been made only by a corps of technicians trained by the manufacturer of the system.

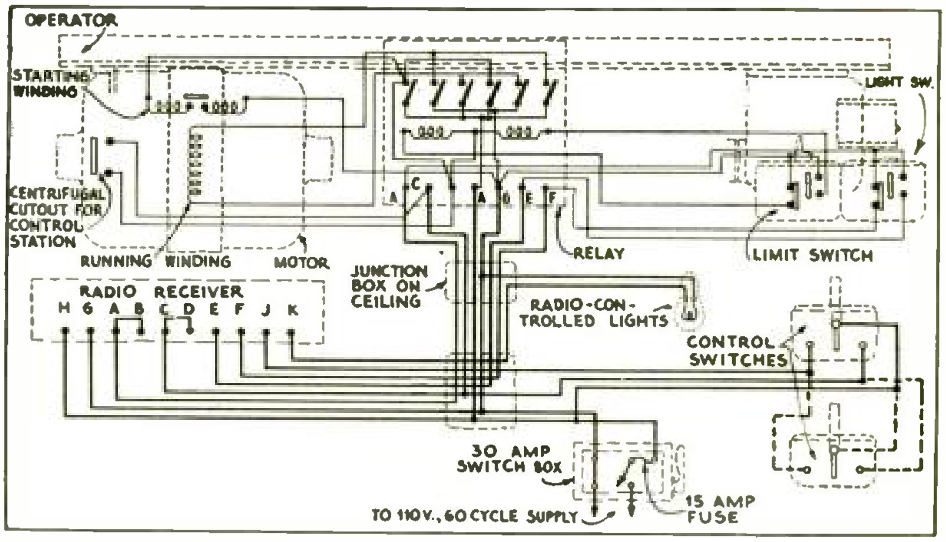
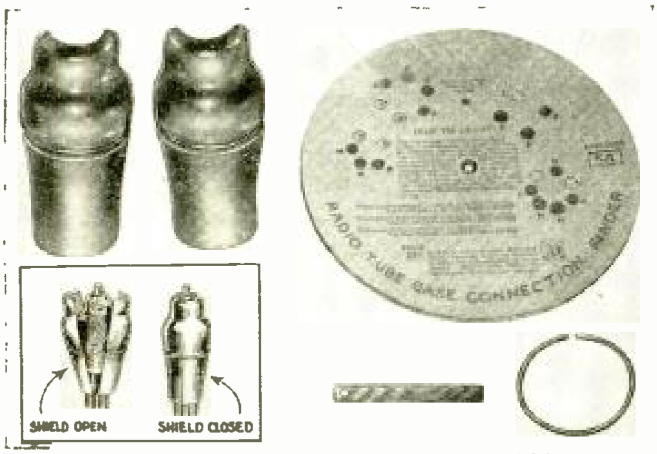


Fig. 3
Complete schematic circuit of the motor and light-control circuits used in this system. The output of the receiver works "the works."

LATEST RADIO EQUIPMENT



Tube shield; and tube-base connection finder (124)

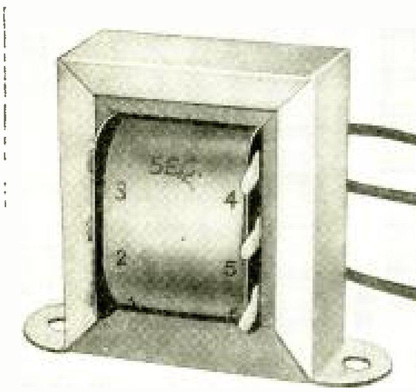
TUBE SHIELD AND TUBE-BASE CONNECTION FINDER

THE illustration to the left shows a new type of tube shield that may be termed "form fitting." The two units comprise the entire shield, and are installed by placing each half of the shield around the tube. The ring, also shown in the illustration, is then snapped into the groove provided, and the job is finished. The long metallic strip is used for making connection to the shield for grounding.

To the right of the photograph is a new tube-base connection finder, a handy little device in these trying times. It is composed of two concentric cardboard discs. To the right of the disc is a small window which indicates the type of tube whose socket connection is desired; in the example photographed, the tube is a 58. The remainder of the disc is taken up by socket holes. When the lower disc is turned to a tube number, the socket connections appear at a socket whose color corresponds to that of the tube number shown at the window.

OUTPUT TRANSFORMER

THE universal output transformer, shown below, is designed to meet the demand for a single unit that will provide the correct impedance matching between various types of audio output tubes and dynamic speakers.



Universal output transformer (125)

GENERATOR CONTROL

FEATURED below is a new device that should find favor among auto-radio users. When installed in your car, it gives remote control of the charging rate of your battery, at will. One of the bugbears in car-radio sets is the drain on the battery. If the charging rate is too high, the battery will be ruined; similarly if the rate is too low. The charging rate may be easily adjusted at will with this device.

Generator charging-rate control (126)

TUNED "AERIAL ELIMINATOR"

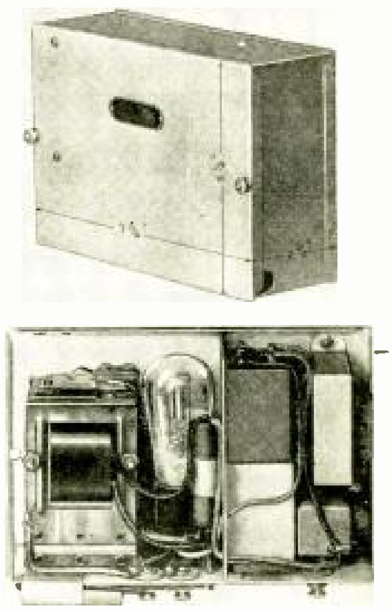
HERE is a novel little device which may be installed on any radio receiver. There is nothing "mysterious" about this unit—it operates on standard coupling principles. Connected to the antenna and ground posts of the average radio set, it eliminates the need for an outdoor antenna, for general local reception; in many instances it even results in improved reception of distant stations. The ground lead affords the necessary pick-up.

The tuned "aerial eliminator" (127)

AUTO "B" UNIT

A NEW auto "B" eliminator designed for auto-radio use has just been announced. The device is compact, measuring about the size of a standard 45-volt "B" battery; it is light, weighing but 6½ pounds; it consumes 2 amperes when delivering its rated output of 180 volts at 25 ma.; it is accessible, since the entire electrical unit may be removed for testing by loosening two nuts; and last but not least, the vibrator is equipped with two points instead of the usual single point.

The photograph below shows the internal and external views of the eliminator. This same company also manufactures an "A" power control relay to control the "B" power unit from the usual switch.

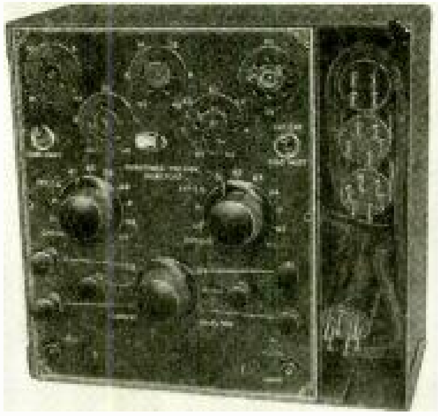


Above, external view of the "B" eliminator; below, an internal view of the unit. Note the size (128)

Name of manufacturer of any device will be sent on receipt of a self-addressed, stamped envelope. Kindly give (number) in description under picture.

THE LATEST TEST UNIT

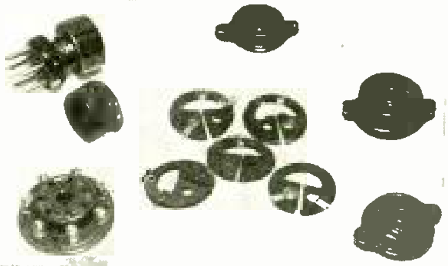
THE unit pictured below is designed to operate in conjunction with any volt-ohm-milliammeter to form a complete voltage, current, and point-to-point resistance tester. When the voltmeter, milliammeter, or ohmmeter is connected to the corresponding posts on the test unit, voltage, current, or resistance between any two points may be measured. The unit uses no adapters, except on the plug.



The test unit (129).

MORE SOCKETS

BELOW are pictured a number of new sockets suitable for various mounting facilities. Center, a group of harnesses, inserted between tube sockets and tube in A.C.-D.C. sets to automatically connect the filaments for batteries. Adapter in upper left, hole-to-prong connections easily made.



Sockets, adapters, and harnesses (130).

A NEW DEAL IN THE RADIO INDUSTRY

A HIGHLY organized campaign to find a new prosperity for the radio industry will be staged this summer and fall under the leadership of the R.M.A. This campaign will consist of two parts: (1) an intensive sales drive during the month of September; (2) and, special, spectacular broadcasting from October 2 to 7, which will be known as Radio Progress Week.

The radio industry, from manufacturer to Service Man, is right now bowed down with the hard times. Cut price competition has destroyed profits, and public interest in radio reception is at a low ebb; but the business tide has turned: general prices are rising, and public gloom is changing to confidence and optimism.

There are now approximately 6,750,000 homes using radio sets that are obsolete, and *13,000,000 homes that have no radio at all*; but the radio industry cannot expect to sit back and let the returning prosperity pour new business into its lap. For every other industry is going to be out after these same dollars from the family budget. Automobiles, refrigerators, travel, clothes, and other strong personal appeals will be scrambling for attention. *It will now be a competition with other industries that will be out energetically selling the home market.*

The Rebuild Radio Prosperity Campaign will have two objectives: (1) to canvass every radio set owner and put his radio receiver into condition, by installing new tubes, parts or accessories, or to replace it with a new set; (2) to canvass prospects for sets.

The prime objective will be to awaken a new popular enthusiasm for the present dependability of radio equipment, the perfection of its tone quality and control, and the perfection of modern programs.

Radio Progress Week, especially, through the cooperation of broadcast studios, advertising agencies and national advertisers, will pass in review before the public the scope, diversity and richness of modern radio broadcasting, and create a public appreciation of the dramatic part it plays in the life of today as a source of entertainment, a promoter of education, a liberator of thought and an influence for progress. In addition, regular broadcasting features of the week will be given a Radio Progress flavor and special local programs will be arranged in many cities. The National Broadcasting Company and the Columbia Broadcasting Company have pledged their hearty cooperation. A colorful program is assured, combining those elements of laughter, melody, romance, drama, knowledge and news, with which radio is enriching our lives.

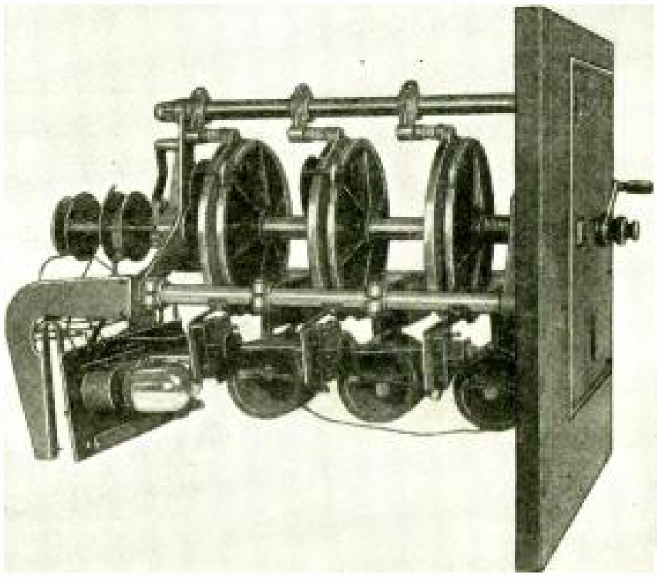
This campaign will benefit the entire radio industry. Prepare to give it your complete support.

A DECADE OF PROGRESS

RECENTLY, there was brought to the attention of the editors of RADIO-CRAFT the Rodgers Single Control receiver shown in the figure. Estimates place the "birth date" of the instrument around 1923. It is extremely interesting to note that this radio set incorporates many of the constructional features which contributed largely to the success of receivers designed in the next ten years.

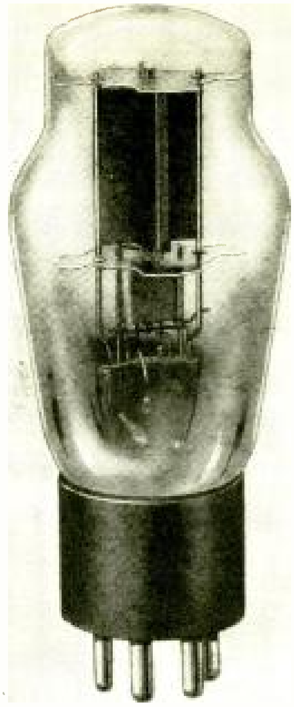
Thus, this device, a product of Rodgers Radio Co., Chicago, Ill., exemplifies single-dial tuning, resistance-coupled A.F. amplification, combined off-on circuit and volume control, drum-dial tuning scale, trimmer condensers, and metal chassis construction.

However, unlike all present-day receivers, which use variable condensers of the inter-leaving-plate type, the broadcast receiver shown in the figure is designed to use three parallel-plate condensers which are ganged in a very novel manner. A hollow shaft extends through the center of the three sets of condenser plates and terminates at one end in a lever and dual-knob control system. By cranking the lever the three sets of parallel plates are slowly drawn together; thus, tuning the figure 8 (astatic) R.F. coils.



THE 2B6—A DUPLEX TRIODE

Another new tube is now added to the list of power output tubes for radio receivers. The 2B6 described below is an outgrowth of the well-known Triple Twin, with all the "bugs" removed. See its rating, given below. A feature of "triple twin" design lies in the value of the output plate resistance, which is also the value of the output load resistance.



The 2B6—an improved Triple Twin.

L. VAN DER MEL

IT WAS not long ago when the only output tubes used in radio receivers were triodes, operated in standard class A circuits. The output of a class A arrangement is characterized by high quality and relatively low efficiency. Later, the pentode made its appearance. The pentode, while also of the class A type, has a higher power output and sensitivity for a given plate dissipation than the triode class A; but, unfortunately, the quality is inferior. This is inherently due to the mismatch of the plate impedance to the output load, in order to minimize the distortion. Its optimum load value is critical and the harmonics rise very rapidly with changing load. Furthermore, the predominating harmonic is third which, if large, becomes disagreeable to the ear. Although pentodes may be connected in the push-pull arrangement, the distortion still persists, at a somewhat lower level, but this system does not eliminate the load problems; it is emphasized because, while the second harmonics cancel in a push-pull arrangement, the third and higher order odd harmonics add, especially at high outputs.

Su·h tubes, however, found much favor among "midget" set manufacturers merely because they permitted large power outputs to be obtained with relatively small signal voltages. In the quest for additional power, class B tubes were designed whose main purpose is to provide very high power output. The system has no improvement over the pentode with respect to quality, in fact in most applications it is worse. Due to its design complications (particularly the power pack requirements) and its high cost, the system is not readily adaptable to receivers.

Thus, it is seen that when one wants quality, the triode class A system is the best, while if one wants power output with quality as a secondary object the class B system should be used. For a happy compromise of power, sensitivity, quality, and cost, the pentode has offered the best solution to the problem until the introduction of the new 2B6. The 2B6 consists of two triodes, and is designed to provide high output at low signal voltages in a triode class A connection. *Thus, this tube when properly used, is capable of combining the advantages of the high quality found in triode class A systems and the high power output characteristic of class B systems.* The results are obtained very economically.

THE 2B6

Heater voltage	2.5 volts
Heater current	2.25 Amp.

INPUT SECTION

Plate voltage	250 volts
Grid bias	—24 volts
Plate current	4 ma.

OUTPUT SECTION

Plate voltage	250 volts
Grid bias	+2.5 volts
Plate current	40 ma.
Plate resistance	5,150 ohms
Load resistance	5,000 ohms
Signal volts (r. m. s.)	25 volts
Power output	4 watts

The schematic circuit of this tube is shown in Fig. 1. It is seen that a single heater supplies two separate cathodes, and that the output grid connects directly to the input cathode inside the tube. That triode section of the tube into which the signal is fed is called the input triode, or section; while that section of the tube which feeds the speaker is designated as the output section. The respective elements of each section are labeled accordingly.

An examination of this circuit shows that the grid bias for the input section is secured by the voltage drop across R_0. Since the steady plate current of this tube is 3 ma. and its self-biasing resistor has a value of 8,000 ohms, the steady D.C. bias is —24 volts. Note that this resistor has no bypass condenser across it. Furthermore, since the input grid is negative with respect to the cathode, no power is dissipated in the input grid circuit.

The output grid connects directly to the cathode as shown, and since the output cathode has a self-biasing resistor of 540 ohms, and since the steady D.C. current of the output section is 40 ma., the voltage drop across this resistor, R_1 is 21.5 volts. The actual bias, with no signal at the input grid, therefore, is the difference between the voltage across R_0 and R_1, +2.5 volts. With this small positive bias, the output grid takes approx 1. ma. current. When a signal is applied to the input section of the tube, an A.C. voltage is impressed on the output grid which, of course, swings this grid alternatingly more positive and then negative. Since the grid is normally a few volts positive more grid power is consumed when it goes more positive during that part of the cycle. In other words, more grid current is required. This grid power

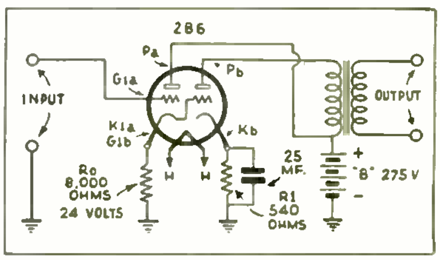


Fig. 1
A schematic circuit of the 2B6.

is automatically supplied by the action of the input section. The inherent compensating feature of this particular direct coupling provides the A.C. voltage across R_0 without distortion irrespective of the changing grid resistance of the output section. It is significant to note that the D.C. power taken by the entire tube with no signal is in excess of that required under maximum excitation. Therefore, the tube operates under class A condition and no complications in power pack design are necessary—standard parts may be used. It should also be noted that since the current from the input triode divides, part going through R_0 and part going through the grid-cathode resistance of the output section, the current for determining the input grid bias should be measured between the input cathode and R_0, not between input plate and "B+."

The resistor R_0, in addition to supplying the required grid bias for the input section, also acts as the load impedance of the input section and, therefore, cannot be shunted by capacitance. In fact, the total load impedance of the first tube is the parallel combination of R_0 and the grid impedance of the output section.

A particularly significant fact is that although the input grid is biased to —24 volts, a signal of 25 volts r.m.s. is required to deliver the rated output of 4 watts. Although the peak value of the signal applied to the tube is approximately 35 volts, this grid does not draw current because of the degeneration taking place, due to the lack of bypass action across R_0. This action may be more fully explained as follows.

A signal of 35 volts peak is applied to the input section. As a consequence of the plate current fluctuation, the A.C. voltage developed across R_0 is 21 volts. Since this voltage is in phase with the signal with respect to ground, the actual peak voltage actuating the input section is 35—21, or 14 volts. This corresponds to an effective value of 10 volts. Since the D.C. bias is —24 volts, the input grid can never draw current. This condition is illustrated by the circuit of Fig. 2 in which the input section has been redrawn so that the signal is applied between input-grid and cathode through the .5-mf. condenser, rather than between input grid and chassis as shown in Fig. 1. In this case, therefore, the signal voltage required for a power output of 4 watts is 10 volts, as calculated previously. Degeneration does not exist in the output section of the tube in view of the fact that R_1 is shunted by a 25 mf. condenser which is more than sufficient to maintain a constant potential across the self-biasing resistor, R_1.

Alternative Connections

The bias voltage for the output section may be obtained in another manner which has the advantage of eliminating the 25 mf. bypass condenser. Figure 3 shows the circuit arrangement which obviates the use of the bypass condenser. The hum level of the tube is so low that the hum introduced by such an arrangement is still a negligible factor. It is down —30 db which is far below that of more conventional output tubes. This circuit also has the additional advantage of having a slightly better frequency characteristic than that shown in Fig. 1, even though the 25 mf. condenser was increased, in test, to 50 mf.

(Continued on page 167)

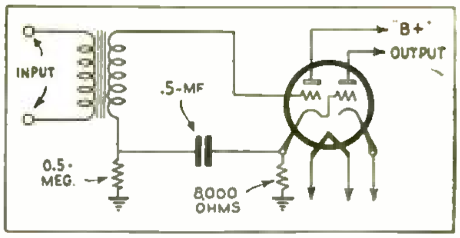


Fig. 2
Feeding the signal from grid to cathode.

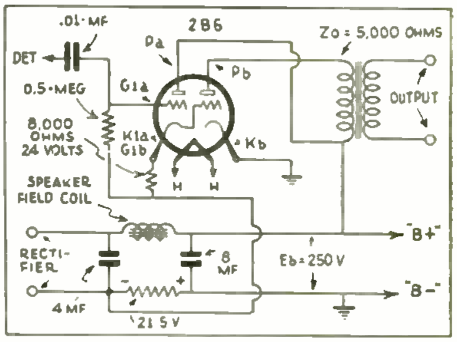


Fig. 3
Eliminating the 25 mf. bypass condenser.

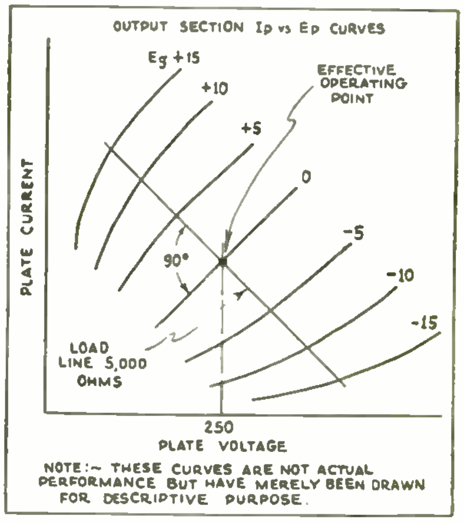


Fig. 6
Plate current vs. plate voltage of the 286.

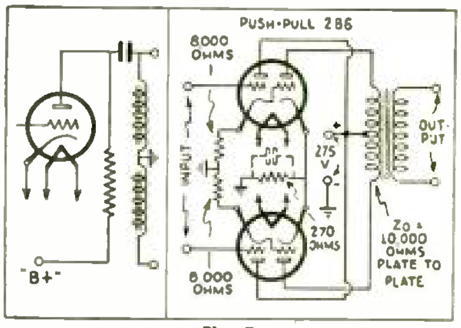


Fig. 7
Two 286's in push-pull.

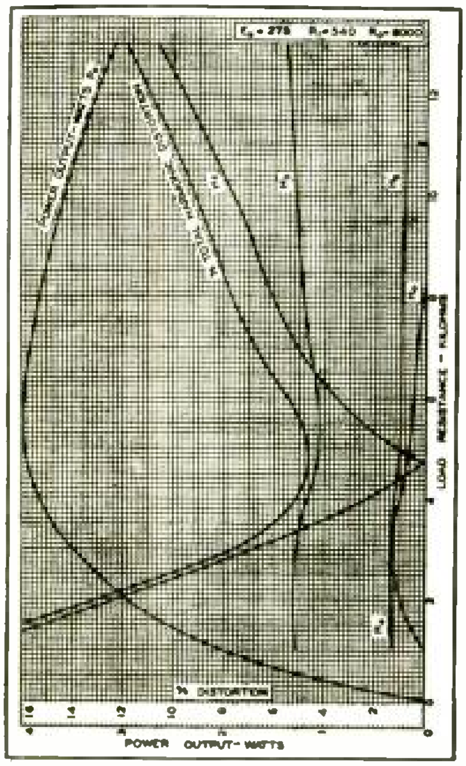


Fig. 4
Curves showing the relation between power output and load resistance.

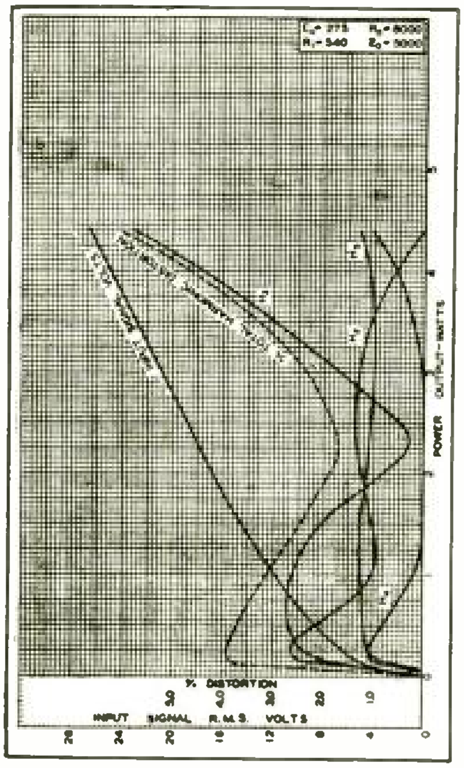


Fig. 5
Distortion vs. power output; and signal volts vs. power output.

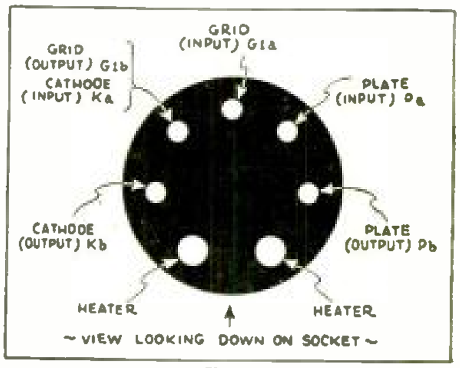


Fig. 8
Socket connections.

CONSTRUCTING THE ALL-WAVE MIDGET "FOUR"

H. G. CISIN

A description of a novel midget receiver which not only covers the broadcast band, but the short-wave bands as well. A switch changes bands, from 15 to 550 meters.

RECENTLY, there has been a considerable demand for an inexpensive A.C. receiver capable of bringing in short-wave as well as the regular broadcast stations. The All-Wave Midget "Four" is designed to meet this demand. No plug-in coils are necessary, because of the use of a new-type all-wave coil having enough windings to cover the band from 15 to 550 meters. The complete set of windings on this new coil, including the tickler windings required for regeneration, take up less space than a single short-wave coil of the ordinary type covering the band from 15 to 80 meters.

Description of Receiver

This new receiver is in the "midget" class, being mounted on a chassis 8 in. x 5 in. x 2 in. high. It uses the latest type tubes and has plenty of "pep." The circuit comprises an R. F. stage with a 58 tube, a regenerative detector using a 57 tube, and a 2A5 output, power amplifier. All three of these tubes are pentodes. The 57 tube, with the special shield arrangement in the dome, permits a decided reduction in output capacitance. This makes it especially desirable for short-wave operation. Moreover, its high transconductance, plate resistance, and sharp plate-current—grid-bias "cut-off" make it ideal for sensitive detection. Grid-leak detection is used.

Photograph of the "deck" of the all-wave ultra midget receiver.

Resistance coupling to the output stage permits the attainment of high tone quality. Regeneration is controlled by means of the condenser 17. A two-gang condenser is employed for the two tuned circuits when used on wave lengths from 200 to 550 meters. For short-wave reception, switch 4 is thrown to the upper position, cutting out the antenna coupler, 1; its tuning condenser, 3; and connecting the antenna to the control grid of the R. F. tube through a small special type condenser.

Switch 13 is connected to the various sections of the all-wave coil, 12, permitting rapid change-over from one band to another. Volume is controlled by means of a potentiometer, 21, connected in the control-grid circuit of the 2A5 output tube. This latter tube is a power amplifier pentode of the heater-cathode type. The indirect heating helps to minimize hum, making this tube preferable to the 47 type pentode. The 2A5 tube has an undistorted power output of 3 watts. With the recommended bias of 16.5 volts and a plate voltage of 250, the characteristic is substantially linear, resulting in a minimum of distortion.

The rectifier may be of the conventional 80 type; or, a 5Z3 may be used in its stead. In the latter case, it should be kept in mind that the filament requires a current of 3 amperes, necessitating the use of a power transformer designed for this heavy current drain. The field of the dynamic speaker also serves as an audio filter choke.

The automatic line voltage control aids the attainment of excellent performance regardless of variations and fluctuations of the supply voltage.

Construction Details

Socket holes and transformer mounting holes are drilled in the metal sheet before the chassis is bent. After the chassis is bent, the five wafer-type sockets are mounted, four on the "deck," and one for the speaker connections at the rear chassis wall. The power transformer, 31, may now be mounted.

The small condenser, 17, is mounted at the right on the front chassis wall, while the volume control, 21, is mounted at the left. The three switches, 4, 13, and 32, are also mounted on the front chassis wall, as indicated in the bottom view diagram.

The chassis is now turned upside down and the all-wave coil, 12, is mounted as shown. The R. F. choke, 18, is mounted next. The two "cardboard" electrolytic condensers, 28 and 29, are each fastened to the sides of the chassis by two thin metal straps; but they should not be put into place until most of the wiring has been completed; otherwise, they will make it difficult to wire up certain of the socket terminals. All other parts below the chassis are soldered in position during the wiring.

The chassis is again turned right-side up and the dual variable condenser, 3 and 8, is mounted. The two trimmer condensers, 3A and 8A, are fastened to the top insulating support of the tuning condenser. The grid condenser, 14, and grid leak, 15, are also fastened to the same insulating support.

The set is now ready for wiring. Push-back wire should be used for all wiring. The filament circuits may be wired in first. The filaments of 5, 16, and 22 are wired in parallel to the 2½-volt filament winding of the power transformer. The center tap of this winding is grounded to the chassis. If a pilot light is used, it should be wired to the 2½-volt winding.

Grid circuits are wired next. Note that the control-grid connections of the 53 and 57 tubes are at the caps, as indicated on the schematic diagram. The socket connections for these tubes are as follows: *Looking down on the socket*, the two large holes are for the filament prongs. Then, starting from the left filament terminal and going around the socket in a clockwise direction, the terminals are cathode, suppressor grid, screen grid, and plate, respectively. Note that the suppressor grid terminal is connected externally (at the socket) to the cathode terminal.

Looking down on the socket of the 2A5 tube, 22, the two large holes are for the filament prongs. Then, starting from the left filament terminal and going around the socket in a clockwise direction, the terminals are cathode, control grid, screen grid, and plate, respectively. In this tube, connection between the suppressor grid and the cathode is made *within* the tube.

After the various grid connections are completed, plate circuits are wired, then cathodes, antenna-coupler primary, bypass condensers, power supply transformer to rectifier tube socket, and filter system. The dynamic speaker output transformer and field coil connections are wired to a four-prong plug, 26, to conform to the connections at the socket, 25. Instead of using binding posts, antenna and ground connections are brought up from below the chassis, using flexible wire. After the wiring is completed, the tubes are inserted, aerial and ground are connected, and the speaker is plugged in. When current is turned on, the trimmer condensers are adjusted for maximum response on broadcast signals. The set is then tested out on the various short-wave bands.

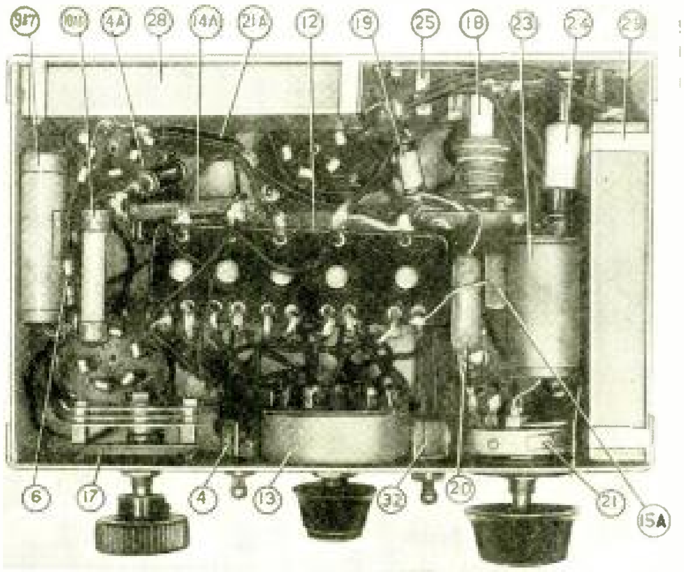
This little midget covers the entire wave band from 15 meters to 550 meters without changing coils. Hence, in addition to receiving conventional broadcasting, it brings in police calls, trans - Atlantic phone calls, foreign stations, and many other classes of interesting short-wave transmissions. The circuit is regenerative for maximum sensitivity. Three pentodes are employed, including the new 2A5 power output tube. Change-over from one waveband to another is accomplished by means of a double-pole five-point switch, connected to a new type coil having a plurality of inter-connected windings. This set is compact, inexpensive, and easy to build.

THIS ALL-WAVE MIDGET—

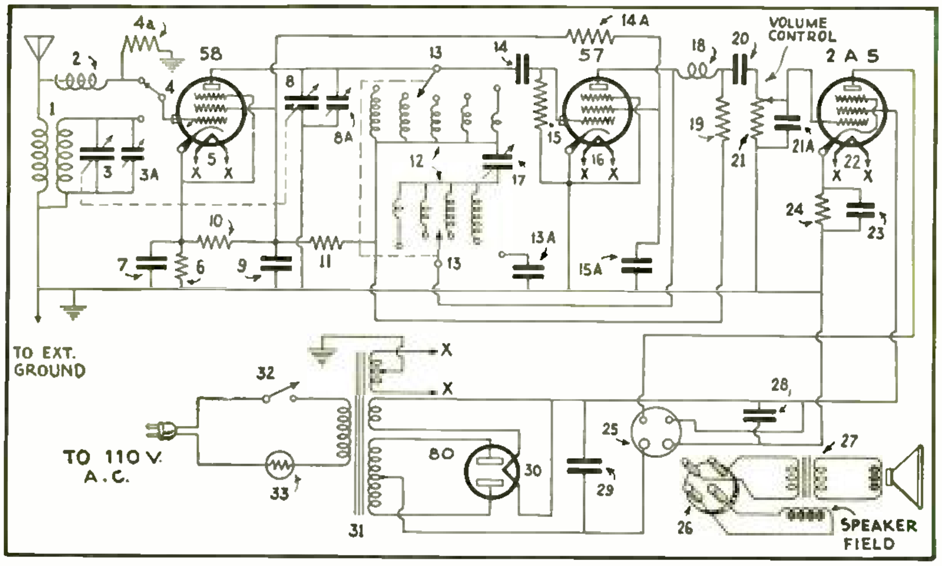
Improvements in midget receivers usually mean only a change in tubes. In this midget, however, the improvements are real—the receiver covers the short-wave bands as well as the conventional broadcast frequencies.

The set is easy to construct, has no special parts, and represents a radical departure from the more conventional sets of the same type.

RADIO-CRAFT is pleased to present this, the first, description of an all-wave "cigar box" receiver.



An under-view of the receiver. Note the smallness of the coils and their location.



Schematic circuit of the set. There is nothing tricky about it to confuse the constructor.

List of Parts

One .000025-mf. variable condenser, 17;
One dual midway variable condenser, .0002-mf. each section, 3, 8;
Two Acratest trimmer condensers, 5 to 25 mmf., No. 2881, 3A, 8A;
One Find-All antenna coupler, 1;
One Find-All R. F. choke, 18;
One Find-All all-wave R.F. coil-set with tickler, 12;
One Electrad 500,000-ohm volume control, type RI-203, 21;
One Electrad Truvolt 1,500-ohm flexible resistor, type 2GB 1000, 6;
One Electrad vitreous enameled resistor, 400 ohms, type H-897, 24;
One Aerovox .001-mf. mica condenser, type 1460, 13A;
One Aerovox .004-mf. mica condenser, type 1460, 15A;
One Aerovox .075-mf. cartridge condenser, type 281, 20;
One Aerovox .002-mf. mica condenser, type 1460, 21A;
Two Aerovox .1-mf. cartridge condensers, type 281, 7, 9;
One Aerovox .0001-mf. mica condenser, type 1460, 14;
Two Aerovox 4-mf. dry electrolytic condensers, cardboard container, type P5-4, 28, 29;
One Aerovox 25-mf., 25-volt cardboard dry electrolytic condenser, type PR25-25, 23;
One 25,000-ohm, ½-watt metallized resistor, 11;
One 500,000-ohm, ½-watt metallized resistor, 14A;
One 100,000-ohm, ½-watt metallized resistor, 19;
One 1 megohm, ½-watt metalized resistor, 15;
Two 10,000-ohm

(Continued on page 167)

CONSTRUCTING A COMPLETE 26-WATT DUAL CHANNEL P. A SYSTEM

A description of a complete portable four stage amplifier for P. A. work. This system is designed to operate from a 110-volt A.C. power line, or directly from a six-volt storage battery.

LOUIS GANCHER*

HISTORY always repeats itself—the radio boom days of 1921 to 1926 brought fame and fortune to many radio business men. Right now, a new industry—that of P. A. amplifier sales and rentals—is in its embryonic stage, and the live-wire radio man will forever revere the fortunate day that he decided to enter this new industry. Its profit making possibilities are really enormous and limited only by the individual's aggressiveness.

A large number of new applications are found for public address systems in every phase of industry, and it is, therefore, no great wonder that many radio dealers and Service Men turn to P. A. work, which they find yields a much more lucrative income than the sale and repair of radio receivers.

*President, Coast-to-Coast Radio Corp

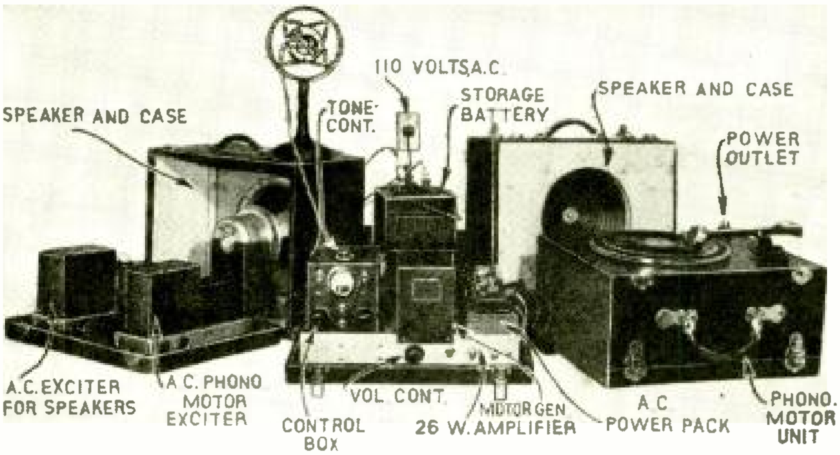


Fig. A
View showing the complete system unlocked. The tuner is not shown.

A Modern P. A. System

The compactness of the modern P. A. system to be described has not impaired its over-all efficiency, quality, or power output. In fact, the employment of high grade components and the careful design and layout of the system has resulted in the perfection of a P. A. amplifier that has all the desirable features of a portable system, such as light weight, high output of good quality with fairly small tubes operating at relatively low plate voltages and an unusual overall economy of power consumption.

Although present operating requirements might only call for exclusive use from 110-volt A.C. light sockets, this system is the logical one to own, for it enables one to secure, at any later date, a suitable 6-volt, storage-battery-operated motor generator, which may be bolted to the chassis in the space left vacant. In the same

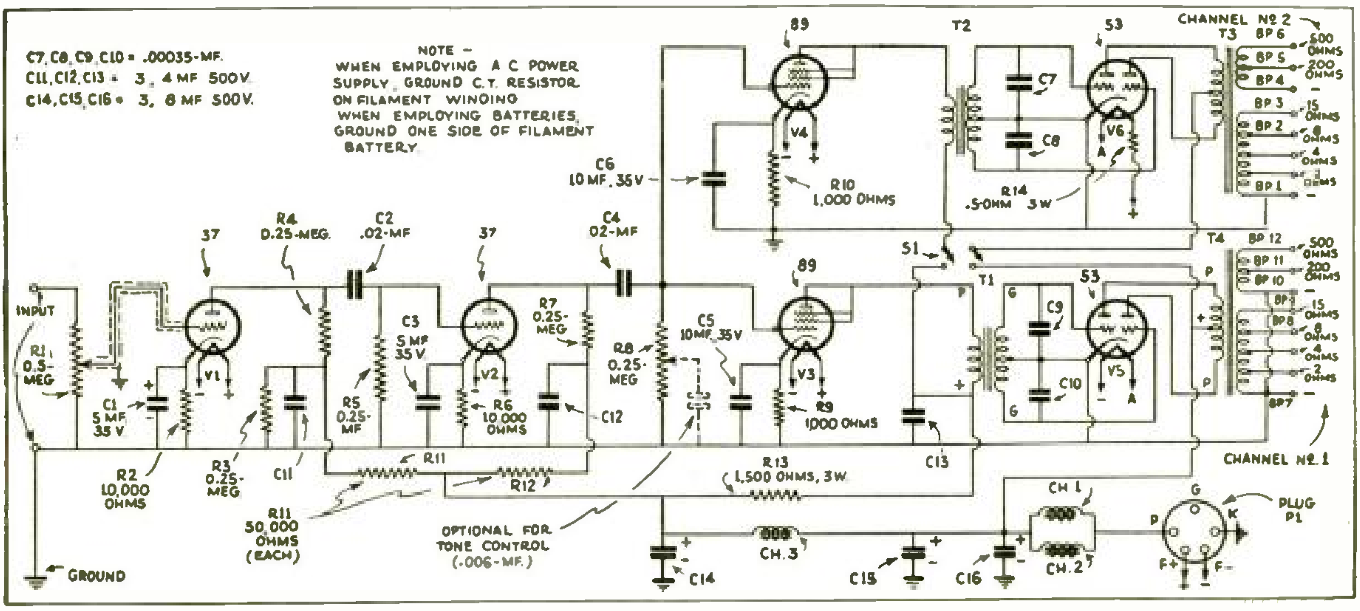


Fig. 1
Schematic circuit of the dual-channel system using two type 53 tubes. Ground BP. 4 to BP. 1.

manner, you can start with the motor generator alone, and then, later on, add the 110-volt A.C. Power Pack.

However, before discussing further details of this system, it might be best to outline the series of articles to follow monthly. This series will describe at length the complete system, giving full constructional details on all the essential units that comprise a complete installation.

Here is the ideal arrangement for a public-address system capable of meeting every application arising in the P. A. field, regardless of whether such applications require operation from a six-volt storage battery in an automobile, sound truck, boat (wherever 110 volts A.C. is not available) or from any commercial 110-volt A.C. power line. Another exclusive feature incorporated in the design of this highly efficient system provides for the *simple and rapid change-over from any one of the sources mentioned previously to any other.*

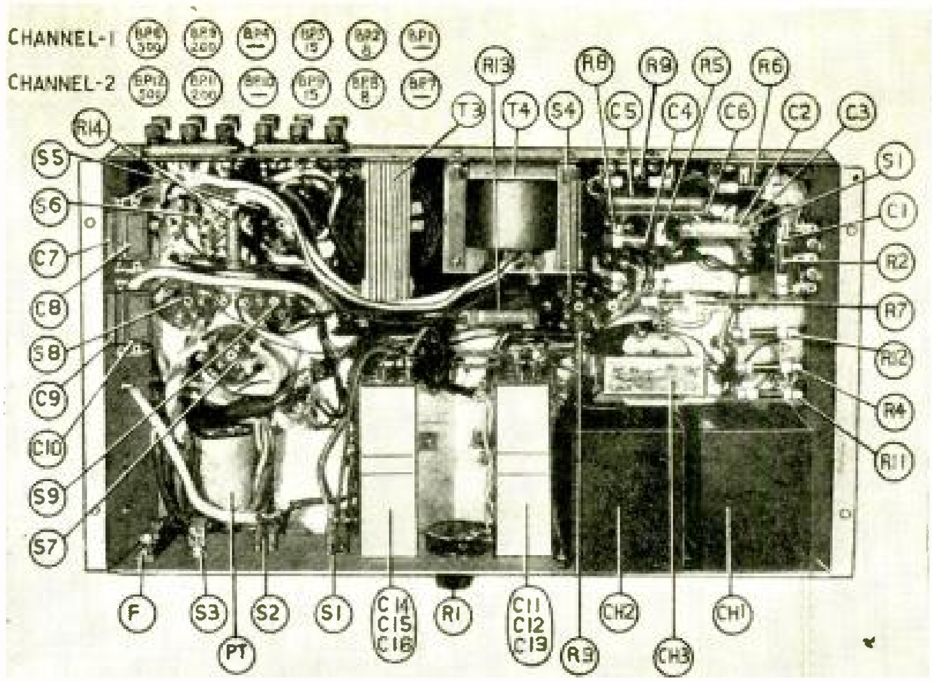


Fig. B
An under-view of the Coast-To-Coast amplifier showing the location of all parts.

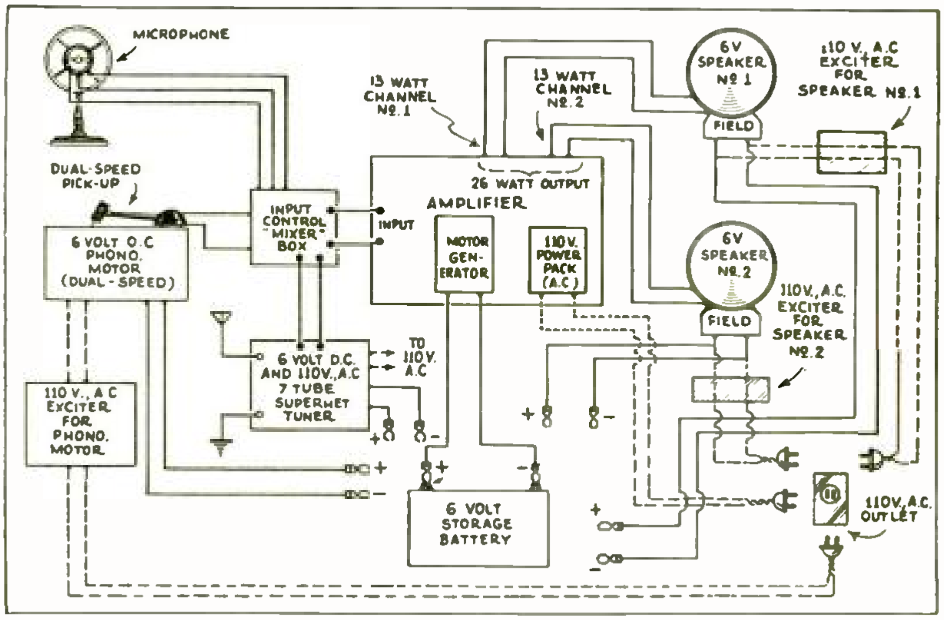


Fig. 3
A block diagram of the entire system from microphone or turntable to the dual-channel output system.

Portable Inter-Locking Feature

The unique method of housing the individual units that comprise the complete P. A. System is meeting the approval of all P. A. Engineers, and is shown in Figs. A, B, and C. From Fig. C, it is clear that, inasmuch as each portable case and associated cover is exactly identical in size, and as the snap-on draw bolts and catches are all fastened to each case in identical positions, it is possible to "nest" or "interlock" any one, two, three, etc. cases together, thereby simplifying the carrying around of complete systems. Obviously, two men are required to conveniently carry three or more amplifier units.

Separately removable handles are another feature. The illustration of Fig. C clearly shows how a complete amplifier system—composed of the amplifier, phono. turn-table, and two speakers—are inter-locked into one unified, easily transported compact unit. The three great advantages offered by this system are:

(1) Ability to change the size of the system to suit any particular method of transportation. Thus the entire outfit may be interlocked into one unified case (as illustrated) for auto use; or, it may be interlocked in groups of two or three cases for carrying by hand;

(2) Each of the P. A. components, ordinarily housed in a separate case, may be separately removed and placed at some remote point to effect proper sound distribution or to provide for the control of the complete system from any strategic position. In fact, the most difficult of P. A. installations are easily handled by this system;

(3) Each of the varied units may be built, or purchased, separately to meet present requirements, with the assurance that regardless of when additional units are built or purchased, the entire system will retain both its unified construction and all of its portable features. The covers of the individual cases also retain the valuable interlocking feature and may, in themselves, be employed in pairs, forming a versatile-purpose carrying case for housing records, cables, etc.

Described in this article is the universally-operated, power amplifier delivering up to 26 watts of audio output. In the second article completing this series (scheduled to appear in next month's issue), there will be described the dynamic speakers equipped with dual fields, permitting 6 volt D.C. and 110-volt A.C. operation; there will also be described the separately-removable input "mixer" control box as well as the 110-volt A.C. exciter, which permits operation of the 6 volt D.C. phono. motor from both sources of current. The universally-operated 6-volt D.C. and 110-volt A.C. superheterodyne receiver will also be fully described. This tuner represents an advanced design, incorporating such improvements as automatic volume control, inter-station noise suppression, visual meter tuning, push-pull power detection, 10 k.c. tuning separation, four-gang oscillator "tracker," band pass pre-selection, and has a sensitivity better than 1 microvolt per meter.

The introduction of the twin class B, 53 tube has heralded the advent of economically operated amplifier systems, wherein the plate requirements are low enough to permit the use of low drain D.C. motor generators. Heretofore, the only other class B tube that was capable of producing 26 watts were two 59's, requiring 450 volts of "B," at 125 ma. Compare that to the 53 tube, two of which also

(Continued on page 170)

THE DESIGN PRINCIPLES OF AN
ALL-PURPOSE TESTER

This article is a bit different from the average run of tester articles in that the author describes the electrical details of a commercial instrument. This article will give you an idea of how the brain of a chief engineer works.

FLOYD FAUSETT*

PROFESSIONAL radiomen are always interested in professional equipment, and there is no testing equipment as professional in appearance as that which incorporates all of the essential testing elements in one compact design; such a tester may be conveniently carried into customers' homes for preliminary tests, or used in laboratories for the detailed testing procedure required for effecting necessary repairs and adjustments. It is the purpose of this discussion to outline the design principles of a modern tester which completely fulfills these desirable requirements.

The rapid changes in the tube and circuit designs involved in new radio developments have made it necessary that the design engineers of radio testers anticipate such changes as far as possible by designing equipment which is readily adaptable to new testing procedure. This has resulted in the development of the new "free reference" point-to-point system of current, potential, and resistance analyses and tube testing, so that the professional radioman naturally asks whether or not the new equipment which is offered to him enables complete "free reference" tests.

Description of the Tester

This new portable laboratory is so designed that any circuit may be used for reference purposes for potential or resistance analyses or for tube testing from the sockets of operative radio sets by the operation of plainly-marked switches which are designed especially for this tester.

The principles of the "free reference" system of point-to-point analyses through an analyzing cable may be compared to the principles of the modern telephone switchboard through which any subscriber may be connected with any other subscriber, and which is easily adaptable to changes in the list of subscribers. The fundamental switchboard principles are practically the same whether the connections be made manually or by dialing switches. The portable laboratory, which is the subject of this discussion is, fundamentally, a miniature switchboard to which all of the circuits of a radio tube socket are extended for any desired measurement by connections made with plainly-marked rotary switches of a special circuit-breaking type, so that it is not necessary to dismantle the radio chassis as is the case when the usual point-to-point tester is used.

*Chief Engineer, Supreme Instruments Corp.

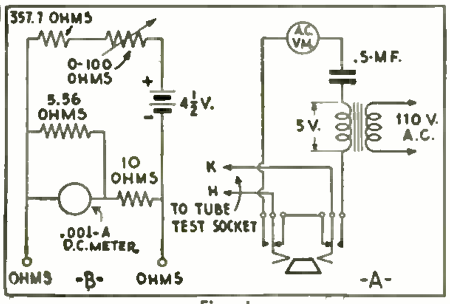


Fig. 1
Fundamental elements of the meter circuit used in the new tester.

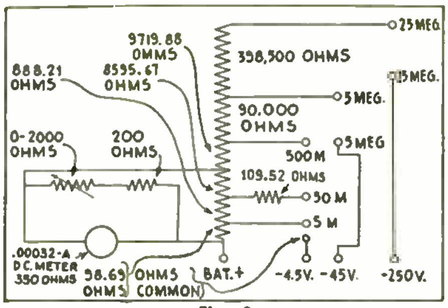


Fig. 2
Circuit of the ohmmeter ranges for values to be measured above 500 ohms.

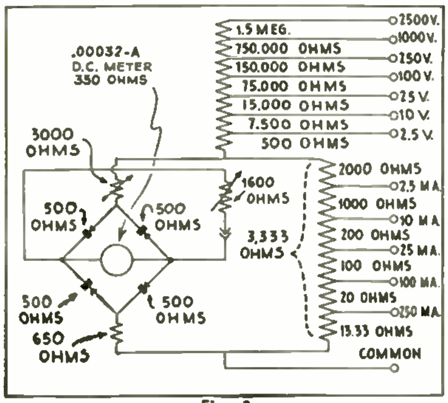


Fig. 3
Circuit of the meter movement with the rectifier included.

While the condition of radio tubes may be easily checked with this tester from the tube sockets of operative radio sets, provisions are made for testing tubes with separate A.C. power supply potentials on a meter which is provided with a colored quality dial divided for "Bad," "Doubtful," and "Good" classifications. This meter is associated with a new circuit which eliminates the necessity of a "bucking current" rectifier, so that the meter needle cannot back violently off-scale when a tube is removed from a tube testing socket before the tester is turned "Off." This arrangement permits the radioman's customers to observe the meter indications of tube conditions in terms which they can understand, instead of referring to a chart of electrical terms which the customers cannot understand. The test indications are based on the principles of the well-known transconductance (or mutual conductance) characteristics of amplifier tubes, and provisions are included for indicating shorted elements, against which the tube testing meter is fully protected.

In addition to the usual tube testing provisions, a special cathode-heater leakage testing circuit is incorporated in this tester. The usual "cathode-heater short test" is inadequate for practical requirements because it is seldom found that the resistance between the cathode and heater elements is low enough to be indicated by such tests. It has, therefore, been found advisable to develop a sensitive metering circuit for indicating leakages as well as shorted conditions between the cathode and heater elements. The fundamental elements of this testing circuit are shown in Fig. 1A.

The milliammeter which is used for tube testing is also used, in conjunction with a small flashlight battery, for a low resistance-measuring range up to 500 ohms, so that the meter needle will be deflected about half scale when measuring a 15-ohm resistor. A resistor of unknown value, when measured on this range, is connected as a shunt to the meter, so that the resistance calibrations range from zero on the left end of the scale to a maximum on the right end of the scale. The circuit for the 0 to 500-ohm range is shown in Fig. 1B.

A circuit diagram of the ohmmeter ranges above 500 ohms is shown in Fig. 2. It will be observed that unknown resistors to be measured are to be connected in series with the ohmmeter circuits, so that the meter calibration for the "OHMS" scale reads from zero at full-scale deflection to a maximum at the left end of the scale. The variable ohmmeter, zero-adjustment rheostats for both meters are mounted on a single shaft, so that one control knob serves to adjust the ohmmeter functions of both meters. The 0/500/5,000/50,000/500,000-ohm ranges are powered by a small 4.5-volt flashlight battery contained in the tester. The 0/5/25-megohm ranges are operated from the A.C. power supply system through a rectifier tube inserted in one of the panel sockets during the test. The ohmmeter ranges are selected by a simple switching arrangement and may be applied through the analyzer cable to radio circuits without the necessity of using test leads or jumpers. The higher ohmmeter ranges are about five times as high as those obtainable with a meter of one milliampere sensitivity. The meter employed for these higher ranges has a sensitivity resistance of approximately 3,000-ohms-per-volt.

A meter of high sensitivity is required for effecting the necessary compensation of crystalline rectifier characteristics for current, capacity, and potential measurements. The meter employed in this tester has a full-scale sensitivity of about 320 microamperes, which is less than one-third of a milliampere. The meter movement is shunted for D.C. measurements so that the full-scale sensitivity becomes 400 microamperes. Part of the resistance connected in series with the meter movement is composed of an alloy which has a temperature coefficient opposite that of the rectifier, so as to "balance out," or compensate, the effect of temperature variations on the rectifier.

A study of Fig. 3 will show that the total resistance of the meter movement combined with that of the rectifier and two series resistors is 5,000 ohms. A divided, or tapped, 3,333-ohm shunt resistor reduces the effective meter resistance to a value of 2,000 ohms. The current then required for full-scale sensitivity is one milliampere, so that the multiplier resistors must have a resistance of 1,000-ohms-per-volt.

By the use of a very sensitive high resistance meter circuit, the resistance variations of the rectifier, owing to temperature and current density variations, are made a comparatively negligible factor when compared to the total resistance values of the meter circuits. This circuitual arrangement enables a universal single-scale calibration of the meter for A.C. and

This "laboratory," the new Supreme Master AAA-1 tester, permits "free reference" or point-to-point tests.

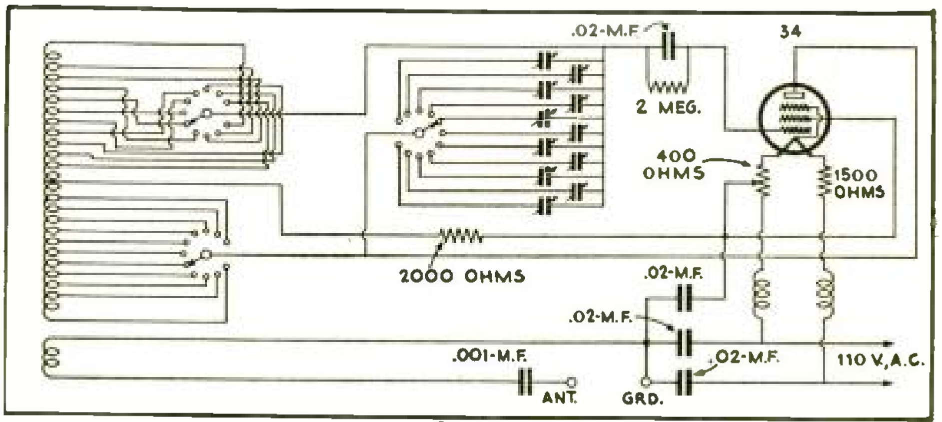


Fig. 4
Here is the oscillator circuit used in the new Supreme Master AAA-1 tester.

D.C. potential and current measurements, in ranges of 0/2.5/10/25/100/-250 milliamperes and 2.5 amperes, and 0/2.5/10/25/100/250/1,000 and 2,500 volts. The meter ranges which are used in radio tube socket analyses are selected by a multi-gang rotary switch, one gang being used for current ranges and one for voltages.

The Multimeter

The sensitive Multimeter is ideally suited for output measurements, and provisions are made for such measurements without the use of troublesome output adapters which are difficult to attach to tubes in close-fitting shields. Output measurements are accomplished by inserting the analyzer plug into one of the power output tube sockets and setting a switch for output indications. Output measurements may be made within any of six ranges.

The 3,333-ohm shunt resistor of the Multimeter is also tapped for three capacity-measuring ranges of 0/0.01/-1.0/10 microfarads for direct readings on the 100-scale of the meter. These taps are not indicated in Fig. 3. The capacity measurements are made in series with the ordinary A.C. power supply system. In addition to these facilities for measuring the capacity of paper capacitors, provisions are made for applying the 250-volt D.C. output potential of the tester for measuring the leakage current of electrolytic and paper capacitors, so that such capacitors can be discarded when the leakage current exceeds one milliampere per rated microfarad. The arrangement whereby capacitive values are directly indicated on a meter scale which is also used for A.C. and D.C. potential and current measurements is unique in radio tester designs, as no separate chart is required.

The Oscillator

The oscillator circuits of this tester are shown in Fig. 4, and are tuned by a tap switch arrangement so that calibration charts are not required, the frequency values being marked on the panel. Eleven fundamental frequencies between 130 and 1,875 kilocycles are provided, with a tuning signal in each of the 20-meter, 40-meter and 80-meter short-wave bands. The oscillator may be operated with either A.C. or D.C. power supply, and is completely shielded with a variable output attenuator.

When operated with A.C. power supply, 100% modulation is auto-

(Continued on page 173)

QUALITY IN AUDIO AMPLIFIERS

The author describes below a novel audio amplifier, used in a commercial receiver, which makes use of the new 2B6, described elsewhere in this issue. Two output tubes are used, each feeding into a separate audio channel.

W. H. HOLLISTER*

IT IS an underlying trait in human nature to follow the common herd. Radio manufacturers are today so busily engaged in imitating each other that it is not surprising that the average radio set, instead of being the marvelous musical instrument it should be, has degenerated into a "cigar box," which cannot cover the eight and a half octaves that are possible in the audio spectrum, and that are necessary for the production of good music.

Manufacturers who once took pride in the quality and tone of their products hang their heads in shame as they look at the red figures on their books after a year in competition with "cigar box" manufacturers.

This tendency toward extreme economy and small size has brought about a rapid development in the tube art. Tubes having tremendous amplification at R.F. and I.F. have been developed, but practically little or nothing has been done toward the development of tubes for the audio end of the set. The commonly used pentode is famous for its high distortion, but is used because of its high gain. The distortion is not so noticeable when the frequency range covered by the small speaker and baffle area is only about 25 per cent of that possible; but when used with a large, well designed speaker and baffle, the objectionable harmonics make its use prohibitive.

*President, Lincoln Radio Corp.

Lincoln, like other custom-built sets, has been catering to the appeal of the exclusive who want the best in music and DX. The audio system is the best that the design of present-day tubes makes possible. However, an ever increasing number of inquiries and requests for something new and better in sound effects and tone led Lincoln engineers to search further for the unusual and exceptional in tonal reproduction. This search extended over the greater part of the last year, and has finally terminated in the development of the new Bin-aural Duo-channel audio system. This is not a trick name designed to arouse your curiosity; rather, it is an exact description of what this system accomplishes: "Bin-aural" means to hear from two directions, and "Duo-channel," as its name implies, means two channels.

However, the outstanding feature of this new system lies in the use of a new super-power output tube, which delivers four watts at less than five per cent distortion. The realization of this new Bin-aural Duo-channel audio system was made possible largely through the use of this new output tube, the 2B6. A study of its characteristics will indicate why this is the case. (See article on this tube elsewhere in this issue.—*Editor*) First of all, at least four watts output was required; second, triode quality was imperative; third, a greater power sensitivity than was possible with any existing triodes was necessary in order to eliminate additional stages of amplification with their attendant distortion.

A quick summary of the existing tubes will indicate their shortcomings. The type 45 tube in class A delivers only 1.6 watts, and 35 r.m.s. volts must be applied to the grid for this power; it is evident that the power sensitivity is low and additional stages would be required. The type 50 tube, of course, was not considered because of the high plate voltages necessary for its operation, which would make necessary the use of expensive transformers, condensers, and rectifier tubes, so that the list price would become almost prohibitive; then, too, the power sensitivity is low, requiring 60 r.m.s. volts applied to the grid to secure the rated power output. The new 2A3 was also tried out and discarded because of its internal construction, having a multiple filament; furthermore, it requires 42 r.m.s. volts for rated output, and has a very high plate current—60 ma. This tube is rated at 3.5 watts.

A study of the characteristics of the new 2B6 tube will plainly indicate why it is superior in every way and why it was selected: rated watts output, 4 watts; total plate current, 44 ma.; r.m.s. input volts to the grid to secure rated watts output, 24; plate voltage, 250; plate battery, 274 volts; per cent distortion, less than 5 per cent. *By less than 5 per cent, we mean that at only 4 watts does the distortion become 5 per cent, and that at less than 4 watts, the distortion is less than 3 per cent.*

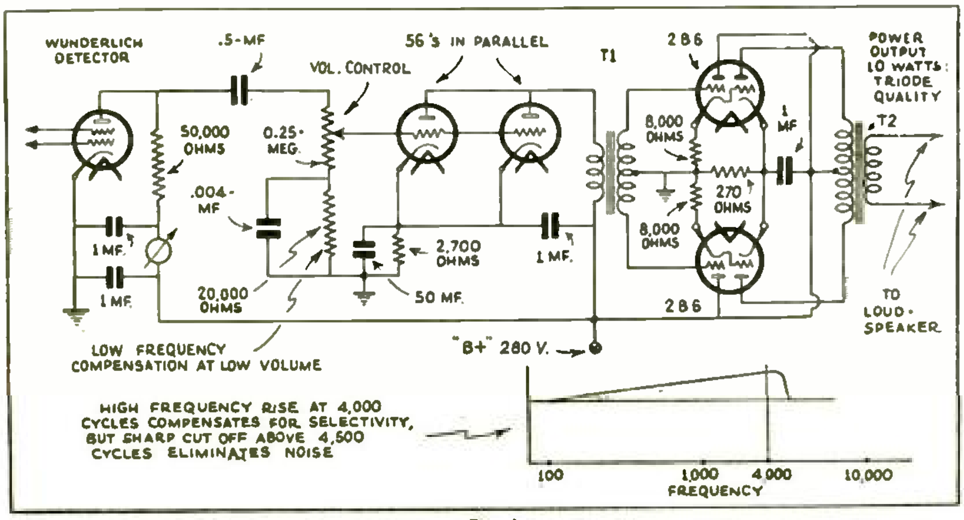


Fig. 1
A circuit illustrating one manner in which the 2B6 tubes may be used.

Using the 2B6

The study of Figs. 1 and 2 will plainly indicate just how this tube is used in two different circuits. In Fig. 1 the two type 56 tubes are connected in parallel to increase their power handling capacity and, also, to reduce their plate impedance which is normally quite high. This latter adds very materially in the transformer design for low frequency response. The push-pull input transformer, T1, is a specially designed transformer having the rising characteristic from 20 to 4,000 cycles, as shown in the figure. It is extremely good at low and high frequencies. The high-frequency rise compensates for the extreme selectivity of the Lincoln receiver. Incorporated in the volume control is a low-frequency compensator to make up for the deficiency of the ear on low frequencies at low volume. The high frequency cut off at 1,500 cycles eliminates noise, hiss, etc.

This is a big improvement over the standard design, but by no means compares with the new Bin-aural Duo-channel system which is shown in Fig. 2. Reference to Fig. 2 will show how the two channels split at the detector plate circuit into a high and low channel, being roughly divided at a thousand cycles, which is the apex of the average ear-pressure curve. Each of these channels operate directly into its own speaker, and each speaker is designed for the best reproduction of the frequencies above and below a thousand cycles in their respective channels. *It can readily be seen, therefore, that exact adjustment of the bass or treble may be secured for any ear under any conditions, as the entire level above or below a thousand cycles is raised or lowered at the will of the operator.* Many startling and beautiful effects may be secured by the placing of the bass and treble speakers in different locations in a room so that a spread, diffused, or orchestral effect is secured; the sound coming from two different directions and in the two different halves of the frequency spectrum creating a naturalness not heretofore possible. Likewise, it has a wide application in the tuning of short waves, as excessive noise or interference may be diminished by reduction of the high-frequency range.

A strange paradox exists today. Broadcast studio managers bend every effort for the production of the entire audio-frequency spectrum, and their use of the highest type of orchestra and vocalists seems to be an empty gesture when one views the "two by four" boxes now displayed as receivers.

It has long been Lincoln's belief that music is more necessary and lasting and fundamental than any other contribution. As one well-known engineer so aptly states: "It is no trick to design a receiver which will receive foreign broadcasts, but how? Of what use is any receiver if the reproduction produced by its operation is not enjoyable?"

TRIODE CLASS A AUDIO SYSTEMS

Many a good receiver was made obsolete when the pentode and class B tubes were first announced. They were made obsolete simply because new tubes were available, and not because the new tubes made reception any better. During the past few months many reputable manufacturers have returned to the triode, class A systems, and have discarded entirely the pentode and class B output tubes.

The general censensus of opinion among these manufacturers is that pentodes are good where high power/sensitivity is desired; class B systems where economical operation, such as in portable sets, is required; and triode, class A audio systems where high quality is essential.

This article by Mr. Hollister treats the audio system used in his latest receiver, and is self-explanatory.

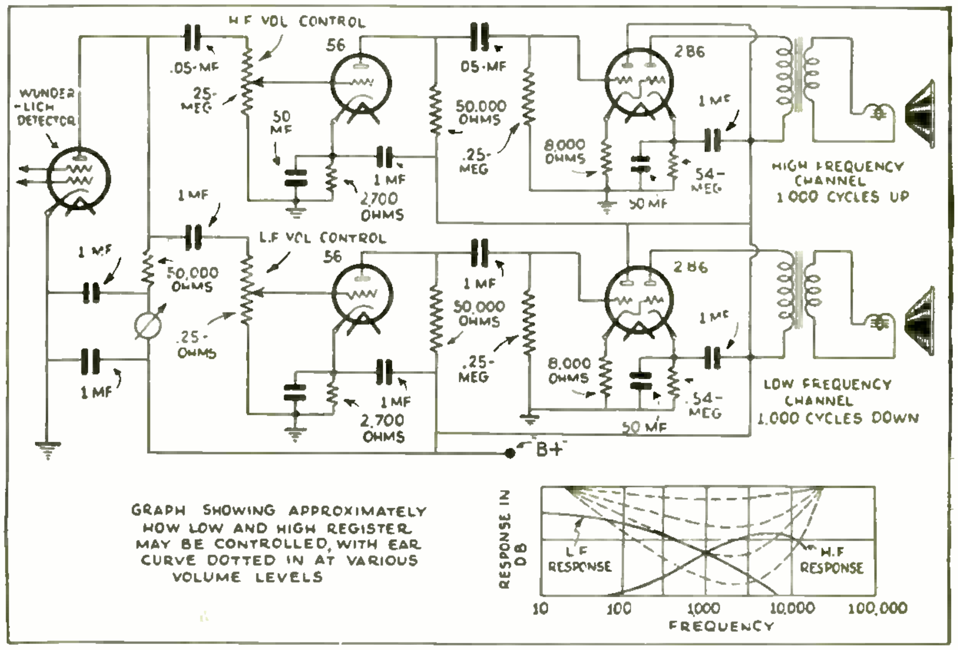


Fig. 2
A circuit superior to that of Fig. 1, and which is adaptable to twin-speaker operation. The response is adjusted to suit the selectivity of the R. F. stages.

FEATURES OF A MODERN 50 KW. STATION

THE General Electric Company is installing at South Schenectady, N. Y., one of the most modern 50 kw. broadcast transmitters in the United States. This transmitter is designed for improved operating characteristics particularly as regards frequency stability, quality of transmission and continuity of operation. Many of these improvements are being incorporated as a result of the company's experience in operating and maintaining broadcast transmitters for the past ten years. The company also has wide experience in the commercial field. This experience has been continually used as a basis for continued improvements up to the present time. It has been the company's policy to incorporate new design features at WGY for thorough operating tests under actual service conditions before such features are included in commercial transmitters. This policy has been applied to the new transmitter and it is confidently expected that many important improvements will result.

It may be interesting to follow the audio signals which are sent out from the studio for transmission to the radio audience.

These signals consist of electric currents similar to those transmitted by the service telephone excepting that the frequencies present include those in the approximate range from 30 to 10,000 cycles. The signals arrive at the transmitter building via a telephone wire line which is specially adjusted and balanced to permit the transmission of all these frequencies without discrimination. This is necessary to insure that the full range of essential frequencies is made available to the radio audience.

At the transmitter building the signals are sent to the transmitter control room where audio control, metering and amplifying apparatus is located. Here the signal is amplified to compensate for the losses sustained in the telephone line and sent on to the transmitter proper.

The signals next pass through a power amplifier to first stage of which employs a 50 watt tube. The second stage consists of two 250 watt tubes operating in push-pull. After passing through this stage, the audio signals attain a voltage level equivalent to ten times the voltage of the ordinary lighting circuit. The power developed is greater than that required to operate three ordinary radio receivers. In the above audio

(Continued on page 174)

NEW ADAPTERS FOR MODERNIZING RADIO EQUIPMENT

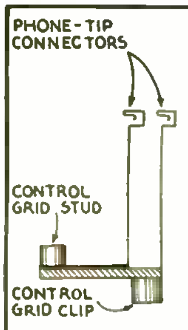


FIG 1

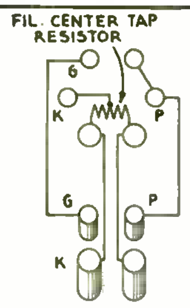


FIG. 2

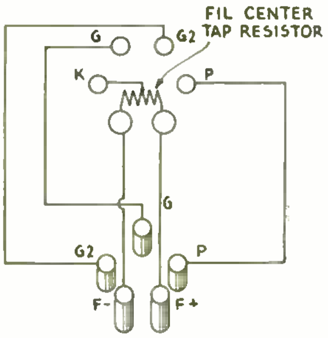


FIG. 3

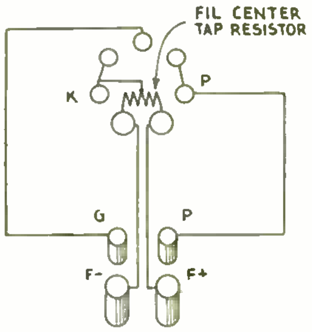


FIG. 4

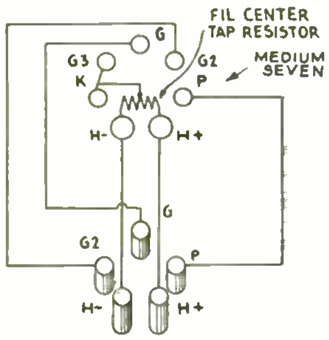


FIG 5

In view of the availability of adapter "blanks," there are described below twenty-two new adapters especially useful for using and testing new tubes in old sets and test instruments.

F. L. SPRAYBERRY*

EVERY time the Service Man changes his testing equipment, or obtains the required number of adapters, along comes another flock of new tubes to be dealt with. As one Service Man has expressed it, his test equipment is "just one piece of apuaratus that is never paid for"—installments are always due in the form of adapters and other additions to the test apparatus. However much new tubes may be needed by the set industry, to the Service Man they are just another evil. To the writer, therefore, it seems that the only thing to do is to make the best of conditions, and keep our test equipment up to date in the most convenient and inexpensive manner.

A series of articles by the writer, on the subject of adapters, appeared in the October, November, December, 1932, and January, 1933, issues of RADIO-CRAFT. The purpose of those articles was to help the Service Man choose the adapters for his test equipment so that tests might be made on new tubes and circuits. The present article is intended to cover some of the more recent adapters which permit the use and test of the new tubes in old receiver circuits and test equipment. We suggest that you read this article through carefully, if you are interested in keeping your equipment modern.

*Sprayberry Radio Data Sheets

New Set Adapters

Now, for some of the very latest adapters. No. 9G1T, Fig. 1, is a unit which Service Men have long wanted. It permits an oscillator, microphone, phono pickup, etc., to be connected in series with the control-grid circuit of a screen-grid tube. To use this adapter, remove the CG clip from tube and attach to CG stud on adapter. Then, place the adapter CG clip on CG of tube. Finally, connect microphone, pickup or other device to the phone tip connections on adapter.

So much for a "convenience" adapter. We will now describe a few adapters that the Service Man may use in demonstrating to a set owner the actual improvement which may be effected in his receiver by incorporating one or more of the new types of tubes.

No. 964KSPR, Fig. 2, permits the use of a 2A5 tube in a 45 socket. Place adapter in the 45 socket of the receiver and then place tube in adapter. After this, you are ready to use the 2A5 tube in place of a 45.

No. 965GKR, Fig. 3, permits the use of a 2A5 tube in a 47 socket.

No. 974GGR, Fig. 4, permits the use of a 59 tube in a 45 socket. Remove 45 tube from socket and insert adapter in socket of receiver. Then place 59 tube in adapter and operate the receiver in the usual manner.

No. 975KSPR, Fig. 5, may be used

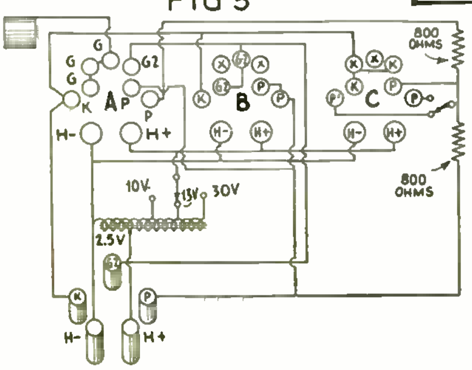


FIG. 6

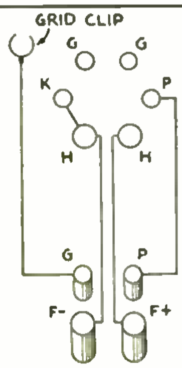


FIG. 7

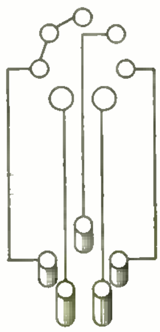


FIG. 8

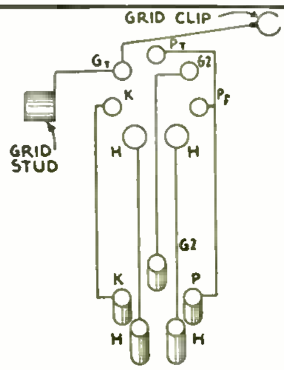


FIG. 9

ADAPTERS

We suppose that everyone knows of the new tubes and circuits that have appeared during the past few months. "What shall I do with my test equipment?" is the cry. Of course, if you can afford it, buy new ones; but if the wolf has been making scratches on your already dull door, then use adapters.

in any receiver to replace the 47 tube with a 59 tube. The adapter is inserted in the 47 socket and the 59 tube placed in adapter. This adapter has the correct center-tap filament connection taken from the cathode circuit so that bias is automatically provided.

While these power tubes may improve the quality or volume of reproduction in older set models, the Service Man is primarily interested in means for determining the relative worth of vacuum tubes. The following descriptions of new adapters for test purposes, therefore, are given.

No. 950TR, Fig. 6, may be used to bring any old tube tester up to date. The only requirement is that the tube tester must have a socket regularly used to test the type 24 tube. This unique adapter incorporates a transformer winding and three "composite" sockets. These sockets are made so as to take four- five and six-prong tubes. The table given below lists the tubes that can be tested in sockets A, B and C of the adapter.

Table A

Type Tube	Fil. Volts
AE	12.6
A26	15
A28	15
A30	15
A32	15
A40	15
A48	15
17	14
18	14
43	25
48	30
272A	10
RA1	15

Table B

Type Tube	Fil. Volts
A22	15
14	14
291	12.6

Table C

Type Tube	Fil. Volts
HZ50	12.6
12Z3	12.6
25Z3	25
25Z5	25
262A	10
96	10

Testing New Tubes

No. 964GL, Fig. 7, is used to test the 2A6, 55, 75 and 85 tubes in almost any type of tube tester which has provisions for testing the 45 or 50 type tubes. This adapter tests the triode section; it is rarely necessary to check the diode section. When testing the 2A6 or 55 tube, place adapter in the 45 socket and connect the control-grid leads. When testing the 75 or 85 tubes, place adapter in the 10 or 50 socket and connect the control-grid leads.

No. 975-AB7, Fig. 8, is used to test the 2A7 and 2B7 in the 24 socket of tube testers. This adapter will also test the 6A7 and 6B7 in tube testers employing a 36 socket. Place adapter in proper socket and test tube in the usual manner.

No. 975-6F7, Fig. 9, is used to test the 6F7 tube in the 36 socket of any tube tester. Place adapter in the 36 socket and make tests as if you were testing a 36 tube. Make sure that the control-grid circuit of the adapter is correctly connected before tests are made on the tube.

(Continued on page 175)

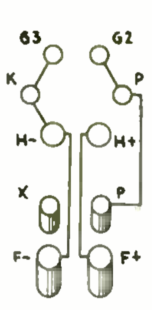


FIG. 10

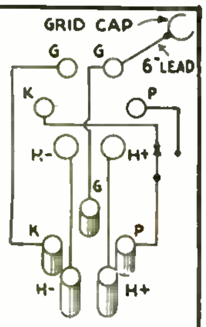


FIG. 11

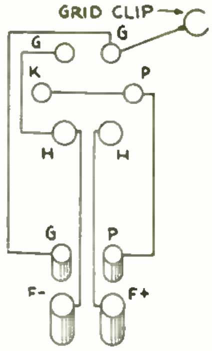


FIG. 12

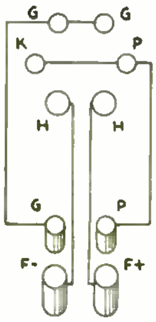


FIG. 13

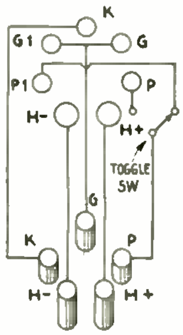


FIG. 14

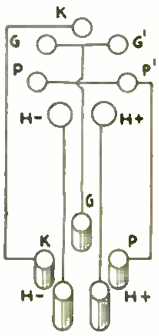


FIG. 15

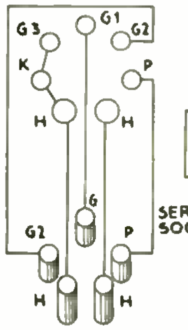


FIG. 16

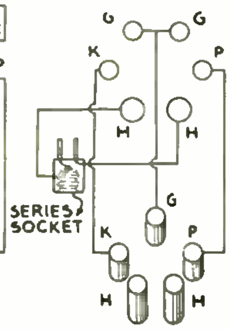


FIG. 17

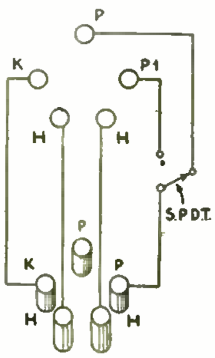


FIG. 22

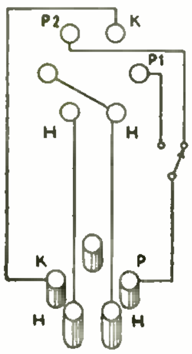


FIG. 21

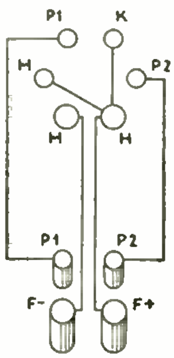


FIG. 20

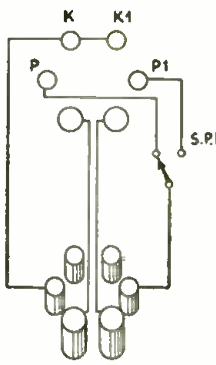


FIG. 19

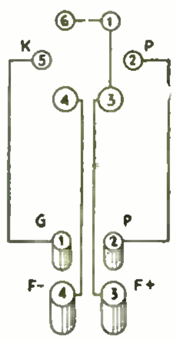


FIG. 18

DESIGNING AND CONSTRUCTING DIRECT-COUPLED A. F. AMPLIFIERS

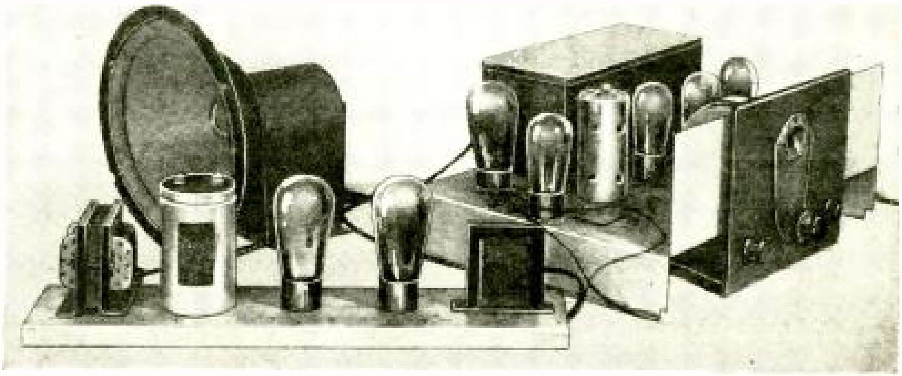
PART II

This article is the second, and final, of the series giving complete theoretical and constructional details of direct-coupled amplifiers.

L. M. BARCUS

IN last month's issue of RADIO-CRAFT we touched briefly upon the construction of a two stage amplifier and gave enough details of the calculations to enable anyone to design his own particular amplifier. It was remarked, at that time, that the two stage amplifier had too small a voltage gain to have extensive uses, and that the plain, three or more stage circuit had drawbacks which limited its applications with ordinary materials. Therefore, this article will touch upon more elaborate types which give high gain and output without demanding other than standard components in universal use today.

In order to derive the benefits of multi-stages without resorting to special apparatus in the voltage supply—which would mean high cost and possibly trouble—a double powered amplifier was developed, as shown in Fig. 4. By using this method, the number of stages may be extended indefinitely without relying upon excessively high potentials; in addition, it does away with some of the bias bypass condensers, which naturally results in an additional advantage—better tone quality.



Typical converted receiver using the circuit of Fig. 4 constructed by the author.

The layout of Fig. 4 is the one preferred for all receivers, including television. Outside of the power units, there is only one audio bypass condenser employed. This gives the lower frequencies a chance to show themselves, and their strength and clarity are amazing. Yet, there is absolutely no trace of the hollow barrel effect usually associated with receivers that produce the lower notes by artificial tone control methods.

For Service Men or others who desire to remodel old receivers whose tuning units are satisfactory, the layout of Fig. 4 is especially convenient. It permits the use of practically all the parts in the receiver, and only requires the addition of a power transformer, a filter choke, and two filter condensers. Because the power stage requires but 250 volts, the 50-volt bias being obtained from the first power unit, and because the current drain is small, the power transformer may be of any of the now obsolete types. They all have a 2½-volt filament winding which is suitable for the 45.

The second audio stage (a 27 or 56) requires a separate filament winding since the filament is at a much higher potential than ground. If the filament of the first-audio socket in the receiver is not individually wired, the power tube winding is usually adaptable, provided that a 45 tube is used. In case 5-volt filaments are used, the voltage may be dropped to 2½ volts by suitable resistors or, if the winding is center tapped, one-half of it may be used.

As a general rule, any audio transformers in the receiver may be used as audio chokes in the revamped set. The primaries and secondaries should be wired in series to obtain the best results. It is preferable, however, to use good audio chokes if the added expense is not objectionable.

The removal of the heavy drain of the power tubes from the tuner power pack will necessitate readjustments of the voltages. In some cases, particularly those where the power section and speaker are separate from the tuner, it may be advisable to use the new power supply for the tuning section and to retain the power section of the set as it stands. A few changes are necessary to adapt such a unit for its new purpose.

Whatever voltage supply is used for the tuner, it must be capable of giving a fairly high potential, since V1 and V2 derive their operating voltages, in addition to the bias for V3. 300 volts is usually sufficient for this purpose. As 50 volts are required for V3, this leaves 250 volts to be divided between V1 and V2. Inasmuch as the triode half of the 55 is diode biased, 90 volts on its plate will tend to accommodate the inequalities of bias and give better results than if the maximum potential were used. This will leave some 160 volts for V2 of which about ten will be required for its bias.

For those desiring a straight amplifier of the type in Fig. 4, for P. A. systems, phonographs, and the like, the only changes are in the first stage where the proper tube is substituted for the 55 and means for its bias taken care of as explained previously. If four stages are wanted, the second power section can be designed to accommodate another tube between V2 and V3. The effect is, in general, that of two, two stage amplifiers placed in series.

It must always be remembered that the second power unit is at a very high potential above ground and its parts must be insulated from the tuner chassis, or first section. For this reason, it is always preferable to build it as an individual unit in conjunction with the power tube and speaker.

The fact that a bleeder current flows through the series of resistances in Fig. 4 does not complicate the calculations to any extent. The only requirement is to add the desired bleeder current to the normal tube currents in each case. In Fig. 4, a bleeder current of 10 ma. was used in the calculations. The 5 ma. of V2 and the 10 ma. bleeder current thus flow through R1, while only 10 ma. passes through R2. V3, of course, has no bearing on any of the current flows, being an entirely separate unit.

Choke 2 of Fig. 4 may be mounted on either unit, depending entirely on mechanical convenience. However, three lead wires are necessary when it is mounted on the power tube unit, the leads running from the points marked

DIRECT-COUPLED AMPLIFIERS

Look through your files of diagrams of commercial radio receivers and notice how many of them use transformer coupling in the audio stages—practically none. Resistance coupling is at the wheel, and it certainly is doing its stuff. Direct coupling is an improved form of resistance coupling; it has all of its advantages and few of its disadvantages. In fact, it's the only "perfect" coupling to use.

with an x. R1 should preferably be placed in the second unit with choke.

One for the Experimenter

For those of an experimental turn of mind, the circuit in Fig. 5 may provide an interesting and instructing amplifier. The cost of construction is practically the same as that of a two stage system, yet it has the added advantages of much greater gain and output.

Unfortunately, the auxiliary power tube is not directly coupled to the source of its signal input, but must make use of the usual stopping condenser. However, this condenser is preferably of a large size and the usual bypass condenser from the power tube filaments to ground is eliminated, so any impairment of tone is more than counteracted.

The use of such an amplifier with power tubes of high gain is somewhat doubtful, although it has been operated with great success with standard low mu tubes, such as the 45. When used with a radio tuner, such an amplifier is sometimes obstructed in its operation by residual R.F. currents which go into a regenerative cycle in the power stages. Such an action is easily overcome by the use of a small bypass condenser from the plate of the first power tube to ground.

While only a few circuits have been presented in these articles the system of direct-coupling must not be construed to be limited to them. This coupling method can be adapted to practically any situation where superb tone is the chief factor. While the author has not actually constructed push-pull arrangements, there is little reason to doubt the success of complete systems. The absence of bias condensers and the removal of other restricting elements of the straight systems should result in beautiful reproduction with tremendous power. The cost, too, is very little more, since the same number of resistors would be used and only additional chokes and sockets needed. In a push-pull circuit based on Fig. 4, the full-wave rectification of the signals would be achieved by the use of twin 55 tubes, each feeding one side of the amplifier, or one 2B7 tube could be used with each diode plate operating into one half of the audio section.

In closing, it is appropriate to stress the fact that any amplifier based on this system should be considered more in the light of a delicate and precise musical instrument than as a soulless bit of apparatus. It is not exacting in its requirements and will perform miraculously over a wide range of values, but every additional care taken in its construction is reflected in increased beauty and mellowness of tone. It will make any speaker sound like a new thing; yet that vital part should be chosen with the greatest of care, and one should be sought which is capable of performing over the extended range of frequencies. The input transformer should be carefully examined. Usually they are small and totally unfit to step down the lower frequencies. If necessary, it may be wise to purchase a separate transformer of the best quality and of generous size. Further, the cone should be so mounted that it has a wide range of unrestricted movement and is not stiff. Finally, a baffle-board of generous size should be used, one that will properly bring out the lowest notes.

(Unquestionably, direct-coupled A.F. amplifiers will become *la mode* in a short time. The technician is referred to the following articles in past issues of RADIO-CRAFT, for interesting data on amplifiers of this type. "Bureau of Standards Audio Amplifiers," by S. R. Winters, September, 1929, pg. 112. "Constructing the Loftin-White Amplifier," by M. W. Sterns, September, 1930, pg. 156. "A Direct-Coupled Pentode Amplifier," August, 1930, pg. 100. "Servicing Direct-Coupled Amplifiers," by Sidney Fishberg, January, 1932, pg. 403. "How to Build a Direct-Coupled Type 45 Amplifier," by S. H. Burns, December, 1930, pg. 354.

Additional information concerning direct-coupled amplifiers, has appeared in the Information Bureau of past issues. *Technical Editor.)*

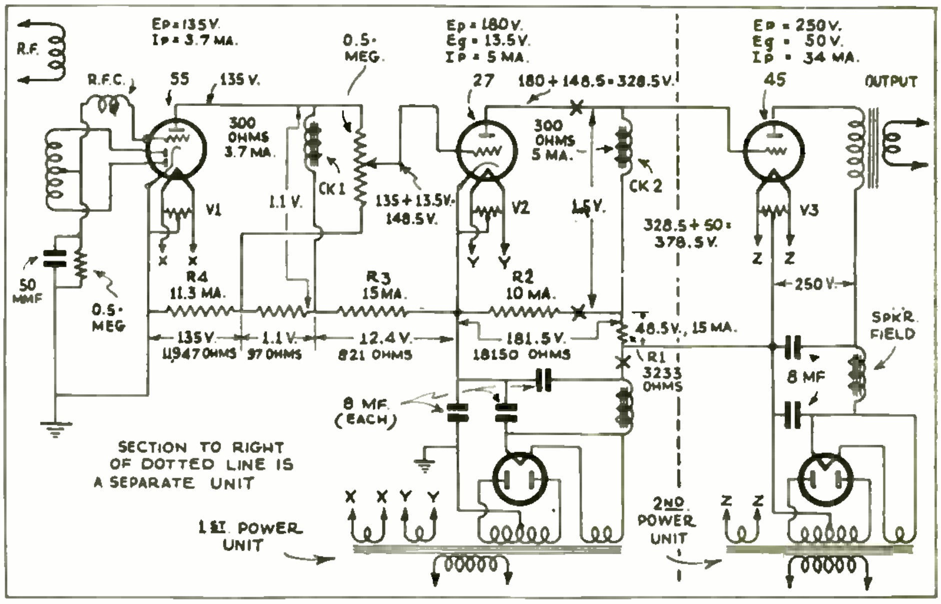


Fig. 4
A double-powered amplifier circuit. See the photograph.

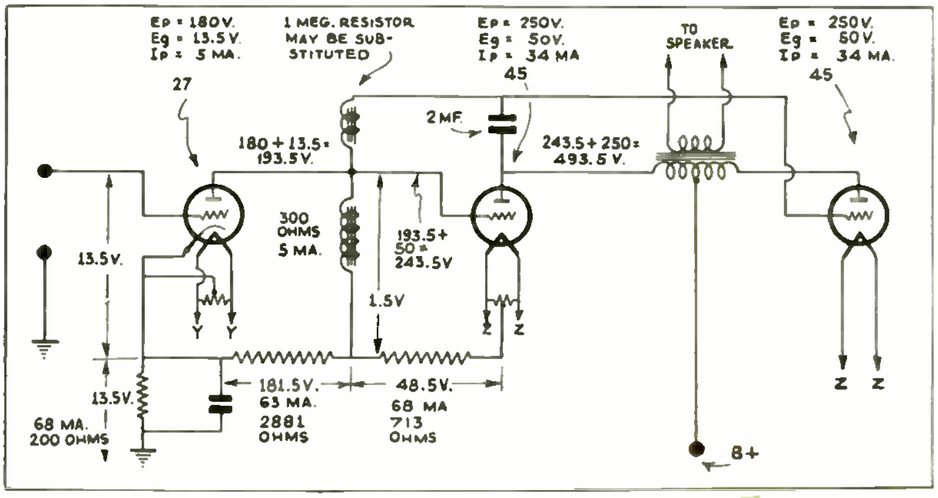


Fig. 5
Here is a good circuit for the experimenter, as suggested by the author.

THE ANALYSIS OF RADIO RECEIVER SYMPTOMS

OPERATING NOTES

R. F. LAMBERT

IN MY prolonged experience with various types of good, bad, and indifferent radio receivers, many unique and interesting problems have been encountered. While some of these experiences together with data concerning them may seem obvious and perhaps even superfluous, they contain, however, information which may be applicable to other radio receivers afflicted with the same form of trouble. For that reason, the experiences related below may prove to be of interest to fellow members of the radio fraternity.

Zenith Model 52

An interesting case of intermittent operation was encountered in this model. Very little, if any information could be obtained from the owner as to the time or duration of these periods of intermittent operation. In an effort to determine the exact location of the trouble, the chassis, automatic tuner, speaker, and the power pack were removed from the cabinet. The usual test and search for intermittent short circuited resistors and bypass condensers was conducted; but nothing could be found to verify our suspicions directed against these "so-often-found-guilty" components.

While testing the receiver, it was discovered that by tapping the metal chassis lightly with a hammer or by shaking the chassis reception could be obtained; but the slightest jar would make the receiver inoperative again. This effect indicated that a loose connection existed somewhere. A systematic search was now instituted in order to locate the guilty member; but the results yielded nothing. The set, which had been tested with the chassis upside-down in order to get at the wiring, was now turned right-side up, so that the rear of the chassis was visible. In looking at the rear of the chassis, attention was attracted to the short pigtail connector which goes from the aerial post to one of the long- or short-aerial terminal jacks. Upon close examination, it was discovered that an imperfect connection existed inside the hollow end of the metal pin tip, which proved to be the reason for the intermittent reception in this receiver. *A typical case of plenty of rosin and no solder.* It was now only a matter of a few minutes to heat up the metal pin tip, drop solder into the hollow end, and then push in the wire to complete this job. See Fig. 1.

Zenith Model 60

The owner of this model receiver complained of abnormal hum in the set. This is a common complaint; a great deal has been written, and numerous suggestions offered as a cure for this objectionable hum. This receiver happened to be one of the older models, and, therefore, did not have incorporated in the chassis the white, 250,000-ohm resistor which is generally to be found in the later models. This resistor is connected across the grids of the second stage '27 type tubes which are connected in push-pull. The usual procedure was followed in installing this resistor, but this change did not result in any improvement. The hum persisted, and was just as loud and as annoying as before. On all these models it is to be observed that the wet electrolytic condenser unit is housed in a metal can which is made up of two parts, held together at the sides with four bolts. The outside of the can and the part of the chassis on which the electrolytic condenser rests are painted; the inside of the can is not painted. Furthermore, this can is fastened to the chassis with two bolts; the idea being that by clamping the sides of the can tightly to the condenser and by tightening the bolts a good electrical connection to the chassis will be made.

Too often it will be found—as was discovered in this case—that the top portion of the lugs on the can, where the heads of the chassis bolts are resting, are thickly painted and, of course, a good electrical connection does not exist, because of imperfect contact between the bolts and the chassis. By scraping off this accumulation of paint, and tightening up the chassis bolts while holding the can in place, the abnormal hum was entirely eliminated. See Fig. 2.

THIS DEPARTMENT

There are various ways of presenting service information: first, we could print the schematic diagram of a receiver and give the values of all parts; second, we could print, not only the diagram and values of parts, but a discussion of the circuit itself, and leave the trouble hunting to the Service Man; third, we could list the symptoms, troubles, and remedies exactly as found by men in the field.

No one method is complete in itself; to be complete, service data must contain a compilation of all three of the above methods. The first two methods are presented in the Radio Service Data Sheets, and the third method is treated in this department.

By splitting the material up into two sections, it is possible to print much more information than would be possible if everything were bunched together. Then again, sometimes, men prefer only the schematic; while at other times they want a discussion.

In any event, this material is available for your reference—make the most of it.

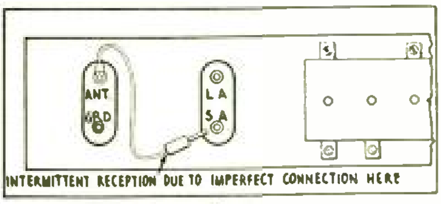


Fig. 1
A tricky poor connection caused trouble in this Zenith model 52.

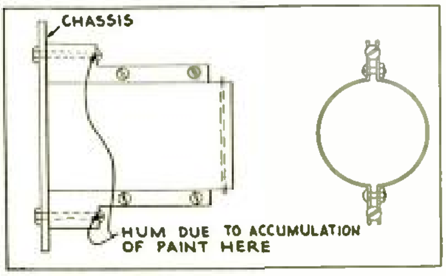


Fig. 2
Another case where poor contacts caused trouble; this time in a Zenith model 60.

Montgomery Ward 62-080, 62-090, 62-100

A frequent cause for a blown filter condenser in these models is generally due to loose plate-spring contacts in the rectifying tube socket. This condition may be recognized by a loud roar in the speaker, accompanied with a mechanical hum; otherwise the set is completely dead—as far as broadcast reception is concerned. The mechanical hum is due to the fact that the socket plate-spring contacts do not grip the plate prongs of the rectifying tube firmly, thus causing the elements in the tube to vibrate violently. This effect can easily be felt by touching the rectifying tube with the fingers.

The reason for the blown filter condenser, which is connected across one of the type 80 filament terminals and ground, is due to the intermittent contact between the tube plate prongs and the socket plate-spring contacts, caused by vibrations of the tube; it is *not* due to a low-voltage rating of the dry electrolytic condenser, as was first suspected. The normal voltage across these points, 80 filament terminal to ground, is about 325 volts. Because of the intermittent contacts between the plate prongs and the socket-spring contacts, the current will, at times, be prevented from flowing, and a high voltage, exceeding the maximum working voltage, is built up across the condenser, and a break-down generally occurs. As a precaution against a break-down of the replacement condenser, an 8 mf. dry electrolytic unit rated as 500 volts, is inserted. It is first advisable to correct the trouble at the socket by bending the spring contacts in order to insure a better contact. In some cases it has been found necessary to replace the socket with a different and better type in order to remedy this trouble.

Atwater Kent 46, 47, 53

These receivers have their filter condensers contained in replaceable cans in the power pack. This arrangement makes it a simple matter to replace the condenser unit in case of shorted units. However, it seldom happens that more than one of them is found to be shorted, and in most cases, it is generally the one connected across the center tap of the output transformer and ground. In this case an externally connected replacement condenser will do very nicely.

After the two terminal strips, the condenser unit retaining spring, and the supporting strip have been removed, you will notice three condenser leads colored blue, green with yellow tracer, and white. The end connections of these wires are embedded in an insulting compound which covers the condenser unit, the choke, and the output transformer unit. Cut the white lead in the middle and remove part of the wire insulation from the other ends. Solder a short piece of wire to the stub emerging from the condenser unit and connect this wire to the black, ground wire; connect the end of the other white wire to the positive side of a 2 mf., 400 volt, dry electrolytic condenser, and insulate the joints. The other end of the condenser connects to the black, ground lead. There is ample room to lay the new condenser on top of the reassembled terminal strips in order to keep it away from the heat generated in the power transformer.

Stewart-Warner 950, 960

When you find one of these sets completely dead except for a slight speaker hum, the first thing to suspect is the bypass condensers connecting the plate and the screen grids of the types 24 and 27 tubes to ground. To determine quickly if this is the cause of the set being inoperative, remove the detector tube, quickly replace it, and note if a click is heard in the speaker; the same procedure should be followed in the radio-frequency stages. If no clicks are heard, it is usually a sure indication that the condenser is shorted. An analyzer test will show no plate, no screen grid, and no control-grid voltages in the radio-frequency, detector and first audio stages. Low plate and grid voltages will be indicated for the type 45 tubes. The shorted condenser is one of a bank of six condensers contained in the filter-choke cell. The leads are easily discernable by inspection of the blue leads, after the bakelite resistance strip has been removed. For replacement, use a 0.5-mf. condenser rated at 600 volts. Simply cut the defective section out of the circuit, connect one lead of the external replacement condenser to the blue lead you have clipped from the shorted unit, and ground the other lead. A convenient place to mount this condenser is on the side of the large filter condenser, between the metal straps holding this condenser in place. One of the straps can be used for holding the new condenser securely in its position.

Fading and Noise in Philco 511

The complaint on a Philco 511 was that the set would perform normally until the door of a refrigerator in the kitchen was opened and then closed; the reception at that moment would drop to a point where it hardly could be heard. Opening and closing the door a second time would, at times, bring the set back to normal volume; at other times it would not. Walking hard on the floor and slamming other doors had no effect on the volume.

The A.C. plug and cord, the ground and aerial connections, and the tubes were carefully inspected and tested and found to be normal. This set has a "range" control, which is nothing but a small variable condenser held in place by a bracket on the chassis. In searching for the cause of the fading, I caught sight of a short piece of wire which was wrapped around the rotor shaft of the condenser; the other end was cold-soldered to the chassis. At one time this wire evidently was intended as a pigtail connection from ground to the rotor shaft. A very splendid idea if properly installed. The wire which had been cold-soldered to the shaft was now hanging loose below the shaft and between the stator plates. Vibrations transmitted to the set from slamming the refrigerator door were evidently powerful enough to cause this wire to move against the stator plates, thus providing a direct path to ground for the incoming signals, as shown in Fig. 3.

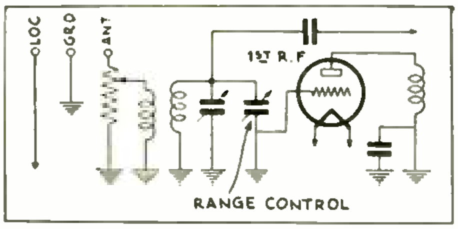


Fig. 3
A cold-soldered joint, a loose connection, and a Philco model 511.

This wire was removed. A small hole was drilled and tapped in the end of the condenser shaft. A lug was fastened to the shaft by means of a screw, and a new flexible insulated wire was soldered to the lug on the end of the rotor shaft; the other end soldered to a lug provided on the chassis. This procedure eliminated the fading signals on this set.

Excessive hum in these receivers—provided it is not due to defective parts—can be greatly reduced, if not almost entirely eliminated, by placing a metal shield can over the detector tube and grounding the can to the chassis.

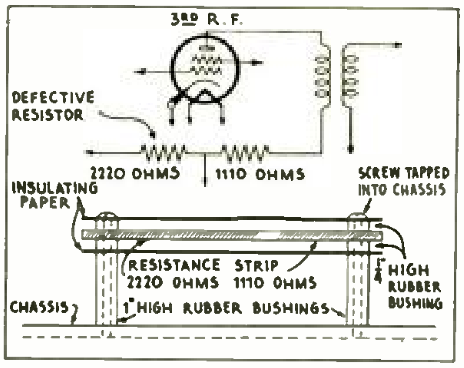


Fig. 4
The resistance strip in Stewart-Warner model 950 receivers that "makes noise."

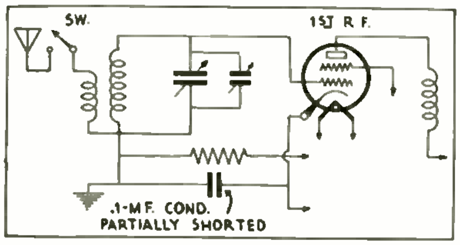


Fig. 5
The partially shorted condenser is still another cause of noisy reception.

Majestic 103

In another case—a Majestic 103 radio and phonograph combination—the set was noisy and faded suddenly. At times, the reception would be fine; but suddenly it would die down to a whisper, only to come back again just as strong as ever. From past experiences with the same type of set having practically the same trouble, it was concluded that the trouble must be in the chassis. After much time wasted in testing tubes and checking the receiver, only to discover, with keen disappointment, that everything seemed to be normal, it was decided to take a good look at the ground and aerial lead-in wires, and to test them for a possible short circuit; *and here is an example where a simple fault can create a major disturbance.*

The visible parts of these two leads consisted of good insulated wires carried from the binding posts down through a hole in the floor to the basement. Close inspection of these two wires disclosed the fact that they were spliced, but not taped, directly underneath the floor boards. Vibrations caused the two wires to touch each other momentarily, thus causing the signals to fade in and out. *It may be worth while to mention that in future similar cases the antenna and ground wires are always inspected before any attempts are made to test the receiver.*

(Continued on page 172)

97 Radio Service Data Sheet

GALVIN MOTOROLA MODEL 77, 7-TUBE AUTOMOTIVE SUPERHETERODYNE

(Self-rectifying Elkonode, separate reproducer, combined oscillator and first-detector, combined A.V.C. and second-detector, push-pull pentode output.)

This superheterodyne has a maximum sensitivity of .025-microvolt-per-meter; the maximum power output, with an input of 1 microvolt-per-meter, is 4 W. This exceptional sensitivity figure permits the A.V.C. circuit to be designed to maintain the same output power level with an input range of 1.5 to 125,000 microvolts-per-meter. Refer to RADIO-CRAFT Data Sheet No. 98, Galvin Motorola model 55, for general aligning procedure. The "A" drain is 5.2 A. The plate potential of V6, V7 is 210 V.; the "B" potential of the remaining tubes is 175 V.

This receiver must be mounted either in an upright or inverted position, *but must not be mounted sideways* as serious damage can result. When replacing the Elkonode unit, *make sure* that it lies with the label either down or up, *not on its side*.

An antenna area of 9 sq. ft. is recommended for this set when installed in cars which permit the use of a roof antenna.

The yellow "A" lead of the "77" connects to any point on the car's electrical system—ammeter, starter button or battery.

It is *essential* that a definite polarity be *maintained* at the Elkonode. For this purpose a polarity changing switch is provided at the rear of the set housing. The polarity is indicated through a small hole at the lower right rear corner of the set housing. If a red disc appears in the window which reads "+ ground," it means that the "B" supply unit is connected for cars having the positive side of the battery grounded; a black disc, reading "— ground" indicates connection for negative-grounded batteries. Be sure to determine that the car battery is grounded in accordance with the marking on the indicator. To change the polarity, proceed as follows: (1) Remove "B" supply unit by prying with a screwdriver in the slots provided on either side. (2) It will then be observed that there are two receptacles on the rear partition—one on the left and one on the right. The former requires no adjustments; the latter may be moved up or down in its slot. (3) Insert a small-shank screwdriver or ice-pick in one of the jacks of this receptacle and adjust up or down for desired indication in window. (4) Replace the "B" supply.

The following makes of cars have the positive terminal of the car battery connected to ground: Marmon, DeSoto, Cadillac, Pierce-Arrow, Dodge, Packard, Graham, Plymouth, Studebaker, Auburn, Hupp, Franklin, Rockne, Ford, Chrysler, Nash twin-ignition. The following car makes have grounded-negative batteries: Reo, Chevrolet, Stutz, Willys-Overland, Cunningham, Lincoln, Continental, Buick, Oldsmobile, Pontiac, Hudson, Essex, Nash single-ignition.

Interference may be classed as chassis pick-up or antenna pick-up. The former is that interference which remains after the antenna connection has been removed from the set.

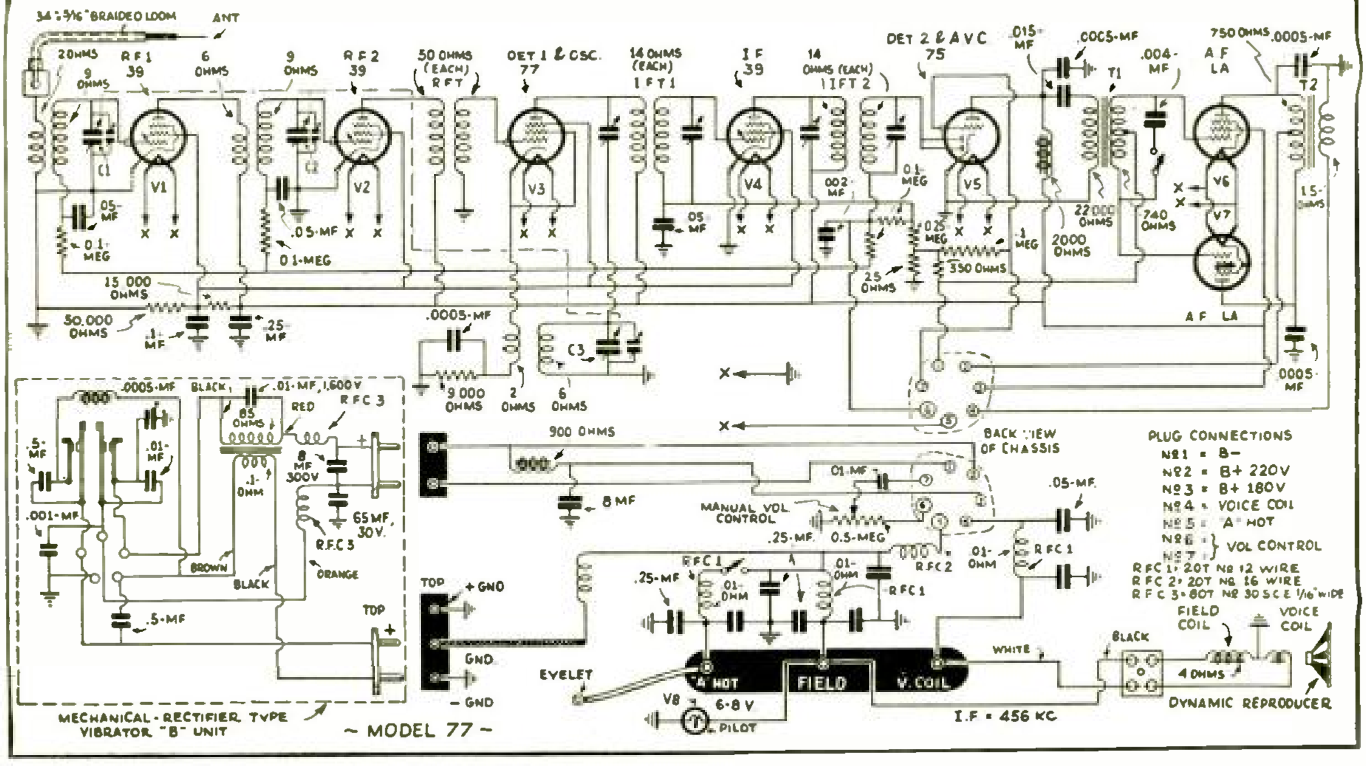
Chassis pick-up via the "A" lead may be eliminated by connecting a filter condenser, or, better yet, a Motorola Dome Light Filter, at the point of the "A" lead attached to the "A" battery of the car, whether at the battery or the starter. If chassis pick-up still occurs, it is due to either of the following causes: (1) Defective condenser in the Elkonode system. Check by replacement. (2) Cover of the set not making good ground to the set housing. Remove cover, and clean lips of cover and set housing with fine sandpaper.

Antenna pick-up may be reduced or eliminated by following the injunctions which have appeared in previous RADIO-CRAFT Data Sheets, and in the book, "Automobile Radio and Servicing," by Louis Martin; additional data follows.

In cars such as the 1932 Pontiac model V-8 car, where the distributor is mounted close to the wooden floor-board, it is sometimes necessary to tack copper screening to the floorboards, grounding the screening to the frame of the car. This prevents the distributor from radiating directly either to the antenna, or to the antenna via the bodies of passengers or driver. Cars with high-tension coils mounted on the dash or on the bulkhead in the driver's compartment are likely to radiate to the antenna. The most simple and positive remedy for the bulkhead mounted coil is to remove it to the motor compartment; it can usually be mounted on the opposite side, thus using the same mounting holes. Dash-mounted coils present a problem due to the built-in switch. It is usually sufficient to shield the high-tension lead from the coil; to prevent leakage, slip loom over the lead before puttng on the shielding braid. In some instances it may be necessary to carry the coil shielding still further; a metal shield-can over the front of the coil is sufficient.

Note that merely because a portion of the car is at ground potential (to D.C.) does not indicate that it may not be a contributing factor in noise pick-up. Thus, an interference-radiating unit may be in proximity to a wire, rod, or other conductor which, picking up this R.F. radiation, carries the interference to a point close to the antenna, where it is re-radiated to the antenna.

As the body and frame of the car act as a return path to the battery for ignition current, and as this metal is of a type which offers considerable R.F. resistance, it is subject to very strong eddy currents. The metal corner post up which the lead of the antenna runs, and the metal frame around the top of the car are the most troublesome sources of eddy currents. The antenna lead should be correctly shielded, and grounded to the metal framework at the top of the car; the capacity between the shield and the lead-in sometimes is sufficient to cause eddy currents to be induced in the antenna-lead shield itself by its coming in contact with the dash, which frequently carries violent eddy currents that are induced in the wire. Therefore, check to determine whether the noise pick-up is increased when the shield is connected to, or insulated from the dash. The 1931 and 1932 Chevrolets are good examples of cars in which the shield should be insulated from the frame.



GALVIN MOTOROLA MODEL 55, 5-TUBE ALL-IN-ONE CAR SUPERHETERODYNE

(Self-rectifying Elkonode, built-in reproducer, combined oscillator and first-detector, combined A. V. C. and second-detector, single pentode output.)

The maximum sensitivity of this receiver is 0.75-microvolt-per-meter; the maximum power output, with an input of 5 microvolts-per-meter, is 2 W. The A.V.C. circuit maintains the power level within the input range of 2.5 to 125,000 microvolts-per-meter. Refer to RADIO-CRAFT Data Sheet No. 97, Galvin Motorola model 77, for interference elimination procedure; also observe the precautions stressed in this Data Sheet. The "A" drain is 4.5 A. The plate potential of V5 is 210 V.; the "B" potential available for the remaining tubes is 175 V.

If chassis pick-up occurs, the procedure is as follows: (1) Use a Motorola Dome Lite Filter. Connect one side to the battery circuit of the car and the other to the end of the yellow wire. Connect battery condenser wire to the ground. (2) If the high-tension coil is located on the instrument panel, shield the high-tension wire from the coil to the bulkhead, grounding this shield at the bulkhead. In some cases it may be necessary to cover the head of the ignition coil with a metal shield.

The alignment of cut-plate variable condensers differs from the alignment of condensers connected in circuit with a padding condenser, in that the cut-plate condenser has a fixed *mechanical* ratio between the capacities of its sections. In the past it has been possible with padders to align the condenser with an accuracy of 10 degrees of rotation of the condenser plates—that is, it could be set at the high-frequency end with all trimmers in alignment, and then re-aligned at the low-frequency end by rocking the condenser while adjusting the padder. However, this procedure cannot be followed in aligning a cut-plate condenser gang.

Use a standard service oscillator and output meter. Connect a 200 mmf. condenser in series with the antenna lead of the oscillator and connect to the antenna post of the radio set. *Caution:* Before proceeding, be sure that the I.F. transformers have been tuned exactly to 456 kc.; otherwise, correct alignment of the R.F. circuits cannot be attained.

Tune the service oscillator to 1400 kc., and align the trimmers of C1, C2. Next, tune the service oscillator to 600 kc. and check the alignment of C1. If it is found that the trimmer must be moved either in or out to return to resonance, as indicated on the output meter (a 0 to 10 V., 1000-ohms-per-volt voltmeter connected to the A.V.C. circuit at X), it is an indication that C1 is not at the correct starting position for the initial setting of the service oscillator. (If, for example, it is found that the trimmer must be screwed down, it is an indication that the R.F. tuning condenser requires more capacity at the low-frequency end. Therefore, return to the initial high-frequency setting of the condenser.) Change the service oscillator setting to correspond with the changed position of the tuning condenser.

Remember that C1 requires more capacity at the low-frequency end so it is necessary to move the condenser a few degrees inward, which gives more capacity to this condenser, leaving the service oscillator in the same position. Adjust the trimmer of C2 until the signal is brought back, then check the alignment of both trimmers.

Return C1 and C2 to the 600 kc. position and re-check the setting of C1; if the condenser has been moved sufficiently while making adjustments at the high-frequency end the trimmer of C1 will show resonance. If it has been moved too far it will be necessary to loosen the setting of the trimmer in shunt, to C1, instead of tightening it as previously.

To align the circuits of I.F.T.3, the non-metallic aligning screwdriver may be inserted in a hole provided in the upper part of the chassis located between I.F.T.1 and the "B" power supply housing.

Spasmodic interference due to an accumulative discharge, resembling static interference in its irregularity, may be traced to the distributor. Connect a mica condenser of .002- to .006-mf. in shunt to the paper condenser which is already across the primary breaker points. This mica condenser affords power factor control to the paper condenser—tends to make it much more effective, in reducing interference.

Following is the most complete listing available of steps to be taken, in the numerical sequence, for eliminating interference.

(1.) Apply distributor and spark plug suppressors;

(2.) Apply generator condenser;

(3.) Re-route to primary wire from coil to distributor, keeping it remote from high-tension wire;

(4.) Connect Motorola Dome Lite Filter to dome light wire at entrance of corner post;

(5.) Shield high tension wire if coil is mounted on instrument panel;

(6.) Shield antenna lead-in wire from radio set to top of front corner post. Ground shield at both ends, if advisable;

(7.) Shield primary wire from coil to distributor;

(8.) Shunt distributor primary breaker points with a .002- to .006-mf. mica condensers.

(9.) Bond upper metal parts of car body to one another and return a heavy copper bond from these points to car bulk-head. (Usually necessary in cars having composite wood-and-metal body construction);

(10.) Bond where necessary all control rods and pipes passing through bulkhead;

(11.) Shield head of coil when mounted on instrument panel;

(12.) Screen floor boards with copper;

(13.) Adjust spark plug points to .028-in., approx.;

(14.) Clean and adjust primary distributor breaker points.

(15.) In cars having rubber motor mountings connect heavy bond from grounded side of battery directly to frame of car.

(16.) Connect a .5- to 1 mf. condenser from hot primary side of ignition coil to ground.

(17.) Move ignition coil to motor compartment side of bulkhead, if mounted on driver's side;

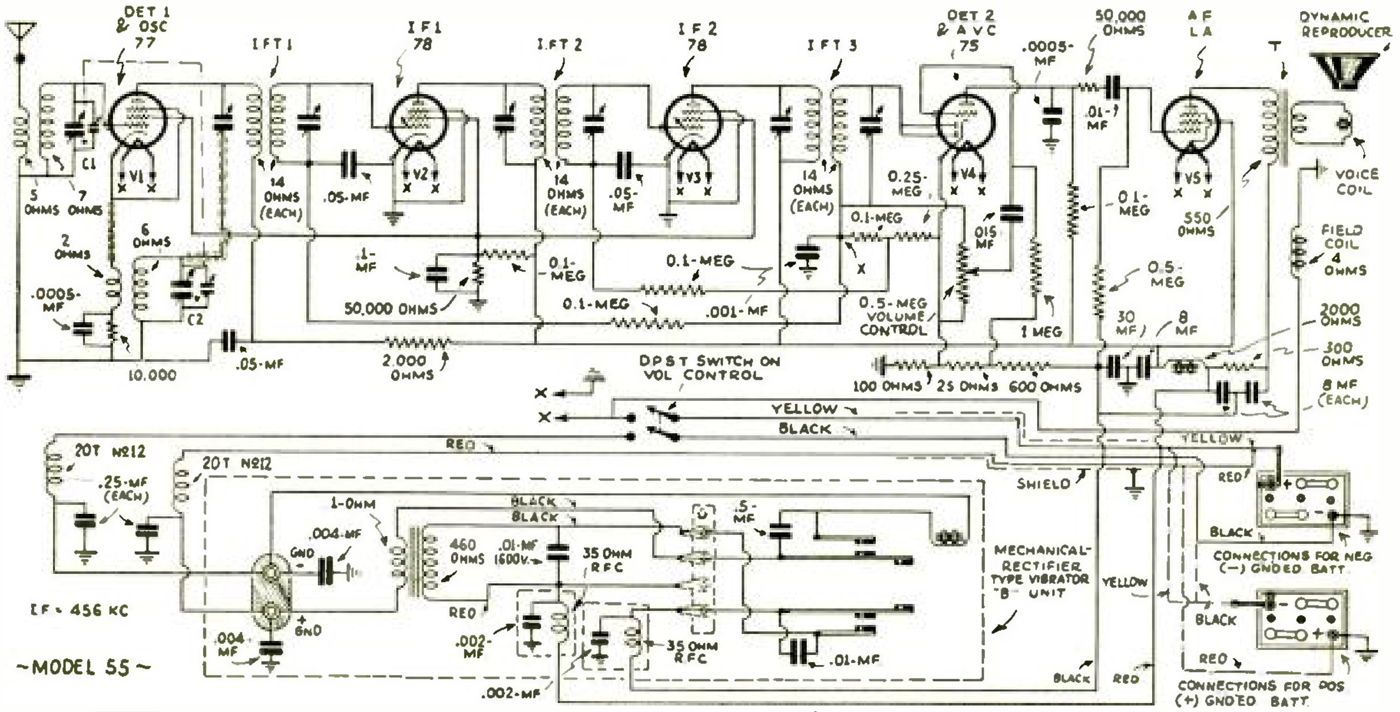
(18.) Clean ignition system wiring. Clean and brighten all connections. Replace any high tension wiring having imperfect insulation.

(19.) Ground metal sun visor and rain trough;

(20.) Make sure hood of car is well grounded. Clean hold-down hasps on both sides.

(21.) Ground instrument panel and steering column to bulkhead.

(22.) When under-car aerial is used connect a .5-mf. condenser to tail and spot light wires.



THE BEGINNER'S "1-TUBE" CRYSTAL SUPERHETERODYNE

The beginner usually regards the superheterodyne as a complex "something" which is mastered only by those vested with supernatural powers. This article will do more to bring such notions back to earth than any theoretical "discussions."

FRANCIS R. HARRIS

BEFORE delving too deeply into our present-day set we wish to call attention to circuits A, B and C in Fig. 1.

● THE Technical Editor of RADIO-CRAFT published them, in a contemporary publication, in the early part of 1925, to answer the "it can't be done" technicians who claimed, vehemently, that a one-tube superheterodyne was an "impossibility." The circuit we intend to use, Fig. 2, is substantially that of A in Fig. 1, with the difference that modern practice has been applied to the design. To maintain the simplicity and low cost that have characterized all the beginners' circuits, (twelve of these are listed on pg. 91 of the August, 1933, issue.—*Technical Editor*) we have used practically every part that has been used previously, and very little else.

Construction

The photograph, Fig. A, shows very clearly the position of the parts used. Since the circuit is now totally different from any of the previous ones, it is impractical to attempt to use the same layout; hence, the first thing to do is to clear the baseboard entirely and clean up all the apparatus, taking off all excess solder and straightening out and cleaning all wires—you will find that you can use most of them again. Also, for the sake of appearance, sandpaper the baseboard and apply a coat of shellac.

Next, mount a pointer on the tuning condenser C2. Mount the new crystal detector, D2, on a little panel with soldering lugs, as shown last month for the first one, (this may seem to be unnecessary trouble, but you will find out why later) and mount two brackets on the bottom of the intermediate-frequency transformer, L3. Now you are ready to go ahead and screw everything to the baseboard in the positions shown. Then proceed with the wiring, marking out with a red pencil, as described in the previous articles, each wire as you put it in place, being very careful to make clean, tight soldered joints—*obtained with a clean, hot iron, clean surfaces and resin flux.* Never use either paste or liquid flux of any kind on electrical work; no matter what the manufacturers say, it will eventually corrode and cause noisy or inoperative circuits.

Not a great deal can be said in the way of instruction for this assembly job except to repeat what was said regarding the electrolytic condenser, C9, namely make certain that the red, or positive, end is attached to the filament side of the bias resistor, R5. Also, be sure that the three-circuit tuner, L2, is wired exactly as shown on the diagram with the connections made to the lugs as marked on the coil, being sure that the lug on the volume control, *away* from the end where the switch snaps, is connected as shown.

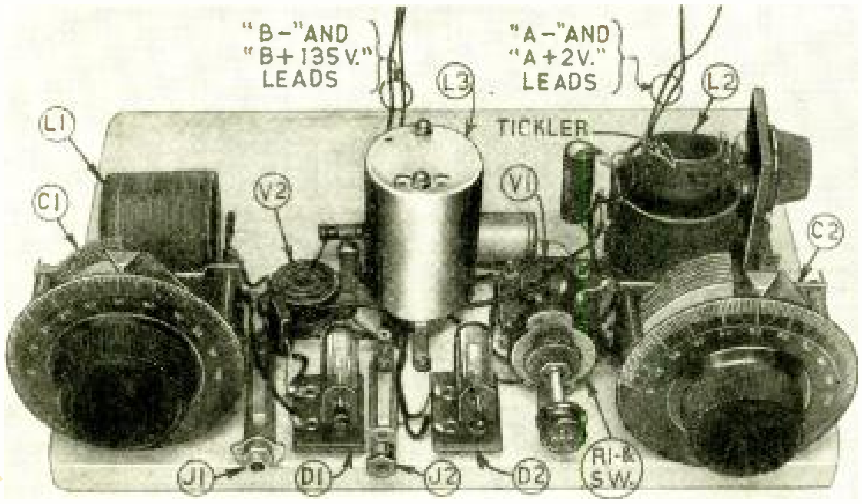


Fig. A
A view of the breadboard crystal superheterodyne. All components are labeled.

Operation and Theory

Now that we have the set built, the next step is to put it into operation; and while we are at it, we will learn why it operates, and thus kill two birds with one stone. The first test should be made with the set somewhere in the general vicinity of your regular broadcast receiver.

First, hook on the "A" battery and place the tubes in their sockets, then turn the combination volume control and off-on switch until the battery switch is "on." The filaments should show a dull red glow; if not, find out why before going further. Next, plug the headphones into the output jack, J2, and attach one wire to the "B" battery, flip the other one across the terminal. A sharp click in the phones indicates probable correct operation; however, if a large spark recurs do not go any further until you locate the short which is causing it. If everything appears to be O.K., make a permanent connection at this point.

Now we are ready to see if our oscillator "perks." Turn on the broadcast set and tune in a station, preferably a weak one which requires that the volume control be turned "way up." If the set is a modern one and fully shielded, it will probably be necessary to run a wire from the antenna post along the dotted line in the diagram of our super. Next, see that the volume control of the super is turned full on (which is the position furthest from the end where the switch snaps), and that the rotor of the oscillator coil, L2, is turned in one of the two directions where its axis is parallel to that of the big coil. Now, slowly rotate the control of oscillator tuning condenser C4 from one end of the dial to the other. If the oscillator is working properly you will hear a squeal from

DEAR BEGINNER: do not let the high-falutin' title scare you. It is a contraction of the even longer technical designation, "supersonic heterodyne"; and simply means that the action on which the circuit depends for its operation, and which we will describe, takes place at a frequency which is beyond audibility. Maximum sensitivity and selectivity are obtained through the use of the superheterodyne principle. Only one tube, or oscillator, V1 in Fig. 2, is required to obtain this action; V2 is only an A.F. amplifier.

the speaker of the broadcast set as the frequency at which the oscillator is operating crosses ("heterodynes," or "mixes") frequencies to which the set is tuned. If this squeal does not occur, turn the rotor of L2 through a half turn and repeat the tuning. If you do not get results, check over the circuit carefully as there is something at fault. The most likely place for trouble is in resistor R2, in the plate circuit of the oscillator tube, which may be of incorrect value; try different values, but do not operate the tube with less than 1,000 ohms here, as it may result in damage to the tube through excessive plate current.

After obtaining the squeal which shows oscillation at one point, tune the broadcast set to several others, always choosing a rather weak station, and see that the oscillator is operating over the whole range.

Now tune the broadcast set to a position where there is no reception, turn up the volume control fully and try to get the squeal. Don't try too hard, though, because you won't get it. The squeal is due to the heterodyne action and requires the presence of two frequencies. You will hear, if you listen carefully, a "thump" in the broadcast set speaker as the oscillator is tuned rapidly past the point to which the broadcast receiver is set.

Producing the "Beat" Frequency

Let us get back to the heterodyne action with which we are concerned in our little set. This action is simply the mixing of two different frequencies which results in the production of a third frequency equal to the numerical difference between the other two. Now this may sound very complicated, but it is really not, and if you keep your eyes and ears open, you will see many examples of it going on all around you. For instance, let two people each whistle a steady tone differing slightly from each other. You will hear a "chord"; if you listen closely you will be able to distinguish the *third note* which the musician calls a "beat" note—that "difference" frequency which is the "resultant" of two frequencies. This is simply the same heterodyne action which took place in your radio set when you produced the squeal; there is a vast difference in the frequencies involved, but the action is identical.

Now let's try a little more experimentation with the radio and the oscillator, and fix thoroughly in our minds just what is this thing called "heterodyne." (Tip: you'd better pick an evening when the family is out, for all this, or you are likely to find your scientific endeavors rudely interrupted.) Set the broadcast set to a weak station with the volume control turned up, and check the presence of the squeal by rotating the oscillator dial. Then, *very slowly*, tune past the point where the squeal occurs. You will hear, first, a very high-pitched whistle which will *decrease in pitch* as you turn the dial until the pitch goes *below* audibility. Continuing to turn the dial will bring the whistle back again, but this time increasing in pitch until it goes *above* audibility. (The heterodyne action did not cease when you failed to hear it as the pitch increased; it merely went above audibility, or became "super-sonic.")

A little simple arithmetic here will emphasize the point clearly. Suppose you had tuned in a station operating at 300,000 cycles a second (300 "kilocycles," or k.c.), and then set your oscillator so that it was operating at 301,000 cycles a second, the *difference frequency* would be 1,000 cycles (1 kc.) which you would hear as a squeal. If you set the oscillator at 299,000 cycles you would also hear the same note since the difference between the two frequencies is still 1,000 cycles. Now, however, if the oscillator is set to 350,000 cycles the beat note would be 50,000 cycles. You could not hear this note, but it would be there nevertheless, and if it were fed into a suitable amplifier it could be built up to any desired level exactly the same as the original signal of 300,000 cycles, except that, being a lower frequency, it would be much easier to handle and could be amplified far more, or through more stages.

The Second-Detector or "Demodulator"

Now, if this 50,000-cycle signal were fed into a second-detector, we would have available an audio signal which is an exact counterpart of that carried by the original 300,000 cycle signal, but at a much higher level than otherwise. The heterodyned signal carries every single modulation which was carried by either of the two original mixing frequencies. Since one of the frequencies was a pure, unmodulated note from our local oscillator, this means that it carries only the modulation present on the signal from the broadcast station. And that's all there is to a superheterodyne; not difficult to understand, is it?

Having found that the oscillator is operating, you can now retire with the set to your own private corner (much to the relief, probably, of the family) for the rest of the adjustments.

Attach the aerial, and plug the headphones into the phone jack, J1; you may also turn off the filaments as we

(Continued on page 173)

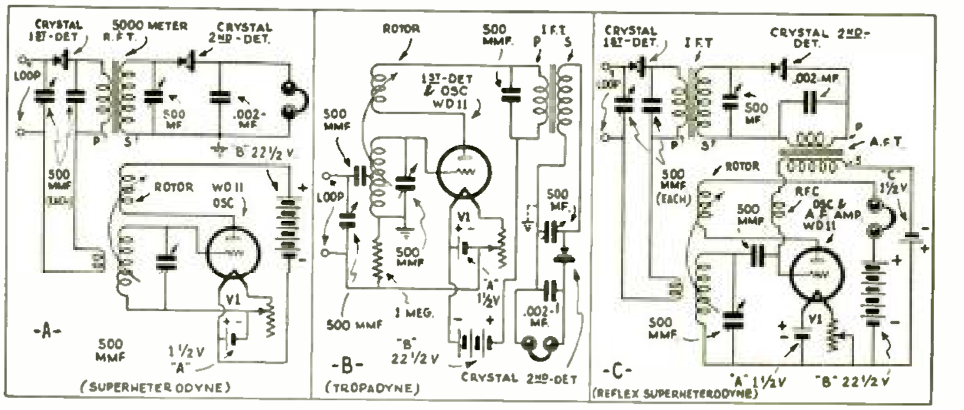


Fig. 1
One-tube superheterodynes published by our Technical Editor some years back.

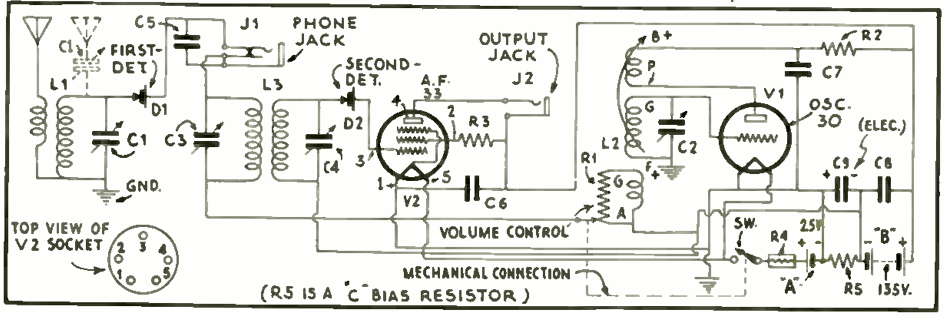


Fig. 2
The crystal superheterodyne circuit described in this article.

READERS' DEPARTMENT

A department in which the reader may convey his thoughts to other readers. Included in this department are letters, kinks, short cuts, and experiments. Send in your ideas.

A 43-FOOT SOUND CAR!

Well, we might say that he "goes in for sound in a big way" in referring to the sound equipment of Mr. P. J. Kingsley, of Cohoes, N. Y., whose lavishly furnished, palatial sound car, said to be the largest privately owned in the world, is illustrated in Fig. A.

Merely to say that the car measures 9x9x43 ft. in length does not convey the picture of opulence personified in the "bus." Therefore, we have asked Mr. J. G. Montross, who designed and installed the sound equipment, to tell the readers of RADIO-CRAFT some of the more intimate details of a mobile sound system to which any sound technician might well aspire. Says Mr. Montross:

The car illustrated in Fig. A, which was built and licensed prior to the restrictions as to length, can maintain a speed of 60 m.p.h. The motor is a 160 H.P. Continental; the chassis is a six-wheel Safeway, with three forward speeds and one reverse. The car does an average of 10 miles on a gallon of anybody's gas.

The interior has all the appointments of a modern home. Dining, kitchen and living rooms, bath and sleeping compartments. An electric-light plant, electric heat, and a water system make living and traveling a comfort and convenience.

This car is divided into three sections. The dining and driving compartment has tables folded into the walls to be used for dining ten people at once. The modern kitchen has hot and cold running water, an all-aluminum sink, an electric refrigerator, a 3-plate electric range with oven, a thrift-cooker, and a built-in closet holding all dishes, pans, etc. Directly off the kitchen is a shower bath, a pullman toilet and lavatory, with hot water on tap at all times. Under the chassis is stored a 160-gallon water supply; the flow is maintained by air pressure. The rear compartment is fitted as a living and reading room; easy chairs, rugs, shaded lamps and a radio receiver with remote control make this room very home-like.

All windows are fitted with shades and screens. Exhaust fans keep the interior ventilated. Electric lights are available at all vantage points; current is furnished by a 110 V., D.C. generator driven by a 4-cylinder gasoline engine. This engine will run continuously for 24 hours on 5 gals. of gasoline and requires very little attention; the heat generated is used to heat the interior of the car.

A ship's ladder takes you to the top deck, built for a speaker's platform, which is 7x10 ft. (completely railed in).

Forward of the platform is the sleeping compartment with four double beds accommodating eight adults. For dressing purposes there is provided directly off the sleeping compartment, a private space having its own pullman-type wash basin.

The Sound System

For sound amplification, two 6-ft. Bud all-aluminum trumpets, with dynamic units, were placed forward on the top deck. Control and field wiring run, in lead-covered conductors, to the driver's compartment.

A Capehart ten-record automatic record-changer houses a Sampson PAM-80 amplifier, a microphone amplifier, control panel and output matching transformer. Power is obtained from a 110 V., 300 W., A.C. converter.

Microphone plugs are placed on the speakers' stand and in the forward and rear compartments. The detector tube of the radio set furnishes the driving signal when high-volume broadcast programs are required for the sound system.

Thousands of people paid admission to see the interior of this car, at a

(Continued on page 169)

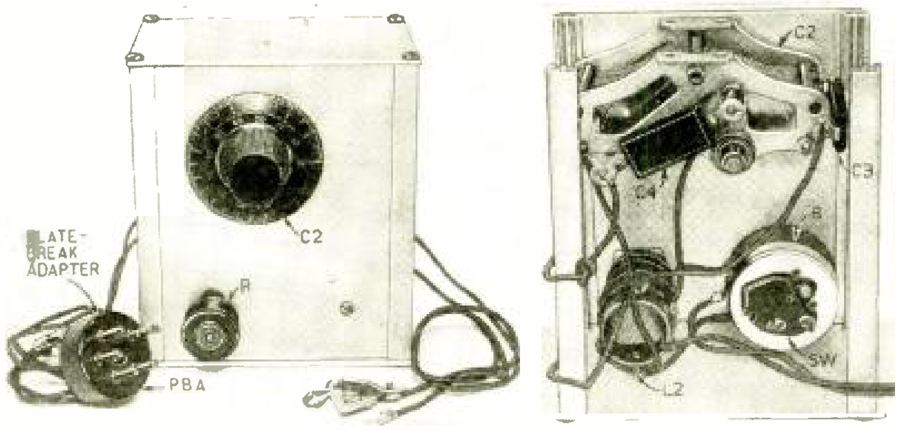
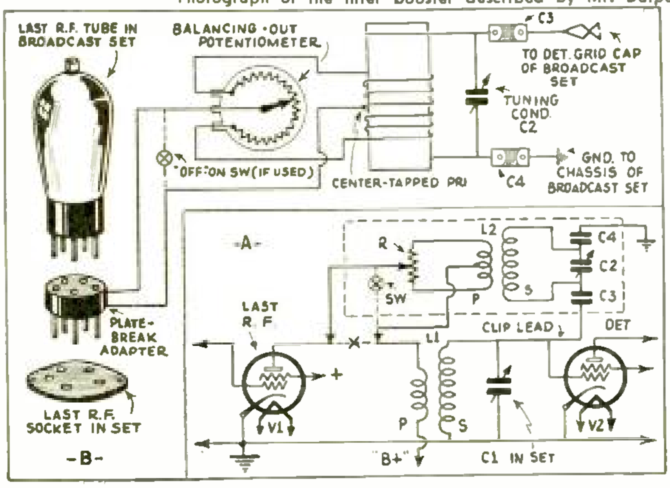


Fig. B
Photograph of the filter booster described by Mr. Dalpayrat.



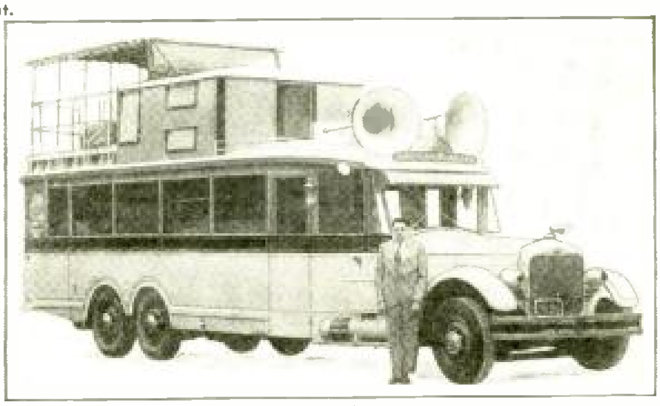


Fig. A, above
The $35,000 "sound car" described by its designer. Some toy, eh what?

Fig. 1, left
The schematic circuit of the filter booster pictured in Fig. B.

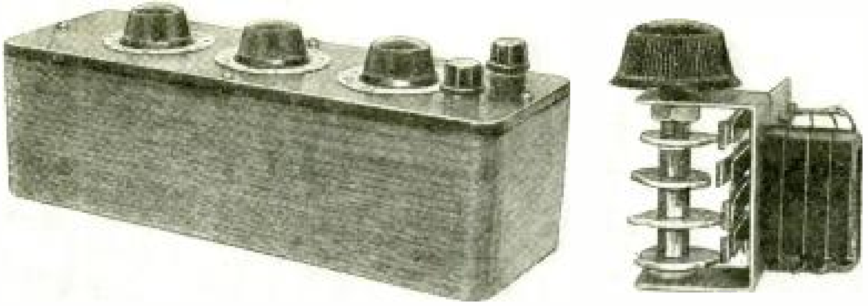


Fig. A, left; Fig. B, right
The completed decade condenser, left, and one switch, right.

HARRY S. KENYON

HOW TO CONSTRUCT A DECADE CONDENSER

The one thing that every experimenter wants and needs is a laboratory. In a laboratory, it is necessary that the apparatus be convenient, accurate, and stable. The decade condenser described below fulfills all these requirements.

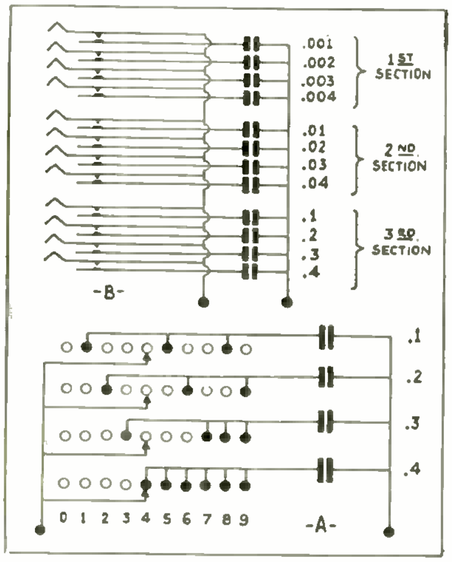


Fig. 1
Schematic circuit of the decade condenser described by the author. The drawing at A shows connection for any section.

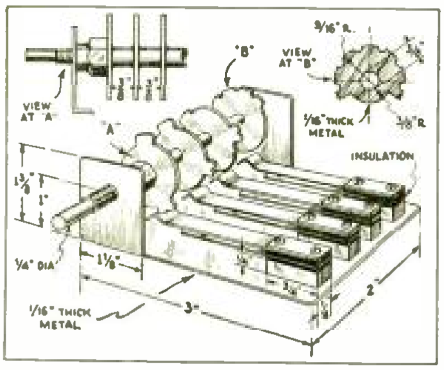


Fig. 2
A pictorial view of the switch to be made by the experimenter. All dimensions are given.

BECAUSE of financial difficulties, the average radio experimenter must usually be content with home-made equipment for his laboratory. This article describes a decade condenser which should fill a much needed place in the test equipment of Service Men and experimenters. It is not only easy to construct, but is quite inexpensive.

Uses of the Decade Condenser

The decade condenser consists of a small number of fixed condensers and a switching arrangement by means of which a great number of different capacities may be obtained; the actual capacity is readable at a glance. The uses for a condenser of this type are numerous. It may be used in the temporary setups of filter circuits; it may be used to pass or suppress certain audio frequencies; an approximate value of the inductance of an audio choke may be obtained by using the decade condenser to tune the choke to resonance with a known frequency.

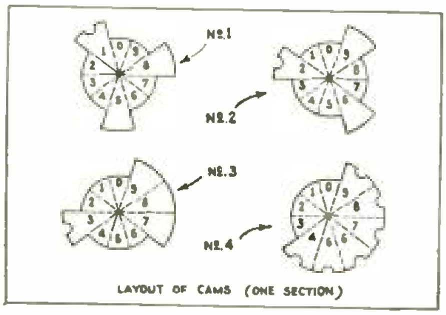


Fig. 3
Details of the cams, also to be constructed. There are four cams to a section, three of which are alike.

The inductance may then be calculated from the following formula:

$$L=\frac{25,344}{F^2C},$$

where

F=frequency in cycles per second; L=inductance in henries; and C=capacity in microfarads.

An A.C. meter may be used as the resonance indicator. The condenser is also very convenient in determining the proper value of capacity in hum-balancing circuits. Another application is in an audio oscillator to provide a wide range of frequencies.

Figure A shows the appearance of a completed decade condenser covering the range of .001 to .999 mf. in .001 mf. steps; it is apparent that the total number of steps is 999. And this surprising total is obtained from only 12 fixed condensers. This range, however, need not be the same as that specified, but may be arranged to satisfy the requirements of the constructor. The box pictured has three units; a two-unit box would have 99 steps; and a four unit box, 9,999 steps.

The need for so few condensers is based on the ability of the switching arrangements to connect the four condensers of each unit in the following combinations:

Dial Numbers	*Condensers in Parallel*	*Total Capacity*
0	None	0
1	.1 alone	.1
2	.2 alone	.2
3	.3 alone	.3
4	.4 alone	.4

(Continued on page 175)

A VALUABLE RESISTOR-CONDENSER CHART

The usual bugbear in radio calculations is the long arithmetical work involved. The author presents here a simple "reciprocal chart" which eliminates the necessity of continual division into the numeral 1, thus greatly simplifying radio calculations.

LOUIS B. SKLAR

RADIO experimenters and service men are often confronted with the problem of finding the value of two or more resistances in parallel, or the value of two or more condensers in series. The usual procedure is to write down the formula: $\frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}$ etc. or $R=\frac{R_1R_2R_3}{R_1R_2+R_1R_3+R_2R_3}$ and then substitute the values of R_1, R_2, and R_3 in the formula and solve for R. One can readily see that although the method of solving for R is an easy one, it requires considerable time to go through a large number of computations in order to arrive at a final result.

Sometimes this method is tiresome, especially during an experiment when a quick and accurate result (with a fair tolerance) is required. It is still more bothersome to those who lack a good knowledge of algebra or who find it difficult to get the right decimal point in calculations.

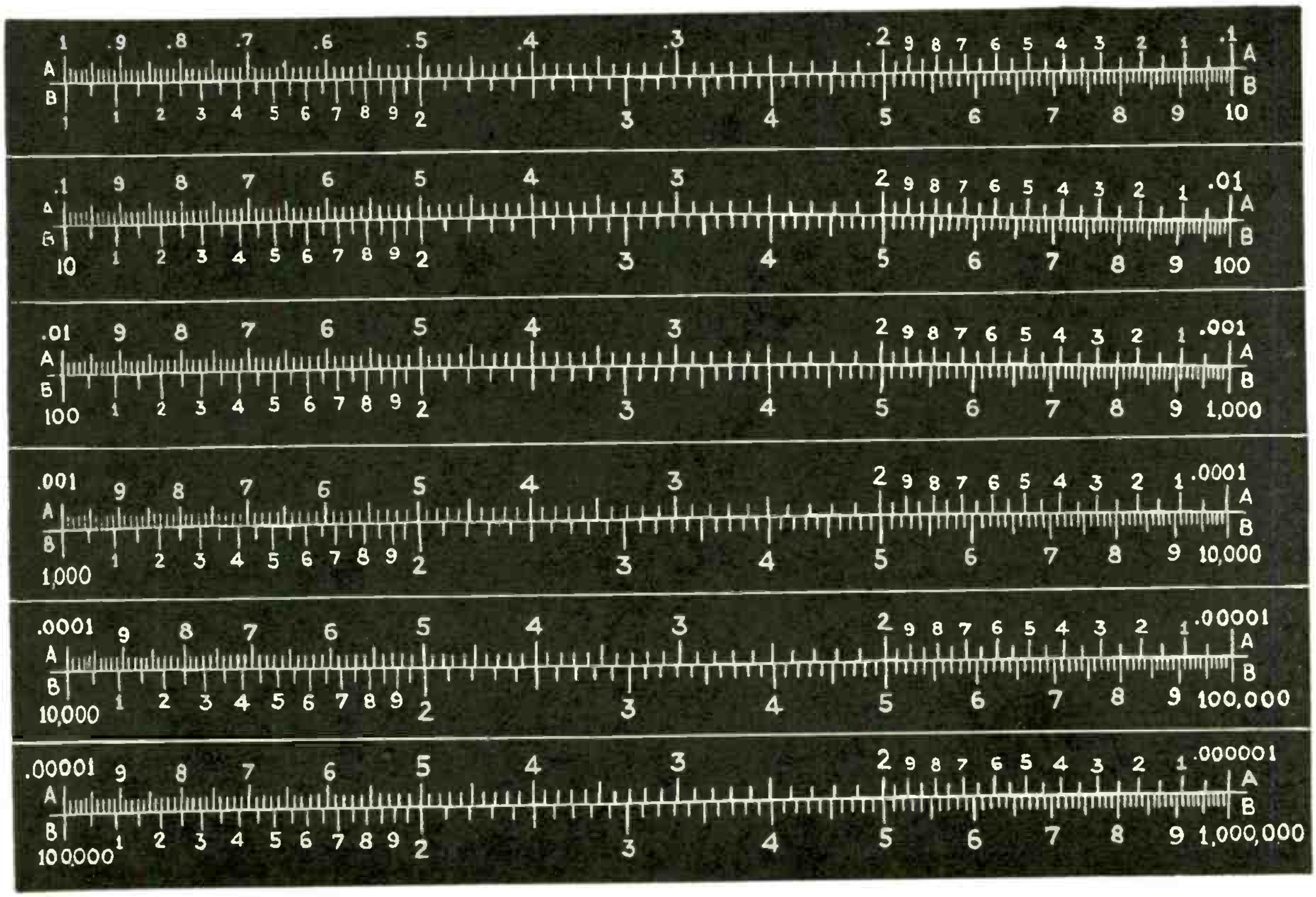
It was with the view of finding a short cut to the value of R, or C, that the writer designed the chart shown in the figure.

With this chart, the final value of R when 2, 3, 4 or, in fact, *any* number of resistors are connected in parallel, or the final value of C when two or more condensers are connected in series, can be easily and accurately obtained.

From the examples shown below, you will see that these results can be obtained without the use of any algebraic formulas or without any intricate calculations. All that is required from anyone who wishes to solve these types of problems is a knowledge of plain addition.

The range of the chart is from .000001 to 1,000,000 units of resistance or capacity. While this range covers almost every conceivable value of resistance or capacity that will arise in practical work, care must be taken, however, not to use different types of units in the same problem. For instance: if you wish to know the value of 1 megohm and 100,000 ohms in parallel, you cannot mix megohms with ohms. What you will have to do, in this particular case, is to change the 100,000 ohm resistor to read .1-megohm, or make the 1 megohm read 1,000,000. The same applies to farads and microfarads, or microfarads and micro-microfarads.

(Continued on page 176)



REWIRING THE A. K. 70-Q FROM 6 TO 2 VOLT OPERATION

The A.K. 70-Q, originally designed for operation from a six-volt storage battery, may now be resurrected and used with the usual two-volt battery. The author, in this interesting article, gives all essential details.

A. A. JANSZEN

RADIO Service Men hear frequent complaints of excessive upkeep costs from owners of the Atwater Kent model 70-Q battery receiver. This situation may be remedied to the advantage and profit of both the set owner and the Service Man. The owner, who is usually located at a distance from a service station, will not need to make so many trips in order to keep his set operating; he will have better performance, greater economy from the standpoint of both "A" and "B" battery consumption and tube replacements, and the Service Man will make a profit on the sale of a set of tubes by modernizing this set. The changes, shown in Fig. 1, are simple enough, and may be made with a minimum amount of equipment in a short time.

Changing the R. F. end of the Set

Remove all tubes and tube shields. Turn the set over, with the rear towards you. This places the filament bypass condenser, H-20, Fig. 2, to your extreme left. Remove all five flexible, filament resistors; these are thin, bunched, white with black tracer. Disconnect the first R.F. filament bypass and the two third R.F. filament bypass condensers from the filament circuits of their respective tubes. These are to be used as bypass units for the voltage divider system in the control-grid circuits of the R.F. tubes. Allow the second R.F. and detector bypass condensers to remain connected.

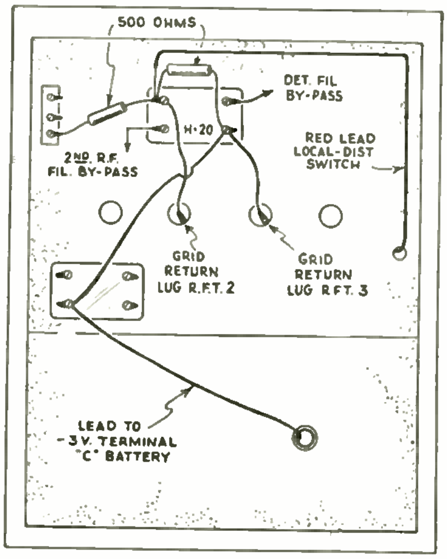


Fig. 2
A sketch illustrating the placement of the parts necessary in rewiring this receiver.

In order to obtain the correct amount of bias on the control grids of the R.F. tubes, we construct a voltage divider system, consisting of two 500-ohm, 1-W. resistors. These are connected in series and mounted as shown in Fig. 2. They are connected between the —3-V. tap on the "C" battery and the chassis. (An extra lead must be brought into the "C" battery compartment for the —3 V. connection.)

This 3 V. tap, which is bypassed by two .1-mf. condensers, is also connected to the grid-return lug on the No. 3 R.F. transformer, (third transformer from rear of set). This places the correct amount of bias on the control-grid of the third R.F. tube to prevent oscillation in the R.F. stages. The center-tap of the two resistors, which is also bypassed with a .1-mf. condenser, goes to the grid-return lug of the second R.F. transformer, and to the red lead from the local-distance switch. This red lead was originally connected to chassis. A grid bias of 1½ V. is secured on the control-grids of the first and second R.F. tubes when the local-distance switch is in the "distance" position. The grid-return lugs are on the transformer coil forms, right in the chassis opening under the transformer shields. The leads from these lugs to the condenser rotor springs are removed.

Connect all filament circuits of the R.F. tubes in parallel with the detector and A.F. tubes. To your left, toward the front of the chassis, you will find a yellow, spaghetti-encased resistor, connected from minus filament on the first audio tube to chassis. This resistor may remain, when an air cell is to be used, as the resistor provides the voltage-drop required to obtain exactly 2 V. on the filaments of the tubes. However, if a two-volt storage cell is to be used, this resistor must be removed. This completes the changes underneath the chassis; the bottom plate may now be replaced.

Turn the set over and remove the pilot light. If an air cell is to be used it must be left out. With a storage cell it must be replaced with another of the correct voltage rating. The lead from chassis to tube shield for the detector may be removed, as the type 30 is non-microphonic. Type 32 tubes are placed in the three, type 22 sockets, 30's in the detector and first audio sockets, and 31's in the 71A sockets.

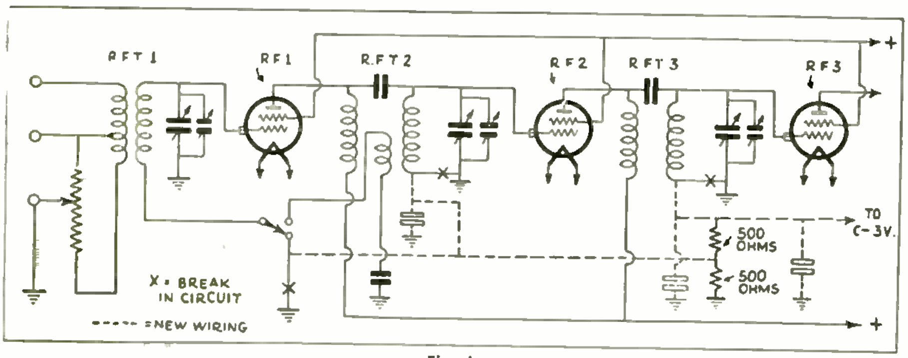


Fig. 1
Schematic circuit of the rewired A.K. 70-Q receiver.

The Audio End

No changes are required in the A.F. end of the set, except that a potential of only 135 V. is used on the plates of the 31's, with only 22½ V. on their

(Continued on page 177)

RADIO-CRAFT'S INFORMATION BUREAU

SPECIAL NOTICE TO CORRESPONDENTS: Ask as many questions as you like, but please observe these rules:

Furnish sufficient information, and draw a careful diagram when needed, to explain your meaning; use only one side of the paper. List each question.

Those questions which are found to represent the greatest general interest will be published here, to the extent that space permits. At least five weeks must elapse between the receipt of a question and the appearance of its answer here.

Replies, magazines, etc., cannot be sent C. O. D.

Inquiries can be answered by mail only when accompanied by 25 cents (stamps) for each separate question.

Other inquiries should be marked "For Publication," to avoid misunderstanding.

INTERCHANGING THE NEW TUBES

(211) Mr. G. Aliquo, Brooklyn, N. Y.

(Q.) It seems to me, that judging by the published characteristics and general descriptions, the new tubes need not necessarily be used only in new circuits, but may, in many instances, be used as replacements of some of the older tube types. Please advise regarding the interchangeability of the new tube types.

(A.) Through the courtesy of the RCA Radiotron Co., the following information is available.

Tube Type	Interchangeable with	Tube Type	Interchangeable with
2A5	PZH	50	585, 586
35	51	71A	71, 71B
36	36A	80	13
37	37A	81	16, 16B
38	38A	82	AF
39	39A, 44	83	AG
44	39, 39A	84	98*, P-861*
47	PZ		(*Mercury vapor type)
*36	64, 64A	*38	68, 68A
*37	67, 67A	*39	65, 65A

(*Interchangeable only in auto-radio receivers, and in A.C. receivers which do not use series heater circuits.)

*83	88, 986, 80M

(*Interchangeable only when the set's power transformer will stand additional filament current drain.)

SHORT-WAVE STATIONS—PENTA-GRID-CONVERTER CIRCUITS

(212) Mr. James Brown, Laredo, Texas.

(Q.1.) I wonder if I could get the names of all short-wave stations, the time of day they broadcast, the wavelength in meters, and the frequency in kc.? I have received F3ICD, Indo-China; CM2MK, Havana, Cuba; and ZL3CZ, Christchurch, New Zealand, on my 10-tube Atwater Kent model 480 receiver.

(A.1.) Every issue of SHORT WAVE CRAFT magazine contains one section or the other of a two-part station list divided as follows: Part 1, relay broadcasting, and experimental and commercial radiophone stations; Part II, police, airport and television stations.

(Q.2.) Are there any commercial radio sets incorporating the new type 6A7 "pentagrid converter" tube described in the July, 1933 issue of RADIO-CRAFT?

(A.2.) Two schematic circuits of radio receivers incorporating this electron-coupled detector-oscillator are shown in Figs. Q.212A and Q.212B. A photographic illustration of the manner in which the circuit of Fig. Q.212A "makes up" is illustrated in Fig. Q212C. The reproducer is in the top of the cabinet; the smaller section of the dual knob controls the off-on switch and volume.

The following tube voltage data relate to the Philco model 54 receiver. The first tabulation refers to a 115 V., A.C. line; the second, 120 V., D.C.

Tube Type	K. to F. Volts	C.-G. Volts	S.-G. Volts	Plate Volts
V1	12	0.15	65	84
V2	12	0.15	52	84
V3	10	0.25	....	38
V4	10	0.5	90	84
V5	....	....	....	146

The filaments in series drop 68 V.: test with an A.C. voltmeter connected to points X. Set R1 at maximum and station selector at 550 kc.

Tube Type	K. to F. Volts	C.-G. Volts	S.-G. Volts	Plate Volts
V1	7.5	0.15	70	90
V2	7.5	0.15	70	90
V3	10	0.25	....	40
V4	10	0.5	92	90
V5	....	.. ....	....	....

The filaments in series drop 70 V.: test with a D.C. meter connected to points X. Set R1 at maximum and station selector at 550 kc.

Power consumption, either connection, 50 W.

"CONSTRUCTING ADAPTERS"—(A Correction)—VISUAL TUNING METER

(213) Mr. Woodrow W. Coffin, Treichlers, Pa.

(Q.1.) The illustration of the adapter for testing Raytheon rectifiers, Fig. 29, in the article, "Constructing Adapters," in the October, 1932, issue of RADIO CRAFT, does not seem to check with the tube connections. Please advise whether the illustration is correct.

(A.1.) Through the courtesy of the author, the following information concerning the series of articles on adapters is available.

In the October, 1932 article, adapter No. 944BRR was shown in Fig. 29. A corrected connection for this adapter is given in Fig. Q.213A. Number 965DSW, Fig. 9, and 965DW Fig. 8, of the same article, are corrected at B. for the former, and at C, for the latter.

In the November issue, Fig. 30, adapter No. 944BRA should be connected as shown at D. Figure 37, adapter No. 421X, is corrected at E. Another adapter, the No. 968 unit illustrated in Fig. 38, is corrected at F. At G is a correction of adapter No. 944LS. Fig. 44.

In the December article, adapter No. 944F should have been numbered 944PT.

The third article, in the January, 1933, issue, showed a No. 944PLC adapter which should have been the No. 944PL; also, the No. 944PLS should have been the No. 944PC.

(Q.2.) I have built the "Triple-Twin" receiver, described in the April, 1932 issue of RADIO CRAFT, in a small cedar chest. Now, I would like to add a novelty to the set in the form of a tuning meter. Please advise how this may be accomplished.

(A.2) The procedure is described in detail, in the article, "The Why and Wherefore of Tuning Meters," in the October, 1932 issue of RADIO-CRAFT. Merely connect a milliammeter of suitable range in the plate lead of the type 27 tube; a 0-5 ma. instrument is recommended. Preferably, it should be of the reverse-scaled type designed for this service.

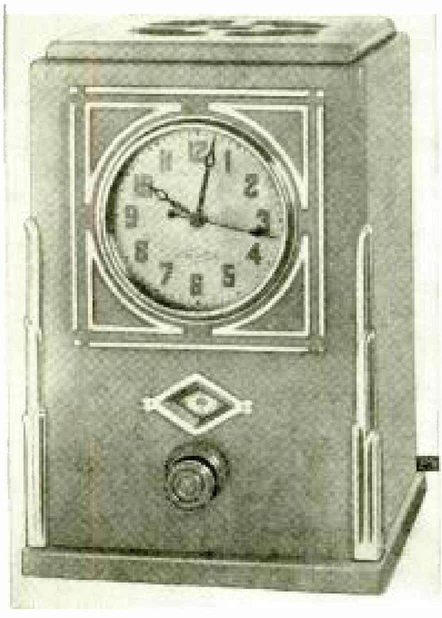
TYPES AD, AF AND AG "SAFETY" RECTIFIERS—TYPE AE TETRODE

(214) Mr. M. Chernega, New York, N. Y.

(Q.1) What is the difference between the "safety" rectifiers described in the "Tube Reference Index" in the March, 1933 issue of RADIO CRAFT, and any other type of mercury vapor rectifier tube? What are the characteristics of these type AD, AF and AG tubes?

(A.1) The following information concerning the "safety" feature in mercury vapor rectifier tubes is furnished by courtesy of the engineering department of Arcturus Radio Tube Co.

In view of numerous reports from the field that the newer sets using the types 82 and



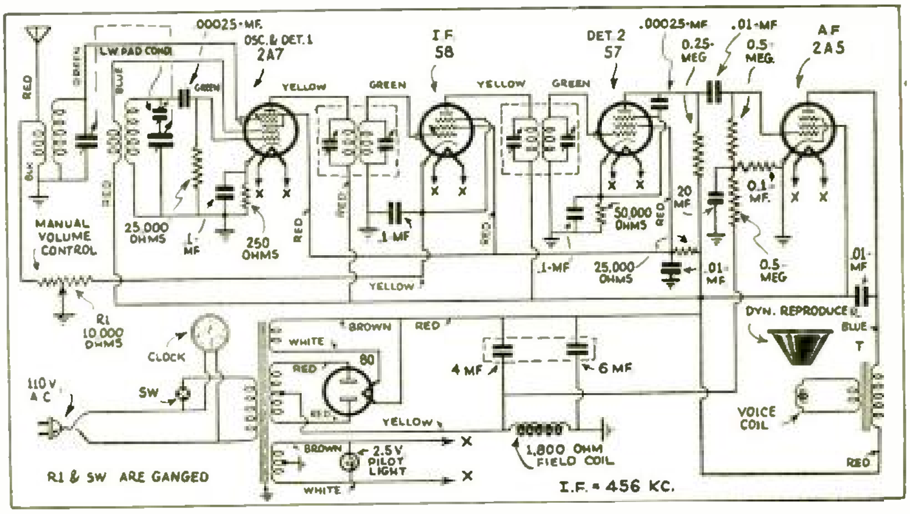


Fig. Q. 212A, above
Schematic circuit of the Velie model KA receiver, using the type 6A7 tube.
Fig. Q. 212C, left
A view of the Velie model KA receiver. Note the symmetry of design.

THE 2B6 TUBE

(Continued from page 143)

Figure 4 shows the relation between power output and load resistance. An inspection of this curve shows that maximum power output occurs at the same load resistance as minimum total harmonic distortion. In these curves, therefore, an output of 4 watts is secured with a load resistance of 5,000 ohms at a total harmonic distortion of 5%. Figure 5 shows the relation between distortion and power output; also, input signal volts and power. Here again it is seen that at a harmonic content of slightly less than 5% the power output is approximately 4 watts with an input signal of 25 volts r.m.s.

At this point the question arises as to how the output section, which is a triode, is capable of delivering maximum undistorted output to a load impedance which is very nearly equal to its plate impedance, while almost all previous triode class A systems incorporated a load impedance which was twice that of the tube. The explanation for this query may thus be answered by referring to the set of curves shown in Fig. 6. These curves show the relation between plate current and plate voltage. A load line of 5,000 ohms is shown. It is seen that this load line intersects the 2½ volt bias line at right angles and that the extremities of this line intersect the grid voltage curves where the curvatures are opposite; in other words, the load line for example intersects the +15-volt grid curve where the curve is concave downward, while it intersects the —15 volt grid curve where it is concave upward. In this manner, distortion approaching the extremities of the plate voltage swings cancel, thus permitting maximum undistorted output with the load impedance equal to that of the tube. This tube is also well adapted for push-pull operation, and a typical circuit is shown in Fig. 7. A common bias of 270 ohms is required for the output section, and a bypass condenser is not required, although it is recommended for high quality. The characteristics of this tube are as follows:

Input Section

Plate (max) Pa, 250-volts
Grid-G1b +2.5-volts
Plate current, 4.0-ma.
Amplification factor, 7.0
Mutual conductance, 600-micromhos
Plate resistance, 11,650-ohms
Load resistance, 8,000-ohms

Output Section

Plate (max) Pb, 250-volts
Grid-G1b —2.5-volts
Plate current, 40-ma.
Amplification factor, 18
Mutual conductance, 3,500-micromhos
Plate resistance, 5,150-ohms
Load resistance, 5,000-ohms
Signal volts*, 25-volts
Power output**, 4.0-watts

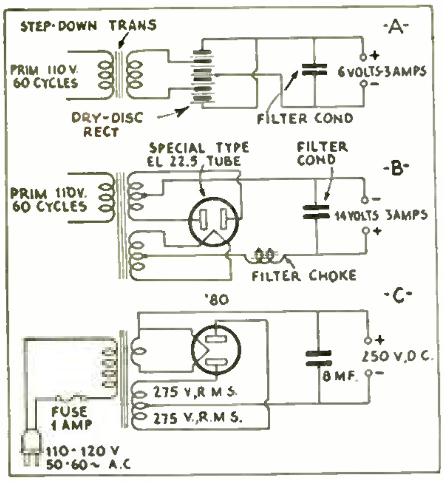
*Volts r.m.s. for rated power.
**5% total harmonic distortion.

Socket connections of this tube are shown in Fig. 8.

AN ALL-WAVE SET

(Continued from page 145)

½-watt metallized resistors, 4A, 10;
One Amperite self-adjusting line voltage control, type 5A-5, 33;
One Acratest power supply transformer, type 5502, 31;
One Acratest toggle switch, S. P. D. T. type 4104, 4;
One Acratest switch, double-pole, 5 position, type 4188, 13;
One Acratest dynamic speaker, 6 in. diam., output transformer for 7,000-ohm impedance primary, 2,500-ohm speaker field, type 490, 27;
Two Acratest 4-prong wafer sockets, type 4062, 25, 30;
Three Acratest 6-prong wafer sockets, type 6934, 5, 16, 22;
One Acratest toggle switch, type 4112, 32;
One Acratest full vision dial and escutcheon, type 7175;
One Acratest 4-prong plug, 26;
One metal chassis 8 x 5 x 2 ins. high;
One piece of No. 18 D.C.C. wire, 1 in. long, closely wound over with about 10 turns of No. 18 D.C.C. wire, 2.



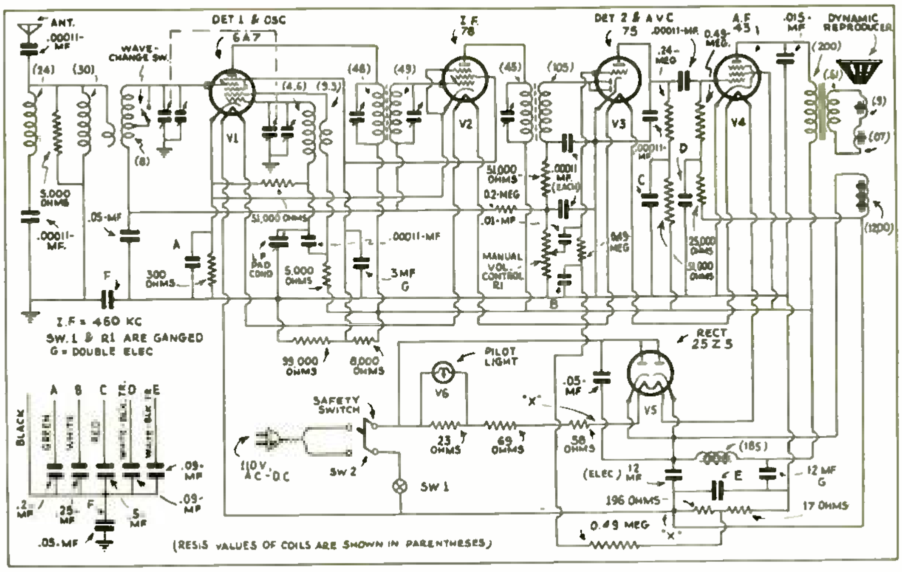


Fig. Q. 215, above
Three types of field coil exciters.
Fig. Q. 212B, right
The Philco model 54 receiver.

83 tubes are rendered inoperative by arc-over of these rectifiers at the end of their useful life, thus burning out the power transformer or the fuse, a "safety" feature has been incorporated in an improved type of mercury vapor rectifier. This tube automatically disconnects itself from the circuit when arc-over occurs. A technical explanation of the tube design follows.

The functioning of a mercury vapor rectifier is quite different from that of a high-vacuum rectifier, such as the type 80. In the mercury rectifier tube the successful operation is accomplished by the combined action of electrons and mercury ions, while in the high-vacuum tube only electrons are present.

As the mercury rectifier is used under load, a condition gradually develops where positive ion bombardment is very apt to localize at a spot on the cathode (filament) and raise the temperature of this spot far beyond the operating temperature.

This local heating tends to encourage two objectionable and dangerous results:

(1) Disintegration of the thermionically active material and vaporization of the metal filament or cathode at the point where positive ion bombardment is concentrated with subsequent decrease in emission, resulting in a greater voltage drop between the plate and cathode and a corresponding increase in the velocity of ionic bombardment.

(2) Heating of the mercury vapor at the point where ionization is localized to a temperature at which the vapor emits electrons. These electrons are drawn to the cathode during the half-cycle it is positive and constitutes a "back-current" or "arc over."

The electrons comprising the "back-current" mentioned above are drawn from the filament, which is common to both sections in most full-wave rectifiers, to the plate of the other section and back through the secondary of the plate transformer to the first plate and thence, via back-emission to the first filament. A complete circuit is thus formed comprising the secondary of the plate transformer and the low resistance from the plate to the cathode of one section of the tube and from the cathode to the plate in the section which has "arced over." The filter and load are thus effectively short-circuited and the current through the secondary of the plate transformer is limited only by its impedance and the drop of approximately 15 V. in each section of the tube.

This circulating current reaches values several times the normal current and is usually sufficient to destroy the secondary winding or the primary winding, in which the current is, of course, increased. This flash-over, or arc-over, is not indicative of a faulty rectifier. It is an inherent limitation of gaseous rectifiers, regardless of the skill and care taken in their manufacture and the tube may operate perfectly a moment before it starts to flash-over.

Following are the characteristics of specific tubes designed to incorporate the "safety" feature.

Type AD Mercury-Vapor Rectifier

This tube is especially designed for small radio sets and is especially adapted for use in A.C.-D.C. receivers.

Filament potential, 6.3 V.; filament current, 300 ma.; maximum plate potential, 350 V., r.m.s.; maximum peak plate potential, 500 V.; maximum D.C. output current (continuous), 50 ma.; maximum peak plate current, 200 ma.; tube voltage drop, 15 V. Bulb is type S-12; base, small 4-pin (clockwise: heater, plate, cathode, heater).

Type AF Mercury-Vapor Rectifier

Filament potential, 2.5 V.; filament current, 3 A.; maximum A.C. plate potential, per plate, 500 V., r.m.s.; maximum peak inverse potential, 1,400 V.; maximum D.C. output current (continuous), 125 ma.; maximum peak plate current, 400 ma.; tube voltage drop, 15 V. Bulb is type S-14; base, medium 4-pin.

Type AG Mercury-Vapor Rectifier

Filament potential, 5 V.; filament current, 3 A.; maximum A.C. potential, per plate, 500 V., r.m.s.; maximum peak inverse potential, 1,400 V.; maximum D.C. output current (continuous), 250 ma.; maximum peak plate current, 800 ma.; tube voltage drop, 15 V. Base is type ST-16; base, medium 4-pin.

(Q.2) What details are there available in reference to the type AE tetrode mentioned in the same listing?

(A.2) The following information is given in connection with the Arcturus type AE output tetrode.

The type AE tetrode is an indirectly-heated (cathode-type) tube. The plate is so designed that there is little tendency for secondary electrons to be attracted to the outer or accelerating grid, and the tube therefore operates as a *pentode*—although no supressor grid is used. This tube was developed to produce as large a power output at low plate and accelerating grid voltages as possible without consuming more than approximately 10.5 ma. plate and accelerating grid current. The heater current is 0.3-A. so the heater may be connected in series with those of other tubes of the same rating; the tube is particularly adapted for use in 110 V., A.C. D.C. receivers.

Heater potential, 12.6 V.; heater current, 0.3-A.; plate potential, 100 V.; accelerating grid potential, 100 V.; control-grid bias, 13.5 V. (negative); plate current, 8.5 ma.; accelerating grid current, 1.75 ma.; amplification constant, 20; plate resistance, 12,000 ohms; transconductance, 1,650 mhos.; load resistance, 13,500 ohms; power output, 400 milliwatts; maximum grid resistor value, 1 meg. Bulb is type ST-12; base, small 6-pin (clockwise: heater, plate, accelerating grid, control grid, cathode, heater). Full automatic grid bias is essential when a grid resistor is used.

FIELD COIL EXCITERS

(215) Mr. Charles Davis, Milford, Pa.

(Q.) What are field coil "exciters" and how are they made?

(A.) A field coil exciter supplies the D.C. required by the field coil of a dynamic reproducer. Some field coils—500 to 3,000 ohms;

(Continued on page 178)

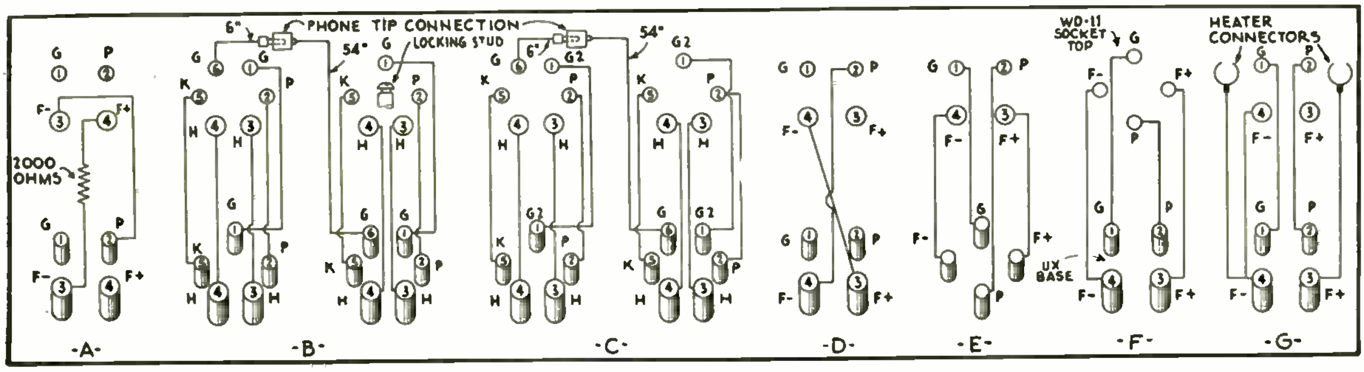


Fig. Q. 213
Corrections to the article, "Constructing Adapters," in the Oct. and Nov., 1932, issues of RADIO-CRAFT. Typographical errors are mentioned in the text.

READERS' PAGE

(Continued from page 162)

number of county fairs. A refrigerator manufacturer placed their line of products on display. (A full-size, 20-sheet bll poster can be placed on each side for advertising.) The cost of building and equipping this car was nearly $35,000; the car was intended as a traveling home and office.

HOW TO MAKE A COMBINATION "FILTER-BOOSTER"

Editor, RADIO-CRAFT:

In Fig. B is illustrated a simple device of unique design which may be attached in a few minutes to any rado receiver to improve its operation. This unit has band-pass characteristics which considerably enhance the tone quality; and in many cases the volume is almost doubled without causing circuit oscillation; finally, the selectivity is increased, resulting in an increase of the signal-noise ratio. The result is shown in Fig. 1.

(Although this little instrument has been tested on sets of widely different design, most of the experiments were made in conjunction with a Savil, 110 V., D.C. receiver of the type described by Mr. Vilkomerson in the December, 1932, issue of RADIO-CRAFT. Consequently, since the results will vary somewhat in each individual instance, the description of operating results will be confined to this set model.)

Resistor R, shown in Fig. 1A, serves the dual purpose of phase changer and volume control. When the arm is at the center, the auxiliary circuit receives very little energy and tuning it will not affect the signal strength. However, when the contact is moved towards one end, the volume will increase and the tuning effect of C2 will become apparent as the knob is adjusted and the selectivity becomes greater.

Moving the arm toward the other end will usually result in a diminution of volume. By detuning a little, it is possible to reduce interference without reducing either the strength of the signal or the quality of the reproduction.

The filter-booster is designed for T.R.F. sets—it is not recommended for superhets. Use only mica condensers for C3 and C4. The band-spread effect that results at the shorter wave-lengths does not change the selectivity of the receiver but merely makes the tuning more convenient; this feature is of particular merit where the set's tuning gang is controlled by a direct-acting tuning control instead of a vernier.

If it is desired to operate the receiver closer to the point of oscillation, reduce the capacity of C4. The plate-break adapter connects into the plate circuit of the receiver's last R.F. tube at X, as shown in Fig. 2A. An off-on switch, ganged with R, may be connected to close the plate circuit, as shown dotted. Resistor R and the variable condenser C2 must be completely insulated from the shield can. Coil L2 is a standard broadcast T.R.F. unit; it must not approach the shield can closer than ½ in. at the sides, nor closer than ¾ in. at the ends. The coil used by the writer was wound on a form one inch in dia., with a secondary to match the condenser used as C2. The primary has 65 turns, center-tapped, wound over one end of the secondary. Four layers of Empire cloth correctly space these two coils. Primary and secondary are wound with No. 32 S.C.C. wire.

List of Parts

- One variable condenser (overall, *maximum* dimensions not to exceed those of the shield-can), 350 mmf., C2;
- One R.F. coil (to match C2), L2;
- Two mica condensers, C3, C4, 250 mmf.;
- One plate-break adapter;
- One potentiometer (with or without switch), straight-line-resistance calibration, 6,000 ohms, R;
- One 2 in. dial for C2;
- One knob for R;
- One Blan aluminum shield can, 5¼x4½x3⅛ ins. deep;
- One battery clip (for grid lead), one soldering lug (for ground lead), 10 ft. flexible rubber-covered hook-up wire.

HENRI F. DALPAYRAT,
New York, N. Y.

(Continued on page 174)

Be sure to turn to page 136 of this issue and read about the new 1933 OFFICIAL AUTO-RADIO SERVICE MANUAL which is now published.

A 26-WATT P. A. SYSTEM

(Continued from page 147)

produce 26 watts, but only require 320 volts at 100 ma.

There is available a 6-volt, storage-battery operated motor generator that was specifically designed to meet the plate current requirements of this amplifier, it is compact and light thereby facilitating its attachment directly upon the amplifier chassis, as illustrated. (The overall dimensions of this generator are 5" lg., 4¼" wd., 4" hg.. and its weight is 7 lbs.)

Another factor in favor of the new 53 tube is the difference in cost between the D.C. generator required for this amplifier, namely approximately $25.00, as compared to approximately $70.00 for an A.C. generator required for the four 50 type tubes. Furthermore, the latter A.C. generator requires two 6 volt storage batteries and consumes approximately 30 amps. Compare that to the average current drain of 8 amps. consumed by the D.C. motor generator required for the two 53 class B, 26 W. amplifiers described here; further, note that this new D.C. generator can be operated from only one 6-volt storage battery; in fact the additional current drain so imposed upon that battery is of small consequence, and will not give any cause for battery troubles.

Description of Amplifier

It will be observed that the input mixer control box can be operated while fastened to the amplifier chassis; or, quickly and conveniently removed therefrom and operated any distance from the amplifier, thereby providing for remote placement (out of sight, if desired) of the amplifier proper. Within this control box are contained the input matching transformers, enabling the use of a single or double button microphone, high or low impedance phono, pick-ups, radio tuner for programs, etc.

The controls on this unit provide for master volume control, fading, and mixing of *any* two inputs. A tone control and individual microphone-button rheostats are also included. Two toggle switches permit optional button-current readings on the milliammeter; another switch gives phono (or "mike") radio selection. All connections are easily made on the rear of this device and a dual conduction cable is run between the control box and the amplifier "input" binding post terminals, shown in Fig. 3. This cable can be made up to 20 feet long, without introducing any appreciable losses or without causing appreciable attenuation of the higher frequencies. The output impedance of the control box matches the input impedance of the grid circuit of the first 37 tube. It is to be noted that a master volume control, R1, is mounted on the amplifier chassis proper; when the control box is employed, this volume control is turned completely "off," so as to confine the volume control action entirely within the input control box itself.

One of the main requisites of an amplifier is gain; the extent of this factor determines the possible undistorted output when weak input sources are to be amplified, such as those emanating from non-sensitive microphones, poor phono pickups, etc. To provide for maximum volume output, a self-contained pre-amplifier is included, and consists of an input stage using one type 37 tube.

This first A.F. tube, V1, is resistance coupled into another 37 tube, VT2, which, in turn, is resistance coupled to two 89 triode driver tubes, V3 and V4. Each of these driver tubes is coupled through an individual step-down class B input transformer, T1 and T2 respectively, into corresponding twin class B 53 output tubes, V5 and V6; see Fig. 1. Each of these output tubes feeds its own channel, equipped with its own universal output transformer. T3 and T4, furnished with secondary windings of 500, 200, 15, 8, 4, and 2 ohms, connected to the six binding posts in each channel. It is apparent there are actually two output channels available, which may, or may not, be used together. Thus, a whole bank of speakers, connected to one of the output channels, T3, may be instantaneously disconnected by means of a switch, S1, without affecting in any way whatsoever the operation of the remaining speakers that may be connected to the other output transformer, T4 channel. As this switch disconnects the "B" supply voltage to both the 89 driver and the corresponding output tubes, maximum economy of operation is thereby obtained, which is particularly desirable when operating the amplifier from either a motor generator or from batteries. At maximum output, the average motor-generator battery consumption is only 4½ amps. when only one channel is being used.

The secondary windings of each output transformer, T3 and T4 may be connected either in parallel or in series, thus allowing the entire audio output of 26 watts produced by this amplifier to be connected to one single channel consisting of either one or several dynamic speakers, with their voice coils of any usual impedance value. A further inspection of the schematic diagram will reveal that each amplifier is separately filtered—insuring fully *stable, hum-proof and noiseless operation* throughout. As shown in the top and bottom views, Figs. A and B, all essential components are separately mounted within individual shields.

Changing From 6 Volts D.C. to 110-volts A.C. or Vice Versa

Without changing any tubes and without making any alterations or internal or external adjustments, you can switch from one type of current source to another! Note how simply this is accomplished: A plug, P1, and cable protrude from the amplifier chassis. For operation from the 6-volt storage-battery-operated motor generator, all you need do is insert this plug into the socket S9, Fig. 2A, the terminals of which are, of course, connected to the D.C. output of the motor generator. It can thus be seen that both the plate and filament voltages are fed through plug P1 from the 6-volt D.C. generator to the amplifier tube filaments and plates.

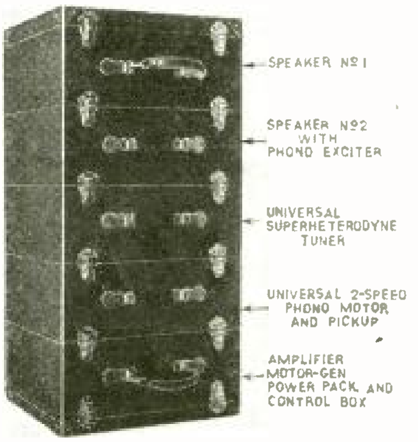


Fig. C, above
The complete system closed for transportation.

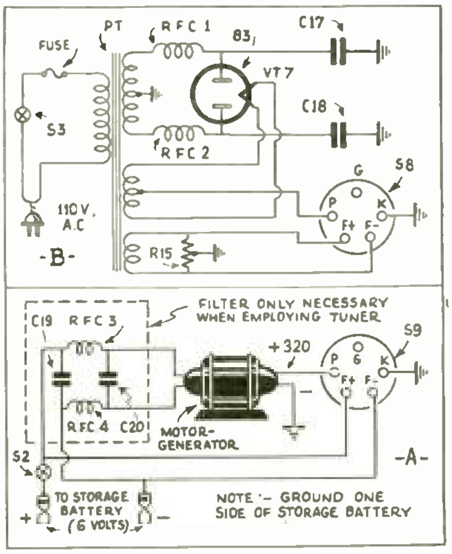


Fig. 2, right
At A, the Socket S9 into which P1 plugs for six-volt operation; at B, socket S8 for A. C. operation.

On the other hand, for operation from the self-contained 110-volt A.C. Power Pack, this same plug P1 is removed from socket S9 and inserted instead into socket S8, Fig. 2B, the terminals of which are connected to the rectified and filtered D.C. output produced in the 110-volt A.C. power pack and to the 6.3-volt A.C. winding on the power transformer PT. In a like manner, for *exclusive battery operation*, this same plug (P1 can be inserted into still another socket, not illustrated) may be connected to a bank of "B" batteries (consisting of seven 45-volt units) and, of course, to a 6-volt storage battery.

The 53 tubes are of the 2.5 volt type, and to simplify the filament circuit of the entire amplifier so that only *one* pair of filament leads are required, the two 53 tubes are wired in series along with a .5-ohm resistor, R14, which reduces the 6.3-volt A.C. or D.C. voltage to the required 5 volts for the two tubes. For the same reason, the 37 and 89 types of tubes are employed, their filaments requiring 6.3 volts A.C. or D.C.

It was an achievement to build this high powered universal operating amplifier onto so amazingly compact a chassis measuring only 19 ins. long (with the mounting flanges), 10 ins. deep, and 3 ins. high. (The auxiliary components mounted above the chassis add another 5¾ ins. to the overall height.) Its total weight, including the input control box, 6-volt D.C. motor generator, and 110-volt A.C. power pack, is but 43¼ lbs.

The 110-volt A.C. power transformer, PT, must have 5% voltage regulation, so that there will be plenty of reserve power to handle the enormous peak currents drawn by the two 53 output tubes. A switch S3 turns this A.C. power pack on and off. Two heavy duty 75 ma. R.F. chokes R.F.C.1 and R.F.C.2 are inserted into each rectifier plate lead; they are used in conjunction with C17 and C18 to eliminate any noise when a radio tuner is used. See Fig. 2B.

For the same reason, R.F.C.3 and R.F.C.4, 15 amp. chokes, together with C19 and C20, are employed with the D.C. motor generator only if a radio tuner is to be used in this P.A. installation. A toggle switch, S2, controls the on-off action of this motor generator. See Fig. 2A.

Another valuable feature of this amplifier is the relatively low plate voltage requirements, which are 320 volts D.C. produced by the motor generator, and, 350 volts A.C. being produced by the power transformer. The latter voltage is rectified by the 83 tube and, in turn, is applied through two heavy "floating chokes," CH1 and CH2, to the remainder of the filter system entirely eliminating any danger of the self-healing, 500-volt electrolytic condensers from ever breaking down.

By employing dual-field dynamic speakers, it is possible to excite their fields from your optional choice of either the 6-volt storage battery or from a suitable 110 volt A.C. exciter.

In the same manner, a 6-volt storage battery operated dual speed (33⅓ and 78 r.p.m.) phonograph motor (consuming only 2.8 amps.) has been especially designed to be used for this amplifier, operating from either (or both) 6-volt D.C. (this can vary from 5 to 7 volts) or from 110 volts A.C. by virtue of a specially designed power source that converts the 110 volts A.C. into 6 volts D.C. at 3.0 amperes!

List of Parts

Two Remington class B input transformers, type T1E665, T1, T2;
Two Remington class B output transformers, type T3E655 with secondary windings of 500, 200, 15, 8, 4 and 2 ohms, T3, T4;
Two Remington filter chokes 30 hy., 200 ohms, 60 ma., CH1, CH2;
One Remington filter choke 30 hy., 500 ohms, 50 ma., CH3;
One CRL 0-500,000 ohm potentiometer, R1;
Two Lynch 10,000 ohm, 1 watt, metallized resistors, R2, R6;
Five Lynch 250,000 ohm, 1 watt, metallized resistors, R3, R4, R5, R7, R8;
Two Lynch 1,000 ohm, 1 watt, metallized resistors, R9, R10;
Two Lynch 50,000 ohm, 1 watt, metallized resistors, R11, R12;
One Lynch 1,500 ohm, 3 watt, metallized resistor, R13;
One 0.5-ohm, 3 watt, wire wound resistor, R14;
One 60 ohm center-tapped resistor, R15;
Two 5 mf., 35 volt, electrolytic condensers, C1, C3;
Two Aerovox 0.02-mf., 400 volt, tubular condensers, C2, C4;

(Continued on page 177)

OPERATING NOTES

(Continued from page 157)

Majestic 20

In this receiver, a Majestic 20, the same trouble of fading of strong local signals was the complaint. The customary tests of the ground, aerial, tubes, and voltages and current readings disclosed nothing out of the ordinary. Inquiries brought out the fact that this set had been repaired once before for the same trouble. Because of the compactness of this set, and because of the necessity of removing the ends of the chassis to get at and unsolder six leads before the bottom pan can be removed, I hesitated a while before undertaking this operation.

Fading of this nature could possibly be due to poor socket contacts. The old reliable plate-circuit break-in adapter was connected to the milliammeter, and then put into service. By jiggling the tubes, one at a time, the trouble was soon discovered to be in the first-detector tube socket. Removing the bottom pan—to the accompaniment of a few unkindly thoughts directed to the awkward design of this particular set—something fell out, which later proved to be part of the detector filament socket spring contact. Whether or not this defect was due to former attempts to rectify the same trouble, is difficult to state; however, the repairs in this case necessitated the installation of a new socket.

Stewart-Warner Series 950

A Stewart-Warner Series 950 emitted an interrupted buzzing noise which continued after the ground and aerial wires had been disconnected. This trouble was quickly remedied by replacing the detector tube with a new 27 tube. The easiest way to determine whether abnormal or excessive hum originates in the detector tube or in the first audio tube is to disconnect the aerial and ground wires; turn on the set and let the tubes warm up; set the volume control on minimum volume position; then remove the detector tube. If abnormal hum still persists, re-insert the tube and remove the first audio tube. If the hum is minimized by this procedure, this tube should be replaced. If it is reduced to normal by removing the detector tube, then this tube should be replaced. Increasing hum with advancing volume control is another sign that the fault is in a defective detector tube.

In another receiver of the same make and model, noisy reception and hum were traced to the two wire-wound resistors, which are mounted on a bakelite strip and covered top and bottom with gray insulating paper. In taking out these resistors, the strip and the insulating papers are generally found to be badly burned, and they cannot be handled without falling into small pieces. In replacing this resistor strip, it is a good idea to mount the strip on two hard rubber bushings, each one about one-inch high, so as to bring this strip up and away from the bottom of the chassis; also, place hard rubber bushings between the strip and the insulating papers in order to give the air a chance to circulate around the resistors. It is important at this time to check over the five colored-carbon-rod resistors which are all mounted on one strip, as you will find that a few of them possibly have changed considerably from the recommended values, especially the 20,000-ohm purple-colored, screen-grid resistor. See Fig. 4.

Another Stewart-Warner receiver had low volume accompanied by sharp, crackling noises. Visual inspection of the receiver and tubes disclosed the fact that the rectifying tube had a deep blue glow. A new tube was substituted with the same result. This clearly indicated that the trouble lay in the power pack. The chassis was removed, and the trouble was traced to a leaky filter condenser in the power pack.

Kolster K28

A Kolster K28 was serviced because of the complaint of a very abnormal hum. On top of the cabinet rested a very beautiful electric table lamp with a high porcelain base. In lifting off the lamp, prior to an inspection, from the top of the cabinet, the abnormal hum ceased immediately. (The lamp *must have been lit!—Editor.)* The cause of the hum was explained to our customer; also suggestions were offered as to a better resting place for the lamp. Our customer, however, insisted that the top of the cabinet was the only place for that particular lamp, and that it was up to me to see to it that the objectionable hum was eliminated. Simple? Yes, very simple in the customers mind; but, unfortunately, I could not at that moment share my customers optimistic viewpoint; however, it really did later turn out to be a very simple little job.

By chance, I took hold of the porcelain base with one hand and, touching the chassis with the other, I noticed that the hum ceased entirely. If the base had been made of metal, I would have thought it to be natural; but this base was made from insulating material! Here, evidently, was the solution of the problem, namely ground the darn thing. I obtained from the customer an old, brass visiting-card tray which, as chance would have it, just fitted the bottom of the lamp base. A wire was connected to the ground post of the set, and the other end of the wire was soldered to the brass tray. It did the trick.

Radiola 33, D.C.

A Radiola 33, D. C. receiver furnished another interesting problem: the complaint in this case was an intermittent, sputtering noise. During inspection, I was informed that the noise was more persistent in the evening than in the day. The dry-cell "C" battery was tested with a low resistance voltmeter, and found to be practically dead. This condition, of course, would lead one to believe that this battery was the source of the noise; but it does not account for the increased noise at night.

The set was removed from the cabinet and all wires inspected for possible loose connections. The four flexible leads connected to the underside of the detector-tube socket terminals were suspected. This socket is of the type known as a "floating socket," and here is where the real trouble was found. One of the flexible filament leads, which at a first glance appeared to be a good soldered connection, was found to be partly broken off, and held only by a few strands of wire to the spring contacts. Replacing with a slightly longer piece of flexible wire cured the trouble. The location of the apartment house and the heavy street traffic at night, accounts for the increased noise at that time.

Clarion A.C. 51

Intermittent reception was the complaint this time. A check with the analyzer disclosed all operating voltages to be practically normal; current readings in the radio-frequency stages seemed to be slightly higher than the recommended values, which pointed to a possible short circuit in these stages. The chassis was pulled out. The green lead at the volume control, which feeds the screen-grid circuit, was unsoldered and the ohmmeter was put into service. Placing one of the testleads to the green wire and the other end to the chassis produced no reading, which eliminated any possible short circuit in these condensers. The red wire, which feeds the cathode circuit, was next unsoldered, and the test repeated. The ohmmeter at this test indicated a partial reading. The leads at the radio-frequency grid bypass condensers were then removed and tested. The ohm meter read the same, indicating a partially shorted grid condenser. A new .1-mf. condenser was substituted and the trouble remedied. See Fig. 5.

Clarion A.C. 70

A peculiar rattle in the speaker is a common complaint on Clarion A.C. 70 model receivers. A Service Man not familiar with this particular model would ordinarily suspect the speaker, and perhaps spend much time in testing it and other components. The real trouble is generally due to the fact that the screen-grid tube is touching the metal shield partition on top of the chassis. Place a few rubber bands around the tube and the rattle will disappear.

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THE RADIO BEGINNER

(Continued from page 161)

will not need the tubes for the present. The set is now operating as an ordinary crystal job, without tube amplification. Tune in, with C1, as many stations as possible and make a careful record of the exact setting of each one. The more carefully and painstakingly you do this part of the job, and the more stations you "log," or record, the easier the rest of the adjustments will be.

Next tune in the most powerful station possible and turn on the tubes, bringing the volume control to its maximum-volume position. Switch the phone plug to the output jack. Varying the contact between the little wire or catwhisker, and the crystal-roller in the second-detector, D2, should now result in scratchy noises in the phones. Adjust this detector so that the wire is *just barely* making contact, and then *slowly* rotate the oscillator condenser, C2, until the same station is heard that was previously heard with the crystal alone.

Adjust condenser C2 to the position of maximum volume; and the second-detector, D2, to its most sensitive position. Then, adjust the two screws, through the holes in the top of the shield can of the intermediate frequency transformer, L3, for maximum volume. This operation varies the capacity of condensers C3, C4, and tunes the transformer to the intermediate frequency of 175,000 cycles, or 175 kc.

If any trouble is had in bringing in the signal, it might be well to adjust these condensers by "feel," turning the screws one way or the other, slowly, until approximately the same *pressure* is required to turn each. But be careful not to run them so far out that the thread comes loose or you might have difficulty getting the adjustment screw back on again.

After you tune in your first signal it is simply a question of varying the adjustments until you get the maximum results from the circuit. If you do this logically and carefully, always making it a point to realize exactly what you are doing each time you turn a knob or screw, you will soon learn a great deal about the most useful and widely-applied circuit known today, the *superheterodyne*.

The reason for making the log of stations with only the crystal will become apparent as you work; for you always know the setting of one tuning dial and have only to find the other.

Design Considerations

The reason for mounting the crystal detectors on the panels is to allow of simplified wiring and interchangeability as one may work better than the other in a given position.

Ganging the two tuning condensers was not attempted for the simple reason that the ganging of an oscillator and R.F. tuning condenser is a rather complicated process, involving the use of what is called a "padding" circuit in the oscillator section to make the two tuning curves "line up." You will see what is meant by this if you plot the curves for the two dials, using dial divisions and frequencies along the two sides of a piece of ordinary "squared" graph paper. Because of the wide capacity-range of the tuning condensers, it was not found *necessary* to modify either the coils or the condensers in order to tune over the entire broadcast band. However, some such procedure (and a tidious, complicated one it is) would be required if it is desired to have the two condenser dials (C1, C2) match.

While it was stated in the beginning of this article that the super was the most sensitive and selective circuit available, do not on this account expect too much of this little set; it was designed primarily to demonstrate the principle of operation, not to be a world beater in picking up stations. In fact, if you live in a particularly poor radio location it might be advisable to add a *second* stage of audio frequency amplification; the circuit following the second-detector will be exactly similar to that shown in the beginners' article in the July issue. And if you are real ambitions, you can also add an R.F. stage as shown in the August issue. If you have followed the series through carefully and intelligently you should be able to do both of these stunts with little trouble.

Below is given a complete list of the parts required; those of you that have followed the series, have most of them. Winding data has been given in previous issues for the two R.F. coils, L1, L2; it is not recommended that you attempt to wind the "intermediates," L3, since this is a job requiring considerable skill and experience. Of course, if you happen to have in the junk box one of the old-fashion type peaked at 30 k.c. or 45 k.c., they will be perfectly satisfactory for this set.

List of Parts

One two-circuit tuner, L1;
One three-circuit tuner, L2;
One 175 kc. intermediate frequency transformer, L3;
Two 350 mmf. tuning condensers, C1, C2;
One mica dielectric fixed condenser, 500 mmf., C5;
Two Concourse paper dielectric condensers, .5-mf., 200 V., C6, V7;
One Concourse paper dielectric condenser, 4 mf., 200 V., C8;
One Concourse dry electrolytic condenser, 20 mf., 25 V., C9;
One Centralab 25,000 ohm volume control, with switch attached, R1-Sw.;
One 10,000 ohm, ½-watt resistor, R2;
One 5,000 ohm, 1 watt resistor, R3;
One Amperite filament ballast, type 3H-1, R4;
One 750 ohm, ½-watt resistor, R5;
One type 30 tube, V1;
One type 33 tube, V2;
One four-prong socket, for V1;
One five-prong socket, for V2;
One single-closed-circuit jack, J1;
One open-circuit jack, J2;
Two crystal detectors, D1, D2;
Two dials, for C1, C2;
One knob, for L2 (tickler);
Two clips for Ant. and Gnd.;
One baseboard, 10 x 14 x ¾ in. thick;
One roll solid push-back hook-up wire;
Three 45 V. batteries, "B";
One 2 V. storage cell, "A."

AN ALL-PURPOSE TESTER

(Continued from page 149)

matically provided. The chief advantage claimed for 100% modulation is that the maximum output is obtained from a radio set at a given input. An unmodulated R.F. signal potential, when applied to a set, will produce no audio output, although the input signal may be strong enough to overload the R.F. or detector elements of a receiver. This fact is evidenced by connecting an output meter to a set which is responding to the signals of a broadcast station; the meter needle will respond to the modulation signals of music or voice, but returns to zero during the intervals between voice or musical impulses, although the carrier energy is just as strong between signals as it is during modulation. With a 100% modulated oscillator, the radioman is much less likely to set the attenuation at a point which will overload the R.F. or detector circuits of a set when erroneous adjustments are likely to result.

Furthermore, most modern broadcasting stations are 100% modulated, and it is logical to conclude that oscillators which are miniature substitutes for broadcast stations should also be 100% modulated. A special stabilized circuit was developed over a period of several months for this oscillator for keeping the frequency constant with varying attenuation and varying power supply potentials. Other circuits with various technical names, using from one to four tubes, have been developed to accomplish such desirable stabilization, but none of these seem to offer any advantages over the present arrangement which has proven entirely satisfactory for practical radio servicing requirements.

All of the controls and parts of this tester are symmetrically arranged on a bakelite panel which measures 11½x19⅝ inches. The panel is mounted in a beautifully-finished hardwood carrying case with a slip-hinged cover in which a commodious compartment is provided for the accessories which accompany the tester, and for such small tools as the radioman may want to use with the tester.

A 50-WATT TRANSMITTER

(Continued from page 151)

power amplifier circuits, improved operation has been effected so that the correct phase relationship of the various frequencies is maintained. It is even more important that the amplification be essentially linear so that harmonic frequencies are not generated to an appreciable extent. This is accomplished by the use of improved transformers, balanced push-pull circuit and over conservative use of tubes which are only called upon to deliver a fractional part of their maximum output power.

The radio frequency (carrier) for the transmitter is obtained from one of two crystal-controlled oscillators. The frequency is determined by a specially ground quartz crystal which is mounted in a compensating holder. This device is mounted in a thermally insulated compartment in which the temperature is maintained relatively constant at a predetermined value. Both crystal oscillators are operated continuously day and night so that they are instantly available for use. The highest degree of frequency stability is thereby attained. This is important from the listeners' standpoint, since it provides the maximum assurance that interference with other high class stations will not be experienced.

The radio frequency carrier is further amplified by screen grid tubes until it is at an approximately similar voltage level to the output of the push-pull audio power amplifier. These currents are then combined or modulated at a comparatively low power level, in a radio amplifier unit rated at 250 watts output. Here, again, design improvements have been made to assure that the carrier will be properly moulded and controlled by the audio signal current so that the fidelity and phase relationship will not be changed.

The combined radio and audio currents are further amplified by two push-pull radio frequency stages rated 5 kw and 50 kw output respectively. Each of these stages requires the use of tubes whose maximum power output is more than four times the rating given above, in order that the combined currents may be amplified with a minimum of distortion.

From the 50 kw. (maximum rating over 200 kw.) stage the combined currents are sent to the antenna over a new type three wire transmission line. The combined currents are then radiated or "broadcast" so that they become available to the Radio audience.

In order that the operators may have proper control of this entire process, it is essential that means be made available whereby the functioning of the various parts of the transmitting equipment may be readily checked. The remote control room is equipped with special monitoring loud speakers which may be connected at various points in the circuit for direct quality checking by ear. Volume controls are used for maintaining the audio currents within predetermined limits. Two different types of modulation indicating devices are supplied for checking the modulating or combining process. One of these is an oscillograph of special design by means of which either visual observation or permanent recording of the combined currents may be made. A careful log is kept of the visual indications of this device at regular intervals. The second device is called a modulation alarm indicator. This device indicates the degree of modulation by means of a conventional meter. It is also equipped with an automatic alarm mechanism so that when a predetermined degree of modulation is exceeded it is immediately called to the operator's attention by an alarm buzzer. Such elaborate precautions may seem superfluous, but recent tests have shown that excessive distortion of signals results if the modulation is allowed to exceed 100%. Under such conditions an additional range of audio frequencies is produced which not only cause a loss of efficiency but which may cause interference in adjacent channels due to the increased width of sidebands.

Frequency monitoring is accomplished at the transmitter by means of a visual indicating meter which is designed to maintain an accuracy of plus or minus 10 cycles. Thus frequent checks may be obtained on the operating frequency and such checks may be entered on the operating log sheet.

The antenna current will be measured at the transmitter by means of a special rectifying circuit. This gives the operator a final check on the power in the antenna. An automatic signalling device is included which sounds an alarm in case the antenna current drops below a predetermined value.

OPERATING NOTES

(Continued from page 172)

A puzzling phenomenon was that of an Apex 28A, series 31. The set would play for about ten or fifteen minutes, and then stop. Turning the switch off and on would produce reception for perhaps another ten or fifteen minutes until it stopped again. Visual inspection of the set disclosed the fact that each time this thing happened, the brightness of the filaments in all tubes would grow dimmer, and then would go out entirely. The A.C. cord, the off and on switch, and the primary of the power transformer were all given a careful continuity test; but all appeared normal.

After going over the chassis and pulling wires for possible shorts or loose connections, nothing was disclosed. The A.C. toggle switch was strongly suspected, and it was decided to remove it for closer inspection. When inspecting this switch, it was discovered that the brown bakelite housing, which covers the lever and spring contacts, was cracked in several places. This condition evidently partly released the hold on the spring contacts which, in turn, made it possible for them to gradually slip down until they became disengaged from the lever. Moving the toggle switch up and down evidently brought them back temporarily, only to drop down again after a short interval of time. A new switch solved this problem.

Low record reproduction in some models, particularly in the General Motors radio and phonograph combinations, can often be traced to broken connections between the tone compensator and the volume control. This tone compensator is hard to get at for testing purposes, as it is located underneath the motor board, close to the volume control. It is wound with very fine wire and the ends are soldered directly to the terminals on the volume control. In almost every case the reason for the broken leads is that the volume control worked loose, and one little turn of the volume control knob would be sufficient to break off the wires. It is advisable, therefore, when confronted with trouble of this nature, to always inspect these leads, even though you may find that the volume control is tight.

It is obvious, of course, that when the leads are found broken, it is only necessary to unwind a few turns and then resolder them to the proper terminals on the volume control. When repair work of this nature happens, it is desirable to replace the ring nut on the volume control with a thin hexagon nut and spring washer, so as to preclude the possibility of a non-remunerative call-back in the near future.

READERS' PAGE

(Continued from page 169)

ZENITH 460—(A correction)

Editor, RADIO-CRAFT:

In the June, 1933, "automotive issue" of RADIO-CRAFT there appears a slight error in the sensitivity rating of the Zenith model 460 automobile receiver. The sensitivity rating is 1.5 microvolts (R.M.A. standard input required to give an output of 50 milliwatts) or 0.4-microvolt-per-meter, instead of 1.5 microvolts-per-meter as you have listed. We will appreciate the publication of this correction.

We feel that the publication of automobile receiver data and schematic diagrams is a real boon to the Service Man. We also believe that every manufacturer of automobile receivers should give the Service Man special consideration in the layout and design of his set. The compact construction of modern receivers makes this feature doubly important.

MARVIN HOBBS, Engineer,
Automotive Receiver Section,
Zenith Radio Corp.

NEW ADAPTERS

(Continued from page 153)

No. 964KS, Fig. 10, is used to test the 57 and 58 tubes. The tube tester with which this adapter is used must have a common connection of the control-grid and screen-grid circuits. The adapter is placed in the 45 socket and the tube in adapter. Tests are then made in the same way that you would test a 45 tube.

Testing Power Tubes

No. 965-79, Fig. 11, is used to test the two sections of a 79 tube in the 37 socket of tube testers. This is an elongated adapter, having a toggle switch and a control-grid lead. Place the 79 tube in the adapter and the adapter in the 37 tube socket of tester. Attach the adapter control-grid lead to the control-grid of the tube. Then test the 79 tube in the same way that you would test a 37. However, be sure to use the toggle switch so that both sections of the tube are tested.

No. 964KPPL, Fig. 12, is used to test the 79 tube in the 10 or 50 sockets of tube testers. To use the adapter, place it in the 10 or 50 socket of the tube tester. Then place tube in adapter and connect the control-grid lead on adapter to control-grid of tube and test as if you were testing a 10 or 50 type tube.

No. 964PP, Fig. 13, is used to test the 19 tube. It tests both sections together. Place adapter in the 30 or 31 socket of any tube tester. Then place the 19 tube in the adapter and test the tube as if you were testing a 30 or 31 type.

No. 975-53, Fig. 14, is used to test the 53 tube in any tube tester. Either section of the tube can be tested by manipulating the switch on the side of the adapter. The adapter is placed in the 27 socket and tests made in the usual way.

No. 975GP, Fg. 15, is used to test both sections of the 53 tube at the same time. The adapter is placed in the 27 socket of any tube tester. The 53 tube is then inserted in adapter and tests made in the usual way.

No. 975KSP, Fig. 16, tests the 59 or other similar seven-prong tubes in any tube tester which has provision for testing the 47 tube. Simply insert adapter in the regular 47 socket and then insert 59 tube in adapter and test as if you were testing a 47.

No. 965AC, Fig. 17, is used to test the 43 or 48 tube in the 27 socket of any tube tester. To test the 43 tube, use a 40 W., 115 V. lamp in the series socket. Place the 43 tube in the six-hole adapter. Then place adapter in the 27 socket of tester. To test the 48 tube, use a 60 W., 115 V. lamp in the series socket and place the 48 tube in the six-hole adapter. Then place adapter in the 27 socket of tube tester. If little or no plate current reading is noted, then the tube is defective and another one should be used in its place.

Rectifiers

No. 964KKH, Fig. 18, is used to test the 25Z5 tube. The tube is placed in the full-wave rectifier socket or the one usually used to test the 80, 82 or 83 type tube. Tests are then made in the same way that the full-wave rectifier tube is tested. This adapter can also be used with any other type of tube tester having provisions to measure the plate current of both plates of the rectifier tube, and providing 25 V. at the filament terminals.

No. 966PP, Fig. 19, is used to test the 25Z5 tube in a 43 socket. Place adapter in the 43 socket and test as if you were testing a 43 tube. However, be sure and manipulate the switch on the side of the adapter so as to test both plates of the tube.

No. 964-6Z5, Fig. 20, is used to test the 6Z5 tube in the 80 socket of any tube checker. Place adapter in 80 socket and then tube in adapter and test in the same way that an 80 tube is tested.

No. 965-6Z5, Fig. 21, is used to test, separately, both plates of the 6Z5 tubes. The adapter is placed in the socket usually used to test the 37 tube. It is then tested in the same way that a 37 is tested with the exception that the switch provided on the side of the adapter must be manipulated to test both sections of the tube.

No. 955-84, Fig. 22, is used to test the 84 tube. Place the adapter in the 37 socket and test as if you were testing an 80 tube. However, be sure and manipulate the switch on the side of the adapter so as to test both sections of the tube.

A DECADE CONDENSER

(Continued from page 163)

5	.4+.1	.5
6	.4+.2	.6
7	.4+.3	.7
8	.4+.3+.1	.8
9	.4+.3+.2	.9

The above example is for the third section of a .1 to .9 unit. It is seen that by adding units in parallel, each unit having a capacity of .1 of that of the next, the range may be extended to that desired.

There are several possible switching arrangements for the condenser. One of these makes use of a four-pole, ten point tap switch. The switch is rather expensive, however, so that for the benefit of those who desire to build their own switches, a cam switch will be described which can be built at quite a low cost.

Figure 1A shows the connections of *one* unit of a decade condenser using the four pole tap switch. Any number of consecutive units may be added in parallel. Figure 1B gives the connections for a complete decade condenser, using cam switches, which covers the range from .001 mf. to .999 mf.

The construction and dimensions of a cam switch are shown in Fig. 2. The cams are cut from 1/16" sheet metal. A convenient method of construction is, first, to cut out round metal washers and then remove the unwanted center sections. If a three unit box is desired, three cams *of a kind* will be required for each unit: or, a total of four cams for each unit. It is advantageous to clamp three washers at a time on a ¼-inch threaded rod (since, for each unit, three are alike) and cut all three at once. Instead of trying to mark the cams directly on the metal, it is suggested that round paper discs of the same diameter and divided into ten equal sections should be glued to the ends of the stacks of washers. Then the sections to be removed can be marked and cut out with the aid of a hack saw and file. Notches should be cut in the cams as shown in Fig. 3 to provide locking at each position.

When completed, the cams may be assembled on ¼-inch rods with ⅜-inch spacers between. Care should be taken to have like numbered segments in line.

There are two methods of fastening the cams to the shaft. One method is to use a threaded rod and clamp the washers (cams) together with a nut at each end. This method is shown in the drawing, Fig. 2. The other method is to clean all parts before assembling, and then, after they are put together on a ¼-inch rod, the whole assembly is heated with a torch and solder flowed into all the joints. This method was used in the switch pictured in Fig. B.

The frame is cut from 1/16-inch sheet metal and bent into the shape, as shown. It has a ¼-inch hole at one end to serve as a bearing for the shaft. The other end has a threaded bushing which serves the double purpose of a bearing for the shaft and a single-hole mounting for the unit.

The contact springs are obtained from phone jacks or switches; or, in the absence of such material, they may be cut from spring brass.

The condensers of the lower capacities should be of the molded mica variety, and may be stacked and bolted to the under-side of the frame. The higher capacities can be of the tubular paper insulated type, and they, also, should be clamped to the frame. All of the condensers should be of non-inductive construction.

A bakelite panel should be provided. The numbers 0 to 9 for each switch may be stamped on the bakelite; or switch plates, with the numbers on them, may be used. A number corresponding to the lowest capacity setting of that individual unit should be placed under each switch. Thus, a box such as pictured in Fig. A would be stamped with .1, .01, .001 mf. sections.

Parts List for .001 to .999 Mf. Condenser

Three four-gang 10 point switches (if used);
One Aerovox fixed condenser, type 1455, .001-mf.;
One Aerovox fixed condenser, type 1455, .002-mf.;
One Aerovox fixed condenser, type 1455, .003-mf.;
One Aerovox fixed condenser, type 1455, .004-mf.;
One Acratest tubular condenser, .01-mf.;
One Acratest tubular condenser, .02-mf.;
One Acratest tubular condenser, .03-mf.;
One Acratest tubular condenser, .04-mf.;
One Acratest tubular condenser, .1-mf.;
One Acratest tubular condenser, .2-mf.;
One Acratest tubular condenser, .3-mf.;
One Acratest tubular condenser, .4-mf.;
Three knobs;
Two binding posts;
One bakelite panel 4x11x$\frac{3}{16}$ inches;
One cabinet 4x11x4 inches;
Miscellaneous sheet metal, machine screws, and jack springs.

AN "R" AND "C" CHART

(Continued from page 164)

We will now take a few examples to illustrate the method of using the chart in solving practical problems of resistors in parallel or condensers in series.

Example 1.—Three condensers of .0003, .0004, and .0005 mf., respectively, are connected in series; what is their resultant capacity?

From the chart we see that the corresponding value of .0003 *on line A* is 3,330 *on line B;* the value on line B for .0004 is 2,500; the value on line B for .0005 is 2,000. Adding together all the B values we get 3,330+2,500+2,000=7,830. At 7830 *on B* we get the answer: .000128 *on line A.*

Example 2.—Find the value of the following four resistors in parallel: R1, 500 ohms; R2, 650 ohms; R3, 800 ohms; R4, 1,000 ohms. The corresponding values of R1, R2, R3, and R4 on scale A are .002, .00155, .00125, and .001, respectively. The sum of these figures is equal to .0058. The corresponding value for .0058 on scale A gives 172, which is the resultant resistance of the four resistors in parallel.

Example 3.—Find the value of the following resistors in parallel: R1, 500,000 ohms; R2, 200,000 ohms; R3, 20,000 ohms. Following the procedure of the first two examples, we find that the corresponding values on the A scale of the resistors connected in parallel are, .000002, .000005, and .00005. Their sum is .000057. The value for .000057 on scale B is 17,500, which is the answer.

The procedure, which is the same for all other problems, is as follows: step No. 1, find the corresponding values of the known resistors connected in parallel or the corresponding values of the known condensers connected in series. Using a pencil and paper, write down each corresponding number found on the chart for each resistor or condenser; step No. 2 add these numbers to get their total; step No. 3, using this new number, which is the sum of the reciprocals of the resistors in parallel or condensers in series, look for its corresponding number on the A scale of the chart. The corresponding number is the final answer.

Observe that all numbers from 1 to 1,000,000 are read from left to right and all numbers less than one—the decimal numbers—are read from right to left. This may be a little difficult to work with at first, especially to those who are not acquainted with the use of a slide rule, but after working out a few problems the reader should have no difficulty in using the chart.

The chart, as the reader can readily see, is nothing more than a table of reciprocals so arranged that it becomes a valuable instrument in solving problems of the type described in this article. It can also be used, however, in other types of problems where it is required to find the values of the reciprocals of certain numbers.

(While charts of this type are not suited to uses which require absolute accuracy, they are satisfactory for most practical purposes. In this respect they are great time-savers. The reader is referred to the following articles in RADIO-CRAFT for additional "chart" information. "Tube Characteristics at a Glance," August, 1932, page 128A. "Tube Data Chart," February, 1933, pg. 512B. "Parallel Resistors," March, 1933, pg. 552. As additional reference material of this nature becomes available it will be published. *Technical Editor.)*

A 26-W. AMPLIFIER

(Continued from page 171)

Two 10 mf., 35 volt, electrolytic condensers, C5, C6;

Four Aerovox 0.00035-mf., mica condensers, C7, C8, C9, C10;

One triple 4 mf. 500-volt electrolytic condenser, C11, C12, C13;

One triple 8 mf. 500-volt electrolytic condenser, C14, C15, C16;

One two foot four-wire cable and five prong plug, P1;

One Remington Power transformer 350-350 volts, 120 ma., D.C., 5 volts 3 amps., 6.3 volts, 3.5 amps., PT;

Two Remington heavy duty R.F. chokes, 15 mh., 75 ma., 20 ohms, R.F.C.1, R.F.C.2;

Two Remington 15 amps. R.F. chokes, 15 mh., 1—1,000 ohms, R.F.C.3, R.F.C.4;

Two Aerovox .00035-mf. 600 volt mica condensers, C17, C18;

Two 8 mf. 35 volt non-polarized electrolytic condensers, C19, C20;

One Coast-to-Coast 6-volt motor generator having class B regulation and delivering 120 ma. at 320 volts, M.G.;

One 2 amp. fuse and mount, F;

One Coast-to-Coast amplifier portable leather case, 19¾" lg., 15¼" wd., 10" hg.;

Two Coast-to-Coast dual-field speakers;

Two Coast-to-Coast 110-volt A.C. exciters for above speakers;

One Coast-to-Coast cadmium-plated base, 18" long, 10" wide, 3" high, drilled, and 2 cans;

Two Coast-to-Coast speaker portable leather cases (with celotex baffles);

One Coast-to-Coast phonograph portable leather case;

One Coast-to-Coast 6-volt D.C. dual-speed phono motor and 12-in. turntable;

One Coast-to-Coast 110 volt A.C. exciter for above phono motor;

One dual speed phono pickup;

One Coast-to-Coast 7-tube 6 volt D.C. and 110-volt A.C. operated superheterodyne tuner;

One Coast-to-Coast portable case for above;

One Coast-to-Coast universal "microphone-phono-radio" meter equipped Input Control mixer box.

MODERNIZING

(Continued from page 165)

grids; this makes it possible to use only one 22½ V. "C" battery, provided it has a 3-V. tap.

Operation

The finished job, after the R.F. compensating condensers have been re-adjusted and the stages properly aligned, has exceptional distance-getting ability, excellent tone quality, and will handle enough volume without distortion for ordinary home requirements. The total drain on the "B" battery is less than 20 ma., at full volume—less than one-half that of the set using 71A's. The "A" battery drain, is, of course, only a fraction of the original—560 ma., well under the maximum allowable for an air cell.

In the sets which we have converted we have had no trouble with circuit oscillation, although with the volume control fully advanced a swish is heard as a carrier is approached. Tuning is very sharp. One of these modernized sets which has been in operation for eight months is still using the same set of "A" and "B" batteries. When tested last week, the "B" batteries registered 39 V. under load, although the owner uses the receiver about five hours per day.

Dealers, who trade in battery sets will find it profitable to modernize the "70-Q." Its value is increased considerably, and considering that usually a new set of tubes is installed when the set is sold second-hand, the cost is negligible.

REMEMBER—
Radio Progress Week
October 2 to 7
(See page 141)

INFORMATION

(Continued from page 168)

are of high-resistance type; these are quite suitable as choke coils in the filter circuit of receiver power packs. Other field coils are of low-resistance design—5 to 15 ohms (the field coil of the "Motor Majestic" model 110 receiver illustrated by diagram in the August, 1932 issue of RADIO-CRAFT, pg. 106, for example, has a resistance of only 6 ohms); they usually connect directly to a low-voltage source, such as a storage battery.

Schematic circuits of three differing types of exciter units are illustrated at A, B and C in Fig. Q. 215.

At A are shown the connections used in the Amplion model AC 210 exciter; and, at B, the model EL 22 exciter. A better known instrument, the Wright-DeCoster model PA-20 exciter, is shown at C.

The first two exciters are designed to supply power to as many as four, low-resistance field coils. The latter is designed to deliver power to several high-resistance field coils, and will deliver 25 W. to a 2,500 ohm load.

THE AMPERE AND THE OHM

The following interesting information has recently been published by the Bureau of Standards.

Absolute Determination of the Ampere

The value of the ampere has been determined in absolute units at the Bureau, using a current balance, in which the force between coils carrying a current is measured. The current balance originally used by Rosa, Dorsey, and Miller was employed, but the apparatus has been modified in many important respects.

Four sets of coils were used. The important constant in the computation of the current from the force between the coils is the ratio of their radii. Eight experimental determinations of these ratios have been made giving results which are self-checking and which show no errors larger than ± 6 parts in 1,000,000. Four series of determinations of the force give results in which the average deviation from the mean is about ± 3 parts in 100,000. The results may be expressed as

1 Bureau of Standards International Ampere = 0.99994 Absolute Ampere.

A report of this work was made at a meeting of the American Physical Society in Washington, and will be published later in the Bureau of Standards Journal of Research.

Absolute Determination of the Ohm

A determination of the ohm in terms of the units of length and time has been made at the Bureau. The method depends on the measurement of a self-inductance in terms of time and the present unit of resistance, and on the computation of the inductance from measurements of the dimensions of the inductor.

Three single-layer solenoids were measured. They were constructed with such care that the inductance can be computed from the measured dimensions with an error of only a few parts in a million. The measured inductance can be measured in terms of resistance and time with about the same accuracy. The result is expressed as

1 Bureau of Standards International Ohm = 1.00045_5 Absolute Ohms.

This result was presented at a meeting of the American Physical Society.

RADIO-DOCTOR, SURGEON

In a past issue of Amateur Wireless (London), we note the following interesting use of telephotography. An Argentinian visitor to Berlin, finding that his eye, which had been troubling him for some time, was rapidly becoming worse, had his eye photographed and the picture was sent by telephotography to the family physician in Buenos Aires. It was received there in 8 minutes, via the Atlantic picture telegraph service, where it was reproduced very clearly, examined by the doctor, and treatment recommended in a short time by radio telegraphy.

ARC THEORY—
WITH PARTICULAR REFERENCE TO THE NEW "IGNITRON" TUBE**

Joseph Slepian* and L. R. Ludwig*

FOREWORD

Dr. Joseph Slepian and Leon R. Ludwig of the Westinghouse Research laboratories have developed a revolutionary method of controlling mercury-arc devices which is more positive and many times faster in action than methods now in use. The arc can be started 60 times a second at any point on the voltage wave, and since there is no grid to be protected from heating, but merely a carborundum-pencil dipping in the mercury pool, large currents can be controlled just as easily as small ones. The small laboratory specimen of the new "Ignitron" tube illustrated, will carry 60 amperes at 185 volts D.C. with only 0.15 average amperes and 30 watts loss in the control element ("igniter").

THE secret of the Slepian-Ludwig control lies in a high-resistance rod, partly immersed in the mercury pool, which when energized starts an arc cathode. For an ⅛" resistor rod dipping ¼" below the surface of the mercury, tests showed the minimum voltage for starting the arc was about 130 volts; a sudden application of 250 volts started the arc in less than 5 microseconds. During tests the starter worked equally well in solidified tin, proving that its operation is independent of the degree of immersion of the rod and that it does not depend upon an actual breaking of contact with the mercury. Based on careful experiments, the extraordinary performance of the "igniter" is believed to be due to conditions at the rod-mercury junction which is found similar to the last contact point of separating contacts.

Sidestepping the baffling problems of grid control for heavy currents in a single leap, "Ignitrons" give eventual promise of radical improvements in control methods in industry and central stations.

(Exactly "how" this new instrument functions is a story that involves deep theory, and one which is presented to those readers of RADIO-CRAFT who want to follow the step-by-step development of technical devices. *Technical Editor.*)

Types of Arcs

The specific form of electrical discharge in gasses which we know as the electric arc is a most essential and useful element in many types of engineering apparatus and in many applications. Its utility in arc lamps, arc rectifiers, arc welders, lightning arresters and spark gaps is generally known. Even in electrical switches, perhaps contrary to popular impression, it plays a useful and desirable role. Sometimes, also, it presents itself in an unwelcome way as in "sparks" on commutators, backfires or arc-backs in rectifiers, "flash arcs" in radio power tubes, etc. *Where the arc is useful, it owes its utility to its ability to carry large currents at a low voltage to a degree incomparably greater than that of other forms of discharge such as glows.* Townsend discharges, cathode rays, positive-ion

*Research Laboratories, Westinghouse Electric & Manufacturing Company.

**Presented before the Winter Convention of the A.I.E.E., January 23-27, 1933. New York City

An "Ignitron" control tube, left; and, right, the pencil of lead dipping into a pool of mercury.

currents, etc., and where the arc is an undesired intruder, it is unwelcome because of this same capacity unique among discharges for carrying large currents at a low voltage. For example, if the "sparks" on commutators only existed as glows, commutation would be a very eas problem, and if the "back currents" to the anodes always remained only in the form of glows as positive ion currents, backfire limits on mercury arc rectifiers would not exist.

The origin or seat of this great capacity to carry large current at low voltage which is enjoyed by the arc resides quite definitely at the cathode, where with a drop of only ten or twenty volts, thousands of amperes per cm^2 are carried. In fact it is only at the cathode that the arc differs essentially from the glow for which the cathode drop is usually several hundred volts, and the current density even at atmospheric pressure is only about ten amperes per cm^2. The problem of the formation of an arc, as distinguished from a glow or Townsend or other discharge, then reduces to a study of the cathode of an arc, and the circumstances which cause an *arc cathode* rather than a *glow cathode* to form.

Theories of Cathode of an Arc

Since gases are normally insulating, the maintaining of a discharge requires the presence of ionizing agents. In the gas itself, ionization by collision with molecules of electrons accelerated by the electric field, seems to be adequate to account for the observed conductivities, at least at low gas pressures. At high gas pressures, of the order of atmospheric, thermal ionization of the gas seems to play a part, and with gradients of ten volts per cm. or so, and current densities of hundreds of amperes per cm.^{2} as are found in arcs, the energy input into the gas is sufficient to raise it to a temperature where thermal ionization plays a part, and actually high enough temperatures are observed.

The current to the anode is carried by electrons, and since the gas already contains free electrons sufficient in number to carry the current with a low gradient the anode introduces no special problem. The anode drop will generally not exceed the ionizing potential of the gas, since with such a drop ionization by collision in the gas next to the anode will take place with sufficient intensity to insure a sufficiency of electrons to carry the current to the anode with enough positive ions to neutralize any excessive space charge.

The cathode, however, does present a problem. The electrons are moved away from the cathode, and the whole current must be carried either by electrons liberated from the cathode or by positive ions from the gas. If the current density is very small, the latter alternative is sufficient and is probably the mechanism of the Townsend or dark discharge occurring at high gradients, just below the sparking potential for the electrode configuration in the gas. The ionization of the gas near the cathode is produced principally by ionization by collision with gas molecules or positive ions.

As the current density in the Townsend discharge is increased, the space charge of positive ions near the cathode causes an increase in the gradient there, and finally electrons are set free from the cathode by impact of positive ions or excited atoms. The essential character of the discharge is not changed, however, and the setting free of electrons from the cathode by such impacts may well be included in the general term "ionization by collision." If there is no other source of ionization than ionization by collision as thus generalized, increase in current density will change the Townsend discharge continuously into the glow with a minimum drop at the cathode of several hundred volts, and with a current density, at this minimum, of about ten amperes per cm.^{2} at atmospheric pressure and varying as the square of the pressure. Increasing the current density above this figure raises the cathode drop.

Ionization by collision alone then can account only for low current density discharges requiring at least hundreds of volts. For an arc cathode to occur, some new ionizing agent must make its appearance. The search for what this new ionizing agent may be forms an interesting chapter in electrophysics.

The first theory was that thermionic emission at the cathode is this new ionizing agent. In most types of arcs the cathode is at a high temperature, and for some arcs, certainly at a temperature high enough for glows in times which are too short for the cathode to heat up. Other ionizing agents are necessary for these nonthermionic arcs. Note, however, that for these thermionic arcs a considerable energy input is necessary to bring the cathode up to the necessary temperature so that such an arc cannot be formed from a glow in a short time.

Another theory, and one which is widely accepted, is that in the arc a very high positive ion space charge density adjacent to the cathode produces so intense an electric field there that electrons in sufficient number are pulled out from the cathode. To form so intense a space charge, however, calls for a current density of several thousand amperes per cm.^{2} so that according to this theory such current densities are necessary before an arc cathode can be formed.

Still another theory is that very intense thermal ionization in the gas layer immediately adjacent to the cathode supplies sufficient positive ions to carry the current to the cathode. Here again, because of the large heat loss from this hot gas layer to the cold cathode, a considerable current density is necessary.

We see that according to all these theories a considerable energy input density or current density at the cathode is a prerequisite for the formation of an arc cathode.

Methods for Initiation of an Arc Cathode

The problem with which the authors have been concerned, and whose solution forms the subject of this paper was the frequent repeated initiation of an arc cathode upon a cold electrode within a very short and precisely placed time interval, less than a thousandth of a second and in gases at low pressures. It is well to consider the known methods of arc cathode initiation to see how closely they come to meeting the requirements of this problem.

(1) The Thermionic Cathode. The method of using a cathode with a separate source of energy to bring it up to a temperature sufficient for thermionic emission is regularly used in hot "filament" gas filled tubes. However, if the "filament" is to be of reasonable size, and the separate source of energy not excessively large,

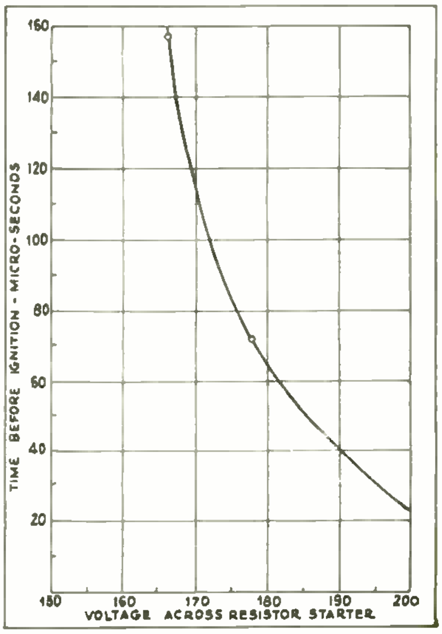

Fig. 1
A voltage—arcing curve.

the filament cannot be brought up to the necessary temperature in the required small time.

(2) Separating Contacts. When metallic contacts are separated in circuits carrying an ampere or more, an arc is formed at once. Several theories have been advanced as to the way in which the arc cathode is formed there. These theories depend upon the great concentration of the current and intensification of the electric field at the last contact point of the separating electrodes. Killian observes that the electric gradient will be high enough for electrons to be drawn from the cathode, and Slepian points out that the energy input into the last contact point will be great enough to thermally explode it into a vapor so highly ionized as to supply sufficient current density for the maintenance of an arc.

Although this method is widely used in switches, arc lamps, welders, and for starting of mercury arc rectifiers, the mechanical inertia of the separating contacts makes this method impractical for solving the problem set by the authors.

(3) The Blowing Fuse. Closely related to the method of separating contacts is the blowing of a fuse wire. The starting of the arc may be by the intense electric field at the first separating points of the vaporizing fuse following Killian, but with the rapidly blown fuse the experiments of Anderson which show the existence of almost completely thermally ionized vapor make Slepian's theory more plausible.

By using a fuse wire or film, the quick and accurate starting of the arc can be accomplished. The requirement of quick and frequent repetition of the starting operation, however, introduces difficulties. One possibility is the quick formation and re-formation of a conducting film upon an insulating surface by condensation from a metal vapor, and the authors have had some success in this way, but the method which is described later is believed to be better.

(4) Spontaneous Transition from Glow to Arc. A glow between electrodes may be readily and quickly started by the application of sufficient voltage. In many circumstances the glow cathode will change spontaneously into an arc cathode. For example, if the energy density at the cathode is large enough, the cathode will heat up, and may reach a temperature for sufficient thermionic emission to permit the change to an arc cathode. But at low gas pressures, since the glow current density is very low, such heating cannot occur, and at high gas pressures, the heating is still too slow to solve the problem of the rapid and repeated initiation of the arc cathods required by the authors.

Nevertheless, sudden and rapid transitions to the arc form of cathode do occur in actual glows even at low gas pressures. The causes of such transitions are not well understood, and the prevention of such occurrences is the fundamental problem of mercury arc rectifiers and similar devices. Researches of the authors and others indicate that these causes are spontaneous and randomly occurring agents lasting individually for only some few millionths of a second, and which somehow cause a sufficiently high current density to appear at some point of the cathode for maintaining an arc cathode. The average frequency of occurrence of such causes varies in a direct manner with the current density and voltage of the glow. At low gas pressures, where the glow current density is very

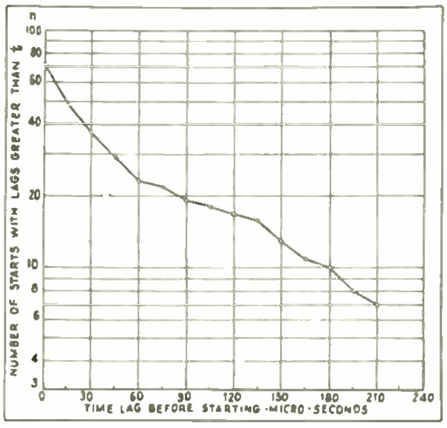

Fig. 2
Times distribution at one voltage.

small, the average frequency of occurrence of these causes is too small for the solution of the authors' problem to be found in this way. Only at high pressures, about atmospheric, is the frequency of occurrence of these causes great enough to give certainty that an arc cathode will form within a few thousandths of a second.

(5) The Electric Spark. This method really is a form of transition from glow to arc and might have been discussed in (4), but it deserves a special place because it deals with a transient form of glow cathode which is particularly effective in initiating an arc cathode at high gas pressures. The spark is initiated by high voltage breakdown between spaced electrodes and since the only ionizing agent at the cathode is ionization by collision, we must describe the cathode condition as a *glow*. The characterizing feature of the spark is the very rapid growth of the current sent through the discharge. Since the glow cathode which initially covers only a small area spreads rather slowly, a very high current density may be built up momentarily in the glow cathode. It is conceivable that a sufficiently high current density may be reached in the glow itself to permit an arc cathode, but it is more probable that in this high current density the frequency of occurrence of spontaneous transition causes becomes sufficiently great to insure the prompt initiation of an arc cathode.

At low gas pressures, even with high applied voltages from sources capable of giving a rapid rate of increase of current, the current density in the glow cathode remains low and an arc is not struck. Generally, one would say that a "spark" does not form at low gas pressures.

(6) The High Frequency Discharge. This method is closely related to the methods described in (4) and (5). A discharge is started between spaced electrodes by application of sufficient voltage of high frequency. Again, since the only ionizing agent is ionization by collision, the condition at the momentary cathode must be described as a glow. However, in the high frequency glow the current density may be very large compared to that at the cathode of a steady or low frequency glow. In the steady glow the current density at the cathode is limited by the space charge of the positive ions. But in the high frequency glow such space charges do not have time to form. Thus high density positive ion currents will flow in alternate half cycles and with such high current density the frequency of occurrence of spontaneous glow to arc transitions will be very great.

The method of the high frequency discharge appears to be practical according to the experience of the authors, but they believe the new method to be described in this paper is better.

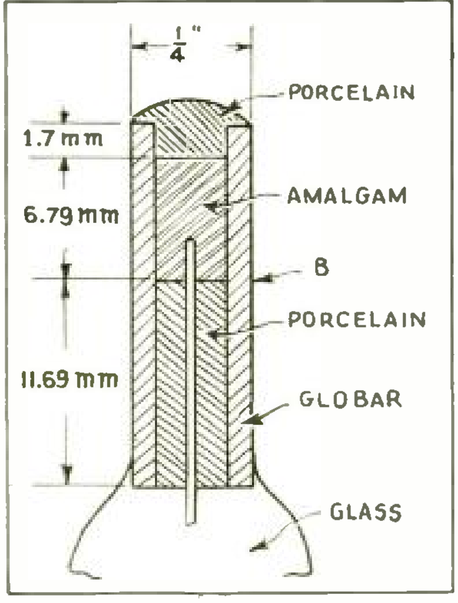

Fig. 3
Globar electric gradient demonstrator.

Turn now and read the "Swap Section" on page 184 of this issue.

CLASSIFIED ADVERTISEMENTS

Advertisements in this section are inserted at the cost of twelve cents per word for each insertion—name, initials and address each count as one word. Cash should accompany all classified advertisements unless placed by a recognized advertising agency. No less than ten words are accepted. Advertising for the October 1933 issue should be received not later than August 9th.

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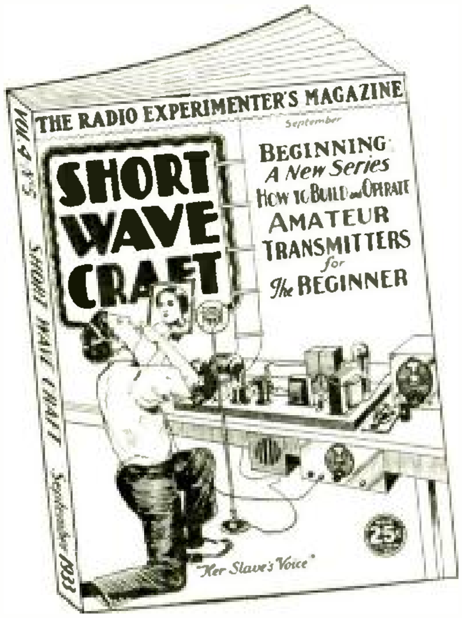


(7) Striking a New Cathode from an Already Existing Arc. If an electrode is made negative with respect to an already existing discharge, a positive ion current will flow to it, which will generally be limited to a small density by space charge. Conditions at such an electrode are essentially the same as those at the cathode of a self-maintaining glow, except that the positive ion currents may be drawn at a voltage in itself too low for the maintenance of a glow. To insure the prompt striking of an arc cathode at such an electrode, the methods already described as effective for the glow may be used. For example, application of a high frequency voltage to such an electrode will result in the prompt formation of an arc cathode.

However, in this case, an additional possibility exists. The density of ionization of the already existing discharge may be raised to so high a value adjacent to the electrode that even with low applied voltage, the positive ion current density will be so large that there will be prompt occurrence of a cause for transition to an arc cathode. This is the method used in the Deion circuit breaker for striking new cathodes on the many plates in the deionizing chamber. The arc which is first drawn at separating contacts is driven by a magnetic field up into slots in the plates, where the reduction of arc section so increases the density of ionization that arc cathodes at once form on the plates.

The authors have also successfully applied this method to the striking of an arc cathode to a mercury electrode in an evacuated vessel. An arc from a separately heated thermionic filament cathode was started, but it was compelled to take a constricted path close to the mercury, thus causing the density of ionization to be very high there. A small voltage difference between the mercury and the discharge would cause the prompt formation of an arc cathode on the mercury.

The Light Contact Arc Starter

A form of arc cathode starter of the separating contact type devised by the authors deserves special mention, because in a considerable degree it was free from inertia difficulty of ordinary separating contacts. A small-section, pointed tungsten rod was placed in a mercury arc tube so that it dipped slightly to a depth of about one millimeter below the mercury surface. On sending sufficient current through the rod, the cathode of an arc was promptly started at the rod mercury junction, and this starting could be regularly repeated sixty times per second. The explanation is believed to be as follows:

The current through the rod heated the rod-mercury junction, but the temperature had only to rise to that at which mercury has a vapor pressure of one millimeter, that is, about 125 degrees Cent. when a film of vapor would form around the rod separating it from the rod and starting an arc cathode on the mercury. In the

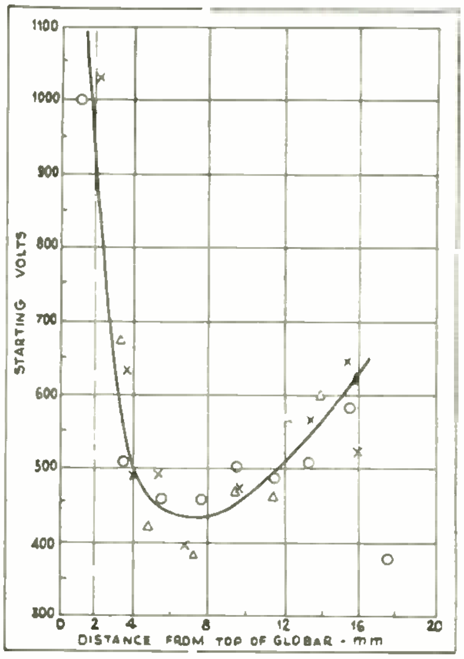


Fig. 4
Results of gradient tests.

particular tube used, when such an arc cathode started, the current was diverted to another anode and the arc cathode moved on the mercury surface away from the rod junction. With the current diverted from the rod, the film of vapor around the rod point promptly condensed, so that the starter was ready for a repetition of the process within a sixtieth of a second.

With an immersion of one millimeter about 200 amperes was necessary for regular striking of the arc. With less immersion, less current could be used, but with the lesser immersion the mercury would sometimes be thrown mechanically out of contact with the rod and would require several sixtieths of a second to return and make contact again.

The New Arc Starter

In attempting to develop a starter of the type of the preceding section and also of the type mentioned at the end of 3, under "Methods for Initiation of an Arc Cathode," it was discovered that a rod of relatively high resistivity partly immersed in mercury had very extraordinary properties with respect to the initiation of arc cathodes on the mercury surface. The first observations were made on a carborundum crystal. It was found that about ten amperes flowing through the crystal would start an arc cathode, and unlike the tungsen rod of the previous section, this current magnitude for starting the arc cathode varied very little with the degree of immersion of the crystal. The voltage required for starting varied with the length of the crystal above the mercury and was less than 100 volts for moderate lengths.

The starting of the arc was extremely regular and reliable. In taking an oscillogram of the operation of a mercury pool cathode vapor tube with such a starter, the starter electrode was connected to the anode of the tube through an auxiliary external rectifier, and the whole was placed in an alternating current circuit. As the oscillogram showed, in each half-cycle of polarity correct for sending current through the external rectifier, an arc was started in the tube.

This extraordinary property for starting an arc cathode was found to be generally enjoyed by materials of considerable resistivity. Thus similar results were obtained with starter rods made of lightning arrester resistor material (clay, lampblack mixtures), glowbar resistors (special carborundum heating elements), galena and ferro-silicon.

No wasting away of the starter rods could be observed even after long periods of operation. Some rods on life test have now been operating sixty times per second, 24 hours per day, for over seven months with no observable deterioration.

The mercury pool was not an essential element in the operation of the starter, as regular operation was obtained with a starter rod partly buried in solidified tin, as well as with a molten tin cathode. Operation was obtained also in air at atmospheric pressure.

The time required for the formation of the arc cathode after the application of the necessary voltage was found to be extremely short. This was investigated with the cathode ray oscillograph by W. E. Berkey. The following results are typical. For a resistor rod of ⅛ in. diameter in mercury dipping ¼ in. below the surface and extending ½ in. above the mercury, the minimum voltage for starting the arc before the rod would heat up appreciably was found to be approximately 130 volts. A sudden application of 250 volts would start the arc within less

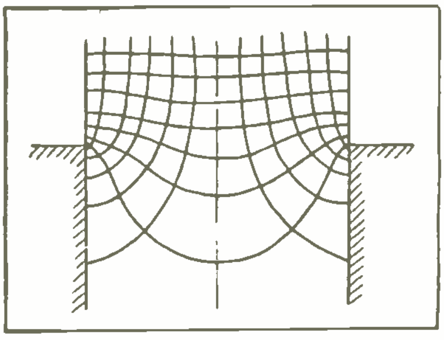


Fig. 5
Starter-material potential and current lines.

than five micro-seconds as indicated by a cathode ray oscillogram of such a starting of an arc cathode; as the voltage was reduced longer time delays between the application of the voltage and striking of the arc were observed. These times varied considerably in test repetitions. Figure 1 shows the variation of the mean time with voltage, and Fig. 2 the distribution of the times obtained at a single voltage.

Observations Bearing on the Theory of the New Starter

The insensitivity of the new starter to the degree of its immersion in the mercury indicated that its operation did not depend upon an actual breaking of contact with the mercury. This is confirmed by the operation of the starter buried in solidified tin, and it was also confirmed by operation obtained where permanent electrical contact below the surface of the mercury was insured by means of a tight metal clamp, and also by a copper sprayed portion of the rod below the mercury surface.

When operated just below the voltage required for regular operation, frequent tiny sparks would be observed at the mercury-rod junction. This suggested that the seat of the phenomenon resided at the mercury-rod junction, and also suggested that the operation might take place in roughly two stages, each stage setting different requirements. First would be the starting of a tiny arc cathode, the tiny sparks observed above. This would call for a very high electric gradient, or very large concentrations of energy to effect a thermal explosion at the mercury-rod junction similar to what occurs at the last contact point of separating contacts. Second would be the building up of the small current flowing from this tiny arc cathode to an arc current sufficient to short-circuit the rod to the holder or another anode. This would call for the ability of the side of the rod immediately adjacent to the tiny "spark" or arc cathode to carry considerable current as the anode of an arc.

Both of these requirements seem to call for the existence of an electric gradient down the rod to the mercury-rod junction. The necessity for such a gradient is beautifully illustrated by some experiments of L. Smede.

As illustrated in Fig. 3, a hollow cylindrical starter, A, made of glowbar was used. Good contact with the internal surface of this cylinder was made up to a level B by means of an amalgam. The electrical connection to the amalgam was brought in under the mercury and of course was insulated from the mercury. A barometric connection permitted the mercury level to be raised and lowered. The voltage required by the starter for regular operation was observed for different levels of the mercury. The results are shown in Fig. 4.

The impressed potential existed between the internal amalgam and the external mercury. When the mercury level was considerably below B, there would be current flow down the cylinder to the mercury from above, and therefore a gradient down the starter to the mercury. As the mercury level approached close to B, more of the current would flow across the cylinder wall to the mercury junction, and less down the cylinder wall. Hence for a given voltage, the gradient down the rod would be lessened. Hence if a gradient of a definite magnitude is necessary down the starter at the junction, the voltage required for starting should rise rapidly as the mercury level approaches B. This the curve of Fig. 4 shows to have been actually the case.

Theory of the New Starter

The observations of the previous section suggest that with respect to voltage and energy concentration, conditions at the starter rod-mercury junction must be similar to those occurring at the last contact point of separating contacts. Electrostatic theory shows that this is the case. Fig. 5 shows the equipotentials and current flow lines for a slab of starter material with parallel plane sides and dipping down a great distance into the mercury. (This field distribution is taken from Maxwell "Electricity and Magnetism" 3d edition, Art. 193, p. 297 and assumes that the electrical resistivity of the mercury is negligible compared to that of the starter material.) The current and voltage concentration at the mercury junction are quite clear.

From the mathematical formulas of Maxwell (in the reference just given), we calculate that the potential gradient along the starter side near the mercury junction is given by

$$(1) \quad \frac{dV}{dx} = \sqrt{\frac{d}{2}}\,\frac{X\alpha}{\sqrt{x}}$$

where d is the thickness of the slab, $X\alpha$, the gradient along the slab far from the junction, and x, the small distance from the junction at which the gradient $\frac{dV}{dx}$ exists. According to this formula, the gradient, and with it the current density becomes infinite at the junction where $x=0$.

Of course, the formula (1) may be considered as applying only so close to the junction as the material may be considered continuous. If we assume that we may consider the material continuous down to atomic distances, that is down to $x=10^{-8}$ cm., and if we take the slab thickness as 0.5 cm., we have for the gradient at the junction,

$$(2) \quad \frac{dV}{dx} = \sqrt{\frac{.5}{2}}\,\frac{X\alpha}{\sqrt{10^{-8}}} = .5\text{x}10^{4}X\alpha$$

If we adopt as our criterion for the starting of an arc cathode, the appearance of a gradient of 10^6 volts per cm. at the junction, we have for gradient, remote from the junction

(3) $X\alpha = 200$ volts per cm.

Actually, less than 100 volts per cm. were sufficient for starting an arc cathode with the materials tested. It seems likely that other phenomena peculiar to the carrying of current across contacts appear also at the junction, such as transition films of high resistivity, or the drawing up of small particles forming bridges, as suggested by Holm.

The first requirement for the starting of an arc cathode at the junction then seems to be the impressing of a gradient of the order of 100 volts per cm. along the starter rod. This practically sets a lower limit to the resistivity of the rod material, since with ordinary metals and reasonable rod dimensions, the current required to maintain such a gradient would be enormous. We may perhaps set 10^{-2} ohms per cm.[6] as the practical lower limit of resistivity of a starter rod of reasonable dimensions.

The requirements of the second stage of the formation of the arc, however, set an upper limit to the resistivity of the rod. The tiny arc which forms at the junction must grow to a magnitude sufficient to short circuit the rod. Since the tiny arc first flows to the rod side as anode, the resistivity of the rod must be low enough to permit the flow of sufficient current through the rod side without requiring excessive voltage. Actually, it was found that the voltage required for starting increased with the resistivity of the rod material. We may probably set a few thousand ohms per cm. as the upper limit for the resistivity of the starter rod.

Applications of the New Starter

Applications of the new starter will be obvious to those familiar with grid controlled gas tubes. In such tubes, until now, an arc cathode was permanently maintained by a separately heated thermionic cathode or a keep-alive arc. The starting of an arc to a main anode was then controlled by a grid. Now the permanent arc cathode and control by the grid may be eliminated, and the starting of the arc to the main anode effected and controlled entirely by the new starter. Thus many of the problems associated with the use of grids, particularly for large currents, are completely eliminated.

TESTING RESISTORS

In the early days of radio, fixed resistors were more or less taken for granted. If they showed resistance values of approximately the desired rating, chances are they would be used. Little real thought was given to other characteristics which have since been recognized as all-important.

Almost every circuit in a modern receiver now contains a resistor and, from the standpoint of the discriminating Service Man, the mere resistance rating is but one of several very important factors about which he wants to be fully informed. Before risking his reputation for good work on a resistor he wants to know whether it will retain its rated value through thick and thin; he wants to know about its voltage coefficient, how much it will deteriorate with age or under conditions of high heat or humidity and he wants to know about other factors all of which have a very direct bearing on its ability to deliver satisfactory reception over a long period of time.

Accuracy of rated resistance value can be taken for granted on units which bear the stamp of a reliable manufacturer who makes them not down to a price but who builds them up to a standard of quality. For instance, the standard tolerance of stock values of I. R. C. resistors is 10%. This is decidedly satisfactory for daily service requirements although, if desired for some particular purpose, resistors with a tolerance of only 5% can be furnished at a slightly higher price.

Low Voltage Coefficient

Voltage coefficient is another highly important resistor factor. Good resistors will measure up to the same resistance values as long as their voltage ratings are not exceeded. However, this point will bear watching in cheap resistors for, obviously, if a unit measures 1 megohm at 10 volts and 800,000 or 900,000 ohms at 200 volts it may cause the Service Man no end of trouble when placed in a set.

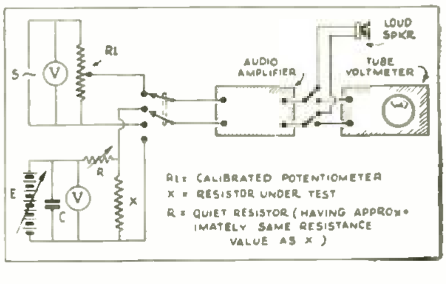
Low voltage coefficient simply means that there need be no hesitancy about using the same value of resistor at different voltages. A 500,000 ohm gridleak, for instance, may have only a few volts across it whereas a 500,000 ohm coupling resistor may carry as much as 200 volts and certainly no Service Man will want to be bothered with having to select different types of 500,000 ohm resistors to use on these different jobs.

Next comes the factor of resistor ageing characteristics. Even wire-wound resistors show a certain deterioration with age and this is why, when making resistors for extremely high precision work, the wire is first aged. Ageing tests over a long period of time on I. R. C. stock resistors have shown a deterioration of less than 2% over a period of years of use.

Humidity characteristics also warrant careful consideration. Humidity tends to increase the value of resistors. Poorly constructed units under test have shown an increase of as much as 50% or 100% as compared to only 10% for quality resistors. In the I. R. C. laboratory these tests are made in a "humidity chamber" which is kept at 40° C. with 90% relative humidity, the latter being obtained by means of a saturated solution of sodium tartrate. Resistors are kept in the chamber for 100 hours and results clearly show the danger of using inferior resistors for it is well known by Service Men that humidity is one of the most potent causes of resistor failure.

The Heating and Cooling Cycle

It is characteristic of a good resistor that, when its normal rated load is removed and it is allowed to cool, the unit will return to



within one or two per cent of the rated value. Some resistors show this permanence of load characteristic under brief tests but fail in longer tests. In the designing of I. R. C.'s, the resistors are given a "life test" of at least 1,000 hours with a load being applied intermittently, 1½ hours on and half an hour off. This simulates the heating and cooling cycle encountered in actual set operation and which has caused many cheap resistors to fail.

On good resistors, the change under load averages about 3½%, units returning to within 1% of their original value upon cooling. An overload of from 50% to 100% applied continuously for 100 hours will not cause them to change permanently more than 10%.

All radio resistors emit a certain amount of microphonic noise. When heard over a simple circuit set up made for this purpose, this sounds like a hiss or a rush. The noise is not objectionable when continuous but trouble comes when it changes to an erratic crackle—and it is this cracking that high-grade resistors are designed to eliminate. The accompanying diagram gives a circuit set-up which will give the Service Man an easy means of testing resistors for noise—a test which will supply convincing evidence in favor of quality units designed and constructed under modern, scientific engineering methods.

Thus it becomes evident that the true quality of a resistor cannot be judged by any single test and further that excellence in a single characteristic is not sufficient to recommend a unit for general use. The high-grade resistor built on quality lines *throughout* will meet *all* of the requirements of the discriminating Service Man and not just a few of them.

The simple testing circuit illustrated utilizes an audio amplifier having an overall voltage amplification of 1,000 or over, with a V. T. voltmeter reading up to 3 volts on its output. A battery supplies the rated load to resistor under test, X, which is in series with a "quiet," wire-wound resistor of about the same value, R. Point X is connected to the input of the amplifier, E, by means of a condenser. The noise developed can then be heard on the speaker or measured by the V. T. voltmeter. If the needle fluctuates wildly, the resistor is very noisy. The actual reading is also a measure of the noise developed under load. A high-grade resistor will give a continuous hissing noise when listened to while a poor one will emit a series of erratic crackles. The potentiometer R1, switch, etc., are used when it is desired to measure the noise by comparison with a known source of voltage S.

PLANE RADIO VS. FIRES

The radio-phone facilities of Transcontinental & Western Air, whose planes fly over Pennsylvania on their coast-to-coast mail and passenger routes, have been of great value to the state in its efforts to prevent forest fires and preserve the natural forest resources, according to George W. Wirt, chief fire warden at Harrisburg, who reports as follows in a recent bulletin:

Pilots of TWA have come to our assistance many times by reporting the discovery of forest fires by means of their two-way radio-phone facilities. The pilot reports the discovery of the fire to his ground radio stations at Harrisburg, Pittsburgh, or Philadelphia, and within a few minutes the fire wardens are in possession of the information.

Often the pilots render particularly valuable service by giving details of location which could not be gained from the warden's observation towers. The pilot, of course, can see the evidences of the fire many miles ahead and is able to get the report to us long before our observation posts are aware of the fire.

In one instance a radio report from a plane of a fire a short distance outside of Pittsburgh was in the Harrisburg fire warden's office six minutes after the pilot spotted it.

(Along the route of TWA, whose huge trimotor passenger planes and smaller mail planes operate over the shortest route from coast to coast, there are nineteen radio ground stations. The pilot of each plane is in constant radio communication with the ground through the radio-phone transmitter and receiver on his plane and on the ground.)

Radio-Craft FREE BOOKLET SERVICE

READERS' BUREAU

On this page are listed manufacturers' catalogs and booklets, chosen because they are of interest to readers of RADIO-CRAFT. You can obtain copies FREE by using the coupon below.

5. CLAROSTAT CONTROL HANDBOOK. A large 32-page book containing detailed specifications of volume controls, attenuators, constant-impedance controls, phonograph pickup faders, tone controls, line ballasts, rheostats, potentiometers and fixed resistors of various kinds, together with valuable circuit-design data. Contains many diagrams and charts, and a guide of replacement volume and tone controls for many commercial receivers. *Clarostat Manufacturing Company, Inc.*

6. MEASURING RESISTANCE BY THE DEFLECTION METHOD. The conventional method for the measurement of resistance involves the use of the Wheatstone bridge, a costly piece of apparatus. However, there are other methods which provide a fair degree of accuracy, enough for all practical purposes. The least expensive is the deflection method, which makes use of popularly priced milliammeters and fixed resistors. This bulletin describes the method completely, and should be very useful to Service Men and experimenters with limited meter equipment. *Shallcross Manufacturing Company.*

11. SUPREME INSTRUMENTS. Contains lengthy descriptions of the Supreme service instruments, including the AAA1 Diagnometer, which is five instruments in one, the model 90 analyzer, the model 40 tube tester and the models 60 and 70 oscillators. Interesting to the Service Man because it tells how his work is facilitated by ingeniously-designed test equipment that indicates the condition of an entire set in a few minutes. New test apparatus to take care of the new tubes is also described. *Supreme Instrument Corporation.*

19. A BAPTISM OF FIRE. Centralab fixed resistors are made by forcing a carefully calibrated resistance material through a plastic ceramic material, and then baking both under terrific heat. This booklet describes the manufacturing process in detail, and lists the advantages claimed for fixed resistors of this type. It is interestingly written and illustrated, and makes good reading. *Central Radio Laboratories, Inc.*

21. READRITE RADIO INSTRUMENTS. This sixteen-page pamphlet contains some valuable hints on the testing of electrolytic condensers, as well as descriptions of the full line of popular-priced Readrite instruments. Worth having. *Readrite Meter Works.*

76. THE COAST-TO-COAST "BROADCAST." The "Broadcast" is the Spring-Summer 1933 edition of a 100-page mail order catalog that is a veritable encyclopedia. Its listings are very varied, and run from soldering lugs to complete 100-watt public address amplifiers. Every article is well illustrated and described for the benefit of radio dealers and Service Men, for whom the volume is specifically intended. *Coast-to-Coast Radio Corporation.*

94. ELECTRAD PRODUCTS. The newest and latest catalog of Electrad products contains twelve pages and lists many types of fixed and variable resistors and five different kinds of amplifiers for public address purposes. The popular Truvolt resistors have been improved by the addition of insulating shields and heat radiating covers, and a number of new sizes have been added to the line. The catalog also contains some valuable data on the application of resistors to radio receivers, transmitters, amplifiers and sound systems, and suggestions on how to compute the value of resistors. A handy and useful catalog. *Electrad, Inc.*

96. TOBE FILTERIZER AND CONDENSERS. The Tobe Deutschmann company is now catering to the Service Man with an extensive line of filter, by-pass and line condensers and radio noise eliminators. Their latest catalog, describing the complete line, has just come off the press. A full page is given to the new "Filterizer" noise eliminating antenna system, an item of particular interest to Service Men because of the money-making opportunities it offers. *Tobe Deutschmann Corporation.*

97. ARCO TUBE BULLETIN. A descriptive folder giving full technical characteristics on the complete line of Arco radio receiving and transmitting tubes, photo-electric cells, television lamps, hot and cold cathode tubes, cathode ray tubes, rectifiers and charger bulbs. This can be posted for easy reference. *Arco Tube Company.*

98. HOW TO USE NOISE REDUCING ANTENNA SYSTEM ON BROADCAST WAVES AND SHORT WAVES is the title of the latest booklet on this important subject. In addition to covering the theory, the *practical application* of the various noise-reducing systems available for broadcast and short wave use, is described also. *Lynch Mfg. Co.*

102. AMERICA'S OLDEST RADIO SCHOOL. This attractive 16-page catalog describes the various course of instruction available at the RCA Institutes, New York. Training is given in the following subjects: radio broadcasting, radio operating, radio servicing, and sound and public address work. *RCA Institutes, Inc.*

103. MILES PUBLIC ADDRESS SYSTEMS. A concise 8-page catalog listing microphones, loud speakers, power units, amplifiers, transformers and incidental accessories. *Miles Reproducer Co., Inc.*

104. WESTON STANDARDIZED SERVICE UNITS. This folder describes a complete series of standardized service units, consisting of an analyzer, tube checker, oscillator, volt-ohmmeter and capacity meter. The units are of uniform size and may be combined in single cases of various sizes, depending on the requirements of the Service Man. *Weston Electrical Instrument Corp.*

105. RADIO BARGAIN NEWS. This dealers' and Service Men's mail order catalog is a veritable buyer's guide. Among the hundreds of items included are auto radio sets, mobile sound amplifiers, dynamic speakers and replacement parts of every description. *Federated Purchaser, Inc.*

106. EX-STAT SPECIALTIES FOR RADIO SERVICE TECHNICIANS. A useful catalog of resistors, condensers and volume controls, prepared especially for the Service Man. Of particular value is a ten-page section listing the correct replacement volume controls for numerous radio receivers dating back as far as 1926. *Tilton Manufacturing Company.*

RADIO-CRAFT 5-106
Readers Bureau
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(3) ☐ Dealer (4) ☐ Jobber
(5) ☐ Radio Engineer
(6) ☐ Licensed Amateur
(7) ☐ Professional or Amateur Set Builder

This coupon will not be honored unless you check off your classification above.

RADIO FURNITURE

While volumes have been written on radio furniture points out E. C. Ritter, furniture designer for the Fada Radio & Elec. Corp., the problem that faces the cabinet designer may be stated in a single sentence. It is this: Execute pleasing designs that will fit into average home surroundings.

It all sounds very simple, but as a matter of fact it has not been so easy to design cabinets in keeping with the premise of having them fit into the multitude of homes. While of course, there have been, and are, radio cabinets distinctly following a given furniture "period," it has been necessary by and large to keep away from strictly period design. That means reproducing with exactitude lines of the great masters of furniture or the periods such as Italian Renaissance, Spanish, Louis XV, Queen Anne and other period pieces. In this respect radio has been forced to become distinctive to a degree and strike somewhat of a happy medium.

While one major survey of American homes showed bed-rooms followed in the order named, French, English, Colonial and modernistic style and living rooms in Colonial, early American, English and French, it can readily be seen that the bed-room furniture maker for example has quite a small problem compared to the radio cabinet maker. He can manufacture certain accepted standard pieces, mostly in suites, and the individual purchaser makes a selection in accordance with his taste, type of home, or general requirements. But in the case of radio the problem may be likened to the purchase of an odd piece to place in a room where the major selection has already been settled. In other words, it is the question of fitting in the radio cabinet to the living room, generally speaking. The manufacturer of radio sets selling in volume must design cabinets as I said at the outset that will fit into average home surroundings and that's no easy task not only because of individual taste in home furniture but also because of certain other characteristics of people in a country as large as ours.

Leaving out the question of general period designs vaguely followed in the making of home furniture there is the question of larger influences which not only the furniture manufacturers must heed but specifically the radio cabinet designer must be particularly careful of including in his calculations. I have in mind one section of the United States that leans heavily toward the more conservative designs in furniture and that, of course, includes radio consoles. Then we get into the heart of a great metropolis and find certain sections where elaborate designs with heavy carvings are the order of the day. These tastes are governed very often by racial background that is stronger than style influences. Then we get into another section of the country where old American tradition holds the people to certain well-defined furniture ideas. Then again, in certain cities there will be several clear-cut major divisions as to types of stores in regard to requirements. One will not handle anything ornate sticking to "quiet" lines while another because of its clientele will have to go in for ornamental design. And so it goes, with varying complications for varying types of trade. And through it all the radio manufacturer, through his furniture design, must strike the right average, so to speak. Radio cabinets, or consoles, must be individual and yet not too "different." Theoretically, it would be ideal to have, say, five cabinet designs to fit each set model and each pocket book at the same time but this of course, would not be practical since it would mean building a tremendously large selection for each line of radio receivers.

Disregarding individual instances of specially designed period consoles it can be said that whenever radio has tried to bring definite period models into the fold a flop has resulted. The sets that have sold in volume have been those that in addition to considerations of technical performance, have been encased in furniture that struck the eye of the average as "right" in appearance and fitted well into the setting where it was to be placed.

It should be understood that I have not attempted to cover this whole subject of radio furniture but merely to touch a few highlights. The next time you see Queen Anne legs on a radio console do not expect the whole cabinet to be Queen Anne. For radio cabinets are, in the main in the minds of the old time furniture people at least—"mongrels," mongrels which perhaps through their trade acceptance by the American public have in turn created a new phase in furniture design and of which time alone can tell whether it is a permanent phase of design or one which will eventually revert to the accepted principles of design which have characterized the furniture industry for so many years.

Cabinet Colors

Still another and very important factor is the *color* of the cabinet. Where the public has a choice of colors in the selection of a radio cabinet no one color is a general favorite but there is a surprising degree of uniformity in the preference shown for each color.

This is at least the tentative conclusion reached by us, based on the initial batches of orders that came upon the heels of the production of the "Super-Fadalette," a miniature receiver in art-leather of four colors, and in burl walnut.

Green, red, ivory and brown are the colors involved in this test of public selection. In anticipating the public preferential reaction in those colors it was decided, after determining the most likely shadings to prove popular, to turn out an equal number of each color. Then it was figured that production of the burl walnut should be in the ratio of 40 percent as against the total number of art leather cabinets. It was necessary, of course, to grade the quantity as to those colors and as to what proportion of the burl walnut cabinets should be made, in advance of any determination of the public trend. As already stated it was agreed there should be no differential in the *quantity* of any color.

How reasonably correct the prior-to-production cabinet orders worked out in relation to the actual sales is revealed in the following approximate ratios:

Out of each 1000 sets sold the division was as follows:

Red	160	
Ivory	142	
Green	165	
Brown	171	
Total Art-Leather		638
Burl Walnut		362
Comparison Unit		1000

While this test is not regarded as absolutely conclusive, it is interesting to note the uniformity with which the public has divided off the four colors. It is also exceedingly interesting to note that an arbitrary color selection by the manufacturers is so closely followed in the field of actual sales.

This is probably the first time that actual color tests as to sales have been made in radio on a scale of any size. Some manufacturers tried out color sets in the past but only with the coming of the art leather cabinet has it been possible to secure the effectiveness that color lends to a small radio cabinet.

MUZZLING NOISE-PRODUCERS

Frank H. Cross

Physicians, surgeons, osteopaths and others using electrical equipment are required to equip their machines with static eliminators to reduce radio interference, in an ordinance recently passed by the City Council of Santa Ana, Calif. The object of the bill is to protect private radio listeners.

The city electrical inspector will inspect all machines in offices.

An elaborate means of tracing radio interference, which is maintained by the Southern California Radio Interference Association of Los Angeles, will assist in making the ordinance effective. The measure requires private radio listeners to have their sets in approved condition for reception, and another section requires that high-tension power boxes of all kinds be equipped with static eliminators.

RADIO PROGRESS WEEK

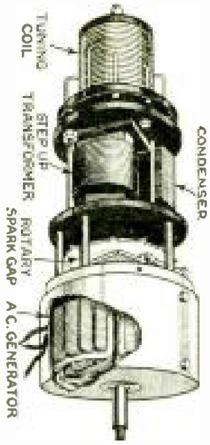
Service Men—get in back of the national publicity which is appearing in support of Radio Progress Week, October 2 to 7. Every effort is being made to cause Mr. John Q. Public to become more "set concious"; to look into the whys and wherefores of new radio sets, and the repair of "old reliable." Keep your eyes and ears open, and prosper with the other "boys."

Outside View of Aircraft Generator

BARGAIN SALE of 3000

Westinghouse Power Generator Aircraft Transmitters

Hundreds of Uses for Radio Experimenters

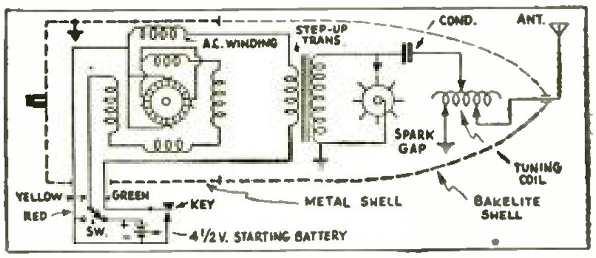


View of Aircraft Generator with Hood Taken Off

The Government Paid Originally $147.00 Each for these Westinghouse Generators

OUR PRICE $4.95

AS LONG AS SUPPLY LASTS



(Technical Specifications)

The special generator illustrated is of the self-excited inductor type. The rotor serves two entirely distinct purposes: 1. It carries the inductors for the A.C. generator, which has stationary field and armature coils. 2. It carries the D.C. armature, which corresponds to the exciter in other machines.

There are two pairs of stator poles—two North and two South. Around these four poles are wound the four field coils which, when energized, produce poles of alternate polarity. Each of these poles is provided with four slots into which are fitted the A.C. windings. The rotor is a 12-tooth inductor that carries the D.C. armature coils which supply the D.C. exciter current required by the alternator; a built-in commutator takes off the generated D.C. Three leads extend through the casing to permit a 4½ V. flashlight-type battery to be switched into circuit for starting, and to control the A.C. output of the generator. Rotated at its normal speed of 4,500 r.p.m., the output is 200 W., at 115 to 125 V. (on open circuit), 900 cycles.

Manufactured by Westinghouse for the U. S. Signal Corps, the sturdy construction of this instrument recommends it to the technician. The rotor turns in ball bearings. In order to perfectly withstand the extremes of temperature and humidity encountered in air-craft service all the coils are thoroughly impregnated with a special compound and then baked. Shaft length (driving end), 2 ins.; diameter, 9/16-in.; the end is threaded for a distance of ⅜-in. At the end opposite from the drive the shaft extends ¾-in. Case dimensions, exclusive of the shaft, 4½x6¼ in. in diameter.

The output of this self-excited generator is fed to a step-up transformer which, in turn, is fed to a 12-point synchronous rotary spark-gap; a rocker permits the single stator point to be accurately adjusted to phase the spark and the power supply. The spark-gap is included in a secondary that comprises a mica fixed condenser, and a tapped tuning inductance adjustable in the range of 250 to 550 meters. This coil consists of 25 turns of No. 14 wire wound on a threaded bakelite form 3 ins. in diameter and 3 ins. long; the over-all length is 4⅛ ins. One set of taps is brought to a contact plate at one end and provided with a switch; the other set is brought to a contact plate at the opposite end and provided with a pair of laboratory-adjusted contacts. A stream-lined bakelite housing slips over the entire transmitter assembly. The over-all length of generator (exclusive of shaft) and transmitter is 18 ins. Weight of complete outfit, 20 lbs.; shipping weight, 35 lbs.

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Enclosed find $4.95 for which ship by express collect one Westinghouse Power Generator Aircraft Transmitter as per your description. If not satisfied I will return outfit and you will refund money.

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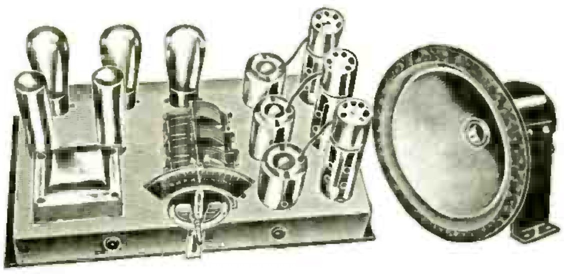
Index to Advertisers

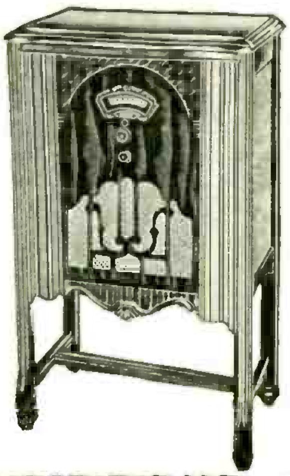
(While every precaution is taken to insure accuracy, we cannot guarantee against the possibility of an occasional change or omission in the preparation of this index.)

Regaining Popularity . . .

6 TUBE CONSOLETTE RADIO



The BEAUTY . . .
FINE CHARACTERISTICS
EXTREMELY LOW PRICE



Of this handsome set has regained the prestige that the Consolette Radio has maintained for several years.

At last a full sized consolette receiver at the price of an A.C.-D.C. midget. Produces remarkable tone quality with ample sensitivity for all requirements. Employs a highly developed T.R.F. circuit using the latest type tubes, thus producing remarkable performance. Beautiful in appearance, will fit into any surroundings. Supplied in two distinctive cabinet designs. Incorporates the following tubes: 2—'58, 1—'57, 1—'56, 1—2A5 and 1—'80 tube. These tubes deliver 6 watts of undistorted output.

Only the finest quality parts are used throughout the entire construction. A matched electro dynamic speaker mounted on a special built-in baffle handles the full output with realistic tone.

PRESSED WOOD INLAID CABINETS

Handsome walnut two tone finished cabinet created by craftsmen with a background of years of furniture building. Finely blended design with attractive pressed wood panels. Exquisitely moulded—the contours form a handsome unobtrusive design. Will harmonize with any home surroundings. Cabinet measures 35½ inches high, 21 inches wide, and 10¾ inches deep.

Our Price
$12.95
Complete Set of Tubes $1.95
Cabinet Only $3.95

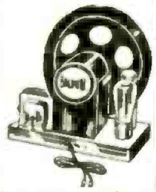
Jensen Model D-7 A.C. Dynamic

Is widely used as an additional speaker in many homes, as well as on public address systems. Will handle an enormous amount of volume without distorting or rattling. Equipped with a 280 rectifier tube. The speaker measures 12½ inches high, 11⅜ wide, and 7-7/32 deep. Baffle opening required, 10 inches. Supplied complete with tube.
Our Price, with tube.................. **$8.95**

R.C.A. 100B-103 Magnetic Chassis

This chassis is the identical one used in the R.C.A. 100A-100B Speakers which list for as high as $35.00. Note built-in output transformer which permits use of 450 volts without distortion, rattling or blasting. Generous oversized magnet. The thick armature is accurately centered, the sturdy metal frame is lined with a special self-baffling fabric, greatly improving acoustic properties of this sensational speaker. Note the corrugated surface of the cone, an exclusive feature—enhances perfectional reproduction qualities considerably; most compactly made; 9" outside diameter, 4½" deep overall.
Our Price.................................. **$2.75**

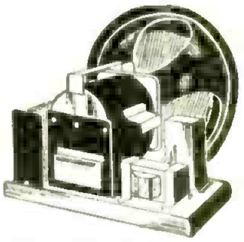
Baldwin A.C. and D.C. Dynamic Speaker Chassis



The tremendous power handling capacity of this speaker makes it suitable for use in modern console receiving sets or for power amplifiers. The A. C. models are equipped with a 280 rectifier tube and an 8 mfd. dry electrolytic condenser to reduce A.C. hum. D. C. models are available with or without output transformers. Field resistance of the D. C. model is 2500 ohms.
Dimensions: 9½ inches high and 7 inches deep.

(A. C. Model, complete with 280 tube.)
Price.................................. $4.95
(D. C. Model with output transformer.)
Price.................................. 3.25
(D. C. Model, less output transformer.)
Price.................................. 2.95

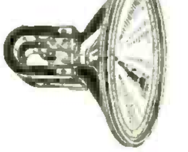
Peerless A.C. and D.C. Dynamic Speaker Chassis



An efficient and powerful reproducer. Ideal for use with the most powerful public address amplifier. It is equally suited for use with any receiver employing the average type of audio amplification system using as low as 90 volts "B" current. The speaker will work with any receiver regardless of output characteristics.
D. C. Model has a 1,000 ohm field and a push-pull output transformer. A.C. Model uses a dry rectifier system with a hum condenser for minimum A.C. hum.
Dimensions: 12 inches high and 8 inches deep.
D. C. Model. Price.................. **$5.95**
A.C. Model. Price.......................... $7.95

FARRAND INDUCTOR DYNAMIC

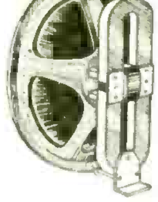
9 Inch Model



The 9 inch model has the two magnets parallel to each other with a bracket placed between them to facilitate mounting. Please specify type of power tube when ordering.
Price **$4.50**

FARRAND Inductor Dynamic

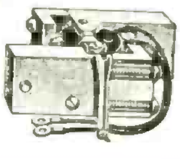
12 Inch Model



These models are not to be confused with the various types now on the market and labeled Farrand Inductors. These models are all factory built and not just put together haphazardly.

The 12 inch models have two magnets standing upright, with a bracket on the bottom to ease mounting. Dimensions of the 12 inch model: 12 inches high and 6½ inches deep.
(12" Model)
Our Price.................................. **$4.95**

Replacement Unit



The genuine replacement unit mechanism for the R.C.A. 100A, 100B, and 103 speaker chassis. This unit is complete in every detail except that it is furnished less the magnet. Guaranteed to be in perfect condition. Can also be used for replacement purposes on any other type speaker.
Our Price.............................. **95c**
With Magnet.............................. $1.25

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RTC's Big September SPECIALS

Every month we list on this page a few STAR ★ items which are not listed in our catalog. These are all specials of which the quantities on hand are not sufficient to catalog them. *Once sold out, no more can be had.* ORDER NOW—TODAY.

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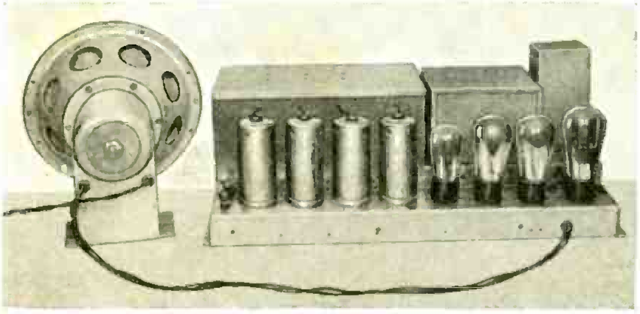
★ "PEERLESS" 7-TUBE SCREEN-GRID T.R.F. RADIO RECEIVER

Complete with Full Dynamic Speaker



Back View

The selectivity and sensitivity of this 7-tube receiver due to its **three tuned stages** are just as sharp as those of an expensive 11-tube Superheterodyne receiver. The construction of this receiver is best described as "standard." Its circuit is none other than the "good old standby" TRF type which is the most reliable. It incorporates two stages of tuned R.F. amplification using type '24 Screen-grid tubes; the power detector is a '24; a single stage of AF voltage amplification utilizing the type '27 tube, feeds a 247 super-power pentode, the full wave rectifier is an '80. All provisions are made for supplying field power for the 9 inch genuine Magnavox, fully shielded full dynamic speaker. Both cone and spider of this excellent reproducer are made of Burtex to improve the high note response (brilliance) without impairing the low note production.

Tuning is extremely simple, the tuned circuits being controlled by a single central knob; a vernier drum-type illuminated tuning dial is employed. The second knob controls the on-off switch and the third, the one on the right, volume control. Coils, tuning-condenser-gang, filter condenser bank, output choke and by-pass condenser bank are all individually shielded. The chassis itself is made of non-magnetic aluminum.

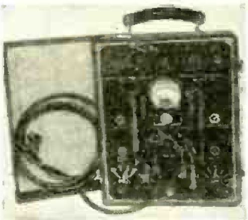
The use of three tuned circuits, employing screen-grid tubes and high gain R.F. transformers, together with careful wiring, and by-passing, result in high sensitivity. Tone quality, too, is extraordinarily fine. Despite the maze of new tubes recently thrown upon the market, it is generally conceded that for average home use a single 247 pentode supplies **adequate power with the least distortion.**

Why build a set when a complete receiver, wired and ready to use, and complete with speaker, can be bought at this phenomenally low price? Here is an excellent opportunity for wide-awake service men to "clean up." Remember that the supply is limited. Hence, "first come, first served." Overall size 21" x 8" x 8½" (set only). Ship. wt. 45 lbs.

List Price $75.00
NO. SP-2000 Peerless 7-Tube TRF Receiver
YOUR PRICE with speaker but less tubes $10.87
LIMITED SUPPLY—ORDER TODAY—TOMORROW MAY BE TOO LATE

BUILD THE "NEW DEPENDABLE" TUBE TESTER

Sold Either Wired or in Kit Form



Here indeed is your opportunity to build one of the finest tube checkers ever designed—an instrument which is MODERN in every sense of the word. Will test all the latest type tubes, including those with 7 AND 8 PRONGS—DIRECTLY—without the use of a single adapter!

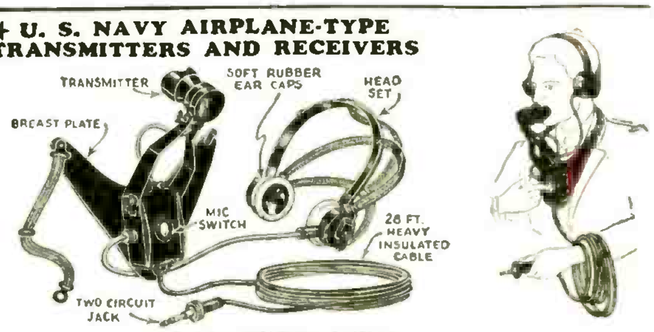
The "NEW DEPENDABLE," despite its high degree of accuracy, is extremely simple to operate. Both plates of the 80—82—83 and other rectifier tubes are readily tested without the use of a "second plate" button.

The instrument employs a high-grade, D'ARSONVAL TYPE, MOVING-COIL METER, insuring thereby extreme accuracy. This instrument will check more than 120 different tubes and even those which have not as yet been placed on the market. The tube tester is amply guarded against tube "shorts," which condition is indicated by the flashing of a small pilot light. All component parts are mounted on a beautifully etched panel and the entire instrument placed in a sturdily constructed, leatherette-covered, carrying case. For operation on 105-125 volts, 50/60 cycles, A.C. This instrument is available either in kit form or completely wired and tested, ready to use. Shipping weight 9 lbs.

NO. 303 "New Dependable" Tube Tester, completely wired and tested.
YOUR PRICE.......... $16.52

NO. 303A "New Dependable" Tube Tester in kit form.
YOUR PRICE.......... $13.52

★ U. S. NAVY AIRPLANE-TYPE TRANSMITTERS AND RECEIVERS



Only 300 at This Unheard-of Price

This microphone and head set outfit was built especially for the U. S. Navy Aviation Corps for plane-to-plane and plane-to-ground communication. Constructed under rigid governmental supervision.

The outfit consists of a low-impedance carbon transmitter securely fastened to a metal breastplate and a set of heavy-duty low-impedance earphones provided with soft rubber cushions. A specially constructed switch on the back of the breastplate, controls the microphone circuit. Twenty-eight feet of heavy conductor cable, terminating in a special brass plug, is furnished complete with this outfit. Two of these outfits make an efficient communication system over long distances.

The U. S. Government probably paid more than $30.00 for each of these outfits. Yet, a fortunate purchase permits us to sell them to you at $1.97, COMPLETE, as shown in the illustration above. There is no question but what considerable use can be found for these delicate, yet sturdily constructed instruments. Ship. wt. of entire outfit, 7 lbs. List Price $40.00. **No. B7216** U. S. Navy Airplane-Type transmitter and Receiver
YOUR PRICE.......... **$1.97**

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HERE IS A PARTIAL LIST OF CONTENTS

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TESTS LATEST TYPE 6 AND 7 PRONG TUBES

NINE METER SCALES AVAILABLE

This new Readrite precision instrument embodies features which have always been desired in any instrument built for service work: (1) low cost; (2) simplicity of design; (3) accuracy of measurements; (4) ruggedness of the complete unit. It is needless to add that the kit is capable of testing anything from old battery models to the latest screen-grid, pentode, and multi-mu receivers.

The "Model 710" is an extremely compact device. The outside dimensions of the carrying case are only 10¼ by 7¼ by 3¼ inches. The analyzer contains a D.C. voltmeter, an A.C. voltmeter and a milliammeter. The D.C. voltmeter has four ranges: 0 to 10; 0 to 60; 0 to 300 and 0 to 600 volts. The A.C. voltmeter has three ranges: 0 to 10; 0 to 140; and 0 to 700 volts. The milliammeter has two ranges; one for 15 mill. reading and the other for 150 mill. **This variety of ranges makes it possible to test every conceivable radio circuit;** high voltage secondaries of power transformers, current drain of all radio tubes, including the high power 250 and 210 tubes, etc.

CONVENIENT SELECTOR SWITCH—The instrument is equipped with a ten position bi-polar selector switch; by means of which readings may be obtained of "C" volts, "C" volts reversed, "K" volts, "K" volts reversed, plate voltage, screen-grid voltage, etc. A 4½-volt battery is supplied with the analyzer, to provide "C" bias, for grid tests, continuity tests, etc.

TESTS PENTODES—"MULTI-MUS" '57's and '58's—'80 RECTIFIERS, Etc.—There are four sockets on the panel of the analyzer to take care of the four, five, six and seven Prong Tubes. There is a "grid-test" push-button. Pin jacks are available for the individual use of all meters, externally, in every range. There is a screen-grid pin jack, and there are two pin jacks for connecting the external battery. Both plates of the '80-type rectifier may be tested by use of a special adapter furnished. Charts are provided for measuring resistances and capacities. The Analyzer is furnished complete with test leads, connecting cables, Burgess 4½-volt battery, several battery leads, UY to UX adapter, '80 rectifier adapter and resistance and capacity charts. Shipping weight, 8 lbs.

Model 710 Analyzer. List Price, $25,
YOUR PRICE.......... $14.71

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ANNOUNCING THE 1934 OFFICIAL RADIO SERVICE MANUAL

This new manual has been in actual preparation for several months. The vast amount of important data, which we have received from manufacturers who are assisting us in the compilation of the book, leads us to believe that the 1934 Manual will be more valuable than any previous editions.

THE necessity of GERNSBACK Manuals in the radio field has been shown by the fact that the total sales of the first three OFFICIAL RADIO SERVICE MANUALS, including the new CONSOLIDATED EDITION, now exceed 80,000 copies. Radio Service Men and others engaged in various branches of radio know the importance of such books, and how they must depend upon them for reliable information. Whether for public-address work, tube information or a circuit diagram, the material needed is certain to be found in one of the OFFICIAL RADIO SERVICE MANUALS. The GERNSBACK Manuals have been constantly used in reference work by leading radio set manufacturers, mail-order houses, jobbers, dealers and, most extensively, by Service Men, for whom these books are invaluable.

In the planning of the 1934 OFFICIAL RADIO SERVICE MANUAL many things have been taken into consideration. First, how we could reduce our own costs, and in turn pass these savings on to our readers. Second, what information not contained in previous editions of the Manuals must be incorporated in the 1934 edition and would be of utmost importance to its users. Third, what advance information we could print that would be useful in the future.

After careful analysis we found that the total cost of producing the 1934 Manual would be considerably less than in former years, and that at this time we could reduce the price of the book to our readers. The Fourth Edition of the OFFICIAL RADIO SERVICE MANUAL will sell this year for $3.50. The book will be published like the 1933 Manual—the volume will be sent to you complete. As usual, we urge that all our readers place their order early so that they will get a copy of the first printing. Usually, at the last minute a tremendous number of orders come to us and quite often orders are held up while the book is going through a second printing.

Anticipating such information as may serve future radio needs, we are holding many pages of the Manual open until the very last minute. Any timely "dope" which we then receive will be included before going to press.

In preparing this new edition many of the outstanding problems of the Service Men have been considered—methods of servicing, the new equipment constantly needed to cope with new tubes and sets, and the other fields of radio, such as public-address systems, short waves, auto radio and others.

The illustrations in the 1934 Manual will be more explicit than before; inasmuch as the diagrams will not be limited to the schematic circuit, but other illustrations will show the parts layout, positions of trimmers, neutralizers, etc. There will be hundreds of new circuits included, and not one from any previous edition of the manuals will be repeated. *This we unconditionally guarantee.*

The number of pages in the new Manual will exceed 400, with hundreds of illustrations, including diagrams, charts, photos, picture layouts, etc. The size of the Manual will be the same as that of the former volumes—9x12 inches, with a flexible, loose-leaf binder.

As in previous years, the 1934 Manual will also include a FREE QUESTION AND ANSWER SERVICE. In each book will be found 25 coupons, which entitle you to free consultation on any radio service topics. These coupons give you a complete mail service—questions on servicing and operating on any set or circuit are answered promptly and accurately by the editors. Remember that, at the regular rate of 25c per question which is usually charged by radio magazines, this service alone is worth $6.00. And for the Manual, we charge only $3.50.

It is quite evident that the 1934 Edition of the OFFICIAL RADIO SERVICE MANUAL will be a decided improvement over previous volumes, and will even surpass the high standard of the former Manuals.

Contents of the 1934 Manual in Brief

- Diagrams and service notes, more complete than ever before in any MANUAL. Not merely the schematic hook-ups will be found, but also chassis drawings showing parts layouts, positions of trimmers, neutralizers, etc.
- Voltage readings for practically all sets, as an aid in checking tubes and wiring.
- All values of intermediate-frequency transformers used in superheterodynes, with the manufacturers' own suggestions as to correct balancing.
- Detailed trouble-shooting suggestions and procedure as outlined by the manufacturers' own engineers—in other words, authentic "dope" right from headquarters.
- Values of all parts indicated directly on all diagrams. WE WILL POSITIVELY NOT INCLUDE DIAGRAMS FOR WHICH PARTS VALUES CANNOT BE OBTAINED.
- A special section for reference to A.C.-D.C. cigarbox midgets.
- A special section for reference to automobile radio.
- A special section for reference to public-address amplifiers.
- A special section for reference to short-wave receivers.
- A special section for reference to remote-control systems.
- A complete compilation of radio tube data, covering both the old and the many new types.
- A special section devoted to test equipment, analyzers, etc., with full diagrams and other valuable information.
- A complete list of American broadcast stations with their frequencies in kilocycles; extremely useful in calibrating and checking test oscillators and in calibrating receivers.
- Free Question and Answer Service, the same as in our last two Manuals.
- No theory; only service information in quickly accessible form.
- Absolutely no duplication of any diagrams; nothing that appeared in any of the previous Manuals will appear in the 1934 MANUAL. This we unconditionally guarantee.
- A handy, easily-consulted master index making it easy for you to find almost anything pertaining to your service problem instantly. This index will include all the diagrams published in all the previous GERNSBACK Manuals, as well as the 1934 diagrams. A big convenience and time saver!

ORDER YOUR COPIES NOW

It is important to every Radio Service Man and Dealer that he receive his copy of the 1934 OFFICIAL RADIO SERVICE MANUAL as soon as it is published. The new book will prove itself to be invaluable as those volumes of previous years. The book as usual comes to you postpaid and free of additional charges.

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RC-9

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