HUGO GERNSBACK, Editor

MARCH 1941

POLICE 2-WAY RADIO
... IN A VEST!
See Page 521

F.M. ADVANCES • V.-T. OSCILLATORS • FIXING FLUORESCENT LIGHTS
V.-T. VOLT METERS • NEW UTILITY TESTER • HOME RECORDING HINTS

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Radio-Craft for March, 1941

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REGARDING HEARING-AIDS

Dear Editor:

I have just finished reading Earl Russell's presumptuous and faintly amusing letter in the column "Radio-Craft's Mailbag." I feel that this calls for a reply, as some of your readers may take this gem of stupidity seriously.

As the old saying goes "Where ignorance is bliss, 'tis folly to be wise." However, it is more than folly and just plain ridiculous, for the ignorance to assume the cloak of wisdom, as Mr. Russell does when he presumes to give advice to others on the subject of hearing-aids. A case, one might say of the deaf leading the blind (or at least the dumb).

Mr. Russell "advises" the near-deaf that the hearing-aid amplifiers described by the writer and by Mr. A. C. Shaney do not have nearly enough volume to be of real service. Although Mr. Russell has been repair- ing radio sets for 20 years, it is evident that he has no conception of the difference between power amplification and voltage amplification.

In designing an amplifier for hearing-aid work, the object to be attained is voltage amplification. The minute voltages generated by the most sensitive hearing-aid amplified so greatly that such high sensitivity will be obtained. Such a device is then suitable for the use of a near-deaf person.

Of course, there are some people who are practically stone-deaf. Many of these people like to refer to themselves as "near-deaf." Presumably, Mr. Russell falls into this category. Such people have no use whatever for a sensitive hearing-aid. They turn on a 10-watt amplifier full blast, put their ear in front of the loudspeaker and complain that the outfit does not have nearly enough volume to be of any real service to them.

Such people need great power amplification. They require an amplifier capable of delivering large amounts of power to the translating device. In such amplifiers, the A.C. plate current of the last tube must be large so that sufficient power is delivered to actuate the speaker or earphone with plenty of volume.

Of course most nearly stone-deaf people (near-deaf) know very well that a power amplifier is what they need. The answer that Mr. Russell says "Hearing is the objective, not size. Too much emphasis has been put on size."

He then answers his own question by stating that the customer wants an 'aid' that can be concealed. In the case of the nearly stone-deaf person, the hearing-aid cannot be concealed, but in the case of the average hard-of-hearing person, the hearing-aid can be concealed to a great extent and therefore it should be, especially as most persons so afflicted are extremely sensitive regarding their infirmity.

Mr. Russell's unwarranted attack upon the profession furnishes further evidence of his lack of knowledge. In his opinion, a man who has spent 20 years fixing radio sets is far better qualified as a hearing-aid specialist than a man who studied 6 years at a university, specializing on the structure and troubles of the human ear. A man who opens years after graduation servicing his fellow men to bring them better hearing.

Mr. Russell considers the carbon microphone "radio physics." Yes, that is his course, that is his privilege. He also thinks that the magnetic earphone is much better than the crystal earphone. As he so quaintly phrases it, "He (Mr. Russell) doesn't get around to speak why and what he means by "it," but if he means that the crystal lacks sensitivity in comparison with the carbon microphone or the radio-phonograph cylinder, there is no need whatever to tell him that this is not the case. The crystal is far more sensitive than either of these devices.

ALFRED A. GHIRARDI

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ALFRED A. GHIRARDI, the author of these books is one of the foremost writers of practical radio texts and is an outstanding authority on radio instruction. His wide experience as a radio engineer, radio instructor, radio magazine editor and technical consultant to many prominent radio manufacturing firms and servicing organizations has built up for him an unchallenged reputation of radio knowledge that is reflected in these three books. Every one of them is acclaimed as being outstandingly superior to anything in its field. They have never been equalled in thoroughness, and the ability to make every phase of the subject clear and easy to learn for the average beginner, that is why they are the favorites of radio beginners, servicemen and experts alike. This is as solid a basis as the main texts in the basic radio theory and servicing courses of every radio school in our English-speaking country in the world. They have had to be "taught" to such advantage.

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NAME

ADDRESS

SEND for FREE illustrated literature describing the school.

WILLIAM WILLIAM

205 West Wacker Drive

Chicago, Illinois

www.americanradiohistory.com
magnetic earphone, I leave it to your readers to judge as to the extent of his technical knowledge.

With further reference to the sensitivity of the "Microphone Tube Audio Amplifier" which I described in the October, 1940, issue, I might remind you that I demonstrated this amplifier at the recent Hi-Fi-Craft and showed them that it was possible to hear the ticking of a high-grade watch more than a foot away from the microphone. In fact, everyone who listened to the performance of this amplifier was amazed at its extremely high sensitivity.

Incidentally, practically all the well-known manufacturers of high-quality deaf aids are now turning out compact hearing aids using—guess what—miniature tubes and crystal mikes. It certainly looks as though the whole world is out of step but Earl.

H. G. Chin,
New York, N. Y.

RE: "BURGLAR ALARM"
Dear Editor:
I'm just a beginner in this popular business of radio and maybe I'm all wrong. In your January issue of Radio-Craft in the "Shop Notes—Kinks—Circuits" section there is a diagram for a very good burglar alarm. The problem is, wouldn't it be a transformer always be using current? Why not connect the "tripping" device in the primary of the transformer? Then there would be current being used while the alarm was disturbed.

Am I wrong? If so I would appreciate the help of all who can show me why I'm wrong. (No pun intended, Mr. Kunts.)

Joseph C. Sever
Forest City, Pa.

You are not entirely wrong. The method you suggest will work, but generally is not preferred. The reason is that your method requires high voltage (110V.) being carried through long leads from the transformer to the metal gate. This in itself is a disadvantage and probably against the safety code of many localities. Then, too, a high voltage had to be broken at the gate contacts, resulting in excessive sparking. Finally, there would always be the possiblity of a spark jumping the metal gate which would prove dangerous to any person touching it. Mr. Kunts' method is safe all-around and the generally accepted one.—Editor.

LIKES "RADIO-CRAFT"
ALMOST VERY MUCH
Dear Editor:
Speaking lightly about the Radio-Craft magazine as a whole, I find it always interesting and worth more than its price. I like very much each and every article published in the magazine, especially of Messrs. A. C. Shanny's, Sprayberry's, etc. I like also the way you "told" the story. Your present way of binding is a very cheap one good only for 5-cent magazines. I hope that someday you would give back the magazine its former way of binding.

By the way, I wish to know if the kink of Mr. James Allen, appearing in the Radio-Craft for the December issue, page 225, is appropriately illustrated.

I am a subscriber to Radio-Craft for about 3 years and am determined to stick always to Radio-Craft. My only regret is that i wish I had subscribed to Radio-Craft much earlier. (Thank you!—Editor)

Michael Madriadian
Sta. Cruz, Manila, Philippine Is.

The binding of Radio-Craft was changed for a good reason. "Handiness" is the am-

suer. It has been found that a technical magazine or one that is often referred-to opens better with the present binding because it ties flat. Most of the radio magazines are now bound in this fashion.

Incidentally, we would like to point out to Mr. Madriadian that not only be magazines using this binding. There, for instance, Life, a 10c magazine, and more important than this—The Reader's Digest, a 25c magazine, with the identical binding, appeared with the largest circulation in the world!

James Allen's kink on "Locating Breaks in Leads" appeared in the Oct. 1940 issue with the wrong illustration. The illustration shown there was for an "Improved Beat-Frequency Oscillator" published in the November issue.

The illustration for James Allen's kink is so simple that we did not think it necessary to run it as a correction. It merely consists of a 1,500 V. transformer, the primary of which is connected to the 110V. A.C. line and the high-voltage secondary terminating in well-insulated test leads.—Editor.

THE VERSATILE AMPLIFIER
Dear Editor:
I am attempting to build the "Versatile Amplifier," described in the Oct. 1940 issue of Radio-Craft, as a hearing-aid for a friend of mine. He now has one of the old type using a carbon mike and bone conductor. He said the bone conductor gave him better results with that type, but far from satisfactory. What I want to know is what would be the best way to improve the sensitivity of a bone conductor if the Xtal Phones prove unsatisfactory.

J. W. Baker,
Kansas City, Mo.

This letter was sent to the author whose reply follows.

In order to couple the bone conductor to the output of the amplifier in place of the crystal phones it will be necessary for you to obtain a coupling transformer having a primary impedance of 8,000 ohms and a secondary impedance which will match that of your bone conductor. Naturally, the primary of the output transformer will be in the plate circuit of the 154 tube.

H. G. Chin,
New York, N. Y.

LIKES OUR SIGNAL CHASER
Dear Editor:
We built the signal chaser shown in the Sept. issue of "R-C." It performed better than our expectations of it were. It was built into a case which measured 10½ inches high, 9 inches wide, and 4 inches deep. The only changes were in using a 524 and a 1,700-ohm speaker field.

The tuning eye failed to close at first. After we changed the "B+" lead from plate to target the tuning eye operated OK from then on. So we came to the absolute conviction that the "B+" lead was shown connected to the wrong terminal on the 6ES.

This is our first trip into the Mailbag.

If you have any all-wave signal generator circuits that are as good as that of the Signal Chaser, send them along in the R-C.

So long, and thanks for all the help on the Signal Chaser and Radio-Craft and, we hope, a signal generator.

Pascal Bros.
Radio Services
Bloomington, Ill.
A "P.A. BROADCAST"

How do you do, Gentlemen of the P.A. Audience: This is Stanley Dowgiala speaking to you over Station PAS (Public Address System) and bringing valuable information to all you P.A. men to help you get better P.A. jobs.

On October 12, 1940, at 8:30 P.M., the Democratic National Committee in Jersey City sent a P.A. system to me. I installed this on their decorated truck and their meeting began. Many speakers had spoken and it came to my attention that the President was speaking on the air, so I notified the chairman and he announced the surprise to a large audience.

In the meantime, I got a small A.C-D.C. radio set, with a built-in antenna, and I tuned-in the station. I waited for the President to speak while the meeting was going on. Then I used a special dynamic mike and relayed the President over the P.A. system. I merely put the mike close to the radio loudspeaker, tuned-in the radio set full-volume, and then the P.A. system at 9 P.M. The President was heard distinctly for over 3 blocks and the people were amazed at how it was done. It also won me a tip and many favors. I made the President speak for himself at that meeting. Some of you gentlemen ought to try it sometime.

I also rent my P.A. system for bus rides and supply them with recording music. I also run dances sometimes at a charge of 25c a couple and also use records. Then again, I am called out to weddings to play records. I buy all types of nationally-sold records. I cover the political meetings every year from October to election. Many clubs invite me to play music for them at their meetings or other affairs. I also cover theatres for special occasions such as anniversaries, prizes, amateur hours, etc., and have installed many in theatres for their own use. I always use the equipment I bought from me. I even had an application from a Funeral Parlor to install equipment for a special occasion and to play organ music for special funerals when their equipment went haywire. I mix with all types of people. My business name is: The Society Radio and P.A. Service.

Always remember this: never try to get rich fast; and, treat your customers with respect. Give them what they want: always satisfy or they will be richly rewarded. Remember their recommendations get results. Be honest in your work and most of all, earn the trust of your personality and smile to people. Most of all, advertise your business by printing your name and address on your P.A. speaker cases and carry some of your business cards with you.

I hope all of this information is of value to you as it is to me. This is Stanley Dowgiala now signing off, and wishing you the best of luck.

Stanley Dowgiala, Jersey City, N. J.

LIKES OUR NEW BINDING . . . ALMOST

Dear Editor:

Recently I visited the Buhl Planetarium in Pittsburgh. There I saw an experiment on Cosmic Rays. I would like to know what is known about these rays to date, their effect, and the simplest circuit diagram of the receiver used to receive them. (*)

May I go on to say (changing the subject) that I very much dislike the present method of binding.

To better appreciate my opinion, slightly dampen thumb and forefinger. Place magazine between these with stitch about ¼-inch away. Now twist thumb and forefinger. The cover will tear away from the stitch just as it would if you have a few dozen magazines in a pile on a high table and they fall on to the floor. Magazine sliding on magazine with disgusting results.

Now take the old binding and give it the finger test. The binding will not budge. All of my old magazines have their covers. Many of the new type do not. A big advantage of the old type is that it has an index on its edge. I think it's about time to get back to the good binding.

Andrew M. Elliott, Ingram, Pa.


May we refer the matter of binding to the reply given in this issue to Senor Madridino.

FROM PORTLAND TO PORTLAND

Dear Editor:

On page 638, of the May, 1940, issue of Radio-Craft, is a problem (No. 159), submitted by Mr. Ettinger of Portland, Pa., telling about the trouble he was having with code interference on the broadcast band of a receiver. The description of the type of interference and given by him, brings to mind a quite similar happening that I experienced a while back. The answer given by you, to his trouble, in my estimation does not present a solution to his problem. My reason for contesting you is best explained by the following relation of my experience in question:

In June, 1940, while aboard the S.S. Aloma Kea off the Pacific Coast of Guatemala, a small Emerson receiver (I don't recall the model number, but it was an A.C-D.C. 5-tube model of about 1939). It was one of those whose cabinet was mounted in an extra stand to tip the whole receiver back in order to gain a better view of the dial from above) suddenly began bringing in London, Berlin, and other 49-meter stations on the high-frequency end of the standard broadcast band, in the vicinity of 1,400-1,500 kc. At the same time, semi-local standard broadcast stations (among them 70Q in Quezaltenango, Guatemala) were coming through as well, at their proper places on the dial.

There was no shortwave band on the receiver, merely the single-band standard broadcast. The mixing-up of 49-meter shortwave signals and standard broadcasters resulted in a rather serious mess of image whistles. Images, involving the 3rd-harmonic of the high-frequency oscillator, is what I took them to be. My explanation was:

Suppose the receiver used a 460-kc.-I.F., and the dial was set at 1,400 kc. Then the I.F. oscillator would be working at 1,860 kc. The 3rd-harmonic of the I.F. oscillator at that time would be 5,580 kc. Then a signal 460 kc. higher, or 6,040 kc. would appear as an image on the original 1,400 kc.

And that's just what happened. The 49-meter stations were held long enough, and with plenty volume, to identify them and establish the frequency. The ship's radio operator, when told the receiver was bringing in London on the broadcast band wouldn't believe it and had to come aft where the receiver was, and operate the controls himself, before he'd be convinced. He brought in London, Berlin, and several code stations which he identified and knew their (Continued on page 648)
SERVICEMEN SAY:  For Bigger Profits—
For Better Servicing—USE GERNSBACK MANUALS

Since 1931 more and more Servicemen have been buying GERNSBACK OFFICIAL RADIO SERVICE MANUALS year after year. The authentic material, easily accessible diagrams and complete service data make them invaluable to dealers and radio Servicemen. Without a Gernsback Manual with you on a repair job, there's time and profit lost. Your service kit or laboratory is incomplete without all the GERNSBACK OFFICIAL RADIO SERVICE MANUALS. There are GERNSBACK MANUALS also for servicing auto-radios, refrigeration and air conditioning equipment.

1935 OFFICIAL AUTO-RADIO SERVICE MANUAL

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Here is the volume which shows a step-by-step analysis of how to service any receiver. It is one of the early editions and covers many old sets, thousands of which are still in use throughout the country. OVER 1,000 PAGES  OVER 2,000 ILLUSTRATIONS  Flexible, Leatherette, Looseleaf Covers  Size 9 x 12 Inches  Net Weight 4½ lbs.

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1936 OFFICIAL RADIO SERVICE MANUAL

Just packed with service data of sets manufactured during 1935 and 1936. Schematic diagrams show speaker connections, power-transformer connections, r.f. and i.f. coil connections, phonograph connections and other information. OVER 1,200 PAGES  OVER 1,800 SETS SHOWN  OVER 2,500 ILLUSTRATIONS  Index of Trade Names  Complete Tube Chart  Stiff, Leatherette, Looseleaf Covers  Size 9 x 12 Inches  Net Weight 8 lbs.

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Volume 2

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This manual is edited by L. K. Wright, who is an expert and leading authority on air conditioning and refrigeration. Nearly every page is illustrated, every modern installation and individual part carefully explained, diagrams furnished of all known equipment, special care given to the servicing of installation end. Necessary tools are illustrated and explained, etc. OVER 352 PAGES  OVER 600 ILLUSTRATIONS  Flexible, Leatherette, Looseleaf Covers  Size 9 x 12 Inches  Net Weight 2½ lbs.

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... novelty radio sets if they also have utility will be more marketable

It is an established fact that among the 35 million odd radio receivers in use in America today there has always been an excellent market for so-called "novelty" radio sets. For years, there have been crops of odd radios, many of which were designed primarily with the idea of novelty, and their appeal for sales was based mainly on novelty rather than utility.

Years ago, in his magazine, SHORT-WAVE CRAFT, the writer designed what was then the first briefcase radio. It was described in the June, 1932, issue of that magazine. It was completely self-contained, including loudspeaker, built in an ordinary briefcase. Many experimenters constructed this set from the design given at that time. It took the radio industry exactly 6 years to catch up with this idea; subsequently they were manufactured in quantities and still are. Here was a novelty set which at the same time had utility. Nor was it a freak set.

Of course, there have been many novelty sets and every month brings numerous new ones. To mention only a few of them, we have had globe sets where the radio receiver was installed inside a terrestrial globe. We have lamp radios where the radio set is contained in the foot of the lamp, the shade being the loudspeaker. We have had book radios; and bed radios combined with lamps. We have had radio sets where the casing was made entirely of plate-glass mirror. The list is really endless. Some of these sets come and go; others have a certain popularity which is maintained for many years.

The writer here wishes to make the observation that constructors who have sudden inspirations as to either novelty or utility radio sets often rush into production without consulting a stylist. This is a very serious oversight. In every instance where a radio set is designed to fill a void, the most important design deficiency of these sets is the radio set, no matter how good, will fail by the wayside and can never attain a real sale unless it is not only designed right but is styled right.

Nevertheless, few radio constructors are stylists. They may know all about radio but do not understand what pleasing lines and what decorative effects or modernistic touches should be added to make a radio set a fast-selling product. It takes an artist and a talent to do this and if he has the knack for this sort of thing, he should be left solely alone and allowed to do the designing. It is one thing—to give a homely analogy—to be a good manufacturer of felt but quite another to be a good fashion modiste and make a beautiful hat from a common piece of felt.

There should also always be a distinction between the gag novelty type of radio set and well-styled utility-novelty type of set, the latter usually will sell well whereas the former will not.

There are as many number of utility radio sets which as yet await big markets—believe it or not. By utility, I refer to a radio set that not only performs as a radio set but has a separate utility in addition. There have been, for instance, a number of clock radio sets. Here we have the utility of a time-piece combined with radio. The great trouble with these sets has been that the clock usually has been of inferior quality. Usually such clocks are not self-starting and if the current is turned off momentarily, the clock stops and must be hand started. The best utility idea of these sets is the type where the clock can be set by means of a mechanism that will be turned on or off at a pre-determined time. Thus, many people dislike alarm clocks but like a clock-operated radio which turns on at a given time in the morning and wakes them up by pleasant music rather than by a shrill alarm. Again, the manufacturers of these devices have fallen far short, in that with few exceptions, the time-setting device is difficult to manage and is not reliable. We know of several of these types which we had in our own home and which tended to go off at the weirdest hours of the night, waking us up at the wrong time, mainly due to faulty contacting arrangements.

But the most stupid part of such devices is that clock makers still persist in believing that the day has 12 hours instead of 24! Rather than making 24-hour clocks, they give us 12-hour clocks. So if we set the alarm for 7 o'clock in the morning and the radio robot dutifully wakes us up, at that hour, it will just as dutifully go off at 7 P.M. with no further ado. That means that we have to hand-set it in some way and that is a memory that morning it will be set right or we will oversleep. A 24-hour clock with half of the dial dark, and half of it in a light color, is the answer to the problem. Then if a cheap clock mechanism with a good time-setting device that can be easily is produced, many radio manufacturers no doubt will adopt it.

Speaking of utility sets, I can think of any number of these but I will only give a few examples for which I know there will be a good market. There is for instance, to the Lady's Boudoir Radio, small but stylish, with modern perfume bottles at each side and other attachments of use to any woman, of which there are many. For the he-man, I can readily imagine a Den Radio which we might call Smokers' Delight. It could be a robot, like the old-fashioned, but the radio set has pipe holders on each side to hold a number of pipes conveniently. There can be an electric lighter with cord attached, ash tray, even a cigarette drawer or case can be provided for. If styled correctly, it will sell well.

Some years ago, I designed an Executive's Desk Radio which has on top a lamp with a green shade, pen and pen holders on each side, and front space for clips, pencils, etc. There was also a clock provided on the face of the radio set. It was described in Feb. and March, 1937, Radio-Craft. This was a project for home construction, and for this reason, it was of course not styled properly. I still believe if styled right there is a market for it.

Most midget sets in use today can be provided with an attractive lamp on the top for very little additional cost. It seems rather strange that the midget-set manufacturers have not turned to this Midget-Lamp Radio utility so far, but rest assured sooner or later, they will.

Then there is the Kitchen Radio. Here we also need a clock arrangement as the woman of the house needs a timer which will turn on either the radio set or an alarm when a given time is up so that the roast or the cake will not burn or get overdone. There could be, in addition, several pencil holders; also a place for a recipe book and one of those gadgets dear to every woman's heart—a mechanical list of what to buy.

And for the bedroom, we need a good Bedroom Radio done in the modern manner, which should have a clock arrangement to wake you up in the morning. It can be provided handsomely with a night-light on top of the radio receiver which can be used wherever wanted. Many people like to sleep with a small neon night-light and this is easily included as utility on a midget set. Then the male member of the household who always thinks of something during the night, can easily use a memo pad which is also incorporated into the set. This can be lifted from a small rack, molded into the casing and at the same time, you pull out a pencil which has a tiny electric light at the end. You write your memo without turning on any light in the room except for the stream of light directed against the end of the pencil while you write.

Then going to the children's room, we can have the Children's Radio set made in gay colors, to be sure. They are even being made now. BUT we provide them with the following utility: a savings bank can be incorporated readily into a midget receiver which does not operate unless you put in a nickel or a dime, when it will play for a determined number of hours, say 3. This is a simple utility, that will appeal to children and parents alike, and will provide another good radio seller.
**THE RADIO MONTH IN REVIEW**

The "radio news" paper for busy radio men. An illustrated digest of the important happenings of the month in every branch of the radio field.

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ABROAD

Death snuffed out the lives of 7 members of the British Broadcasting Co.'s staff at the B.B.C. Headquarters in London, last month, when a Nazi bomb traced its lethal path into the building during a broadcast.

The Associated Press reports that, according to the "Princeton (N. J.) listening center" Germany in recent months has been using an increasingly intense propaganda war against the U.S. via S-W. radio.

A U.P. report from Alexandria, Egypt, mentions the use of a "secret weapon" in an air attack against the Italian Navy;

in the opinion of the New York Daily News it may be the "Queen Bee flying torpedo." The only authoritative advice which Radio-Craft has to report on these Queen Bees— and this readers will recall—is the use of these radio-controlled airplanes as robot gunnery targets. The News gives this data on their type of construction: biplane, about 18 ft. long and 20 ft. span.

From China comes an A.P. report that the broadcast of one of President Roosevelt's fireside addresses over XHMA, American station in Shanghai, allegedly was jammed by Japanese interference.

An issue of PM newspaper, last month, uses a column to tell how C.B.S. recordings of B.B.C. broadcasts show that an English nightly program to America aims to de-bunk German broadcasts.

The proprietor of a bar in Padua was fined 25s. and had to park a month in jail, for listening to a British news broadcast, A.P. reported from Rome last month.

A U.P. report from London tells of the execution last month, at Pentonville Prison, of 2 German spies caught with a portable radio transmitter said to have been intended to be used to send information to Germany.

The current hit show "The Corn Is Green," was broadcast to its author in London because the wire presented his seeing the show in New York, columnist Charles A. Wagner last month reported in The Mirror (New York).

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DEFENSE

A Merica's defenses were strengthened last month when Major Edward ("Amateur Hour") Bownes passed over to the Navy full title to his 61-ft. yacht Edmar, and 30-ft. light-cruiser Edmar, Jr.

Radio amateurs, who may have occasion to contact the War Department, now can call the Department's radio net control station W.A.R. Frequencies for amateur contact are: 4,025 mc., 5.5 to 4. mc., 15.35 mc., and 14 to 14.4 mc.

Chairman Stephen Voorhees of the Advisory Board of Industrial Education last month urged radio manufacturers in the Metropolitan area to aid employees to obtain the free instruction being given by New York vocational schools, in radio servicing, code, and theory.

Last month the American Radio Relay League announced the appointment of a representative and 6 regional advisors to the Amateur Radio Committee of the Defense Communications Board. Other groups represented on this Committee: Federal Communications Commission, Army, Navy, and the National Youth Administration.

Commercial cooperation in the Defense Program includes the following: Crosley...
Radio Corp. has opened an office in Washington, D. C., to speed production by better cooperation with Government depts. . . Air Radio and Instrument Co. is conducting special classes designed to train enrollees for defense jobs paying $125 to $200 per mo. . . National Union Radio Corp. has agreed to give a month's salary, carry group insurance, and re-employ staff members, who join the Colors voluntarily or by draft. . . Hygrade Sylvania Corp. will carry the group insurance of its enlisted employees, will re-employ them, and in addition to giving a month's salary to 1-year enrollees, offers an additional, equivalent sum to enrollees for 3 to 6 years' Service in the Army or Navy. . . In a full-page advertisement in newspapers, last month, American-owned and American-controlled R.C.A. called attention to the manner in which its 27,000 employees are serving in the Defense Program.

SOUND

ONE of the newest uses of Public Address systems: a "drive-in" church, in St. Petersburg, Florida, where patrons remain in their car-seats and honk their "Amen’s."

"Cavalcade of America," special recordings of 12 outstanding historical dramas, is available at nominal cost to schools from the Association of School Film Libraries in New York City.

Each jar of Dorothy Gray, Ltd., Throat Cream now has packed with it a 2-sided transparent phonograph disc. Played-back, it spouts instructions.

Latest idea by Muzak for getting its advertising-free music into private homes, profitably (for Muzak), involves the use of an "injector box" which connects to the master antenna of apartment houses. Apartment leasors merely tune Muzak’s wave-length for all-music programs; and perhaps pay a slightly higher rental.

F. W. Woolworth’s Xmas attraction (at its Church and Vesey St. store in New York City), a Talking "Santa," deserves special mention. An interphone system enabled a remote commentator to listen-in, via a transducer (loudspeaker possible as a microphone) concealed in the body of a 3-foot-high Santa Claus doll, to comments of persons who came upon the figure, unexpectedly, at the foot of a flight of stairs, and to startle the natives out of their wits by a well-put quip or two; or even to hold a conversation from his place of concealment on another floor, with the more hardy customers who ventured to reply to leading questions, as for example the old stand-by: "And what would you like Santa to bring you for Christmas?"

Bell Telephone Laboratories last month was granted Patent No. 2,321,856, by Arthur E. Schuh, for a "soap" that greatly reduces grain noise in sound-recording wax "motheres." The usual crystallization of the recording wax is eliminated by the "soap," a compound of steric acid, montan wax, sodium carbonate, and basic lead carbonate, the New York Times reported.

The "Statewide Telephone Meeting" of the New Jersey Bell System, last month, brought 14,000 Company employees together in one huge family to hear President Barnard deliver a holiday message. Employee groups in a total of 17 municipalities were joined by the copperwire network; terminal equipment included 60 loudspeakers and 40 amplifiers that enabled all to hear the State-wide roll call and ensuing program, all directed from the Mosque Theatre in Newark; station WOR aired part of the program over the Mutual broadcast net.

NEW ELECTRON MICROSCOPE

The new streamlined version of the RCA Electron Microscope, shown here, was demonstrated to the Institute of Radio Engineers last month. Magnifying up to 100,000 times, it exceeds by 20 to 50 times the magnification possible with any optical microscope; instead of glass lenses it uses lens-effects obtained electronically. The Gold Medal of the American Institute of the City of New York, is scheduled to be given to Dr. Wendell M. Stanley, in February, for his work in demonstrating the properties of the "tobacco mosaic virus," a particle (seemingly neither molecule nor organism) so tiny it is invisible except to the Electron Microscope.

POLICE 2-WAY VESSEL RADIO

(Cover Feature)

New York City's Police Commissioner Lewis Valentine (left), and Mayor LaGuardia, help Policeman William Proctor modulate the 2-way vessel radio set developed by Gerald S. Morris, Supt. of the Police Telegraph Bureau. Cost: $115; range, about 100 ft.; weight, about 11 lbs.

Photo—Wide World Photos.

"HEARING" RUBBER IMPURITIES

The above photo shows the set-up in Bell Telephone Laboratories for testing the dielectric properties of "pigmented" rubber containing not only coloring matter but also fillers and reinforcing agents. A capacity-inductance bridge and D.C.-resistance galvanometer are used in testing measurements.

BONE "HEARING" TEST

An important part of the work of the New York League for the Hard of Hearing, Inc., is the giving of hearing tests. The "Bone conduction" test of this little girl's hearing has just been completed and the verdict is: OK!
NEW CIRCUITS IN MODERN RADIO RECEIVERS

In this series, a well-known technician analyzes each new improvement in radio receiver circuits. A veritable compendium of modern radio engineering developments.

F. L. SPRAYBERRY

(Fig. 1.) INDIVIDUAL DEGENERATION APPLIED TO PHONO PICKUP CHANNEL

EMERSON Model ET.—A degenerative circuit couples the speaker voice coil to the (crystal) pickup so that the degenerative action applies over the entire pickup channel without regard to any other means used in the A.F. amplifier alone.

It is well known that every component in the signal circuit is capable of contributing something to the harmonic content or distortion of reproduction. Hence by including every possible item in the electrical part of the signal circuit within the degenerative action it is possible to minimize the distortion to the greatest degree. The circuit shown in Fig. 1, as applied to the pickup has a special advantage, in that it greatly improves the linearity or “flatness” of the audio response. In this way the attenuation of high frequencies due to the pickup would be compensated-for to some degree.

(Fig. 2.) DIRECT “PHONO” CONNECTION MADE IN SMALL RECEIVER

RCA Model 10X.—The phonograph jack is wired permanently in the 1st audio input requiring no switching to change from radio to phonograph operation.

For phonograph operation the phono terminals are simply plugged into the jack and the radio tuner is detuned so that no signals will be received. The radio volume control with the usual grid coupling condensers then serves as a tone control and the volume must be controlled at the pickup unit. The circuit is shown in Fig. 2. Provided that the pickup circuit makes use of a high series resistor, the pickup need not be removed from the circuit for radio reception because the grid circuit is not shunted with too low an impedance for satisfactory volume.

(Fig. 3.) RECTIFIER ELEMENT USED AS FLOATING FILAMENT STABILIZER

SILENTONE (SEARS, ROEBUCK & CO.) Model 6721 and 6761.—One of the elements of the power supply rectifier (2S26GT) is placed in series with the filament system thus acting simply as a series resistor and having slight voltage regulating qualities.

This circuit represents an improvement in efficiency as the 2 rectifier elements are in series thus reducing slightly the resistance required in series with the filament circuits. Moreover the resistance changes in the plate circuit of the rectifier element in the filament circuit as in Fig. 3, are in the same direction as the voltage changes, that is, they both increase and decrease at the same time. This, of course, tends to stabilize the current in the circuit, makes the voltage at the filaments easier to filter, and permits a much simpler connection for battery operation.

(Fig. 4.) VARIABLE TREBLE AND BASS COMPENSATORS AS TONE CONTROLS

STEWART-WARNER Models 118D1 to 118D9 and 118D1-Z to 118D9-Z.—By-passing the high frequencies across the upper section of the volume control by means of condenser (1) in Fig. 4 provides high-frequency compensation. Varying the impedance to the top of the volume control by means of a potentiometer (67) permits continuous control of the treble range of response.

As the condenser section (53) of the bass compensator is made more or less effective by means of another potentiometer (68) the degree of bass compensation naturally changes. As the impedance across (53) reduces, the ratio between the high and low frequencies becomes more nearly normal. This same adjustment increases the impedance from plate to ground of the 1st A.F. amplifier and reduces the phase angle of this impedance (68 and 68) practically to zero so that there is little or no frequency discrimination. Thus tone is controlled by 2 potentiometer actions acting on different parts of the audio spectrum.
SERVICING

OPERATING NOTES

Trouble in...

CROSLEY MODEL 159—32-VOLT RECEIVER

When one of these come in you can bet your shirt (almost) that it will be one or more of the common ailments that we have usually found. Squealing and oscillation, while tuning, is usually due to the 8-mf., 200-V. condenser in the chassis (vibrator unit is separate from chassis). This is connected from "Bi-" to ground. Loss of volume and tone is caused by the 6-mf., 25-V. condenser connected from the type 43 tube cathode to ground when replacing these open condensers use types of a higher voltage rating. Common too is the need for setting-up the vibrator points after they have been in service for about 3 years. The vibrator is of the synchronous type, and usually, it will be found that with a little filing the points can be adjusted again by means of the adjustment nut provided.

ALL 2-VOLT SETS USING ON-OFF SWITCHES THAT GROUND THROUGH SHAFT

A common fault in these sets is intermittent fading, and then tuning out at intervals of about a minute, after the volume has been turned up. The shaft becomes a poor conductor to ground on these switches, after they have been in use for a year, due to oil and oxidized metal. Best repair is to solder a pigtail connection from the movable switch arm to ground directly. These switches usually ground the "A-" battery lead and the "B-" return (which is through a bias resistor).

1937 PHILCO FORD RADIOS

A common complaint in this sets is no reception, or possibly, reception of only 1 strong local station. This complaint usually comes in after a heavy rain! If you remove the front cover of the machine you are usually greeted by a shower of water. The whole trouble lies in the fact that the cowl ventilator rubber gasket becomes "dead" on the 37 cars and allows water to leak in which will run into the set through the small holes in the back cover. The set and the bulkhead of the car form a natural trough. The holes mentioned are seats for grounding straps on the inside of the cover.

The remedy I used was to remove the set, dry it out very thoroughly, realign, and then before installing, scrape the paint away from around the holes on the back cover and solder the holes shut.

M. C. TURNER, Langdon, N. Dak.

ATWATER KENT 55

If this set is "dead" and no click is heard when the 37 A.F. driver is pulled out of its socket, check for an open cathode resistor (shown in sketch).

WILLARD MOODY, New York, N. Y.

MDIGETS [Using 352SGT Rectifier]

When the set is inoperative and the pilot light burned out, replace the 352SGT before replacing the pilot. This tube has a tapped heater, which furnishes voltage for the pilot. One side of the heater often burns out, thus placing a high voltage across the pilot light, and burning it out instantly.

THOMAS PREWITT, Plainfield, Ind.

STEWARD-WARNER (models 5R4, 5R5, 5R6 and 5R7)

Increasing sensitivity of 5R chassis in wood cabinets. In those locations where extreme sensitivity is necessary in a radio set, the 6X wood cabinet models (5R4, 5R5, 5R6 and 5R7) can be stepped up by the introduction of a slight amount of regeneration. This change can easily be made as follows.

Disconnect the 0.05-mf. condenser No. 23 from the suppressor-grid terminal of the 12SK7 socket. In the Underwriters-approved sets (model 05-5R, etc.) connect it instead of the "B-" terminal of the volume control. This is the terminal nearest the 12SQ7 socket, and is clearly indicated in the tube socket layout of the service manual. In non-approved models (07-5R, etc.) connect condenser No. 23 to ground.

After the condenser change has been made, re-adjust the receiver. It is especially important to re-adjust trimmer No. 9, the broadcast oscillator padder, exactly as explained in the service manual. When align-

ZENITH (Chassis 5709)

I recently had this model in for service with a complaint of weak and noisy reception and the tuning eye 675 also did not work.

I first checked the 6TS socket and found the 1 meg. resistor between the plate and target grid. Replacing the resistor only caused the eye to work very weakly on a strong signal. I next checked the A.V.C. resistors and condensers and found them OK. The rather unusual trouble was found in a leaky coupling condenser that connects the antenna coil with the presselector coil. (Note that this is not the 1st R.F. coil.) Replacing this condenser with a 0.00025-mf. mica condenser completely cured the trouble.

The defective condenser is white and looks like a resistor, and is mounted inside the presselector coil.

C. R. PRESTON, Grafen, W. Va.
FLUORESCENT LIGHTING

Latest Sideline for Servicemen

This is the 2nd in a series of articles on fluorescent lighting as it applies to the radio Serviceman. Part I in the January issue deals with the theory of these lamps, their characteristics and the circuits used in their application. Part II, presented here, pays special attention to the interference which may be created in radio receivers by the mercury arc between the lamp electrodes; and to means of combating this interference.

PART II

RADIO INTERFERENCE

JOHN T. BAILEY

EVERY wide-awake radio Serviceman is on the watch for new fields of service from which he can derive some extra revenue, provided that these new fields do not require him to buy new test instruments, stock special parts, interfere with his regular work schedule, require too much study in some phase of electrical work inharmonious with his present knowledge and experience in the radio or electronic field.

BUSINESS PROSPECTS

The suppression of radio interference is an activity that the Serviceman has accepted as his legitimate professional responsibility, and since he is well qualified by experience in this field and has the necessary equipment to cope with this problem, it is natural that the advent of new electrical devices, oil burners in the past, electric razors recently and new fluorescent lamps, should mean added business for him.

The public has been quick to recognize the many benefits of fluorescent lighting, the result being that new lighting installations are being installed everywhere. Inasmuch as fluorescent lighting is a new and specialized method of producing illumination, the sale of fluorescent equipment may best be left to experienced representatives of the lamp and fixture manufacturers but after the installation is made there may be a few instances, such as in restaurants, night clubs, stores, residences and similar establishments where artificial illumination and radio are desired simultaneously, of radio interference complaints. This is the opportunity for the radio man and although the revenue from this work may not justify its solicitation, it will no doubt lead to future radio repair and sales work.

MERCURY-ARC INTERFERENCE

It is well known to all radio Servicemen that when a circuit is interrupted, the spark generated will oftentimes create a frying sound in nearby radio receivers. A fluorescent lamp when operated on 60-cycle alternating current is, by the nature of its operation, turned on and off 120 times per second. The mercury arc established between the lamp electrodes causes sparking at the electrodes where the circuit is interrupted, thus giving rise to radio interference which may be radiated in one of 3 ways:

(1) Direct radiation to antenna or lead-in from lamp bulb.
(2) Direct radiation to antenna or lead-in from power line supplying lamp.
(3) Line feedback from the lamp to radio set by way of power line.

Oftentimes, interference may be traced not only one of the above-mentioned forms of radiation but may be found to come from a combination of any or all of them.

While the fluorescent lamp can justly be praised for the efficient way in which it transfers ultra-violet energy into visible radiation for the use of the human race, it should be reprimanded for shifting a small amount of energy into that part of the spectrum which we would like to have free for radio reception. A graph plotted with relative interference against frequency would reveal that the broadcast frequencies from 550 to 1,000 kilocycles are most affected. For higher frequencies, the noise is not
usually objectionable because of the low field strength and because the energy is confined to narrow bands.

In an attempt to radiate the set up by the arc stream, during the starting period, the starter device may give rise to some electrical noise. The condenser included in the R10 (dubbed a "filter bug" by the trade because of its lively efforts to establish the arc in the lamp) to minimize noise originating at this point is quite effective and unless the condenser is defective no trouble should be expected from the starter.

To check this condenser, remove the starter from its socket after the lamp has started. If the noise increases, then the condenser is not defective. When the starter is located under one end of the lamp it may be difficult to remove without removing the lamp. In these cases, remove lamp and starter, replace the lamp and with a short, insulated wire stripped about ¼-inch on each end short the two terminals in the starter socket for several seconds. Then remove the wire and the lamp will start. If the noise level remains the same it may mean that the starter and a new starter should be tried. A shorted condenser will cause the lamp electrodes to glow without allowing the arc to strike.

**BULB RADIATION**

Direct radiation from the lamp bulb is of a particularly objectionable character as it falls off rapidly as the distance between the lamp and radio is increased. Although the magnitude of this bulb radiation varies with the watts consumption of the lamp, bulb radiation or radiation emanating from the supply lines feeding the lamp can be avoided by separating the lamp and radio set by at least 10 feet.

If separation by 10 feet is not feasible then it will be necessary to take these precautions:

1. Shield (and ground) the lead-in where it passes 10 feet of the lamp or install a noise-reducing antenna system.
2. Provide a good ground for the lamp.
3. If the radio is of the A.C.-D.C. type, an external ground is not required because the chassis is usually connected to one side of the line thus acquiring a ground potential.
4. Surround the lamp with a grounded wire-screen mesh. This, of course, can be done only in certain instances where the appearance of a screen would not be objectionable. The mesh should be large enough so as not to reduce the transmission of light materially.

For instances where the lamps are enclosed by glassware or plastic it is possible to install a screen cylinder between the glass and lamp. If this is done, provisions must be made for relamping.

(4) For radio receivers with built-in directional antenna systems, adjust the position of the radio set to pick up a minimum of noise.

**Portable, battery-type radio set is handy for bulb radiation sleuthing since the line feedback factor is eliminated by this method of probing for noise.**

**LINE RADIATION**

The power lines feeding the lamp may serve as a source of radiation to the radio set or to the antenna system unless the separation is about 10 feet as explained under the discussion of bulb radiation. The same general precautions apply about shielding the lead-in but, in addition, noise reduction can be obtained by applying a grounded shield to that part of the power line near the radio set. In many instances this is not possible because the wires are already too thin to place a shield around it or for extension cords in residences this remedy could be easily applied. If the power lines are run in metal conduit or are of the BX type make sure that good highfrequency bonding is in effect at all junction boxes.

Line radiation can be reduced also by inserting a filter in the line of the lamp. This procedure shuts the noise to ground before it can enter the line and be radiated through the air to the radio receiver or antenna lead-in.

**LINE FEEDBACK**

If noise energy is allowed to enter the power lines from the lamp, it may feed back to the radio set through its power supply circuit. This energy may never reach the radio set if the lamps are installed in the house because of the line impedance, therefore when the line is short the possibility of feedback is greater.

Line feedback can be eliminated by the use of filters either at the lamp or at the radio set. The method of filtering at the lamp may require many filters even if many lamps are contributing to the general noise level. However, if individual filters are applied to the nearest lamps, noise trouble should subside. Applying a filter at the radio receiver is positive in protection against feedback but requires greater high-frequency attenuation and probably will require greater current carrying capacity of the filters than individual filters at the lamps. As in any power line noise reduction work, inductive or capacitative filters are more effective than merely capacitative reactances, but the cost is greater.

The generation of noise radiation by fluorescent lamps is inherent in the operation of all discharge-type lamps but it is felt that as improvements are continued in the manufacture of this new light source, material reductions can be expected in the problem of radio interference.

This article has been prepared from data supplied by courtesy of Westinghouse Electric & Mfg. Co., Lamp Division.

Watch for Part III, the concluding installment, of this series of important articles on Fluorescent Lighting from the Serviceman's viewpoint.

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**SERVICING**

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**OPERATING NOTES**

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**BOOK REVIEWS**

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**PHOTOTUBES (1940), Published by RCA Mfg. Co., in size 8 ½ x 11, illustrated, 16 pages. (Single copies available gratis.)**

In "Phototubes," are given detailed descriptions and diagrams for the use of phototubes in light-operated relays, for light measurements, and in sound reproduction. Commercial types of one manufacture are illustrated, and working diagrams complete with electrical values and design data are given. This booklet is a valuable working manual for the electronic specialist and experimenters.

**PHOTO RELAYS, THEIR THEORY AND APPLICATION (1940), by F. H. Shepard, Jr. Copyright by John M. Coffen. Size 6 x 9 ins., paper cover, well illustrated, 28 pages. Price, 25c.**

The greater consumption of electronic applications and formerly industrial electronic application engineer in one of the same companies, has prepared "Photo Relays, Their Theory and Application," with a view to presenting a description, of photoelectric devices, graduated from the elements of the subject to the eventual conclusion of practical applications.

Essentially practical in its treatment, this book presents a compilation of valuable information on the use of photoelectric, cell systems, and glow discharge tubes.

Chapter I, Photocell Phenomena; Chap. II, Amplifiers; Chap. III, Glow Discharge Tubes; Chap. IV, Light Sources; Chap. V, Applications.
National Union Model W-2

5-Tube Superhet: 110-V. A.C./D.C.; Automatic Volume Control; Tuning Range 528 to 1,730 kc.; Average Sensitivity 35 Microvolts (for 0.05-Watt Output); Power Output 0.8-Watt, Undistorted; Power Consumption 28 Watts; Built-in Loop Antenna.

Alignment Procedure

The following equipment is required for aligning:

1. Signal generator which will provide an accurately calibrated signal at the test frequencies as listed.
2. Output indicating meter; non-metallic screwdriver.
3. Dummy antenna—0.1-mf. and 200 mmf.
4. Volume control—Maximum for all adjustments. Allow chassis and signal generator to “heat up” for several minutes. Connect ground post of signal generator to “B” (12SK7GT—prong No. 3) in chassis.

Signal Generator

Frequency Connection Setting at Radio Set Antenna Setting
466 KC. Signal grid 0.1-mf. Turn rotor to full open 1st I.F. (C7 and C8) 2nd I.F. (C9 and C10)
1,780 KC. Antenna clip 200 mmf. Turn rotor to full open Oscillator (C2)
1,000 KC. Antenna clip 200 mmf. Turn rotor to max. output Antenna (C3)

Note—To obtain dial scale calibration, tune-in an 800 kc. signal. The pointer should be at the 800 kc. mark on the dial. If it is not, first remove the celluloid crystal by taking out the 4 buttons at the corner. Hold the tuning knob and shift the pointer to the 800 kc. mark.

Caution

The metal chassis is connected to one side of the line through a 0.2-mf. condenser. Both A.C. and D.C. power lines are generally grounded on one side. If the side of the line not connected to the metal chassis through this condenser is grounded and the metal chassis comes in contact with an external ground, this condenser will be connected across the line and there will be an increase in hum.

Therefore, in any service work on the chassis, keep it on a wood or other insulated surface to avoid contacts with ground. The person working on the set should avoid getting in contact with any ground.

Radio Service Data Sheet


Complete schematic diagram of the National Union Model W-2, 5-tube, A.C./D.C. Loop Antenna Receiver, I.F.-456 kc.

Sketch showing locations of main components and trimmers.

Radio-Craft for March, 1941
HERE'S A BIG SAVING
for Any Serviceman Who Makes Frequent Volume Control Replacements

WHAT IS IT?
This IRC Master Radiotrician's Control Kit, factory packed with 18 Type D Universal Controls, 6 switches and 5 extra shafts of special design (1) Enables you to give better, faster service; (2) Saves time and cost by eliminating frequent need for ordering special controls; (3) Avoids frequent trips to your jobber; and (4) Helps systematize your shop by supplying a good-looking container that enables you to tell at a glance just what controls should be re-ordered. You can actually meet from 60% to 75% of your replacement needs with this Kit!

CAN I AFFORD IT?
No serviceman who uses controls frequently can afford to be without it. You pay only the standard net price of the controls, switches and shafts. The All-Metal Cabinet (worth $2.50) is included free.

DOES IT CONTAIN THE CONTROLS I NEED?
The carefully selected control assortment is based on a nation-wide survey of servicemen's needs. It includes only popular controls, widely universal in application, thanks to the Tap-in Shafts. If you find by experience, however, that, due to some local predominance of certain sets, you would prefer any other IRC Type D Universal Controls, your jobber will gladly make the exchange at any time.

HOW WILL I KNOW WHAT CONTROLS TO USE?
Included free with your Cabinet is the latest IRC Volume Control Guide. This indicates exactly what controls to use for practically all sets you may be called upon to repair.

WHAT ABOUT OBOLESCENCE?
The only things that could become obsolete are the shafts and, as fast as new shaft styles are required, IRC will have them—of Tap-in design and constructed for use with the Type D Controls contained in your cabinet.

ARE "MIDGET" CONTROLS ANY GOOD?
Don't call IRC Type D Universal Controls "Midgets"! Actually, they are small-size replicas of the larger IRC Type CS Controls—the only small controls that are exact mechanical reproductions of a manufacturer's larger controls. You can use them satisfactorily wherever Type CS or old-style larger controls have been used in the past.

WHAT ABOUT TAP-IN SHAFTS?
IRC Tap-in Shafts make controls easier to install in a crowded chassis by obviating the necessity for removing other parts. They won't pull or vibrate loose. A variety of special shafts enables you to make the 18 Controls handle an amazing variety of jobs, standard and special.

WHY HURRY?
Well, why postpone getting your Cabinet and starting to collect dividends on a good-paying investment? And don't forget the re-allocations of broadcast station wave lengths! Countless customers will want you to re-adjust their push-button tuning. Carry your IRC Control Cabinet on these jobs. You'll be surprised how many control replacement jobs you can also sell—and do the work right then and there!

WHAT'S THE BAD NEWS?
There is none! Your total investment is only $14.97 net (List, $24.95). This equips you for the big majority of control replacements—and you get the $2.50 Cabinet free. Many IRC jobbers are glad to extend easy terms and otherwise cooperate in making your IRC Control Kit actually pay for itself in the time, money and effort it saves during the first few months you own it! See it at your IRC jobber's today, or write to us for folder.

INTERNATIONAL RESISTANCE COMPANY
401 North Broad St., Philadelphia, Pa.

TYPE D UNIVERSAL VOLUME CONTROLS
WITH TAP-IN SHAFTS
**SERVICING**

303 Radio Service Data Sheet

CROSLEY "GLAMOUR-TONE" MODEL 26BB (Chassis Model 26)

8-Tube A.C. Superhet; 3 Bands [550 to 1,600 kc.; 1,600 to 5,000 kc.; 6 to 18 mc.]; Broadcast-band Built-in Adjustable Loop Antenna; Stage of R.F.; Electric Pushbutton Tuning, Variable Bass Compensation; 12-in. Speaker; Push-Pull Output; Tone Control; A.V.C.

**ALIGNMENT PROCEDURE**

Preliminary

Output meter connections: Plate to plate of 6F6s

Generator ground connection: To chassis or ground lead

Dummy antenna to be in series with generator output.

Position of volume control: Tiltile or Street

To check Inaee generator is adjusted approximately the correct frequency and not the image frequency which will then tune in the image frequency which is approximately 919 kilocycles lower than the dial. If the frequency shown on the meter is not more accurate than the funda-mental, tuning must be held to the image which is ap-

**IMPORTANT ALIGNMENT NOTES**

When aligning the shortwave bands, "OSC" trimmers can be adjusted until the circuits are aligned to the correct frequency and not on the image which is approximately 919 kilocycles lower than the dial. To check, increase generator output, tune-in the generator (which should then tune in the image frequency which is approximately 919 kilocycles lower than the dial). If the frequency shown on the meter is not more accurate than the fundamental, tuning must be held to the image which is adjusted to the wrong peak. Correct peak is the 2nd peak to trimmer from the closest position.

Repeat the original alignment procedure for more accurate adjustments. Always keep signal generator output as low as possible to prevent action of the A.V.C. circuit.

**Signal Generator Alignment Chart**

<table>
<thead>
<tr>
<th>Alignment Points</th>
<th>Dummy Antenna</th>
<th>Frequency Setting to Receiver</th>
<th>Band Switch</th>
<th>Tuning Cond. Setting</th>
<th>Trimmer Adjusted</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>0.025 mf.</td>
<td>Grid of 6A6GT</td>
<td>H.C.</td>
<td>Full open</td>
<td>H.C.</td>
<td>No. 2</td>
</tr>
<tr>
<td>2.</td>
<td>250 mfd.</td>
<td>1,650 kc.</td>
<td>H.C.</td>
<td>Full open</td>
<td>H.C. &quot;OSC&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>3.</td>
<td>250 mfd.</td>
<td>400 kc.</td>
<td>H.C.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;OSC&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
<td>H.C.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;OSC&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>5.</td>
<td>250 mfd.</td>
<td>1,200 kc.</td>
<td>H.C.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;ANT&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>6.</td>
<td>250 mfd.</td>
<td>18.3 m.</td>
<td>H.C.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;ANT&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>7.</td>
<td>250 mfd.</td>
<td>5.3 m.</td>
<td>H.C.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;ANT&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>8.</td>
<td>250 mfd.</td>
<td>5.9 m.</td>
<td>H.C.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;ANT&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>9.</td>
<td>250 mfd.</td>
<td>13.3 m.</td>
<td>S.W.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;ANT&quot;</td>
<td>No. 2</td>
</tr>
<tr>
<td>10.</td>
<td>250 mfd.</td>
<td>18.0 m.</td>
<td>S.W.</td>
<td>Approx. 60 on dial</td>
<td>H.C. &quot;ANT&quot;</td>
<td>No. 2</td>
</tr>
</tbody>
</table>

**SOCKET-TO-CHASSIS VOLTAGES (125 V. LINE): 1,000 OHMS/VOLT METER. ON 500 V. SCALE: ±10%**

6C127 - R.F. Amp.
6B6G - Osc. Mod.
6B6G - Cathode Amp.
6B9T - Det.
6S8G - V.C.A.F.
6J5 -禅.
6L4 - Rectifier.
6M4 - Output.
6G9 - Plate Mod.
6L6 - Plate Mod.
53D0 - Rectifier.

Drop across speaker field 65 V. of field, 50 V.

**RADIO-CRAFT for MARCH, 1941**

Connecting a phone pickup to the circuit.

www.americanradiohistory.com
**SERVICING**

**Unbeatable and Easy to Own**

MORE than 3,000 SUPREME Models 504 Tube & Set Testers in constant and profitable service prove it to be the unbeatable value in the test equipment field. There are many combination tube and set testers but only SUPREME offers those necessary and desirable advantages found in the Model 504.

Take SPEED, for instance. As a multimeter, 31 ranges and functions are at your finger tips. Only two pin jacks and two rows of quick acting push buttons are necessary to give you complete control. Functional switches are on one side of the panel and range switches on the other side of the panel. All that is necessary is to press one button on the left hand row for the function desired and one button on the right hand row for the range desired.

As a tube tester, merely rotate the smooth acting roller chart to the type desired and "follow the arrows." Leakage tests are equally simple. With the same set-up just press one button after another on the right hand side of the panel.

Protection against OBSOLESCENCE Is Important. The Model 504 is built to be modern today, to stay modern tomorrow. It provides for all filament voltages from 1.4 volts to the full line voltage, of course, but much more than that—It is the only INSTRUMENT having the PATENTED DOUBLE FLOATING FECLAMENT RETURN SELECTOR SYSTEM which automatically re-connects every tube socket to the proper arrangement while the coil is being used. There are at least 200 different types of tubes in use today and the Model 504 will take care of them—automatically—even unknown to the operator. That’s why the 504 has only one socket for each type of tube—it is impossible to put a tube in the wrong socket.

SPEED in testing electrolytic condensers too. All electronic capacitors, including high voltage filter capacitors and low voltage-high capacity bypass condensers are checked at their CORRECT WORKING VOLTAGE on an English reading scale.

These are just a few of the many PLUS advantages you have when you own a Model 504 Tube & Set Tester. It is beautiful in appearance, sturdily built, carries a year’s free tube setting service, and best of all, it is EASY TO OWN. If you can afford a telephone or if you can afford your cigarettes, you can afford the Model 504. This complete laboratory, combining a 7-way tube tester, a 31-range set tester and a complete condenser analyzer, costs you no more than $18 a day on the world’s easiest installment terms.

**MODELS 504, 543, 542**

ASSURE YOURSELF OF GREATER PROFITS BY DOING RADIO SERVICE JOBS MORE QUICKLY. USE GERNBACH MANUALS. SEE PAGE 518.

**SAVE UP TO 50%**

**FACTORY-TO-YOU**

**AMPERITE**

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**FACTORY-TO-YOU**

**AMPERITE**

**FACTORY-TO-YOU**
NOW that the Federal Communications Commission has permitted Frequency Modulation on a nation-wide commercial basis, it is important that certain improvements be made in F.M. receiver design, from 2 important standpoints:

(1) Lower sensitivity, to permit adequate quieting on all signal inputs down to the ultimate limit imposed by receiver tube noise; and,

(2) More satisfactory quieting, by effecting better limiter operation.

Both of these receiver improvements are necessary if the full noise-reducing properties of F.M. are to be demonstrated and effectively employed to permit the realization of satisfactory full-range reproduction.

SENSITIVITY

It is proposed to consider initially the requirement of adequate sensitivity. It can be shown that the receiver inherent noise level is approximately 1 microvolt r.m.s., when referred to the antenna input. This is determined by computing the thermal agitation noise in the grid circuit and the shot noise in the plate circuit of the first tube. The shot noise is referred to the grid circuit by dividing by the first tube gain. These 2 noise voltages are then combined by taking the square root of the sum of their squares. This total noise voltage is then referred to the antenna input by dividing by the antenna coil gain.

It can also be determined experimentally that a signal at the limiter input of approximately 4 volts r.m.s., is required for 20 db. (or 10 to 1) noise reduction. It is thus seen that a minimum voltage gain of 4,000-000 times is required to the limiter input and since a limiter amplification of at least 5 is required for adequate deviation sensitivity, the required total voltage gain, exclusive of audio amplification is 20,000,000 times.

The limitations on the voltage gain that can be realized at the intermediate frequency will be investigated followed by a study of the difficulties involved in completing the required total gain at the signal frequency. The solution to the problem as incorporated in the F.M.-90 General Electric Frequency Modulation Translator (or adapter—Editor) will then be described. This, incidentally, is a complete frequency modulation receiver, except for audio amplification and is designed to plug into the phono jack of an ordinary receiver.

The amplification that can be realized at the intermediate frequency is, of course, limited by feedback tending to cause instability or oscillation. Feedback may occur in any or all of the ways enumerated.

(a) Through common plate, screen-grid, A.V.C., or heater circuits.

(b) Overall or stage-to-stage stray inductive coupling.

(c) Overall or stage-to-stage stray capacitative coupling.

All of these feedback paths can be theoretically eliminated by filter networks and extensive shielding except the capacitative feedback through the plate-to-grid capacity of the tubes themselves. Formulas for determining the maximum gain of single and multi-stage amplifiers before oscillation from plate-to-grid tube capacity occurs have been developed in the literature. Experience indicates that 2 stages of intermediate frequency amplification prior to the limiter are capable of supplying all the amplification that can be obtained with stability. The theoretical maximum stage gain of such an amplifier is given by the equation

\[ G = \sqrt{\frac{e_m}{2nf}} \]

where \( e_m \) is the mutual conductance of the tube and \( f \) is the intermediate frequency.

It will be noted that the gain factor of the tube is \( g_m/e \). The 6SK7 is somewhat superior to the 6AB7 (1853) in this respect and hence will be considered in the computations. The 6AC7 (1852) is slightly superior to both, but is not preferred due to its high cost and somewhat questionable reliability.

The remaining factor influencing the amplification is the intermediate frequency. Since the voltage gain per stage decreases as the square root of the intermediate frequency it is desirable to employ as low a value as possible. It should not, however, be reduced to the point where some difficulties are encountered. For a 42-50 megacycle frequency modulation band, the intermediate frequency should preferably equal or exceed 4 megacycles in order to preclude the possibility of images occurring within the frequency range covered. Another factor to consider is direct I.F. pick-up. This renders 4 megacycles undesirable since it would pick up the 80-meter amateur...
phone band. Many other considerations are involved in the selection of a suitable intermediate frequency which are outside the scope of this article. Many of these factors have been considered by the Radio Manufacturers' Association and they have as a result recommended an intermediate frequency of 4.5 megacycles.

**EFFECTIVE I.F. GAIN**

With this as a basis it is found that a theoretical I.F. gain of 122 per stage is possible. This figure is, however, subject to 2 revisions. The first of these is a factor of 2 required to counteract the feedback by oscillation amplifying process. This assumes the use of critically-coupled, 2-coil transformers and comes about from the fact that until tuned to the same frequency, the individual circuits of each transformer have approximately twice their normal impedance and hence represent a condition much more susceptible to oscillation. This then reduces the theoretical gain to 61 per stage.

The second revision is to provide some safety factor for variations in tubes, inductances, line voltage, power transformers, rectifier drops and tolerances in other components. The difficulty in obtaining useful information from this formula lies in the proper evaluation of this second factor. Indications are that it should be at least 2, thus resulting in a theoretical stable gain per stage of approximately 30. Hence, the gain of the I.F. amplifier prior to the limiter is about 900 exclusive of the converter gain.

The converter voltage gain is normally included as I.F. amplification, but since the converter input represents essentially zero impedance to I.F. it is not involved in stability considerations. It is obvious, therefore, that the converter gain should be made as large as possible. This indicates the use of a high-μ pentode such as the 6A87. Operated under suitable conditions as a converter this tube will provide about 1.25 times the gain of a 6SK7 operated as an amplifier. Thus the converter voltage gain should be about 37.5 providing a total theoretical I.F. voltage gain of 33,800.

It should be emphasized at this point that the above voltage gain figure assumes that all sources of feedback except that through the plate-to-grid capacity of the tubes have been eliminated. This is never entirely true especially when an additional I.F. amplification of 6 is subject to the limiter. Practical experience dictates that I.F. voltage gains at 4.5 megacycles appreciably in excess of 15,000 to the limiter input are decidedly risky from a production standpoint. It is possible that receivers made on a custom-built basis could be designed with a total I.F. voltage gain lying somewhere between the theoretical 33,800 and the maximum practical production value of 15,000. Suppose for the sake of argument that the maximum gain permissible ahead of the limiter is 20,000. We have previously found that a total amplification of 4,000,000 was necessary. This leaves a gain of 200 to be supplied by the R.F. amplifier.

**R.F. GAIN**

The antenna coil gain that can ordinarily be obtained can be computed with a fair degree of accuracy from the formula

\[
\text{Ant. coil gain} = \frac{Z_e}{Z_p} \times 0.707
\]

where \(Z_e\) is the equivalent secondary impedance, \(Z_p\) is the primary transmission line impedance of 100 ohms.

The factor of 0.707 is necessary since the reactance in the primary circuit is not normally tuned out, \(Z_p\) is represented by the parallel combination of the tuned circuit input impedance of the tube. At 46 megacycles, the former is about 15,600 ohms with a well-designed antenna coil and the latter about 6,800 ohms for a 6A87 tube. This gives a net secondary impedance of 4,600 ohms.

Hence

\[
\text{Ant. coil gain} = \frac{4600}{100} \times 0.707 \times 6.8 = 4.8
\]

The required R.F. gain is therefore 4.8.

The theoretical voltage gain of a single-stage R.F. amplifier when all sources of feedback except that due to plate-to-grid tube capacity have been eliminated can be computed in a similar manner to that previously employed for the I.F. amplifier. The formula for a single-stage amplifier is given by

\[
G_{\text{total}} = \frac{E_{\text{out}}}{E_{\text{in}}} = \frac{Z_p}{Z_e} 
\]

where \(G_{\text{total}}\) = Mutual conductance of tube = 5,000 X 10^-10

\(Z_p\) = Grid-to-plate capacity of tube = .015 X 10^-9

\(f\) = Radio frequency = 60 X 10^6

A 6AB7 tube is assumed in this instance since the computed gain can not be readily obtained with the lower \(Z_p\), 6SK7, tube. A frequency of 60 megacycles is assumed since the highest frequency would be most susceptible to oscillation from this feedback source, therefore

\[
\text{Gain} = \frac{5,000}{.015 \times 10^{-9}} = 2.12 \times 10^{10}
\]

As in the case with the I.F. amplifier this figure is subject to revision. There are no coupled circuits in the R.F. amplifier but a reduction in amplification is necessary to take account of variations in tubes and other components, variations in line voltage, etc., as enumerated previously.

As before, the factor should be at least 2 to prevent manufacturing and field difficulties. This reduces the theoretical gain to 22. Again, it should be emphasized that this gain figure assumes that all sources of feedback except plate-to-grid tube capacities have been eliminated. In an R.F. amplifier it is even more difficult to approach this.
HERE IS Sylvania's latest sales-builder ... a radio chassis chart that will discourage the most optimistic home tinkerer.

More clearly than any other promotion piece we've ever seen, "What Is Wrong with Your Radio" convinces your customer that only an expert can make radio repairs ... and YOU'RE THE EXPERT.

Write Hygrade Sylvania Corp., Dept. RC31, Emporium, Pa., for a free copy of this mailing piece ... and for full information on the 25 other silent salesmen Sylvania offers you either free, or at substantial savings.

Sylvania's Silent Salesmen

1. Window Displays, dummy tube cartons, timely window streamers, etc.
2. Counter displays
3. Electric Clock signs
4. Electric Window signs
5. Outdoor metal signs
6. Window cards
7. Personalized postal cards
8. Imprinted matchbooks
9. Imprinted tube stickers
10. Business cards
11. Doorknob hangers
12. Newspaper mats
13. Store stationery
14. Billheads
15. Service hints booklets
16. Technical manual
17. Tube base charts
18. Price cards
19. Sylvania News
20. Characteristics Sheets
21. Interchangeable tube charts
22. Tube complement books
23. Floor model cabinet
24. Large and small service carrying kits
25. Customer card index files
26. Service Garments
27. 2-in-1 business forms
28. Job record cards (with customer receipt)

SYLVANIA

SET-TESTED RADIO TUBES

Also makers of Hygrade Lamp Bulbs, Hygrade Fluorescent Lamps, and Miralume Fluorescent Light Fixtures.

condition. The actual plate-to-grid capacity is considered in the capacity between the antenna and R.F. sections of the gang condenser; as well as by the leads associated with the same. These leads also provide induction coupling which is difficult to entirely eliminate. Indications are that even with considerable shielding the effective plate-to-grid capacity is more than doubled by these external contributing sources. An an approximation, therefore, we can assume that the practical stable gain is reduced to a value of not more than 10.

The realizable gain is reduced still further by an additional source of feedback in the gang condenser of the conventional common rotor type. This results from common impedance coupling in the ground returns and cannot be eliminated at these frequencies by the expedient of employing individual wipers, for each gang section. In practice this feedback source reduces the stable R.F. tube gain obtainable to a value of approximately 6. It is possible, of course, to eliminate this latter source of feedback by using a gang condenser construction with insulated rotor sections and individual wipers insolated from the frame. This construction is difficult, however, from the con-

The performance of this circuit as used in the JFM-90 will now be considered in some detail. Figure 2 indicates the computed input impedance of the 6AB7 tube and the computed tuned circuit impedance plotted against frequency. The input conductance of the 6AB7 was first computed as an amplifier using the formula $g_m = \frac{V_2}{I_2}$. This was then halved since the tube operated as a converter. The latter often has its mutual normal con-

duction. The reciprocal was then taken to
to obtain input impedance and the result plotted. The tuned circuit impedance was computed knowing the inductance to be 0.45-microhenry and the effective circuit Q to be 120 with the primary loaded with 100 ohms. The net result of these 2 parallel impedances is then seen to be nearly constant at 7,000 ohms.

The antenna coil gain can now be computed in the manner previously discussed and the result is shown in Fig. 3. The actual measured gain is also plotted. The computed gain is nearly constant at 6.8 while the actual gain varies from 6.2 to 5.6. The agreement is seen to be reason-

ably close. It should be noted that the an-
tenna gain computed previously assuming the 6AB7 tube to be operated as an ampli-
fer was 4.8. The difference, of course, is due to the higher input impedance of the tube when operated as a converter.

The impedance of the last converter tuned circuit was computed using the data for input impedance plotted against the 1st I.F. and are shown in Fig. 4. The net equivalent of these 2 impedances is plotted and seems to be approximately constant at 15,000 ohms. The first converter gain can then be computed assuming the g, of the 1st converter to be 2,500 microhms. This is shown in Fig. 5 along with the amplification as actually measured. It is again seen that the agreement is good, the computed voltage gain varying from 29 to 26. The actual voltage gain from 34 to 42.5.

The total voltage gain ahead of the 2nd converter is shown in Fig. 6. The computed gain is seen to vary from 210 to 24, and the total gain with the actual gain varies from 238 to 25. It is readily evident, from this, that we can essentially realize the amplification of 200
which we found necessary to provide the total required voltage gain of 4,000,000 prior to the limiter input.

Having disposed of the problem of obtaining sufficient voltage gain to produce a signal large enough to provide adequate limiting on any input down to the actual receive level we were in a position to undertake the 2nd required improvement of more satisfactory limiting.

**SINGLE-TUBE LIMITER**

The limiter used in previously available production receivers was the conventional "single tube grid-bias" type. As is well known, this merely consists of a grid condenser-resistor combination in conjunction with a shunt reducing the grid leak so as to prevent grid voltage variation active in changing plate current.

The control-grid bias limiter though simple and somewhat complicated in operation, its purpose, of course, is to remove amplitude modulation. In order to describe its operation, first assume a constant grid voltage applied to the limiter grid having a peak-to-peak amplitude several times the active voltage swing of the tube. Assume also that the limiter is turned on, then charge the condenser sufficiently to provide the required negative bias which is nearly equal to the peak amplitude of the plate circuit to which the condenser discharges. The grid leak is so small the signal has to go through the condenser then discharges more rapidly.

It is seen that this is a limiter operating in this manner the plate current flows in pulses produced by part of each positive grid cycle. The remaining part of the positive grid cycle is negative, and since the grid does not drive the grid beyond cut-off, now assume that some amplitude modulation in the form of an increase in signal amplitude occurs. It can be seen that the grid will become more positive by this increase in signal and the plate current will tend to increase. However, since the voltage of the plate comes smaller since a smaller percentage of the total positive grid cycle produces plate current. This tends to reduce the average plate current. The trick is to select a value of grid resistor so that these 2 effects produce no net change in the fundamental component of the plate pulse. The difficulty is, however, that this balance will only hold over a small input range. If a signal having 10 times or 1/10 the amplitude desired is applied, the limiting will be reduced and the limiter this balance will no longer hold and a new value of grid resistor will have to be found for each case.

This is one of the main difficulties with the single tube grid bias limiter. The other concerns its operation on impulse noise for which it is notoriously ineffective. This is due to the time constant of the grid condenser-resistor combination which is too slow to properly follow short-duration impulse noises. The grid condenser can only be reduced so much before it seriously affects the sensitivity. In practice the grid condenser is reduced as much as possible and then a severe compromise made by reducing the grid leak from 20,000 to 50,000 ohms. This is much too low a value to permit the desired balance for normal amplitude modulation as previously explained which requires grid resistance of the order of 125,000 to 200,000 ohms.

**CASCADE LIMITER**

These difficulties are essentially removed by the use of a cascade limiter. Figure 7 shows the cascade limiter employed in the Sprague lab. At the lower right of the figure is a cascade limiter which consists of 2 GI97 limiters. This type of limiter is used in cascade utilizing resistance coupling between the stages. This produces a gain in the 1st limiter of approximately 40 which is noted, therefore, that the maximum signal that can be applied to the 2nd limiter is only 3 times the active grid voltage swing of the 1st limiter. If the active grid swings of the 2 tubes are equal, the 2nd limiter only has to handle a 3-to-1 signal ratio. This permits the choice of a grid resistor which will provide an excellent balance of increased peak current vs. reduced transit angle for all signal inputs. The gain of the 1st limiter is 50,000 ohms and picked to provide a short time constant and consequently good limiting on impulse noise.

The large reduction of impulse noise in the 1st limiter makes time constant considerations for the 2nd limiter much less important, and the 2nd limiter grid resistor can be chosen substantially without regard to time constant. A 190,000 ohms is chosen in this instance. On direct listening tests this cascade grid bias limiter has been found superior to all previous types of non-grid bias and direct-coupled limiters that have been tested.

The combination of greater sensitivity and better limiting can be shown by a single curve showing the amount of limiting in decibels plotted against signal input.
Figure 8 shows such a curve for the JFM-90 receiver and also includes a curve for a representative receiver of last year's production which employs an R.F. amplifier, 2 stage I.F., and a single wide band limiter. The tremendous improvement in the new receiver on both counts is immediately evident.

“COMMERCIAL” SENSITIVITY

It will be noted that it requires approximately 4-microvolt signal to produce 20 db. quieting. This is due to the presence of peaks of random noise which have about 4 times the r.m.s. amplitude of 1µv. The question might be raised of whether a 4-microvolt sensitivity might not have been just as good as the 1-microvolt value we were endeavoring to obtain. It is felt that this latter sensitivity is desirable to take care of the variations of sensitivity in production and possible later misalignment. Manufacturing final test limits are generally about 3 times that of a representative normal receiver and additional reductions in sensitivity are likely to occur in storage, shipment and normal use. It is thus evident that some receivers in actual use will be deficient in sensitivity possibly by a factor of 3 to 5 times.

The effect of such sensitivity loss on quieting signal input was determined for the JFM-90 by adding adjustable bias to the I.F. amplifier to reduce the I.F. sensitivity by the desired amounts and then the quieting signal input measured. The result of these measurements is shown in Fig. 9 and for comparison a similar measurement was made on an ordinary type of F.M. receiver requiring a quieting signal input of 10 microvolts. It will be noted that the required quieting input does not change for the JFM-90 with gain reductions of as much as 5 to 1 while that of the ordinary receiver increases in linear fashion.

IMAGE REJECTION

It is obviously impossible in an article of this nature to cover in such detail all the features of the JFM-90 translator. In view of the new type double superhetodyne circuit used a brief review of its performance as regards image rejection may be of interest.

In the usual double superhetodyne 2 sets of images have to be considered, one differing from the signal by twice the 2nd harmonic of the signal frequency, the other by twice the 1st I.F. In the common-oscillator double superhetodyne circuit used in the JFM-90, however, the 1st I.F. is variable making the image frequency fixed at the same frequency as the 2nd I.F., namely 4.9 megacycles. Although this means that the 1st tuned circuit alone is effective in providing I.F. rejection a tremendous improvement is obtained in the JFM-90. It is felt that this is not only adequate from a commercial standpoint.

OSCILLATOR DRIFT

The importance of good oscillator stability requires no comment. This problem, normally quite serious in an F.M. receiver, has been alleviated in the JFM-90 by the reduced bandwidth of the discriminator, namely, 18.85 to 22.85 megacycles. The oscillator circuit is shown on the schematic diagram, Fig. 1.

To further reduce drift a 7A4 locotube type tube is employed using a mica-filled balelite socket. Hard-prubber stator insulation is used on the gang condenser, and the oscillator coil is wound on a ceramic form. Trimming is accomplished with an air condenser and the grid condenser is of the zero-temperature-coefficient ceramic type. The remaining drift is substantially removed with a shunt ceramic condenser having a suitable negative capacitance. The resulting drift is indicated in Fig. 10.

Drift precautions are maintained throughout the remainder of the circuit. The I.F. trimmers are of the condenser type having the major portion of the capacity in a fixed silver-mica unit and only that necessary to compensate for manufacturing and tube tolerances in the adjustable unit. All R.F. and I.F. coils throughout the translator are wound on ceramic forms. The discriminator has wider peak separation than in some previous designs to further alleviate the effects of drift and to provide less critical tuning. The discriminator curve is shown in Fig. 11.

The I.F. selectivity curve of the JFM-90 is shown in Fig. 12. It will be noted that approximate critical coupling is employed with 17 db. deviation down about 2 times from normal input. The I.F. system was somewhat over-designed to cope with the situation existing until Jan. 1 where adjacent channel operation of F.M. stations was prevalent in the same locality. Eight tuned circuits were provided in this connection by using the first 2 transformers of 3-coil construction.

Concluding, the writer wishes to express his appreciation to Messrs. L. M. Ewing and C. L. Truesdale for the data presented and to Mr. R. B. Dome whose lecture material was utilized in the computations included in this article.

RECOLLECTIONS OF BROADCASTING'S EARLY DAYS

Versatile was the word for a radioman back in the early days of the broadcasting business. I recall John B. Gambling, for 15 years a familiar WOR voice. John likes to remember:

... When he used to go out on "remote" assignments to hotels and night clubs, with an amplifier under one arm, "B" batteries under the other, a coil of wire on his neck, and huge batteries in his hands, which he dipped into his Tuxedo pants. WOR had only one set of remote broadcast equipment in those days, so John had to lug his load to his various places during a night... When he was pinch-hitting for "The Man in the Moon," the first kiddie's broadcaster, "Little Sylvia of 999 Newark Ave nue has been a very good girl, so Sylvia I'm going to pin a big, bright star right over your house."... When I was a kid, I always felt that "Ice," I.M. I was never able to get so frightened she fainted in his arms. When he interviewed the late Queen Marie in her boudoir in a special train en route to New York City from Washington, D. C. When he took two parts in WOR's first dramatic show, "Step on the Stairs," a mystery thriller through Enemy lines and war zones. He did it well. He would monitor the program, then dash out for his lines, then rush back into the control-room again.

Alas, the programs consisted of either/and/or a pianist and singer, and the staff pianist used to do four consecutive fifteen minute programs under four different names.

MODEL 1600-E

DEALER NET PRICE $21.00

DC scales of the instrument read: Voltage 0-10-50-250-1000 (25,000 ohms per volt); 0-1-5-10-50-250-500 milliamperes; Resistance, low ohms, backup circuit, 1/2 to 500 high ohms, 20,000-200,000 ohms and 2 and 20 megohms. Batteries included for all ranges but 20 megohms. 22½ volt battery for that range can be mounted inside the tester case; brackets provided. AC Voltage 0-10-50-250-1000 at 2000 ohms per volt. A plug-in copper-oxide rectifier, easily replaced in case of overload, is used to obtain AC readings. Model 1600-E, less case for mounting in panel...

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In case with handle for portable use...

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MODEL 1620

This is a counter type, lever switch operated tube tester. Four "quick change" non-obsolescent features, including RED DOT Lifetime Guaranteed Instrument. Speed Roll Chart, New Control panel and Switching Section can all be replaced should unanticipated changes make it necessary.

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534 RADIO-CRAFT for MARCH, 1941

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A GENERAL UTILITY TESTER

For Servicing Electrical Appliances

Radio men looking for new fields to profitably explore, will do well to consider the possibilities afforded by Electrical Appliances, as Mr. Litt here capably shows. The design and use of an A.C.-D.C. "appliance tester", measuring up to 100 amperes, 1,000 volts and 5,000 watts, and down to 1/50th ohm, and especially devised for this service, is described in this article. Circuit features incorporated in the instrument are diagrammed and analyzed.

SHEPHERD LITT

Radio servicemen in recent years have been looking for newer equipment so that fields associated with radio, which their knowledge of electricity and radio covers, could be serviced. Appliance repairs, a field very close to radio repairing, has been sorely neglected. It is true that most radio servicemen have fixed small defective equipment such as Toasters and electric irons. However the larger electrical appliances have been usually neglected. This is not because the Servicemen do not know how to repair such appliances but rather because of a lack of suitable equipment. With a simple tester such as described below, motors, electric ranges, heaters, irons, washers, sun lamps, vacuum cleaners, electric refrigerators and even air conditioning equipment may be successfully serviced. Further, the cost of operation of these various appliances may be easily computed and estimates given, all based on the prevailing price per kilowatt-hour rate.

The Utility Tester here described (see Fig. 5 for circuit diagram) operates on simple electrical laws and is basically a multi-range voltmeter reading both A.C. and D.C. By taking each section of the instrument separately, a better understanding of the instrument can be had.

D.C. VOLTOMETER

The voltmeter section uses a simple voltmeter circuit known to every serviceman. It consists of a 0-1 ma. meter and a group of series resistors to give the proper voltage ranges. Six D.C. ranges are available, viz.: 0/1/10/50/100/500, 1,000 volts. They are selected by 6 positions on a 2-deck, 7-position rotary switch. The sensitivity of the meter is 1,000 ohms/volt. (See Fig. 1.)

A.C. VOLTOMETER

The A.C. voltmeter is not so conventional. It makes use of the same 0-1 ma. movement but with a half-wave rectifier across it. A current-limiting resistor is placed between the half-wave rectifier and the meter. This resistor determines the amount of linearity of the A.C. scale. The higher this resistance, the more linear the A.C. scale. An 800-ohm resistor is used in this instrument to give a fairly linear scale and at the same time eliminate needle vibration. The multiplier resistors are placed between the source of voltage and the rectifier.

Because of the amount of current taken by the rectifier, the A.C. sensitivity of the meter is approximately 400 ohms/volt. This relatively low sensitivity is of no importance since most A.C. voltage readings are taken of low-impedance lines. Therefore the meter movement need not be as highly sensitive as for D.C. use. The A.C. ranges are taken from the lower deck of the 7-point 2-deck switch. Six voltage ranges are available, viz.: 0/1/10/50/100/500, 1,000 volts. This allows a very wide range of voltage measurements. (See Fig. 1.)

AMMETER

The ammeter circuit (Fig. 2) is also unconventional. It consists of a single shunt across which a voltage drop is measured. The ordinary ammeter uses multiple resistances placed across the meter movement itself. These resistances carry a large current necessitating a switch with very large contacts which is impractical on ranges over 1 ampere. The circuit used here eliminates the need of a large switch since only a small amount of current flows through the switch contacts. It makes use of the fact that the voltage drop across a resistor varies in proportion to the current through that resistor, in other words, Ohm's law. If this resistance is made 1 ohm, the voltage drop across this resistance will be equal to the current passing through the resistance. By connecting a multi-range voltmeter across this resistance a very simple ammeter can be had.

WATTS

If the amount of current flowing through the circuit is multiplied by the voltage across the circuit, watts or power consumption results. Since this instrument contains both a direct-reading voltmeter and an ammeter, the watts drawn by any appliance can easily be measured. (See Fig. 3.) The scale of the instrument has all the necessary computations on it, but since there is a power loss in the 1-ohm resistor, this power loss must be added to the scale reading to indicate the power drawn.
money in the bank!

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Save money on an up-to-the-minute tester in just a few hours, spare time. It's instructive, and you'll get a kick out of it, too. These RCP Kits have every latest feature in test equipment. They're complete — no extras to buy!

MODEL 44K
SUPERTESTER COMPLETE KIT $17.35

SPECIFICATIONS
0/10/100/250/1000/5000 volts DC; 0/1/10/100/1000/10000 volts AC; 0/200 microamperes DC; 0/10/100/1000 milliamperes DC; 0/1/10/25 amperes DC; 0/500 milliamperes AC; 0/2.5/5/25 amperes AC; 0/400/4000/4 megohms; (40 megas with extra battery); Db. meter, 3 ranges — 10 to 500; Measuring range from .002 to 1 Mfd.; Inductance from .3 to 70 Henries; (direct reading from charts); 4½” square D’Arsonval meter; Hardwood carrying case; All necessary parts.

MODEL 446K
MULTITESTER COMPLETE KIT $8.49

SPECIFICATIONS
0/5/100/250/500/2500 volts DC; 0/1/10/100/1000 milliamperes DC; 0/10 amperes DC; 0/10/100/500/1000 volts AC; 0/500/100,000/1 megohms; (will read as low as 1 ohm); Four Db. ranges — 8 to +55; Output meter four ranges; 3” square D’Arsonval meter; Walnut finish case; All necessary parts.

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Chapter II. Geometry and Algebra—Rectangles—Circles and Ellipses—Triangles—The Metric System.
Chapter III. Trigonometry—The Right Triangle—Trigonometric Ratios—The Unit Circle.
Chapter IV. How to Measure Surfaces and Capacity.
Chapter V. Powers and Indices—Ratios and Proportions.

Mr. Shaney advised in this connection as below.

A higher-powered hearing-aid cannot be conveniently made wearable. If you would have no objection to having this unit designed to fit a space of approximately a 4-in. cube, I shall be pleased to present such a design in a future issue of Radio-Craft. 

EDW. J. GEORGE, Los Angeles, Calif.

Mr. Shaney advised in this connection as above.

A higher-powered hearing-aid cannot be conveniently made wearable. If you would have no objection to having this unit designed to fit a space of approximately a 4-in. cube, I shall be pleased to present such a design in a future issue of Radio-Craft.
A GREAT deal of material has been printed with reference to the basic design and use of the V-T. Voltmeter, or "V.-T.Vm." so that now it may be in order briefly to review what we have learned and to take stock of the methods available to those unable or unwilling to pay the prices asked for such equipment, prices which range from about $20 to over $100 of hard-earned money. (A number of V-T. voltmeters have been described in construction articles in past issues of Radio-Craft.—Editor)

Fundamentally, as has been so often remarked, the "V.-T.Vm." is a detector of alternating current, or in other words, it is a direct current amplifier. There is an essential difference in the operation of the instrument according to whether it is to be used on A.C. or D.C. and there is a further classification possible of the A.C. instrument, which is one concerned with the fact of its mode of operation on (a) peak, (b) effective or (c) mean values of alternating current.

SLIDE-BACK

The classic example, and one which you will find in many texts on measurement of electrical quantities, is that of the slide-back type of voltmeter depicted in Fig. 1 (1). This type, while accurate, is apt to give trouble, since a stable source of bias supply is required, and, in addition, stray currents may flow through the grid-circuit meter. Also, it generally has low sensitivity unless an expensive galvanometer is used in the plate circuit at a sacrifice of ruggedness and maintenance of calibration. Of course, a D.C. amplifier could be used, but there still would remain the necessity for adjusting the meter for every single voltage test. The main advantage of such a peak voltmeter is its very high input impedance, which is essentially that of the grid to cathode of the tube. Also, it measures the peak value of an alternating current, a useful feature in determining, for example, the overload point in an audio amplifier grid circuit.

The connection from the voltmeter to the receiver circuit being tested should, of course, be shielded, and the shielding insulated to prevent the possibility in the case of an A.C.-D.C. receiver of shorting the power line; or in the case of an ordinary A.C. receiver of shorting, through allowing the cable to touch the wiring, of any section of the set.

For stability, a high resistance, of the order of 10 megohms, should always be connected across the input circuit to provide a constant path for the flow of direct cur-

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**V.-T. VOLTMETERS**

**Theory and Practice**

A Serviceman casts an expert eye over published descriptions of vacuum-tube voltmeters, discusses their pros and cons, and concludes with the construction details of a "V.-T.Vm." he finds exceptionally suitable in his everyday service work.

WILLARD MOODY

---

rent from the grid of the tube in the V.-T.Vm. to its filament or cathode, depending on the type tube used. This will remove the possibility of unregulated variations in the plate circuit. In the case of the instrument designed to work on D.C. a condenser across the input will filter out the A.C. A.D.C. (Advanced Laboratory Practice) This discussion involves a great acquaintance with integral calculus. A less mathematical treatment is given in the "Radio Engineering" of F. E. Terman.

"DUAL-TRIODE" BALANCE V.-T.Vm.

An easy-to-understand analysis of the V.-T.Vm. is given by Terry in his "Advanced Laboratory Practice." This discussion involves the most elementary explanation of the V.-T.Vm. since it is closely related to rectification of alternating current as in the detector of a triode circuit.

In the "Radio Engineering Handbook," chapter by R. F. Field on Measurements, there is given a circuit which is of particular interest, since a form of it is today being used, with some improvements, in the Rider VoltOhmyst, a very good commercially-made V.-T.Vm. Turner and McNamara, in a 1912 issue of the Proceedings of the Institute of Radio Engineers, first published the data. The circuit is of the "dual-triode" balance type, and is similar in principle to the sensitivity test circuit used for checking the matching of type 45 tubes in push-pull, as shown some years ago in "Popular Radio." The modern circuit, by Rider, uses a high resistance in the cathode lead, as shown in Fig. 4.

SERVICING-TYPE VACUUM-TUBE VOLTMETER

The circuit which I am using, while not so complicated, is satisfactory for my purposes, as it will be for most other Service-masters and amateurs. See Fig. 5. The amplification, as given in the Proc. I.R.E., is in the vicinity of 100, which means in combination with modern high-mu tubes render unnecessary the use of complicated bridge circuits or D.C. amplifiers to achieve sensitivity.

Also, the instrument can be made to check accurately voltages and conditions which are not so well done by employment of the oscilloscope with its manifold problems; the V.-T.Vm. is a time saver, not time consumer. For flat-top alignment the oscilloscope is used in adjusting the I.F. as far as receiver servicing goes. For checking A.F.C. or A.V.C., the V.-T.Vm. is my favorite instrument. Eventually, I believe, portable instruments will supersede and thereby render obsolete our present antiquated meters of 1,000 to 20,000 ohms/volt.

The advantage of the V.-T.Vm. extends also to the measurement of resistance at low current values. This is an distinct advantage, as you can get knocked on your ear with the wrong choice of the present-day equipment using high voltage on the Megohm ranges of the tester.

REFLEX V.-T.Vm.

For measurement of A.C. the V.-T.Vm. may consist simply of an amplifier with output meter calibrated in volts or db and a suitable source of calibrating voltage under control, which may be checked against the unknown, as shown in Fig. 6. A less complicated circuit is shown in Fig. 7. This circuit is of the reflex type, using the gain of the triode to supply the A.C. voltage necessary to allow current flow in the diode which in its turn supplies a negative bias for the triode grid, reducing the plate current by the amount or in accordance with the value of the unknown applied voltage. This circuit appeared some time ago in an article in Electronics magazine, and has been slightly modified.

TESTING A.V.C. CIRCUITS

One of the most useful features of the V.-T.Vm. is the ability it has for checking the A.V.C. circuit of modern radio receivers. This is shown in Fig. 8, where we have a typical A.V.C. circuit. The test probe may be placed across the circuit consisting of the 0.05-mf. condenser to ground, to check the amount of A.C. across if audio voltage appears here, it indicates that the condenser is open or leaky and should be replaced. If with the D.C. instrument the bias to the controlled tubes does not vary according to the strength of the received carrier, being low off resonance, increasing to the maximum value of perhaps 20 volts when tuned to a strong station, then the A.V.C. supply is at fault and may be checked by the usual routine resistance measurements.

For the final result, the resistance measurements must usually be made; why, then, should we use the V.-T.Vm.? Because, it saves the time which might be otherwise spent in checking the separate parts of the network; by localizing the trouble it enables the tester to service only that part of the A.V.C. which is likely to be at fault. The first condenser, in the A.V.C., might have been shorted partially, without affecting anything else. The V.-T.Vm. confirms this, before allowing you to rip the parts out for test.

It is also useful in determining dynamic characteristics; if the controlled tubes are within proper bias, a point particularly important when detuning is experienced as the result of a change in the input capacity of A.V.C.-controlled tubes. In this connection, refer-
**GREAT NEWS!! . . . THE NEW**

**Utility Tester**

The Utility Tester is a new kind of instrument for testing all electrical appliances—WASHERS, IRONERS, REFRIGERATORS, RANGES, VACUUM-CLEANERS, TOASTERS, PERCOLATORS, HEATERS, SUN LAMPS, AIR-CONDITIONING, MOTORS, etc. The Utility Tester enables every possible measurement necessary to service any electrical appliance.

Mr. Radio Serviceman, here is a new source of revenue for you. The Utility Tester will enable you to accept and economically service electrical and industrial jobs you have been compelled to pass up in the past. You already possess the fundamental electrical knowledge necessary to service electrical and industrial utilities, and now you can have the instrument which will enable you to apply this knowledge to a new and lucrative source of extra income.

**SPECIFICATIONS:**

- 3 WATTAGE RANGES: A.C. AND D.C. 0-100 Watts, 0-1000 Watts. The Utility Tester reads the actual wattage consumption of any appliance, motor, etc., while it is in operation. Thus you can actually prove to the layman the actual consumption of any appliance and compute the actual cost per hour operation, basing your calculation on the local current cost. This is a feature never before obtainable in any instrument selling for less than $50.
- 5 VOLTAGE RANGES: A.C. AND D.C. 0-1 Volt, 0-10 Volts, 0-50 Volts, 0-100 Volts, 0-500 Volts, 0-1000 Volts.

The Utility Tester comes complete with portable cover, self-contained battery, test leads, and all necessary instructions. Shipping Weight: 11 lbs.

**SUPERIOR INSTRUMENTS CO., 136 Liberty St., Dept. S.T., New York, N.Y.**


dence may be made to RCA Patent Note No. 101, which deals with the subject exhaustively. The main point is that for very large values of bias, due to the non-linearity of the tube characteristics, and to cathode lead inductance within the tube, 3rd-order demodulation effects and changed input impedance may result, with consequent detuning and distortion. (1)

The V-TVm. is also useful for checking the amount of hum voltage across filter condensers, or the A.C. across any condenser, which is a positive indication of the efficiency of the particular condenser under examination. It gives illuminating knowledge of the function of parts, refreshes the lagging memory with constant evidences of how a circuit should operate, refers you continuously to basic theory and radio fundamentals, allowing you to service all makes of radio receivers with more certainty, since knowing tube characteristics, you become ever more concerned with the heart and soul of the receiver: its tubes. Less dependence is thereby placed upon circuit diagrams, which while extremely convenient and desirable, may not always be available. This is particularly true in the case of the Serviceman who does not live near the "big city" and does not have access to as many diagrams as his more fortunate city dweller. If he will concentrate on basic circuit data, and tubes, he will be able to service radio receivers with a good deal more precision than would be expected under the conditions described.

**ACCURACY**

The V-TVm. is also a satisfactory if not a better substitute for the oscilloscope in

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**Radio-Craft** for March, 1941

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**SOUND IS BOOMING! . . . so Radio-Craft goes to town**

The May issue of RADIO-CRAFT will be a "Sound Special." Home Recording and Phone-Radio Combinations have taken the public by storm, so RADIO-CRAFT is going to town! The May issue will be devoted mainly to Sound. This, of course, includes public address as well as home recording and phone-radio combinations.

In addition to the usual departments on this topic, there will be special articles and construction projects which will be of considerable value to Servicemen, Sound Specialists, and radio men in general—not the ordinary run of articles but specially-prepared material for this issue.

In addition to this, there will be the usual departments devoted to Servicing, Test Instruments, Electronics, Radio Developments, etc.

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Build Your Own Versatile

MODERN MULTI-TESTER

In the December, 1940, issue of RADIO-CRAFT the author described a simple multi-range meter which even a novice could easily construct. This month another such unit is described for the benefit of readers who desire to construct for themselves a somewhat more ambitious multiple test meter—one with even more ranges and greater convenience of operation. A 200-microampere basic meter affords a sensitivity of over 2,000 ohms/volt.

MILTON REINER

The meter to be described provides a number of unusual features. First of all it serves the purposes of 27 individual meters as follows:

- D.C. voltage: 0-10/100/250/1,000/5,000
- A.C. voltage: 0-10/100/250/1,000/5,000
- D.C. microamperes: 0-200
- D.C. milliamperes: 0-10/100
- A.C. microamperes: 0-1/10
- A.C. milliamperes: 0-1/10
- D.C. amperes: 0.1/0.1
- A.C. amperes: 0.1/0.1
- Decibels: -10 to +15, 10 to 35, 15 to 45, 25 to 65
- Resistance: 0.40/40,000 ohms /4 megs.
- Capacity: 0.01- to 1.0 mfl.

Output meter: Same ranges as A.C. volts.

- Second, the inclusion of high current and voltage ranges—both A.C. and D.C.—permits measurement of values utilized in cathode-ray and television equipment, transmitting equipment, neon and fluorescent lamp installations; starting surge currents of motors, and the high values encountered in many industrial as well as miscellaneous radio applications. Because of practical considerations—and safety—separate tip-jacks are provided for these higher ranges.

- For all normal measurements the ranges are selected by means of the main selector switch. Thus for all D.C. measurements (including resistance), the test probes are plugged into the pair of D.C. tip-jacks and any desired range is then selected by means of the switch. For A.C. measurements it is only necessary to shift the probes to the pair of jacks marked “A.C.,” then select any A.C. range by means of the switch.

The circuits and discussion which follow will enable anyone to duplicate this meter unit. To make this entirely practical, and to make possible an instrument of highly professional appearance, the entire kit of parts, including the embossed panel, all resistors, jacks, switches, the meter (with its A.C., D.C., High-Ohms, Low-Ohms and Decibel scales), and a sturdy wood case with carrying handle, have been made up in the form of a coordinated kit which is both simple to put together and low in cost.

The R.C.P. model 411L meter employed is of the square type, 4½ ins. wide x 4 ins. high, with the outer scale approximately ¾ ins. long. A 200-microampere d’Arsonval movement is utilized, its readings at full-scale accurate to within 2%. All resistors supplied with the kit are accurate to within 2% of their rated values.

The complete circuit is shown in Fig. 1. But to facilitate matters for the student or novice who may wish to construct such a unit—and do with a full understanding of the functioning of every circuit—the individual circuits for the various types of measurements are shown in the other illustrations.

CIRCUIT BREAKDOWNS

Fig. 2.—Figure 2, for instance, shows the complete circuit utilized in measuring direct current. In these measurements the 3rd deck

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(C) of the 3-deck, 12-position selector switch is not employed and is therefore not shown.

Considering the meter circuit alone for the moment, it will be seen that it represents a closed loop of 1,000 ohms, consisting of the 500 ohms of the fixed resistor, the balance of the total current will flow through the meter. Where the resistance of the meter branch is high as compared with the shunt branch, then the current through the meter is a very small fraction of the total current, and the sensitivity the same as when the rectifier is in the circuit. It is for this reason that the 302-ohm resistor is employed in the D.C. voltage measurement circuit of Fig. 4. As before, the 2 small resistors in series with the 302 ohms have no place in the circuit but are left in as a matter of convenience.

With the meter shunted to sensitivity of 476 microamperes (2,100 ohms-per-volt in voltage measurements) the multiplier values work out as shown in Fig. 4.

In the A.C. circuit, for voltage measurements, Fig. 5, the ohms/volt sensitivity is the same as for D.C. measurements. Here, however, there is no shunt across the meter for reasons already explained. It might be well to point out here that the full-wave rectifier is conductive through the meter only on one-half of each cycle, the other half-cycle being bypassed around the meter by the other side of the rectifier. The purpose of this latter branch is to prevent high inverse voltages developing across the rectifier during the inoperative half-cycle—voltage which on the higher ranges would be sufficient to cause the rectifier to arc over.

**OHMMETER**

In Fig. 6 are shown the ohmmeter circuits. In the 40,000-ohm position of the switch we have the standard ohmmeter circuit. In this case the meter is shunted by 5.05 ohms, reducing its sensitivity to 20 ma. The internal series resistance is 215 ohms plus approximately 5 ohms represented by the meter and its shunt, plus whatever is added from the variable "Ohms Adjust" resistor. With the 7.5 volt battery this results in a total of 375 ohms but as the battery drops the variable resistor provides means for compensating the drop in order that the ohms scale still will remain accurate. This will hold true until the battery has dropped to 5.5 volts. Beyond this figure the "Ohms Adjust" knob will no longer permit full-scale deflection and the battery should be discarded.

The 4-megohm circuit is similar to the one just described except that the shunt is eliminated, allowing the meter its full sensitivity in order that high resistance values may be measured without resorting to higher battery voltage.

The Low Ohms circuit varies materially from the others in that the resistance under measurement is shunted across the meter, instead of in series with it. In this instance the meter is again also shunted with 5.05 ohms, making its total resistance 5 ohms and its sensitivity 20 milliamperes. The battery, its variable series resistance and the fixed 275-ohm series resistor, also constitute another shunt across the meter. Because this latter combination will be adjusted for a resistance of about 375 ohms it has no material bearing on the overall resistance of the meter circuit.

When the resistance to be measured is connected to the input jacks its shunting effect will decrease the meter current. If it is 6 ohms for instance, it will cut the meter reading to half-scale. Thus very low values of resistance can be measured with accuracy—down to less than 1/10th-ohm.

**CAPACITY METER**

The capacity measuring range of Fig. 7 utilizes the ability of condensers to pass alternating current and the fact that the amount of current passed varies with the capacity. For this measurement the usual A.C. tip-jacks are connected across the A.C. line as though this line voltage were to be measured. The switch is set in the 250 V. position but with the separate "Capacity" switch in the circuit the 250-volt multiplier

RADIO-CRAFT for MARCH, 1941

Elements of the complete schematic circuit of the Modern Multi-meter, shown in Fig. 1.

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Due to unforeseen circumstances, a number of interesting articles scheduled to appear in this issue of RADIO-CRAFT had to be held over for the next issue. Watch for them in the April number!
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Bob Henry, W9ARA

HENRY RADIO SHOP

RADIO-CRAFT for MARCH, 1941
MODERNIZED AMPLIFIER

The Question . . .

I am enclosing a circuit diagram (Fig. 1) of an amplifier which I obtained in 1935 or 1936. This unit is of course quite obsolete, due to high-drain tubes being used, such as a 69 driver which is a 2WA-volt tube and requires 2 amperes for its heater.

I would appreciate it very much if you would send me any information on reducing the drain and improving the amplifier as a whole.

Could a 69 be changed to a 42, triode-connected? I have done this, but there seems to be too much distortion.

I am a subscriber of Radio-Craft, and like it very much. Please continue to run your Sound Department, as I have learned a great deal from it.

Ed Corell, Silverhill, Alabama

The Answer . . .

A recommended circuit is given in Fig. 2. You will note that quite a drastic revision has taken place, not only in circuit, but in tubes, as well.

You will rarely find an obsolete amplifier circuit that can be modernized by simply interchanging tubes.

One of the reasons the 42 (triode-connected) did not operate satisfactorily as a 69 triode-connected, is that the latter is capable of delivering much more undistorted driving power (a 69 triode delivers approximately 1.25 watts; a 42 triode delivers approximately 0.8-watt). In addition, the driver transformer originally designed for the 69 driver will not operate as well with a 42 driver because of differences in recommended plate loads. Assuming that you were willing to replace the driver transformer, substitution of a 42 in plate of the 69 would save approximately 1.3 amperes, but the driver transformer would still undoubtedly be the limiting factor in the operation of the amplifier. Your present amplifier draws approximately 4.8 amperes at 6 volts. The revised circuit draws approximately 2 amperes, which is a saving of nearly 50%.

Furthermore, the performance of the latter amplifier will greatly exceed that of your original model.

You will note that the driver transformer has been completely eliminated and an electronic inverter substituted, instead.

Electronic mixing is also employed in order to avoid the possibility of controls developing noise when used ahead of the 1st stage, as in your original model. When the 10-meg. feedback resistor is connected from the 500-ohm tap of the output transformer to the grid of the 6SCT inverter, the gain should be reduced by approximately 8 db. If the gain is increased, or oscillation is encountered, the plate leads of the power output stage should be reversed.

With 300 volts available at the "B" point, the amplifier should deliver approximately 19 watts. A 5,000-ohm plate-to-plate transformer should be used. Your present class B transformer is probably 4,000 ohms plate-to-plate, and I suggest you try this unit before purchasing a new one. The lower impedance will reduce power output slightly.

Thank you for your commendatory remarks.

8-CHANNEL ELECTRONIC MIXER

The Question . . .

Preamplifiers and mixers for several high-impedance microphones are common and easily obtainable, but little need has ever been found for a mixing system for several high-output, high-impedance inputs such as used for phonograph and other electronic devices.
SOUND

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The growth of the electronic musical instrument field has brought forth a need for such a system, and I would like to have your assistance in designing one for an Electronic Orchestra which I am organizing.

I intend to use this with a standard amplifier. I will need 8 microphone inputs and at least 5 input channels for high-output electronic instruments. Each input must be controlled separately without having any effect on the other input channels. This is necessary, as foot-control units will be used. I intend to build it on a separate chassis so a power supply can be included with it, if necessary.

CHARLES FREY, Ottawa, Ohio

The Answer...

The type of circuit you require is illustrated in Fig. 3. You will note that electronic mixing is used throughout. Four twin triodes (6SC7's) are employed to provide 8 grids, each one of which connects to its independent volume control and associated channels. Three 6SC7's are used as preamplifiers for the microphone input channels. While independent volume controls for the high-level inputs are connected in this circuit, these may be eliminated if the foot controls of each electronic instrument are used only. On the other hand, it might be desirable to use both controls. The one on the instrument for the musician to adjust, and the one on the preamplifier for some pre-determined maximum setting.

Some economy could be effected by using 1 common cathode resistor and bypass condenser for all 6SC7 tubes, this would require a 600-ohm resistor and a 100-m. bypass condenser. You will note that 1/4-meg. isolating resistors are employed in the plate circuits of the 6SC7, so as to avoid undue shunting between channels. All resistors may be of the carbon 1/2-watt type, excepting those otherwise indicated. Reasonable care should be exercised in placing the power transformer and filter chokes away from any of the input circuits so as to avoid hum pick-up. The electronic mixer should feed into a voltage amplifier which employs a tube having a comparatively low input capacity. Otherwise, appreciable loss of high frequencies may result. A 6C5 is excellent for this application.

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MAILBAG
(Continued from page 517)

Requests for F.M. licenses last month included Wnuk Corp. (New York), and Sea- board Broadcasting Corp. (Glenside, Pa.), thus bringing the total of applications for station licenses to 58; 7 construction permits for F.M. stations in the New York area have been granted by the F.C.C.

NEWSP SHORTS

(a National Association of Broadcasters estimate).

New York City is contemplating the use of 2-way radio equipment aboard ferries as a convenience to the boat-travelers. Mayor LaGuardia acknowledged last month.

The $4,500,000 Edison Memorial Bridge over the Raritan River at Trenton, N. J., was dedicated last month.
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HOME RECORDING

Theory and Practice of Sound-on-Disc

Sound recording equipment introduced in 1940 enabled radio men generally—servicemen, experimenters, etc.—to "feel their oats" in this new field. Radio manufacturers finding wide acceptance of modern sound recording facilities have gone to town in incorporating sound recording equipment in their new lines for 1941. Mr. Queen draws on his wide practical experience as a sound recordist to tell RADIO-CRAFT readers short-cuts and recommended procedures for obtaining best results with sound recording equipment. A useful bibliography on sound recording concludes this article.

I. QUEEN

MANY of the current lines of radio sets are featuring a sound-on-disc recorder as part of the combination, so that it is possible to make recordings either from the radio set's output, from a microphone, or from both simultaneously. There is also available on the market separately various types of cutting heads, screw feeds, motors and pickups so that the experimenter may assemble his own recorder utilizing his own ideas in the building. The response from the public this past year shows definitely that home recording is here to stay and is becoming an entertainment and educational necessity. This has been made possible by modern developments whereby a result may be obtained comparing favorably with many professional discs and with the expenditure of far less time, effort and money.

PROSPECTS

The progressive radio salesman and serviceman would do well to gain a firm knowledge of the principles which are involved so as to be able to solve difficulties which may arise in this new branch of radio. An enterprising technician will find dozens of practical ways in which to profit by selling accessories, and repairing and setting up apparatus for recording enthusiasts.

The first sounds of the baby, a child's musical accomplishment, and family harmony groups, may be recorded and placed away in an album to be brought out time and again for entertainment or to refresh the memory. The historic broadcasts of these critical times will become invaluable in the future, while favorite broadcasts may entertain again and again. "Special occasion" greetings recorded and sent on to distant relatives and friends take on a new personal meaning. There is no surer way of checking on code-sending ability or musical study than by listening to oneself over and over again.

The business opportunities involved are many. Sales messages may be sent from headquarters to branch personnel, and store demonstrations become far more effective when accompanied by a spoken sales message. Small sound-effects records may be made up and sold to dramatic groups or parties.

To aid the radio man to take advantage of these opportunities, only a few of which have been enumerated, this article will describe the principles involved, the systems used, and how to surmount the difficulties which may be encountered. It should prove of interest to both beginner and to those

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who may have had some experience with home recording.

**THEORY**

Thomas A. Edison found when he spoke into a horn directly connected to a needle, that the latter vibrated in accordance with his speech. He wound a metal foil about a revolving cylinder and placed the fixed needle in contact with the foil. The vibrating needle scratched-in lines in the foil, and when the needle was again allowed to swing from its groove, the original sounds were reproduced. Because the cylinder was inconvenient to handle and difficult to make use of when duplicates were required, the foil was now in common use (except for machines such as the Ediphone). Also, the disc allows recording on both sides. The grooves along which the vibrations take place are in the form of a spiral from the outside towards the center of the disc.

The usual cutter takes the form of Fig. 1 which shows the scheme of a magnetic cutter. The soft-iron armature is placed between the poles of a powerful permanent magnet on the pivot F. Turns of wire are wound around the armature and on passing audio currents through the winding, the movement of the armature is passed on to the cutter, causing a lateral vibration of the cutter about its central position. Damping is required to bring the needle back to its neutral position when no modulation is applied, and this may take the form of rubber or oil damping, the latter being more efficient but expensive.

Assume for the moment that the unmodulated or "silent" groove approaches a straight line such as at the edge of the record, a high frequency will look like Fig. 2A frequency of the same power level will be as in Fig. 2B. It is seen at once that the amplitude of the lateral movement depends directly upon the speed of the cutter and that the limit is reached when this is sufficient for the needle to swing from its groove into the adjacent one, ruining the record. There is also a limit to the high frequency which can be recorded, since the higher we go the more the tendency of the needle to move at right-angles to its groove, which is impossible.

Edison's invention used the vertical cut in which the needle was first up and down along the groove as against the common lateral cut which is being described. While the first was unsuitable for common electrical recording, it had the advantage that its volume level was not limited by the proximity of the grooves. It is desirable to put on the disc the maximum lateral swing possible, and, on the other hand, it is economical and practical to place as much sound on one record as we can. For ordinary home recording, it is customary to use a cut of approximately 100 lines or grooves per inch. The spacing is determined by a screw feed which carries the cutter slowly while the stylus revolves. A magnetic cutter needle assembly possesses a fair amount of inertia and so tends to move at a constant speed along the groove. For example, let us apply a given power at different frequencies to the cutting head. At 100 cycles then, the needle will make the cut in 20 cycles, since at the former frequency it is changing direction twice as much. The distance traveled therefore will be the same for both. This is raised to the "wobbling" characteristic. Playing-back with a magnetic head will be normal since the higher frequency, causing the rapid fluctuation, will have twice the voltage amplitude since the amplitude is half, the voltage for both recordings will be equal at the playback output.

A serious difficulty will take place in recording since the lower frequencies will cut over the grooves long before the higher ones, and the space available will be wasted when recording the latter. To solve this, cutters are purposely restricted in their low-frequency response in assembly and made to follow a "constant voltage" characteristic from about 350 cycles down, that is, in this range, the amplitude is governed only by the voltage and not the frequency. In the playback, of course, means are taken to raise the "low" considerably to make up for their deficiency. In cutters there is also a deliberate cutting down of the extreme high frequencies since it has already been shown that such frequencies at high amplitude cannot be cut by a needle.

Crystal cutters are also used to some extent. These are worked on the same principal as crystal microphones and may have the same limitations as to humidity and temperature. They cannot stand much overload, but have good frequency response. Un-corrected crystal cutters follow a constant voltage characteristic and the input must be corrected electrically if an ordinary cutting is to be made.

**DISC SPEED**

There are 2 general speeds now in use, 78 r.p.m. and 33 1/3 r.p.m., the former being common for home recording. Diameter sizes are usually 10 ins. and 12 ins. although smaller ones are available. Considering linear speed along a groove, it can be seen that near the edge of the disc the diameter is much greater than near the center. From the previous discussion, it is readily understood that the greater the linear speed, the better will higher frequencies be cut, so that near the center of the disc there is a falling off of fidelity. This is usually not very noticeable unless the grooves are very close to the center, and could be remedied by gradual manual control as the arm moves along. An ordinary tone control could be utilized.

While it is unlikely that the experimenter or home recordist will encounter 33 1/3 r.p.m. recordings as often as the faster ones, a description of the system used will be given.

This slow speed is used extensively for transcription work and formerly for movie work. A 16-in. record rotating at 33 1/3 r.p.m. gives a full 15-minute recording when cut at approximately 125 lines-per-inch. Because of the close groove spacing, the maximum modulation applied must be below that of home recordings, but due to the fact that the discs are made of a special low surface-\(\text{spacial}\) noise-level material, more amplification may be used in playing back. The slow speed shows that with the same equipment poorer fidelity will be obtained. However, proper equalization of the "highs" brings them up when playing back so that high fidelity results.

Near the center of the disc, however, the fidelity is decidedly poorer due to very slow speeds. To overcome this, several steps must be taken. First, the equalization of the highs must proceed progressively while the disc is in motion; that is, while cutting, the highs must be boosted far above normal while the inside is being cut and not so much as the grooves nearer the edge are cut. Secondly, since the needle will dull after a few minutes' use, and since it cannot be changed while the recording is taking place, it is necessary to change the inside and allowed to work out towards the edge. While the needle is new and can best follow the high frequencies near the center grooves; after the point has rounded off slightly, it is following the grooves nearer the outside, thus balancing the result. Proper equalization may take place automatically.
WAX VS. INSTANTANEOUS

Professional and commercial recordings entail intricate processes, which are available only to manufacturing concerns which specialize in them. A brief description will be given.

The cutting takes place on a heavy, thick disc made of a wax-like material. The wax is then sent to be processed as follows: it is "painted" with an exceedingly fine copper powder which makes it conducting. On immersion in a copper-plating bath a thin layer of copper is deposited upon the wax and the two are then separated. The copper layer is backed up with suitable metal and is known as a master. It is the reverse of the wax master and Eminedge in one has a corresponding depression in the other. The master may be used to stamp out playback records in a press. If records are required in large quantities, the master undergoes additional, similar processes which give a "mother" similar to the wax and a "stamper" similar to the master. This safeguards the master against damage.

The home recordist on the other hand is interested in only one or possibly a few playback discs. There are several types of blanks available for such instantaneous recordings. The oldest type is the aluminum disc which is sometimes pre-grooved; that is, it requires no feed screw. The cutter simply widens the groove and modulates it. The present-day and most satisfactory blanks are those made either of heavy card or thin metal and coated on both sides with celluloid. The latter may be either nitrate or acetate. The former is highly inflammable and must be handled with care while the latter being absolutely safe is widely used. Both are excellent materials; they have low surface noise, and they cut easily, thus requiring less needle pressure. With good care such records may be played back hundreds of times. In cutting celluloid-coated discs, a thin thread of material is cut from the surface and means are provided with recorders to have this pushed out of the way of further cutting. Because no cutting processes are involved with these type discs, the quality is excellent and noise low.

The general types of needles may be used with instantaneous recordings: (1) steel, (2) alloy, and (3) sapphire. The first is very inexpensive, but wears quickly, so that the point of the needle of the record is sharper than further on, though good results may be obtained. The alloy needle is long-lasting and can be sharpened inexpensively, giving economical and satisfactory service. The sapphire is the most satisfactory in service since it may be used a comparatively long time before resharpening is in order. It should, however, be handled carefully because it is brittle and therefore susceptible to damage.

Additional copies of instantaneous discs are best made by re-recording the first from a second turntable, the output of the playback being fed into the amplifier and the output of the amplifier supplying the cutter. Because of the fact that the noise in the "master" will be present in all the others, it is possible to make these duplicates before the first has been played more than a few times. If quite a few copies are wanted, it is best for the individual to decide whether to make all copies from one, or after a while, to choose one of the duplicates for further re-recording. With care, and the use of needles and cutters of uniform quality, there will be little additional noise will be introduced.

The turntable used for both cutting and playback should be free from slight variations of speed under varying load. For in-

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The cutting thickness when fed high-level sounds must cut through more disc material, and thus the turntable can supply this load, there will be momentary variations. In playing-back, these changes of speed will manifest themselves as "wows." A momentary increase in the recording turntable will result in a momentary increase of frequency in the playback, and vice versa. The average ear will detect a 1% change in frequency.

Microphones

The recordist will in general use either of 3 types of microphones: (1) the crystal, (2) dynamic, or (3) velocity. The crystal is a very good talking mike and has a high output so that it requires no special preamplifier. Certain models come in directional types and are valuable where room reverberation is likely to be met. Being a high-impedance mike, it cannot be used very far from the amplifier unless transformers are used to and from the line. They may be susceptible to humidity and high temperatures.

The velocity microphone is a very low level device but has an excellent frequency and directional characteristic. It may be spoken to from either front or back, its sensitivity dropping gradually and at the sides it has practically no response. Its low impedance makes possible long lines to the amplifier (which must be equipped with a matching transformer). The velocity type cannot be used out-of-doors due to wind.

The dynamic microphone is probably the most rugged of all and can be used under practically all conditions. It is somewhat directional especially to voice frequencies. It is usually of low impedance, and though its sensitivity is somewhat low, its output can easily be handled.

The power level of electrical devices such as microphones is measured in decibels (db.). The definition of the decibel is 10 times the logarithm of the ratio between 2 given power levels. In practice one level is chosen as reference or zero decibel and the given level is compared with it. For those acquainted with mathematical procedure it may be stated that tables of logarithms are readily available and require no calculation to determine to know the level of a power 10 times greater than that of the reference value. The logarithm (from the tables) of 10 is 1, and 10 times this value is the answer in an answer of 10 db. To simplify calculations it may be remembered that every time we multiply a power by 10 we add 10 to the db. value. The level may be so many db. plus or minus depending upon whether it is higher or lower than the zero value. In most instances the zero level is 0.001-watt. Because a vacuum tube is a vacuum-operated device, when microphones are concerned, it is usual to choose reference value as 1 volt per bar, the bar being a linear measure (created by the sound). The bar is equal to a megadyne per square centimeter.

Monitoring—Mixing

There are 3 distinct purposes of monitoring the sound input as the recording is taking place. First, we wish to check-up on the quality of the recording, make sure that nothing has gone wrong as far as mike and amplifier are concerned. Second, we wish to make sure that the level is as high as possible for high ratio of headphone input without overcutting. Third, we must obtain proper balance between the several sound sources (assuming more than one).

To accomplish this purpose it is necessary to listen to the sound either on headphones or on a speaker. Since the latter would interfere with the original sounds (if a microphone is being used), the headphone operation is essentially the same as when recording. If a complete recorder does not come equipped for headphone operation, it is possible to place a high-resistance 'phone across a low-impedance cutting head (assuming the D.C. is excluded from the circuit) for there will be only slight change in resultant impedance; or, a pair of headphones may be connected into the amplifier at the detector output, and some switching arrangement made for shutting off the speaker.

When using the microphone in anything but a small, well-furnished room it may be noticed that a distinct echo or reverberation is present. This is due to the fact that the sound is being reflected from walls, floor and ceiling. A heavy rug on the floor will decrease the difficulty while curtains and drapes will help as far as the walls are concerned. Since certain sounds increase the sound input without producing a corresponding increase in reverberation, this may be tried, although with some microphones it is not good policy to have too closely, breath noises being accentuated.

It must be understood that what we normally hear in a room and what a mike will hear in the very same room may be two entirely different things! With 2 ears, we have the faculty of being able to concentrate on wanted sounds, subconsciously rejecting interfering noises. We may, for instance, be able to carry on a conversation in a room filled with other voices, even when the latter are loud compared with our own. A mike, however, not having this characteristic, picks up sound only in relation to its strength. A room which may seem correct for microphone use, may, for other reasons give distorted results when actually monitoring on the 'phones, and on the finished record, due to reverberation being reflected from the walls. A directional mike will greatly decrease reverberation troubles.

As stated above, we wish to cut the record at as high a level as possible for best results. For this it is imperative that we have complete and variable control of the eye, being more sensitive to intensity changes than the ear. It is common practice to use a logarithmic or electronic visual indicator for this purpose.

Several trials will determine how far the eye closes for maximum modulation and the amount must be used, for any time. A more precise arrangement would be one using a meter to show the power level. Two general methods are in use: (1) the vacuum-tube voltmeter; and, (2) the copper-oxide rectifier. One of the figures shows the connections involved.

The vacuum-tube voltmeter is biased almost cut-off, and as a result, the D.C. meter in the plate circuit will indicate relative voltage inputs. Its advantage is that it takes no power from the input, but on the other hand, it requires a filament and plate voltage supply.

The other method uses a rectifier in conjunction with a D.C. milliammeter. The audio frequencies are changed to D.C. The rectifier usually takes the form of copper washers, one side of each of which is oxidized. The pure copper is connected to the negative side of the output.

The bridge connection shown in the diagram will give the greatest output with least strain on the rectifier elements for a given voltage input. The meter is very sensitive to temperature and humidity, breakdown occurring at about 150 deg. F. The diagram shows a tapped sec-
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MODERN MICROPHONE TECHNIQUE

This is the 2nd article in a series of 3 designed to answer many questions on the choice and use of microphones (and on amplifier input considerations) in Public Address work, and Home and Semi-Professional Home Recording. Sound specialists in every branch of the field were consulted during the preparation of this article in an effort to present concrete, applicational information on this topic. Part I, last month, analyzed Crystal, Dynamic, Velocity and Cardioid microphones.

PART II—The Microphone and Its Relation to the Amplifier

THE basic requirements outlined in Part I of this series may help the technician to select a particular type of microphone for his application. The next step involves the technique of connecting the microphone to the amplifier. Specific types of installation will necessitate the selection of a particular kind of basic microphone. The academic conception of "connecting" a microphone to an amplifier simply means running the two wires from the microphone output to the amplifier input. In actual practice, however, a number of factors tend to complicate this apparently simple procedure.

BASIC CLASSIFICATIONS

Electrically, microphones may be classified into 3 distinct groups:

(1) Resistive
(2) Inductive
(3) Capacitive

Resistive microphones are those types in which the prime moving element is resistive in nature. This is particularly true of the carbon-type microphones, wherein carbon granules are employed. Its impedance is exactly equal to its resistance. When this microphone is coupled to a low-impedance transformer, the output terminals of the microphone are resistive because of the reflected resistance connected to its primary. When the carbon unit is coupled to a high-impedance transformer the output terminals of the microphone become predominately inductive because the coefficient of coupling is usually low (in high-impedance transformers).

Inductive microphones are those types in which the prime moving element is inductive in nature. This is particularly true of dynamic microphones, wherein a moving coil is employed. Its impedance is practically equivalent to its inductive reactance. Its D.C. resistance usually is negligible. When this moving coil is coupled to a transformer, the output terminals of the microphone are inductive, because of the reflected inductance connected to its primary.

Capacitive microphones are those types in which the prime moving element is capacitive in nature. This is particularly true of the crystal-type microphone. Its impedance is equivalent to its capacitive reactance. When this crystal unit is coupled to a transformer, the output terminals of the microphone become capacitive, because of the reflected capacity connected to its primary.

THE MICROPHONE LINE

Although microphone lines, per se, may appear to be a prosaic item for discussion, a brief analysis of the types and their characteristics will disclose some unusual problems.

Microphone lines may broadly be classified into long and short. While there is no arbitrary classification of the two, 100 feet is popularly regarded as the dividing line. In other words, microphone lines up to 100 feet are usually constructed as short lines. Those exceeding 100 feet are considered long. This terminology, of course, is confined to microphone lines only as discussed within the scope of this series of articles.

H. S. MANNEY

Microphone lines may also be shielded or unshielded. If shielded, the lines may be composed of 2 wires and a shield, or a single wire with a surrounding shield. The shields of such lines may or may not have an external insulating cover.

Microphone lines may further be classified as high impedance or low impedance. While no official line of demarcation differentiates either type, popular terminology has restricted the use of "low impedance" to all lines up to and including 600 ohms. All other higher impedance lines are simply classified as "high impedance." They may range up to 100,000 ohms.

Most popular high-impedance velocity microphones are terminated at 10,000 ohms; others at 5,000 ohms, and some as low as 2,000 ohms. The relative importance of these terminal impedances will be discussed after the various characteristics of lines have been covered.

LINE RESISTANCE

Microphone lines display 3 electrical characteristics:

(1) Resistance.
(2) Inductance.
(3) Capacity.

RADIO-CRAFT for MARCH, 1941
The quantity of these characteristics is determined by the length and type of line.

The relative importance of each of these 3 characteristics will greatly affect the selection of the impedance of the microphone as well as the input circuit of the amplifier.

The resistance of a line is proportional to its length, and therefore, actual resistance of any microphone's line can be found by either direct measurement or by referring to the line chart. This resistance plays no important part in high-impedance lines. In a low-impedance line, such as 50 ohms or 25 ohms, the resistance of a long microphone line can introduce a considerable loss. This is illustrated in Fig. 1 where E is the voltage generated by the microphone, ZL, its terminal impedance, RL, the resistance of the line, and ZL1, the input transformer. Although ZL may equal ZL1, the loss becomes appreciable when RL approaches ZL. The loss in db may be expressed mathematically as follows:

\[ Z_L + R_L + Z_L^1 = \text{Loss db} = 10 \log Z_L \]

It will be noted that the loss becomes smaller as ZL and ZL1 become large, with a given fixed value of RL. This simply means that the line resistance may be neglected in high-impedance circuits. In calculating the line resistance, 2 wires should be taken into consideration, that is the one going from the microphone to the amplifier, and its return lead, so that the actual wire length would be double the distance of the microphone cable.

Another point to remember in employing low-impedance circuits is that frequency discrimination will occur when line losses become large. This phenomenon is brought about by the fact that the inductive generator is feeding the resistive-inductance network and the resistance displaying a non-frequency discriminating characteristic while the load may display a frequency discriminating characteristic. This condition would bring about a loss of low frequencies, which may sometimes be desirable.

LINE CAPACITY

It is apparent that a shielded wire will have some capacity. It is also obvious that the longer the shielded line, the more the total capacity. Likewise, the less the distance separating the wires (whether close wire and its shield or each of the twisted wires), the smaller will be the capacity of the line. This is of a negligible value in low-impedance lines, but may assume an appreciable value in a high-impedance line.

The capacitative characteristic of lines is of great importance when dealing with crystal microphones, because the crystal microphone is a capacitative generator, as illustrated in Fig. 2. This device has effectively no series resistance. Any capacity connected in parallel will reduce the output voltage, but will not introduce any frequency discrimination. This can easily be analyzed by referring to Fig. 3 wherein a crystal microphone is connected to a cable having measurable capacity Zc. The voltage which appears across Zc:

\[ Z_c \]

Zc will be proportional to \( Z_c + Z_L \). As Zc and ZL are both capacitative in nature, their relative impedance will remain proportional through the entire audio spectrum thereby accounting for the fact that no discrimination occurs when long, capacitative lines are used in conjunction with crystal microphones that do not employ internal step-down transformers.

This capacitative nature of a long, high-impedance line, however, will greatly impair the original characteristics of an inductive microphone. It may, under some conditions, actually resonate at some audio frequency, and thereby produce a very undesirable peak. Furthermore, it will nearly always introduce an appreciable frequency discriminating characteristic, usually a predominant loss of high frequencies.

Therefore any high-impedance inductive or resistive microphone will lose high frequencies when coupled into a long, capacitive line. Capacitative microphones, on the other hand, will not display frequency discriminating characteristics when coupled to such lines, but will suffer reduction in output.

LINE INDUCTANCE

When a twisted pair of wires are run for an appreciable distance, the line may display, in addition to resistive and capacitative characteristics, an inductive reactance, which is effectively placed in series with the generator, as illustrated in Fig. 4. If the microphone is of an inductive nature and the amplifier input of an equivalent inductance, no frequency discrimination will occur, but a drop in effective voltage will be noticed at the amplifier input.

It will be noted that this nicety of frequency balance is only maintained when the characteristics of the line are similar to those of the microphone and the amplifier input. When variations exist between these 3 elements, some form of discrimination will occur. The usual end result is a loss of high or low frequencies.

These phenomena are outlined for the technician so that he may affect suitable remedial measures and correct any noticeable discrimination in the coupling link between microphone and amplifier.

AMPLIFIER INPUT TERMINALS

Input terminals of all amplifiers can broadly be classified into 2 groups:

1. High Impedance
2. Low Impedance

The high-impedance type may be further classified into resistive or inductive.

All low-impedance inputs employ transformers for matching the line impedance to the input grid circuit. Some high-impedance inputs similarly employ transformers. This is particularly true of bridging amplifiers, wherein a 5,000-ohm input is bridged across a 500-ohm line so as to provide minimum loading effect. All ordinary high-impedance microphones have their inputs terminated directly into the grid circuit of an amplifier without any intervening component.

If an amplifier employs an input transformer, the characteristics of this latter unit are just as important as those of the transformer employed within the microphone. The frequency response of any inductive microphone can be no better than the frequency of the transformer into which it feeds. As most input transformers must be built small to avoid excessive hum pick-up, an appreciable amount of loss is usually encountered because of transformer inefficiency.

When it is difficult to decide whether or not to use high- or low-impedance lines, one used has disadvantages of an additional input transformer within the amplifier which should always be taken into consideration. Its response and efficiency are of vital importance.

Furthermore, a low-impedance microphone necessitates the use of 2 transformers, one within the microphone and one within the amplifier. On the other hand, high-impedance crystal microphones require no transformers, while high-impedance velocity or dynamic microphones require a single transformer within the microphone itself, and none in the amplifier.

For a non-frequency-discriminating match, it is important that the inductive micro-
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SOUND

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Phone feed into an inductive input having similar impedance-frequency characteristic.

This general rule holds true for all ideal coupling circuits between microphone and amplifier. When a cross-match is made, that is, a capacitive microphone coupled into a resistive input, or a resistive microphone coupled into an inductive input, some form of frequency discrimination is sure to occur. Under some conditions, this type of discrimination may be desirable and used to full advantage. In most cases, however, the technician is unaware of, and therefore does not control, the discriminating characteristic introduced by the link which couples the microphone to the amplifier.

MICROPHONE EQUALIZATION

Frequency discrepancies which may exist in a microphone, its coupling link, amplifier input, or speaker, and its acoustic environment may be compensated for by suitable selection of equalizer circuits within the amplifier proper.

For varied applications, it is usually advisable to provide a variable set of equalizers so that any predetermined frequency response characteristic may be obtained from the entire system from microphone to speaker or recording head. The design of equalizers is both varied and complex. Design details are beyond the scope of this discussion. Some fundamental principles, however, will be outlined in the hope that technicians may be able to correct for some frequency discrepancies.

The most distorted form of frequency discrimination occurs when the character of the original sound is altered to a noticeable degree. This usually occurs when the system attenuates or accentuates either or both high and low frequencies. Ordinarily, elaborate equipment would be required to check the overall response of a complete system. In all practical work, however, a competent technician can easily judge what type of discrimination is taking place, so that fundamentally, the problem evolves itself into incorporating an equalizer within the amplifier, which will attenuate or accentuate either or both the high or low end of the audio spectrum.

A simple high-impedance output coupling circuit, which can easily be interposed between 2 high-impedance stages, is illustrated in Fig. 5. Likewise, a high-frequency attenuator is illustrated in Fig. 6. Basic low-frequency accentuation and attenuation circuits are given in Figs. 7 and 8, respectively. The degree of equalization required will determine the values of the various resistors, inductances, and capacities.

Some experimentation will usually provide the desired degree of equalization. Where a complex frequency discrimination occurs, as when the frequency response characteristic is composed of predominant hills and valleys, the design of a suitable equalizer becomes involved, and unless absolutely necessary, should not be attempted by the layman.

EVALUATING THE FREQUENCY DEFICIENCIES

When a system is being judged for lack of presence of any portion of the spectrum, care should be taken not to be misled in the wrong direction. For example, a system that has a prominent boost cannot be assumed to be a good system as though high frequencies were lacking. On the other hand, a system that accentuates high frequencies, may appear to be lacking in lows. It is obvious that the best corrective method is to eliminate the source of trouble and not introduce an additional source of discrimination.

For example, the system which has excessive highs and appears to lack lows may be subjectively corrected by introducing a high-frequency accentuating circuit. This is not the most desirable procedure to follow, for it is usually much simpler and more economical to reduce the excessive high frequencies. This latter method will not introduce any secondary troubles, such as increase of hum when low frequencies are accentuated. It is hoped that this discussion will bring to the attention of technicians, many conditions with relation to the use of microphones which affect the overall response of the system and that better judgement will be exercised in the selection of various components in view of the characteristics outlined.

The following, concluding article will outline several points which should be considered when actually using the microphone.

Feature Articles in the MARCH RADIO & TELEVISION

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Improve Audio Output

Fixed bias, an important feature in audio amplifiers, has been thus far supplied by either expensive or inconvenient devices. The author of this article has developed very unusual and economical circuits to be used in their stead.

JOEL JULIE

In many receivers and in many audio amplifiers it is often advantageous to have more than one independent power supply. Changes of current in one part of the circuit affect the voltages of other parts of the circuit. Generally in radio receivers all the voltages are obtained from one power supply, since this is the cheapest method of obtaining the desired result. However this situation has its advantages for the Service-man inasmuch as it affords him an opportunity to suggest to customers improvement in operation through the addition of a separate power supply, as for example one of those here described, to achieve greater operating efficiency (primarily, greater amplifier power output; greater dynamic range — for a given input), and hence, improved tone quality.

Let us concern ourselves in this article only with the factors affecting the power output. The power output of an audio stage depends largely upon the plate supply and grid supply voltage of that stage and the stability of those voltages under different loads; this stability is what is usually called the regulation of the power supply.

REGULATION

As far as class A operation is concerned, where the operating point is chosen on the straight part of the characteristic we would have no trouble with the regulation of the power supply, since the plate current remains practically constant under varying signal strength. In class A then, we can get along successfully with one power supply, obtaining the grid voltage as a voltage drop on a cathode bias resistor or on a resistor placed between the minus (—) terminal of the plate supply and the ground. These arrangements are known as self-bias since the plate current is fed through a resistor, providing its own bias. Fixed-bias is a bias voltage supplied by an independent source. The great majority of output tubes will work with practically the same degree of efficiency with fixed-bias or self-bias under class A operation. Significantly, most tubes, though, operate more efficiently if fixed-bias is applied, even though operated in class A only.

SELF-BIAS EFFICIENCY

In class AB operation, where the operating point is chosen near the cut-off point of the characteristic, the plate current of the output stage varies considerably with the variation of the signal strength. If self-bias were used the variations of the plate current would cause variations of grid voltage, thus causing displacement of the operating point of the output stage. A class AB stage operated in such a manner would not work very efficiently. In fact a pair of 2ASs will supply 15 watts output at 300 volts plate voltage with fixed-bias as compared with only 10 watts output with self-bias; a pair of 6L6s will supply 40 watts at its maximum ratings with self-bias as compared with 60 with fixed-bias. The same ratio of power output holds true with almost all the output tubes. Strangely enough there are some tubes, like the 6F6, operated as a pentode, that will work as efficiently with self-bias as with fixed-bias even in class AB. The number of these tubes, though, is very small.

For those cases where an independent power supply for grid bias is necessary, various arrangements were used in the past, which were either inconvenient or expensive, or both. These are still being used today—bulky "C" batteries or expensive, completely independent "C" power supplies. In Figs. 1, 2, and 3, is shown a convenient and cheap method of obtaining a fixed "C" supply voltage, which is adaptable to many conditions of service.

SINGLE-ENDED OUTPUT

In Fig. 1 we have the design applied to a condition of transformerless operation (A.C. only). We use a voltage doubler operated as 2 independent power supplies. One section of the rectifier supplies the plate and screen-grid voltages; the other section, control-grid voltage. The field of the speaker is utilized as a filter choke for the control-grid voltage. Provided that the capacity of condenser C1 is large enough the plate voltage of the output tube can be taken.
NEW FM AUDIO AMPLIFIERS

Designed by A. C. Shaney

FREQUENCY RANGE: 13-30,000 c.p.s.; 25 db
POWER RANGE: 450 to 30,000 milliwatts
MUSICAL RANGE: 11 Octaves

OUTSTANDING IN BASIC PERFORMANCE, CONSTRUCTION AND USE

Three outstanding features are designed for use with frequency modulation reception, standard FM tubes, and conventional FM receivers. The push-pull connection is suitable for field excitation. The use of high-voltage rectifiers, untuned resistance, modulation transformers, interchannel transformers, AC and DC, balancing, and other new ideas render greater circuit stability than conventional amplifiers.

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17 WEST 20th STREET NEW YORK, N. Y.

from the cathode of the rectifier.

That arrangement will provide for better regulation and also will make available to the output stage, the maximum voltage obtainable, or 120 volts.

The appropriate values of resistance and capacity when using a type 45 power amplifier and rectifier, for example, would be about as follows:

RESISTORS
R1, 75,000 to 100,000 ohms, ½-w.;
R2, 400 ohms, 10 W.;

CONDENSERS
C1, 40 mf. or more, 150 V.;
C2, 10 mf., 150 V.;
C3, 30 mf., 150 V.;
C4, 25 mf., 25 V.;

MISC.
Field, 2,000 ohms;
Choke, 400 ohms, 12 hy., 30 ma.;
Transformer T, output, 4,500 ohms (impedance).

A type 43 tube operated in such a manner would deliver about ½ watts; a 25B6 would deliver as much output as a 6P6 having 250 volts on its plate. It can readily be seen that in small A.C. receivers, the cost of the power transformer can be saved while we may still obtain as much power as we could with the transformer. As compared with the regular voltage doubler this circuit has many advantages, the most important of which is better regulation and, of course, the welcome feature of a fixed "C" bias supply.

This circuit makes possible for the first time, the attainment of fixed-bias in transformerless-operated apparatus, without the necessity of using batteries.

PUSH-PULL TRIODES

In Fig. 2, a circuit of 2 independent power supplies is shown using a single transformer of exactly the same size as if 1 power supply were used. The only difference is that the high-voltage winding is divided into 2 parts; one that supplies 35 volts for the plate voltage, and one that supplies 140 volts for the control-grid and field excitation—if for example we are considering a pair of 6AS8.

The rectifier VR2 is heated from the same source as the receiver tubes. Its cathode is connected to ground. As a result we may increase the output of the amplifier from 10 to 15 watts without increasing the size of the transformer.

As a 2nd advantage the lower operating voltage for C1 may be mentioned. Ordinarily for 1000 volts on grid, plate and control-grid voltages were to be obtained from 1 power supply, the operating voltage for C1 would have to be 900 volts, necessitating the use of a high-voltage condenser, or better yet, 2 condensers in series. A 3rd advantage is better regulation since the field excitation remains from the bias voltage supply, thus making the resistance of the plate supply circuit as low as possible.

Under these conditions we would have for the values of the component parts—

using, for example, a pair of 6A8S as the power tubes, a 6T4 rectifier, and an 84 grid and field supply rectifier—the following:

RESISTORS
R1, R2, 50,000 ohms, ½-W.;
R3, 20,000 ohms, 15 W.;
R4, 600 ohms, 10 W.;

CONDENSERS
C1, C2, 8-mf., 350 V.;
C3, 30 mf., 150 V.;
R3, 30 mf., 100 V.;

Misc.
Field, 750 ohms;
Choke, 100 ohms, 12 hy., 125 ma.;
Transformer T1, output, 3,000 ohms plate-to-plate;
Transformer T2, power, 5 V., 2 A.;
Transformer T3, output, 20,000 ohms plate-to-plate;
Transformer T4, power, 2 V., 2 A.;
Transformer T5, power, 1 V., 2 A.;
Transformer T6, output, 50,000 ohms plate-to-plate;
Transformer T7, power, 750 V., 2 A.;
Transformer T8, power, 1000 V., 2 A.;

These transformers are of the conventional design, are of conventional size, and are suited for the purpose.

Misc.
Choke, 100 ohms, 12 hy., 125 ma.;
Transformer T1, output, 3,000 ohms plate-to-plate;
Transformer T2, power, 5 V., 2 A.;
Transformer T3, output, 20,000 ohms plate-to-plate;
Transformer T4, power, 2 V., 2 A.;
Transformer T5, power, 1 V., 2 A.;
Transformer T6, output, 50,000 ohms plate-to-plate;
Transformer T7, power, 750 V., 2 A.;
Transformer T8, power, 1000 V., 2 A.;

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Transformer T7, power, 750 V., 2 A.;
Transformer T8, power, 1000 V., 2 A.;

These transformers are of the conventional design, are of conventional size, and are suited for the purpose.
VACUUM-TUBE OSCILLATORS
And How They Work

What are the factors which enable a vacuum tube to generate alternating current, i.e., function as an oscillator; and, frequently of more immediate importance to Servicemen, which may cause an oscillator circuit to cease operating? These fundamentals are here given microscopic examination. Any radio man reading this article, if he takes care to absorb the information it presents, cannot fail to have a firmer grasp on one of the basic building blocks of modern radio servicing equipment and reception. This article, by the Chief Instructor of a well-known radio school, has been reprinted by special permission from National Radio News.

J. A. DOWIE

In every radio transmitter, in every superheterodyne receiver and in radio servicing equipment, we find oscillators producing the signal. It is this oscillator that supplies the signal that is so essential in carrying out our work. Since it is so important in radio, let's study in greater detail how it works. That is, how does an oscillator operate in generating the signal and how does it continue to develop a signal after it is placed into operation?

OSCILLATOR CIRCUITS

There are a large number of different types of oscillators in operation. There are oscillators which maintain oscillation by ionization of gas and by the projection of electrons through chambers where the rate of travel of the electron determines the frequency of oscillation. In this discussion I am going to cover only the operation of the better-known oscillator circuits.

The oscillators that are used most extensively in the radio field are, for example, the tuned-grid, the tuned-plate, the Armstrong, the Miesnner, the Hartley, the Colpitts, the Colpitts-Franklin, the push-pull and the push-pull types with either the tuned-grid or tuned-plate, or both.

In my discussion I will cover these circuits and their operating characteristics. It will be pointed out that when you understand the characteristics of oscillator circuits which depend upon capacitative or inductive feedback that you will understand the operating characteristics of all of the conventional types of oscillator circuits mentioned above.

PHASE RELATIONSHIPS

It can be stated that the primary requirement in order to sustain oscillations in either an inductive or a capacitative feedback circuit is that the applied grid-to-cathode voltage must be approximately 180° out-of-phase with the plate-to-cathode voltage. This means that when the grid-to-cathode voltage is rising in a positive direction the plate-to-cathode voltage must be dropping in a negative direction. That is, the tube itself acts as an amplifier. Then, too, if the reversal is of a sine wave character the waveform of the signal generated will be a pure sine wave. Remember that the voltage applied to the control-grid of a tube which is not overloaded controls the plate circuit output waveform and that the triode tube is easily adapted to the inductive or capacitative feedback types of oscillating circuits.

In an oscillator circuit the tube does not become an oscillator—it continues to act as an amplifier—amplifying the voltage which is applied to its grid circuit and sending it through the circuit coupled to its plate. When the plate circuit is properly coupled to its respective grid circuit so that it continues to amplify the signal it excites itself, the circuit and the tube become an oscillator.

Since the tube continues to operate as an amplifier even though it is in an oscillatory circuit, it is only some of the important characteristics of vacuum-tube amplifiers.

BASIC CIRCUITS

In Fig. 1A is shown a triode having electrode supply voltages, its operating point being at (a) on the Eg-Ip characteristic curve shown at B.

It can be shown that as the grid voltage of the tube is driven in a positive direction by some force that this will result in a decrease in plate voltage between P and K. This is due to the increase in plate current, the voltage drop being in the plate load and the polarity or phase of the voltage in this circuit being in a negative direction.

Now when the grid is driven in a negative direction in the grid circuit the plate circuit voltage goes in a positive direction.

This can be proven by Fig. 1B. Point 1 on the grid voltage moves positive to point 2 and the plate current increases from point 3 to point 4. An increase in plate current means a drop in plate-to-cathode voltage; and from a high positive value to a less positive value with respect to the cathode. It is therefore evident that the voltage applied to the grid-cathode circuit must always be 180° out-of-phase with the change taking place in the plate circuit of the tube in order to have the tube excite itself and thus maintain oscillation.

So long as the signal voltage on the grid of the tube does not swing beyond points b and c on the Eg-Ip curve there will be

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no waveform distortion introduced and if the coupling between the grid and plate circuit permits uniform waveform changes, then a sine wave will be developed in the plate circuit and consequently at the output of the oscillator. This condition of operation is known as "class A" amplification.

AMPLIFIER CHARACTERISTICS

The efficiency of an oscillator is dependent to a large extent upon the class of operation. As in the case of the various classes of amplifiers used, the class A, B and C, the efficiency of the oscillator tube is the same as if it were an amplifier insofar as the tube is concerned. Figure 2 shows the relationship between the grid bias voltage, grid swing and plate current for the three fundamental types of amplifiers all of which may be used in the operation of an oscillator.

The outstanding operating characteristics of a properly-operated class A amplifier is the fact that the variations in excitation do not produce a change in the average D.C. plate current. That is, the increase in plate current are equal to the decreases and for this reason the average current taken from the power supply does not change. The grid excitation therefore drives the grid current in phase with respect to the cathode of the tube.

In the class B amplifier increases in grid excitation produce proportional increases in the average D.C. plate current, that is, an increase in excitation raises the output of the oscillator. The grid excitation is sufficient to drive the grid positive but not off the straight portion of the E-g characteristic.

The class C amplifier is operated so that further increases in grid excitation show no further increase in the average plate current. This condition of operation can only exist with the flow of grid current. The grid is driven positive and far enough to drive the D.C. plate saturation point. It can also be stated that an oscillator employing a class C amplifier has very high harmonic content as the plate current exceeds the saturation point as can be seen at the upper-right in Fig. 2.

HOW PHASING IS OBTAINED

As stated there must always exist a 180° phase shift in the voltages between the grid and plate circuits in order to use a triode as an amplifier tube in an oscillator circuit. This required phase shift can be obtained by means of a transformer or through the aid of a phase-shifting network or phase inverter consisting of another tube.

Most oscillatory circuits use a transformer consisting of either 1 winding having a tap on it or 2 separate windings. For example, Fig. 3A shows a tapped transformer, often referred to as an autotransformer. The position of the tap being selected to give the required excitation voltage for the class of amplification desired.

The transformer winding gives us the desired phase shift because one end of the winding will always be of opposite polarity with respect to the other. No coil or winding on a transformer can have the same polarity when the winding is wound in one direction. One end always be positive while the other is negative. This is the condition when all turns are linked together by the same electromagnetic field.

If we use an oscillator coil having 2 windings then the windings must be connected so that the grid end of one winding will be of opposite polarity with respect to the plate end of the other, thus keeping the 180° phase shift. The connections will be as shown in Fig. 3B.

COIL POLARITY

Oftentimes the Serviceman is required to make an oscillator coil replacement and he is confronted with the job of connecting the unmarked leads of an oscillator coil to produce oscillations.

In order to connect the coils of an oscillator so the phase will be correct, refer to Fig. 3B. Note that a and d are at opposite ends of the oscillator coil. If lead c is connected to the plate coupling condenser C, then to insure proper polarity lead b must be connected to the grid coupling condenser C. It isn't difficult to remember this requirement. I always says that "when the grid is at one end of a coil form having 2 windings then the plate must be at the other end of the coil form when the 2 coils are wound in the same direction." That is, these 2 leads are always on the opposite ends of the 2 coils or at the 2 inside terminals.

This rule holds good regardless of the placement of the tuning condenser or condensers or the method used in supplying power to the oscillator circuit. The tuning condenser or condensers do not shift the phase of the voltage across the coils sufficiently to stop oscillation.

FEEDING POWER TO OSCILLATORS

Figure 3B shows how the power or electron voltages are supplied to the tube so it can amplify by what is known as the shunt or "parallel" feed method. The signal voltage generated is in parallel with the path taken by the power to the tube electrodes.

In Fig. 3C the same circuit components are shown but connected to give us the series feed method of supplying power to the tube electrodes. Note that the coupling condensers are now bypass condensers and are connected to the cathode of the tube.

It is, of course, possible to use the series feed in the grid circuit and the parallel or shunt feed method in the plate circuit or shunt feed in the grid circuit and series feed in the plate circuit. The method of feed selected by the engineer in the construction of the device may be any one of these combinations. The series plate feed method being somewhat more efficient than the shunt feed method as this method prevents Bp from shunting the plate circuit of the oscillator.

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**FIG. 2**

![Fig. 2](image)

Fig. 2. Relationship between control-grid bias voltage, grid swing and plate current for class A, B and C amplifiers. In class A, the grid never swings positive; in class B the grid swings positive only over the linear region of the plate current characteristic; in class C the grid swings beyond the plate current saturation point.

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**Fig. 4**

![Fig 4](image)

Fig. 4. Those plate and grid currents and voltages represent operating conditions in the oscillator circuit of Fig. 3. Remember that graphs like these are always read from left to right. When comparing 2 voltages, that one which reaches a positive peak closest to the vertical mid-line is said to lead the other; thus, Vb in A leads do in B.
AUTOMATIC "C" BIAS

Although the circuit shown in Fig. 3A has a "C" battery to enable class A operation of the tube at a given point on its Ej-1p curve, it is being connected to the cathode Rg may be considered the load on the rectifier. The voltage across Rg is dependent upon the changes in plate current and resistance.

Now that we know how the proper polarity of the winding can be ascertained, how power may be fed to the tube and how the grid bias voltage is developed, we can determine how oscillations are developed and maintained.

GENERATING OSCILLATIONS

Assume that the cathode of the tube in Fig. 3B is at its operating temperature and that the "B" battery voltage is applied instantly.

Upon application condenser Cpe will start to charge up to the value of the D.C. voltage dropped in the resistor Rp. Plate current will start to flow through winding L2. This causes a magnetic field to be present about coil L2. This field will appear to be of a steady value because the flow of the D.C. voltage is assumed to be constant. This is not, however, the case. The moment the plate voltage is applied the magnetic field about coil L2 starts to expand, which according to the well known electromotive law would link the coil L1 (due to its inductive relation), and would consequently induce an e.m.f. or a difference of potential across it.

In the usual case coils L1 and L2 are wound as stated above where coil L1 would produce a positive potential at the terminal a and a negative potential at b, the grid which is connected to a would receive a positive charge. This immediately neutralizes the "space charge" between the cathode and plate and allows more plate current to flow and this in turn increases the production of a negative grid bias. This causes a greater field to exist around coil L2 and results in a greater charge on the grid. As the plate current then increases and in turn applies a greater positive potential to the grid.

Of course this action continues until the plate current is limited by the emission characteristics of the tube or by the automatic "C" bias circuit. The rectified voltage across L1 is fed to the grid and, as shown above, the rectified grid current is across the resistor Rg. The turns ratio and amplification factor of the tube will also affect the peak value of plate current.

When the peak plate current value has been reached, the magnetic field collapses and as a result the grid is driven negative. This produces another pulse in plate current which tends to aid in making the grid more negative. The grid may be driven so far negative that the plate current is completely cut off. The next cycle of operation will be reversed and as before the operation will start all over again.

Thus it can be seen that the polarity of the coils L1 and L2 must be correct to cause the proper changes in plate current.

TURNS RATIO

It should also be evident that the greater the turns ratio of L1 to L2, the higher the peak voltage across terminals a b. That is, the voltage across winding L1 should be high and naturally the greater the number of turns in coil L1 the higher the voltage developed. This means more excitation voltage and also more plate current as more power will be required to supply the extra excitation. These facts also apply to the operation of the circuit shown in Figs. 3A and B.

The turns ratio factor is also present and holds true when the interelectrode capacitance of the tube is considered. This appears around the entire circuit and when the tuning condenser of Fig. 3A and d in Figs. 3A, B, and C. When the tuning condenser is inserted between terminals a and d, it causes the turns ratio to increase and this increases the number of turns. This is due to the fact that the condenser tunes the circuit to resonance and allows a higher voltage to exist across the coil and naturally with a larger magnetic field.

EXCITATION REGULATION

For a given plate supply voltage it is possible to find the correct excitation voltage by either selecting the proper number of turns or regulating the coupling, or both, in an oscillator circuit. The excitation voltage is also affected by the automatic bias voltage placed on the oscillator grid and the load coupled to the output circuit.

For efficient operation of the oscillator circuit, and for a given power output we must select the correct amount of excitation to give the class of operation consistent with the type of performance we desire. This value will usually be a little less than the amount of plate current that will give the most power output. There are other factors such as frequency stability and waveform that must be taken into consideration in the selection of the circuit values. It is the work of the radio engineer to select the proper operating characteristics of an oscillator circuit.

The output of the oscillator is affected by a change in the oscillator plate voltage for each given point on the Ej-1p and the grid and plate circuits. It is also a fact that an increase in the D.C. plate voltage causes an increase in the D.C. plate current, the generated R.F. tank voltage, the R.F. tank current, the R.F. grid and plate current as well as the self-adjusting grid biasing voltage.

These factors are all related to the power supplied to the oscillator for a fixed amount of coupling. It can also be stated that for a given supply voltage it is impossible to change any of the other currents or voltages in the oscillator circuit without changing all other values. An increase in the coupling of the load to the oscillator circuit will affect all of the values of currents and voltages, that is, their relationship to the other values.

GENERAL DISCUSSION

In discussing how oscillations are maintained we stated that the plate current increased to a value established by the emission characteristics of the tube. An oscillator functioning properly, however, will not operate very long as it will lose its emission and become defective. It is for this reason desirable to provide a self-biasing resistor having a value such as which produces the causes the production of the automatic "C" bias voltage that will give class B or C operation. Lower efficiency of operation is obtained when using either class B or C operation.

The self-biasing grid voltage thus developed should limit the peak plate current rather than the emission characteristics of a tube in a well-designed oscillator circuit. The ability of the self-bias voltage developed to limit the plate current is often referred to as a "braking action" that limits the grid A.C. voltages for a fixed amount of excitation and prevents them from reaching unsafe values of operation.

In Figs. 4A and B we find the plate and grid voltage curves respectively. Note that the A.C. grid voltage decreases to a maximum while the A.C. tank circuit or plate current increases to a maximum at the same time that it maintains a correct phase relationship between the input and output voltages of a tube used in an oscillator. The plate current as shown, in Fig. 4C, and as pulse is generated the driving power to sustain oscillations, it is, this change in current that is fed back into the tank circuit to maintain the resonant circuit into natural oscillation.

The area of this pulse when we view it as a graph represents available oscillating power and is greatest at the area of the plate current pulse the more power that is available. Technically speaking any increase in peak current, any increase in the operating angle, and any trend on top of this pulse steeper and more flattened to indicates more operating power; for all of these factors increase the area of the plate current pulse to.

The amount of power consumed by the oscillator has a number of important functions to perform. It must overcome the losses in the tank coil, it must overcome the power lost in the grid resistor, the power lost in the grid cathode of the tube, and the power dissipated in the plate circuit feeding the grid circuit. The power dissipated in the grid circuit feeds power to the load and any other incidental circuit losses as well as to develop enough excitation to drive the grid circuit of the
biasing grid voltage can be measured with a voltmeter having a "high-resistance per volt" rating. When there is any increase in the automatic D.C. grid voltage for a given value of grid resistance we have an indication of more A.C. tank voltage. This result could be remembered and taken into consideration when servicing oscillators.

The author of this article is on the teaching staff of National Radio Institute.

### Home Recording

#### Theory and Practice of Sound-on-Disc

(Continued from page 551)

depth of cut may cause difficulty in tracking and the playback will slide from groove to groove. If the cutter has adjustments for varying the angle of needle and depth of cut, experiment will show that one adjustment will give a cleaner cut and a minimum of scratch. The best way to check-up on finished records is to examine the grooves by means of a high-power magnifying glass. A light coming at an angle to the disk will show the grooves as dark and the surface or "lands" as white. Unusual wear on records may be detected in this way before the disks are entirely ruined.

An ingenious device for playing-back records, due to Philco, is the photoelectric cell reproducer.* The assembly consists of a bulb, a vibrating mirror attached to the needle, and a photoelectric cell as shown in the diagram. The vibrations of the mirror modulate the light passed to the cell. The light supplied will show the grooves as dark and the surface as "lands" as white. Unusual wear on records may be detected in this way before the disks are entirely ruined.

The principle of creation of sounds by a vibrating mirror modulating a steady light source is in a way analogous to the galvanometer method of recording on film which the writer described in a 2-part article in Radio-Craft beginning November, 1939. A few of the articles there is also a full account of monitoring, mixing and studio procedure which the reader will find helpful for recording on disc. It is hoped that this present article will be of help to all readers who now own recorders or who contemplate acquiring such apparatus in the near future.

Technicians interested in sound recording may also wish to look up one or more of the following articles which have appeared in past issues of Radio-Craft:

- "How to Conduct a Sound-on-Film Recording Studio," Part I, Jan. 39; Part II, June 39.
- "Constant Groove-Speed Recording...," 1939.

THE "ACCELETRON"
Generates Energy of 2,300,000 Volts!

A new device which gives electrons the smallest negatively charged particles of matter known to science, almost the 186,000-mile-a-second speed of light in a glass doughnut-shaped vacuum tube, was described to the American Physical Society last month by Dr. D. W. Kerst of the General Electric Research Laboratory at Schenectady, N. Y.

In the course of their whirling the electrons gain 2,300,000 volts of energy, something hitherto requiring much larger apparatus and great insulation, Dr. Kerst disclosed. The device is expected to make possible the easier performance of experiments in physics.

The accelerator looks like a miniature atom smasher of the cyclotron type but unlike cyclotrons, which can handle only positive ions at great speeds, it accelerates electrons.

Instead of being made of solid iron as in the cyclotron, the accelerator's magnet, which surrounds the glass vacuum chamber, is composed of thousands of pieces of iron so that it can be used on alternating current. Instead of the electrons encircling the magnetic core by following a coil of wire, as they do in a power transformer, electrons in the induction accelerator do not travel on wires but are free to circulate about the magnetic core in the doughnut-shaped vacuum tube.

Hence they make many revolutions, the equivalent of a many-turned winding in an ordinary transformer. In 200,000 revolutions the electrons gain about 2,300,000 volts energy and travel approximately 60 miles.

At the end of this long flight the electrons are directed against a target. The present laboratory model of the accelerator, small enough for use on a table, produces radiation equivalent in intensity to that of 10 millicuries of radium. Larger models, which can be constructed on the same principle, are expected to give more energy.

Dr. Kerst is a native of Madison, Wis., and a graduate of the University of Wisconsin. He later was a member of the faculty at the University of Illinois and while there did the initial work on the induction electron accelerator (or "Acceletron," as Radio-Craft calls it).

ROBESON TECHNIQUE
OF ACOUSTICS CONTROL

Paul Robeson, concert vocalist, is shown here (and on Radio-Craft's cover) with the equipment he uses to control concert-hall acoustics. Photo — Courtesy The Evening Bulletin (Philadelphia, Pa.).

Philosophically, Robeson has been experimenting with the two acoustics of the theatre — the acoustics in the stage and the acoustics in the auditorium. The stage acoustics are in the hands of the scenic designer and the audience's acoustics in the hands of the acoustician.

Paul Robeson, concert vocalist, is shown here (and on Radio-Craft's cover) with the equipment he uses to control concert-hall acoustics. Photo — Courtesy The Evening Bulletin (Philadelphia, Pa.).

Fig. 1. Diagram showing instrument placement on concert stage for Robeson Technique. The letters S indicates the position of the singer; M represents the microphone (located in the footlights though); the audio amplifier and loudspeaker are off-stage, out of sight.

Fig. 2. Frequency characteristic of equipment used in the Robeson Technique. Only "significant" frequencies are fed back to the performer. The selected frequency band constitutes a highly directional beam, of an optimum intensity level, which only the performer can hear.

SOUND control apparatus developed at Stevens Institute of Technology has been used experimentally during recent rehearsal periods at the Metropolitan Opera, according to an announcement made last month by Edward Johnson, General Manager.

The experiments have been devoted primarily to creating acoustic conditions on the stage which are as satisfactory to the artist as the acoustics of the theatre are to the audience. Through the use of several elements of this "Robeson Technique," it is now possible for offstage choruses and upstage singers to hear the orchestra as easily as if it were present in the same room.

Orchestral balance can be preserved backstage in a manner not possible by traditional methods. Solos are being assisted by the "acoustic envelope" or less than a foot in diameter announced recently at the Chicago meeting of the Acoustical Society of America.

The use of this technique, a singer on the stage is able to hear himself as if he were in a small, highly reverberant room. The audience is totally unaware that the Technique is in operation.

The experiments which have been in progress since October are being undertaken as a cooperative enterprise by the Metropolitan Opera Association, Stevens Institute of Technology, The Rockefeller Foundation, and Theatrical Protective Union Local No. 1. They are being conducted under the supervision of Harold Burris-Meyer of Stevens Institute of Technology, who pioneered much of the sound control technique now used in radio, motion pictures, concert and the legitimate theatre. The Robeson Technique has yet to be tried out for recording or radio but the desirability of its use seems probable.

Concert singers and instrumentalists perform by choice in small, highly reverberant rooms since in them they are able to hear...
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they themselves easily. However, they deploy the acoustic conditions of the large concert halls and auditoriums. The nature of the complaint is that the artist cannot hear himself.

The results of not being able to hear are the catalogue of the artist’s woes: tension, inability to relax, a feeling of being ill at ease, of low vocal efficiency, forcing the voice in an effort to project, using a higher key than is best for the song in an effort to get out more volume and fill up the house.

Several years ago, Mr. Paul Robeson discovered that if he stood in front of the speaker of a public address system which was being used in the concert, he enjoyed some of the desirable acoustic conditions usually associated with the small studio. Last winter, on the occasion of the stereophonic recording of the first Forest Scene from The Emperor Jones, technicians of Stevens Institute discovered the possibility of using this phenomenon to surround the performer by an “acoustic envelope” tailored to his demands. Experiments were conducted in the Maplewood (New Jersey) Theatre which has many acoustic limitations. A setup similar to that used in the studio was then devised for Mr. Robeson and used by him on a concert tour.

The first step in devising the system was to find out what it was about the acoustics of the small, reverberant room that was significant as far as the artist is concerned. It was found that the results the artist hears himself if he can perceive a difference in any characteristic of sound between the original sound as it leaves him and the reproduced sound as it comes back. It is the difference which counts.

Time differences are most useful. If the artist hears the reproduced sound later than the original, he is not satisfied that he is hearing himself and is able to do this even though the reproduced sound be of much less intensity than the original one. It seems entirely logical that time difference should be satisfactory since time difference is a characteristic of long reverberation or room resonance.

Time difference is achieved by placing a directional speaker 50 feet or more from the artist—perhaps at the back of the stage—so that the sound to the speaker is 50 feet or more from the artist. Review the diagram, Fig. 1. Low frequencies lack directional characteristics; they are not readily absorbed by wall surfaces or audience; and, when a foot light is used, the microphone will pick up low-frequency sounds transmitted by the floor if the system responds to low frequencies. High frequencies, on the other hand, are directional enough to be kept away from the audience and are absorbed readily enough so that they are below background if they ever do get out.

The response curve is not particularly critical and, as shown in Fig. 2, is cut off below 500 cycles, has a flat peak at 2,000 cycles from which it drops off slowly, and is down 10 decibels at 6,000. Thus only the significant harmonics are projected to the artist.

The Technique is fully effective when the sound level, at the position of the artist, is not measurably altered by turning the system on or off. A level set well below the point of regeneration for the empty house is safe, and more than adequate for the full house.

In the first concert in which the Technique was tried at Carnegie Hall, Mr. Robeson was able to sing at the lower key than he had ever used before for that number in concert. “The enthusiasm of the artists who have tried it bears anything of the sort I have encountered,” comments Professor Burris-Meyer.

OPPORTUNITY AD-LETS

Advertisements in this section cost 15 cents a word for each insertion, address and initials must be included at the above rate. Cash should accompany classified advertisement to be accepted. Unanswered advertisements, as well as others, are deleted at the time the next issue is printed. Twenty percent for twelve insertions. Deadline for March, 1941, issue must reach us not later than February 7th.

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If you subscribe now to RADIO-CRAFT you receive valuable premiums absolutely FREE! A Genuine Electric Dry Shaver—see page 567. The Radio-Television Reference Annual—see page 546.

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1941 SUPER SKYRIDER
The Hallicrafters
2611 S. Indiana, Chicago, Ill.

THE latest Super Skyrider has a tuning range of from 500 kc. to 42 mc. in 6 bands. Other features include 6 degrees of selectivity—3 with crystal, 3 without; 2 high-gain R.F. stages; front-panel antenna trimmer control; headphone and phone jacks; temperature-compensated high-frequency oscillator; provision for mobile or battery operation; remote standby control; noise limiter circuit; beat oscillator; free-wheeling band-spread dials, and a main dial having an auxiliary micrometer scale.—Radio-Craft

NEW AUTO ANTENNA
Ward Products Corporation
1921 E. 45th St., Cleveland, Ohio

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[Image of a phonograph]

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can be mounted anywhere at any angle.....only a screwdriver is required.

**NEWS OF TELEVISION**

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The U. S. Department of Commerce reports television set manufacturing amounting to a total of 4,091 sets, at an average price of $200, during 1939.

Allen B. Du Mont Labs. announced that the delay television-tube, which affords 625-line flickerless scanning at 15 frames/second, now is available with a white screen (which therefore supersedes the earlier orange-screen type).

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This Directory is published in sections — 1 section per month. This method of publication permits the DIRECTORY to be constantly up-to-date since necessary revisions and corrections can be made monthly. All names preceded by an asterisk (*) indicate that the company makes trade names.

If you cannot find any item or manufacturer in this section or in previously-published sections, just drop us a line for the information.

Note: Section I of this Directory was published in the October, 1940 issue, Section VI, presented here, concludes the 1st Edition of the Directory. Next month: Section I. Revised.

While every precaution is taken to insure accuracy, Radio-Craft cannot guarantee against the possibility of occasional errors and omissions in the preparation of this Classified Directory. Manufacturers and readers are urged to report all errors and omissions at the earliest moment to insure corrections in the very next issue.

VIBRATORS

(Also see Battery Chargers, Eliminators & Rectifiers)

Airplane

Aircraft

Auto-radio

AV

Farmeradio

FY

Inverted

I

Neon Lighting

N

Radio transmitting

RT

WIRE

Antenna (receiving)

AR

Antenna, Transmission (receiving)

AX

Antenna, Transmission (transmitting)

TX

Concentric cable

C

Cords (attachment)

CA

Hookup

H

Insulated cable

I

Litzdraht ("Litz")

LW

Magnet

MW

Microphone cable

M

Radio harness

RH

Resistance

RES

Resistance cords

R

Shielded

SH

When writing to companies listed here please mention that you saw the listing in the Radio-Craft "Classified Radio Directory"

RADIO-CRAFT for MARCH, 1941

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TUBES & PARTS

Ballast (regulating)

BR

Cathode

C

Industrial

IN

Miniatures (hearing-aid and/or radio receiving)

M

Physical

P

Receiving (including rectifiers)

RR

Transmitting

TM

Voltage control

V

AMERICAN TELEVISION CORP., 130 W. 56th St., New York, New York, N. Y.

AMERICAN ELECTRIC CORP., 561 E. New York St., New York, N. Y.-BR

ARCO TUBE CO., 277 Central Ave., Newark, N. J.-J

AUGUST A. SCHWATZ CORP., 1801 Pannin St., Houston, Texas, -P, RR

CRIUS BIOS S. F., 420 F土耳洲 St., Jackson, Miss.-BR, C, IN, P, RR, TX, V

DOW RADIO CO., 1759 E. Colorado, Pasadena, California, -BR, TX, RR

DOWaso-Teleco RADIO CORP., 15233 Warner Ave., Garden, Mich.-RR

FEDERAL TELEGRAPH CO., 200 Mt. Pleasant Ave., Newark, N. J.-J

FISCHER DISTRIB. CORP., 227 Fulton St., New York, N. Y.-BR, C, P, RR, WR

FISHER ELECTRIC CORP., Schenectady, N. Y. & Bridgeport, Conn.-BR, C, IN, P, RR, TX, M

F.G., Sn PMI LABORATORIES, INC., 1236 N. Kane Ave., Chicago, Ill.-JR

GAUSS D. D. RADIO CO., 15233 Warner Ave., Garden, Mich.-RR

HERBERT H. HORN, 1310 S. Olive St., Los Angeles, Calif.-CA

HYGRADE SYLVANIA CO., 500 5th Ave., New York, N. Y.-BR, RR

HYTRON CORPORATION, 78 Lafayette St., Salem, Oregon, P, RR, TX, V, M-J

J. P. F. D. MANUFACTURING CO., 4111 Hamilton Ave., Toronto, Ont., Canada

KON-RADE TUBE & LAMP CORP., Inc.-Owensboro, Ky.-BR

T. R. MCIELROY, 100 Brookline Ave., Boston, Mass.-BR

M & G HEARING AIDS CO., 30 N. Michigan Ave., Chicago, Ill.-M

McEVAR-EMERSON RADIO CO., 219 W. Chicago Ave., Chicago, Ill.-BR, C, RR, TX, M

NATIONAL RADIO CORPORATION, 57 State St., Newark, N. J.-BR, C, P, RR, V
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dress Guide, are mere prelude to Amplifiers, Public Ad-
dress Guide and Accessories and more. A really
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like this? It’s a ‘must’ for all broadcasting stu-
dents, radio and electronics engineers.

THE CONTENTS
To actually show the scope and magnitude of the
AMPLIFIER HANDBOOK AND PUBLIC ADDRESS GUIDE, an attempt has been made to
list within this particular section. A thorough reading of the
contents shows the comprehensiveness of this book.

A Resume of the Contents of the
AMPLIFIER HANDBOOK
AND PUBLIC ADDRESS GUIDE

FOREWORD

INTRODUCTION
Definitions—decibels, frequency, input, output, impedance, etc.

SECTION I—SOURCE
Carbon microphones (single-button and double-button)
Condenser microphones
Velocity (ribbon) microphones
Dynamic microphones
Crystal microphones (sound-cell types, crystal diaphragm types)
Cardioid microphones
Contact microphones

SECTION II—AMPLIFIERS
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Commercial voltage amplifiers

The Power Stage
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Class AB amplifiers
Class A, B, amplifiers
Class AB, B amplifiers
When to apply amplifiers

Power Supplies
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Full-wave rectification
Voltage doublers

Filter Circuits
Power supply regulation, etc.

Practical Hints on Amplifier Construction
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Placement of components
Tone compensation
Inverse feedback
Remote control methods

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Power cone speakers
Radial (360° distribution) speaker baffles

SECTION IV—COORDINATION
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Matching speakers to P.A. installations

Phasing speakers
Effect of mismatching speakers to amplifier output

A typical P.A. installation (in a skating rink)

SECTION V—USEFUL PUBLIC ADDRESS DATA AND INFORMATION
Speaker matching technique
The ABC of Db., VU, Mu, Gm and Sn
Charts and formulas useful to the practical P.A. sound man
Handy index to important articles on public address and sound

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Following is a listing of those companies which publish catalogues, house organs, (or HO), and one or both, whether these publications are available gratis (F), or whether a nominal charge is made (C), is indicated. Finally, identifying letters signify the particular group to which this literature is directed (Engineers, Dealers, Consumers, etc.). Please mention RADIO-CRAFT when writing to these organizations.

NATURE OF PUBLICATION
Catalog - G
Construction Booklet - G
House Organ - HO

CHARGES
Free - F
Price - c

AVAILABLE TO
Anyone (being all-inclusive, no other listings are given, if "A" is indicated) 
Amateurs (licensed radio) - AR
Consumers - C

Doers
Con D; Dealers - Bu
Electronic Specialists - ES
Engineers - E
General Experimenters - G
Jobbers - J
Manufacturers - M
Marine Supply - MS
Musicians - MU
Radio Action - Ra
Servicemen - S
Sound Specialists - SS
Talking Machines - T

THE ACME ELECTRIC & MFG. CO., Water St., Geneva, N. Y.-C, F, A.
ACOUSTIC COUNCIL, INC., 1270 6th Ave., New York City, C, F, A.
ACOUSTIC CORPORATION, 1250 W. 2nd St., Los Angeles, Calif., C, F, M.
ACOUSTIC CORPORATION, 1260 W. 2nd St., Los Angeles, Calif., C, F, A.
AEROVOX CORPORATION, New Bedford, Mass.-C, F, A.
ALLEN PRODUCTS CO., 715 Center St., Brockton, Mass.-C, F, A.
ALLEN ELECTRIC & EQUIPMENT CO., 2101-2117 Market St., Philadelphia, Pa., C, F, A.
ALLIED RADIO CORP., 833 W. Jackson Blvd., Chicago, Ill.-C, F, A.
ALLOY BALEFF CO., 722 Berea Ave., Godfrey, Ala.-C, F, A.
AMERICAN ELECTRIC CO., INC., Utica, N. Y.-C, F, A.
AMERICAN GAS ACCUMULATOR CO., 1029 New Haven Ave., New Haven, Conn.-C, F, A.
AMERICAN LAVA CORP., Cherokee Blvd. & Manufacturer Rd., Nashville, Tenn.-C, F, A.
AMERICAN PHONIC CORP., 1250 W. Van Buren St., Chicago, Ill.-C, F, A.
AMERICAN ROLLING MILL CO., Middletown, N. J.-C, F, A.
AMPHERITE COMPANY, 561 Broadway, New York, N. Y.-C, F, A.
AMPLIFIERS CO. OF AMERICA, 37 West 20th St., New York, N. Y.-C, F, A.
AMPYROL CO., 201 North Western Ave., Chicago, Ill.-C, F, A.
APPALACHIAN WIRE & INCS., 11 W. 42nd St., New York, N. Y.-C, F, M, E, D.
ARCO TUBE CO., 227 Central Ave., Newark, N. J.-C, F, A.
ARLAVOX MFG. CO., 430 S. Green St., Chicago, Ill.-C, F, A.
ASTATIC MICROPHONE LABORATORY, INC., 830 North Western Ave., Chicago, Ill.-C, F, A.
ATLAS CONDENSER PRODUCTS CO., 56 Westchester Ave., New York, N. Y.-C, F, M, D.
ATLAS PRESS CO., Kalamazoo, Mich.-C, F, A.
AUTOMATIC SOUND CORP., 1417-39th St., Brooklyn, N. Y.-C, F, A.
AUTO DEVELOPMENT, INC., 1241 Bryant Ave., N., Minneapolis, Minn.-C, F, M, E, D.
AUDIOPHONICS INC., 11-13 Jefferson Ave., New York, N. Y.-C, F, M, D, E, S.
AUTOMATIC APPARATUS CO., 123 Liberty Ave., New York, N. Y.-C, F, A.
Baker & Co., INC., 113 Astor St., Newark, N. J.-C, F, A.
BANK'S MFG. CO., 501 N. Winthrop Ave., Chicago, Ill.-C, F, A.
BARKLEY MFG. CO., 403 W. Madison St., Chicago, Ill.-C, F, A.
BATTERY MFG. CORP., 100 Franklin Blvd., Arco, Penna.-C, F, A.
BETTER MANUFACTURING CO., 4447 W. Van Buren St., Chicago, Ill.-C, F, A.
BIOGRAPH MFG. CO., 4701 South 18th Ave., Chicago, Ill.-C, F, A.
BOND PRODUCTS CO., 1319 Hamilton Ave., De FOY, C, F, M, D, E.
BOSONT MOLDING CO., 326 Myrtle Ave., Boon- ton, N. J.-C, F, A.
BOSTON BATTERY CO., 55 Dickerson St., Newmarket, N. H.-C, F, A.
BRADLEY CO., 1326 S. 2nd St., Milwaukee, Wis.-C, F, A.
BRADLEY MFG. CO., 55 Dickerson St., Newmarket, N. H.-C, F, A.
BRUSH BATTERY CO., Crooks & Getty Ave., Clifton, N. J.-C, F, A.
BRUIKING LABORATORIES, INC., 750 Main St., Winchester, Mass.-C, F, A.
BRUSH CO., 403 W. Baltimore, Detroit, Mich.-C, F, A.
THE BRUSH DEVELOPMENT CO., 1311 Perkins Ave., Cleveland, O.-C, F, A.
BUFFALO BATTERY CO., 101 Clinton Ave., Buffalo, N. Y.-C, F, A.
BUD RADIO, INC., 509 Cedar Ave., Cleveland, Ohio, F, A, E, D, S.
BURGESS BATTERY CO., P. O. Box 121, Freeport, Ill.-C, F, A.
BUSCH FOUNDATION, INC., 2430 W. 26th St., Brooklyn, N. Y.-C, F, D, S.
CAMBRIDGE INSTRUMENT CO., INC., 375 Grand Ave., New York City, C, F, A.
CARDWELL MFG. CORP., 219 Monticello Ave., Milwaukee, Wis.-C, F, A.
CARRON MFG. CO., 415 S. Delaware St., Chicago, Ill.-C, F, E, D, SS, G, A.
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AND ACCESSORIES

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And, of course, the longer your subscription runs, the more merchandise you obtain FREE. As we expect a tremendous response to this offer, we would suggest that you send your remittance without delay, as our supply of parts is limited and we won’t be able to duplicate this offer again.

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For instance, if you recently subscribed to our radio magazine, we have the largest surplus houses in the East ready to sacrifice a huge quantity of radio parts and accessories which cost the original manufacturers thousands of dollars.

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573

www.americanradiohistory.com
SMALL INDUCTION-TYPE A.C. MOTOR REPAIRS

OPEN-CIRCUIT DUO STARTING WINDING

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A2

4 MF, 400V

A2

B1 Running Winding

B2

VOLTAGE SUPPLY

220V

TO CONNECT FOR H/D, PARALLEL A1 A2 AND B1 B2.

OPEN-CIRCUIT THROUGH SWITCH TO CENTER OF PARALLELED COILS.

- RADIO Servicemen frequently have occasion to repair washing machine, refrigerator and small bench machine motors. The majority of these motors are of the induction type using a separate starting winding of a finer gauge wire than the main or running winding. About 80% of the failures of these motors are due to the starting winding burning out because of the centrifugal switch sticking. To rewind this winding takes time; too, there is always the danger of damaging the main winding during repair, resulting in a complete rewind. However, by connecting a condenser of from 2 mf. to 4 mf. capacity, and of the rated voltage of the motor, and also disconnecting the faulty starting winding from switch, the motor will now start as good as new, i.e., converting motor into a “capacitor” type.

I have used 4-mf., radio-type condensers on several 1/4-horsepower motors with successful results, saving time.

The exact type and size of condenser for any size motor may be calculated from the following formula:

\[ Z = \frac{1}{C} \times \frac{V}{I} \]

where

- \( Z \) = impedance of motor
- \( V \) = line voltage
- \( I \) = motor current in amps.

(B) \( C = \frac{Z}{2\pi f} \)

where

- \( C \) = Capacity in farads of required condenser.
- \( 2\pi f \) = 28.28 x frequency of line.
- \( Z \) = from above formula (A).

R and X, of motor may be neglected. Above, for a 1/4-h.p. motor, works out to approximate 5 mf. but in practice even a 3-mf. condenser gives sufficient field phase displacement to start the motor.

WANDSWORTH,
Kotze Road,
Mowbray, Cape Town, South Africa

ELECTRIC BENCH FLASHLIGHT

- IN order to save on flashlight batteries, I devised the power supply arrangement here illustrated, for bench use.

An output transformer will frequently serve in this arrangement. The transformer may be enclosed in its own box, as a safety measure, as illustrated.

A. MARINO,
Staten Island, N. Y.

REPAIRING SPIDERS

- WHEN the spider on dynamic loudspeakers which have the spider located in the center of the voice coil becomes weak, it may be strengthened in the manner here illustrated.

Cut a thin pasteboard disc with the same diameter as the spider. Coat the spider and one side of the disc with household cement. Place the two together and allow them to dry for at least an hour. When thoroughly dry, center the voice coil and the speaker is ready to use. The pasteboard disc serves also as a dust cap.

ROBERT ROBINSON,
Silver City, New Mexico

HANDY ANVIL

- HERE is an idea simple enough in its conception, yet an extremely useful substitute for a bench anvils, the idea for which might not occur to some radio experimenters. I made my “anvils” from an RCA electrodynamic loudspeaker. I find it useful for sinking rivets by putting a web in the center hole in the top. Of course not all speakers are constructed in exactly the same way.

WALTER C. MUELLER,
Chicago, Ill.

INTERFERENCE ELIMINATION HINT

- NEXT time you fail to obtain satisfactory reception, try a pair of 0.1-mf. condensers across the line, as shown in the sketch. In a 15-story apartment house, with elevator and other noise, a Stromberg-Carlson table model played very well on a short
antenna and ground connection. Without the filter there was a terrific racket. In a case in suburban territory, shortwave reception in the presence of a trolley, as well as apartment house elevator interference, was practically impossible.

In a second case the filter not only cleared reception but raised the apparent signal strength of the overseas broadcaster. In still another instance, where a vibrator-type inverter was used for supplying power from D.C. to an A.C. phonograph-radio, the filter cut out the vibrator interference on Radio. The writer is convinced this kink will pay dividends, and it is obviously cheaper than a regular line filter. Only precaution is this: use plenty of tape for good insulation.

The conditioners, in series, are shutted across the power line; the junction of the 2 conditioners is connected to ground (the wall-plate).

WILLARD MOODY
New York, N. Y.

BOOK REVIEWS


Technicians who wish to learn the telegraphic code as revised last year in accordance with the Cairo Conference, should obtain a copy of "Study Guide." This book contains questions which are representative of the scope of questions contained in the various elements of the Commercial Radio Operator's License Examination—by the Federal Communications Commission.

This book is divided into chapters as follows:


The sound field at last has a book all its own. In "Elements" the author of Acoustical Research of RCA, and lecturer in Electrical Engineering in Columbia University, has drawn upon his work to give there an exceptionally useful treatment of acoustical principles and their applications—which extend throughout nearly all fields of engineering. Complete working methods are given in this well-illustrated book.

The range embraces Radio Broadcasting, Radio Reception, Public Address, and Sound Motion Pictures. This book offers extensive treatment of the following topics: Sound Waves; Acoustical Radiating Systems; Mechanical Vibrating Systems; Electrical, Mechanical and Acoustical Analogies; Acoustical Elements; Driving Systems; Direct Radiator Loudspeakers; Horn Loudspeakers; Microphones; Miscellaneous Transducers; Measurement of Architectural Acoustics, and the Collection and Dispersion of Sound, Speech, Music and Hearing.


Experimenters, and more particularly, electronic specialists, will be interested in this new book which discusses polarized light from first principles to its practical application through the medium of Poloraid.

Polarized light finds its application in radio as an important element, for instance, certain types of television operation. For experimenters in this field, therefore, the book "Reference on Polarized Light" will be especially welcome.
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You Get Professional Test Equipment
plus Experimental Outfits!

. . . Includes 146 RADIO PARTS for building a complete Receiver, RADIO TOOLS and a modern TESTER-ANALYZER. You also receive 8 BIG SHIPMENTS OF RADIO EQUIPMENT for conducting actual experiments with your own hands. I show you how to create Radio defects... how to correct them. This practical "beforehand" experience will come handy again and again when you are called on to do actual Radio repair work later on.

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"Now just a few words about your Course— the more I get into it, the more I wonder how you can give so much for so little. I believe it to be the finest of its kind obtainable, and would urge anyone wishing to study Radio seriously to study Radio actually in the fine style of the Sprayberry Course."

George W. Kirkby, 521 Elway Bl., Nelson, B.C., Canada.

"SO MUCH FOR SO LITTLE!"

While I have not had out my "Studies" yet, I have made over $500 net in the last six months, doing some full and some part-time radio servicing.

I must say every way with your Course, and I am mighty glad I started on the whole line, making me a student of the Sprayberry Course."

Wendell M. Carbonell, 60 History Bl., Rochester, N.Y.

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No matter if you desire to BE YOUR OWN BOSS in your own business or if you'd like a good job in Radio, my Training will give you the useful knowledge and experience you can use. Days of delay mean precious time wasted, get training for a money-making Radio career now...

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Washington, D. C.

Please send my FREE copy of "HOW TO MAKE MONEY IN RADIO."

Name ____________________________
Address __________________________
City _____________________________ State ______

Tear off this coupon, mail in envelope or paste on penny postcard.
Be Sure To Get These N.U. Condenser Specials!

$7.50

PACKED IN ONE CONTAINER

TWO DRAWER STEEL CABINET

Here's a honey of a steel utility cabinet with the drawers partitioned to make it easy for storing small parts. You'll find this cabinet a mighty useful addition to your shop equipment and best of all... you get it FREE on this limited offer. Don't delay, take advantage of this deal and get your FREE steel cabinet. Cabinet size is — length 11½”, width, 9½”, depth, 5”.

NO DEPOSIT ON CABINET

You can buy the condenser assortment for $7.50 plus a 30 N.U. points contract. Points contract can be added to present N.U. contract. You get the cabinet FREE now. There is no deposit. (The condenser assortment comes to you packed with the cabinet.)

$14.35

Popular CONDENSER ASSORTMENT LIST

This fine assortment of popular type N.U. condensers will move fast, give you a good profit and insure the good will of your customers. If you're already using N.U. condensers, you'll be sure to snap up this offer in a hurry. If you don't know yet how really good N.U. condensers are, here's a great opportunity to try them! The assortment you get on this limited offer consists of:

3-78450 1-AT2015
1-78445 1-AT2025
1-78440 1-AT4015
1-78450 1-AT1615
3-78450 1-AT1645
3-T601
4-T602
3-T603
5-T610
2-T625

List Value of N.U. Condensers in Kit, $10.00. Dealer Price Walasco Stapler, $3.30 (Packed Together) YOURS FREE ON THIS N.U. CONDENSER DEAL DEALER PAYS $5.00 FOR CONDENSERS, THE ADDITIONAL $2.00 IS REBATED WHEN DEAL REQUIREMENT IS COMPLETED. HOW YOU GET IT Just order from your N.U. distributor. Your total payment is $7.00. You sign an agreement for 75 points and deposit is refunded when the 75 purchase points are completed. Points can be used on N.U. Tubes, Sound X/Tra Tubes, N.U. Radio Batteries or N.U. Condensers. The National Union Program on free equipment has helped thousands of dealers to own the "finest radio shop in town". POINTS ARE COUNTED AS FOLLOWS:

1 Tube = 1 Point
1 Electro Condenser = 1 Point
10 Paper Condensers = 1 Point
2 Numite Condensers = 1 Point
1 Radio Battery = 1 Point.

See Your Jobber or Write

NATIONAL UNION RADIO

57 STATE STREET, NEWARK, N. J.