RADIO CRAFT

AND POPULAR ELECTRONICS

NOV 1943

25¢

CANADA 30¢

RADIO-ELECTRONICS IN ALL ITS PHASES

Photo by U. S. Army Air Corps

THE war record of America's radio tube engineers is an impressive one. Yet these able and ingenious men, too, have their "problem children".

In this category are the miniature tubes used by our combat troops in communication radio sets. Admittedly these tubes are tough little "hombres" —especially "tough" for that selected group of engineers whose responsibility is to produce them by the tens of thousands. Only because of the sweat and tears of these men has the flow of miniatures to our armed forces been maintained and steadily expanded month after month.

That National Union is one of the nation's important manufacturers of miniatures is evidence of the success of N. U. engineers in helping to solve one of this Industry's most difficult war production problems. Thus do research and development experiences in wartime build a reservoir for post-war accomplishment.

For the advanced types of tubes and application data you'll be wanting when peace returns with its new opportunities, *count on* National Union.

NATIONAL UNION RADIO CORPORATION, NEWARK, N. J.
Factories: Newark and Maplewood, N. J., Lansdale and Robesonia, Pa.

NATIONAL UNION
RADIO AND ELECTRONIC TUBES

Transmitting, Cathode Ray, Receiving, Special Purpose Tubes • Condensers • Volume Controls • Photo Electric Cells • Panel Lamps • Flashlight Bulbs

Certainly--I Give You Both TRAINING AND EXPERIENCE when I Train You at Home to BE A RADIO TECHNICIAN

LEARN RADIO THOROUGHLY

from My Easy-to-Understand Lesson Texts

My Course is a tested, proven way to learn Radio at home in spare time. My 67 Lesson Texts give you the fundamentals of Radio in practical, easy-to-grasp explanations and hundreds of illustrations, charts, and diagrams. You learn quickly—because my lessons are prepared especially for home study. Throughout your training N.R.I.'s staff and resources will be squarely behind you. N.R.I. has stuck to the one job of teaching Radio for 29 years. Our combined efforts have made the Course so interesting, so clear and complete, that we believe you—like thousands of other N.R.I. students before you—will be "old friends" with Radio almost before you know it!

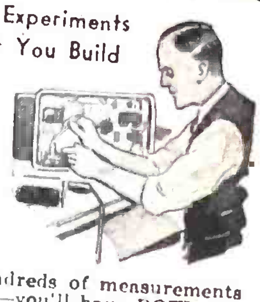
BUILD RADIO EQUIPMENT

With 6 Big Kits of Standard Radio Parts I Send

Think how much PRACTICAL experience you'll get by building a real "Superhet" Circuit — a Measuring Instrument—an A.M. Signal Generator—and other standard Radio Circuits! Assembling and testing many Circuits, you "learn by doing"—learn how to identify, wire, install standard Radio parts, to test, align Radio Circuits that you will encounter in actual work as a Radio Technician or Operator. Such knowledge represents the difference between a skilled, well-paid Radio Technician or Operator and the too-common "Radio screwdriver-mechanic." After a few months of this **practical** experience, you'll be ready to run your own Spare Time Shop, fix the Radios of your friends and neighbors—get PAID while learning!

PROVE YOUR KNOWLEDGE

By Tests and Experiments on Equipment You Build



By the time you've conducted more than 60 sets of experiments on the Radio Circuits you build with parts I supply—have made hundreds of measurements and adjustments—you'll have BOTH the theoretical knowledge and practical experience you need to make EXTRA money in spare time while learning, and to fix commercial Radio equipment. I show you how to test the performance of the circuits you build and how to use test equipment in measuring voltage, current, resistance, amplification—how to test and align circuits for most efficient operation—how to detect troubles in circuits and how to correct them. You learn these facts quickly by actually working with real Radio equipment instead of simply reading books.

GET ACTUAL EXPERIENCE

And Earn $5 to $10 a Week EXTRA in Spare Time While Learning

The moment you enroll for my Course I start sending you EXTRA MONEY JOB SHEETS that show how to earn EXTRA money fixing Radios. Many N.R.I. students make $5, $10 a week EXTRA in spare time while still learning. Fixing Radios pays better now than ever before. With new Radios out of production, fixing old sets, which were formerly traded in, adds greatly to the normal number of servicing jobs. Right in your neighborhood, there's probably room for more spare and full time Radio Technicians. Many N.R.I. students have paid for their Course with spare time money. And now—while the Radio repair business is booming—you have an opportunity which may never be repeated, to earn EXTRA money in spare time while you train to be a Radio Technician or Operator.

Why More Radio Technicians and Operators Now Make $50 a Week Than Ever Before

There is a real shortage today of trained Radio Technicians and Operators. The Radio repair business is booming. Broadcasting Stations, Aviation and Police Radio, Public Address Systems, and other Radio branches are scrambling for Operators and Technicians. Radio manufacturers, now working on Government orders for Radio equipment, employ trained men. The Government too needs hundreds of competent civilian and enlisted Radio men and women. You may never see a time again when it will be so easy to get started in this fascinating field.

Be Ready to Cash in on Jobs Coming in Television, Electronics

Think of the NEW jobs that Television, Frequency Modulation, Electronics, and other Radio developments will open after the war. You have a real opportunity. Get into Radio NOW and be ready to cash in when Victory releases the amazing wartime Radio developments for peacetime uses!

Mail Coupon for Sample Lesson and 64-page Book—Both Free

MAIL THE COUPON. I'll send you a FREE Lesson and my valuable, 64-page, illustrated book. They're packed with facts about Radio. You'll see snapshots and letters from men I trained, so you can know what N.R.I. did for others. You'll read a description of my Course—"50-50 Method"—6 Experimental Kits—Extra Money Job Sheets. You'll have my free lesson to keep. And you'll see many fascinating jobs Radio offers and how YOU can train at home. No obligation—no salesman will call. If you want to JUMP YOUR PAY—mail coupon in an envelope or pasted on penny postcard!

J. E. SMITH, President, Dept. 3MX, National Radio Institute, Washington 9, D. C.

TRAINING MEN FOR VITAL RADIO JOBS

GET SAMPLE LESSON FREE

MAIL THE COUPON

I want to prove that our Course gives practical, money-making information; that it is easy to understand—what you need to master Radio. My Sample Lesson Text, "Getting Acquainted With Receiver Servicing," tells how Superheterodyne Receivers work—why Radio Tubes fail—how to fix Electrodynamic Speakers, Output Transformers. Gives hints on I. F. Transformer repair—how to locate defective soldered joints—Antenna, Oscillator Coil facts—Receiver Servicing Technique, etc., etc. 31 illustrations. I will send you this Lesson FREE. Mail the Coupon!

EXTRA PAY IN ARMY, NAVY, TOO

Men likely to go into military service, soldiers, sailors, marines, should mail the coupon now! Learning Radio helps men get extra rank, prestige, more interesting duties, MUCH HIGHER PAY. Also prepares for good Radio jobs after service ends. Over 1,700 service men now enrolled.

GOOD FOR BOTH 64 PAGE BOOK SAMPLE LESSON FREE

J. E. SMITH, President, National Radio Institute
Dept. 3MX, Washington 9, D. C.

Without obligating me, mail your Sample Lesson and 64-page Book FREE. I am particularly interested in the branch of Radio checked below. (No salesman will call. Write plainly.)

- ☐ Radio Service Business of My Own
- ☐ Service Technician for Radio Stores and Factories
- ☐ Spare Time Radio Servicing
- ☐ Auto Radio Technician
- ☐ Aviation Radio
- ☐ Operating Broadcasting Stations
- ☐ Army, Navy, Radio
- ☐ Operating Police Radio Stations
- ☐ Operating Ship and Harbor Radio

(If you have not decided which branch you prefer—mail coupon for facts to help you decide.)

Age ....

Name ....

Address ....

City .... State 4FR

RADIO CRAFT

▼ AND POPULAR ELECTRONICS ▼

"RADIO'S GREATEST MAGAZINE"

HUGO GERNSBACK, *Editor-in-Chief*
FRED SHUNAMAN, *Associate Editor*
G. ALIQUO, *Circulation Manager*

IN THE NEXT ISSUE

Radio Pilot Mine Destroyers
by HUGO GERNSBACK

Electrical Measurements
by ALFRED A. GHIRARDI

R.F. Oscillator Facts

FM Transmitter Systems

Radio-Electronic Course

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POPULAR ELECTRONICS

WARTIME RADIO

SERVICING

SOUND

RADIO TRAINING

DEPARTMENTS

FOR RADIO MEN IN THE SERVICE!

"WRITE A LETTER"

As you know, the Hallicrafters make a wide range of Radio Communications equipment, including the SCR-299 Mobile Communications unit. We are proud of our handiwork, proud of the job you men have been doing with them on every battlefront.

RULES FOR THE CONTEST

We want letters telling of actual experiences with this equipment. We will give $100.00 for the best such letter received during each of the five months of November, December, January, February and March! (Deadline: Midnight, the last day of each month.)

We will send $1.00 for every serious letter received so even if you should not win a big prize your time will not be in vain.

Your letter will be our property, of course, and we have the right to reproduce it in a Hallicrafters advertisement.

Good luck and write as many letters as you wish. V-Mail letters will do.

W. J. Halligan

BUY MORE BONDS!

the hallicrafters co.
CHICAGO, U.S.A.

2611 INDIANA AVENUE · CHICAGO, U.S.A.

MAKERS OF THE FAMOUS SCR-299 COMMUNICATIONS TRUCK

Australia
June 18, 1943

Hallicrafters
Chicago, Illinois
U.S.A.

Dear Sirs:

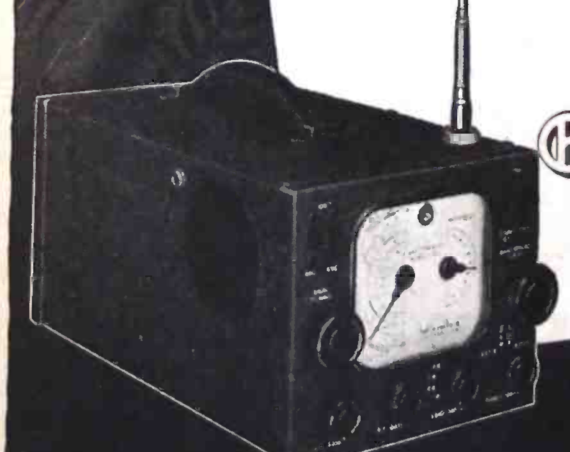
In the May issue of QST, appeared a picture of your Hallicrafters Model S-29 Radio...and a group of men and myself listening in on a program...in the New Guinea area.

The Radio which appears in this picture was purchased by myself in August, 1941. This same radio has been in continuous operation...and has caused no trouble.

This Hallicrafters Model S-29 was one piece of equipment which every man...was anxious to carry. It was carried at all times...through New Guinea jungles...in the midst of a jungle swamp ...where tropical rains fell heavily...in extreme damp heat, this radio never once faltered. It brought untold relief to every fighting man... caused tense nerves to become relaxed, bringing happy moments to dark surroundings. The part played by this instrument could never otherwise be duplicated. Every night...the fellows would listen to the news from home. Notes were taken ...and news was called to the troops on front line duty. Without this radio there would have been no contact with the outside world.

This same radio is operating perfectly and the only replacement needed was a new set of tubes.

Sincerely yours,
Glen V. Blakeslee
Glen V. Blakeslee



BUY MORE BONDS!

the hallicrafters co.
CHICAGO, U.S.A.
WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT

. . . . FM — Television stations after the war will dot the country, linked by radio relay towers . . . .

EDITORIAL

HUGO GERNSBACK
Founder

MODERN ELECTRICS	1908
ELECTRICAL EXPERIMENTER	1913
RADIO NEWS	1919
SCIENCE & INVENTION	1920
RADIO-CRAFT	1929
SHORT-WAVE CRAFT	1930
WIRELESS ASSOC. OF AMERICA	1908

THE FUTURE OF FM

HUGO GERNSBACK

I am in receipt of the following letter from a soldier:

Lubbock Army Flying School,
Lubbock Texas.

"Just as almost every soldier, I am, during the term of my service, looking forward to what the post-war world holds forth for me. Since I want to be a broadcaster, your opinion on the shape broadcasting will take, will be of value to me.

"First I would like to have your idea as to whether Frequency Modulation will be successful in the smaller cities in the Western states. Considering that FM does not cover a wide range compared to present type transmitters, will they ever be used, except just in the large Eastern cities where great numbers of people are reached within a small area? Of course, there are means by which programs may be 'piped' from the East via the networks.

"And should television come a few years later, there will be the need for more television-FM transmitters to cover the territory now served by radio. In that case, is it possible that a small progressive city of five or six thousand population—where merchants are fairly well sold on the value of advertising and where agriculture, oil and air base are the principal means of support at present—be able to make a small-power FM transmitter worth while?

"I shall certainly appreciate your favoring me with your opinion on these questions.

Glen Givens"

To the question as to whether Frequency Modulation will be successful in the Western States particularly in smaller cities, the answer is an emphatic *yes.*

As I have mentioned in this column before, FM already was highly successful at the time of Pearl Harbor. Since then the war effort naturally interfered with the rapid progress of FM, due to the scarcity of steel for towers, as well as necessary radio equipment.

On September 30th of this year there were already in operation in the United States fifty Frequency Modulation stations. The F.C.C. has on hand at present applications for 107 transmitters, while construction permits have been given for 9 F M stations. That, however, is nothing as compared to what will happen after peace has been declared. All authorities are unanimous that after the war, there will be a gradual change from the present type of broadcasting (amplitude modulation) to FM.

It can also be considered that for all practical purposes FM and television transmission are one and the same because both travel on six-meter wave lengths and below. The two will be inseparable in the future as they already are at present. Radio engineers are agreed that there may be as many as 2,000 or more FM transmitters dotting continental United States when the system gets into full swing.

These stations will not be linked together by metallic telephone lines as is the case now with our broadcast networks. The FM-Television networks will be entirely and solely linked by radio waves through the means of relay stations. This will do two things: 1. Frequency Modulation being practically staticless, we will not have to contend with noisy wire lines and there will be no interruptions due to line failure, to floods, snowstorms, sleet and the like. 2. Dispensing with telephone transmission lines, also, will make the FM-television networks much cheaper in operation, because the cost of the expensive wire lines will exist no longer.

From all the above it can readily be seen that small cities, not only in Western states, but throughout the

(Continued on page 113)

RADIO THIRTY-FIVE YEARS AGO

In Gernsback Publications

From the October, 1908 issue of MODERN ELECTRICS:

Editorial (excerpt): "A short word has long been needed to express what is now known under the name 'wireless telephone.' It sounds decidedly odd to say 'I shall wireless telephone you,' or 'I shall telephone you wirelessly.' The word 'radiotelephone' expresses the idea a good deal better, but still it sounds strange if we say 'I shall radio telephone you.' Better would be the shorter word radiophone."

Interesting radio articles in the same issue:

Collins' Long Distance Wireless Telephone, by *A. Frederick Collins.*

Aerials, by *A. C. Austin, Jr.*

Aerophone Tower. Illustration shows the first radio telephone transmitter (broadcast station erected on top the 125-foot Terminal Building, near 42nd and Park Avenue, New York, N. Y.) erected by Dr. Lee De-Forest's Radio Telephone Company.

The Audion: a Third Form of the Gas Detector by *John L. Hogan, Jr.*

Selective Tuning, by *A. M. Curtis.*

From the November, 1908 issue of MODERN ELECTRICS.

The Production of Sustained High-Frequency Oscillations by *M. A. Deviny.*

Editorial by Mr. Gernsback chastising early radio amateurs who as yet were not concerned with any radio law. "Nobody cares how many messages the amateur catches as long as he keeps in the dark and does not "talk back." While we talk of wireless message making, we must mention the wireless "joker (?)". "This pest located in New York, Chicago or anywhere, will send a plausible message calling up an ocean liner stating the machinery of his ship is damaged or some other plausible yarn."

Radio articles in the same issue:

Suspension and Insulation of Aerials by *A. C. Austin, Jr.*

Two New Detectors. (Special audion and variation of electrolytic type.)

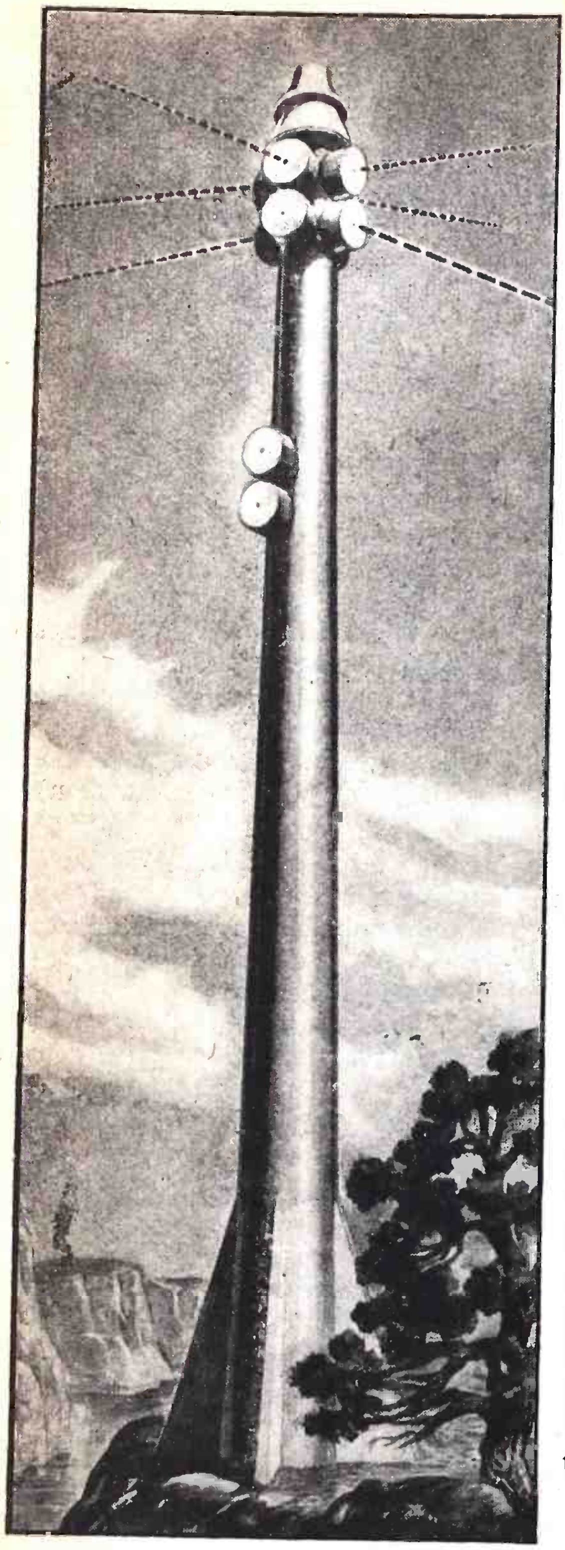
How to Make an Electrolytic Detector by *C. C. Whitaker.*

Antenna Phenomenae by *Sewall Cabot.*

Selective Tuner with Weeding Out Circuit, by *H. H. Holden.*

RADIO MONTH

News Events of Interest



The artist's idea of the RCA television towers, which will relay several programs in various directions.

AUTOMATIC television networks made possible by radio relay stations and other new developments, which eventually are expected to lead to international television, are a post-war prospect, according to Ralph R. Beal, Research Director of RCA laboratories.

A radically new form of "lighthouse" radio relay station already developed by RCA will make relaying of television programs a simple matter, according to Mr. Beal.

The relay transmitters will operate on microwaves with the energy concentrated almost in a beeline. Practically all the power is made to serve a useful purpose; it is not scattered as in broadcasting. Therefore, relatively small amounts of power will operate the relay transmitters. The apparatus is simple and compact. It must be to perform in the domain of tiny wavelengths which bring radio men so close to the frontiers of light.

Ultra-short waves and centimeter waves travel in a straight line and leave the earth on a tangent at the horizon. The area of the earth's surface touched by such waves, is much like that touched by a stick held against a basketball. Obviously, if we use high towers or antennas on lofty buildings or mountain peaks, we capture and re-transmit the waves at higher levels, and therefore their effective range is lengthened. With the use of radio relay stations, the average range is about 30 miles, depending upon the terrain and various other factors. An airplane over Washington, D. C., carrying a television receiver, intercepted the pictures from the NBC aerial on the dome of the Empire State Building 200 miles away. But for such long distance reception of the ultra-short waves, the plane had to go up 20,000 feet.

The circuits can carry not only one television program but several simultaneously, as well as "FM" sound broadcasts, telegraphic traffic and facsimilie.

The radio map will be dotted with stations in cities like Schenectady, Utica, Syracuse, Minneapolis, Erie, Buffalo, Louisville, and many others. By the use of radio relays these too will become outlets for the television network which before many years pass after the war, will weave from the east across the Mississippi and the mid-west plains to meet a Pacific Coast link striking eastward across the Rockies. A relay station atop Pike's Peak might well be the key station to complete a transcontinental television chain.

These unattended relay stations located 20 to 50 miles apart will not only link television stations into national networks but will open up a new era in international communications, through development of trunk lines over such vast areas as Russia and China.

Even the Himalayas will be no barrier to such radio relaying. Their high mountain peaks will speed the process, for relay stations at such altitudes can reach far beyond the horizons of the valley. China would then have a new Burma Road to the western world—a road of television.

POST-WAR predictions slumped slightly last month, according to the statisticians who follow this phase of radio activity. The only contribution of note was made by Gilbert Seldes, head of the Television Program Department of Columbia.

"When television comes," said Mr. Seldes, "it will include color." This, he thought, might be "right after the war" or might take a year or two. He stated also that it would reach many more cities than at present believed likely, and will be much cheaper than present estimates would lead one to believe. "A certain tube used in television used to cost $85.00," he pointed out. "After the war it will cost $5.00. The price of a good radio set will be the price of a medium-quality television receiver."

"In art," he went on, "we can show the depth and texture of a painting as it's never been seen before. In news coverage we have visualized news in such a way as to combine flash news and the movie's March of Time style with something else more potent than mere immediacy."

Seldes explained, "Four months after war broke out President Roosevelt talked on the air and said he wished he had a map he could show all his listeners at the time. We gave him the map. We gave the public a lecture in geo-politics first, and then as he spoke we moved the camera just enough so that people could see the places he mentioned—but not enough to distract them from his speech. When he said, 'the distance from one point to another is'—we showed the distance. We had lines and arrows marked."

•

RELEASE of 56,153 shelfworn but still serviceable batteries for distribution to volunteer amateur radio operators serving in the War Emergency Radio Service in the States of New York and New Jersey, was disclosed last month by Sinclair Hatch, Regional OCD Director in New York.

These batteries, said Mr. Hatch, will make it possible to put into immediate service many radio units now idle for lack of batteries as well as providing an auxiliary power source for those units operated solely by power from commercial power lines.

•

RADIO PLANNING BOARD, proposed early in the year by the Institute of Radio Engineers, was organized at a meeting held in New York September 29.

Representatives were present from the American Radio Relay League, FM Broadcasters, Inc., Institute of Radio Engineers, American Institute of Electrical Engineers, International Association of Chiefs of Police, National Association of Broadcasters, National Independent Broadcasters, Radio Manufacturers' Association and Aeronautical Radio, Inc.

A permanent plan of organization was worked out, under which sub-committees or Panels will deal with separate radio subjects and report to the Radio Technical Planning Board as a whole.

Further details will be settled at a meeting which will be held in the near future. The group appointed Dr. W. R. G. Baker, Vice President of General Electric, Chairman of the new RTPB for a period of one year.

IN REVIEW

to the Radio Technician

X-RAYS are now being employed to catch defective hand grenades which might explode prematurely while these are still on the factory conveyor belt, it was revealed last month by General Electric engineers.

The new device, first of its kind in existence, determines whether the fuse assembly is correctly made up. Each of these assemblies contains two powder charges and a slow-burning fuse. If too small a charge is placed in any of the three, the grenade may explode before the thrower gets it clear of him.

The fuses are set upright on a movable belt which passes through the machine. As each one passes the X-ray, it is penetrated by a 100,000-volt beam and its shadow is thrown on a fluorescent screen. The screen is scanned by a photo-tube, and as long as the fuses are normal, nothing happens. When a fuse with a "short" powder charge passes through the beam, there is less blocking effect and more X-rays reach the fluorescent screen. More light is emitted by the screen, and this is noted by the photo-tube. Relays are set in action which ring an alarm and flash a red light, at the same time placing a dab of red paint on the defective grenade and making a record of the rejection on a chart.

The new machine, now in practical use, can check fuses at the rate of 4,000 an hour.

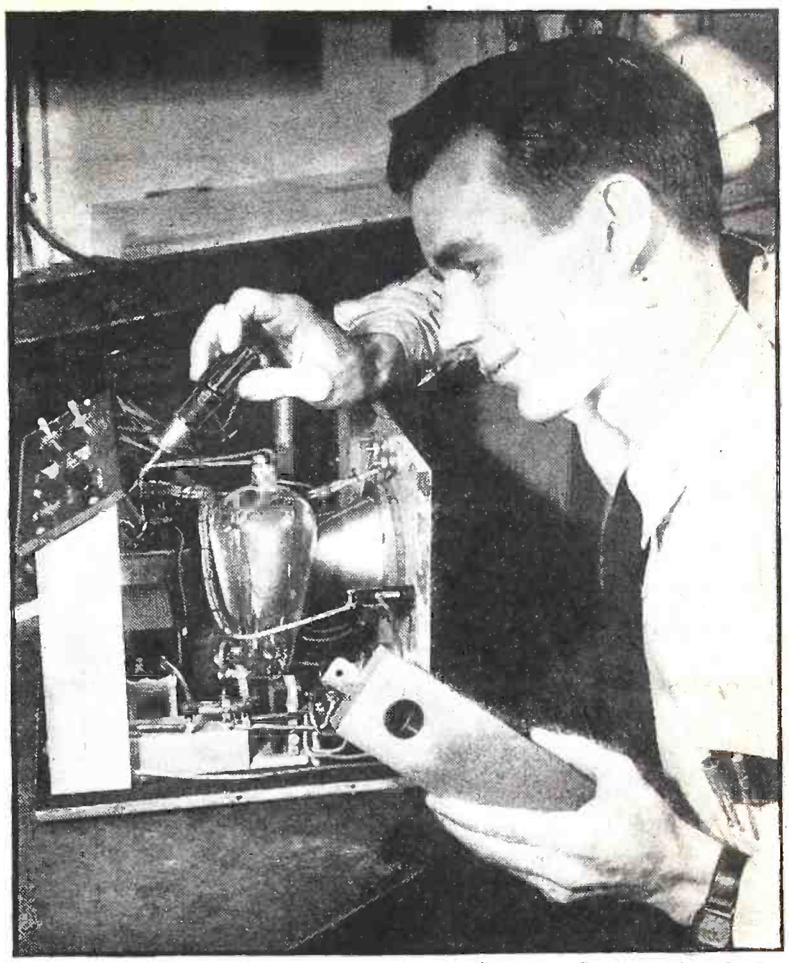
•

INTERNATIONAL radio programs beamed to Britain are an important factor in promoting Anglo-American cordiality, reported Robert Foot, Director General of the BBC, last month. In a cable to Brigadier General Frederick H. Osborn, Director of the Special Service Division of the U. S. Army, which produces the programs, he expressed especial appreciation of the "Command Performance" and "Mail Call" broadcasts. The cable follows:

"British Broadcasting Corporation is sincerely appreciative of radio programs produced by Special Services for broadcasting by BBC domestically and overseas. All these much enjoyed by listeners and effective in promoting Anglo-American cordiality. Special Command Performance for July Fourth now received and scheduled domestically and for forces overseas. Many thanks for continued cooperation. Robert Foot, Director General."

•

LATEST radiophoto circuit between New York and Berne, Switzerland, one of the few neutral countries left in Europe, was opened last month by RCA Communications. The Switzerland circuit is the sixth opened by RCA since the beginning of the war, the others being to Sweden, Russia, Egypt, Hawaii and Australia.



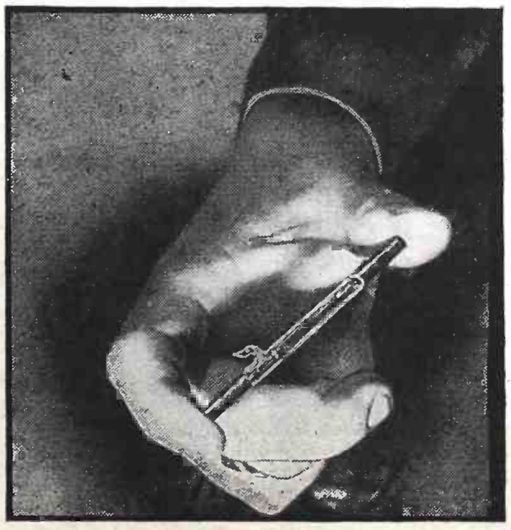
The 27-year-old inventor, S. Lawrence Bellinger of the General Electric research staff, makes an adjustment on the power pack which lights the new high - speed photographic lamp.

Courtesy General Electric Co.

PHOTOGRAPHS with an exposure of but one millionth of a second, brief enough to stop a rifle bullet or any fast moving object, can now be made by a new high speed electronic light equipment developed by engineers in General Electric's laboratory.

This device, using a small mercury lamp no bigger than a cigarette, consists of a small portable box, 10 inches square and weighing less than 20 pounds. On the front is the light source, resembling a small auto headlight, which can be operated manually by means of a push button, or automatically by electrical contacts or a phototube and preamplified. It will illuminate 20 square feet of area with sufficient intensity to photo the fastest moving objects, in fact in tests has "stopped" a wheel revolving at 70,000 revolutions per minute.

Fastest camera shutters of the usual type, with blades moving between the lens elements, ordinarily operate at a minimum of 1/300th second. Focal plane shutters, consisting of slits in a curtain moving immediately in front of the film, cut this down to 1/1200 second. Recently published high-speed photographs of athletes, etc., have been made with a lamp giving exposures of 1/30,000 second, but 1/33 as fast as the new G-E unit.



Mercury-vapor lamp with a one-second life.

The new device uses standard and easily replaceable electrical parts and a single electronic tube, with a 100-watt Mazda mercury lamp as the light source. Such a lamp is now used as a high intensity light for illuminating airports, television and motion picture studios, and for other purposes. Its brightness in such installations is one-fifth of that of the sun's surface.

The ordinary 115-volt A.C. household lighting circuit is used to operate the unit. The current is rectified by an electronic tube and then used to charge a capacitor, really an electrical storage tank. In three seconds enough power is accumulated to operate the lamp at full flash intensity.

At approximately 2000 volts and 2000 amperes, it reaches a maximum of some 4,000,000 watts. Since current flows for only about a millionth of a second the total energy in each flash is very slight. It is only enough to light a 40-watt lamp for a tenth of a second.

"Because of the pressure of war work, for which the unit was made, we have not been able to experiment fully with many fast moving objects," according to S. Lawrence Bellinger, who was active in its development. "Rather we have confined our efforts to using the device for studying high speed machinery, such as turbine and supercharger parts.

"The small mercury lamp has a lifetime of but one second but despite this brief period it will last the ordinary newspaper photographer 500 years for it is good for 1,000,000 exposures."

Earlier devices which could make photographs at an exposure of one one-hundred-thousandth of a second were unable to accomplish many things expected of the new tube. Although stroboscopic devices made studies of extremely fast-moving machinery possible, this lamp can be used in photographing non-periodic events, for which the stroboscope was useless.

POPULAR ELECTRONICS*

PART X—PRACTICAL USES FOR PHOTO CELLS

By RAYMOND F. YATES

THE photoelectric cell has a totally unsuspected versatility. Those skilled in its use are able to make it perform miracles. The student of electronics who believes that the use of such cells is limited to opening doors and counting objects through interruption of the light beam is a long way from ascribing to this device its full measure of usefulness.

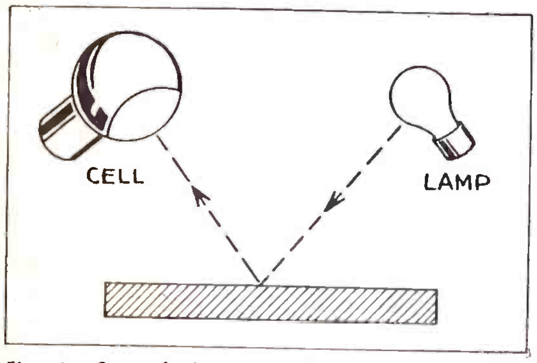


Fig. 1.—One of the simplest applications of the photo-tube, a surface-polish meter.

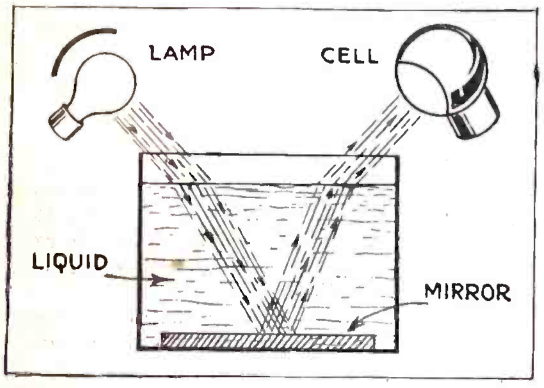


Fig. 2.—A device for measuring the characteristics of a liquid by checking its refraction.

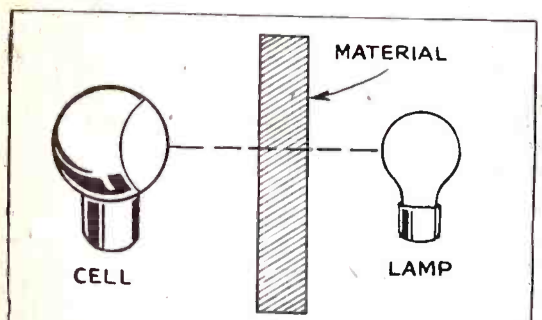


Fig. 3.—Photo-cell used to measure light-transmission characteristics of a material.

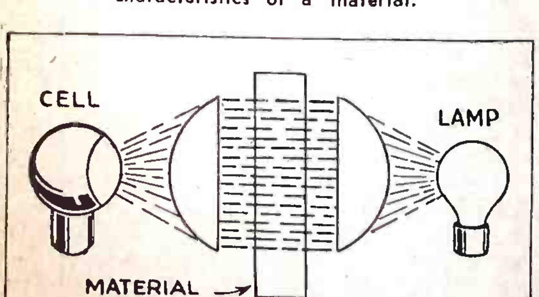


Fig. 4.—A more refined device for the same purpose as the set-up of Fig. 3.

In the first article of this series, we listed a large number of applications of the photoelectric cells of various types. In this installment, we shall cover the finer points of such applications.

One is amazed at the degree of sensitivity in the matter of light reflected from surfaces. Obviously, the intensity of the light will depend not only upon the source but also, in the case of reflection, upon the nature or polish of the surface functioning as the mirror.

Fig. 1 supplies the method used both for practical and experimental work. The student may set up such an arrangement, connecting the output of his photoelectric cell to a milliammeter. Various materials are set in the beam of light. Paper, glass, wood and other substances may be employed. It will be noted that the current generated by the cell will vary within wide limits depending upon the nature and the degree of polish or lack of polish carried by the mirror.

This method is used commercially in the automatic inspection of surface finishes. Some tests are purely laboratory, others take place on the production line with automatic rejection of unsuitable pieces. With the proper equipment, this method of inspection has become so highly developed that differences which will pass undetected by the eye will be caught instantly by the photoelectric cell.

A variation of the method, used in the measurement of refraction in liquids or in the control of certain chemical processes, is illustrated in Fig. 2. Here a mirror surface is placed at the bottom of a vat containing the liquid to be inspected. The current on the output of the cell will vary according to the shifting of light coming from the liquid. This, in turn, will depend upon the refractive index of the liquid, which may change to a definite degree as the result of a chemical process. A certain index may represent what the chemist calls an "end point." Here the cell may either ring an alarm or, working through electrically operated valves and relays, control the flow of chemical used in the process.

The transmission co-efficient (of light, that is) may also be measured through liquids and transparent or translucent solids in the manner shown in Fig. 3 and 4. Here the student will understand the advantage of employing lenses for the concentration of the light. These help make electronic apparatus of this sort a great deal more efficient and, consequently, far more reliable. Therefore, it will be very much to the interest of the student to study elementary optics.

Of course, the method shown in Figs. 3 and 4 may also be employed in the inspection of liquids of various kinds in place of the method shown in Fig. 2. Indeed, the former is the method employed in the checking of water turbidity at sewage disposal plants.

*Application for Trade Mark Title, pending in U. S. Patent Office.

Fig. 5 provides the actual details of a commercial installation for the determination of the density of liquids.

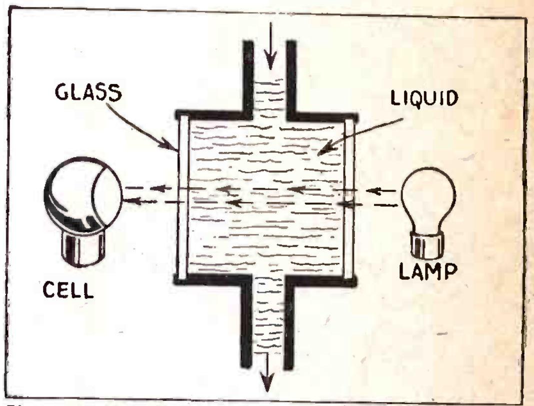


Fig. 5.—Apparatus of this type is commonly used in chemical plants, sewage disposal installations, etc.

Let us note, then, that photoelectric cells may be employed to measure (1) refractive index, (2) reflective conditions of surfaces, (3) variations in color and (4) transmission co-efficients.

While we do not have space available for a lengthy treatment of the matter, photoelectric color comparison has now reached a high degree of usefulness and application. Color comparators are available as standard equipment and are widely used in the dye and paint industries. Not only has the use of such cells greatly increased our knowledge of colors but has made inspection for color a fine art. Once a sample of the proper shade is placed in the machine, the degree of all variation will be scientifically measured and observed in actual units.

It will quickly be seen that, should an object interpose itself between a source of light and a photocell, the shadow cast by the object can be made to fall upon the cell and that the size of this shadow will determine the amount of current generated by the cell. Such an arrangement may be so perfected as to detect and measure extremely small differences in size. Thus equipment of this sort is used a great deal for inspec-

(Continued on page 116)

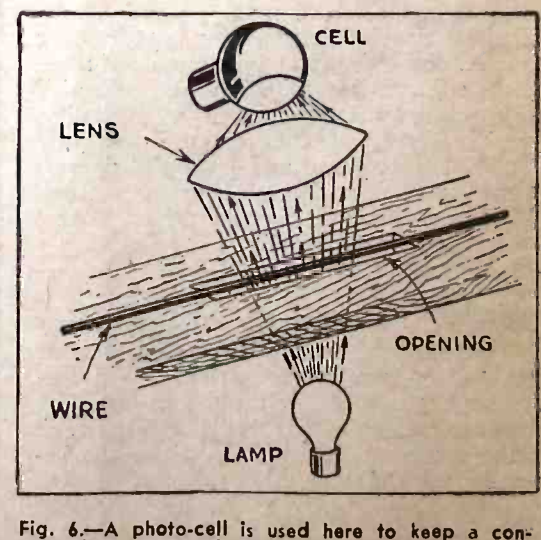
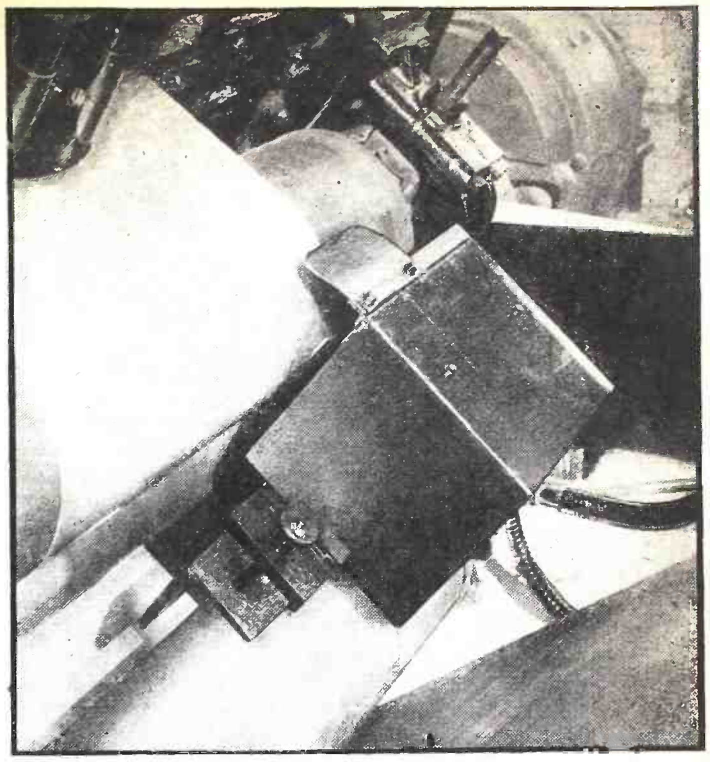


Fig. 6.—A photo-cell is used here to keep a constant check on the diameter of a wire as it is drawn.

The Promise of Electronics

By L. A. UMANSKY*



This photo-electric cell, which keeps colors in register, has made savings of many thousands of dollars in color-printing.

THERE is no better way to illustrate the already wide use of electronics in our industrial life than to point out that in 1943 more than 25 billion Kw.-hours, or about 10 per cent of all electrical energy generated in the United States by any source of power and for any purpose whatsoever, will pass through electronic devices. I refer, of course, to the rapid growth of the electro-chemical and light metal industries which require a very large bulk of D.C. power, employing electronic rectifiers.

Electronic control has already revolutionized the art of resistance welding, bringing into play heretofore unknown precision, speed, and reliability. And this fact, in turn, has brought about profound changes in many of our manufacturing industries.

The electronic control of motors—and, therefore, of machines driven by these motors—has long ago passed from laboratories into factories, and is accepted by engineers and users as a routine matter. No one familiar with industrial engineering considers any longer as a daring or pioneering feat the use of electron tubes for accurately controlling the speed or acceleration of motors; for the precision positioning of a sheet of paper on a printing press; for color matching; for controlling wire tension; for smoke detection or for temperature control—to mention a few out of hundreds of cases.

Therefore, industrially speaking, we do not subscribe to the claim that we are "on the verge of an electronics age" which will supposedly dawn on us after the guns stop firing. We are in this electronics age already, and actually have been in it for years. *Industrial electronics is not only a promise for tomorrow—it is an accomplishment of today.*

*Asst. Mgr. Industrial Engineering, General Electric Co.

We look upon electronics as another tool added to our well filled tool chest and used side by side with other tools on hand. Knowing as we do all other phases of electrical engineering, which we have helped to develop in the past 65 years, we certainly will not make you believe that these brilliant and basic accomplishments of the past, like the induction motor, transformer, high-voltage apparatus, amplidyne, and so forth, will be relegated to oblivion by electronics. In the true perspective of things, electronics has taken its place as an equal partner, side by side with other electrical apparatus, enhancing rather than superseding it.

We use electronics because in many cases it gives us better results than we can get with other tools, or because the engineering problem cannot be solved otherwise. Nothing but harm will accrue to engineering progress, and more specifically to the electronic art, if electronics is used without discrimination, just because it is relatively new and, therefore, fashionable. For instance, in some applications, resistance-type electric heating can give results equally as good as radio - frequency induction heating, and do so at lower first cost and higher efficiency. Electronic equipment would then be a misapplication and, therefore, poor engineering. Luckily, electrical engineers have a good assortment of tools available, so that they can and should pick the right one for the application.

Parade of industrial electronic tubes. Here may be seen the stout metal Ignitron, beside one of the large Pliotrons used in electronic heaters. Next to it is a screen-grid Thyratron, and in the foreground a number of the many tubes used in the manifold industrial applications of Electronics.

What are, then, the advantages of electronics and when do we use and recommend electronic equipment?

In many control and measurement applications, the use of electronics gives us a chance to detect and then to amplify signals so small that they would be lost otherwise. This may be called the "extension of our electrical senses." In the same category fall numberless counting and inspection devices replacing the human eye or human touch with something much finer, faster, and more reliable. In a fast industrial process, this application of electronics opens a new page, fulfills a newly created function.

An electronic device has no mechanical or electrical inertia. Its speed of response is high. This is just what is needed for many fast-moving processes. A good example is the ignitron contactor for resistance welding.

An electronic equipment has no moving parts. This usually means lower maintenance and installation cost.

A power rectifier to convert A.C. power to direct current requires less material—and critical material at that—than an equivalent rotating equipment. Its efficiency is higher.

For induction or dielectric heating, requiring very high frequency, say several hundred kilocycles or even megacycles, nothing but electronic equipment will do—a good example of when electronics is a "must." In short: *Electronics is employed when it can do the work in a better or in a simpler way, or at lower over-all cost.*

The great majority of industrial equipments employing electronic parts also include other apparatus. In fact, in most cases, the electronic part comprises the small end of the whole. For instance, an electronic speed regulator with a cost of only, say, $500 may be combined with a $50,000 equipment including motors, generators, control, switchgear, etc. In such a case, the electronic part, taken by itself, is practically worthless; the rest of the equipment without electronics may not deliver the goods—the two together, properly blended, solve the problem.

It is obvious that for best results engineers interested in industrial applications

(Continued on page 122)

Radio Glider Bomb

By HUGO GERNSBACK

COVER FEATURE

DURING the present war, strangely enough, radio-controlled war machines have not been used as extensively as they might, despite the fact that the art is old and radio literature as well as patents abound with machines and implements that can be controlled from a distance by radio impulses.

At the first electrical exposition held in New York—and this incidentally was before 1900—Dr. Nikola Tesla controlled a model ship in a water tank and also blew it up, all by radio!

One of the earliest radio-controlled machines was described in my former publication MODERN ELECTRICS, of July, 1908. The device ran under the unusual title, "The Ceraunograph," invented by the Rev. P. J. Philippe, S. J. of Spring Hill College, Mobile, Ala. While it was only a miniature model it foreshadowed its future war use. It was operated by a one-inch spark coil with its two old-fashioned spark balls. By operating a multiple switch the following devices were operated at a distance: a cannon, an electric light, a fog horn, an alarm, a light signal, and a fan motor.

Incidentally the miniature cannon shown in the photograph on page 116 of MODERN ELECTRICS went off realistically with a tremendous bang.

Dr. Nikola Tesla, in his autobiography in the writer's magazine, the ELECTRICAL EXPERIMENTER of June, 1916, and October, 1919, dealt quite exhaustively with radio controlled devices which we called *Wireless Automata*. One of the photographs shows an actual model which he constructed and which was controlled by radio at a distance; it rolled on four wheels and could be steered from afar.

About this time radio men also became acquainted with the work of the American, John Hays Hammond, Jr., who has since become probably the greatest exponent of the art in controlling machines by radio at a distance. Indeed some of his patents were sold to our own Navy and were used at the time when Billy Mitchell demonstrated how airplanes could sink battleships. For this occasion the U. S. Navy equipped several obsolete battleships with radio control devices so effectively that not a human soul was required on board the battleships, yet they were steered over zig-zag courses, made to run circles and figure eights. As a matter of fact the entire battleship with its power plant and everything on it was controlled from shore by radio control just as if a crew were on the ship operating it. In spite of this, Billy Mitchell—not having to worry about anti-aircraft batteries—demonstrated that battleships could be sunk by bombers.

Late last September Prime Minister Churchill described in the House of Commons a new war weapon, a radio-directed rocket powered bomb, now being discharged from heavy bombers of the German *Luftwaffe* against Allied shipping.

In this war the Germans as well as the Americans and the Russians have been using rocket bombs, which however are shot from a cannon to start their flight.

In the case of the new German device, which is only new in the application of old methods, the following action most likely takes place:

The instant the radio-glider bomb is released its rocket goes into action as well. Mr. Churchill mentions the fact that the parent bomber first climbs to a height of about 35,000 feet, before it releases the radio-bomb. At such a height it is almost impossible to damage or hit the parent bomber because it is up too high. Anti-aircraft fire is ineffective at such a height. Now when the radio-glider bomb is released, it presents a much smaller target than the bomber does and is therefore not so vulnerable. Moreover by not carrying anyone aboard, the Germans do not risk valuable lives when releasing radio-controlled rockets.

FACTS OF THE NEW NAZI GLIDER BOMB

THE new device is an actuality, now being used by the Nazis against Allied shipping, as reported by Prime Minister Churchill in the House of Commons on September 21st last. Launched from a parent bomber, at a height of 35,000 feet, it is powered by rocket propulsion.

It is radio-controlled and steered from the parent bomber which remains at a sufficient height, out of reach of anti-aircraft fire.

The Radio Glider Bomb, according to Mr. Churchill, has already taken its toll of Allied convoyed ships.

The device employs well-known elements and only the combination of all these elements makes it new.

The best method of fighting the new menace is by means of Allied fighter aircraft to keep the attacking parent bomber away from the target. A smoke screen over the convoy is another good defense.

Inasmuch as the operator in the parent bomber must keep the Radio Glider Bomb under continuous visual observation, it follows that it cannot operate effectively in darkness or fog.

Radio defense by means of "jamming" the enemy control signals is difficult and complex, as brought out in this article.

Radio-controlled war machines therefore have come of age and we may expect other devices of this nature before very long. But as the Allies have had considerable experience with radio controlled devices we might hazard the guess that we can go the Nazis one or several such schemes better in the not too distant future.

It appears that the Nazi machine is formidable and according to dispatches printed in *"The New York Times"* the device weighs probably more than one thousand pounds. It is therefore not to be taken too lightly for the moment, or not until effective counter measures have been perfected.

The new radio-glider bomb will probably take its toll mainly as a surprise weapon. While up to the time we go to press no further details of the radio bomb have appeared in print, the following may be taken as a rough blueprint of the construction of the German aerial device:

It is in short a bomb or torpedo fitted with glider wings that is dropped from a heavy bomber; it then glides towards its target, directed by radio installation in the mother craft.

In all probability the radio-glider bomb is attached underneath the fuselage of the bomber and released by the usual device whereby the bombardier merely presses a button or pulls a release lever which disengages the glider bomb from the parent bomber. Mr. Churchill speaks of the machine being powered and propulsed by a rocket. Rockets are not new. They were used as far back as 1232 when the Chinese employed them to repel the Tartar Hordes. Modern power rockets have been experimented with for many years, both in the United States by Professor J. H. Goddard and in Germany by the late rocket experimenter Max Valier.

We next come to the problem of steering it. When launched the rocket glider bomb must, of course, be pointed downwards and it descends not only by the force of gravity alone, but is helped to gain speed by its own rocket propulsion as well. This gives it the necessary high speed which makes it almost invulnerable to anti-aircraft fire.

The glider part and in fact the entire device is probably painted in a bright color so that the radio operator on board the parent bomber can follow the descent of the rocket through high power glasses and then by means of radio control, steer it to the target.

When a number of such radio-controlled glider bombs or torpedoes are let loose against a convoy, the chances are that one or more will make a hit or a near hit, raising sufficient havoc in the convoy to either sink a number of ships or doing heavy damage. That, of course, is the main idea behind the new device.

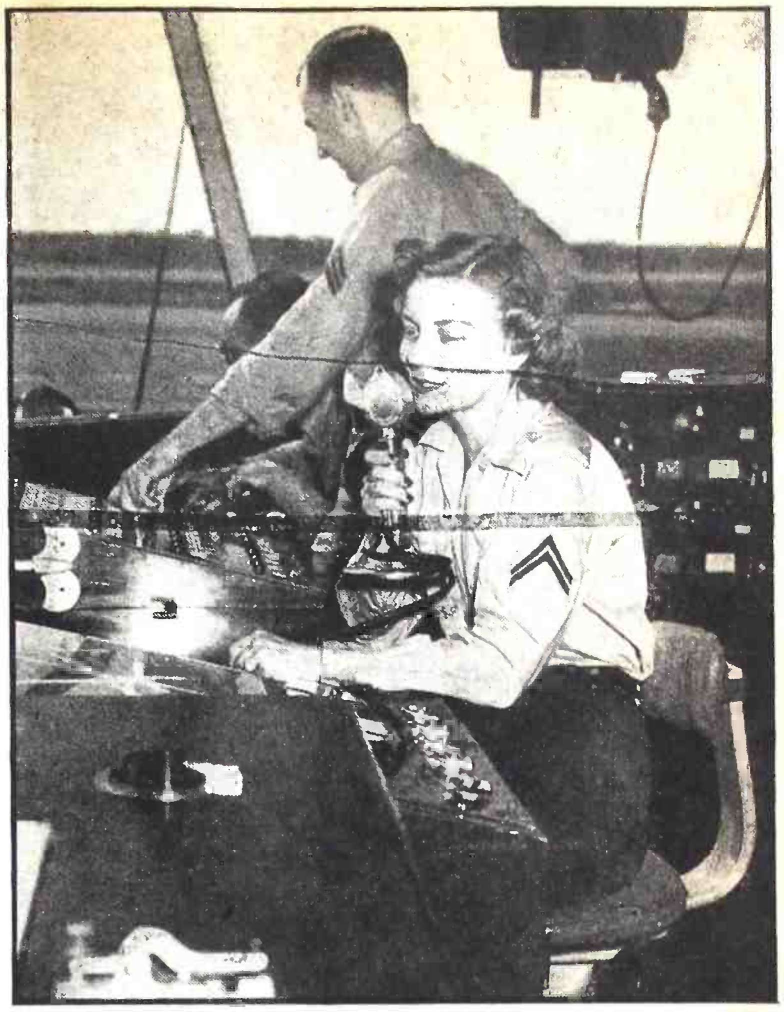
At first thought several objections to the new war machine will offer themselves. These are that the device can be used only within the effective radius of the land based bomber (the Germans not having at present any carriers to make the glider bomb effective far out at sea). But such a bomber within a radius of 300 to 500 miles from land presents a serious threat. It becomes more serious when a flight of

(Continued on page 110)

Women in the MARINES

By PFC. HALLIE E. HOUCK*

***Radio activities** form an important sector of the work of these members of the Women's Reserve, U. S. Marine Corps.*



Corporal Priscilla Wilson, of Braintree, Mass., stands by to give the "All Clear" to a pilot about to land. This is one of the most interesting types of work handled by the Women's Reserve.

THE place of women in radio is no longer questioned; performance has proved their expertness in this field.

But, women especially trained to free fighting men of the United States Marines to wage the famed Marine Corps brand of warfare against the Axis, add another chapter to the colorful history of the Corps.

Radio, because it is vital to the successes of Marine Corps aviation and the ground forces, is one of the highly specialized fields of the Marine Corps Women's Reserve.

Hundreds of women are being trained for radio work in specialist schools and at Marine Corps air stations.

Future women radio operators are in schools at the University of Wisconsin in Madison and at Miami University in Oxford, Ohio. They are a highly selected group, as are the women in the Marine Corps radio mechanics school recently opened at the U. S. Marine Corps Radio Materiel School in Omaha, Nebraska.

At the operators' schools the women learn how to operate radio transmitting and receiving equipment, and maintenance and care of radio equipment. Four months' training are required to complete both the radio operators' and mechanics' courses.

Their schooling includes adjusting and repairing radio direction finders and sound equipment and they must understand the basic operating principles of all Navy radio and electrical equipment. To round out their training they are given courses in typing, shop practice, and how to handle tools.

When, upon successful completion of the course, they are sent to an air station to free a man to fight, they know how to operate radio transmitting and receiving equipment and to send and receive messages in International Morse Code; their training enables them to set up, place in operations, disassemble and pack ground radio equipment; to tune and adjust radio transmitters, replace tubes and batteries, and make minor adjustments.

Finally, they know how to operate radiotelephone equipment, they are familiar with joint radio-telephone procedure and with the methods of transmitting messages by voice radio.

Experience in radio or electrical repairs and maintenance, high school or college courses in physics, and mathematics through higher Algebra are desirable qualifications for those women who choose to do their part in the war by becoming trained radio mechanics.

Upon being graduated from the mechanics' school, they are highly competent at inspecting, installing, testing and repairing radio transmitters, receiving instruments and related equipment in connection with the maintenance of Marine Corps communications. They can handle field testing meters and devices like veterans and when something's wrong with equipment they can isolate the trouble and either make the necessary repairs or replace the defective parts. Should it be a loose connection they can do workmanlike resoldering jobs. They know how to test and repair Marine Corps field sets and field telephone equipment.

An interesting application of radio operation is employed by women who have chosen to become Link Trainer instructors and control tower operators. Both schools for these jobs are located in Atlanta, Georgia.

The Link Trainer is the marvel that looks like a plane and goes through all the maneuvers of a plane, yet never leaves the ground.

The women who become instructors conduct themselves as if they were in the radio tower. By transmitting signals to the student pilot—which he receives through head phones—the instructor teaches him the art of blind flying. The instructor keeps a chart of the aviator's performance and from that the pilot corrects himself until he has reached the expert stage.

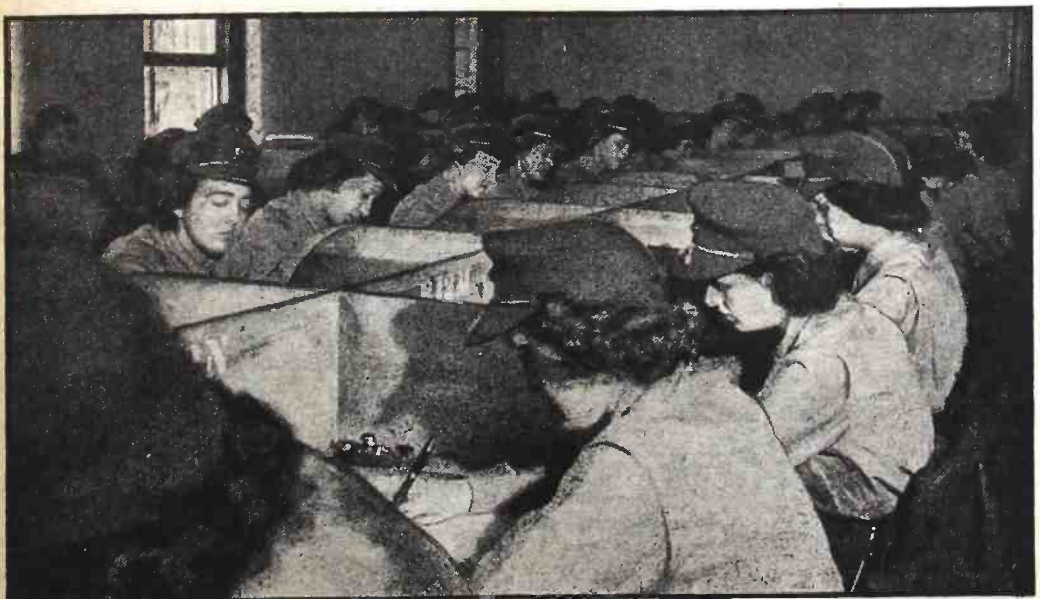
Control tower work, a field which Women Reserve members find fascinating, includes radio and voice techniques, radio aids to air navigation, and knowledge of the Federal Communications Commission rules and regulations.

The operator in the control tower at one of the huge air stations talks to the airplanes in the air by means of the control radio transmitter, or signals them with a hand-operated light signal.

She regulates the landings, take-offs, turns, and direction of flight over the airdrome, keeps airplanes in flight informed as to local weather conditions.

Radio is among more than 80 assignments open to members of the Women's Reserve. Each is vitally important in meeting the slogan of the women, "Free a Marine to Fight."

*Public Relations Office, U. S. Marine Corps Women's Reserve, Washington, D. C.



Many hours of training go into the duties of those members of the Marine Women's Reserve who would become expert radio operators. Here they are practising code reception.

ALFRED A. GHIRARDI

METER ERRORS

How, Why and to What Extent

INHERENT INACCURACIES—PART I

HOW accurate are the measurements made with the types of electrical indicating instruments commonly used in radio and electronic service work? A surprisingly large number of experienced servicemen, as well as novices engaged in radio and electrical work, have a mistaken idea about the accuracy of their measurements. This may be because they are unduly impressed by the scientific-looking graduated instrument dials (whose apparent precision frequently is deceptive). They ignore completely the innumerable sources of error which are constantly likely to be present within the instrument itself; in taking the reading; due to the particular method of making the measurement; and due to the surroundings.

One thing is certain, *such measurements never are 100 per cent accurate*—nor do they need to be! To use a test instrument intelligently and tell exactly how accurate is any particular measurement made with it requires complete knowledge of the *various* individual inaccuracies that occur in the measurement. Not only the amount of each inaccuracy present, but also its influence upon the reading obtained (whether it tended to *increase the reading, or decrease* it) would have to be considered. This knowledge will also enable precautions to be taken for minimizing these errors whenever possible.

MAIN TYPES OF INACCURACY

The four common types of inaccuracies which may occur in measurements made with electrical indicating instruments, and the many contributing causes of each, are grouped and arranged for quick reference in the convenient breakdown chart of Fig. 1. This chart merits careful study, for the serviceman who understands the information it contains cannot help but learn to use his electrical indicating test instruments more intelligently, and better interpret the readings he obtains from them. He will also be more anxious to take better care of his instruments so that the degree of accuracy originally built into them by the manufacturer will be preserved.

Notice from Fig. 1 that there are *four* possible types of inaccuracy in such measurements. They are:

1. Those which are *inherent* in the instrument itself due to its particular design, construction, and the calibration of its scales. These are present even in brand new "commercially perfect" instruments of its type.
2. Those which may occur through inaccurate reading of the pointer position by the *observer*.
3. Those which may occur because of the particular way the instrument is being used during a measurement, or the condition under which the measurement is being made.
4. Those which may have developed in the instrument subsequent to its manufacture and calibration (as a result of use, rough handling, damage, etc.).

We will investigate each of these in detail, together with its contributing causes. *Inherent errors* will be considered in this article. The others will be discussed in subsequent articles to follow in this series.

NO INSTRUMENT IS PERFECT

First of all, get this fundamental fact firmly in mind: *Because of practical construction difficulties no commercial electrical indicating instruments are guaranteed to indicate 100% correctly at every point on the scale—only very expensive laboratory-type instruments even begin to approach such hundred-per-cent perfection!*

Some inaccuracies are inherent in every instrument—they are a part of it! The inherent accuracy, sensitivity and reliability of an electrical instrument are determined by its *design*, the *quality* and suitability of its materials, the *care* given its construction, the *precision* with which it has been assembled and calibrated at the factory, and *how carefully* it has been used and handled since.

The degree to which inherent errors may be eliminated from an instrument during its design and manufacture is governed solely by the expense which it is desirable to incur in its production. To make indicating instruments with the price-range of the average serviceman, accuracy has to be sacrificed somewhat. Indicating instruments may be purchased for from less than a dollar up to several hundred dollars. As

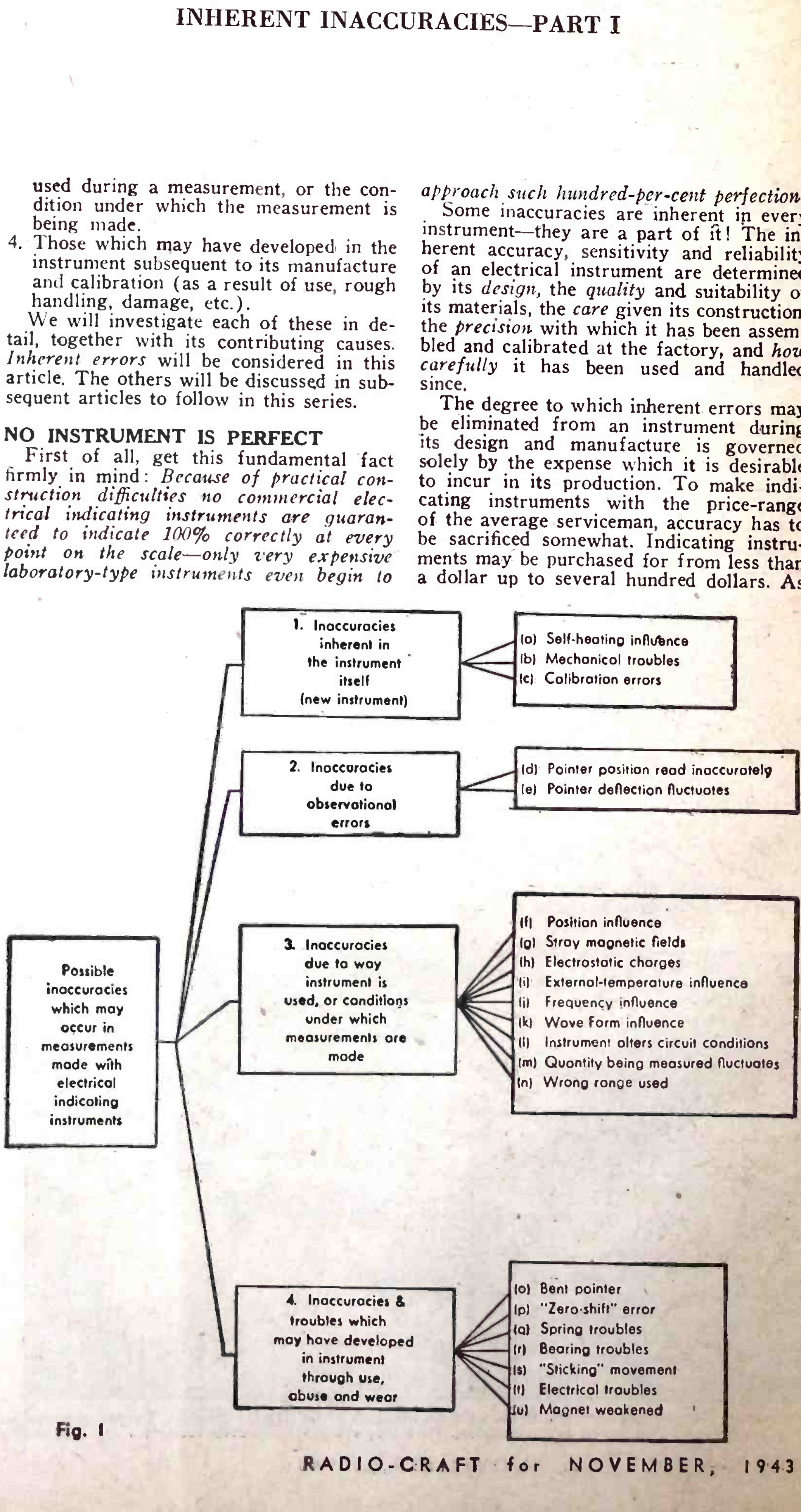
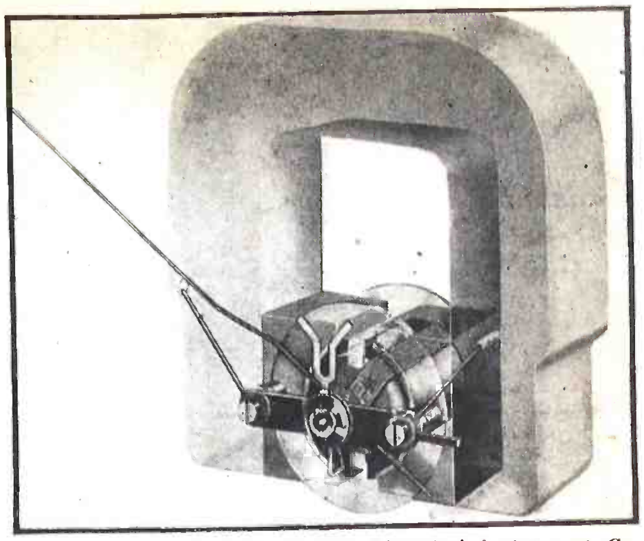


Fig. 1

—THEIR CAUSES

Are Measurements Inaccurate?

By ALFRED A. GHIRARDI



Courtesy Weston Electrical Instrument Co.

A typical moving-coil meter, with the case removed.

a rule, among the instruments of any given manufacturer, the higher the price of an instrument, usually the better the quality of materials used in it and the more precision and care exercised in its workmanship and calibration. Ordinarily, the indicating instruments employed in present-day, high-grade radio test equipment represent a practical and acceptable compromise between inherent accuracy and price—they provide sufficient inherent accuracy for the work (usually *within 2% of full-scale reading* for permament-magnet moving-coil D.C. instruments, and to within 5% on A.C. for rectifier-type A.C. instruments), the necessary sturdiness, and moderate price. Their manufacturers deserve unstinted praise for their clever designs, carefully selected materials and utilization of every technical advance and every possible manufacturing economy. Their products are really fine, rugged instruments at prices much lower than we would expect to pay for almost any other delicate device of equal complication and precision!

But the serviceman should always remember that these instruments are *not 100% precise!* No manufacturer claims them to be, and no user should expect them to be! The accuracy ratings are usually specified frankly in the manufacturer's catalog or specification data.

CAUSES OF INHERENT INACCURACY

Understanding then, and admitting, that certain inherent errors *do* exist in the electrical indicating instruments we are to use in our troubleshooting and testing, and realizing that it is impracticable to eliminate such errors entirely, the user should understand what they are, what causes them, how much they will affect the instrument indicatings at various points on the scale, how measurement inaccuracies due to them can be minimized, and whether they affect seriously the worth of the measurements to be made with the instrument.

The common causes of these inherent inaccuracies may be classified as follows:

(a) Self-heating influence
(b) Mechanical troubles
(c) Calibration errors

They have been grouped at the upper right in Fig. 1, and each will now be explained.

EFFECTS OF SELF-HEATING

One possible source of inherent inaccuracy is that caused by self-heating within the instrument (see item *a* in Fig. 1). Most instruments contain sources of heat confined within a relatively small enclosure: movable coils of very fine wire having resistance, springs, shunts, multiplier resistors, rectifiers, dial lights, etc., through which currents flow. The general effect of this heat is to raise the temperature of various parts of the instrument, increasing the resistance of the metallic current-carrying circuits, thereby decreasing the current flowing for a given voltage. This correspondingly *weakens* the actuating forces tending to cause deflection of the movable coil and pointer. For example, if the circuit of a voltmeter were wholly of copper and this all at a uniform temperature throughout, it will be seen that since the temperature coefficient of resistance of copper is 0.24 per cent per degree F., the instrument current-per-volt would vary nearly 1% for each 4 degrees F. temperature change, making a most unsatisfactory instrument. Actually, the situation is not as bad as this since in a voltmeter the series multiplier resistor (which forms the greater part of the resistance of the voltmeter) is usually made of a material having a very low resistance temperature coefficient. Since the resistance of the copper movable-coil winding therefore comprises only a minor part of total resistance of the circuit, the effect of temperature and consequent resistance changes in the copper part of the circuit are greatly minimized.

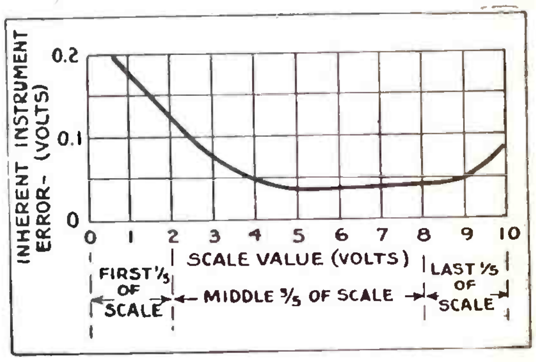


Fig. 3.—Accuracy of a meter varies with the portion of the scale on which the reading is made.

Fortunately, there are available for the movable-coil spiral control springs certain alloys that have characteristics such that a temperature increase tends to *weaken* the elastic force of the spring. In well-designed instruments, the restraining springs made of this material *weaken* just enough to offset the *decrease* in actuating force caused by the resistance *increase* of the movable coil, so this source of error is balanced out. By these and other design refinements, the actual self-heating error in commercial test instruments for all ordinary temperature changes is kept negligibly low.

Then too, the self-heating error which may result in any given instrument depends upon the value of the current of voltage under measurement, and upon the length of time the instrument is kept in the circuit. Fortunately, since the currents flowing through most radio and electronic servicing instruments are fairly small and the instruments are kept in the circuit for only a very short time while a reading is being taken, this source of error is not an important problem.

The influence of *external* temperature variations upon the accuracy of indicating instruments is, naturally, practically the same as that of self-heating. Since external temperature changes involve conditions *external* to the instrument, inaccuracies caused by them will be considered later when discussing errors caused by conditions under which the measurements are made.

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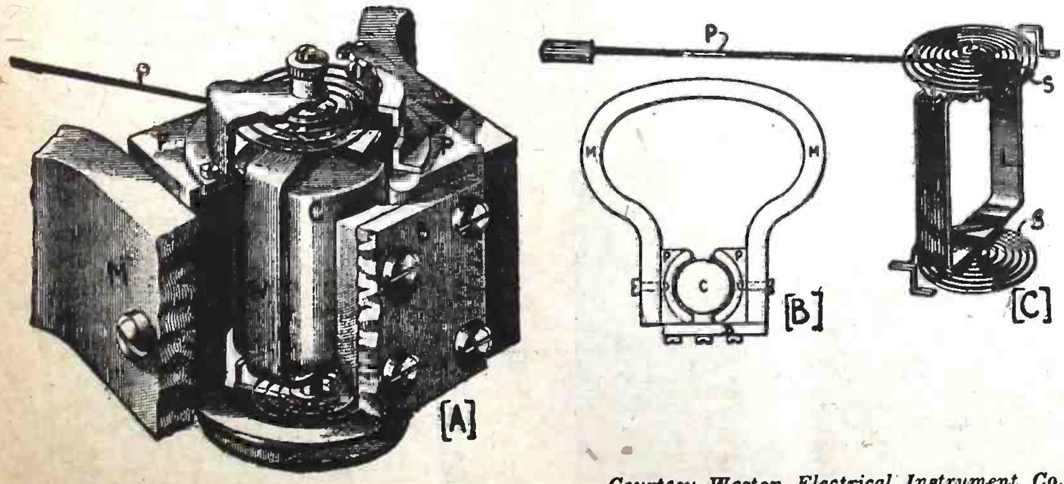


Courtesy Weston Electrical Instrument Co.

Fig. 2.—The D'Arsonval movement, as used in modern moving-coil electrical measuring instruments.

Sound-On-Wire For Our Troops

Courtesy Armour Research Foundation
The news magnetic recorder. Wire reels are plainly visible, and pencil points out the recording head through which the wire runs.

SOUND-ON-WIRE is the oldest system of recording. The earliest experiments along this line were made by Valdemar Poulsen, better known as the inventor of the oscillating arc. Although from its inception the method had advantages that have not since been attained by any other system, one difficulty prevented it from becoming entirely popular. This was the tendency of round wire to twist or rotate. It was necessary to record *lengthwise* along the wire. This technique introduced numerous problems, and never was entirely satisfactory.

A few years ago a number of devices which substituted steel tape for wire, were produced. These were entirely successful, but experiments aimed at taking advantage of the universal availability and cheapness of round steel wire were continued. The solution was found by Marvin Camras, staff worker of the Armour Research Foundation, Chicago.

Details of the new recording head are not being released, as the instrument is being used solely in military service at present. It may however be said that the feature of the new method is that the sound is recorded symmetrically from the center out, all round the wire. Thus it becomes unimportant whether or not the wire rotates between the time it is recorded and played back.

This great handicap overcome, the many advantages of wire recording can be realized. One of the first of these is cheapness and compactness. In the commercial model of the new machine which is now being manufactured by General Electric, one-half a pound of wire will record one hour's ordinary speech. If high-fidelity is required, the speed at which the wire moves through the head must be increased, and the same half-pound of wire can be used to record one-half hour of fine music.

As compared to disc, sound-on-film and any other recording methods used up to date, sound-on-wire recording is infinitely rugged and durable. Records have been played as many as 200,000 times and are still in good condition. Age has little effect on them—some of Poulsen's original records are still usable after 40 years. It is further suited to long-time recording because of its compactness, which makes storage of large numbers of records over long periods a simple matter.

For business uses, where records are of little value after being used once, the wire recorder has another striking advantage. Once used, the steel wire may be demagnetized, erasing the record. It may then be used over again, practically indefinitely.

To those readers who have been following the recent series on pickup performance, the new method's advantages over sound-on-disc will seem to lie more in the direction of high-fidelity. The "pickup" in this device remains close to the surface of the record, *without touching it*. All the problems of needle size, groove depth, weight of head, varying drag over different portions of the record, etc., disappear entirely.

Sharp variations of magnetism permit the use of low speed recording, the amount of wire required for a given recording being only one-fifth of that used in the original Poulsen apparatus. Conversely, by advancing the machine to its high-fidelity speed the frequency range may be made to extend far above that of the now universally-used disc record, with very slight variations in volume being faithfully recorded as well. Present models are more concerned with voice recordings, and are rated for a 5,000-cycle top.

The new device makes possible a news and entertainment service to American troops in the field, which would be impossible with older means.

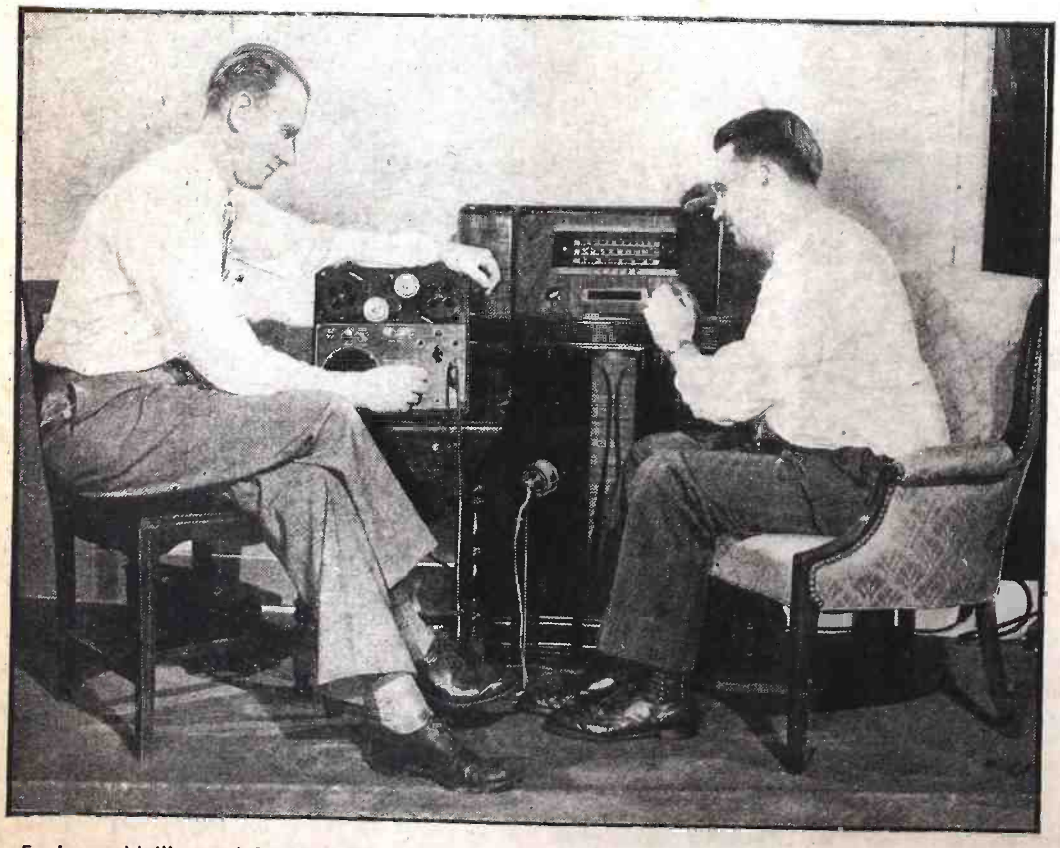
Two General Electric engineers, E. A. Malling and A. W. Sear, of Bridgeport, Conn., pick up two news roundups and the "Army Hour" broadcast each week on a regular radio receiver, and record the programs on the new electronic unit. The wire, on spools, is then air mailed from Bridgeport to Washington where it is put on a transport plane and flown directly to Algiers, Africa.

These wire recorded programs are then played back to soldiers who cannot hear the broadcasts in any other way, and to army officers and war correspondents. This also gives correspondents an opportunity to listen in on their own broadcasts, and to follow the war news from other fronts, according to Colonel E. M. Kirby, chief of the Radio Branch of the Army's Bureau of Public Relations.

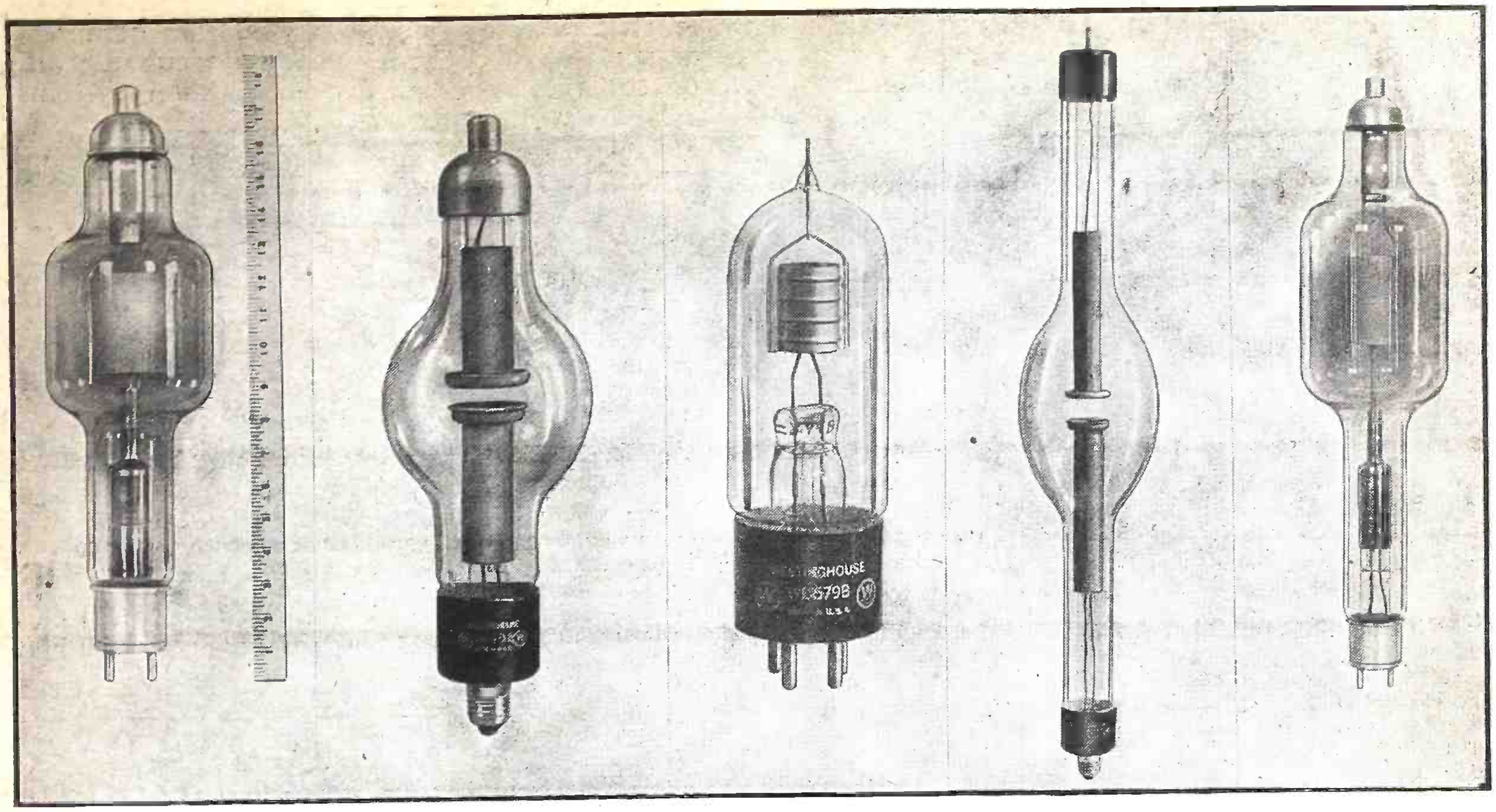
The army hopes that the new lightweight wire recorder will bring a new dimension and flexibility to radio's coverage. Experiments in planes 30,000 feet above ground and in jeeps, using power from the electrical systems of the vehicles, have proved the value of wire recording.

"Radio reporters have been anchored to stationary radio transmitters in a war of movement," said Colonel Kirby. "If they go to the front they cannot broadcast until they return to the transmitters. In the Southwest Pacific this means a distance of 1500 miles both ways. In the Tunisian campaign, it meant several hundred miles, and for Sicily,

(Continued on page 122)



Engineers Malling and Sear pick up a program and record it for transmission to our soldiers abroad.



KENOTRONS

WHILE the term Kenotron may be applied to any two-element, high-vacuum rectifier tube, in practice it is usually confined to such tubes as are designed to work at extremely high voltages. Thus one seldom or never hears the humble but useful 80 called a Kenotron, but such tubes as the Westinghouse WL-612 or the G-E GL-411—both designed to work with plate voltages in the order of 150,000—never get any other name.

Where plate voltages are extremely high, the voltage drop inside the tube becomes unimportant in proportion. In many applications which demand high voltages, currents are very low. Thus the high-vacuum diode rectifier is preferable for many applications, due to its cheapness of construction, as well as to the problems that would be encountered in attempting to design gas-filled rectifiers for high voltages. Kenotron tubes are also used where comparatively small currents and voltages are required, but a certain ruggedness is required, as in home radio receivers and some industrial devices.

Some special features are necessary in the design of such tubes, on account of these high voltages. The elements must be so constructed as to prevent high-velocity electrons from running wild about the tube, and for this reason we see the peculiarly-shaped shields surrounding the plate and cathode in some of the models. Should an electron, accelerated through a voltage of 150,000, reach the envelope, it would very likely come right out through the glass. The high voltages also make the use of "corona shields" necessary. These are attached to the sockets and are maintained at the same voltage as the element whose connections are brought through that end of the tube. Otherwise dangerous electrostatic strains might exist between these portions of the bulb and nearby parts of the socket.

HIGH FILAMENT CURRENTS

The extremely high filament currents drawn by certain of the higher-power tubes attract instant attention. These may be as high as 50 amperes, and even the small tubes with a 2.5-volt filament use several amperes. Filament voltage is critical if output is to be kept near maximum, and for this reason most installations using kenotrons are equipped with a filament voltmeter.

If low output currents are required, plate and filament voltages may be reduced, with a corresponding increase in tube life. Caution is required in following this practice, particularly in the case of tubes with thoriated tungsten filaments, as low filament voltages with large plate currents will result in a "stripped" filament, with greatly impaired emitting ability. In many cases such tubes may be restored to their original condition by operating them with normal or above-normal filament voltage for a short time, no plate voltage whatever being applied during this period.

A FEW KENETRON APPLICATIONS

One of the earliest uses of high voltage kenetrons was in smoke precipitation systems, where the extremely high charge given to the smoke particles caused them to settle on plates of opposite polarity. A direct descendant of the smoke precipitator is the Precipitron, which uses a pair of WL-579-B kenotrons, to deliver a voltage of approximately 12,000 D.C. These tubes are rated at only 25 milliamperes average output current, but for this application the rating is ample, practically no current being drawn.

Another common use for kenotrons is to supply high voltages required to operate cathode-ray tubes. As larger and larger tubes are used in television, this may well become a very important application. Surge generators used in insulation testers also use the tubes to supply sudden voltages to check the insulation of generators, motors, power cables, etc.

A very interesting use is found in the sandpaper industry. Here the kenetron is used to create a strong electrostatic field in which the particles of abrasive material are charged to a very high voltage. The abrasive is then projected toward adhesive-coated paper spread above a negatively-charged plate. The electrostatic attraction is such that the larger ends of the particles are drawn to the paper, producing a sandpaper with all the sharp points upward. There are indications that a somewhat similar method may be used in paint-spray machines, each droplet of spray being given a charge, and the metal being painted, a charge of the opposite polarity. With such a machine,, every drop of spray reaches the object being painted, and is travelling at its greatest velocity at the moment of arrival. No free-floating paint would remain in the atmosphere, and the spray-room would be both a cleaner and healthier place.

Brief characteristics of some representative kenetrons are given below:

TECHNICAL DATA AND RATINGS

Tube Type Number	Type of Cooling	Filament Volts	Filament Amperes	Crest Inverse Anode Voltage	Maximum Average Anode Amperes	Maximum Crest Anode Amperes
WL-456	Air	11.0	20	140,000	0.06	0.50
WL-608	Oil	10.0	10	60,000	0.06	0.20
WL-612	Air	10.0	50	150,000	0.24	0.75
WL-613	Air	11.0	10	140,000	0.06	0.20
WL-660	Air	10.0	10	230,000	0.03	0.10
WL-579-B	Air	2.5	6	20,000	0.025	0.27
KC-4	Air	20	24.5	150,000	1.0	
GL-411	Air Oil	10	14.5	100,000 150,000	0.3	

Frequency Modulation transmitter circuits are simple. They require little power, and are admirably adapted for short-wave work. Most of the post-war short-wave applications will undoubtedly use them in preference to the present less efficient or satisfactory amplitude modulation systems

Frequency Modulation

By JULES M.

FREQUENCY MODULATION, or FM, differs from the older AM or amplitude modulation in the manner in which the audio modulation (speech, music or other signal) is applied to the carrier. In amplitude modulation, the frequency of this carrier is rigidly maintained, and the signal impressed by varying its amplitude. The power of the carrier in an FM system on the contrary, is maintained at a constant level; it is the frequency which is deviated. This deviation of frequency must be exactly proportional in extent to the *amplitude* of the modulating audio signal, and the rate at which it occurs must be proportional to the frequency of the modulating signal.

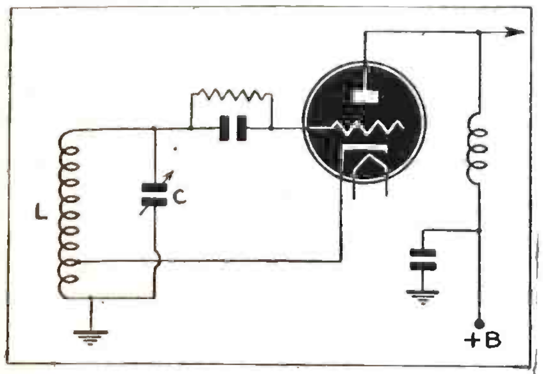


Fig. 1.—A straight Hartley oscillator, a circuit easily adaptable to frequency modulation.

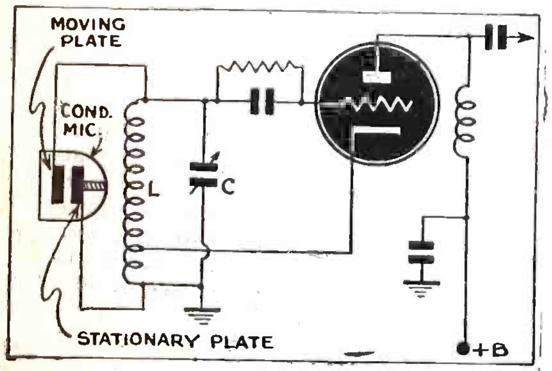


Fig. 2.—Crude FM circuit, with condenser mike.

With these two requisites in mind let us now view some of the simpler methods of accomplishing this, to get a vivid picture of what happens. In Fig. 1, you will find the simple modified Hartley oscillator. The two factors which determine the frequency of this oscillator are the inductance of the tank coil L, and the capacity of the tank condenser C.

It is known if either L or C are varied the frequency of oscillation will vary accordingly. Take for example manually rotating the condenser C back and forth through resonance; rotating to a higher capacity, the oscillator frequency goes down; rotating to a lower capacity the frequency goes up. The same is true for the inductance. We know at resonance the following condition must exist:

$$Z = \sqrt{R^2 + (XL - XC)^2}$$

In other words, the capacitive and inductive reactance must be equal at resonance. It is also evident that the amount of frequency deviation will be proportional to the amount we change either L or C, and the rate at which this deviation takes place will be proportional to the rate or speed at which we change C or L. These principles just described give the basis for the following discussion.

We have shown what happens when either the L or C are varied manually. The problem at hand, however, is to cause this variation in L or C of a transmitter oscillator with respect to the modulating power. The diagram of Fig. 2 shows how we can vary the tank capacity of the oscillator by means of a condenser microphone.

In this diagram we have the same modified Hartley except the capacity determining resonance is not the tank capacity C alone, it is the tank capacity C and the capacity of the condenser microphone in parallel. A condenser microphone consists of two plates separated by a dielectric. One plate is stationary, and the other is the moving diaphragm of the microphone. It can be readily seen that this type of microphone acts as a variable condenser with its capacity determined by the amount of vibration of the diaphragm. This vibration of the diaphragm is caused by voice vibrations of the air particles. As it vibrates the total capacity of the oscillator tank is varied at that rate and the oscillator frequency shifts. This is shown in Fig. 3.

Here we have one instantaneous cycle of vibration of the diaphragm of the condenser microphone. In the positive half cycle let us say the diaphragm moves closer to the stator. This will increase the capacity of the microphone, and since it is in parallel with the oscillator tank, the total tank capacity will increase proportionally. Hence the oscillator frequency will decrease (A to B). On the negative half cycle the capacity C will decrease and the oscillator frequency will rise (B to C). D to A and C to E represents the resting frequency. It can be seen that the deviation will be proportional to amplitude of the modulating signal, and the rate at which the deviation takes place is proportional to the frequency of this signal.

This method of producing FM is not practical for three reasons: the system would restrict the choice of microphone to a single type; the variation of the capacity of a condenser microphone would be too small; and a very low powered oscillator would have to be employed to realize the small variations of a condenser microphone.

Although this system is not practical for commercial use, it shows the principle and gives rise to understanding of the systems employed commercially to accomplish FM.

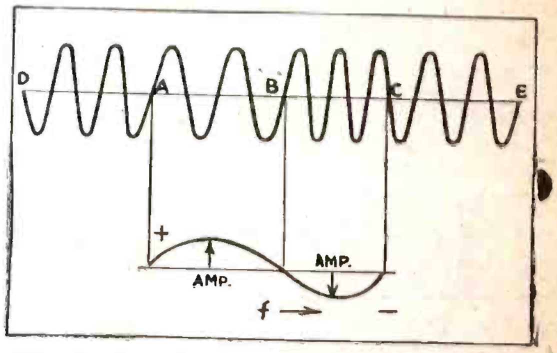


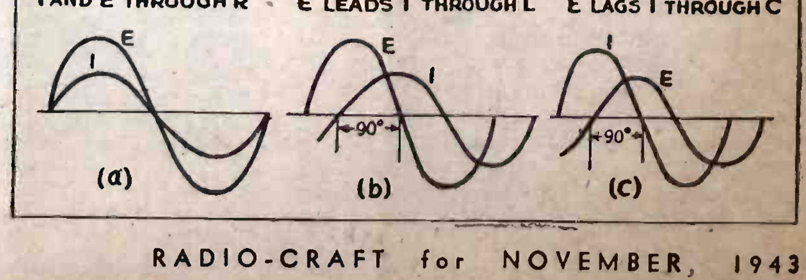
Fig. 3.—Simple frequency-modulated wave.

This brings us to the principles involved in the reactance method of modulation. The end to be obtained is to allow the capacity or inductance of the frequency controlling oscillator to be varied electronically rather than mechanically.

Whenever that word "electronics" comes up, so does the "vacuum tube" come to the mind. This is exactly what we are referring to. Let a vacuum tube act as a variable capacitive or inductive reactance to vary the oscillator frequency. We already know that a class "A" amplifier acts as a linear variable resistance, that is, if the grid is made positive the plate current increases, and if the grid is made negative, the plate current decreases. From a resistive point of view: if the grid is positive the internal resistance of a tube is decreased, and if the grid is made negative, the internal resistance of a tube is increased.

Looking at the characteristics of a class

Fig. 4.—Phase in radio circuits. At a, current and voltage are together, in a resistive circuit. Voltage is one-quarter cycle (90 degrees) ahead of current in the inductive circuit of b, and at c, where the circuit contains a condenser, the current leads the voltage by the same 90 degrees.



The principles underlying Frequency Modulation systems are clearly and simply explained in Mr. Kleinman's series of articles, the first of which appears here. Students and Servicemen will be well advised to keep abreast of this important new branch of the radio-electronic art

for the New Trainee

KLEINMAN

"A" amplifier, we can also see that the plate current is in phase with the applied signal voltage on the grid. Therefore, the tube presents itself to a load as a varying resistance. Now let us see how the tube can be made to resemble a varying reactance. By definition, a reactance is the opposition to the flow of A.C. current due to either inductance or capacitance in a circuit. The reactance in either case is caused by a counter E.M.F. which opposes any change in the current flowing through a circuit. We know that through an inductance the voltage *leads* the current by 90° and through a condenser it *lags* the current by 90°, while through a D-C resistance the current and voltage are in phase. These three characteristics are shown in Fig. 4.

At "A" is shown I and E through a pure resistance; at "B" through a pure inductance, and at "C", a pure capacitance. The picture is simplified by sine and vector analysis. We also know if there is a pure resistance in series with an inductance the voltage across the combination will lead the current through the combination by some angle less than 90°, and in a circuit containing a pure resistance and capacity in series the voltage will lag the current by some angle less than 90°. This can be seen from the formula:

$$\tan.\ \vartheta = \frac{X_L}{R} \quad \text{or} \quad \tan\ \vartheta = \frac{X_c}{R}$$

where ϑ is the phase angle, X_L is the inductive reactance, and X_c is the capacitive reactance. If the resistance is infinitely high with respect to the resistance, ϑ will be practically 90°, and if the resistance is infinitely high with respect to the reactance, ϑ will be practically 0°. *Remember* that through the capacity or inductance themselves, there is a phase shift of 90° between voltage and current. Now we are ready to investigate the methods by which an amplifier is made to appear as either a capacitive or inductive reactance.

INDUCTIVE REACTANCE CIRCUIT

A vacuum tube may be made to appear as an apparent inductive reactance if its plate current lags its plate voltage by 90°. This principle was explained in the preceding paragraph. In Fig. 5 is shown a simple circuit by which this may be accomplished.

As shown in the figure, we have two very conventional stages, a class "A" modulator and an electron coupled oscillator. You will also notice that two pentode tubes are shown. These two tubes are usually of the same type for uniformity and ease of circuit design. Pentodes are generally found in commercial equipment due to their greater power sensitivity. The reactance modulator is operated class "A", utilizing cathode bias. An electron coupled oscillator is usually employed because of its excellent frequency stability. The oscillator may be biased close to class "C" so that the power output remains relatively constant over the entire frequency range of operation. The power supplies usually employed incorporate voltage regulator tubes to maintain constant potentials to modulator and oscillator plates and screen grids.

INDUCTIVE CIRCUIT ANALYSIS

Analysing the circuit, we find that the components controlling the resting frequency of the oscillator are C_t and L_t. The oscillator obtains its grid bias by virtue of the grid-leak-condenser combination R4 and C3. The remaining oscillator circuit elements are conventional and need no further explanation. The reactance modulator is a simple class "A" amplifier which is cathode biased by R2. It is seen in the diagram that the plate of the reactance modulator is connected to the oscillator tank through a blocking condenser C2; therefore, the voltage on the plate of the modulator is the D-C plate voltage, and the oscillator R.F. tank voltage. Now since C_t and L_t are at resonance, the R.F. tank voltage and current are essentially in phase. This R.F. voltage and current in the plate circuit of the modulator is fed to the grid of the modulator through network C1 and R1. Now it is essential that the R.F. voltage and current be in phase through this network; therefore, the resistance of R1 is made high with respect to C1 at the frequency of operation. The reason this network is employed is to block off the D.C. plate voltage of the modulator from the grid.

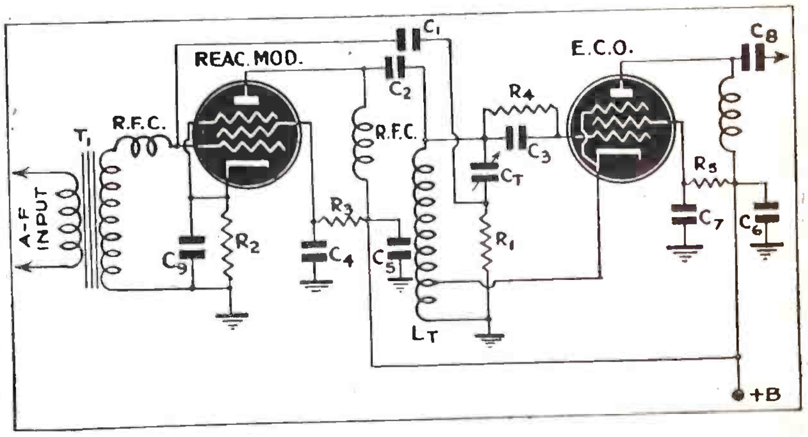


Fig. 7.—Another type of capacitive modulation circuit. The reactor tube in this system obtains its phase-shifting voltage from a network in the oscillator circuit.

Continuing, the R.F. current flowing through the grid by-pass C will lead the voltage across it by 90°, since the voltage across C is the audio voltage impressed on the grid of the modulator by the microphone and transformer T1; thus we have the A.F. voltage on the modulator grid lagging the R.F. current in the oscillator tank by 90°, since the R.F. tank current and tank voltage are in phase, and the R.F. tank voltage is the modulator plate voltage; the modulator A.F. grid voltage will lag the R.F. plate voltage of the modulator by 90°, and since the modulator is operated class "A", the plate current will be in phase with grid voltage, so that the A.F. plate current of the modulator will lag the plate voltage by 90°; therefore, the modulator acts like an inductive reactance in parallel with the tank.

Applying an audio signal on the modulator grid will vary the internal resistance of the tube and accordingly, the apparent lagging plate current, so that the net inductance of the oscillator tank is varied. If the modulator grid swings positive, the lagging plate current increases. This represents a decrease in the apparent inductance. Since the apparent inductance and the tank inductance are in parallel the net inductance

(Continued on page 102)

Fig. 5.—A simple circuit with inductive modulation.

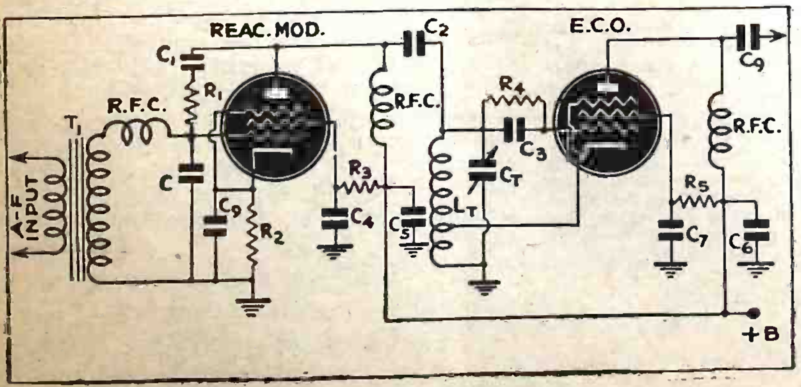
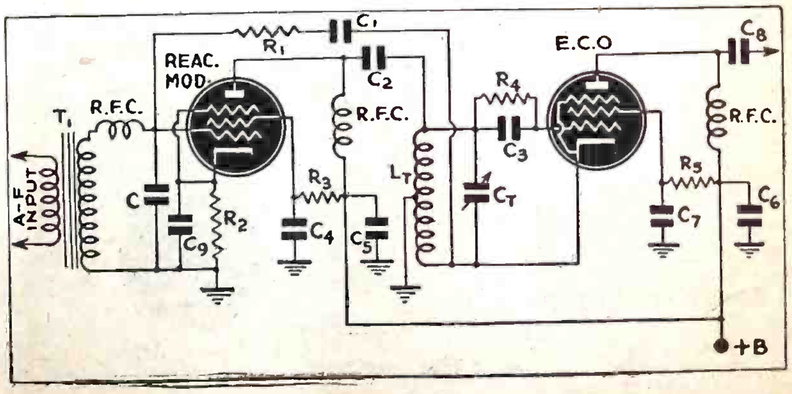


Fig. 6.—The reactor tube here acts as a capacity.



Capacities

By HERBERT B.

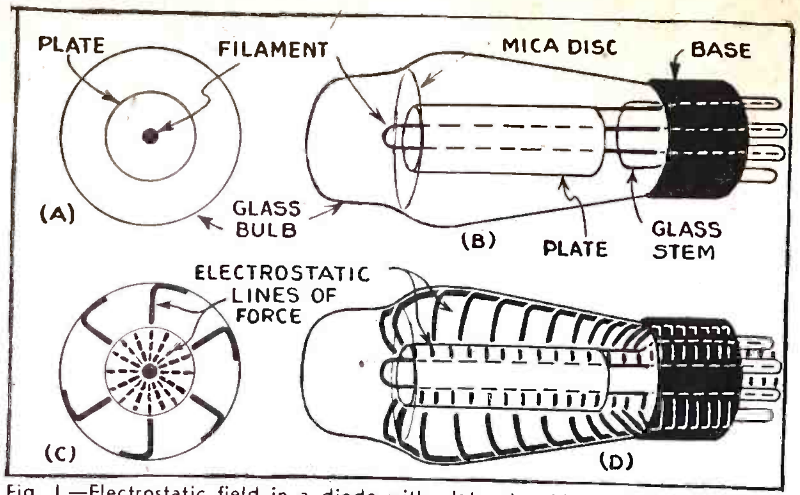


Fig. 1.—Electrostatic field in a diode with plate at a high voltage relative to the filament.

THE elements of an electronic tube form a very efficient condenser, because of low leakage, low dielectric-hysteresis loss and low absorption loss. This is due to the nature of the vacuum dielectric. These capacity effects are—in some oscillator circuits—utilized to good advantage; in amplifier circuits, they are very undesirable; in some ultra-high-frequency circuits they prevent operation of the tube altogether.

The structure of vacuum tubes involves bringing its elements out to terminals through common insulators such as glass, bakelite, or ceramic materials. Figures 1-A and 1-B are top and side views of a simple diode.

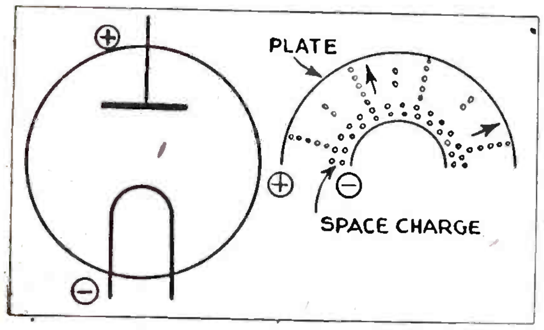


Fig. 2.—Effect of the space charge in preventing electron flow. Higher plate voltage reduces this charge and increases the current.

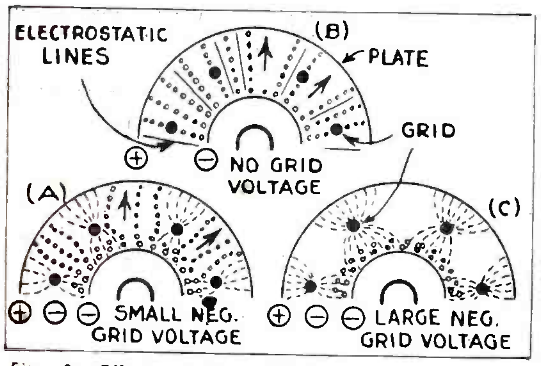


Fig. 3.—Effect of the grid in an electron tube. Electrostatic lines of force are shown by dashed lines—electrons by dots.

If a difference of potential exists between the plate and filament, an electrostatic field will exist between these elements. This field will extend through the vacuum, the glass stem, the bakelite socket and through the outer glass of the tube, as pictured in Figure 1-C and 1-D. The top view illustrates how the elements form a co-axial cylinder type of condenser. These diagrams show clearly that the capacity effects in an electronic tube exist not only between the elements, but also between the leads. For example, in some types of tubes, the inter-lead capacity may become as high as 30% of the total effective interelectrode capacity.

(In heater type tubes, when 60 cycle current flows in the filament, the cathode and filament form a miniature diode. Potential difference should be kept as low as possible between them, to prevent the varying electrostatic field from causing 60 cycle hum in the cathode circuit.)

THE ELECTRON TUBE IN ACTION

When a suitable voltage is applied to the filament, it becomes hot, and emits negatively charged electrons. These are literally shot out into space, and radiate in all directions. However, a cloud of electrons will gather about the filament, forming a space-charge, because emitted electrons will tend to repel those in the space behind them. If a positive potential is now applied to the plate, a dielectric field of force will exist, as shown in Figure 2. The plate will now attract electrons along the paths of the electrostatic lines of force. In doing so, it will tend to decrease the space charge, and at a certain value of plate voltage (saturation point) the space charge will have disappeared. Figure 2 is a diagram of diode tube action, the arrow showing direction of electron flow.

These various capacities act as by-pass condensers, and their reactances cause appreciable circuit losses at high frequencies. However, some of these same capacity effects are utilized in controlling plate current. In Figure 3-A the control grid has a small negative potential. Every part of this grid has a small surrounding electrostatic field, *which distorts the large field* that would normally exist between cathode and plate. Some of the emitted electrons will now be repelled by the electrostatic force between grid and cathode. Others will pass into the open spaces and will be propelled toward the plate. Thus, a small negative charge tends to reduce the plate current. In Figure 3-B, a large negative potential has been applied to the grid, and no plate current flows. Electronic flow in a triode is controlled by both the plate voltage and the grid voltage. The tube will serve as amplifier or oscillator because a small variation of grid voltage will cause a large change in plate current. With zero grid bias, electrons flow freely to all parts of the plate as in Figure 3-C.

Here we have condenser action, with considerable current passing through the dielectric itself. This current is not due to "break-down," but to the fact that the hot cathode is emitting electrons. The electron flow is dependent on the effective surface area of the plate and grid, the distance between them, the degree of "vacuum," the potential difference between the elements, and the heat of the cathode. Note that this definition is essentially the same as that for the amount of energy that can be stored in a condenser. There is an important relation, then, between interelectrode capacitances and electron flow in a thermionic vacuum tube.

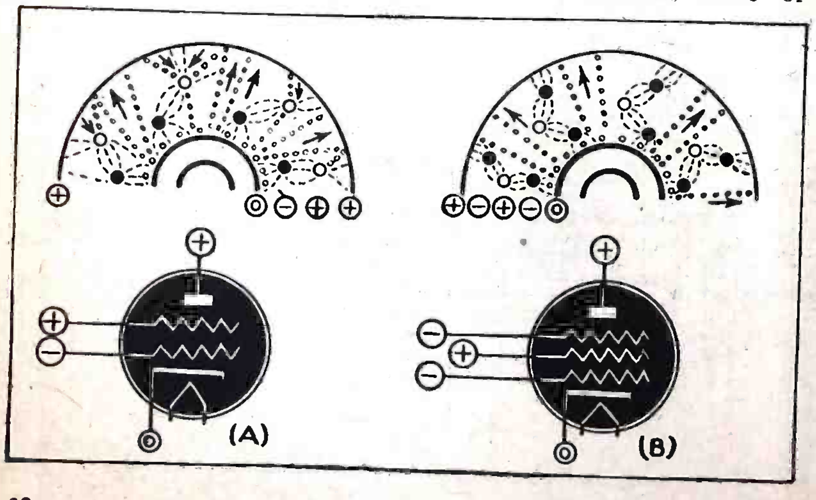


Fig. 4. — Interelectrode fields become more complex as the second grid is introduced in the tetrode (A), and the third in the pentode (B). These two grids are opposite in action, one accelerating electrons emitting from the cathode — the other repelling any which may try to get back from the plate.

INTERNAL CAPACITY OF A TRIODE

The flow of electrons from cathode to plate is synonymous with plate current. In practice, diode current is varied by changing the plate voltage, which changes the strength of the electrostatic field. A rise in filament voltage (within certain limits) would also increase plate current because of a higher rate of electron emission.

In order for an electronic tube to have amplifying properties, a change in input voltage must result in a proportionately larger change in output current. This is accomplished by the use of a *control grid,* which usually consists of a spiral of fine wire placed between grid and plate. In the case of a typical receiving triode, this grid is brought out to a terminal prong in the base, along with the plate, cathode, and filament connections. In the diode, the total capacitance between the plate and filament is represented by the symbol C_{pf}. In the triode of Figure 11, there are four separate capacitances:

C_{gp} — grid-plate
C_{gk} — grid-cathode
C_{pk} — plate-cathode
C — cathode-filament

In the Tube

MICHAELSON

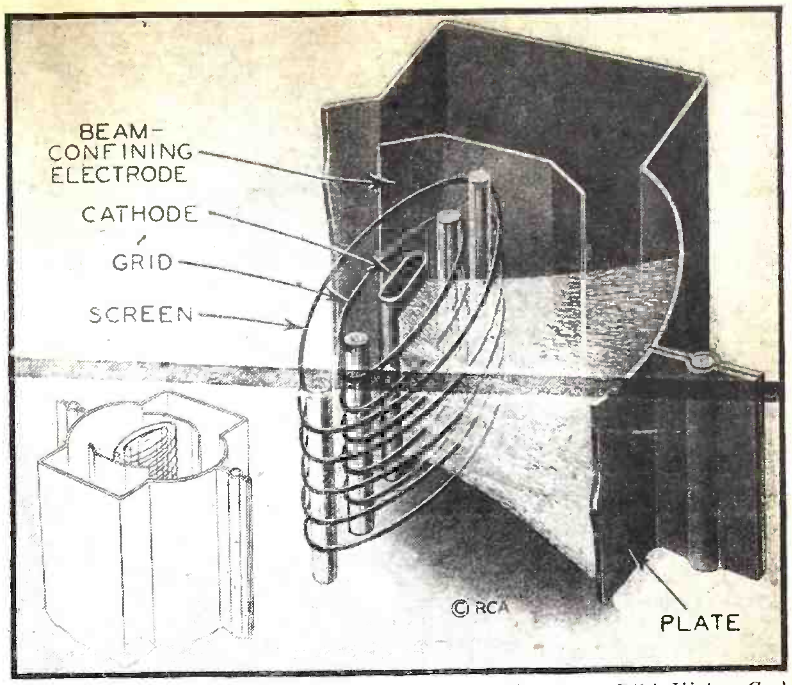


Fig. 5.—The beam power tube, of which the 6L6 is probably the most common example.

(Courtesy RCA-Victor Co.)

THE EFFECTIVE INPUT CAPACITY

In triode amplifiers, the *input capacity* is the sum of the capacitances between the grid and other elements. When the tube is operating, the plate load affects this value, and the *effective input capacity* may be calculated approximately by the equation

$$C_g = C_{gk} + C_{gp}(1 + A)$$

"A" is the effective amplification of the tube.

This effective input capacity is often considerably greater than the actual geometrical capacity of the tube. For example, let us assume that a certain triode has a grid-to-cathode capacity of 3 mmfd. and a grid-to-plate capacity of 6 mmfd. The input capacitance is the sum of these, or 9 mmfd. If this triode is placed into operation in a class A audio amplifier stage with suitable circuit constants, it might have a gain of about 40. That is, the ratio of A.F. voltage across its plate load to the signal voltage across its input would be 40-to-1. This ratio is determined by the physical characteristics of the tube, and by the nature of its plate load impedance. The effective input capacity, according to the above equation, is

$$C_g = 3 + 6\,(1 + 40)$$
$$C_g = 249 \text{ mmfd.}$$

In this amplifier stage, the plate load is now by-passed with considerable capacitance. At 10,000 cycles, the reactance of a 249 mmfd. condenser is only 64,000 ohms. The tube feeds back part of the higher audio frequencies to the grid circuit, and the high frequency-response characteristic of the amplifier stage is poor. In a triode R.F. amplifier, there is a similar feed-back of higher frequencies, often resulting in oscillation and a sharp decrease in the gain of the stage.

The *input resistance* of a triode is the opposition to D.C. that exists between the grid and all other tube elements. The *input impedance* is the vector sum of input resistance and effective input capacitative reactance, expressed by the equation

$$Z_i = \sqrt{R_g^2 + X_c^2}$$

Z_i is the input impedance
R_g is the input resistance
X_c is the reactance of C_g

The above holds true only when the plate load is partly resistive and partly reactive. If the load is purely resistive, then

$$Z_i = X_c$$

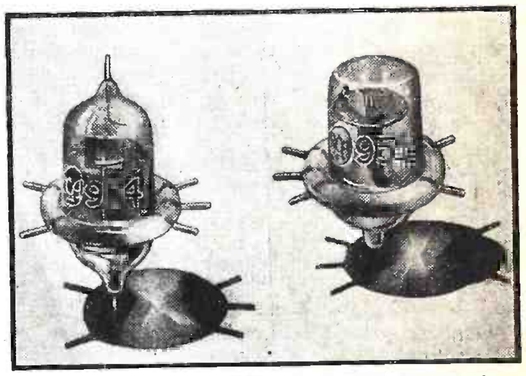
The *input admittance* is the reciprocal of this impedance.

The feed-back of energy in a triode amplifier can be counteracted by the use of a neutralizing condenser. This is placed in the external circuit in such a way that an equal amount of energy is fed back, the voltages of the two feed-backs being 180° out of phase.

TETRODE AND PENTODE TUBES

In triode amplifiers the interelectrode capacities tend to reduce efficiency, and a small change in plate supply voltage will vary the plate current. Both of these difficulties are largely overcome by the use of a tetrode, which has a *screen grid* between the control grid and the plate. A positive potential is applied to the screen grid, whose electrostatic field accelerates the flow of electrons toward the plate. A few of these will strike the screen grid itself, resulting in a small current in the screen circuit. The action of the screen grid reduces effective grid-plate capacity, decreases the space charge and increases the amplification factor of the tube. If poor voltage regulation of the power supply causes a small drop in plate voltage, the plate current will remain practically unchanged, because the positive screen grid is still attracting electrons toward the plate.

Secondary emission occurs in all thermionic vacuum tubes. When electrons are forcibly attracted to a positive plate, other electrons at the plate surface are dislodged and radiated. In a triode, these emitted electrons are attracted back to the plate again, because of the action of the electrostatic field. In a tetrode, these secondary electrons are often attracted by the positive-
(*Continued on page* 108)



(Courtesy RCA-Victor Co.)

Fig. 6.—Two of the midget "acorn" tubes especially designed to work at ultra-high-frequencies.

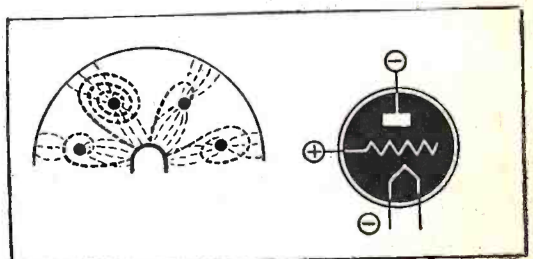
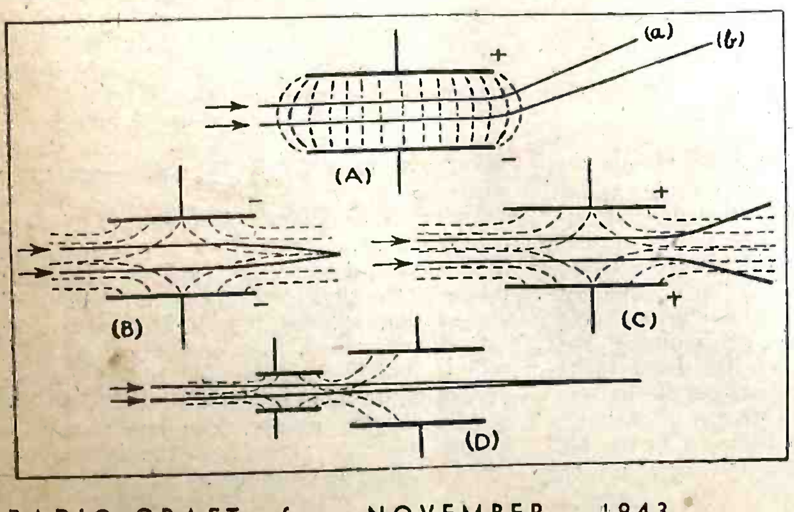
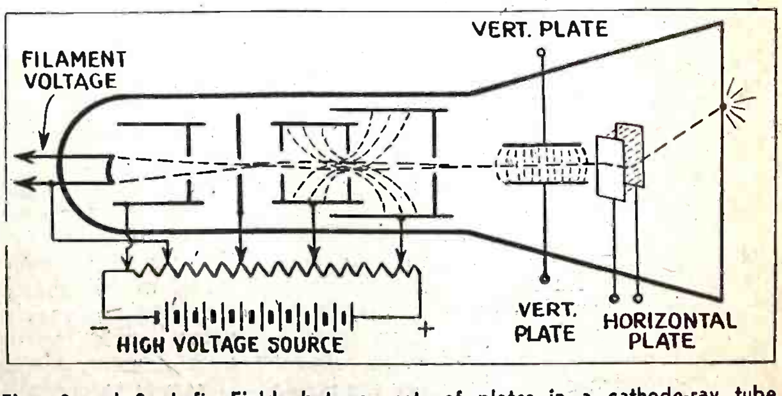


Fig. 7.—Paths of the electrons and direction of field in the Barkhausen-Kurz oscillator.

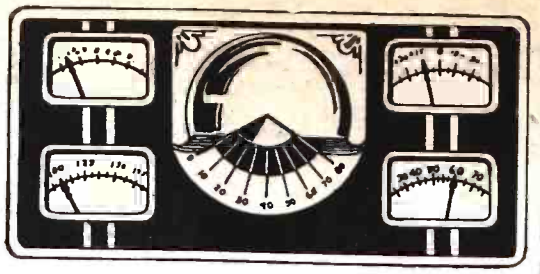




Figs. 8 and 9.—Left: Fields between sets of plates in a cathode-ray tube and their effects on moving electrons. Above: How the plates are lined up in the standard tube.

Electronic

SPEED INDICATOR



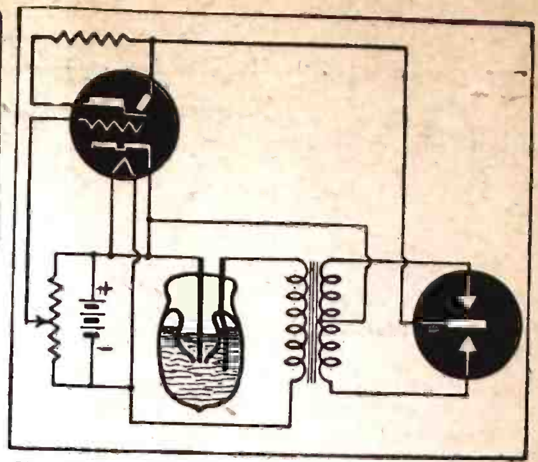


Fig. 1, left—The Electronic Speed Indicator as it might appear on the instrument board of a car.
Fig. 2, above—The interrupter power supply.

By S. R. WINTERS

POST-WAR automobiles may be equipped with an electronic device for indicating speed, gasoline, oil, heat, and other variables. Already the electric eye has been introduced as an exact and automatic means of parking automobiles, without scraping rubber tires. Now, the General Motors Corporation proposes to employ an electronic eye on the instrument panels of motor vehicles, instead of the present moving-element type of indicating apparatus.

Conventional electrical measuring instruments, with their indicating needles mounted on a moving element, are subject to wear, according to Donald W. Randolph, inventor of the electronic indicator. The electron stream is immune to any adverse effect of vibration. This novel indicator has no wearing parts, has a power supply of low voltage and yet variable enough for controlling the indicating means visible on the electron tube. The latter is the well-known type 6E5 used as a "tuning-eye" in receivers, and is a triode amplifier. The indicating elements are located in the outer end of the tube, readily visible. The triode elements are situated in the center of the tube, supported in the conventional manner.

ELECTRON-RAY TUBE ON PANEL

To accommodate this unique automobile speed indicator, a sheet-metal instrument panel is bulged outwardly to receive the electron tube. A 90-degree sectional opening is provided in the panel, close to the end of the tube, and a scale adjacent the arched edge of this opening permits of the observation and measurement of the area of the discharging electrons. The outer end of the 6E5 extends through an opening in a sheet-metal rim, fixed to the rear side of the panel for support therein, and the base of the tube finds a resting place in the usual socket. This is supported behind the automobile instrument panel.

The units for indicating the speed of a motor car—or the diminishing amounts of gasoline and oil, as well as the degree of heat—consist of a target (so-called because electrons bombard it) in the form of a dish, supported on rods and electrically connected thereto. These rods are also sealed in the press of the electron tube, and one of them acts as a target conductor and extends outwardly through the target. The inside cone-shaped or tapering target—which is actually the automobile indicating elements—is "dressed up" with a material that lights up with the ease of a lightning bug when showered with electrons. However, the outer ring-like portion of this panel acts as a guard or shield to prevent any stray electrons from reaching the inside surface of the electron tube.

The target or heart of the indicator itself has a central opening through which extends the end of the triode cathode from which, when heated, electrons flow at the rate of trillions a second to bombard its surface. A ray-control electrode also extends through the central opening of the target, in side-by-side relationship to the end of the cathode, thus shaping the path of electron flow to the tapering surface of the target or indicating element. This ray-control electrode is, in reality, an extension of the plate of the triode tube and is electrically connected to it.

When the fluorescent coated indicating device, or rather its conical surface, is bombarded with streams of electrons from the filament the automobile instrument panel becomes as "lit up" as a drunken man staggering toward a supporting lamp post. The area of the surface thus showered by electrons is determined by the electric energy impressed on the ray-control electrode. As the latter becomes increasingly positive, the greater is the area of lighting effects on the target and at a certain voltage value the entire surface of the target becomes fluorescent. If, however, the electrode becomes less positive, the stream of shooting electrons, on the target, is curtailed and a dark portion of the sectional form appears on the indicator. This shadow increases in angle and circumference on either side of the dotted line, indicated at A in diagram 1, which line extends radially outward from the center of the target and goes through the center of the control electrode.

This "magic eye" or triode-amplifying tube is very sensitive to variations in voltage of the ray-control electrode, in the range from zero-dark to about 180° of darkness. (However, there are on the market other types of electron tubes which afford an even greater angular spread.) The 90-degree segmental opening in the indicating panel permits of one-fourth of the area of the target to be observed and one radial edge of this opening coincides with line A of Fig. 1. Thus one edge of the dark area acts as the indicator of changes of the shadow area and the lighted area, these variations being measured on a graduated scale.

POWER SUPPLY AND CONTROL

The means of controlling the tube, as well as the power supply are diagrammatically illustrated in Figure 2. The triode filament is connected to a 6-volt storage battery, and the cathode is connected to the positive terminal of this battery. A potentiometer is employed for varying the grid voltage. This potentiometer consists of the usual resistance element, connected across the battery. It serves to control the stream of electrons between the end of the filament to the target, so that the illuminated area on the indicator is proportional to the movement of the movable contact.

To its center arm is also applied the varying voltage which controls the shadow area of the indicating tube. The source of variable voltage may be a generator, the terminal voltage of which is directly proportional to speed.

INTERRUPTER FOR HIGH VOLTAGE

The high voltage required for the tube's plate and the indicating element or target is supplied by an interrupter, a transformer, and a triode rectifier. The interrupter is a glass tube, practically filled with mercury, and having two electrodes extending into the tube and sealed in the walls of it. The inner end of one of the electrodes is embedded in a tip of high resistance substance and is supported in an inward projecting tube-like portion of the tube, having a tiny opening in the end thereof so that only a restricted area of the tip is in "touch" with the mercury. The inner end of the other electrode is so placed as to be in contact with the mercury unceasingly.

The outer ends of these two electrodes are connected in series with the primary winding of the transformer and the 6-volt storage battery. The current passing through this circuit prompts the tip of the high resistance material to be heated just enough to give off a vapor from the mercury in contact with the tip. This interrupts the flow of electric current, which subsequently permits the mercury to condense, thus again completing the circuit. This cycle of operation recurs at regular intervals, depending upon the size of the parts of the interrupter. This frequency of the interruption of the flow of electric current in the primary coil induces a high voltage alternating current in the secondary coil of wire of the transformer. The center tap of the latter is connected to the positive terminal of the storage battery and the end taps are connected to the electrodes of a full-wave rectifier.

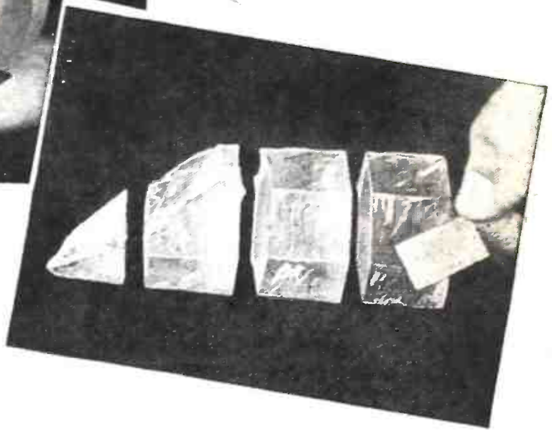
The use of an interrupter instead of a vibrator in the primary circuit will be interesting to many old-timers, who bid the interrupter good-bye as a useful device many years ago, and imagined they would never again meet it in the radio-electronic world.

Virtually any reasonable number of electronic indicator tubes may be mounted on the instrument panel of an automobile. Each tube is connected to the storage battery and high-voltage power supply in the manner already described. The indication of each tube is controlled by the amount of voltage impressed on its grid element, controlled by any measuring device. The latter may be located near or remote to the instrument panel or source of power.

A tray of crystals ready for sorting. Some complete crystals may be seen. Other pieces are broken from larger crystals.
Courtesy Reeves Sound Laboratories

Courtesy Long Lines
A few pieces cut from natural quartz crystal.

This crystal is partly blocked out for sawing into wafers for transmitter control. One of these is held at the extreme right.
Courtesy Reeves Sound Laboratories



QUARTZ
Radio's Wonder Rock

QUARTZ is one of the best insulators on earth. It is used especially at ultra-high frequencies, where other insulating materials might cause serious R.F. losses. Yet this super-insulator is —under certain circumstances—a producer of electricity in its own right, and its use as such is more important to radio than its applications as an insulator.

All our broadcast stations depend on this remarkable quality of the radio rock, as indeed do all radio transmitters, with the exception of a few small or temporary sets, and some which must be operated on a large number of non-pre-determined frequencies.

Crystals of quartz are "piezo-electric" (so-called from the Greek *peizo* "I press"). When cut into small flat plates and subjected to pressure, an electric potential is set up between the two faces of the plate.

A flat disc or wafer is cut out of quartz crystal and placed between two metal plates so that electrical contact can be made with the faces. Pressure on the plates causes a voltage difference between them, and if they are electrically connected, a minute current will flow momentarily.

Conversely, if voltage is applied across the two metal plates—and consequently the faces of the piece of crystal—it is physically distorted, twisted out of its normal shape. Its molecules move out of place under the influence of the voltage, ready to spring back as soon as the electrical pressure is removed.

But when such a piece of quartz is subjected to an electrical impulse suddenly applied and suddenly removed, the molecules which were pushed out of place do not come back to their normal positions and stop. Inertia works just as well in a piece of quartz as in any other material. The molecules spring past their old positions, then oscillate back and forth several times before coming to rest.

Each time they move out of place a voltage is generated across the faces of the disc or wafer, and therefore a number of electrical impulses are generated. As the frequency at which the impulses are produced is governed by the natural frequency at which the quartz vibrates, this frequency is absolutely fixed for any given piece of quartz. This natural frequency, in turn, is governed by the thickness of the quartz plate, so that by grinding it thinner, the frequency may be raised to any required point.

By making a small quartz plate of the correct thickness to produce electric impulses of a desired frequency, and inserting it in the grid circuit of a tube whose plate circuit is tuned somewhere near the natural frequency of the crystal, a "crystal-controlled oscillator" is made. The slight jolt caused by turning on the plate voltage (or even by slight variations in grid circuit voltage due to fluctuations in the supply voltage, adjustment of the plate tuning condenser, etc.) may start the quartz crystal into oscillation. If the plate circuit is not tuned too far from the natural frequency of the crystal, each impulse set up in the grid circuit produces a plate circuit voltage change which, when fed back through the grid-plate capacity of the tube, supplies that circuit with a voltage at the right time to give the crystal a push on its next oscillation. The effect is like that of a child on a swing, with a little friend helping to push. If the swing is given a succession of pushes at exactly the right moment, each oscillation is a little larger than the last, till the swing is oscillating at its maximum amplitude (usually set by the strength of the child pushing the swing).

The same thing takes place in the quartz crystal. Each little electrical push causes it to vibrate more vigorously, till it reaches a maximum determined by the amount of voltage fed back when the tube is oscillating at its maximum output. It is often necessary to control the amount of feedback, for it is quite possible to stimulate the crystal to a point where it oscillates so vigorously as to crack, or even fly apart.

The problem of getting the pushes at the right time is settled by the crystal itself. It is a very stiff material, and vibrates at its natural frequency without paying much attention to distracting factors. The coil-condenser combination in the plate circuit of the tube is a rather broad-tuning circuit, and will feed enough voltage back to excite the crystal, even though it may be tuned to one side or the other of what would otherwise be its operating frequency. Tuned too far away, feed-back drops and the crystal stops oscillating.

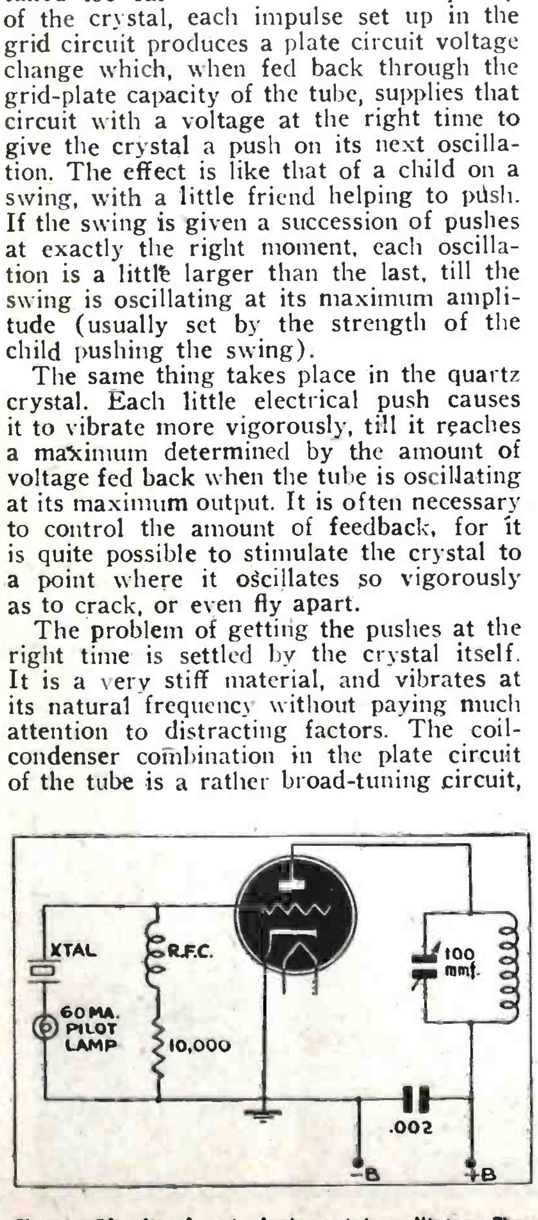


Fig. 1—Circuit of a typical crystal oscillator. The pilot lamp acts as a fuse to prevent overloads.

The action of the crystal in controlling frequency is exactly that of the pendulum on a clock, which is also a frequency-control device. An outside force puts it into motion, and that motion takes place at its own natural period of oscillation (whether crystal or pendulum). This motion is in turn used to control the frequency of the impulses (electrical or mechanical) which excite it, at the same time controlling other devices coupled to the apparatus. These are the hands in the case of the clock, and are usually amplifiers in the case of a crystal.

To control a transmitter, crystals are used in the grid circuit of a small power tube (Fig. 1). Its output is then used to drive a larger tube. Several stages of amplification may be necessary before sufficient power is generated to drive the big output tubes of a broadcast station.

As the natural frequency of a crystal varies somewhat with temperature, crystals used in broadcast transmitters are enclosed in small chambers in which the temperature is controlled by thermostats. The frequency of even some of the "short-wave" stations may thus be controlled to within a few cycles per second.

The quartz crystal is also used in communications receivers for code reception. By inserting a crystal in one of the intermediate frequency amplifier circuits, the sharpness of tuning is greatly increased. Only those frequencies which are very close to that of the crystal are then passed. This increases the selectivity of the circuit to such a degree that instead of being measured in kilocycles, it may be stated in cycles.

Though such a circuit is so selective as to be useless in broadcast or any other type of phone reception, it is exceedingly valuable in receiving C.W. (continuous wave) signals from crystal-controlled transmitters. With the aid of such a "crystal filter" reception is possible under interference conditions which would leave the operator incapable of distinguishing between a dot and a dash—if indeed he could hear them at all.

Piezo-electric qualities are exhibited by other minerals than quartz, though most natural crystals have them in a much smaller degree. The artificially built-up crystal of Rochelle salts is much *more* active than quartz, but is not sturdy enough for transmitter control.

The loudspeaker is possibly the most prolific source of defects in a radio receiver. Open fields and transformer primaries, off-center and open voice coils, cracked and warped cones, all contribute to make some of the most exacting repair jobs with which the serviceman has to deal.

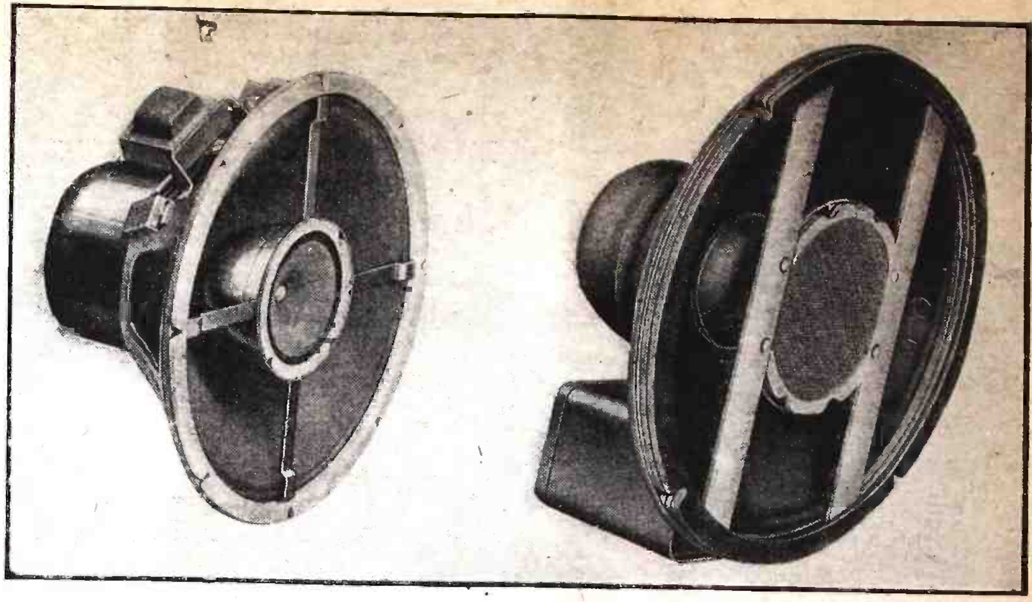


Photo Courtesy Jensen Electric Co.

LOCATING DEFECTS IN RADIO RECEIVERS

PART II

By D. B. LOONEY

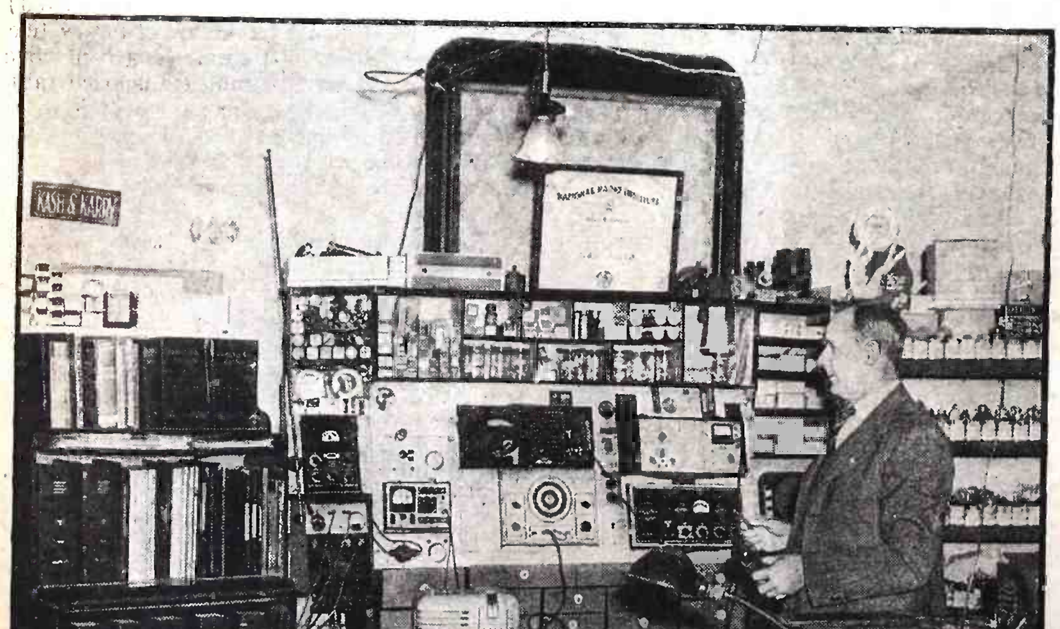
HERE we are concerned with air-core r. and i.f. transformers as well as with r.f. chokes. Coils consist simply of copper wire and insulation, but several types can develop.

Lowered Q Factor. A coil which becomes damp or coated with conductive dirt will develop high r.f. resistance, which has the effect of lowering the Q factor. This in turn affects the operating characteristics of the stage in which the coil is used. For example, lowered Q factor in an r.f. coil can cause poor sensitivity or poor selectivity even in a properly aligned stage, and can cause low output in an oscillator stage. The Q factor of a coil could be measured with a Q meter, but this information would be of no value unless the normal Q factor and the permissible tolerance in Q factor were known.

Inspection of the coil and temporary adjusting of resonant circuit trimmers are the usual techniques for isolating the trouble to a coil having lowered Q factor. Trimmer adjustments will be sharp for a high Q coil, but quite broad for a low Q coil. Experience in evaluating receiver performance and adjusting tuned circuits will help you to decide when a coil should be baked out or replaced because of lowered Q factor.

Shorted Turns. These may develop in all coils, particularly those employing special diamond, basket or bank windings. If a great many turns are shorted out, and the normal resistance of the coil is indicated on the circuit diagram, the defect may be detected with an appreciable reduction in coil resistance. Otherwise, the action of the circuit is the only clue to the trouble. For example, in the case of an r.f. coil in a resonant circuit, more capacity will be needed to align the receiver, and both sensitivity and selectivity will be poor even after alignment. We also have the possibility that adjacent coils may touch each other, particularly when wound close together or one over the other. Here an ohmmeter test from one coil to the other will verify the trouble.

Opens. The windings in a tightly wound coil may break due to expansion with temperature, especially at points where the wire passes through the coil form or connects to a terminal. More often, however, corrosion at a terminal will create a high-resistance joint. In a primary coil which carries the plate current of a tube, the direct current may start electrolysis which causes corrosion and an open. Noise will be the first symptom that this condition exists. An ohmmeter test will indicate above-normal coil resistance and high resistance due to corrosion at joints.



The successful radio shop of Mr. H. B. Mathews of Houston, Texas. The part that exact knowledge plays in good radio service is demonstrated by the large case of manuals and reference books and their prominent position in the shop. (The motto on the wall is very appropriate at present.)

IRON-CORE COIL DEFECTS

Since iron-core coils are used chiefly in audio frequency and power frequency circuits, we are not concerned with changes in Q factor. Actual mechanical defects in the coil windings or failure of insulation between windings are the two chief problems here.

Opens. These are readily detected with an ohmmeter. They can be due to electrolysis, particularly at the terminals of filter chokes where fairly high currents are flowing through joints formed by dissimilar metals. Of course, a sudden voltage surge or continued overloading of a coil with excessive current may melt the wire and cause an open.

Shorts. Shorts between turns due to failure of insulation are not readily detected with an ohmmeter, but it is usually possible to detect shorts between layers of windings because this creates a greater change in resistance.

Shorts in coils are best located by their effect upon receiver operation. For example, if there is a short in a choke coil, normal current will give a lower a.c. voltage drop than normal across the coil, with hum as the symptom. A short in a power transformer will cause overheating with eventual production of smoke and charring of the

(*Continued on page* 118)

RADIO LINES

By FRED SHUNAMAN

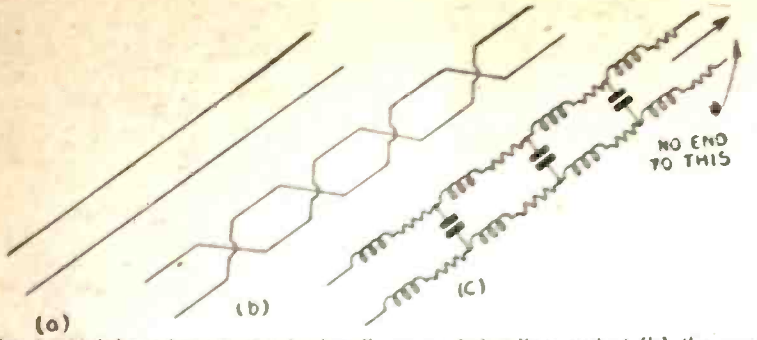


Fig. 1—At (a) we have a standard radio transmission line, and at (b) the same line as it often appears in practice, with transpositions, (c) shows how such a line looks to the radio-frequency currents flowing through it.

THE radio trainee is never out of trouble. No sooner does he learn a thing—thoroughly—than he is told something that contradicts it flat. Starting out with simple things like conductors and insulators, he assures himself that he knows just where electricity will go and where it won't. Then he is introduced to A.C. and the condenser, and sees current flowing in a circuit containing a perfectly good insulator. When he gets up to electron tubes, he finds cases in which even the unshakeable Ohm's Law appears to be ignored. And when he gets through all these difficulties and knows—or thinks he knows—R.F. theory, he is up against a new sticker when he runs into antenna problems. He finally does learn how you can have current on a short piece of wire that goes nowhere, and as he fast becomes an authority on standing waves, nodes and loops, he believes that now, at last, he does know radio!

Then he runs into the transmission line! All that he has learned about tuned circuits goes into the discard. The critical and skittish high-frequency currents which (he was told) had to be guided along carefully insulated and isolated wires, cut to the fraction of an inch, are supposed to find their way to the antenna along a pair of carelessly-twisted wires, any length! Travelling along these crude-looking conductors, they are actually expected to deliver power at the end, and that without serious loss. If it is inconvenient to use two wires in the line, one will do! It may also be any convenient length.

The student is naturally suspicious of these lines, but he notes that the old radioman seems to like them! The expert amateur, not content to use one between the transmitter in his cellar and the aerial on the roof, has an "exciter" on his study table, "link" connected—with a transmission line—to the aforesaid output stage in the cellar. The broadcast man, with a station in an unfavorable location, thinks nothing of mounting the aerial on a high building a block or so away, and running a line several hundred feet to it. All this without benefit of tuning or any other engineering apparent to the new radioman. He is bewildered and suspicious. These lines ignore all the rules of radio. They seem so simple as to be impossible to understand. There must be a catch somewhere!

Transmission lines really are as simple as they look, however, as we hope to show immediately. "But" says the trainee who has been studying up a little, "isn't this contrary to everything we have ever learned about radio? And if it's simple, what is this impossible-named 'iterative impedance' we read about? An impedance that remains the same whether you have a mile or ten of line, and doesn't even change with frequency. Doesn't this contradict all our ideas of A.C. behavior?" It does, and since the road to knowledge lies through harmonizing contradictions, we are on the way to learning something about transmission lines—and about radio!

Let us first get clear on how currents act in an antenna system. It may be a good idea to re-read the excellent article, "Radio Antennas and Radio Waves," in the September issue. Note that high-frequency currents can flow back and forth on a single piece of wire connected to nothing. (We can set up such currents by exciting a similar piece of wire with a transmitter, a few feet away from our "free" aerial.) At the middle of this wire, fairly heavy currents flow. We would expect the impedance here to be fairly low. Out toward the ends, voltages rise and current drops; the impedance becomes higher, in other words. At the ends we have practically infinite impedance (no place for the current to go), zero current and high voltages.

This high voltage is due to crowding together of electrons at one end of the wire, with corresponding scarcity at the other end. As soon as the exciting voltage drops, these electrons start to rush back again. The radioman says they are *reflected* from the end of the wire. The result is that we have two sets of waves on the wire—those due to the impulses from the transmitter, and the reflected waves. If the wire is cut to a suitable length (a half-wavelength for example) the two sets of waves re-inforce each other and we have a *standing wave*.

AN INFINITE TRANSMISSION LINE

Standing waves can take place on wires other than carefully-cut antennas. It was because of unpleasant and unexpected problems on the first A.C. power lines that they were first brought emphatically to the attention of the engineering profession. These lines showed queer characteristics—insulators would pop at certain—always the same—points, though voltages were kept well within the supposed bounds of safety. At other points the conductors would burn out continuously. Investigators rushed to the scene of trouble found voltages many times higher than that supplied by the generator at the points where the insulators kept on breaking down. Amperes were practically nil. At the other trouble points, fantastically heavy currents would be found, with no voltage to speak of. *Reflection* was the reason, though it was some time before the engineers found it out, and longer before they discovered the remedy.

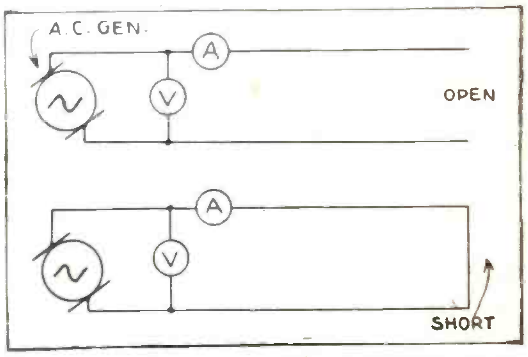


Fig. 2—How the characteristic impedance of an alternating-current transmission line is measured.

To go over the ground they did, let us study a line like that of Fig. 1. This may be a power line, or the more familiar radio line, consisting of two pieces of wire about four inches apart. It may also be the well-known "doublet lead-in" (two pieces of insulated wire, more or less tightly twisted), a piece of co-axial cable, an ordinary telephone line, or even a single length of wire. Fig. 1 (b) is the common transposed radio lead-in.

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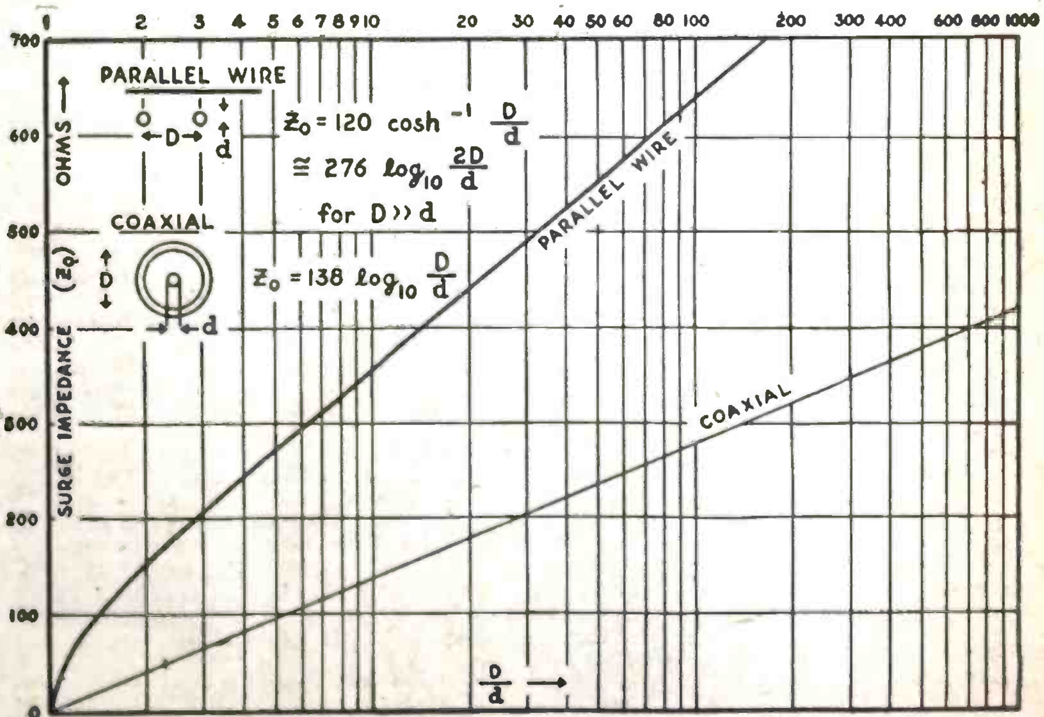


Courtesy Federal Telephone & Telegraph Co.

Fig. 3—Chart for readily calculating the impedance of all parallel-wire and co-axial lines up to 700 ohms.

Radio Service Data Sheet

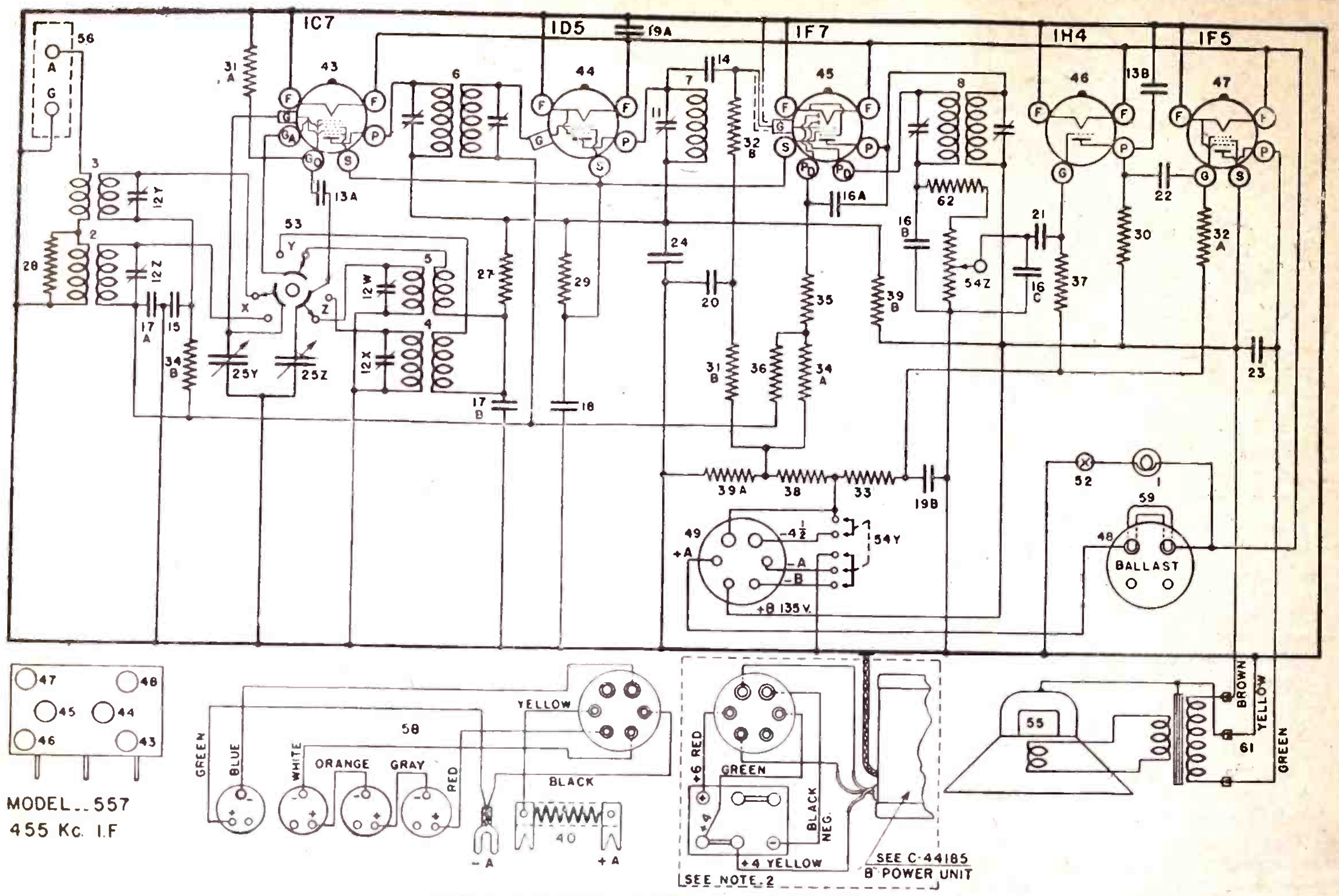


FIG. 1—WIRING DIAGRAM—MODEL 557

FIVE-TUBE,
TWO-BAND
SUPERHETERODYNE
RECEIVER

CROSLEY RADIO

MODEL 557

FREQUENCY RANGES
BROADCAST BANDS
540 TO 1725 KC.
SHORTWAVE BAND
5800 TO 15,000 KC.

CIRCUIT DESCRIPTION

Five octal base glass tubes are employed in a superheterodyne circuit which consists of a combination oscillator-modulator tube, two stages of I-F amplification—the second transformer of which is single tuned—and two stages of audio amplification. The 1F7G tube serves as the 2nd I-F amplifier and detector and supplies delayed AVC voltage to the 1C7G and 1D5G tubes. The two flexible resistors, items 38 and 39A, supply bias voltage to the 1C7G, 1D5G and 1F7G tubes and also serve to reduce the "C" battery drain in proportion to the drop in "B" voltage caused by usage.

ALIGNMENT PROCEDURE

Connect one terminal of the output meter to the plate and the other terminal to the screen of the 1F5G output tube. Be certain that the meter is protected from D.C. by connecting a condenser (.1 mfd. or larger—not electrolytic) in series with one of the leads.

Tuning I.F. Amplifier To 455 Kilocycles

(a) Connect the output of the signal generator through a .02 mfd., or larger, condenser to the top cap of the 1C7G oscillator-modulator tube, leaving the tube's grid clip in place. Connect the ground lead from the signal generator to the ground (G) terminal of the receiver. KEEP THE GENERATOR LEADS AS FAR AS POSSIBLE FROM THE GRID LEADS OF THE OTHER SCREEN GRID TUBES.

(b) Set the station selector so that the tuning condenser plates are completely out of mesh. Turn the volume control to the right (ON).

(c) Turn the band selector switch to the left (Broadcast Band).

(d) Set the signal generator to 455 kilocycles.

(e) Adjust both trimmers located on top of the 3rd I.F. assembly for maximum output. (See Fig. 2 item 8).

(f) Adjust the 2nd I-F trimmer condenser, Fig. 2 item 11, for maximum output.

(g) Adjust both trimmers located on top of the 1st I.F. assembly, item 6, for maximum output.

(h) Check operations (e), (f) and (g) for more accurate adjustments.

ALWAYS USE THE LOWEST SIGNAL GENERATOR OUTPUT THAT WILL GIVE A REASONABLE OUTPUT METER READING.

> This set is primarily designed for operation from a 2-volt "A" battery. However, it may be used with a 3-volt "A" battery if a Crosley W-44118 ballast tube is used in the socket provided, or may be operated from a six-volt storage battery with the Crosley Model 117 power supply unit. No "B" or "C" batteries are required if the six-volt battery and power supply unit are used.

Aligning R.F. Amplifier

When aligning the R.F. amplifier the output lead from the signal generator is connected to the antenna (A) terminal of the receiver. For the Broadcast Band a .00025 mfd. condenser should be connected in series with the output lead of the signal generator and for the High Frequency Band a 400 ohm carbon resistor should be used in place of the condenser.

(a) With the station selector adjusted so that the tuning condenser plates are completely out of mesh and the band selector switch set for the band being aligned, adjust the "OSC" shunt trimmer so that the MINIMUM CAPACITY SIGNAL (c) is heard (it is not necessary that the receiver tune through this signal).

(b) Adjust the station selector so that the SHUNT ALIGNMENT signal is tuned-in with maximum output. Then adjust the "ANT" shunt trimmer for maximum output. Readjust the station selector slightly so that the generator signal is tuned-in with maximum output and check the adjustment of the "ANT" trimmer. DO NOT READJUST THE OSCILLATOR TRIMMER.

NOTE: When shunt aligning the High Frequency Band care should be exercised so that the circuits will be aligned on the correct frequency rather than on the image frequency which is approximately 910 kilocycles less than the fundamental. To check on this, increase the output of the signal generator 10 times, or more, and try to tune-in the signal both at the generator frequency as indicated on the station selector dial and at 910 kilocycles less. If the circuits have been properly aligned the signal can be tuned-in at both positions but much stronger at the correct frequency.

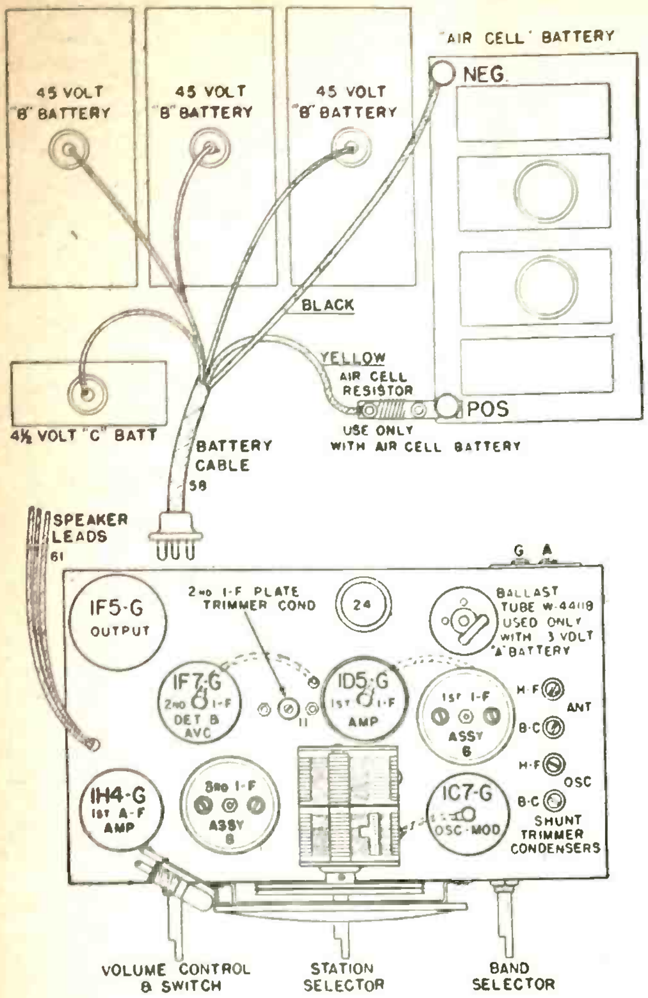


Fig. 2 Top View Model 557

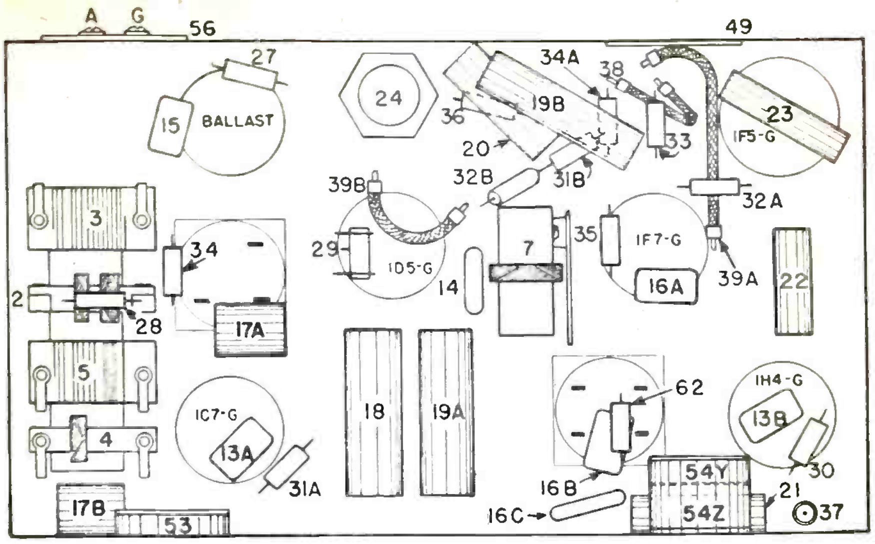


Fig. 3—Underchassis view of the Model 557 receiver.

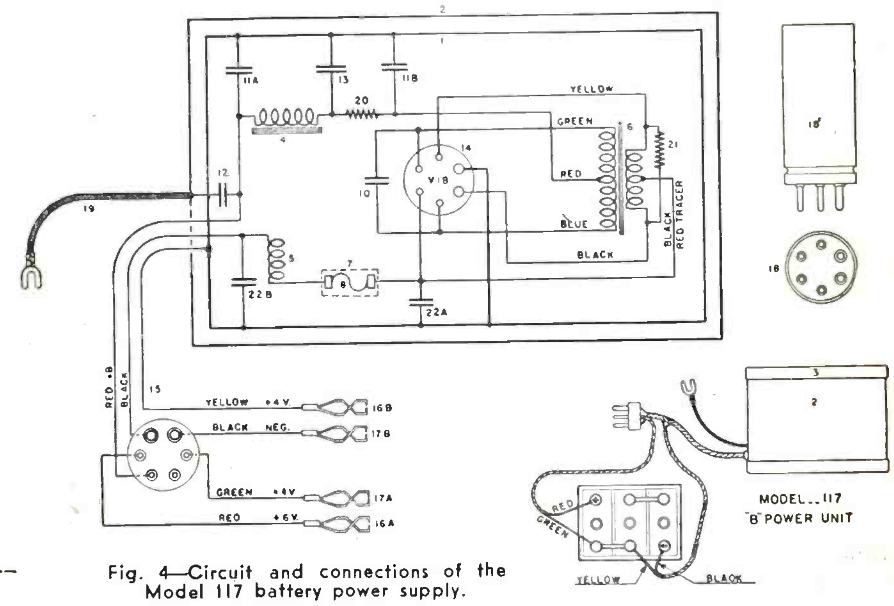


Fig. 4—Circuit and connections of the Model 117 battery power supply.

PARTS LIST

Item No.	Description
1	Dial Light Bulb, 2 V .06 Amp.
	Light Brkt. Assy
2	Ant. Coil, B. C.
3	Ant. Coil, H. F
4	Osc. Coil, B. C.
5	Osc. Coil, H. F
6	1st I-F Assy., 455 Kc.
7	2nd I-F Plate Coil Assy., 455 Kc.
8	3rd I-F Assy., 455 Kc
9	NONE
10	NONE
11	2nd I-F Trimmer Condenser
12	4 Section Trimmer Condenser
13AB	Condenser, .00025 Mf. Molded
14	Condenser, .0005 Mf. Molded
15	Condenser, .0005 Mf. Molded
16ABC	Condenser, .0001 Mf. Molded
17AB	Condenser, .02 Mf. 160 V.
18	Condenser, .25 Mf. 200 V
19AB	Condenser, .3 Mf. 160 V
20	Condenser, .1 Mf. 200 V.
21	Condenser, .02 Mf. 200 V.
22	Condenser, .05 Mf. 200 V
23	Condenser, .003 Mf. 400 V.
24	Condenser, 16 Mf. 250 V
25	2 Section Var. Tun. Cond.
	Glass Dial Face
	Dial Mask (Paper)
	Dial Mask (Metal Disc)
	Dial Support Ring
	Dial Support Bracket
	Dial Pointer
	Pulley Assy
	Drive Shaft
	Cable Tension Spring
	Drive Cable - 17½ Inches
	Pointer Mounting Screw
26	NONE
27	Resistor, 10,000 Ohm ¼W.
28	Resistor, 20,000 Ohm ¼W.
29	Resistor, 30,000 Ohm ¼W.
30	Resistor, 40,000 Ohm ¼W.
31AB	Resistor, 60,000 Ohm ¼W.
32AB	Resistor, 75,000 Ohm ¼W.
33	Resistor, 100,000 Ohm ¼W.
34AB	Resistor, 300,000 Ohm ¼W.
35	Resistor, 500,000 Ohm ¼W.
36	Resistor, 1 Megohm ¼W.
37	Resistor, 2 Megohm ¼W.
38	Resistor, 1,400 Ohm ¼W Flex.
39AB	Resistor, 2,000 Ohm 1½W. Flex.
40	Resistor, .70 Ohm (Air Cell Series)
43	Socket, Type 1C7
44	Socket, Type 1D5
45	Socket, Type 1F7
46	Socket, Type 1H4
47	Socket, Type 1F5
48	Socket Ballast
	Tube Shield
49	Socket (Power Cable)
50	NONE
51	NONE
52	Dial Light Switch and Brkt. Assy.
53	Band Selector Switch
54Z	Volume Control (1 Meg.)
54Y	Batt. Switch
55	Speaker, Spec. No. R-6000, C8 and D2, 6"
	V. C. and Cone Assy. for 31PJ3 "A" Spkr
	Output Trans. for 31PJ3 "A" Spkr
	Cone Mounting Ring for 31PJ3 "A" Spkr
	Speaker, Spec. No. R-8000, B2, 8"
	V. C. and Cone Assy. for 41PJ3 "A" Spkr
	Cone Mounting Ring for 41PJ3 "A" Spkr.
	Output Trans. for 41PJ3 "A" Spkr
56	Ant. and Gnd. Terminal Assy.
57	NONE
58	Battery Cable
59	Ballast Sock. Jumper Wire
60	Ballast Tube
61	Speaker Cable
62	Resistor, 200,000 Ohm ¼W
	Cabinet—Table
	Cabinet—Console
	Knob—Lower—Dial Light Switch
	Knob—Upper—Station Selector
	Knob—V. C. and Band Switch
	Rubber Mtg. Foot
	Escutcheon
	Grille—for 7D Cab
	Grille—for 7MA Cab

Parts List For 117 Convertor

Item No.	Description
1	Chassis Pan
2	Case Bo...
3	Cover
4	"B" Filter Choke
5	"A" Filter Choke
6	Power Transformer
7	Fuse Panel Assy
8	Fuse (4 Amp.)
9	NONE
10	Condenser, .01 Mf. 1,000 V.
11AB	Condenser, .05 Mf. 200 V.
12	Condenser, 20 Mf. 150 V.
13	Condenser, 16 Mf. 200 V
14	Socket for Vibrator
15	Cable and Plug
16AB	Batt. Clip—Pos
17AB	Batt. Clip—Neg.
18	Vibrator—4 Volt
	Gnd. Clip—Vibrator
19	Bonded Lead
	Grommet
20	Resistor, 100 Ohm ½W.
21	Resistor, 220 Ohm ½W
22AB	Condenser, .5 Mf. 130 V
	Cushion Strap
	End Plate 1½" x ½" (2)

BATTERY CONNECTIONS

If the receiver is to be operated from individual "A", "B" and "C" batteries, the "A" battery may be an air cell type, a two-volt storage battery or a three-volt dry "A" battery. Three plug-in type 45-volt "B" batteries and one plug-in type 4½-volt "C" battery are required.

CAUTION: Do not connect or disconnect batteries or insert or remove ballast tube with the "ON-OFF" switch in the "ON" position, otherwise damage may result.

Fig. 2 shows the proper method of connecting the battery cable to the batteries. The YELLOW lead should be connected to the positive (+) terminal and the BLACK lead to the negative (—) terminal of the "A" battery. The resistor supplied on the YELLOW lead is to be used only if the "A" battery is an air cell type. The plug having two small pins and one large pin should be inserted in the 4½-volt "C" battery and the three plugs having three small pins are to be inserted in the "B" batteries.

If a three-volt battery is to be used, a Crosley W-44118 ballast tube should be used in the ballast tube socket on the receiver chassis. It will be necessary to pry the connector out of the ballast tube socket before the tube can be inserted. THE AIR CELL RESISTOR SHOULD NOT BE USED with three-volt "A" battery and ballast tube, nor with a two-volt storage battery.

SIX-VOLT POWER SUPPLY

The Crosley Model 117 Power Supply Unit, Fig. 4, is designed to permit the Model 557 receiver to operate from a six-volt storage battery without the use of "B" and "C" batteries. It is especially adapted to the circuit of this set, and cannot be used with any other type 2-volt receiver without redesigning the receiver.

DIAL LIGHT

If it becomes necessary to replace the dial light bulb, use only part No. W-37188 which is rated at 6/100 ampere (60 milliamperes). Dial lights which use more current than this will reduce the life of the "A" battery.

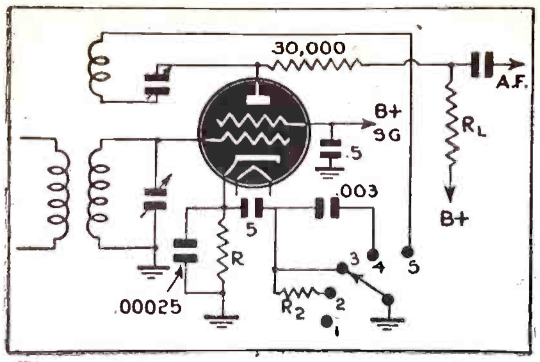


Fig. 1—Fidelity control by a simple switching arrangement in the detector cathode circuit.

In these circuits and ideas from Australia the American reader will find an original approach to many of the problems common to radioists the world over. Some of Mr. Straede's methods are not particularly applicable here—others so appropriate that we can only wonder why we had not already thought of them ourselves.

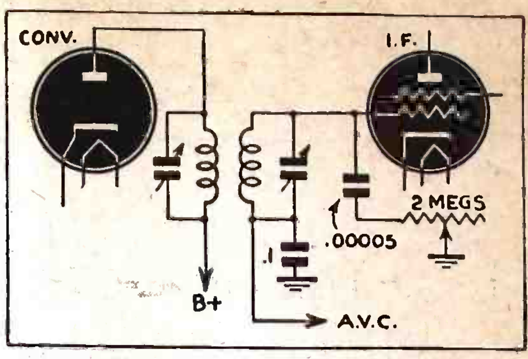


Fig. 2—Selectivity control for intermediate stages.

Simple High-Fidelity Circuits

By JOHN W. STRAEDE

ONE type of high-fidelity detector is the "infinite-impedance" variety — actually a plate detector with inverse feedback. ("Infinite-impedance" is generally applied in the U.S.A. to a circuit which Mr. Straede would no doubt call a "cathode follower."—Editor.) Unfortunately, this type of detector gives very little gain and so an extra tube is required if distant stations are to be received.

Instead of the extra tube, a switching device can be used to "rewire" the circuit to a conventional plate detector for DX work. The same switch can include positions for semi-DX, high-boost and bass-boost. In the circuit shown in Fig. 1 a simple 5-way switch with a grounded moving arm is used. This type of switch is not at all expensive, owing to its simplicity. One tap is open, that tap being for "high-fidelity."

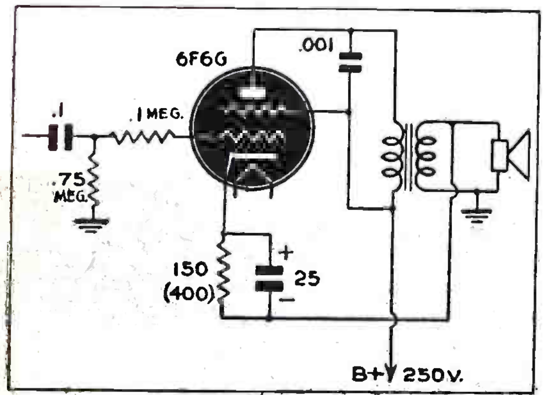


Fig. 3—A simple and effective way of supplying inverse feedback to a power output stage.

For DX reception, the bias resistor of the plate detector is shunted, not only by the small mica condenser necessary for detection, but also by a large capacity electrolytic to prevent degeneration. To obtain a high boost effect, a smaller condenser is used, while to get a bass-boost, the selectivity of the receiver is increased by adding some fixed regeneration, the actual amount of feedback being controlled by an adjustable condenser of the trimmer type. The 6J7G (or 6C6) and 57 type tubes are particularly suited for plate detection (or grid-bias detection, as it is sometimes called). The bias resistor should be about 15,000 ohms, as a minimum.

I.F. SELECTIVITY CONTROL

Selectivity when receiving a distant station is desirable for two reasons. It enables reception free from the background of an interfering local station, and causes a decrease in response to the upper radio frequencies, thus making static noises less noticeable. (A famous American set uses a selectivity control as a tone control.) Elaborate systems of movable-coil transformers, variable band-pass coupling condensers, etc., have been used, but the simple system of Fig. 2 is quite efficient, though limited in its scope. The secondary of the first I.F. transformer is shunted by a small condenser in series with a variable resistor of large maximum value, at least 1 megohm.

When the resistance is a maximum, normal DX reception is obtained, any damping due to the resistor being balanced by a little regeneration (if necessary). When the resistor is reduced to a low value, the primary and secondary circuits are highly damped, decreasing the selectivity (and sensitivity) so that the upper audio frequencies are not attenuated. When the resistor is at its minimum value (usually several ohms), the circuits are not only so damped, but the secondary is actually detuned. For this reason some experimenters connect a fixed resistor of about 500 ohms between the condenser and the variable resistor.

CATHODE INVERSE FEEDBACK

The idea of Fig. 3 is a method of inverse feedback, the degeneration voltage being taken from the voice coil of the speaker and applied to the cathode of the output tube. This system is voltage feedback and is positive or negative according to the polarity of the voice coil connections. If positive feedback is obtained, due to incorrect connections, the sensitivity of the stage is increased —it may even cause oscillation such as howling or motor boating—with the tone entirely ruined.

Any inverse feedback system taking the voltage from the voice coil compensates to a certain extent for distortion produced by the output transformer. The gain reduction ratio (which is practically equal to the distortion reduction ratio) produced by the circuit shown depends on the type of output tube and the voice coil impedance. The effect is greatest for tubes with a high amplification factor, such as the 6V6.

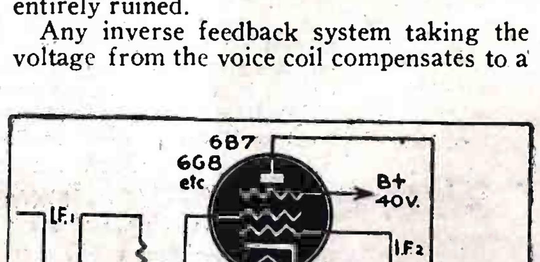


Fig. 4—A reflex detector with volume control so located as to adjust both I.F. and A.F. signal gain.

If feedback by this system makes the response too level, the cathode by-pass condenser can be omitted, giving more inverse feedback, but of a different type, so that the bass and treble humps are partly restored.

REFLEX VOLUME CONTROL

Reflex circuits in which the volume control is in the A.F. section suffer from a minimum volume effect due to the reflex tube acting as a biased detector. This occurs most when the I.F. signal is greatest and is overcome in the circuit shown in Fig. 4, by having the I.F. controlled as well as the A.F. The volume control should be of a high resistance to avoid excessive loading of the tuned circuit (a little loading is desirable as it reduces sideband cutting and thereby improves the high-note response). It also reduces the chances of instability which is always likely to occur in a reflex circuit. A 6B8G tube is shown in the diagram, but a 6G8G can be used. The latter seems to be less critical as regards voltages, but produces more distortion when operating at full volume.

Most tone controls act by cutting off more or less of the "highs" so that at one end "normal" reception is obtained, while at the other the "highs" are reduced and the bass predominates. Unfortunately, the highs are already reduced in most receivers, so such a tone control can only make things worse. The type of tone control shown in Fig. 5 acts in the usual way over half its range, but for the other half it actually boosts the highs because of the small condenser connected from the "hot" end of the volume control. At a midway position, normal reception is obtained. The values given for the condensers are not critical—the larger the value the more pronounced the effect, but if they are too large the lows are also affected and the tone control is no longer of use.

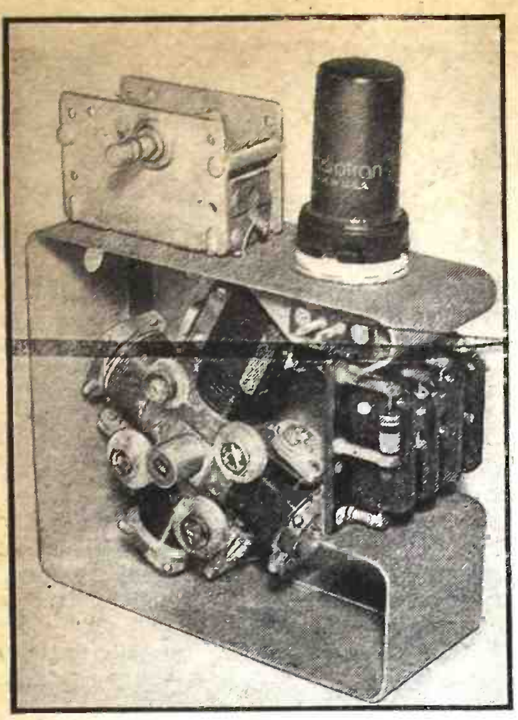
Recently the writer had to build a mantel receiver, "reasonably small, but with tone as good as possible." Only local stations were required, but the quality had to be just right.

In working out the design the following features were considered first:—

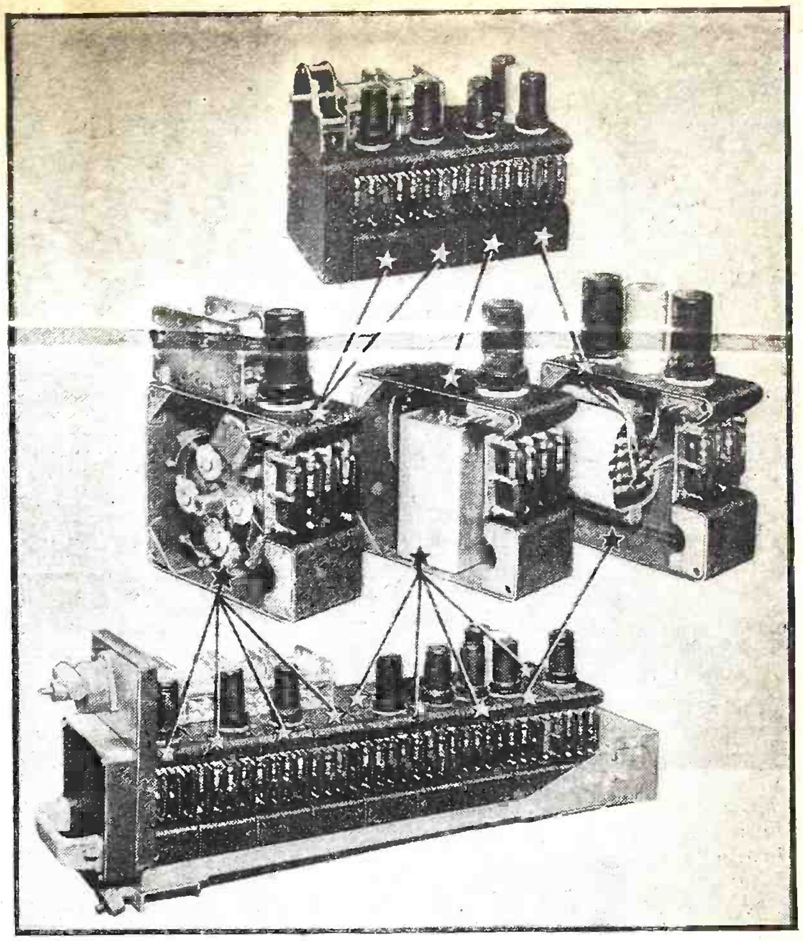
1. A large speaker, 8 in. at least, with plenty of field excitation.

2. T.R.F. circuit, with diode detector, but not diode biassed.

(Continued on page 123)



Left is the basic unit of the new type of receiver. The section shown is an R.F. four-band tuning section, with turret-type coils. At the right are seen R. F., I. F., and audio units, and two receivers made up by combining these. Note the B.F.O. (I.F. unit) in the lower receiver.



"UNITIZED" NEW RADIO

A NEW departure in standardization and replaceability of radio parts is seen in the recently-released Harvey Unitized Radio now being manufactured on the West Coast. Built for aircraft and military use, they go one step further in the direction of part replacement than has hitherto been achieved.

When an I.F. (or other) stage in one of these Unitized radios goes bad, the operator makes only enough tests to discover which stage contains the defects, then yanks it out and substitutes a complete replacement stage. The defective stage then can be returned to the factory, or serviced at the ground station, while the radio is giving service in flight.

The set is composed of a number of detachable units, resembling that of Fig. 1. These are strung together with a number of bus wires, which run the whole length of the set, making connections to each unit. It is the work of a minute to pull out the busses, whereupon any of the units may be detached and replaced by a spare.

This arrangement may also be of use in servicing a set where replacement units are not obtainable, as in some of the R.F. and A.F. units in sets using two or three R.F. stages and more than one audio stage. In these sets, a unit may be removed and the set operated with one less audio or radio stage while repairs are being made.

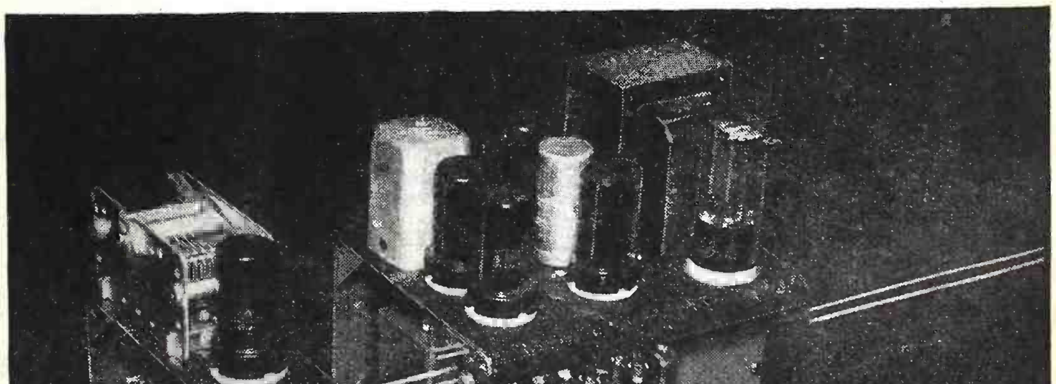
A further advantage which will occur to the regular serviceman is that, even though ordinary servicing methods be used, parts in this set will be easier to replace than in many standard receivers. Accessibility is at a maximum, practically every part being on the outside of the units.

Three main types of "cells" are constructed, R.F., I.F. and A.F. Various receivers may be built up from combinations of these standard cells, when hooked up with a standard detector unit. The unitized construction is specially adapted to special types of apparatus, as the addition of one none-standard unit may be all that is necessary to make a highly-specialized piece of apparatus. Such is the automatic airplane direction finder, in which only one cell is required, in addition to the three basic types. This is a thyratron unit containing two tubes and controlling the rotation of a loop orienting electric motor. Other types of special cells are crystal filters and beat oscillators for communications receivers.

The R.F. cell, with its turret-mounted short-wave coil assembly, is especially interesting. The familiar four-coil unit, covering the bands between 200 Kc. and 20 Mc., is engaged by a quarter-inch shaft, one side of which is flat to match the shaft-way in the turret assembly. All wave-change units in the receiver are thus rotated by the same shaft. Variable condensers, mounted on top of the cell, are likewise rapidly and easily connected, and move as a gang, irrespective of the number coupled together.

Plate leads are brought out of each cell through horizontal pin jacks, this system tending to cut down stray capacitance due to the longer leads which are so often found in conventional receivers. Shields between the units form a highly effective means of isolating the plate and grid coils of any one tube.

These units are now being used in the assembly of several standard types of sets, from a four-tube Scout Car model to a 10-tube communications receiver with a two-stage pre-selector, noise silencer, crystal filter and beat-frequency oscillator.



How the units are assembled. The set is held mechanically by four rods through the corners. The long "knitting needles" shown are the bus bars, and coupling between stages is through the double pin jacks.

Servicing Notes

Trouble in . . .

. . . . CANADIAN ROGERS

If any of these sets using spray-shield tubes starts oscillating, wind a wire (size 18 bare) around the tube where the glass meets base. It seems that the metal spray breaks away at this point.

(This suggestion is applicable to old Majestic tubes which use the same type of spray-shield.)

William Robertson,
Sudbury, Canada.

. . . . AIRLINE 62-318

Loss of volume, but no distortion whatsoever, voltages check O.K.

The trouble is in the I.F. can at the rear of the chassis. The trimmer condensers are grounded.

Remove the I.F. can from the chassis and insulate thoroughly.

Paul Hoffman,
Tama, Iowa.

. . . . WESTINGHOUSE WR386

Oscillation and dead receiver. Often caused by screen by-pass condensers (0.1, 400-v.) opening up. Stubborn oscillation in the I.F. stage can be cured by a resistor of 100 to 1,000 ohms, inserted in series with the grid lead, right at the socket. This will cure the trouble with little loss in gain. If the set is inoperative, check first the decoupling resistor in the R.F. stage, as this is prone to burn out, because of the by-pass condenser shorting. Replace with a 1,000-ohm, ½-watt unit, and put in a .01 mfd., 600-volt condenser.

Intermittent operation of this set is caused by the cathode resistor of the 6K6-GT, which cracks from overheating and makes and breaks contact.

R. W. Sederholm,
St. Cloud, Minn.

. . . . GRUNOW 11-G

Static-like noise on the broadcast band. This trouble is caused by a bad plate winding on the broadcast R.F. coil, which is located just under the left edge of the band-switch shield, in a small zinc can. (This is as viewed from the bottom with the shafts pointing away from you.)

Shunt the winding with a 10-volt meter, while the set is playing. If the coil is bad the needle will fluctuate as the static crashes are heard. A new coil will stop the noise. If no new one is to be had, remove the old coil carefully, making a connection diagram, then unwind the plate coil, which is a piece of No. 34 silk-covered enamel wire 28 inches long. Rewind and the noise will clear up.

It is a good idea to give the finished coil a coat of coil lacquer or polystyrene dope before re-installing in the radio.

Nesler Radio Service,
Dubuque, Iowa.

. . . . RIM-DRIVEN TURNTABLES

On some rim-driven turntables—particularly the cheap types—the rubber drive wheel makes a very considerable amount of noise rolling on the inside of the metal turntable. This sound is then amplified and is reproduced by the speaker as a sort of motor noise.

I eliminated this and made the turntable slip-proof by gluing a thin strip of old inner tube rubber to the inside of the drum.

ATTENTION SERVICEMEN!

Do you have any Servicing Notes available which you would like to bring to the attention of the readers of *Radio-Craft?* If so, send them along and if they are published a six months' subscription to *Radio-Craft* will be awarded you. If your notes are illustrated you will be given a six-months subscription.

. . . . REFINISHING RADIO CABINETS

When refinishing deep dents in wooden cabinets the most satisfactory way is to drill a hole a little bigger than the dent, about half-way through the cabinet. Then fill the hole with plastic wood, sand off and finish it with stain or varnish in the regular method. This holds the plastic wood much better than if you just fill in the dent.

Robert Nissen,
Albany, Oregon.

. . . . BOSCH 605

If these sets whistle as each station is tuned in, or develop a loud squeal which ceases if the finger is placed on control grid of 6K7, check the 12-mfd. condenser which is connected from the negative terminal of the filter choke to ground.

I find that replacing this condenser with a 16-mfd., 150-volt electrolytic cures this trouble. Note that the plus terminal is the one connected to the chassis.

Owen C. Phelps,
Winslow, Indiana.

. . . . ZENITH 6J257 AND SIMILAR MODELS

Poor tone in these models is generally caused, not by defective filters or by-pass condensers, as one suspects at first, but by one or more open dial-light bulbs.

These are 2.9-volt, white bead, bayonet base and are connected in series with the 1J6 power output tube. Replace the bulbs and the tone is automatically restored.

P. B. Schafer,
Marietta, Ohio.

. . . . PHILCO 40-158

If this set breaks into oscillations and birdies intermittently, replace the .05 mfd. a.v.c. filter condenser. (No. 16 on the schematic.)

. . . . PHILCO 42-1013

Complaint—no volume.

The trouble has been found due to an open volume control on several sets.

. . . . PHILCO PT3

The sets cut in and out or take a long time to come on with full volume.

Change the .02 condenser from the 7C6 to 50L6 tubes.

Leonard Chioma,
Tarrytown, N. Y.

. . . . ZENITH MODEL 5G500

If this set is O.K. on batteries but distorts when played on A.C., change the molded resistor, part No. 62-1096, 140 ohms, or the two-section Candohm, part No. 624120, 1060 ohms on each side.

These resistors occasionally check perfect when cold but fail to maintain proper voltages when they warm up.

P. T. Adams,
Cleveland, Ohio.

. . . . MAJESTIC 1937 MODELS

Intermittent drop in volume in the automatic tuning models, also indicated on the tuning eye. It appears to be an R.F. stage trouble, and the serviceman may waste considerable time looking for it.

The trouble is due to an intermittent grounding of the leads to the automatic tuning dial light where they pass through the chassis. By replacing the plain rubber covered leads with braid this trouble will be permanently fixed.

Another trouble on the same model is a noisy tone control. This has been repaired by dismantling and thoroughly cleaning the metal slipring and shoe with a pencil eraser.

B. E. Olsen,
Winnipeg, Man.

. . . . G-E FD-62

Loud hum, not due to any of the common causes.

This is caused by one of the two pilot lamps being grounded to the chassis. Grounding does not put undue voltage on them or the tubes, and may pass unnoticed, as the electrolytic condensers are immediately suspected.

I have repaired a number of this model in which this hum was the complaint.

Sgt. R. H. Goudeau, Jr.
Camp Crowder, Mo.

. . . . EMERSON FU428

Set O.K. after repair, inoperative when placed in cabinet. On removal, played perfectly again.

The dual 20-mfd. condenser protrudes slightly from the underpart of the chassis and is pressed upward when the mounting screws are tightened. This causes two bare wire leads, that lie directly under the filter condenser, to short.

Since the filter condenser cannot be made to lie wholly within the shallow chassis, simply wrap a piece of tape around one of the shorting leads and the set will work again.

George Murakami,
Newell, Calif.

. . . . BELMONT 1070

Hum, not caused by poor filtering.

Remove the volume control ground lead from the tube socket and solder it directly to ground lug at left of control.

This isolates the volume control ground lead, stops the hum, and gives better results.

Carl Baker,
McRoberts, Ky.

. . . . SENTINEL 44A, 60B, 90B

These models have been inconsistently for the same trouble—squeals and oscillation below 800 Kc.

The fault lies in the 50,000-ohm resistor across the padder condenser.

Replace this resistor and the trouble disappears at once.

Robert Richard,
Madell, Okla.

A MOVING-COIL PHONO PICKUP

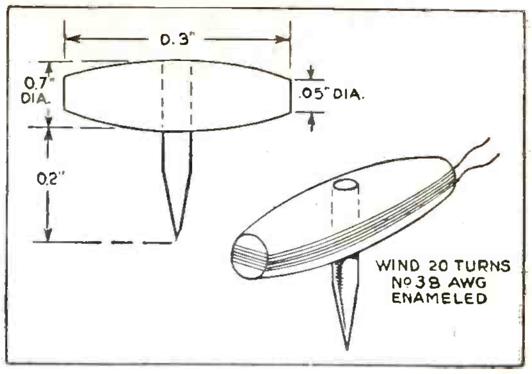


Fig. 3.—Construction of the moving coil.

A NOVEL method of improving phonograph pickup performance is suggested by John Brierly, British sound and phono experimenter, writing in a recent issue of *Wireless World*, (London). He holds that many of the defects of reproduction can be traced to the inertia and stiffness of the moving parts of the ordinary pickup. He therefore designed a moving-coil pickup which compares with the ordinary unit much as the moving-coil speaker compares with the older magnetic type, the stiffness and damping of which in many ways parallel that of the magnetic pickup.

The Brierly pickup should be constructed with as small and light a magnet as possible. New types of alloy steels are constantly increasing the efficiency of permanent magnets, and it is possible to get a strong magnetic field with a much lighter magnet than was the case with older pickups. The constructor of a pickup is likely to be limited, however, by the types of magnets available during the war, and it may be necessary to base the unit on an old magnetic pickup. The best possible magnet should be obtained, as field strength is an important factor in the operation of the device.

POLE PIECES

The pole pieces of mild steel can conveniently be formed from the keeper supplied with the magnet, or from a piece of mild steel obtained from a machine shop. Having been cut into two by a hacksaw, each part should be filed until it is 1/3 in. wide, i.e., the width of the magnet (as supplied the keeper is slightly more than this). Each pole piece should then be 7/16 in. long, 3/16 in. thick and 1/3 in. in width. At one end of each pole piece, parallel with the 1/3 in. sides, a groove 0.1 in. wide and 0.05 in. deep should be filed; at right angles to this a groove 0.25 in. wide should be filed. Each pole piece now has, as it were, four claws, and when these are put together the gap so formed should be 0.1 in. between faces. The construction of the pole pieces is completed by chamfering the side so that the surface of the opposed faces is 0.1 in. instead of 3/16 in. across. (Fig. 1 c). The claws can also be reduced by careful rounding of the corners so that only a small area of the original surface is left for contact with the opposite pole piece. This will help to reduce the magnetic short-circuiting of the gap which, in practice, is not serious, and is accepted on account of the simplification of construction.

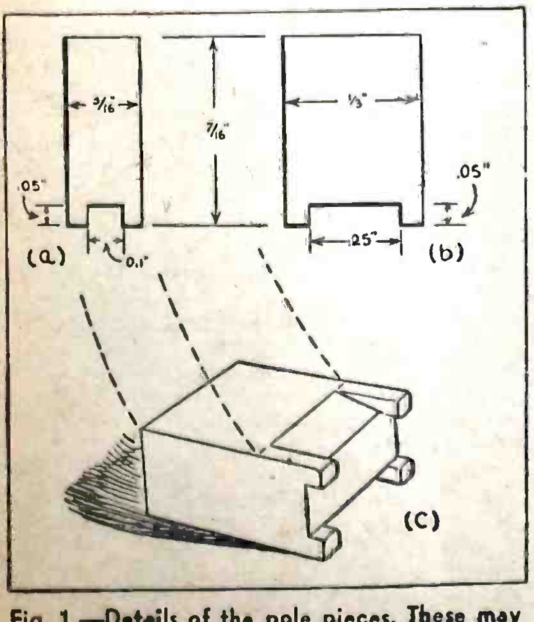


Fig. 1.—Details of the pole pieces. These may be modified to suit available magnets.

Next comes the construction of the end plates which, in the final assembly, bind the magnet, pole pieces and coil into position. The construction of these should be quite clear from the diagram (Fig. 2). They may be made from any light, rigid and non-magnetic material such as aluminum or bakelite. It will be noticed that a strip of rubber not more than 3/16 in. wide and 1/16 in. thick is secured round the edge of the front plate and a slit about 1/32 in. wide is cut from the middle of the bottom edge of the back plate for a distance of 5/32 in.

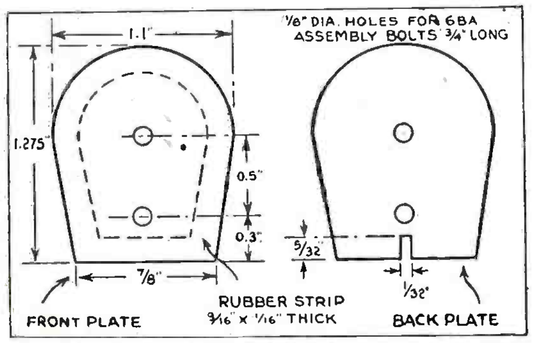


Fig. 2.—How the front and back plates are made.

It is felt that at this stage the reader will have a good idea of the general arrangement, and attention can now be given to practical coil designs. It should be emphasized that although the method of construction and the dimensions of the coil and pole pieces must necessarily be given separately, the two are quite inseparable and it will be appreciated that the exact dimensions of the pole pieces are entirely dependent on the coil design, so that any substantial alteration to the coil will require an appropriate modification of the pole pieces. The method of mounting the coil, however, is such that slight inaccuracies are largely absorbed and the final assembly is neither critical nor difficult.

The outstanding problems for the design of a coil using a steel needle were, on what should the coil be wound, could the material be not only light but sufficiently resilient to grip a steel needle without any special clamping device and at the same time be capable of transmitting energy to the coil without appreciable loss or frequency discrimination, would it be tough enough to withstand the strain of use and constant needle changing without collapsing and finally, of course, would it be easily obtainable? It is obvious that if a substance could be found to satisfy all these requirements, then the coil former and the needle-holding device could be combined into one, thus reducing the mass to an absolute minimum and simplifying construction.

CONSTRUCTING THE FORMS

The writer has experimented with a large number of materials, including various plastic materials, and one that has been found most satisfactory is celluloid (Xylonite). Fortunately this is already likely to exist in the majority of households, namely, the translucent, slightly transparent, and usually, though by no means invariably, colorless material from which a very large number of toothbrush handles are made.

The dimensions of the coil system are shown in Fig. 3, but it should be noted that the dimensions given are for the former itself, and allowance has been made for the space taken by the winding. Before referring to the actual construction, mention should, perhaps, be made to the shape of the former. The completed coil is made circular in cross-section and is tapered towards the ends. This is done so that the restoring force is kept low while permitting considerable damping of the coil for movements in other than the desired direction.

The construction of the coil former and the winding of the coil are quite simple. A piece of the selected material is cut 1/3 in. x 1/5 in. x 1/5 in. A steel needle of the long-playing type is gripped in a small hand vice and the material is then pierced as if using a bradawl, taking care that the hole bored is at right angles to the length. The tapered part of the point should pass right through so that a parallel hole is left in the block.

The material can now be conveniently filed down to the correct shape and dimensions, and during this process it is advisable to keep the needle in position, since it is easier to see that the correct disposition of the former round the needle is being maintained. The final dimensions should be very slightly less than 1/3 in. long, a diameter of 0.07 in. in the middle (this has

(*Continued on page* 128)

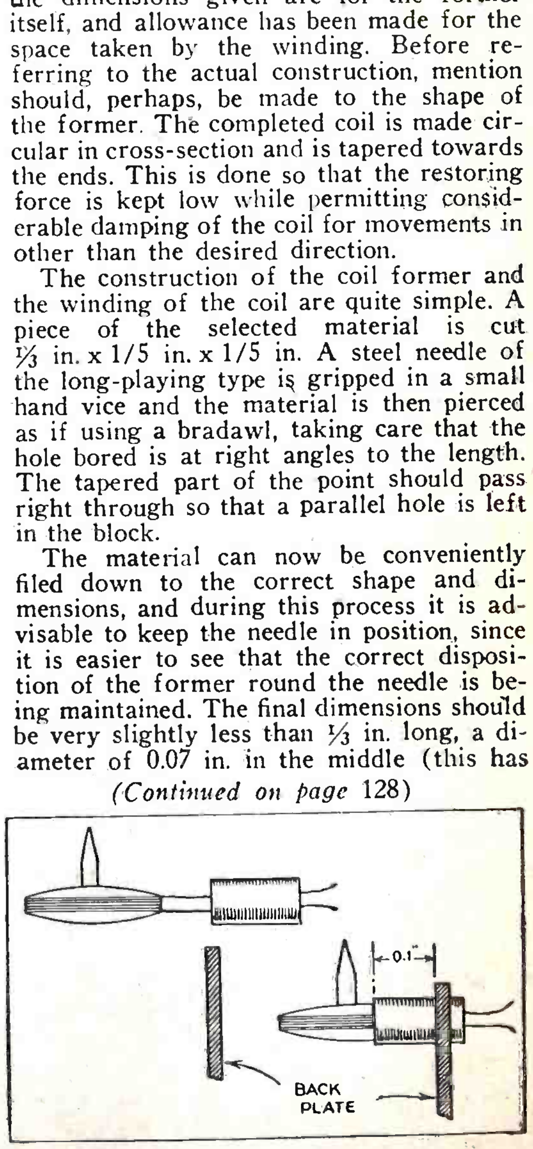


Fig. 4.—How the moving coil is put in place.

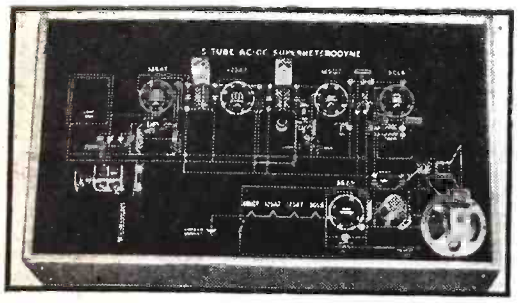
Latest Radio Apparatus

DEMONSTRATOR BOARD

Lafayette Radio Corp.
Chicago, Illinois

THIS 5-tube A.C.-D.C. Superhet Demonstrator Board is designed for radio and physics classroom training programs and for lecture and demonstrating purposes.

It is laid out schematically in bread board style with actual radio parts mounted



in position for quick removal and replacement to demonstrate function at each part in the circuit. Terminals are provided at all tube elements for measurement of voltages and signals. Jumpers are provided to open condenser, resistor and coil circuits and to short out these circuits wherever no damage will result.

The schematic diagram is in color according to the R. M. A. code; grid circuits in green, plate circuits in blue, B positive circuits in red, and balance of circuits in black. Tubes are included.—*Radio-Craft*

•

ROTARY CONVERTERS

Kato Engineering Co.,
Mankato, Minn.

THESE new improved designs are available in 225 and 350 volt-amperes continuous load capacities at 3600 r.p.m. with 40° C. temperature rise. Available for changing 32-, 110- or 220-volts direct current to standard 110-volts, 60-cycle, A.C. ideal for operating standard A.C. appliances, radio and electronic equipment, electric signs, coin-operated machines, etc., in location where direct current only is available.

Designed to keep radio interference down to a minimum and to provide best possible

wave forms to facilitate all phases of radio filtering. When converters are to be used for operatng sensitive radio and electronic equipment, it is quite often necessary that special filtering device be used. Special filter may be furnished which is contained in sheet metal base upon which converter is mounted. This filter has been designed after many months of special research work by our engineers and is giving excellent service.

Upon specification, speed governor can be furnished which is helpful in maintaining close frequency control with a variable D.C. input.—*Radio-Craft*

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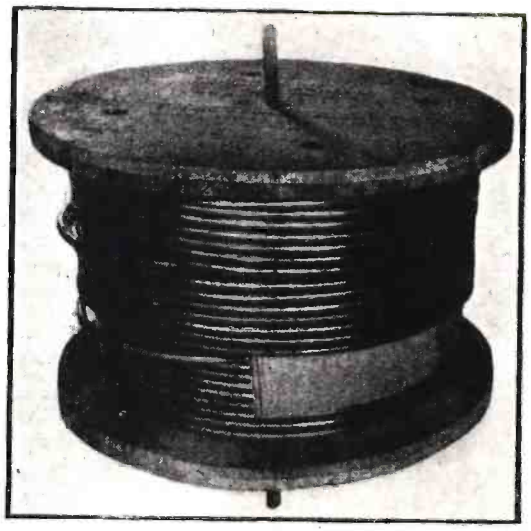
LONG CO-AXIAL CABLES

The Andrew Co.
Chicago, Ill.

THE cable is wound on wooden reels in lengths up to several thousand feet and is electrically identical to rigid cables of the same size. Considerable time and labor is



saved in installation because: 1—The cable is easily uncoiled and bent by hand to the desired contour; 2—Connectors, junction boxes and expansion fittings are not necessary, thus eliminating the hazards and defects which result from soldering in the field and eliminating the need of using skilled technicians in installation; and 3—To prove that all splices are pressure tight and to exclude foreign matters and moisture during shipment, the cable may be fitted at the factory with special Andrew glass-insulated terminals and shipped under pressure.—*Radio-Craft*

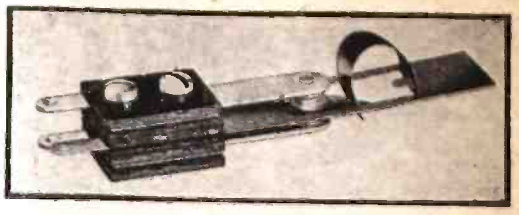
•

SNAP-ACTION SWITCH

Acro Electric Co.
Cleveland, Ohio

BETTER contact pressure and greater speed of operation is secured in this new small, open blade, snap-action switch. It is designed for a wide variety of applications, including machine tool control devices, aircraft landing gear controls and for construction of various relays and contactors.

A unique patented rolling spring produces a positive snap action with less than 6 oz. operating pressure. Consequently smaller coils may be used in relays incorporating this new development. This is also aimed to save both space and weight. The engineering design and operation of the rolling spring switch minimizes contact burning because of its extremely fast action. Under



tests of many millions of operations no weakness has been shown.—*Radio-Craft*

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PORTABLE TUBE TESTER

Radio City Products
New York, N.Y.

THE new portable Model 804, Advanced Design Dual-Tester is equipped for direct testing of all acorn tubes as well as all old and new types of regular receiving tubes, rectifiers, etc. It is compactly contained in a handsome, sturdy oak case with removable cover, size 14½" x 13" x 6", weighing only 12¼ pounds. It is supplied complete, ready for operation on 105-135 volts, 50-60 cycles. Outstanding features are the Dynoptium tube test circuit; double line fuses; meter protected against burn-out by instrument fuse; sensitive leakage, noise and hum tests provided; also method of A.C. measurement which eliminates errors inherent in copper oxide rectifier types. The Ohmmeter reading ratio is 500,000,000 to 1; current reading ratio—1,000,000 to 1; voltage reading ratio —100,000 to 1. There is an electrostatic leakage tester for all mica and paper condensers, also an electrolytic leakage tester for all electrolytic capacitor readings. A battery tester determines the actual condition of batteries testing under load for various voltage ratings. D.C. Voltmeter ranges from 0-10-25-50-250-1000-5000. A.C. Voltmeter ranges from 0-10-50-250-1000-5000. Output Voltmeter ranges—0-10-50-250-1000-5000. D.C. Milliammeter ranges: 0-.5-2.5-10-50-250-1000; D.C. Ammeters: 0-10 amperes. Ohmmeter: 0-250-2500-250,-000-2.5 Megacycles; 25 Megohms.—*Radio-Craft*

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VOLTAGE REGULATOR

Amperite Co.,
New York, N. Y.

THE new type Amperite ballast-regulating tube automatically controls the voltage delivered to a vibrator used for airplane service. With a battery variation of 20 to 30 volts—50%, the voltage on the vibrator is kept between 6.0 and 6.3 volts—5% variation. Included in the Amperite is an automatic thermal switch which automatically turns on an auxiliary circuit 10 seconds after the vibrator is started. Similar Amperite regulators can be designed to control the current and voltage applied to any load provided the total wattage consumed by the Amperite itself is not more than 40 watts. With a 10% change in current through the Amperite the voltage drop increases 200%. An ordinary nichrome wire would only increase approximately 10%.—*Radio Craft*

The Listening Post

Edited By **ELMER R. FULLER**

STATION E A Q on 9.86 mcs., in Madrid, Spain, is being heard quite regularly from 7 to 7:15 pm, E.W.T. Their programs consist mostly of news in English, and they announce that they will verify, and welcome reports from their listeners. Reports on reception of this old timer should be sent to "Spanish Broadcasting Network; The Voice of Spain for North America; Madrid, Spain." This information was supplied to us by Lindsay Russell, of Needham, Massachusetts.

The question has arisen as to the present operation of K Z R H of Manila, now in the hands of the Japanese. We have not received any reports of this station being heard in several weeks, and we would like to know if anyone has heard it lately.

Once more we wish it understood that all times given in this department are *Eastern War Time*, and will be until we return to Standard Time, after the war is our victory. Every month several write and wish to know what time belt we use. Nearly all radio information is based on Eastern Time.

Does anyone besides Robert Hoiermann, of Alliance, Ohio, hear the South American hams which are still on the air? Bob is the only one reporting to me that he hears them, and quite regularly. We wish that some of you other fellows would listen for them once in a while. They use the 20 and 40 meter bands. A new Paraguayan, Z P 1 G R, was heard by Bob this month, and he says that they are beginning to come in better now that winter and the better DX season is approaching. We hope that conditions will continue to improve as they have for the past couple of weeks.

A letter has been received from the Office of War Information, New York City, stating that it is again permitted to publish the beams used by the American short wave radio stations. For some time, this was thought to be of possible aid to our enemies, but this view has been changed. Also, a complete revision of the U.S. station schedules has been made in this issue.

Reports for the past month have been received from Robert A. Grimm, Georgia; Ying Ong, Arizona; Gilbert L. Harris, Massachusetts; Kenneth Noyes, California; Robert S. Duggan, Jr., Georgia; Kenneth Loewen, Kansas; Harold Held, New Jersey; Office of War Information, New York City; Robert Hoiermann, Ohio; Lindsay Russell, Massachusetts.

In order to conform to the individual taste of as many of our readers as possible, and to satisfy several who have written to me; this month we are changing our order of presenting the station list to you. Quite often, it is very useful to have a list of the stations by country, as well as by frequency. For this reason, this month's list has been arranged for you by the country by which the station is associated. If anyone has any other way, they would like to have a list arranged, drop us a letter, and we will see what can be done.

Country-Call	City	Frequency and Schedule
Alaska		
———	———	**17.48**; Saturdays, 6:45 pm; irregular.
Algiers		
AFHQ	Algiers	**8.96**; 6:30 to 7:45 pm; irregular.
———	Algiers	**12.11**; 1 to 5:30 pm; "Radio France".
Algiers		
———	Algiers	**15.98**; 8 to 9:45 am.
AFHQ	Algiers	**16.025**; variable times.
Arabia		
ZNR	Aden	**12.115**; 1 to 1:30 pm.
Argentina		
LRX1	Buenos Aires	**6.120**; "Radio El Mundo"; 9 to 12 pm.
LRA1	Buenos Aires	**9.69**; afternoons.
LRA5	Buenos Aires	**17.72**; Fridays only, 5 to 5:30 pm.
Australia		
VLG2	Melbourne	**9.54**; East North America beam, (English) 8 am; Asia beam, (French, Thailand) 9 am.
VLG	Melbourne	**9.58**; Western North America beam, (English), 11 am.
VLG3	Melbourne	**11.71**; Tahiti beam, news in French; 1:55 am; British beam (English), 2:55 am; Pacific beam (Japanese), 3:30 am; New Caledonia beam (French), 4:30 am; Allied Forces in South Pacific beam (English), 5:30 am.
VLG9	Melbourne	**11.9**; Asia beam (English), 10:15 am.
VLG4	Melbourne	**11.84**; Asia beam (Chinese, English, Malay, Dutch), 6:15 am.
VLG6	Melbourne	**15.230**; Western North America, evenings; news at 1:10 am in English.
VLI9	Sydney	**7.28**; Eastern North America beam (English), 8 am.
VLI2	Sydney	**11.87**; British beam (English), 2:55 am.
VLI3	Sydney	**15.32**; Western North America beam, evenings; news at 1:10 am in English.
Bahamas		
ZNS2	Nassau	**6.09**; evening transmissions; off at 9 pm.
Beirut—Lebanon		
FXE	———	**8.030**; 6:30 to 6:45 pm; irregular.
Belgian Congo		
OPL	Leopoldville	**11.675**; 3:15 to 3:30 pm; 4:30 to 4:45 pm.
OPL	Leopoldville	**17.775**; 2:15 to 3:45 pm; 4:15 to 4:30 pm.
OPL	Leopoldville	**19.205**; 12:45 to 1:30 pm; 2:30 to 2:45 pm; 7:15 to 7:30 am.
OPL	Leopoldville	**20.040**
Bermuda		
ZFA2	Hamilton	**6.122**; Mondays, 7 to 7:45 pm.
Brazil		
PRL7	Rio de Janeiro	**9.720**; "Radio Nacional"; 6 to 9:55 pm.
PSH	Rio de Janeiro	**10.22**; 8:15 to 8:30 pm.
PRL8	Rio de Janeiro	**11.150**; afternoons and evenings except Sundays; off at 11 pm.
PRL8	Rio de Janeiro	**11.72**; "Radio Nacional"; nightly beamed to North America; off at 10:55 pm.
PPH	Rio de Janeiro	**12.97**; 5:45 to 6:15 pm.
PSE	Rio de Janeiro	**14.925**; North America beam, daily, 7 to 8 pm.
PRE9	Fortaleza	**15.465**; 5 to 9:08 pm; variable.
PRL8	Rio de Janeiro	**17.850**
British Guiana		
———	Georgetown	**6.020**; 7 am to ?
British Honduras		
ZIK2	Belize	**10.610**; 9 to 9:15 pm.
Canada		
CFVP	Calgary	**6.030**; Sunday, 10 am to 1:30 am; Monday to Saturday, 8:30 am to 2 am.
CFCX	Montreal	**6.005**; Sunday, 7:30 am to midnight; Monday to Saturday, 6:45 am to midnight.
CFRX	Toronto	**6.070**; Sunday, 9 am to midnight; Monday to Friday, 7:30 am to 12:05 am; Saturday, 7:30 am to 12:45 am.
CBRX	Vancouver	**6.160**; 10:30 am to 2:30 am.
CBFW	Vercheres	**6.090**; daily, 7:30 am to 11:30 pm
CBFY	Vercheres	**11.705**; 7:30 am to 11:30 pm.
CJRO	Winnipeg	**6.150**; 6 to 11 pm.
CJRX	Winnipeg	**11.720**; 12 noon to 4:30 pm.
Chile		
———	Santiago	**5.85**; 7:40 pm to midnight.
CEC	———	**10.620**; 7:30 to 8:15 pm; irregular.
China		
XGOY	Chungking	**9.630**; East Asia and South Seas, 2:30 to 4 pm; 7:35 am to 9:55 am; North America beam, 10 to 11:30 am.
XGOA	Chungking	**9.720**; 7 am to 1 pm.

(Continued on following page)

Country-Call	City	Frequency and Schedule
XGOY	Chungking	11.900; Asia-Australia-New Zealand beam, 6 to 6:30 am; East Russia beam, 6:30 to 7 am; Japan beam, 7 to 7:30 am; European beam, 11:35 am to 12:30 pm.
XPSA	Kweiyang	8.484; 7:30 am to noon.
XGAP	Peiping	10.250; 10 am to noon.
Colombia		
HJAB	Barranquilla	4.785
HJAG	Barranquilla	4.905
HJAD	Cartagena	4.835
HJAP	Cartagena	4.925
HJDP	Medellin	4.885
HJDE	Medellin	6.145; evening transmissions.
HJFK	Pereira	4.865
Costa Rica		
TIGPH	San Jose	5.875
TIEP	San Jose	6.700; "La Voz del Tropico"
TIPG	San Jose	9.615; "La Voz de la Victor"
TILS	San Pedro	6.165
Croatia-Slovenia		
———	———	11.37; "Croatian Freedom Station" 2:30 to 2:40 pm.
Cuba		
COBF	Havana	6.04; relays CMBF.
COCO	Havana	6.100; evenings.
COCD	Havana	6.130; 7 pm to midnight.
COBQ	Havana	9.250; relays CMCQ evenings.
COCH	Havana	9.437; evenings.
COX	Havana	9.64; 1 to 11:15 pm.
COCQ	Havana	9.67; evening transmissions.
COK	Havana	11.623; daily, 1 pm to 1 am; Sundays, 2 to 8 pm.
CONY	Havana	11.730
COGF	Matanzas	11.805; afternoons.
COKG	Santiago	8.955; evenings.
Dominican Republic		
HI2T	San Francisco de Macoris	6.485;
Ecuador		
———	Guayaquil	7.345; 9 to 11 pm.
HCJB	Quito	9.97; 6:45 pm.
HCJB	Quito	12.455; "Voice of the Andes"; daily, 8 am and 6 and 9 pm in English; other times in Spanish.
Egypt		
———	Cairo	7.495; 3:15 to 6 pm.
SUV	Cairo	10.055; afternoons; irregular.
El Salvador		
———	———	14.480; 1 pm to ?
———	———	15.175; 1 pm to ?
England		
GSL	London	6.11; American beam, 7 pm to 12:45 am.
GRT	London	7.15; 10:45 pm to midnight.
GSC	London	9.58; North America beam, 5:15 pm to 12:45 am.
GRX	London	9.69; 10:45 pm to 12:45 am.
GRG	London	11.68; 5:15 to 7:15 pm.
GVU	London	11.78; North America beam, 6:30 to ? pm.
GBC	London	15.32; afternoons.
Finland		
OIX3	Lahti	11.785; 9:15 am.
OIX4	Lahti	15.19; North America beam, 9:15 to 9:45 am.
France		
———	———	9.620; "Voice of France"; 4 to 5 pm; 9:45 to 10:15 pm.
———	Vichy	9.62; North America beam, 9:45 pm.
———	Vichy	11.845
———	Vichy	15.250; 11:15 am to 1:30 pm.
———	Vichy	17.765
French Equatorial Africa		
———	———	9.04; "Radio Club"; 9 to 10:20 am; 2 to 3:20 pm; 5 to 5:30 pm.
———	———	9.98; "Radio Club"; 9 to 10:20 am; 2 to 3:20 pm; 5 to 5:30 pm.
FZI	———	11.970; "Radio Brazzaville"; 3:45 to 4 pm; 11:30 pm to midnight; also heard 6:45 to ? pm.
French Indo China		
———	———	11.705; "Radio Saigon"; 8 am to noon.
———	———	11.78

Country-Call	City	Frequency and Schedule
Germany		
DXP	Berlin	6.03
———	Berlin	6.120; North America beam; variable times.
DJX	Berlin	7.290; variable times; North America beam; news in English at 7 pm, other times.
DZD	Berlin	9.52; North America beam, evenings.
DZD	Berlin	10.543
DJD	Berlin	11.77; North America beam; evening transmissions.
DJZ	Berlin	11.800
DJP	Berlin	11.855
DZE	Berlin	12.130
DJL	Berlin	15.11
DJB	Berlin	15.20; North America beam, 7 to 9:45 am; 5:50 to 8:30 pm.
Gold Coast		
———	Accra	15.430; heard testing at 2:20 pm.
Greece		
SVM	Athens	9.935
Guatemala		
TGWB	Guatemala City	6.480; 7 am to 8:10 pm daily, except Sunday
TGWA	Guatemala City	9.685; 9:55 pm to 12:45 am daily.
TGWA	Guatemala City	11.760
TGWA	Guatemala City	15.170; daytime transmissions.
TGWA	Guatemala City	17.800
Hong Kong		
JZHA	Hong Kong	9.47
Hungary		
HAT4	Budapest	9.125; 9:15 to 9:30 pm; 10:15 to 10:30 pm.
———	———	9.835; "Hungarian Nations Radio"; 2:15 to 2:27 pm; 7:15 to 7:27 pm; speaks German.
Iceland		
TFJ	———	12.235; 12.210; heard early mornings; irregular.
India		
———	———	9.59; "National Congress Radio"; 11:15 to 11:55 pm.
———	———	9.59; "Voice of Free India"; 9 to 11 pm.
———	———	11.470; "National Congress Radio"; 12:15, 12:53 pm.
———	———	11.470; "Voice of Free India"; 10 am to 12:05 pm.
———	———	15.220; "Voice of Free India"; 10 am to 12:05 pm.
———	———	15.220; "National Congress Radio"; 12:15, 12:53 pm.
Ireland		
———	Athlone	9.595; 7:10 to 8 pm.
———	Athlone	15.129; "Radio Eirean"; 2:30 to 5 pm.
———	Athlone	17.84; 8:30 to 9:30 am; 1:30 to 2:15 pm.
Italy		
———	Rome	7.230; day and night; news in English every hour.
2RO19	Rome	7.31; day and night.
2RO3	Rome	9.630; 6:30 pm to midnight.
———	Rome	9.750; day and night.
———	———	9.780; "Italian Undercover Station"; variable times of evening; sometimes afternoons.
2RO22	Rome	11.81; North America beam, 7 pm to midnight.
2RO	Rome	11.910; day and night.
2RO6	Rome	15.300; day and night.
2RO24	Rome	15.465; heard 10 am to 12:40 pm.
Jamaica		
ZQI	Kingston	4.70; Sunday, 6:15 to 6:55 pm; daily, 6:15 to 7:15 pm.
Japan		
JLG2	Tokyo	9.505; 7:30 to 7:45 am; 8 to 8:45 am.
JZI	Tokyo	9.535; 11 am to 12:30 pm.
JRAK	Tokyo	9.565; 7 to 9:30 pm.
JVW3	Tokyo	11.725; 11 am to 12:30 pm.
JZJ	Tokyo	11.80; 7 to 9:30 pm.
JLG4	Tokyo	15.105; 2 to 4 am.
Java		
YDA	Batavia	18.135; India beam, ? to noon.
Manchuria		
MTCY	———	11.775

(Continued on page 106)

The Question Box

All queries should be accompanied by a fee of 25c to cover research involved. If a schematic or diagram is wanted, please send 50c, to cover circuits up to five tubes; for five to eight tube circuits, 75c; over eight tubes, $1.00.

Be sure to send the fullest possible details when asking questions. Give names and MODEL NUMBERS when referring to receivers. Include schematics of your apparatus whenever you have such. Serial numbers of radios are useless as a means of identification.

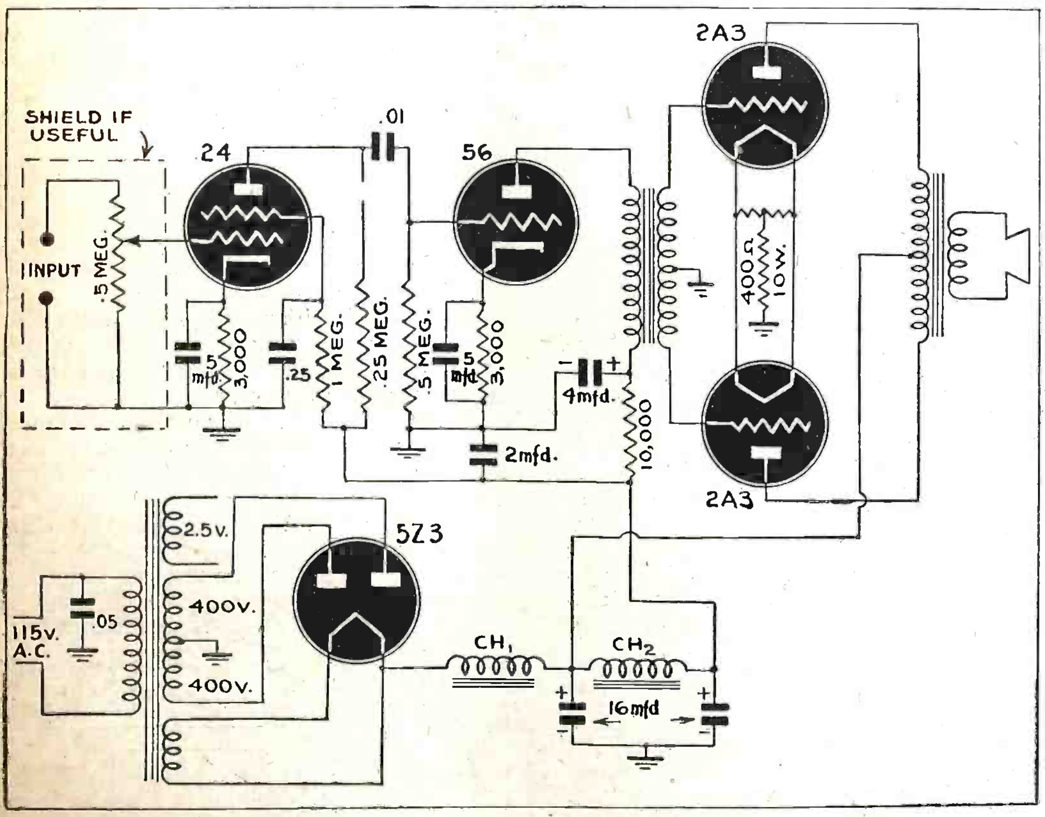
All letters must be signed and carry FULL ADDRESS. Queries will be answered by mail, and those of general interest reprinted here. Do not use postcards—postmarks often make them illegible.

No picture diagrams can be supplied. Back issues 1942, 25c each; 1941, 30c each; 1940, 35c each. Any issue, prior to 1940, if in stock, 50c per copy.

AMPLIFIERS FROM OLD RECEIVERS

? *I would appreciate a diagram of an amplifier using old-type 2.5-volt tubes. We have numbers of 26's, 27's, 24's, 56's, 2A5's and 2A3's.—A.F.E., Cleveland, Ohio.*

A. The Question Box has printed several schematics of apparatus using old-type tubes. An amplifier with a pair of 2A5's appeared a short time ago. The one shown here is for 2A3's but may readily be adapted to 2A5's or 47's by reducing the cathode resistor to about 300 ohms and adding the screen leads. Needless to say, equivalent 6-volt tubes may be used in this circuit. The 56 may also be replaced by a 27, with little difference in results.



METERS AND WAVEFORMS

? *I have never happened to run across the answers to the following questions in any publication, and I think that others may also be interested in them.—H. W. D'E., Passaic, N. J.*

1.—An emission-type tube-tester measures the current in the plate circuit of the tube. What is measured in the mutual-conductance type of tester?

A. The mutual conductance of the tube is indicated by the amount of plate-current change for a given change in the grid voltage. This is measured in the mutual-conductance tester by varying the grid-voltage by a fixed amount and noting the amount of plate current change. These testers, like the emission type, are usually constructed to read on a good-bad scale.

2.—If a pair of coils of similar inductance are compared, is there any clue as to which has the higher "Q"-value, or can any simple measurement be made?

A. The "Q" of a coil is the ratio of its resistance and reactance at radio frequencies. There is no "simple way" of measuring the H.F. resistance, an R.F. oscillator being a necessity. Suggest however that if the D.C. resistance of one is much higher than that of the other, that may be taken as a not-too-reliable indication that its R.F. resistance might also be higher, and the "Q" accordingly lower.

3.—There are three types of current to be measured, A.C., D.C., and pulsating D.C. To measure these we have two kinds of milliammeters available, A.C. and D.C., and three kinds of voltmeters, D.C., A.C. and rectifier A.C., all assumed of medium resistance, say 1,000 ohms per volt. Assume a loaded circuit with unknown characteristics to be measured, that is, we do not know what part of the set it is nor what type or value of current it carries. The final answer must tell us completely what it is, and the question is: Using each type of meter, a milliammeter in series and a voltmeter in shunt, what will each one read, with each type of current? What are the dangers of harm to the instruments?

A. If absolutely nothing was known about the characteristics of the circuit, there would be great danger of damage to instruments. It is, however, possible to get a rough idea of some of the characteristics by inspection. (Whether the voltage was in the order of 10 or 10,000 would be indicated by the insulation, and the amount of current by the size of the conductors.)

Having made what intelligent inferences are possible, first use an A.C. voltmeter of the highest range likely to be needed. Observing the results, it will be possible to substitute one that will give a reading in such part of the scale as to be reasonably accurate. Now a D.C. voltmeter may be shunted across it momentarily, and if the reading is the same or (for some types of A.C. meters) about 10% lower, it may be assumed you have a pure D.C. circuit. If it remains on zero, your circuit is pure A.C. Widely different readings on the two meters would indicate pulsating D.C.

Given the type of current, the next step would be to use appropriate milliammeters, if meters apparently large enough to handle the supposed current were available. Again the safety rule is to use large meters till the approximate current is discovered.

Should the current be pulsating D.C.,

(Continued on following page)

A.C. meters should be used, as they indicate the effective current and voltage in the circuit. A D.C. meter, on the other hand, registers zero on pure A.C. and since a pulsating D.C. current can be broken down (mathematically) into a constant and an alternating component, measure only the constant current component of pulsating D.C., causing large errors in certain types of pulsating current circuits. The exact error would depend on the wave form. It might however be difficult to deduce that waveform from a comparison of the two meters, and a cathode-ray oscilloscope is needed for such a job.

As you see, it is quite easy to get a higher reading on an A.C. than a D.C. meter, and, paradoxical as it may seem, A.C. meters are the only correct ones for measuring certain D.C. circuits.

A couple of points in regard to the apparatus. Where voltmeters of 1,000 ohms per volt resistance are used, milliammeters of practically zero resistance must be employed to be sure of accurately measuring current in an unknown circuit. The rectifier type A.C. voltmeter is so called because of its construction, and gives the same results as any other A.C. voltmeter of equal sensitivity. An A.C. voltmeter of 1,000 ohms per volt is extremely likely to be a rectifier type.

SHORT-WAVE CONVERTER

? *Will you please send me a diagram for a short-wave converter?—R.C.S., Denver, Colo.*

A. The diagram shown here will work with ordinary short wave coils. Use two separate variable condensers with slow-motion tuning dials. Once the set is working well, a few turns may be taken off the grid windings of the oscillator coils (at least for the 160 and 80-meter coils) to make the two dials read alike. On the higher frequency coils this will not be necessary.

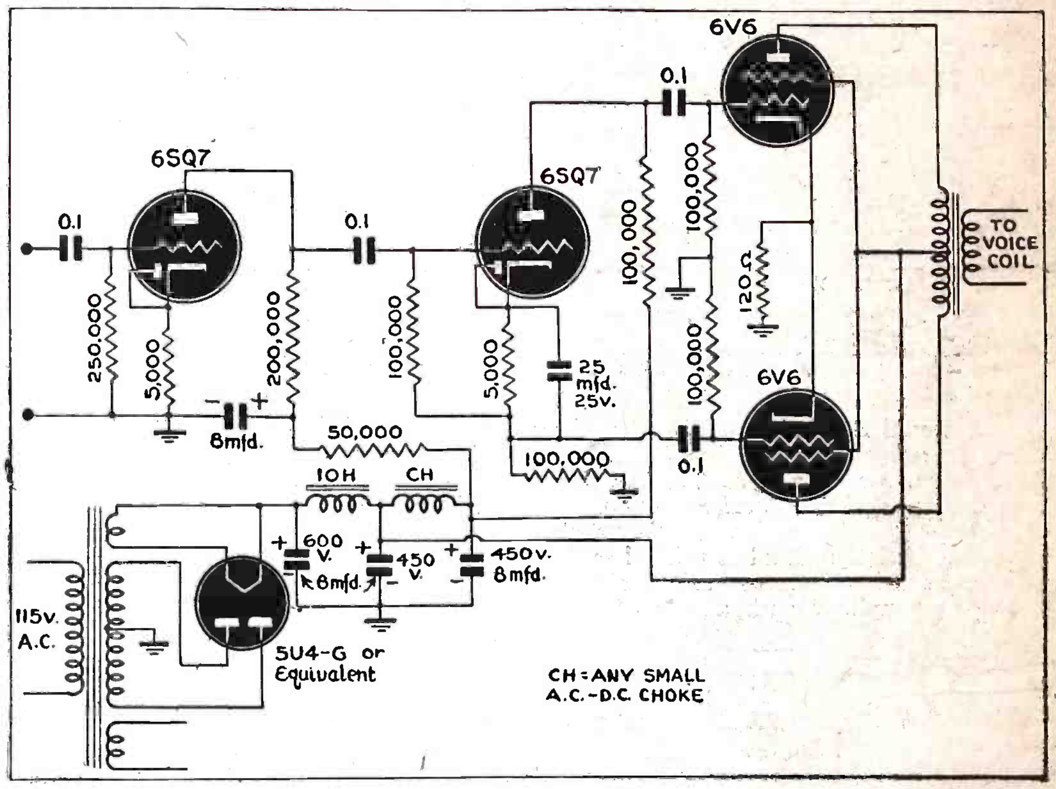
The coil marked I.F. should be a 455-Kc. type, tunable up to about 600 meters. The tuning range of these I.F. transformers is specified in the catalogs, and you should be sure to obtain one with a wide range. It can then be connected to the input of the receiver and tuned to some point between 550 and 600 Kc., or if better results are obtained, may be hooked right across the grid of the first I.F. tube and ground, and tuned to the I.F. of the receiver.

A HI-FI AMPLIFIER WITH 6SQ7'S

? *Kindly publish a diagram for a small amplifier. I have several 6SQ7 tubes, 2 6V6's and a 5U4. This amplifier is to work from a phonograph with crystal pickup and its own volume control. Low-note reproduction is essential, but extreme output is not so important.—L.V.M., Newport News, Va.*

A. The schematic given here will fill your requirements. Low-note reproduction is assured by large blocking condensers and relatively low-resistance grid-leaks. No cathode by-pass condenser is used on the first tube. The "kangaroo" inverter circuit is used, as it is the only one adaptable to the tubes you have.

The double choke and the filtering system in the plate circuit of the first tube should eliminate feed-back as well as hum. The choke marked "10-henry" may be the speaker field, if your speaker is a low-resistance type. The second choke may be one of the small A.C.-D.C. type, as the current drawn through it is very small.



2-TUBE MIDGET AMPLIFIER

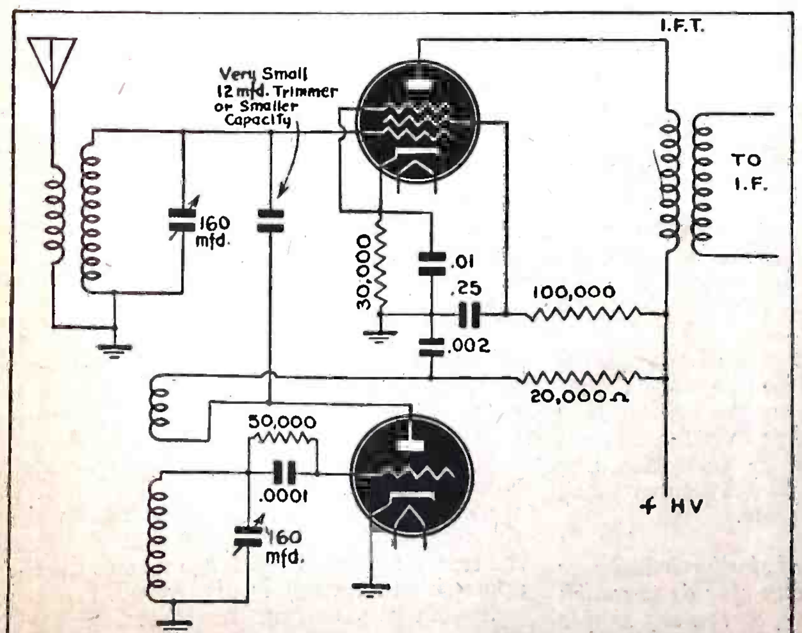
The 2-tube midget amplifier on Page 496 of the May issue looks like the same diagram which appeared in January, 1940.

I built this amplifier but it wouldn't work till the 3000-ohm resistor shown connected to the ground side of the 10-mfd. condenser was removed and placed on the opposite side of this condenser.—*I. G., Akron, Ohio.*

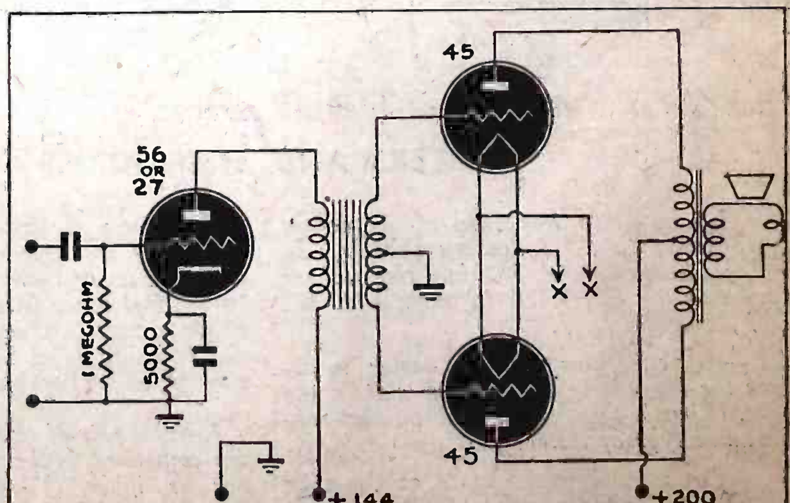
MAJESTIC AMPLIFIER

? *I would like to add an amplifier to my present receiver, for greater power. I have a Majestic Model 90 power pack in good condition, as well as most of the other parts of the set.—J. J. M., Buffalo, N. Y.*

A. If your input transformer is in good condition, the Model 90 amplifier may almost be lifted out bodily and used as is. An input circuit is shown. The top input lead may be attached to the plate end of the output transformer—the bottom end to the chassis of your receiver. If a permanent job is required, better results will be obtained by taking out the receiver output transformer and substituting a large audio-frequency choke. The filaments of the 45's must be attached to the filament winding which has a center tap and a resistor to the negative terminal, as this resistor furnishes the bias for these tubes. The 56 may be hooked up to the other filament winding.



Set at the left is a short-wave converter, using 6J7 and 6C5 or their equivalents, such as 77 and 76. Below is an amplifier made from the audio end of an old Majestic radio. Voltages shown are as supplied from the Model 90 power pack.



Diagrams for

The Radio Experimenter

If you have a new Hook-Up, send it along; a pencil diagram will do. Be sure to include a brief description.

All diagrams and descriptions accepted and published will be awarded six-month subscription. Diagrams may be for receivers, adapters, amplifiers, etc. Send them to **Hook-Up Editor, RADIO-CRAFT, 25 W. Broadway, New York City 7.**

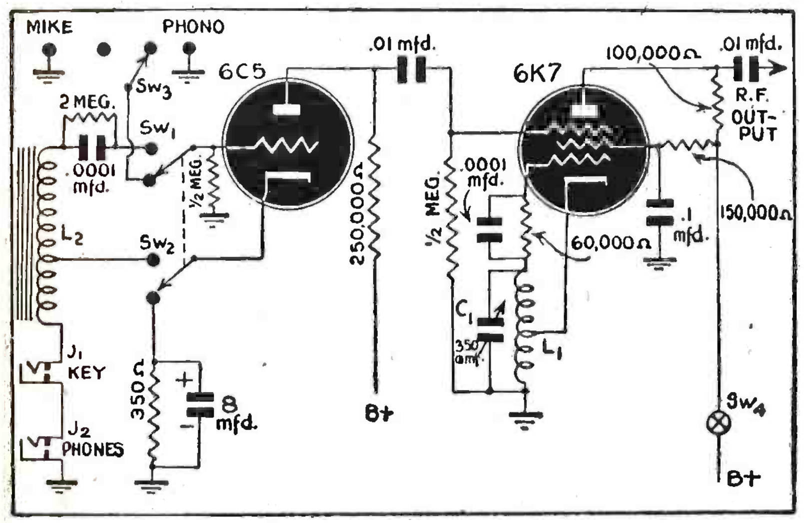
CODE AND PHONO OSCILLATOR

Not being able to find a diagram for a code-practice oscillator which could also be used as a phono oscillator, I finally designed this one, which I believe will interest your readers.

Both oscillators are of the Hartley design, using a 6K7 as the R.F. oscillator, and a 6C5 as the audio oscillator. The secondary of an input transformer is used as the inductance in the audio oscillator. When the ganged switches Sw.1 and Sw.2 are in the "up" position, the 6C5 acts as an audio oscillator; when they are down the tube is an audio amplifier to amplify the signals from "PHONO" or "MIKE," which is controlled by Sw.1.

The 6K7 is a radio-frequency oscillator. Coil L1 is wound with 135 turns of No. 30 copper enamelled wire on a 1-inch form, and tapped for the cathode 35 turns from ground. If the set is being used only as an audio oscillator, Sw.4 may be used to remove plate and screen voltages from the 6K7.

The output of the 6C5 when used either as a code oscillator or as an amplifier, is condenser-coupled to the suppressor grid of the 6K7. This provides sufficient modulation. One person may practice code with phones plugged in to J2, or several may listen to the signal from the receiver loudspeaker when the 6K7 is used to transmit it to the receiver. When used this way, the rig acts like a phono oscillator.



If condenser C1 is calibrated this set may be used as a signal generator because J1 and J2 are of the closed-circuit type. Removal of the phones and key closes the cathode circuit to ground, and provides a continuous audio oscillation, which in turn modulates the R.F. oscillator.

FRANK HAIBIN,
Mobile, Ala.

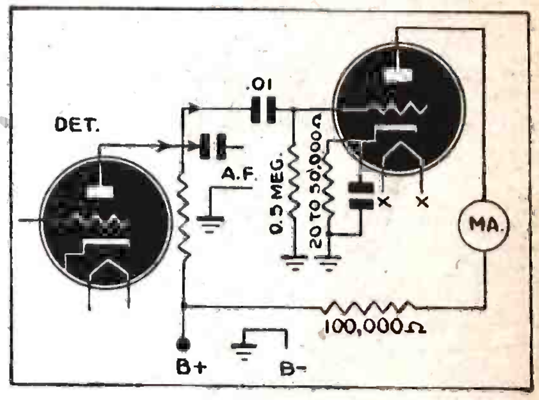
TUNING INDICATOR

Here is a diagram of an amplified tuning indicator.

It is possible to use a common "A" and "B" supply with this diagram. Any triode that has a cathode can be used, such as the 76, 37, 56, or 27, according to whatever "A" supply is presently on the receiver.

One of the main features of this item is that it will work even on a one-tube set.

RICHARD GRAHAM,
Teaneck, N. J.



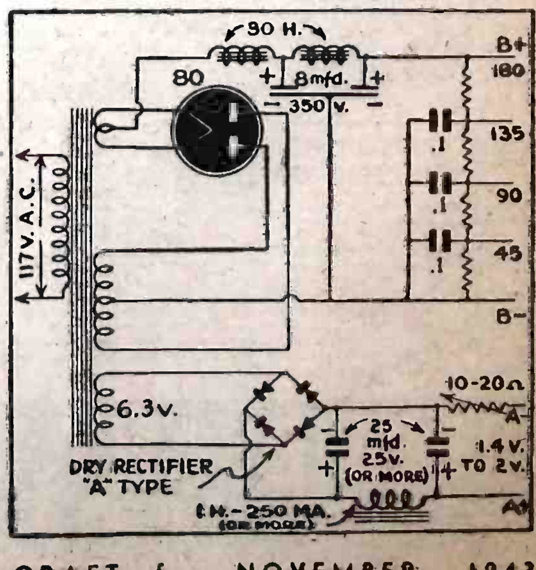
POWER PACK FOR PORTABLES

I found this pack to be very useful around the shop. Most of the parts can be picked up in the serviceman's junk box.

I found the 0.1 mfd. condensers quite satisfactory for bypassing the bleeder sections, though possibly larger ones might be better in certain cases. The bleeder resistors will have to be calculated for the currents drawn by the particular receiver. This should be easy, as the amount to be drawn can be estimated from the tube manuals.

The secondary of the power transformer must have a voltage of 6.3 to supply the 1.4 battery voltage. The rectifier is from an old battery charger.

J. GRAULICH,
Brooklyn, N. Y.



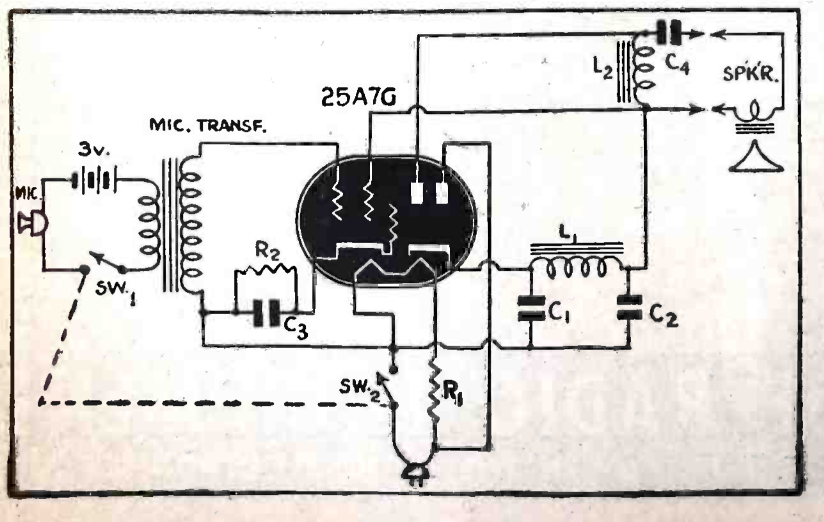
COFFEE POT AMPLIFIER

Some time ago a local restaurant, of the "coffee pot" type, where they shout out orders like "Gene Autry on a white saddle!", asked me to build a cheap yet durable amplifier for use between the counter and the kitchen.

So I got busy and started to assemble such a unit. In order to keep down the expense of the proposition I decided on using a dual purpose tube, and cutting down necessary parts to the minimum.

For a microphone I used an old carbon mike, and a 3:1 audio-frequency transformer for the mike transformer. For the loudspeaker in the kitchen, I used an old 5-inch diameter magnetic type loudspeaker.

For a cabinet I used an old midget type receiver cabinet. The cabinet, containing the loudspeaker and the amplifier, is kept in the kitchen; the mike of course at the counter. When the counterman receives an order he barks it into the mike and it is heard distinctly above the kitchen clatter by the chef.



The circuit I used may or may not have appeared before in *Radio-Craft*, but the idea and the use to which I put it may be new to some of your readers.

Anyway I believe it is rather original and perhaps some others can build such a communicator such as this.

GERALD SAMKOFSKY,
Brooklyn, N. Y.


"HOGARTH'S ECHOPHONE EC-1
SURE SOOTHES THE SAVAGE BREAST"
SGT. KILDAY
-CAMP LEE

(Continued from page 81)

is *decreased* and the frequency *rises*. When the grid swings negative the lagging plate current of the modulator decreases and so does the apparent inductance; therefore, the net inductance increases and the oscillator frequency is *lowered*.

By this analysis, it is plain that the oscillator frequency is deviated from its resting frequency linearly with respect to the amplitude of the audio and the *rate* of deviation is linearly proportional to the frequency of the audio. The R.F. choke shown in series with the modulation grid and the secondary of the microphone input transformer is used to keep R-F out of the microphone circuit. It is self-evident that a very small amount of audio power is required to give satisfactory deviations. Deviations of 50 Kc. are easily obtainable with the lower power type transmitting tubes. Since FM transmission is carried on at U.H.F. the oscillator is usually operated at some low frequency for stability and followed up by a number of frequency multipliers to reach the final operating frequency. This factor also necessitates a small deviation at the oscillator as the deviation is multiplied as the frequency is multiplied. This provides every flexible and compact transmitting system for portable or mobile work.

THE CAPACITIVE REACTANCE METHOD OF MODULATION

We have described how a vacuum tube may be made to resemble an inductive reactance. In this paragraph we are going to show two practical methods of making the modulator appear as an apparent capacitive reactance. Referring to Fig. 6, it is seen that the circuit of Fig. 5 has been changed very little to accomplish this.

You will notice that only two changes have been made in the circuit. First the cathode is connected to the bottom end of L_T and ground is tapped up on the coil for proper feedback. This is to make the bottom end of the tank "hot" to R.F. Second, the R.F. feed-back circuit to the grid of the reactance modulator is connected to the bottom end of L_T rather than the top end. This is to obtain the proper phase relationship.

CIRCUIT ANALYSIS

Here it is also plain that the modulator plate voltage consists of the D.C. plate voltage and the R.F. voltage impressed from the oscillator tank L_TC_T. The R.F. voltage and current fed to the modulator grid through the network C_1R_1 are 180° out of phase with the R.F. voltage and current fed to the modulator plate through C_2 with all other things remaining the same. The R.F. current flowing through the modulator grid by-pass C still leads the voltage across it by 90°, and the voltage across is the audio voltage therefore the audio grid voltage lags the tank voltage by 90° at point 1, and the modulator plate current will be in phase with grid voltage; therefore the modulator plate current will lead the R.F. tank voltage at point 1 by 90°, but since the R.F. voltage applied to the modulator plate is taken at point 2 which is 180° out of phase with the voltage at point 1, the A.F. plate current will *lead* the modulator plate voltage by 90° so that the modulator appears as an apparent *capacitive reactance* across the oscillator tank. When the modulator grid swings positive, the leading plate current increases which represents an increase in the net capacity of the oscillator tank (capacities in parallel add) and the oscillator frequency is lowered.

When the modulator grid swings negative, the leading modulator plate current decreases and this represents a net decrease of the oscillator tank capacity; therefore, the oscillator frequency rises. The same circuit design rules and adaptations apply that were described for the inductive reactance method.

In Fig. 7 is shown a modified version of the capacitive reactance method of modulation. This system shown in Fig. 7 works on the same principle as the system in Fig. 6, but the method of obtaining the leading modulator plate current is interesting enough to merit explanation. It can be seen that Fig. 6 has been altered only in two respects to give us this modified version of Fig. 7. First, the modulator grid by-pass (phase shift) condenser has been removed; second the feed-back condenser and its reactance is made very small to all frequencies encountered. R is inserted in series with the oscillator tank condenser C.T. The value of R is made extremely low with respect to the reactance of C_T (usually about 10 ohms for R).

ANALYSIS OF THE MODIFIED CIRCUIT

The R.F. current flowing through C_T leads the voltage across it is the R.F. tank voltage impressed on the modulator plate; this leading current through C_T also flows through R to ground producing a voltage drop across R which will be in phase with the current flowing through it, since the current flowing through R is leading the tank voltage by 90° then the voltage across R will also lead the tank voltage and modulator R.F. plate voltage by 90°. This leading voltage then fed to the grid of the modulator through C_1, since the grid voltage leads the plate voltage by 90°, and plate current being in phase with grid voltage the modulator plate current will lead the modulator plate voltage by 90° and the modulator will appear as a variable capacitive reactance across the oscillator tank. There are many modifications of both methods thus described, but they work on essentially the same principles.

STABILIZATION METHODS

From the previous explanations it has been seen that only self-excited type oscillators apply to the reactance method of FM. Self excited type oscillators do not provide the necessary amount of frequency stabilization in circuits thus described; however there are two methods of providing increased frequency stability of the oscillator; one of which will be described here. In Fig. 8 is shown a method by which the phase shift is tuned, thus providing greater stabilization of the oscillator's resting frequency.

When the modulator is placed across the oscillator tank its apparent inductive or capacitive reactance is reflected into the oscillator tank decreasing the Q of the oscillator tank, thereby decreasing the oscillator's frequency stability. In Fig. 8 it is seen that the modulator input circuit is tuned by L_1 and C_1 to the oscillator frequency. The R.F. is then linked from oscillator tank to the modulator tank for feed back and phase shift. The phase shift takes place through dynamic grid-filament capacitance of the modulator tube, so that the modulator is effectively an apparent capacitive reactance.

This phase shift is tunable by C_1, and since this tank is damped by R_1, the modulator reflects practically a constant reactance back into the oscillator tank and its stability factor is raised considerably.

In one method used quite extensively in practice, a pair of balanced modulators are used with push-pull input and parallel output. Since the tube inputs are 180° out of phase one tube will act as an inductive reactance while the other acts as a capacitive reactance. Any resultant reflected impedance will be balanced out, so that oscillator frequency stability is maintained over a wide range.

CRYSTAL-CONTROLLED OSCILLATORS

Another method of stabilization utilizes a crystal controlled oscillator in conjunction with a discriminator and mixer and will be discussed in detail in the installment on special circuits.

Even with an electron coupled oscillator and one of the two methods of stabilization the resting frequency will still not be stable enough for commercial FM broadcast. Here is where it is absolutely necessary to maintain a stability of the highest possible value. The most stable type is of course the crystal controlled oscillator. Unfortunately, the capacitance and inductance of a crystal are too small in value to apply the reactance method of modulation to this type of oscillator.

In a succeeding instalment the methods of *phase modulation* will be explained. This method permits the use of a crystal controlled oscillator, and is used extensively in broadcast and commercial communications where frequency stability is essential.

(This is the first of a series of articles on frequency modulation by Mr. Kleinman. The second, which deals with another phase of this important subject, will appear in the December issue.)

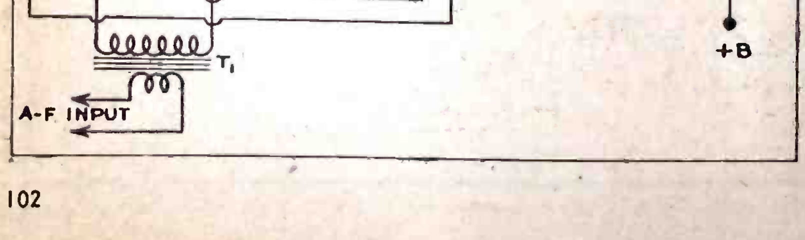


Fig. 8.—A tunable phase-shift with a link coupling is used in this circuit, as a means of improving frequency stability. The reactor tube in this circuit is effectively a capacitor.

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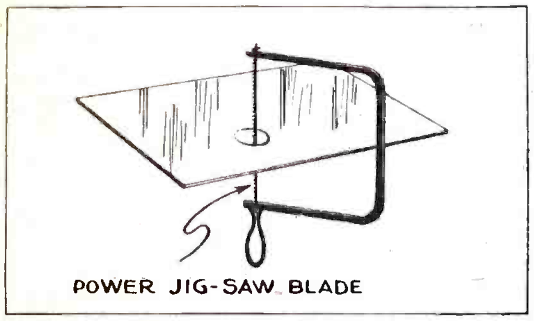
RADIO KINKS

ALUMINUM CUTTER

Following is a diagram of a cheap and efficient manner of cutting holes in aluminum or sheet metal for tube sockets, etc. A coping saw may be purchased from a five and ten cent store and a blade for a power jig saw from a hardware store. A hole is drilled in the chassis near the edge of the circle to be cut. The jig saw blade is slipped through and fastened to the frame of the coping saw. By changing the position of the blade, a circle is cut out.

The small necessary cost of the saw and blade is a saving over that of a circle cutter or a punch for cutting metal.

WM. N. PLIMPTON,
High Bridge, N. J.

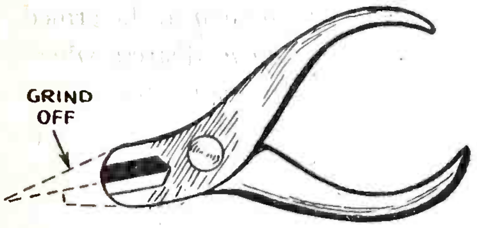


SAVE THE OLD PLIERS

When you have trouble with the breaking and bending of long-nosed pliers, making them useless for the purpose intended, grind off the noses.

Instead of having to discard them, you have a novel pair of diagonal cutting pliers.

AMOS BAFF,
Liberty, Mo



A GOOD CONTACT MIKE

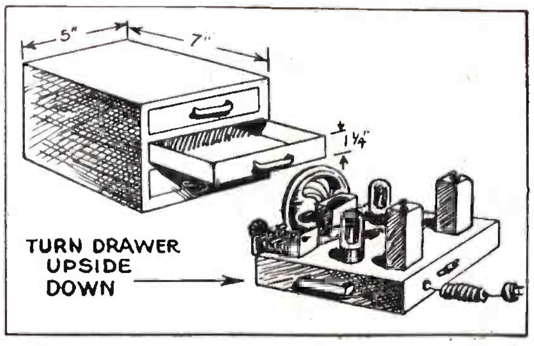
A single head phone makes a very good contact mike. This is a mike that is placed on the body of a string instrument so that the music can be amplified through your phone oscillator or amplifier.

A phone in which the magnet has become quite weak is best. If the notes do not come through, cut washers from thin writing paper. Place them between the diaphragm and shell one at a time. The object is to increase the space between the diaphragm and the armature. Next glue a piece of felt or flannel with a hole in the center to the ear piece of the phone. Mount the mike on the bass side of the tail piece, just behind the bridge, using scotch tape to make it secure. Plug it into the input of your phone amplifier and you are ready to go places.

ERNEST W. CARLSON,
Oswego, Montana.

CHEAP METAL CHASSIS

As everyone knows, it is very difficult to obtain a metal chassis, but I have found a way to get some of a reasonable size.

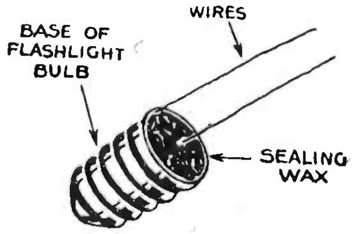


Many of the ten cent stores still have 75 cent metal cabinets with drawers. Take out a drawer, turn it upside down and you have a chassis!

PETER VIEMEISTER,
Roslyn, New York

FLASHLIGHT TEST LEADS

To use flashlight batteries for testing purposes, take an old flashlight bulb and remove the glass and wires leaving only the metal shell. Then solder two wires



on the contacts and fill the whole thing with sealing wax. Then screw it into a flashlight. You will find that it works very well.

MICHAEL F. BENSON,
Fort Qu'Appelle, Sask.

6-VOLT WINDCHARGERS

As a precaution against the burning out of lamp bulbs and causing serious injuries to the radio set due to lightning discharges, the steel tower on which the windcharger is mounted should always be grounded. The grounding of the tower may cause disturbances on the radio when the windcharger is running; especially over the short-wave bands. To avoid this disturbance a single-pole single-throw switch may be connected in the ground line between the tower and the ground connection. In good weather the switch is left open so as not to cause any disturbance; but in an electrical storm the switch should be closed to make the ground circuit complete.

To make battery changes without having to take time to cut the windcharger off is possible if a single-pole single-throw switch is connected between the two generator wires just above the ammeter connections. The switch is left open, until a battery change is made. When the change is to be made the switch is closed, to ground the generator so it will not burn out. In this way the batteries may be changed without cutting the windcharger off. In severe electrical storms the battery should be disconnected from the charger, and the switch closed.

W. L. SUMRULD,
Snyder, Texas.

SWITCHES FROM OCTAL TUBE BASES

The octal tube bases and sockets serve admirably in making all kinds of switches.

Fig. 2 is recommended as an impedance-matching switch for sound systems where the switch is mounted directly on the speaker baffle cabinet, since it does not rattle as a certain popular brand on the market does.

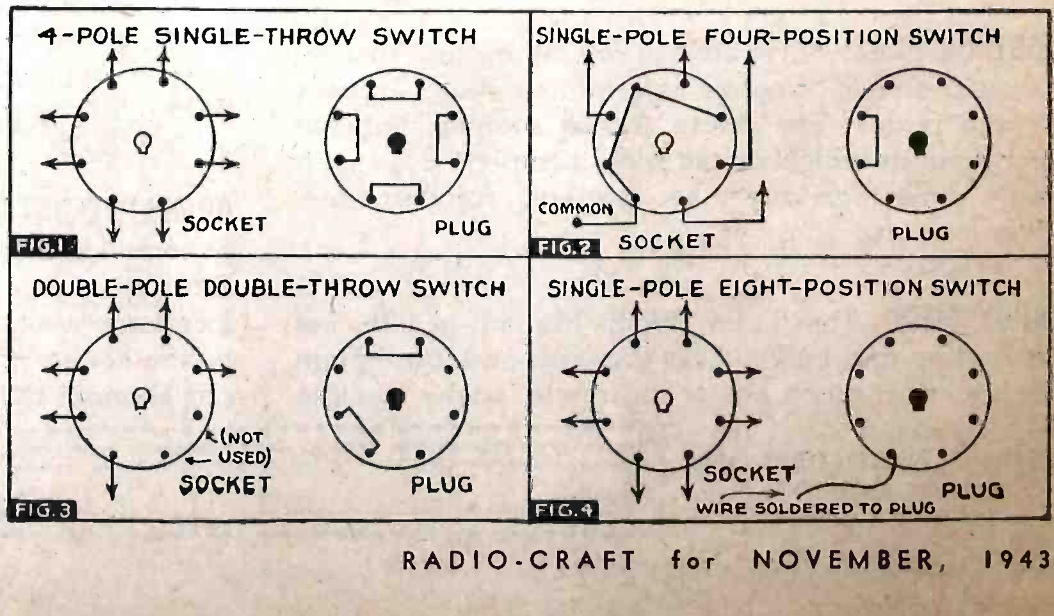
The remaining figures represent other combinations which often arise, and which the reader may find use for.

A dab of paint on both the plug and socket identifies the positions. In some cases the guide pin is snapped off with a pair of pliers to facilitate changing positions.

The glass type tube-bases can be cut to proper size with a hacksaw and filled with sealing compound.

The drawing shows several possible combinations for various purposes. Other combinations can be made as desired, and by connecting coils, condensers or resistors across plug terminals, various circuit combinations can be made up.

JOHN GARCIA
Tampa, Florida



THE LISTENING POST

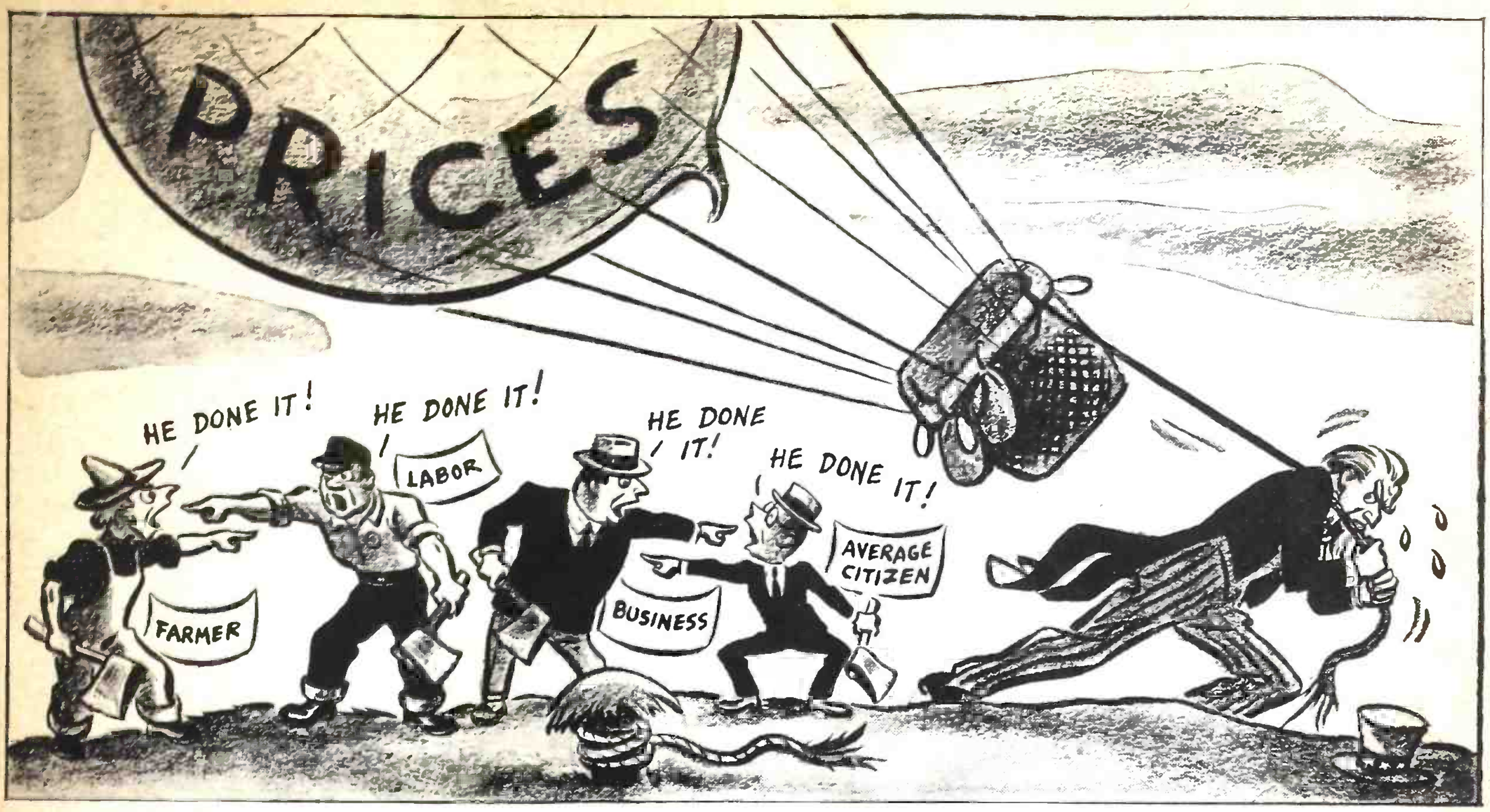
(Continued from page 96)

Country-Call	City	Frequency and Schedule
Malaya		
———	———	11.84; "Radio Shonan"; controlled by the Japanese.
Martinique		
———	Fort de France	9.7
Mexico		
XEWW	Mexico City	9.50; evenings.
XEFT	Mexico City	9.543; evenings.
XBBH	Mexico City	10.050; 11:25 am to 12:45 pm; at times all day, Spanish.
XEWI	Mexico City	11.900
Morocco		
CNR	Rabat	8.035
Mozambique		
CR7BI	Lorenco Marques	17.915
CR7BE	———	9.84; news (English) 4:50 pm daily.
Newfoundland		
VONH-VONG	St. Johns	5.980; 7:30 to 8:15 pm.
Nicaragua		
YNDG	Leon	7.660; 7:30 pm to ?
Norway		
LLH	Oslo	9.645
Nova Scotia		
CHNX	Halifax	6.130; Sunday, 8 am to 6:55 pm; Monday to Thursday, 6:45 am to 10:15 pm; Friday and Saturday, 6:45 to 11 am.
CJCX	Sydney	6.010; Monday to Friday, 7 to 11 am; Saturday, 6:45 to 11 am; Sunday, 8 to 11 am.
Panama		
HP5F	Colon	6.030; 11 pm to ?
HB5A	Panama City	11.70
HP5Q	Panama City	11.74; evenings to midnight.
HP5G	Panama City	11.790; 9:45 pm to ?
Peru		
OAX4Z	Lima	6.082; "Radio Nacional".
OAX4H	Lima	6.095; "Radio Mundial".
OAX4W	Lima	9.415; "Radio America"; 9 pm to midnight.
OAX4T	Lima	9.562; "Radio Nacional"; 2 to 8 pm.
Philippines		
KZRH	Manila	9.64; unheard in recent months.
Portugal		
CSW7	Lisbon	9.735
Rumania		
———	———	11.6; "Rumanian Freedom Station"; 1:45 to 1:55 pm; 4:15 to 4:25 pm.
U.S.S.R. (Russia)		
———	Moscow	5.44; 6:48 to 7:25 pm.
———	Moscow	9.48; 6:48 to 11 pm.
———	Moscow	10.445; 7:40 to 8:20 am.
———	Moscow	11.947; 7:30 to 11 pm.
———	Moscow	12.19; 6:48 to 7:25 pm.
———	Moscow	15.750; North America beam, 7:40 to 8:50 am; Sundays, 8:20 to 9:30 am.
U.S.S.R. (Siberia)		
———	Komsomolsk	9.545; 7:40 to 8:20 am; 10:15 to 10:30 am.
———	Komsomolsk	15.11; 7:40 to 8:20 am; 5:15 to 5:40 pm; 6:48 to 7:25 pm; 9:15 to 9:40 pm; 11:15 to 11:40 pm.
———	Komsomolsk	15.230; 7:40 to 8:20 am; 10:15 to 10:30 am; 5:15 to 5:40 pm; 6:45 to 7:25 pm; 9:15 to 9:40 pm; 11:15 to 11:40 pm.
Senegal (Africa)		
FGA	Dakar	15.345; 3:15 to 5:20 pm.
South Africa		
ZRK	Cape Town	6.098; day and night transmissions.
ZRL	Cape Town	9.626; daytime transmissions.
ZRD	Durban	6.148; day and night transmissions.
———	Durban	9.755; day and night transmissions.
ZRH	Johannesburg	6.007; evening transmissions.
ZRH	Johannesburg	9.523; daylight transmissions.
Spain		
EAQ	Madrid	9.86; 7 to 7:15 pm.
EAJ3	Valencia	7.037; 4 to 6 pm.
Sweden		
SBU	Motala	9.535; 12 to 2:15 pm.
SBP	Motala	11.705; 12 to 2:15 pm.
SBT	Motala	15.155; 12 to 2:15 pm; morning transmissions.
Switzerland		
HER4	Berne	6.165; Canadian beam, 9 to 11 pm, except Saturday.
———	Geneva	9.520; 9 to 10:45 pm.
HER4	Berne	9.535; North America beam, evenings except Saturdays, 9:30 to 11 pm.
HBF	Geneva	18.45
HBH	Geneva	18.48
Thailand		
HSP5	———	11.72
Turkey		
TAP	Ankara	9.465
TAQ	Ankara	15.195
Uruguay		
CXA19	Montevideo	11.705; evenings.
Vatican City		
HBJ	Vatican City	11.74
Venezuela		
YV5RN	Caracas	4.92; evening transmissions.

Following is the revised list of the United States stations:—

City and State—Call	Frequency and Schedule
Boston, Massachusetts	
WBOS	7.832; European beam, 12:15 to 1 am; East South America beam, 8:30 pm to midnight.
WBOS	9.570; European beam, 5 to 7 am.
WBOS	15.210; European beam, 7:15 to 9:30 am; 11 am to 5:15 pm; North European beam, 9:45 to 10:45 am; East South America beam, 5:30 to 8:15 pm.
WRUA	7.575; North African beam, 8:45 to 11:45 pm.
WRUL	7.805; North African beam, 2:15 to 6 am.
WRUL	11.730; Caribbean beam, 6:30 to 7:15 pm; Central America beam, 7:30 pm to 2 am.
WRUL	15.350; European beam, 10 am to noon; 12:05 pm to 6:15 pm.
WRUS	9.700; Mexican beam, 7:30 pm to 2 am; North African beam, 2:15 to 6 am.
WRUS	15.130; North African beam, noon to 7:15 pm.
WRUW	6.040; North African beam, 2:15 to 4 am; Central American beam, 7:30 pm to 2 am.
WRUW	9.700; Caribbean beam, 6:30 to 7:15 pm.
WRUW	11.730; North African beam, 8 to 10 am; European beam, 2:30 to 6:15 pm.
WRUW	17.750; North African beam, 10:15 am to noon; European beam, 12:05 to 2:15 pm.
Cincinnati, Ohio	
WLWK	6.080; European beam, 12:15 to 4:30 am; West South America beam, 8:30 pm to midnight.
WLWK	15.250; European beam, 8:30 am to 5:15 pm; West South American beam, 5:30 to 8:15 pm.
WLWO	7.575; European beam, 12:15 to 2:30 am.
WLWO	9.59; West South America beam, 8:30 pm to midnight.
WLWO	11.710; European beam, 6:30 to 9 am; 3:45 to 5:15 pm.
WLWO	17.800; European beam, 9:15 am to 3:30 pm; West South America beam, 5:30 to 6:45 pm.
New York City	
WCBX	6.170; European beam, 11:45 pm to 3 am.
WCBX	9.490; Latin America beam, 5 to 11:30 pm.
WCBX	15.270; European beam, 7 am to 4:45 pm.
WCDA	6.060; Mexican beam, 7 pm to 2 am.
WCDA	11.145; European beam, 5 to 6:45 pm.
WCDA	17.830; European beam, 7:45 am to 4:45 pm.
WCRC	9.650; European beam, 12:15 to 2 am.
WCRC	11.830; Latin American beam, 5:25 pm to midnight; European beam, 6 am to 5:15 pm.
WKLJ	7.565; North African beam, midnight to 3 am.
WKLJ	9,750; African beam, 3:15 to 7 am; 4:30 to 11:45 pm.
WKLJ	15.290; North African beam, 7:15 am to noon.
WKTM	6.370; European beam, 8:15 pm to 5 am.
WKTM	11.893; European beam, 6 to 8 pm.
WKRD	7.820; European beam, 7:30 pm to 12:30 am; North African beam, 12:45 to 4:45 am.
WKRD	9.897; European beam, 5 to 6:45 am.
WKRD	12.967; North African beam, 12:45 to 3:30 pm; European beam, 5:15 to 7:15 pm.
WKRD	15.190; Central Africa beam, 7 to 9 am.
WKRD	17.760; South African beam, 9:15 to 11:15 am; Central Africa beam, 11:30 am to 12:30 pm; North African beam, 3:45 to 5 pm.

(Continued on page 119)



Never mind "who done it"—pitch in and help *get* it down!

THIS IS YOUR UNCLE SAM talking—but I'm going to talk to you like a DUTCH uncle, to keep all of us from going broke.

Ever since the Axis hauled off and hit us when we weren't looking, prices have been nudging upwards. Not rising awfully fast, but RISING.

Most folks, having an average share of common sense, know rising prices are BAD for them and BAD for the country. So there's been a lot of finger pointing and hollering for the OTHER FELLOW to do something—QUICK.

The government's been yelled at, too. "DOGGONNIT," folks have said, "WHY doesn't the government keep prices down?"

Well, the government's done a lot. That's what price ceilings and wage controls are for—to keep prices down. Rationing helps, too.

But let me tell you this—we're *never* going to keep prices down just by leaning on the government and yelling for the OTHER FELLOW to mend his ways.

We've ALL got to help—EVERY LAST ONE OF US.

Sit down for a minute and think things over. Why are most people making more money today? It's because of the SAME cussed war that's killing and maiming some of the finest young folks this country ever produced.

So if anyone uses his extra money to buy things he's in no particular need of . . . if he bids against his neighbor for stuff that's hard to get and pushes prices up . . . well, sir, he's a WAR PROFITEER. That's an ugly name—but there's just no other name for it.

Now, if I know Americans, we're not going to do that kind of thing, once we've got our FACTS straight.

All right, then. Here are the seven rules we've got to follow as GOSPEL from now until this war is over. Not some of them — ALL of them. Not some of us — ALL OF US, farmers, businessmen, laborers, white-collar workers!

Buy only what you need. A patch on your pants is a badge of honor these days.

Keep your OWN prices DOWN. Don't ask higher prices—for your own labor, your own services, or goods you sell. Resist all pressure to force YOUR prices up!

Never pay a penny more than the ceiling price for ANYTHING. Don't buy rationed goods without giving up the right amount of coupons.

Pay your taxes willingly, no matter how stiff they get. This war's got to be paid for and *taxes are the cheapest way to do it.*

Pay off your old debts. Don't make any new ones.

Start a savings account and make regular deposits. Buy and keep up life insurance.

Buy War Bonds and hold on to them. Buy them with dimes and dollars it HURTS like blazes to do without.

Start making these sacrifices now—keep them up for the duration—and this country of ours will be sitting pretty after the war . . . *and so will you.*

Uncle Sam

KEEP PRICES DOWN!

Use it up · Wear it out
Make it do · Or do without

This advertisement, prepared by the War Advertising Council, is contributed by this magazine in co-operation with the Magazine Publishers of America.

CAPACITIES IN THE TUBE

(Continued from page 83)

ly charged screen grid, tending to reduce plate current and to increase screen current. When the values of screen and plate voltage are nearly equal, this secondary emission effect is particularly marked. The action of the tetrode is illustrated in Figure 4-A, the placement of the grids being irregular, as shown.

In order to further increase the amplifying possibilities of a tube which has little grid-plate capacity, a third grid, called the suppressor grid, is utilized. The tube now becomes a pentode. It is useful in amplifier circuits because this third grid reduces the effects of secondary emission. The suppressor grid is usually operated at cathode potential. An electron being emitted from the plate surface will now be returned to the plate because of the action of the electrostatic field existing between the suppressor grid and plate. The screen grid in a pentode may even be operated at a somewhat higher potential than the plate without appreciable loss of amplification due to secondary emission. The suppressor-grid to plate capacity can also be utilized to advantage in negative transconductance oscillator circuits. The input impedance of tetrodes and pentodes is high because of low effective grid-plate capacity. However, if the tube is operated in a high-gain circuit, at high frequencies, the effective amplification will lower its input impedance. Figure 4-B illustrates the electronic action of a pentode.

THE BEAM POWER TUBE

Beam power tubes, which have particularly high power sensitivity, are of both tetrode and pentode design. Of particular interest is the beam power tetrode in which the suppressor action is provided by a space charge. In this type of tube, the control grid and screen grid are perfectly aligned so that the stream of electrons travels in "beams" between the turns of wire, as illustrated in Figure 5. The screen may be operated at a higher potential than the plate, and its strong electrostatic field acts to propel electrons toward the plate at a high rate of speed. Most of these electrons move rapidly in a straight line to the plate, very few touching the screen grid because of its position. In the area between screen and plate, the combined electrostatic fields of many low-velocity electrons form a space-charge, similar to that surrounding a hot cathode. This space-charge region acts to repel secondary electrons coming from the plate, much the same way as the electrostatic field of a suppressor grid functions. The tube contains a pair of beam-forming plates which concentrate the electron streams into a small, dense, space-charge area. They are operated at cathode potential, and their position, by concentrating the beam and strengthening the space-charge, helps to prevent the return to the screen of stray secondary electrons.

Multi-electrode tubes, containing six, seven, or even eight different elements, all utilize interelectrode capacities and the accompanying electrostatic fields of force. In converters, mixers, etc., the extra electrodes provide adequate electrostatic shielding for efficient circuit design and flexibility of operation. Rectifier-pentodes, diode-triodes, double triodes, triode pentodes, and others, combine two or more functions in a single glass or metal envelope. They are constructed so that the electric fields of the various elements do not conflict materially at broadcast-band frequencies. Some multi-purpose tubes have been developed which work at higher frequencies, but low inter-element reactances at short wave-lengths restrict their use somewhat.

THE CATHODE-RAY TUBE

Another type of electronic tube which makes use of interelectrode capacities is the cathode-ray tube. Essentially, it consists of a vacuum in which an "electron gun" shoots a stream of electrons toward a fluorescent screen. Before they reach the screen their paths are refracted either by external coils mounted close to the glass envelope, or by *deflection* plates. The latter method will be described briefly here, because it is a pertinent example of inter-electrode capacities.

In the preceding considerations of thermionic vacuum tubes, the electron stream was almost always parallel to the electrostatic lines of force. If high-velocity electrons travel at right angles to the lines of force, their path is bent. The higher the speed of the electron, the less the refraction, as depicted in Figure 6-A, where electron *a* is moving at higher velocity than electron *b*. If on the other hand, a group of electrons passes between plates having a like charge, the paths become either focussed or diffused, as shown in Figure 8-B and 8-C. The length of focus of the electron paths can be controlled by varying the distances between the plates of the arrangement in Figure 8-D, or by varying the voltages.

Several combinations of focus and dispersion are used in the electron gun, out of which finally emerges a thin, hairline stream of electrons, moving toward the fluorescent screen. Figure 9 shows the action of a simple cathode-ray tube, where variations of voltage applied to the horizontal and vertical deflecting plates will produce a moving luminous dot on the screen. The direction and intensity of electrical impulses can thus be reproduced graphically on the screen.

CAPACITY EFFECTS AT U.H.F.

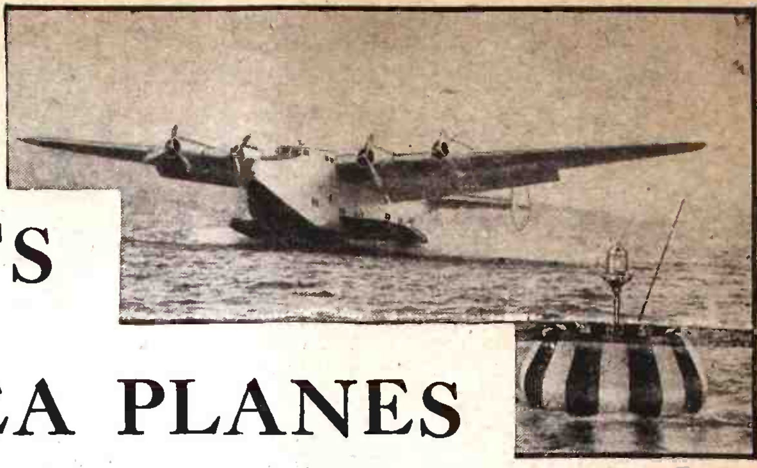
Ordinary thermionic vacuum tubes will oscillate up to at least 100 megacycles. However, at frequencies above about 30 megacycles (10 meters) their power output and general efficiency drops rapidly. At these ultra-high frequencies, input admittance becomes of great importance. As frequency rises, capacitative reactance decreases. Input resistance also diminishes, because even when the control grid is negative, there is sometimes the effect of electrons flowing from cathode to grid. At very short wave-lengths the time required for an electron to travel from cathode to plate may be longer than the time interval of one cycle of signal current. Under such conditions, a negative grid can draw current, resulting in a low effective input resistance. If the reactance and resistance are thus decreased by a rise in frequency, the input admittance will likewise be lowered, causing considerable R.F. losses within the tube. Also, there is increased mutual induction between the leads, causing losses which would be negligible at lower frequencies.

Tubes have been developed which are especially designed for high frequency applications. These have very low interelectrode capacities because of small elements, short leads, and well-spaced terminals. Some or all of these leads are brought out to the top and sides of the tubes, reducing stray capacities that would exist in a stem and base. The input admittance of these tubes is reasonably high. In a 956 acorn tube (illustrated in Figure 6) the electron transit time is negligible at wavelengths above 0.7 meter.

In very high frequency oscillators, the effects of interelectrode capacities are critically important. For example, in one form of the Barkhausen-Kurz oscillator, the triode grid is operated at a positive potential of about 100 volts, and the plate at a small negative potential. Electrons emitted from the cathode are attracted toward the grid, following the general direction of the electrostatic lines of force. Some of them strike the grid at once, and the rest pass between the wires toward the plate. Being negative, the plate repels them, and they flow back toward the grid again. *Some* of them will strike the grid, the rest passing through once more, moving back and forth several times. These oscillations between cathode and plate cause a very high frequency voltage to be developed between the electrodes. See Figure 7. The interelectrode capacities and the applied voltages are the *only* factors which determine the frequency of these oscillations.

In all of the various uses of thermionic vacuum tubes, the interelectrode capacities have an important function. Future developments in the science of electronics will depend in no small part upon new applications of these capacities.

RADIO LIGHTS FOR SEA PLANES



LANDING lights for planes present more than one problem in war areas. The ideal would be a light bright enough to give the pilot of the landing plane perfect vision, but absolutely invisible to anyone else. While such a light is impractical (at the least!) with present techniques, a close approach to it is made with the new Westinghouse Seadrome light, here illustrated.

This lamp is visible to everyone within its range. Its feature is that it is turned on *by radio signals* from the arriving plane, and is again turned off as soon as the plane is safely on the ground. Because the light remains on for the shortest possible time, the danger of its being used by enemy attackers is minimized.

The lamp itself is of the fluorescent type. Red, green, gold and white lamps are used, each having its special significance as a buoy and landing indicator. The lamps are lighted by batteries, supported by the same unit which floats the lamp.

Not much is known of the heart of this device—the electronic instrument which turns on the light when signalled to do so by the incoming plane. Presumably it is an extension of the same "Mystery Control" principle used to tune ordinary radio receivers from a remote point, though radiomen could suggest other types of radio-controlled relays that might do the job as well, or better. The details of this electronic relay are being kept secret till the end of the war, however, to avoid giving useful information to the enemy.

Thus the waves that increase the safety of the aviator in flight by keeping him in touch with his base and supplied with all pertinent information, now assure his safety in landing after a successful flight.

Close-up of the radio-operated landing light. The large, sea-worthy float acts as a buoy in daylight.

The buoys which support the lamp are conspicuously painted, serving as landing aids during the hours of light. The colors of the buoys serve to indicate in the language of the navigator where the safe channels lie, and may carry other information to the pilot bringing in the plane.

RADIO GLIDER BOMB

(*Continued from page* 74)

bombers with their radio glider bombs are being used.

The second objection is that it is practical only in fair weather. In case of fog it would seem to be useless because the radio control operator in the bomber cannot see the convoy. Even in a haze it would be a difficult problem to steer by radio such a small object as a radio glider bomb, because from a height of 35,000 feet it becomes a miniscule object. It probably would also be difficult to use it even in bright moonlight; although here there is a slight advantage because the parent bomber need not climb to a height of 35,000 feet—it being more difficult to use anti-aircraft guns at night, even in bright moonlight as against bright sunlight. All considered the new Nazi device will not panic the Allies because it can only be used at certain times where there is no fog and in bright daylight. Thirdly, it cannot be used out at sea. Lastly the convoy can also hide in a smoke screen, as is shown in our cover illustration.

We now come to the radio element. The layman at first will think that the easiest way to stop a radio-controlled rocket bomb is by "jamming" the enemy bomber's radio transmitting impulses in such a way that the rocket would be forced into an erratic course and drop harmlessly into the sea.

This, however, is not necessarily true for the following reasons: John Hays Hammond, Jr., as well as other experimenters long ago thought of ways and means to safeguard a radio-controlled machine in such a way that enemy radio interference will be ineffective in most cases. They have done so by the simple device of a rotary switch. One such switch is in the radio-control transmitter room, the other in the receiver of the controlled device at a distance. The two switches separated by thousands of feet are synchronized and operated by clock work or electric motors in such a manner that they can be rotated at will at any speed. Moreover this speed is variable. In other words you can make the switches travel fast or slow at the will of the control operator. Next the radio impulses are sent through the correct switch-sector in such a manner that only at certain fractions of a second the right impulse will go through at the transmitter and be received at exactly the same instant through its corresponding switch-sector at the receiver.

This gives an idea of the difficulty to interfere with modern radio control. Moreover it is also possible to change the radio wave lengths or frequencies every few seconds—automatically if necessary—raising the problem to the utmost complexity. Thus, even if every convoy was radio-equipped so as to "jam" an oncoming radio-controlled glider torpedo it would be most difficult to stop it in this manner. Simply because we cannot know exactly when the correct impulse comes through, nor do you know the wave length at which this is accomplished. It is as if one wanted to open a modern safe in a hurry by trying to guess its combination. It just cannot be done—and don't forget that when the radio-controlled torpedo is released from a distance of 35,000 feet up, it is a matter of a minute or less before it will strike, giving the radio defense on board of ship much too little time to do anything effectively. That is the reason why radio-controlled devices are exceedingly difficult to tamper with by radio impulses alone.

No doubt an answer will be found even to this complex problem in due time—there is *always* an answer to *every* war machine. The Allies have one effective answer; that is to send fighter aircraft aloft to keep the bombers so far away that it becomes impossible for them to see the target well and follow down the flight of the radio-controlled rocket. Once we achieve this the problem is solved. This of course means that we must have carriers with effective aircraft to provide the successful air-umbrella for the convoy. Without such a cover a radio-controlled glider bomb, no doubt, can cause serious havoc.

POST-WAR HORRORS?

From a recent broadcast:

"If you, personally, have ever heard the roar of Niagara Falls—or the thunder of a battleship's broadside—or the scream of a plane in a power dive—you realize how tame these same sounds are when you hear them on even the finest conventional radio.

"But with the post-war—model, the newest kind of radio—the roar of Niagara or the tiniest tinkle of dropping water—becomes so lifelike that it's virtually *impossible* to distinguish the real from the recreated effect."

So not only will we have to struggle with the electronic ice-box and the electronic door-opener in that age to come after the war, but we will also have to do it to the accompaniment of a battleship firing broadsides in the parlor, while the neighbor's radio across the court is picking up the news broadcast of blasting operations.

While, perhaps, listening to a favorite orchestra, we are suddenly aroused by a terrific crash—an airplane failing to pull out of a power dive. Off we dash to the window to see if we have unexpected visitors in our front yard. Comes the dawn—it is Junior on the floor above listening to the "Aviation Aces!"

Wonderful things these post-war radios! We can see and hear all the horrors of the world without taking part in them or even being near them.

Cheerful prospect, no?

NEEDS LABORATORY MECHANICS

THE Civil Service Commission is searching for Laboratory Mechanics for war work in the National Bureau of Standards, Washington, D. C., one of the principal research and testing laboratories of the Government.

Laboratory Mechanics are needed to do work connected with the construction, installation, assembly, maintenance, overhaul, repair, and operation of the following types of equipment: (1) Electronic Equipment, (2) Machine Shop Equipment, (3) Automotive Equipment, (4) Electrical Equipment, and (5) General Equipment.

No written test is required, however, applicants for these positions must have had education or experience in one or more of the optional fields. A minimum of 6 months of appropriate mechanical experience or appropriate War Training course is required for the lowest-salaried positions. Additional training is required for higher-paying positions.

The positions pay $1,752 to $2,798 a year (including overtime pay). Applicants must have reached their eighteenth birthday but there is no maximum age limit.

Announcements and application forms may be secured from first- and second-class post offices, Civil Service Regional Offices, and from the Commission in Washington, D. C.

Persons now using their highest skills in war work should not apply. Federal appointments are made in accordance with War Manpower Commission policies and employment stabilization plans.

A SERVICEMAN TO HIS SON

By EUGENE CONKLIN

Dear Son:

Your last letter asked me what's cooking on the radio service front? Considering that you were ready to jump into the business when the Pearl Harbor fracas started, it's natural that you should be interested. So I'm jotting down a few of the happenings that I've observed and hope they'll hit the spot.

The greatest change is in the labor end of the game. I never thought I'd live to see the day when ladies in "pants" took over the servicing game. But I'd say that about 75% of all service shops now boast feminine service benchers. Almost every radioman is spending several nights a week instructing a group of girls who want to do their part for Uncle Sam but whose families don't want 'em to leave the old home town.

These gals learn what a resistor or condenser really means and get so they can read set schematics like nobody's business. They spend about six or eight weeks learning fundamentals in the schoolroom nights, and then the radioman picks a couple of likely ones from the class to come into the shop as part time helpers.

They handle the shop correspondence, wield a broom, handle the few customers who haven't found out there's a war on and want trigger-quick service. After the war you're going to find gals in radio service shops by the bucketfuls. And there'll be room for them too with all the new fields opening up!

Lately servicemen have been working with the physics high school teacher in teaching radio to boys and girls between fifteen and seventeen. These lads and lassies want to pick up some small change before they join up after graduation. They're willing to put in nights after school and after supper doing radio work. The advantage they have over feminine and housewife labor is that after receiving the training they won't work a few months and then hike out for more fertile fields in high pay defense factories.

So much for labor. You're right about the old sets turning up. Every serviceman I've talked with tells me that sets made back in the late 20's, and early 30's are coming into shops. It's impossible to get replacements for many of these old antiques. But their owners want to hang on to them, so it's up to us to put them in some sort of shape. Some servicemen have a standing ad in the classified sections offering to buy up any old radio sets and amateur parts from short wave fans about to go into service.

Several shops take three days out of every month and close up the shop, actually refuse to accept any new sets during that time. They spend those days or a week sometimes in cleaning up the "slush pile," just like the drycleaners. This is becoming a more common practice every day. Other shops refused to answer telephone calls inquiring when a radio is fixed and ready. Instead they send a postcard to friend customer when the set is finished. These shops ask their customers not to phone or come in to ask about a set in the process of being worked over. Instead the serviceman tells them he'll drop a card when its all slicked up and ready to shine.

Radiomen are requiring a deposit of one-third the estimated service cost (as near as it can be figured) on the spot, from every customer. That's not meant as an insult to the customer either. It's just that events happen so fast and furious these days servicemen have to protect themselves in the clinches. Credit is out too so far as the average "servicenter" is concerned.

Delivery is another wartime headache. Lucky OPA unfroze a tiny bit, because the servicemen were going screwy. One hired a horse and buggy to go round and collect cutsomers' sets, another made arrangements with dry cleaning and laundry trucks to pick up customers' radios and bring 'em to the shop. Others took their truck and made set collections from 6 to 8:30 a.m. Customers were up if they knew friend serviceman was about to blow in for a pickup or to return the family chassis.

Home servicing is universally *OUT*. Servicemen are turning thumbs down on "drop out to the house" requests. And there's every reason to believe that in the postwar periods servicemen will continue to insist on having sets brought into the shop. It's a much saner procedure, no matter how you look at it. (How about a 500-pound console, phono-radio set?—*Editor)*

Tube stocks are *very low*. Servicemen are praying for reinforcements on the tube horizon. Stocks of parts are nothing to brag about. Set stocks are at a new low. In short, the stock question would cause an attack of chronic bluitis to anyone but a confirmed optimist. But as compensation servicemen are using their craniums for something more than a scratching post. They're using Yankee ingenuity and making makeshift parts work as they never perked before. Out of this war period will come new circuit ideas and shortcuts for servicing that you and I never dreamed of in our wildest nightmares.

Bye and large the public is having its radio wants cared for, not perfectly it's true, but adequately. Well, I have to sign off now as I have to do a little chore on a 1943 GE that's acting up. Good luck, son, and write again soon.

Your Loving Dad.

FREE REFERENCE GUIDE

A NEW reference guide, *Trail Blazers to Radionics and Ultra-High Frequencies,* just published, will fill a long-felt need for workers in the U.H.F. spectrum. The main articles from the chief American and foreign publications, extending over a period of years, have been indexed and classified in convenient form.

This bibliography is divided into several sections, including such subjects as antennas, wave propagation, aviation, measurements, crystals for U.H.F., etc. There are three main groupings: Articles from the proceedings of the I.R.E., from miscellaneous engineering publications, and books.

This guide is introduced by a section of thumbnail sketches of pioneers of the art, from Thales to Armstrong. The book is free and may be obtained by addressing: UHF Reference Guide, c/o *Radio-Craft,* 25 West Broadway, New York 7, N. Y.

THE FUTURE OF FM

(Continued from page 69)

length and breadth of the land, will no doubt have their own transmitters. Consequently small progressive cities, strategically located, who will be first on the ground, will obviously share in the prosperity which will surely go to these small relay transmitters throughout the country.

All of the above is no longer theory, but much of it already is a fact. It gives me pleasure to quote from one of the best authorities in the field, Ralph R. Beal, Research Director of RCA Laboratories. Mr. Beal, himself, answers a few questions.

"Will there really be a nation-wide television system similar to that of broadcasting?" Mr. Beal contends that there is a definite promise of a radically new method of communication—the automatic relay of television images and messages from city to city, from country to country.

"Are radio relays sufficiently developed so that television can depend upon them for distribution of its pictures from city to city?" Beal's answer: "Automatic unattended radio relay stations, located 20 to 50 miles apart, will link television stations into national chains. The routes of these radio relays will extend to any part of the world. They can go through the jungles, from island to island, across mountains and the polar wastes. Neither tropical heat, nor arctic snow, neither fog nor hurricane will 'cut' these global lines. They can be built to be practical, efficient, and foolproof.

"The relay station looks like a streamlined lighthouse with little bulging eye-like windows at the top, facing to the four winds. Behind each of these windows is a highly directive centimeter wave antenna.

"Multiple channels make it all the more promising in efficiency, flexibility and service. The relay towers will handle numerous circuits, for example, down and back from New York to Washington. Furthermore, the circuits can be multiplied to any reasonable extent, not only to carry one television program but several simultaneously, as well as FM sound broadcasts, telegraphic traffic and facsimile. In fact, relay circuits should be among the busiest in the air."

According to Mr. Beal, relay stations with a 50-mile range will toss television images beyond the horizon to be picked up by other stations and relayers. Already telecasts from New York have been intercepted 129 miles away, at the Helderberg mountains, near Schenectady, without intervening relays in the Catskill Mountains. Philadelphia also has re-broadcast the New York programs without intervening delays.

Obviously, according to Mr. Beal, if we use high towers or antennas on lofty buildings or mountain peaks, we capture and retransmit the waves at higher levels, and therefore their effective range is lengthened. With the use of radio relay stations, the average range is about 30 miles, depending upon the terrain and various other factors. It is interesting to note that an airplane over Washington, D. C. carrying a television receiver intercepted the pictures from the NBC aerial on the dome of the Empire State Building 200 miles away. But for such long distance reception of the ultra-short waves, the plane had to go up to 20,000 feet.

I believe the above answers Mr. Givens' questions. I might add that much more could be added to the subject because the surface has as yet not been scratched, while the greatest things in FM-television lie still in the future.

RADIO LINES

(Continued from page 87)

For the purposes of our study, we are going to imagine this line *infinitely long*. It just isn't going to end! (No one is planning to construct such a line—thinking about one just makes it easier to imagine some of the things that happen on an ordinary transmission line, complete with beginning and end.)

Our "infinite line" (yes, that's all an infinite line is) is now connected to a source of power. We may attach its ends to a 60-cycle generator, or terminate them in a loop of wire and couple it to the output of a radio transmitter. We may expect to put some power into it, as the two wires have a certain capacity to each other (or the single lines to earth). We can consider it a sort of condenser, and expect a charging current to flow. But as current flows into the line, it meets with some resistance, and as the advancing current builds up a magnetic field around the wire, it also has to overcome some inductive reactance.

WHAT THE LINE IS MADE OF

The line then looks to the current very much like the structure of Fig. 1 (c). For purposes of study, it can be broken down into a number of parallel lengths of wire, each having a certain amount of inductance and resistance and with a certain capacity between each length. You can make your lengths a centimeter or a mile—it makes no difference.

It should be quite possible to measure the impedance of such a line, if it were not for the fact that it is infinitely long, and measuring the infinite is not a practical proposition.

We *can* measure the impedance of such a line, though, and do it with a rather short section. Fig. 2 shows how. We first measure the section with the ends open and then with them shorted. If the section is made short enough, the impedance when open-circuited should be practically infinite, and there will be *no* measurable impedance when it is shorted. If we lengthen the lines a little, the open-circuit impedance drops (due to the increasing capacity), while the short-circuited impedance rises (because of the inductive reactance of the lengthened wire).

Obviously, if the line were made long enough, there would be little difference between the short- and open-circuited impedance. Actual experiment with a few short sections shows that these two impedances approach each other with remarkable speed, and a point is soon reached where they are so close it is hardly worth while to add more sections. If the impedance of the line when open is (for instance) 201 ohms, and that of the same section shorted, 199 ohms, we must believe that however far the line is extended, the impedance will be close to 200 ohms.

If we are working with short lines at low frequencies, and cannot bring these impedances so near together with the length of lines at our disposal, the "characteristic impedance" can readily be calculated. Simply measure the open-circuit and short-circuit impedance of the section and take the geometrical mean. (Multiply the two figures together and get the square root of the product.)

HOW THE IMPEDANCE IS MEASURED

The impedance of the line is a combination of opposing reactances. Its inductance tends to increase the impedance per centimeter or mile—the capacitance between wires to reduce it. Hence we have an interesting situation. The characteristic impedance in ohms (usually denoted by the symbol Z_o) can be found by the formula

$$Z_o = \sqrt{\frac{L}{C}}$$

L being the inductance in micro-microhenries and C the capacity in micro-microfarads. The interesting thing about this formula is that you can take any units you like, and the impedance will be the same. If these reactances balance out at 200 ohms for one mile of line, it will still be 200 ohms for two miles. The impedance is repeated, or "iterated." And that's all there is to "iterated impedance."

This impedance is affected chiefly by the spacing of the wires in the line, since the inductance remains more or less constant for a given length, but the capacity increases rapidly as the two wires are brought closer together. The greater the capacity, the lower the impedance. Thus it is possible to construct a line to any given impedance by simply spacing the wires.

The impedance can be easily calculated. It is equal to $276 \log \frac{2D}{d}$ when D is the distance between the centers of the two wires and d their diameter. If we have two No. 12 copper wires spaced 4 inches apart, $\frac{2D}{d} = 99$ approximately. (The diameter of No. 12 wire is .0808 inches, according to the wire table.) The logarithm of 99 is 1.9956. Multiplying by 276 shows us that we have a line of approximately 550 ohms impedance.

The single-wire line is a special case. Its impedance cannot be easily computed, and is usually taken as about 500 ohms, though obviously it must vary somewhat according to its surroundings.

A FINITE "INFINITE LINE"

Now for the reason we have made the line infinitely long. High-frequency (or other) currents are not bothered by standing waves on such a line. They just keep right on going—there is nothing to reflect them back. This is why even very high frequencies can be piped down such a line with the ease of D.C. in a battery circuit without bothering about tuning.

Again our watchful student breaks in. "But there ain't no such animal!" he insists. "First you introduce your infinite line simply as an illustration, and now you are proposing to run current along it. You are simply trying to kid us."

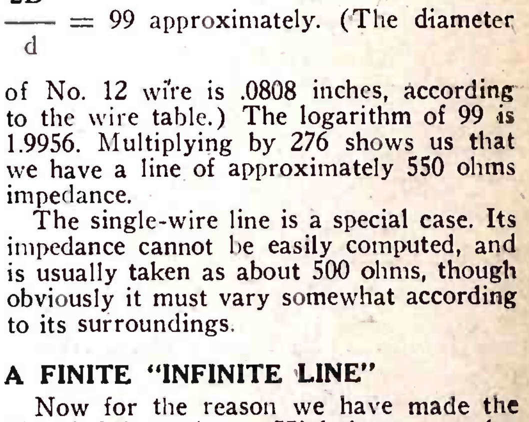


Fig. 3—(a) Ordinary "doublet antenna" with low-impedance lead-in. (b) Doublet for high-impedance line.

There is no intention of trying to deceive the reader. We are out for bigger game. What we intend to do is kid Mr. High-Frequency himself! And that can be done by a very simple trick. It has already been made clear that *at any point* on our hypothetical 200-ohm line, the current sees a 200-ohm impedance before it. *We simply cut the line at any convenient point, and slip a 200-ohm resistor across the open ends.* The effect is the same as if the line extended into infinity. The current has no way of finding out that it doesn't!

TERMINATIONS THAT TAKE POWER

So now we can get an infinitely long line into a good-sized room. Our problems are not all solved, however. We must not only find a way of terminating the line so that it looks infinitely long to the currents travelling on it, but we have to get them off that line again, if we are going to deliver any power to another circuit.

This is comparatively simple. If we are working with 60-cycle current, all we have to do is terminate our line with a transformer winding, motor or other piece of apparatus so designed as to present the proper impedance to the line. You can then take power from the finite "infinite line" with no trouble.

The same thing can be done with radio frequency. In most cases transmission lines are used to carry currents from a transmitter tank to an antenna system. We have learned that the impedance of a straight half-wave antenna is close to zero at the center and practically infinite at the ends. We can therefore, by connecting across larger or smaller sections of it, match any desired impedance. This can be done as shown in Fig. 3, (a) and (b). The ordinary "doublet antenna" of Fig. 3(a) is fed by a transmission line of about 75 ohms impedance, so connected that the ends are about ten inches apart, at the center of the antenna. The impedance at this point is close to 75 ohms. To prevent shorting our transmission line, the center 10 inches of the antenna is taken out and an insulator inserted. This is another example of the tricks you can play on radio frequency. The antenna is used to meeting an impedance of 75 ohms at this point, and does not know that its middle section has been taken away and the line inserted instead. On the other hand, the line, meeting its characteristic impedance of 75 ohms, imagines that it extends indefinitely.

If we have a higher-impedance (wider-spaced) "feeder" we simply connect its ends to points farther from the center. In this case it is not necessary to use insulators, the feeder terminals "looking into" the same impedance, whether they look to the center or the ends of the line. (This type of connection is actually not quite as simple as that, because it is made across points on the aerial which present a higher impedance than the characteristic of the straight part of the line, and the line impedance increases steadily through the V-shaped portion, which acts as an impedance transformer.)

(The term "feeder" used above follows transmitter terminology, because these lines have become very popular in transmitters. The line is fully as applicable to receivers, and is as much a transmission line when it is transmitting energy from the antenna to the input coil of a receiver as when taking it from the output of a transmitter to the aerial.)

When a transmission line is used to couple two coils together, as in a transmitter, the job is even easier. Such "links" are made with a turn or two of wire at each end, as coupling loops, and coupling to the coils is varied for best results.

POPULAR ELECTRONICS

(Continued from page 72)

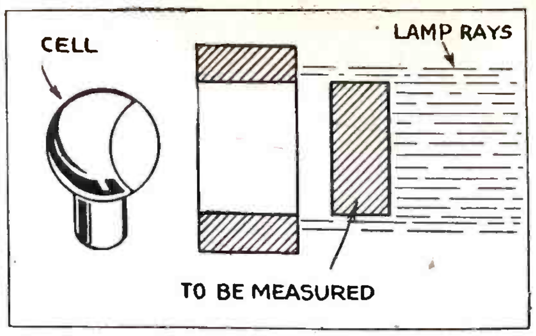


Fig. 7—Photo-electric version of the go-no-go gage. Piece is passed if no light gets by. A second slightly larger gage is used to reject oversize parts.

tion in factories. Even wire issuing from a wire mill may be constantly checked for diameter in the manner shown in Fig. 6. The wire casts a shadow, therefore variation in its diameter varies the amount of light reaching the cell. Such equipment may be easily arranged so that should the wire exceed certain limits or tolerances, the machine producing it may be automatically stopped.

Fig. 7 illustrates the principle employed in photoelectric "go-and-not-go" gages. The piece being tested casts a shadow over an opening. If the piece is exactly the same size as the opening, no light will pass and the cell will give no response. Should the piece be under size, however, light will pass and the piece will be rejected.

Fig. 8 shows a simple application in the measurement of liquids by the aid of a manometer tube. This equipment may be adjusted in such a way as to ring an alarm when the liquid falls below a certain definite level, or to hold it between two levels.

The application of photoelectric equipment in the matter of weighing is relatively easy. We have in use today photoelectric operated scales where the beam of light is

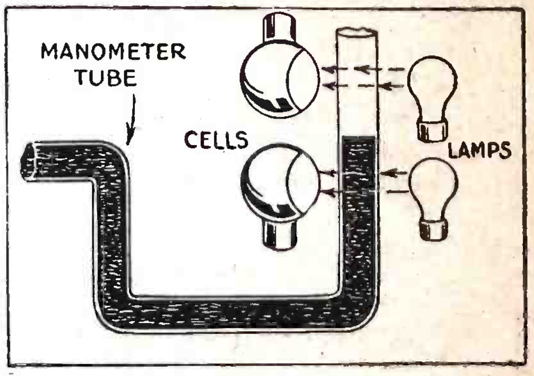


Fig. 8—Liquids may be kept to a constant level with the dual photo-cell circuit illustrated here.

intercepted by the beam of the scales when it falls. Thus does the high speed weighing of certain powders or other packaged goods sold by the pound become possible. Highly developed photoelectric scales have been in use for several years now and are very accurate.

Although a number of methods are used for the electronic control of temperature, the one shown in Fig. 9 is perhaps the simplest. It is very efficient and reliable although perhaps not as sensitive as some other methods. The student will instantly see how easy it would be to set up this equipment in his own home and to install an automatic heat control for his furnace using this method. Even the most inexpensive photo cell may be employed in this manner although there is some question as to the advisibility of using a home made selenium cell.

In the earlier part of this article, some mention was made of measuring the density or transmission factor (light) in liquids through the medium of the photoelectric cell. The same method applied to measuring

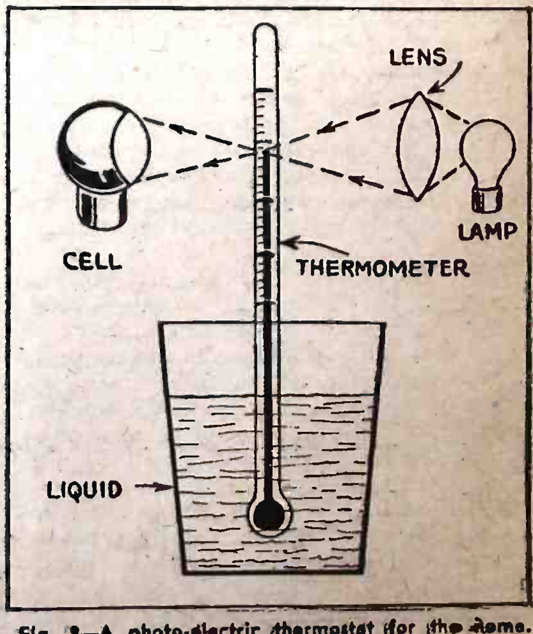


Fig. 9—A photo-electric thermostat for the home.

the density of smoke passing up a chimney. This is not a theoretical but an actual use of the photoelectric cell and a highly successful one that not only greatly saves coal but also helps to meet certain city ordinances.

Fig. 10 shows the very simple method employed in measuring the r.p.m. of a shaft. The output of such a cell is connected with electrical devices that actually control the speed of the shaft and very close regulation may be had in this way.

We may venture to say that the application of the photoelectric cell is limited largely by the imagination of the engineer or the inventor. Offhand, a novice might have a difficult time of it trying to devise a method whereby electrical resistance units could be tested at high speed by photoelectric methods. Electrical and not merely mechanical inspection is necessary. What is actually needed is a photoelectric device that will measure the electrical resistance

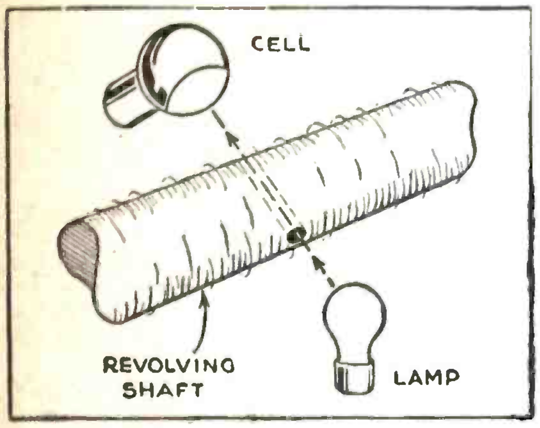


Fig. 10—(above) A photo-electric speed indicator.

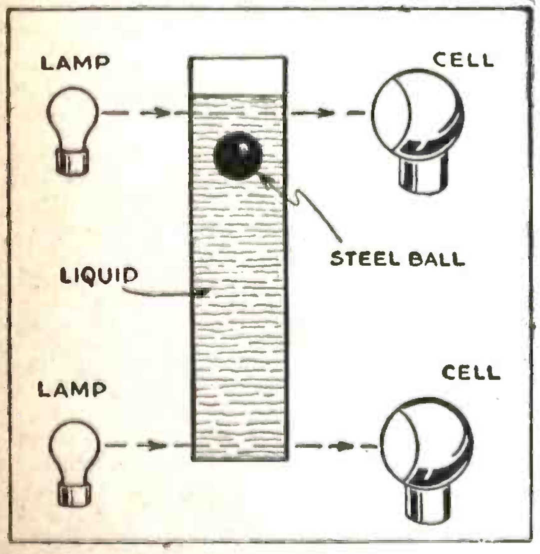


Fig. 11—A viscosity meter. The cells measure the time the ball takes to descend through the liquid.

of each unit in such a way that it will reject those above or below a certain standard value.

This accomplishment is relatively easy when a light beam reflecting galvanometer is employed in the manner shown in Fig. 11. The beam of the instrument swings to the right and left and strikes one of two photoelectric cells separated by a shield. Thus the units are separated into groups. Of course, a larger number of cells could be used with this arrangement and further division made.

Fig. 12 illustrates another chore that one, offhand, would say could not be done. This equipment, relatively simple, is used to measure the viscosity of liquids. The liquid to be measured is placed in a special container, a photoelectric cell being arranged at the top and one at the bottom. These cells are used with a special electrical timing device so that the interval between the functioning of the cells may be accurately measured on a moving tape.

Now it so happens that the speed of sinking of a heavy body in the liquid will be a function of the viscosity or "thickness" of the liquid. The ball will sink much more quickly in gasoline than—for example—in molasses. In mercury it might not even sink at all. Therefore a change in the viscosity of the liquid will change the length of time required for the ball to sink through it. Thus when a steel ball is placed in the liquid, it will sink, pass the first photoelectric cell and then move on to the second one. The second cell then functions to stop the recording mechanism. The resulting time measurement may easily be converted into terms of viscosity.

This device is of considerable value in measuring differences between the viscosity of oils, in which this quality is important. It is interesting as being a slow-motion variant of the exact device used to measure such things as speeding rifle bullets.

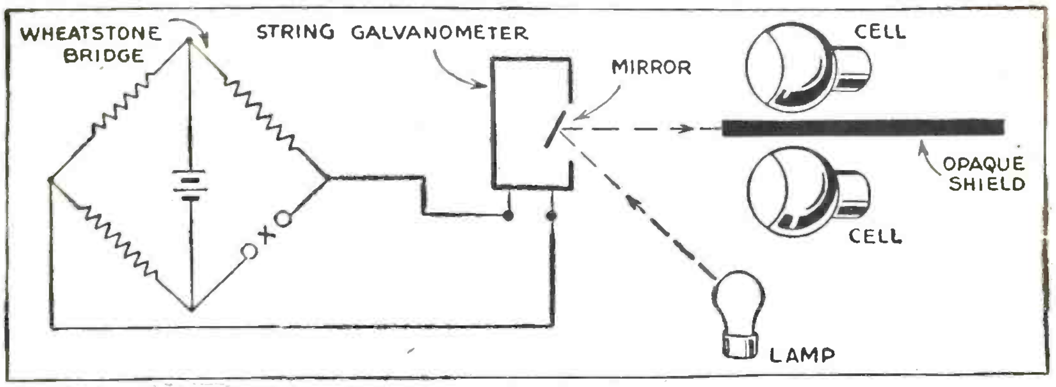


Fig. 12—A tolerance meter. Resistor to be checked is inserted at X. The string galvanometer is adjusted to throw a light on the shield between the two photo-cells in cases of perfect balance. If the resistance is high, light swings one way—if low, in the other direction. This circuit may be made automatic, with exact, high and low resistors sorted and deposited by a conveyor arrangement.

REMARKABLE POSSIBILITIES

Remarkable possibilities in post-war radio, with the chance that anyone who wishes may have his own radio station, were foreseen by FCC Commissioner C. J. Durr, in a speech to the Democratic National Women's Club in Washington.

"New techniques are constantly being developed," he told the gathering. "Many remarkable developments now secret will doubtless come to light when the war is over. Some day we may have a frequency for everybody who wants to start a radio station, but that day isn't here yet."

Commissioner Durr's contribution to the Post-War Radio discussion is on the opposite side to that of FCC Chairman J. L. Fly, who recently warned hearers against the idea that we might live in "a Buck Rogers world, with living-rooms like the radio control room of a battleship."

LOCATING DEFECTS IN RADIO RECEIVER

(Continued from page 86)

insulation, and with lowered output voltage. These same effects will appear when turns are shorted to a grounded iron core and the transformer circuit is grounded at some other point, but the short to the core can also be detected with an ohmmeter.

An odor of burned insulation and a charred appearance is always an indication of a defect in an iron-core transformer. A hot unit without these symptoms does not necessarily mean a defective unit, however; a certain amount of heat is normal in transformers which are handling power. The exact amount of heat varies with different manufacturers and with different transformer uses; some transformers will operate quite cool, while others are designed to operate at the heat limit set up by the Board of Fire Underwriters.

Removal of all of the tubes is an easy way to check a power transformer for shorts; if the smoking and overheating stops when all loads are removed by doing this, you either have a broken-down filter condenser which is drawing excessive current, or you have a shorted tube or some other short to ground in a plate or screen grid supply circuit. If the smoking continues, the transformer itself is defective, or there is a short in the rectifier tube socket or in the transformer leads.

LOUDSPEAKER DEFECTS

In addition to becoming defective, loudspeakers are subject to normal wear and aging due to the fact that the voice coil-cone assembly is continually moving during operation. Once a defect has been isolated to the loudspeaker, you have the following possibilities to contend with:

Weak Flux. An open can occur in the field coil of an electrodynamic loudspeaker due to corrosion, electrolysis or over-loading. If the field coil is also serving as a filter choke, as is usually the case, the receiver will be dead. If there is a separate filter choke, there may be enough residual magnetism in the iron core of the loudspeaker to permit operation, but sounds will be weak and greatly distorted. A simple ohmmeter check will reveal an open field coil.

Weak and distorted reception will also occur when the permanent magnet in a p.m. dynamic loudspeaker loses its magnetism. You must remember, however, that there are many other possible defects in a receiver which can produce these same symptoms. The defect should definitely be isolated to the loudspeaker before making extensive tests on the loudspeaker.

Open Voice Coil. The voice coil may open at one of its joints or in the flexible leads which connect it to the output transformer secondary. The voice coil leads are subject to breakage even though extremely flexible, because these leads must connect between fixed terminals on the loudspeaker and rapidly moving terminals on the voice coil. An ohmmeter will detect an open in the voice coil if you first disconnect one voice coil lead from the output transformer.

Grounds. You can have a ground in the field coil, the voice coil or in a hum-bucking coil. Grounds can be found by a simple ohmmeter test between the suspected coil and the frame of the loudspeaker, if inspection of the circuit diagram shows that no ground should exist.

Defective Spider. The flexible material of the spider may become brittle and crack, or may lose its elasticity. When the condition is serious, the symptoms will be a peculiar type of distortion. Visual inspection of the spider will reveal the trouble in most cases.

Sometimes the spider will get loose at the points where it is glued to the cone, causing fuzzy tones. Regluing with cone cement will fix this. Partly loosened dust caps in the center of the cone will cause the same trouble.

Off-Center Voice Coil. As a loudspeaker ages, there is usually a certain amount of entirely normal warping and shifting of parts. Rough handling can cause this same warping and shifting, and the condition becomes serious when the voice coil rubs against the pole pieces.

Iron filings, bits of metal, or hard particles of dirt lodged in the voice coil can cause the same trouble as a shifted spider or other shifted parts. You can detect a rubbing voice coil by pushing the cone in and out with your fingers when the receiver is turned off, for the vibration due to rubbing will be transmitted to your fingers, and you can hear the grating or scraping sound of the voice coil rubbing against the pole piece. The symptoms of an off-center voice coil are distortion of low notes and buzzing sounds. There is much more voice coil movement at low frequencies than at high frequencies, hence rubbing of the voice coil may distort men's voices without affecting women's voices.

Cone Defects. A cone may become hard and flexible due to aging and drying out; the result is a rattle and failure to give normal fidelity. The outer edge of the cone, which is cemented to the frame, may become loose and cause raspy, fuzzy sounds and distortion at low audio frequencies. A cone may become softer than normal, causing distortion, or may actually crack or tear, resulting in a defect you can readily see on inspection.

LOCATING DEFECTS

Once the defective part in a receiver is located, any one with a little mechanical ability and a knowledge of soldering can make the necessary replacement or repair in a few minutes. The real work of a Radiotrician is locating the defective part or connection, or locating the cause of the trouble in such cases as improper alignment of tuned circuits.

When the trouble in a receiver is simply a defective part or connection, and unlimited time is available, a person with a little training in the use of a tube tester, an ohmmeter, and perhaps a condenser tester can test each part and connection in the receiver until he locates the defective one.

Of course, the chances are good that the defective part will be located long before running through the entire test procedure for all parts. But even if you were able to average 50 tests per chassis, you can readily imagine what an enormous amount of time is required when using a part-testing technique of this nature.

As a matter of fact, there are many servicemen, without the type of professional training you are now acquiring, who actually do test various parts one after another until they find the defect. With experience they learn that certain parts or connections should be checked first for each type of complaint. They become good guessers unconsciously, without knowing why, but with professional servicing techniques you can locate troubles faster than these men right from the start of your servicing career. Your techniques will work on all sets, whereas testing of parts will tell nothing at all about many kinds of receiver troubles.

Reprinted by courtesy of National Radio Institutes, Washington, D. C.

LISTENING POST

(Continued from page 106)

City and State—Call	Frequency and Schedule
WKRX	**9.897;** North European beam, 6 to 8:45 pm.
WKRX	**12.967;** North African beam, 6 to 8 am.
WKRX	**15.190;** North European beam, 10 am to 12:45 pm; Central African beam, 1 to 5 pm.
WKTS	**6.120;** North African beam, 11:45 pm to 3:30 am.
WKTS	**7.565;** North African beam, 3:45 to 5 am; 8 to 11:30 pm.
WNBI	**9.670;** European beam, 12:15 to 2 am; 4:30 to 5:15 pm.
WNBI	**11.870;** East South America beam, 7 pm to midnight; Sundays only.
WNBI	**15.150;** European beam, 6 am to 4:15 pm.
WNBI	**17.780;** East South America beam, 5:30 to 6:45 pm; Sundays only.
WRCA	**9.670;** Brazilian beam, 8 to 11:30 pm.
WRCA	**11.893;** European beam, 5 to 8:45 am; 3 to 4:45 pm.
WRCA	**15.150;** Brazilian beam, 5 to 7:45 pm.
WRCA	**17.780;** European beam, 9 am to 2:45 pm.
Los Angeles, California	
KROJ	**9.897;** N.E.I.—Oriental beam, 10:15 pm to 3:45 am; 11:15 am to 2:15 pm; Australian beam, 4 to 9 am.
KROJ	**15.190;** N.E.I. Oriental beam, 2:30 to 8:45 pm.
KROJ	**17.760;** Australian beam, 9 to 10 pm.
San Francisco, California	
KES3	**10.620;** 1 to 6 am; N.E.I.—Oriental beam.
KES2	**8.930;** N.E.I.—Oriental beam, 6:15 am to 1 pm.
KGEI	**7.250;** Oriental beam, 1 am to 1 pm.
KGEI	**11.79;** South America beam, 5 pm to 12:45 am.
KMI (KOJM)	**17.090;** South America beam, 11 am to 2 pm.
KRCA	**9.490;** Oriental beam, 1 am to 1 pm.
KWID	**7.230;** Oriental beam, 6:30 am to 12:45 pm.
KWID	**9.570;** Australian beam, 3 to 6:15 am.
KWID	**15.29;** Oriental beam, 1 to 2:45 am; South American beam, 1 to 9 pm.
KWIX	**9.57;** South American beam, 8 pm to 12:45 am, daily; Oriental beam, 1 to 2:45 am; 7:30 am to 4:45 pm.
KWU	**15.355;** Australian beam, 4:30 to 6:15 pm daily; Sundays, 4:45 to 6:15 pm; off on Wednesdays; N.E.I. beam, 7:45 to 9:30 pm; off on Wednesdays.
KWV	**10.840;** Australian beam, 2 to 4:45 am; South American beam, 5 to 7:45 am.
KWY	**7.565;** 8:30 to 10:30 am daily; Sundays, 9:30 to 10:30 am.
Schenectady, New York	
WGEA	**7.000;** Brazilian beam, 8:30 to 11:30 pm.
WGEA	**9.530;** European beam, 3:30 to 6 am.
WGEA	**11.847;** European beam, 6:15 am to 4:45 pm; Brazilian beam, 5 to 8:15 pm.
WGEO	**6.190;** European beam, 12:15 to 2:10 am.
WGEO	**9.530;** East South America beam, 5:30 pm to midnight.
WGEO	**15.330;** European beam, 6 to 9:45 am; 10 am to 3 pm; 3:15 to 5:15 pm.

•

One of the things we like about FM is the way it forces itself upon people's attention. Like, for example, the other day at a luncheon in Philadelphia when Lowell Thomas was being awarded a medal by the Poor Richard Club of that city. All during the ceremonies, soft music kept coming from the public address system that had been set up so everyone in the room could hear the speeches. Even after the speeches started, the music was still there, persisting gently, giving the flattest phrases poetic grandeur.

It all seemed like a nice touch until, at an odd moment, a voice broke in and announced the call letters of a local FM station. The public address system, by one of those electronic flukes, was acting just like a receiver and picking up the signal. Nobody knew what to do about it, so nobody did anything. FM is like that. You just can't push it out of the way.—*FM*

METER ERRORS—THEIR CAUSES

(*Continued from page 77*)

INFLUENCE OF MECHANICAL TROUBLES

Certain troubles of a mechanical nature (see item *b* of Fig. 1) may also influence the inherent accuracy of an indicating instrument.

The position which the movable coil and pointer assembly (see Fig. 2) assumes during any measurement made with the instrument is determined by the action of two opposing forces—the *measuring* torque and the *control* torque. These forces in electrical indicating instruments are derived from quite separate elements of the mechanism, the former originating in forces (the interaction between the intense concentrated magnetic field produced by the permanent magnet and that produced by the current-carrying movable coil) developed by the electrical magnitude under measurement, and the latter from springs arranged to oppose the measuring torque. The movable part (movable coil and pointer assembly) of the instrument is deflected as soon as sufficient torque is developed in the measuring elements, causing the pointer to traverse the scale, and at the same time the springs to develop a counter-torque. The mechanical arrangements are such that the counter-torque *must* increase with the amount of deflection, otherwise the movable coil and pointer, once they had begun to deflect, would immediately swing to the end of the scale. The deflection of the movement continues until a balance between the deflecting torque and the counter-torque is attained, at which time the position of the pointer represents the value of the electrical magnitude under measurement.

In practically all portable instruments, and in most switchboard-type instruments, the counter-torque is derived from the pair of spiral springs (see Fig. 2), mounted above and below the movable coil. The inner end of their spirals is connected to the movable-coil shaft and the outer end of the stationary bearing. The characteristics of these springs determine the extent to which the movement will deflect before a balance is obtained. In other words, the *springs control the reading obtained*. That is why their quality and condition have such an important bearing on the instrument's inherent accuracy, and the permanence of this accuracy. Their mechanical characteristics are determined largely by their material, size, shape and heat treatment. Because these springs are so important they are subjected to such rigid inspection before the test instrument leaves the factory of any reliable manufacturer, that they are almost certain to be perfect. However, troubles may develop in them through use, or abuse, of the instrument as we shall learn in the next chapter.

Excessive friction in the jewel bearings is another mechanical trouble that will cause inherent inaccuracies, but here again the original factory inspection is so thorough that there is very little likelihood of this condition being present in an instrument when it is purchased, or after normal careful use. However, rough handling or excessive wear (to be discussed later) may in time create excessive friction, resulting in error. Excessive bearing friction usually manifests itself in a sluggishness of action and a noticeable uncertainty of zero. Errors due to it may be materially reduced by gently tapping the instrument while readings are being taken.

CALIBRATION ERRORS

For comparatively expensive instruments that are to have a high degree of accuracy, the scales are individually calibrated and hand-drawn for each instrument. It is not necessary, of course, to determine every scale division by test, especially on direct-current instruments whose scale divisions are nearly uniformly spaced. It is usually considered sufficient to determine about 10 or 15 points of the scale by actual test, and fill the intermediate points in by hand or by a mechanical method. The acccuracy claimed for the scales of such high-grade accurate portable direct-current instruments is of the order of 1/10 of a scale division. This refers to the error at any point on the scale. In some instruments of this class, fewer points on the scale are actually calibrated, but a correction curve giving correction data for every point on the scale accompanies the instrument.

In mass production of medium-priced

electrical indicating instruments of the type used for radio-electronic service work it is necessary to minimize all production costs involved in the manufacture. Therefore, the cost of calibrating a complete individual scale for each instrument would be prohibitive. (Anyway as we shall see later, such high accuracy of calibration is not necessary for radio test instruments.) Instead, the manufacturer first individually calibrates a few sample instruments of the type in order to establish a fair average of the particular deflection characteristics for that model of instrument. A composite of these scales is then drawn up for use as a "master." A quantity of the scales is then engraved or printed—all similar—for the entire production run. These are fastened in place on the instruments. Then each individual instrument is given a final adjustment by trial to make its indication check with the scale marking *at one point.* The point at which the check is made is usually *somewhere between two-thirds and three-quarters of the full scale deflection* (or approximately in the center of the portion which is customarily used the most on each range).

Consequently, the inherent accuracy of most such instruments is almost perfect at this region of the scale, but is lower at all other regions. Bearing friction, the initial starting torque necessary to move the movable coil and pointer assembly, and the fact that in the "at rest" position the movable coil is in the weakest part of the permanent magnet field, all create rather high error on the first one-fifth of the scale of a permament-magnet, movable-coil instrument. (This is one reason for instrument manufacturers designing their test equipment so that a multiplicity of ranges are available and no accurate measurements need be taken within this first one-fifth portion of any scale.) The remaining four-fifths of the scale has better accuracy. Above the 4/5 point, the accuracy of most of these instruments again *decreases,* but not nearly as severely as at the lower end of the scale. In general, on multi-range instruments, the accuracy over the last one-fifth of the scale is just slightly lower than that over the fourth one-fifth. Therefore, insofar as the instrument itself is concerned, it usually has its greatest *inherent* errors over about the first 1/5 of the scale, true for each range. The following indicating instrument inherent accuracy test figures, taken on the 0-10 volt range of a commercial D.C. servicing voltmeter, illustrate this:

True Voltage	Instrument Reading	Instrument Error (Volts)
1.0	1.17	+0.17
2.0	2.12	+0.12
4.0	4.05	+0.05
6.0	6.04	+0.04
8.0	8.04	+0.04
10.0	10.07	+0.07

In Fig. 3, the instrument error (in volts) is plotted against the instrument readings. Notice how much larger the error is over the first one-fifth of the scale than over the middle three-fifths and the last one-fifth region. Notice, too, that the error is very low between ⅔ and ¾ of full scale (the region at which most such instruments are calibrated) and that it increases slightly again at the upper end of the scale.

Naturally, since such instruments *do* have inherent *calibration* errors (see item *c* of Fig. 1), they do not give highly accurate readings, but there is no alternative, since the prices at which they are sold makes individual complete-scale calibration impos-

(Continued on following page)

(Continued from previous page)

sible. The fact that the error is not the same over the entire range, and the reason for it, is important to remember. As we shall see later, this fact makes it advisable to so choose the range of the instrument that the reading for the quantity being measured falls within a definite, desired portion of the scale, if fairly accurate readings are required.

Of course, if the shunts, multipliers, resistors or condensers employed in a particular instrument are not accurate in value, the accuracy of the entire instrument will be affected since the deflections of its pointer will then not be in accordance with its calibrated scale. Any subsequent changes in these values, due to overheating or "aging" of the resistors, condensers, control-springs or magnets, will also affect the deflection of the pointer, and consequently the inherent accuracy of the instrument, as we shall see later.

(This is the first of a series on The Sources of Error in Electrical Measurements, by Mr. Ghirardi. The second will appear in an early issue.)

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THE PROMISE OF ELECTRONICS

(Continued from page 73)

of electronics should be thoroughly familiar with the whole range, characteristics, and possibilities of electrical apparatus. A carpenter cannot build a house using nothing but a hammer; he also needs a saw, a chisel, and a few nails, and he must be equally skillful in using them all.

Above everything else, the engineer needs a thorough knowledge of the industry itself and of its processes, from all angles: electrical, mechanical, or chemical. Then a proper place for the best use of electronics is easily found—to improve the product, to lower its cost, to increase its output.

We are optimistic about the bright future of industrial electronics; we know that it will require on our part some hard and diligent work, all of our wits, and a good deal of enthusiasm. And we are ready to contribute freely of all these ingredients.

●

SOUND ON WIRE

(Continued from page 78)

add another hour's plane ride. As a result radio has encountered for the first time in its history a limit of time and distance."

The army will lend the recorders to accredited network correspondents as soon as there are enough off the assembly lines to insure even distribution among all the networks, Colonel Kirby said. Further tests are under way to determine methods of field servicing, censorship and transportation of the wire spools to and from the fronts. Soon radio correspondents using the new units can bring the war directly into the home of every American.

Two models are constructed. The model 55 has built-in recording, playback and instantaneous erasure features. It weighs 40 pounds, and uses 5 standard receiver-type tubes. The frequency range is from 200 to 5000 cycles, with a variation of plus or minus 3 decibels. The whole instrument is contained in a case only 13 x 9½ x 12 inches in size.

The second model is a small recording unit, especially adapted for use in planes. It uses two 28-volt tubes, weighs roughly 8 pounds, and its dimensions are 5½ x 5½ x 12 inches.

(*Continued from page* 90)

3. Triode output.
4. At least 3 watts undistorted power.
5. "Hi-Fi" low frequency response.

No attempt was made to get the set down to "midget" proportions. To get full field excitation a 60 Ma. power transformer and a 5V4G rectifier allowed plenty of current plus a large voltage drop. Only one T.R.F. stage was used, but high gain iron-core coils and careful alignment partly made up for that.

THE DETECTOR CIRCUIT

The diodes used for rectification are isolated from the control grid of the "detector" tube by a condenser. A.C. shunting of the diode load is negligible due to the large value of grid resistor. This large resistor, together with the large condenser between the second and third tubes, gives a really good bass response. The output tube is a 6B5 (octal equivalent is 6N6, actually two triodes directly coupled internally) and gives a maximum output of over 6 watts. The R.F. stage and power supply are quite conventional, the latter containing plenty of filtering. Even without a baffle, the bass response is noticeably better than from an ordinary "midget" set, while in a thick wooden mantel cabinet, with half the back covered, the tone and volume are amazing.

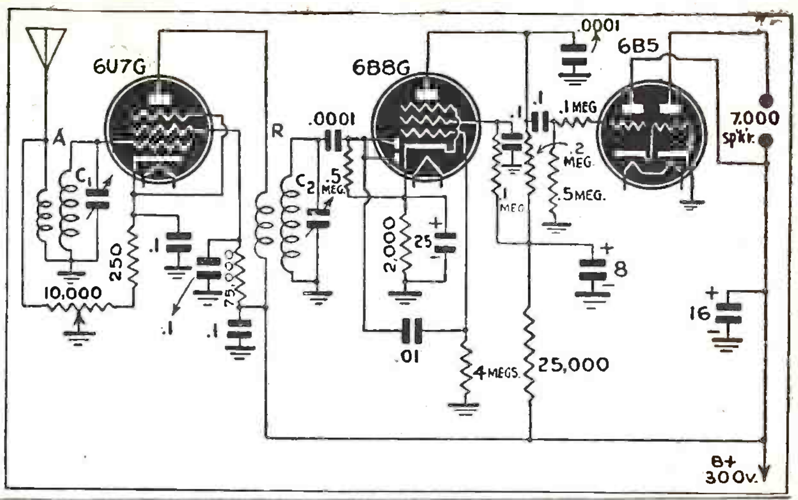


Fig. 6.—An Australian small Hi-Fi receiver. The circuit is not startlingly different from that of the usual small three-tubers, but the choice of tubes is original, making possible two stages of R.F. and two of A.F. in a three-tube receiver, without reflexing.

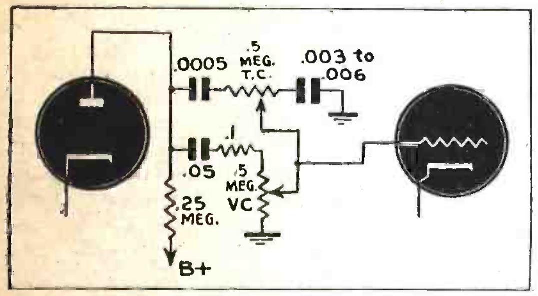


Fig. 5.—This tone control gives actual treble boost.

AN EASY RADIO BOOK

A BOOK which has been eagerly awaited by salesmen, manufacturers, advertisers, industrial engineers, publicity men and others, has just been published.

Entitled "The ABC's of Radio," (Written So You Can Understand It), it is intended to give a background of understanding of the fundamental principles of radio-electronic science to persons whose activities make a more intimate acquaintance with electronics and radio desirable. It was the outgrowth of a training course prepared for sales personnel and others employed in non-technical positions in the radio industry, and as such has been tested in use and rendered wholly practical.

While there is no intention of making radiomen through the study of the book, the authors realize that even at present, the growing use of electronic apparatus makes a general knowledge and understanding of their operation desirable, and that soon this will be *absolutely necessary* for the average manufacturer, executive or engineer. Therefore it was prepared so that the intelligent individual can obtain this knowledge without too much concentration or study, and in the course of a few evenings of pleasurable reading.

The book was prepared by the staff of the Electronics Department, General Electric Co. It is sold at its cost price, 25c, and may be obtained through this magazine. Simply address all requests to ABC's of Radio, c/o *Radio-Craft*, 25 West Broadway, New York 7, N. Y., enclosing 25c.

Restrictions on the sale of copper wire urgently needed in radio and electrical repair work have been relaxed. Repair and wiremen may now obtain wire required for their work without recourse to the priority formerly required.

The Mail Bag

LICENSING FOR SERVICEMEN NEEDED?

Dear Editor:

May I once again have the privilege of voicing my opinions in the Mailbag section. Thanks to Mr. Noones for his letter in the July issue. Apparently Mr. Noones has overlooked the fact that when a radio has become defective, it is necessary to repair the defective part or parts, and this can not be accomplished by just walking in and taking a passing glance at the machine. If such were the case, it would be an easy matter to repair 25 or 30 sets during 8 hours and have a few minutes to speak to each customer.

I believe Mr. Noones would do well to get a copy of *Radio-Craft*, April, 1942, and read Mr. Buck's letter, very slowly. Mr. Buck states that in five 8-hour days, he travels approximately 250 miles, to 100 homes. The following is a quotation from the letter, "the income from service is quite immaterial, the sale of merchandise being the object." Now would you say that this serviceman was selling service, or parts?

Possibly test equipment is just to look at, and not needed to service modern radios, but if such be the case, why are our governments demanding all the available apparatus for military purposes? Surely they are not doing this for the fun of it when there are so many serious problems to handle.

Why do some of our so-called servicemen get up in arms when the subject of licensing is mentioned? Can it be that they fear they could not pass a reasonable test? I tend to agree with Mr. Thoden, who wrote in the July issue, when he says he would rather be out of business entirely rather than try to compete with the man who is working for his health, as it were.

I believe I know the type Mr. Thoden has in mind—the man who repairs sets for a pittance just to get the customer, and whose work is a disgrace to the profession. Not only does he deprive legitimate servicemen of business, but when the owner of a set he has repaired finds out he has made an error and takes it to a competitive man, the regular charge looks like an exorbitant price to him. Not only that, but his confidence has been shattered, and it is hard to convince him that his set has really been repaired. Most of the "gyps" who give the legitimate man so much trouble are in this class.

I am quite sure that a solution to this would be, to license all service men, have a standardized rate for various jobs, and a union to see that the employees received a fair and decent wage. I may add that the Canadian Government has recently passed an order, and all reconditioned radios must carry a 90-day guarantee, I believe this is a step toward licensing servicemen.

Thanks to you, Mr. Kinard, I am quite sure by your letter that you will build a fine business and your customers will come back for future repairs as well as send you many new ones. A satisfied customer is much more valuable than many dollars spent in advertising.

B. W. EMBREE,,
MacGregor, Man.

240 SETS A DAY— A NEW RECORD?

Dear Editor:

Your Mailbag section has several letters concerning Embree vs. Buck, "How many can a man repair in a day?"

Quite recently, I have exceeded twenty jobs a day myself, but I want to tell you about one of my friends, Norman L. Harper, (R.M. 1/c), before he entered the Navy.

He was out of town, (Charleston, Mo.) for a day or so. It was just after Pearl Harbor, and the jobs poured in. When he returned to the shop, there were about 60 sets on hand.

Without stopping for anything, Harper started into the pile. It was 4.30 P.M. when he started. At 6.30 P.M. every case had been diagnosed and all but three were in the "ready-to-go" section. Total service charges, $195.10 (parts and tubes included). Add it up, Mr. Embree!

(Needless to say, the three open jobs needed replacements not on hand.)

J. W. FLEURDELYS,
Corpus Christi, Texas

(As Mr. Fleurdelys has no motive for prevarication, *Radio-Craft* must accept this startling saga of radio repair as strictly true. It is worthy of note that, at this rate of one radio every 2 minutes, (and provided with sets enough to keep him employed) Mr. Harper would turn out, not 20, but 240 sets in the course of an eight-hour day. His gross earnings, on the same basis, would run up to $4,680 for the radioman's usual six-day week. We shrink from computing the annual figure.

Did somebody say there was no money in radio servicing?—Editor)

A REQUEST FOR OLD-TIME CIRCUITS

Dear Editor:

Here is my subscription for one year. As I enjoy the magazine, and have not been able to get all issues at newsstands, I am taking this means of assuring that I don't miss any.

I am not an old-timer in radio and electronics, but find your magazine very interesting and helpful. Though I am not able to make many well-founded comments, I would like to make one suggestion. For those of us of limited knowledge, in a position where we can get few of the needed parts and tubes—even in the junk box—circuits and receivers using more of the old and commonly available tubes would be very welcome. I am speaking of the types found in so many abandoned sets, such as 27's, 26's, 24's and 71A's.

I know these are not as desirable as amplifiers, but for this very reason there are numbers of them *available*, which makes them important for local and experimental use.

F. J. HUBERTY, M. D.,
Appleton, Wis.

MORE ON HOME RECEIVER REPAIR

Dear Editor:

In regard to the Aug. issue of *Radio-Craft*, there was a letter, IS HOME REPAIR NONSENSE, brought up by an Army private who seems to wholeheartedly disagree with Mr. Fred Shunaman. You also ran a footnote following his article asking for our views on this matter. Well we want it known that we are 100% behind Mr. Shunaman. We have all due respect for the Signal Corps or any other branch of the military service, and want that understood here and now. Now if we may be so bold, we would like to quote some of the army private's words, figures, and also add our little bit too.

He states that he had $150 worth of test instruments and about $75 worth of tools. What we would like to know is, how he managed to transport such a layout of equipment and tools from house to house in addition to the innumerable parts and replacements necessary to do a real service job? If he can do this (moving all that equipment, tools, and replacements) service the set, and still charge the average service charge . . . we agree he's not gypping the customer. He is, however, gypping himself and his fellow servicemen, and taking bread from their mouths. If we have to combine the "moving business" and radio servicing . . . we also agree that he should get a moving fee too, and we still won't call him a gyp.

Now let us look at the other angle. If he doesn't take his equipment along with him, what's the good of having tools and test equipment, in the first place, if you're not going to use it? If he's done any service work at all, he'll have to agree that it is sure far from average service conditions which you have to contend with in Home Servicing. Speed in a job like this is absolutely essential because you not only have to work in the eyes of the public but also have to put up with being asked innumerable immaterial questions while trying to concentrate on the job at hand. Due to the very limited amount of equipment which you are able to have with you, what you don't have in the line of tools, equipment, and replacements must be compensated for with your skill, concentration and ingenuity. How are you going to do either of the latter efficiently? With your customer usually talking his head off to you and children running around enjoying themselves getting snagged up in your equipment!

We believe our friend, the army private, will agree that good service equipment and replacements, should be treated as such if they are to be depended upon, and furthermore are rather expensive children's playthings. Especially so when you charge a very nominal fee. We would like to know how he can achieve any degree of concentration, when answering questions, continually looking out for his tools, equipment, and replacements, not even to mention the work of actually servicing the set satisfactorily?

In closing we want to emphasize that we are not saying that all Home Servicemen are gyps. We just believe that there is no other place to do a good, speedy, efficient job than at a properly set up workbench. In our opinion, it can be readily seen by all that the well-equipped service bench is the proper, speediest, and most efficient place to do one's servicing, even though the army private stipulates that he carries a soldering iron stand with him. We too had stands for our irons. Even in the shop!

Pfc. Herman W. Hollatz
Pfc. Bert E. Ziefesch
S/Sgt. Lester G. Kieffer
Pfc. Harry Wilson

A FEW HARD KNOCKS—AND A BOOST

Dear Editor:

I have a few "knocks" to throw; have been reading *Radio-Craft* for several years and have been waiting to write.

Radio-Craft is considered a servicemen's magazine. Take the August, 1943, issue:

On Page 665 is a condenser tester. This has appeared I'd guess 500 times in various radio magaiznes in the last three years. It's so simple as to be not worth printing. A non-radio man (tinkerer) knows this circuit.

On Page 668 a *very* simple superhet. Diagrams have appeared before. One look at commercial sets and you can build most any 1 to 100-tube set.

On Page 672. Record player (wireless). This has appeared many times and is in service manuals by the hundreds.

In the Question Box there are so many stupid questions. Doesn't anyone know anything? Let them buy a $2.00 diagram book and figure out their own circuits. Asking for simple amplifier, detector circuits! They should know! If they don't, let them buy some simple beginners' books. Please advise the ones who ask stupid questions and send in a kindergarten kid's special circuit, to buy your books Nos. 7, 2 and 8 and possibly 5, and maybe *Radio-Craft* could become a REAL MAG.

Give us more service information, building of new type instruments, latest on television, FM and various articles on new devices. More by Sprayberry and his type of writers.

See what most of the Servicemen have to say about this.

I don't want to be disagreeable with beginners, but why ruin a magazine when they can spend 10c to 25c for a book and not waste space in a good mag?

I won't go into telling about the *good articles* as the letter would never end.

W. G. Esluk,
Wichita, Kansas

(Radio questions are "stupid" only when they are asked by advanced radio men. Unfortunately not everybody is advanced and has many years of experience back of him. There must always be beginners, for logically, there would be no *Radio-Craft* at all otherwise.

Even our correspondent was a beginner once and he probably also asked simple radio questions at one time. Nor, does every beginner know where and how to get beginner's books, but he does know that magazines like *Radio-Craft* help to educate those with little radio knowledge.

The most unfortunate part of the situation is that experienced radio men are intolerant towards those who have little radio education and who are looking for "light." *Radio-Craft* is a general type of magazine and caters to both the radio engineer and the radio beginner. *Radio-Craft* would not be doing its duty nor its job if it left the newcomer out in the cold. It intends to continue its 14-year-old policy of helping the beginner become an efficient radio man, because no radio engineer ever was born that way—he too had to be a beginner.—*Editor)*

NEW FREE TUBE CHART

A NEW War Time Tube Substitution Chart has just been published. This chart is designed to help radiomen replace discontinued, obsolete and hard-to-get tubes with their modern and obtainable equivalents. Seventeen by twenty-two inches in size, it may be hung conveniently above the bench for ready reference. More than 280 tubes replaceable by current types are listed.

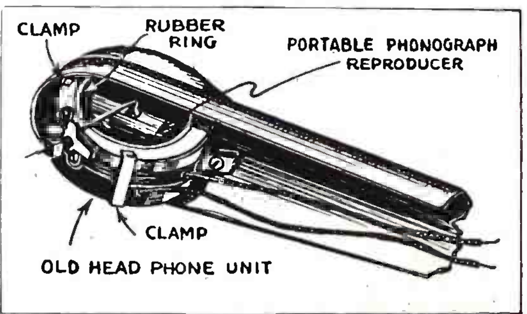
The lower part of the chart contains a functional cross-index of present-day tubes, as an aid in making war-time substitutions. Tubes are classed in this list as Rectifiers, Power Amplifiers, Voltage Amplifiers, Diode Detectors with amplifiers, and Converters, also being classed according to filament voltage and current.

This chart may be obtained free of charge. **Send all requests to** ***War Time Tube Chart***, c/o *Radio-Craft*, 25 West Broadway, New York, 7, N. Y.

EMERGENCY PICKUP

MY phonograph pickup went bad and as I was not able to get a new one, I devised this from a headphone unit and the reproducer of an old mechanical phonograph.

The mica was removed from the old reproducer, and a phone diaphragm inserted instead. It was bored at the center and the stylus soldered into it. Another diaphragm was placed over the magnets of the headphone unit, and the first one put on top of it. Thus the real contact is between the bit of solder at the center and the diaphragm beneath the one seen in the picture. The two units (mechanical head and headphone unit) are held together tightly by the clamps shown, and the rubber ring under the rim of the reproducer head assures satisfactory contact. The two diaphragms prevent contact between the magnets and the end of the stylus which projects slightly through the outer diaphragm.



As will be seen, it was necessary to cut into and recess slightly the molded composition of the headphone cap to accommodate part of the reproducer mechanism.

The unit was mounted in the old tone arm. A hole had to be cut in the top end of it, through which about quarter of the new unit projects. A cap for this was made from thin aluminum. It does not look quite as well as the illustration would indicate, but is good enough for the purpose. It is held in position by two small screws through holes drilled just ahead of and behind the opening. These also hold the clamps which keep the unit in place. One of these is visible in the picture. A piece of wire is also wrapped around the unit and tightened around the two screws.

I use this with a phono input transformer, R.C.A. type, though due to the high impedance of the phone unit, probably an ordinary audio transformer would do as well.

JOHN J. LEAP,
New York City

(This ingenious unit was tested by *Radio-Craft* and was found to give results comparable to the ordinary commercial magnetic pickup, both as regards quality and volume.—*Editor)*

Index to advertisers

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

BOOK REVIEWS

PRACTICAL RADIO COMMUNICATION (Second Edition), by Arthur R. Nilson and J. L. Hornung. Published by McGraw-Hill Book Co. Stiff cloth covers, 6½ x 9 inches, 927 pages. Price $6.00.

The second edition of Nilson and Hornung's standard work has been thoroughly revised to meet the greatly changed conditions and methods which have come in since the first edition was published in 1935. According to the authors, approximately two-thirds of the text is new. Frequency modulation and the new short-wave techniques are dealt with, and the treatment of such subjects as marine and broadcast transmitters is up-to-date.

The subjects are now so grouped that all basic radio principles are concentrated in the first eight chapters. Even these have been re-written to conform with the modern approach, and in some cases, as in the chapter on antennas, to include the results of new developments and new methods.

Aviation radio has the place of honor, immediately after the end of the portion devoted to basic principles, a long chapter being devoted to it. Radio beacons, direction finders and other radio aids to navigation are handled in this chapter, as well as straight airplane transmitters and receivers and ground-station apparatus.

Three chapters are devoted to broadcast radio, practically the same ground being covered as in the older book. Four chapters on Marine Radio follow. One of these is new, and deals with the recently-adopted radio auto-alarms, the RCA and Mackay types being described in full. All the apparatus covered in the Marine section is modern.

The chapters on Motors and Generators, storage batteries, etc., formerly found in the first part of the book, are now placed at the end, to be studied after the student is familiar with the apparatus in connection with which they are to be used. This seems an excellent idea; it is much easier to sustain interest in these subjects when the prospective operator knows just where they fit into the radio scheme.

●

INDUSTRIAL RADIOLOGY, by Ancel St. John and Herbert R. Isenburger. Published by John Wiley & Sons, Ltd. Stiff cloth covers, 6 x 9 inches, 298 pages. Price $4.00.

The nature of this work makes it suitable for the electric or radio technician who has no previous X-ray experience, for the radiologist about to embark in the industrial field, and for the industrial technician who wishes to learn more about the new instrument being used to further his work.

After a brief history of radiology and a chapter on the influence of X-rays on matter, the theory of X-ray generation is dealt with in a comprehensive and simple manner, with a number of schematics and photographs of industrial instruments.

A chapter each is given to the Radiography of large castings and forgings, of welded vessels and structures, and of small objects, followed by another on a number of interesting examples which do not fall exactly within the limits of the foregoing chapters.

The economic angle is not overlooked, and a chapter is devoted to operating and cost data. Another chapter, dealing with the future of industrial radiography, has as its most important feature a chart showing the progress of the art—in numbers of factories equipped with X-ray machines—up to the present.

The question of human safety is kept in view throughout the book, safety measures both in construction of machines and buildings, and in the manner of operation, being discussed at various points. The book has an exceptionally large Appendix of nearly 100 pages.

●

ELECTRONIC PHYSICS, by L. Grant Hector, Herbert S. Lein and Clifford E. Scouten. Published by the Blakiston Co. Stiff cloth covers, 6 x 9 inches, 355 pages. Price $3.75.

It is about time that a beginners' Physics was written from the electronic point of view. Too much of the orthodox presentation of the subject to the beginning student has been influenced by traditions and concepts from the past. These, almost unconsciously passed on by teachers, confuse and slow down the student.

This work starts out as a text on practical electricity. A sop is thrown to the teachers, who may experiment with their amber and bits of paper, but the mystery of their positive and negative charges is dissolved into the simple rubbing of electrons off one surface onto another.

Carrying on through the standard subjects of electric circuits, electrolysis, batteries, magnetism, generators and motors to inductance and capacity and alternating current circuits, the book fills twelve of its twenty-four chapters.

Electronics proper begins with Chapter 13, devoted to electron tubes. It is followed by X-rays, chapters on light, mirrors and lenses, infra-red and ultra-violet, photoelectricity. Another chapter deals again with electromagnetic waves, from the more advanced point of view the student has reached during his course, and the book ends with two chapters on radioactivity and the transmutation of elements.

Most of the figures are printed in two colors, red and black, which makes the diagrams more attractive and easier to follow.

●

FUNDAMENTALS OF RADIO, for those preparing for war service. By L. O. Gorder, Kenneth A. Hathaway and Carl H. Dunlap. Published by the American Technical Society. Stiff cloth covers, 5½ x 8½ inches, 351 pages and index. Issued with a 96-page supplementary study outline and workbook with flexible fibre cover and spiral wire binding, size 8 x 11. Price for both, $2.50.

Though issued as one of a "Pre-Induction Training Series" and written in correspondingly simple language, this book will be found useful for more advanced groups, and is quite suitable as an all-around elementary radio text.

Getting away from a rather bad start, (the student is advised to skip the third chapter and return to it later), the standard subjects are dealt with in a lucid manner easily grasped by the trainee. Figures and illustrations are helpful to those who have had no opportunity to see or handle the objects discussed.

The study outline accompanying the book introduces an interesting method of self-study, or alternatively, may be used as a time and labor saver by the teacher of a class. In its most valuable sections, it consists of a number of "Quiz Questions" with answers in the back of the book. A second quiz, under the name of "Comprehensive Examination," presents its questions in the "True or False" method popularized by radio programs, which while not as effective as the multiple-choice answer system, does an excellent job of sustaining student interest.

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REFERENCE DATA FOR RADIO ENGINEERS, H. T. Kohlhaas, Editor. Published by the Federal Telephone and Radio Corporation. Flexible leatherette covers, 5½ x 8½ inches, 200 pages. Price $1.00.

As a radio engineers' handbook, this little volume covers a wide scope, including a group of general engineering tables and engineering material data, much of which is useful to the radio engineer branching out into industrial applications. The table of trade-names of plastics is interesting and directly useful to the radio engineer, for example, though it cannot be called a radio subject.

In straight radio, the usual wire tables, reactance and impedance formulas and charts, color codes, etc., are to be found, with material on attenuators and filters, as well as network theorems. There are 26 pages of tables on vacuum tubes and amplifiers, and 5 pages on transmission lines.

Other sets of tables are ranged under the sub-heads: Radio Propagation and Antennas, Noise and Noise Measurements, Non-Sinusoidal Waveforms, Telephone Transmission and Mathematical Tables.

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RADIO MATERIEL GUIDE, by Francis E. Almstead and F. R. L. Tuthill. Published by McGraw Hill Book Co. Flexible leatherette cover, 5 x 7½ inches, 242 pages. Price $2.00.

Radio materiel, in the sense given it here, is in its general classification "the standard information on general electricity, simple circuit behavior and operation of essential equipment." In other words, this is a book aimed at the pre-induction student, as well as for elementary work in post-induction classes.

A small work, it covers the whole field, and naturally suffers in places from an overabundance of brevity. This is coupled with a tendency to use standard definitions and brief explanations, well known and understood by the authors and all old radioists, but probably not so well by the green student.

(Continued on following page)

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The approach is highly practical, the book starting out with a chapter on arithmetic needed in radio work and its use in calculating values of capacity, inductance and reactance. The use of tools and the making of splices is discussed in the second chapter, and the study of direct current and Ohm's Law is aided with photographs and drawings of resistors actually used to introduce the resistance factor into the student's equations.

A chapter on sonic wave behavior, important in many military applications, is included.

A MOVING-COIL PHONO PICKUP

(Continued from page 93)

been found to be the minimum that can be relied on to support the needle) tapering to 0.05 in. diameter at the ends.

For the winding the writer used No. 38 A.W.G. aluminum wire because a quantity of this was available, but enamelled copper wire will give practically the same results. With regard to the gauge, this is not in the least critical, and, though No. 38 is probably the easiest to handle for coils of the size under consideration, higher or lower gauges may be used and the turns increased or diminished accordingly to keep the weight of the coil approximately the same.

The method of winding is as follows: With the former impaled on a needle, grip the needle in a vice in a convenient position. Spread a quantity of Duco cement or "coil dope" round the former, then wind on the requisite number of turns, taking care that each and every turn is "drowned" in the cement. Press the coil so that unnecessary adhesive is squeezed out, and remove surplus. The beginning and end of the winding are, of course, brought out at the same end, and should be left for the moment about 2 in. or 3 in. long. The weight of the coil without the needle should be in the region of 75 milligrams.

The needle used with this coil should be cut to between 0.25 in. and 0.275 in. long, and the end should be touched up with a file so that no sharp edges cut and enlarge the holder.

For mounting the coil in the gap, an inch or two of 1½ mm. inside diameter rubber tubing, with walls about 1 mm. thick, should be obtained. A 3/16 in. length should be slipped over the "lead-out" wires of the coil. The ends of the tube should then be gripped with two pairs of small pliers, when the tube can then be easily pulled into the slit in the back plate and arranged so that about 0.1 in. protrudes on the coil side (Fig. 4). The ends of the wires should then be gently pulled until the end of the coil "noses" into the rubber tube. A 0.1 in. length of tubing is slipped over the other end of the coil, and is ready for assembly of pole pieces, magnet and front plate.

With regard to tone arms, the writer feels rather hesitant in making any specific suggestions. The chief difficulty in adapting a tone arm of any other pick-up is that, in general, they are almost certain to be far too heavy; and, as has been pointed out earlier in this article, it is essential to use one which is as light as possible. An arm for this pickup was made from aluminum cut from an old amplifier chassis. It was bent to shape, and stayed at three points along the bottom edges, the effective mass being about ⅜ oz. Other tone arms for pick-ups of similar design have been made from an old aluminum hot-water bottle which had been overlooked in the search for salvage, and also other odds and ends.

With regard to the downward pressure, it should be variable between ½ oz. and 2 oz., or fixed at a compromise of about ¾ oz. It should also be mentioned that the turntable should be padded to lift the record about ¼ in., otherwise the attraction of the magnet to the steel turntable appreciably increases the downward pressure.

With a 1.7-ohm coil coupled to a 150:1 ratio transformer, the average output across the secondary was about ⅛ volt.

One final point which should not be overlooked, the lead-out wires from the coil should be soldered to the flex lead at not more than ½ in. from the coil, and this flex should be firmly clamped by a tag under the lower of the two assembly bolts.

SPRAGUE TRADING POST

ARMY E NAVY

A FREE Buy-Exchange-Sell Service for Radio Men

EQUIPMENT FOR SALE—RCA Chanalyst (used very little); Supreme 585 Diagnometer (factory-modernized): C-D capacitor bridge model BN; IRC resistance analyzer-indicator; Superior utility tester; E-200 Precision signal generator; RCA neon output indicator; Rider's Manuals 1 to 12 incl. Ed. H. Showers, Sheridan, Pa.

FOR SALE—Hallicrafter S-19-R in original condition and carton. High Fqcy. band now receives 200-400 range band. May be changed back to 10 meter band if preferred. Andrew H. Lessenden, 515 E. Normal Ave., Kirksville, Mo.

FOR CASH OR TRADE—One McElroy Oscillatone AC DC code practice oscillator, complete with 117N7GT tube. Like new. Am badly in need of 0-1 ma. meter or any good multitester. R. N. Lewis, Dublin, N. C.

WANTED AT ONCE—Triplett 1200F circuit tester in good condition. Will wire money at once. R. B. Thackeray Radio Service, Box 266, Main St., Melvin, Ill.

WANTED—Will pay top price for Ecophone EC-1, or any similar type of receiver. Lt. Santo Giampapa, Box 9, R. A. F. S., Roswell, N. M.

WANTED URGENTLY—A V-O-M or single meters. Triplett No. 666H preferred. Describe fully. Also need neon glow tube. J. A. Jensen, Box 3788, San Juan, Puerto Rico.

WANTED FOR CASH—A windcharge generator, 6 volts; also National FB-7 receiver with coil and power pack; or Pioneer 400-watt AC, 100 watt DC. Pvt. Louis De Marco, Jr., 410th Sq. AB, Pyote, Texas.

WANTED—Triplett model 1604 set tester in good condition—also Weston Model 772. Have a Jewel 199 analyzer in good condition less adapters to swap or sell. $20. Franklin C. J. Slay, Apt. 5-R, 243 W. 107 St., New York 25, N. Y.

BOOKS WANTED—"Gauges and Fine Measurements" by Rolt; also "Light Waves and Their Uses" by Michelson. Will pay cash. Oliver Riddel, 1332 Hood Ave., Chicago 40, Ill.

WANTED—Model VI McMurdo Silver radio or a Scott 20 or 30 tube radio in good condition. Name best cash price. Paul Capito, 637 W. 21 St., Erie, Pa.

WANTED FOR CASH—RCA or Philco signal generator. Phil's Radio Service, 668 Saratoga Ave., Brooklyn, N. Y.

EQUIPMENT WANTED—Have just opened shop and need the following at once: analyzer (Weston preferred); signal generator; tube tester, and set of Rider's Manuals. Cash. H. B. Strickland, Route 1, Box 171, Brunswick, Ga.

WANTED—Tube tester, not more than 2-3 years old in good condition. Give price, make, model no. Carl W. Wells, Frost, La.

WANTED—Good tube tester for latest tubes; V-O-M, signal generator and condenser tester. C. E. Harris, 411 Spencer Ave., Indianapolis, Ind.

FOR SALE—Astatic S-12 studio type 16" long arm, crystal pick-up for $7.50. Will swap two new RCA 8005 tubes for four RCA 809's or four Taylor T 20's or TZ 20's. Best offer takes Sylvania 860 tube. Have some metal, glass, and acorn types for sale. Fred Craven, 2216 So. 7th St., Philadelphia.

WANTED—Second i-f transformer for Grigsby Grunow Majestic #161. Also want mobile PA system complete with mike and speakers. Give full details. Janus Radio & Electric Shop, 207 Ella St., McKees Rocks, Pa.

TEST EQPT. WANTED—Tube tester, signal generator and V-O-M for cash. John F. Bowers, 82 Columbia St., Adams, Mass.

WANTED IMMEDIATELY—Signal generator; V-O-M; and condenser checker. Describe fully. Owen & Owen Radio Service, Rt. No. 6, Box 237, Louisville, Ky.

TUBES FOR SALE—Guaranteed uncartoned tubes at 50% off list: 3-1A4; 2-1B4-951; 4-1A6; 2-1B5; 6-1C6; 8-1C7; 2-1D5; 2-1D7; 1-1E5; 1-1F4; 5-1F7; 5-1H6; 4-1J6; 1-2A3; 8-2A5; 3-6A7; 2-6B5; 1-6B7; 1-6D7; 2-6F7; 3-19; 2-22; 10-26; 10-27; 12-30; 6-32; 2-33; 8-34; 6-35; 4-36; 2-37; 3-38; 5-39; 3-42; 4-43; 3-45; 2-49; 5-53; 2-55; 3-56; 8-57; 8-58; 3-59; 6-71; 4-76; 6-77; 8-78; 2-79. Following at list: 5-6A8; 1-6J7; 1-6K7; 1-6Q7; 4-12Z3; 1-12A5; 2-15; 10-80; 8-45; 4-47, and 1-84. Money refunded for any tubes not satisfactory. Goodwin Radio Shop, Rankin, Ill.

AMPLIFIER WANTED—Small 5- or 10-watt type. Also dual speed recorder for cash. Albert Schafer, 629 18th St., Moline, Ill.

SELLING OUT EQUIPMENT—Transmitting and receiving, meters, tubes, parts, turntable motor, metal chassis; also letter-size mimeograph. Most new, some used, but all good cond. Write for list. Kenneth Hanifan, 1409 W. Central Ave., Toledo, Ohio.

FOR SALE—Philco #077 AC operated all-wave signal generator 115 kc to 37 mc used very little. Guaranteed like new, $30. Dave's Radio, 1316 42nd St., Brooklyn 19, N. Y.

FOR SALE OR TRADE—Confidence Special tube tester. Has O-1 m.a. meter. First $8.50 takes it. Also one knocked-down Triplett 1200B V-O-M with diagram, $9. Want Solar BQC condenser checker. Ray Parker, 112 Avenue C West, Kingman, Kans.

WANTED FOR CASH—RCA or Dumont 3" 5" 'scope. Also RCA or WE microphones. Super Sound, 4906 Augusta Blvd., Chicago 51, Ill.

WILL PAY CASH for good used 110-V A-C record player; also used RME-510-X frequency expander, and used small amplifier with microphone for use with record player, F-M converter, and for recording. Gilbert L. Harris, 215 East Main St., North Adams, Mass.

WANTED IMMEDIATELY—Tube tester and V-O-M or set tester. Will also pay cash for condenser tester. Give details and quote lowest price. Elmer A. Folsom, Dorm. #1, Newcastle St., Brunswick, Ga.

RIDERS MANUAL #13 wanted for cash. Jim's Radio Shop, Mankato, Kans.

WILL SWAP RCA phono oscillator, MW photo electric eye, 955 acorn tube, also 25B8, 6F8, 117Z6GT, 1ZA7, 117N7, 117L7GT and many other tubes. Steve Lesko, Nanty-Glo, Penna.

URGENTLY NEEDED—Signal generator, any well-known make, in good condition. An electrically-operated (110V A.C.) would be considered. R. S. Stine, 230 McClelland St., Cambridge Spring, Pa.

FOR SALE—Power packs, radio parts, and record players. Write for details. All letters answered. Mathews Radio Service, P. O. Box 387, Bloomingdale, N. J.

RECORDER WANTED—Model "Y" Presto portable complete. West Electric Shop, Portland, Ind.

WANTED—Tube tester, signal generator, and vibrator tester. Late models only. Have for sale used speakers, chokes, power transformers, 15" jig saw. Royce Saxton's Radio Shop, Route 1, Pontiac, Ill.

TUBE TESTER WANTED—Also multimeter, sig. generator, tubes, and Rider's Manuals. G. L. Condrey, 108 Woodstock Rd., Route 8, Richmond, Va.

FOR SALE—Meissner analyst No. 10-1154 complete. Best offer takes it. H. H. Pahl, 108 Main St., Horicon, Wisc.

TUBES TO SWAP OR SELL—Following types: OZ4; 1G4 GT/G; 1G6 GT; 1S4; 6L6G; 7A6; 7B5; 7C5; 7Y4; 40; 42; XXB; XXD; XXFM. G. M. Bechtel, 558 Fourth Ave., Westwood, N. J.

YOUR OWN AD RUN FREE!

The "Trading Post" is Sprague's way of helping radio servicemen obtain the parts and equipment they need, or dispose of the things they do not need during this period of wartime shortages. Here then are a few hints which may help you benefit from it:

Answer interesting ads while they are "fresh." Don't wait until the magazine is several weeks old. Do not send letters in reply to advertisements to Sprague. Write direct to the advertiser.

Study the "For Sale" ads first to see if what you need is listed before sending in your "Wanted to Buy" ad. The Trading Post appears regularly in Radio Retailing—Today, Radio Service-Dealer, Radio-Craft, Radio News, and Service.

Please do not specify the magazine in which you would like your ad to appear. We'll do our best to get it in one of the leading publications, but it only complicates matters when a certain publication is specified.

Please don't ask us to run an ad in which you ask more than the normal price for parts or a piece of equipment.

Don't offer to accept C.O.D. telegraphic or telephone replies to your ad. Some individual Trading Post classified advertisements have pulled as many as four and five hundred answers!

Answer ALL inquiries to your advertisement promptly—even though some of them may have arrived too late. This is only common courtesy.

When sending your ad to Sprague, please address it to the department number shown below. This serves as a valuable guide to our advertising department.

Obviously, ads featuring equipment "For Sale or Trade" generally bring better results than those wanting to buy hard-to-get equipment. Preference will thus be given to ads offering parts or equipment for sale.

Write your ad carefully, clearly and keep it short. Many ads received are unintelligible or hard to decipher—and this causes unnecessary trouble.

"Emergency Ads" will receive first attention and Sprague, of course, reserves the right to eliminate any ads which do not seem to fit in with the idea behind this special wartime emergency advertising service.

Dept. RC 311

SPRAGUE PRODUCTS CO., *North Adams, Mass.*

SPRAGUE

SPRAGUE CONDENSERS
KOOLOHM RESISTORS

Obviously, Sprague cannot assume any responsibility, or guarantee goods, services, etc., which might be exchanged through the above advertisements