RADIO NEWS

APRIL
1943
25c
In Canada 30c

LD UNIT OPERATING
ISON CONTACT SET

ARMY'S ELECTRONIC BUGLER

★ FIRE FIGHTING A. M. NETWORK

★ A DISTORTION METER FOR P. A. MEN

RCA STARTED IT...

and RCA continues to lead it!

Two years is a long time in an industry as fast-moving as Electronics. Yet it has been almost that long since RCA Tube Distributors received a graphic demonstration of this field in RCA's now-famous presentation *"Electronics on Parade."* Long years before this, many of the Electronic developments now being heralded as "new" and "revolutionary" were a familiar story to RCA.

Remember: The *Magic Brain* of ANY Electronic equipment is an electron tube and, since the days when Radio itself was a scientific novelty, RCA has been the fountain-head of tube development. Wherever Electronics is already on the job, chances are, it has been RCA that led the way. Wherever Electronics will lead in the future, you can count on RCA to continue in the forefront of the parade!

RCA

RCA RADIO ELECTRONIC-TUBES

RCA Victor Division, **RADIO CORPORATION OF AMERICA,** Camden, N. J.

Volume 29 Number 4 **RADIO NEWS** April, 1943

★ *Leading the Industry Since 1919*

FOR THE *Record* BY THE EDITOR

THERE seems to be plenty of life in the television field today. Most of the television stations are receiving renewals of their licenses, although these licenses cover only a temporary basis. According to the interest exhibited by the television receiver owners, and the many effective purposes that television broadcasts are serving, there is every indication, however, that these temporary licenses will be extended.

An unofficial census made by Harry R. Lubcke, Director of the Don Lee Television Station, W6XAO, shows that there are some 7200 television receiving sets in operation in the major television centers of the country such as New York, Schenectady, Philadelphia, Chicago and Los Angeles. In the New York area, television programs are on about nine hours a week. Three television stations are in operation in this area. In Schenectady, the schedule covers ten hours a week. In Philadelphia and Chicago, four-hour television schedules are offered. A six-hour per week television schedule is maintained in Los Angeles. Oddly enough, according to Mr. Lubcke, there are still quite a few hundred television receivers available for sale. In southern California alone there are over a hundred available.

Whether or not television broadcasts will continue over a period of extended time is, of course, dependent upon the length of the war. If the war goes beyond a year or so and replacement parts become increasingly difficult to obtain, it may be necessary to curtail such transmissions. The replacement problem is also a serious one in television receivers. Pooling of parts has already eliminated bottlenecks in some instances. And every effort will be made to continue this form of cooperation. Since the government looks upon television with great favor, there is always the possibility of special grants of equipment being supplied for both transmission and reception.

That television is a dominant factor

(*Continued on page* 74)

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On the Cover: Operating a small liaison contact set from advantageous outpost. Scott Field AAFTTC Photo.

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ALL★AMERICAN TEAMWORK—1943
OFFICIAL U. S. NAVY PHOTOGRAPH
SIGNALS are called on a "flat-top" . . . and a smooth-working team of men and equipment swings into action. The hardest game of all begins —War—with death-dealing steel and men's lives at stake.
Networks of communications systems become the nerve center of action. Microphones at battle stations carry the signals to the team. Men rely upon their Microphones in the thick of the fight. They must get the signals through.
Shure Microphones are made to work under fire. They achieve new standards of ruggedness. They will get the signals to the team and help coordinate the efforts of every fighting man for Victory.
SHURE REACTANCE SLIDE RULE
Makes extremely simple the calculation of complicated problems in resonant frequencies. Also helps in the solution of circuit problems involving inductances and condensers. Covers a frequency range of 5 cycles per second to 10,000 megacycles. Indispensable for radio and electrical engineers, technicians and circuit designers. Send 10c in coin to cover mailing costs.
Shure Brothers are supplying Microphones to all of our armed forces. Additional plant capacity is available to Manufacturers who require Microphones for their contracts.
SHURE BROTHERS, Dept. 174X 225 West Huron St., Chicago, U. S. A.
Designers and Manufacturers of Microphones and Acoustic Devices
SHURE
MICROPHONES
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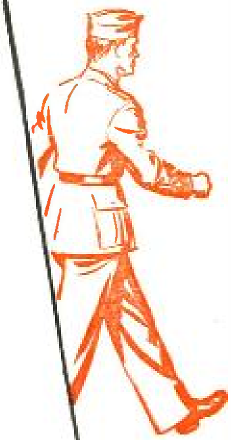
IMPORTANT NOTICE

to Radio Service Engineers, Dealers and Hams

Who Are Entering the Service of Our Armed Forces



A critical shortage of radio test equipment is seriously handicapping repair work in the civilian radio field.

Do not store your radio test equipment for the duration. It will only deteriorate and become obsolete.

Be patriotic. Sell your meters, signal generators and other test equipment so that it will be able to function efficiently where it will do the most good.

Now is the time when your test equipment will bring a fair price, and the money you receive, invested in War Bonds, will help you when the Victory comes.

If you do not know some one who needs your test equipment, list your inventory with your Mallory distributor. He will help you dispose of it to real advantage.

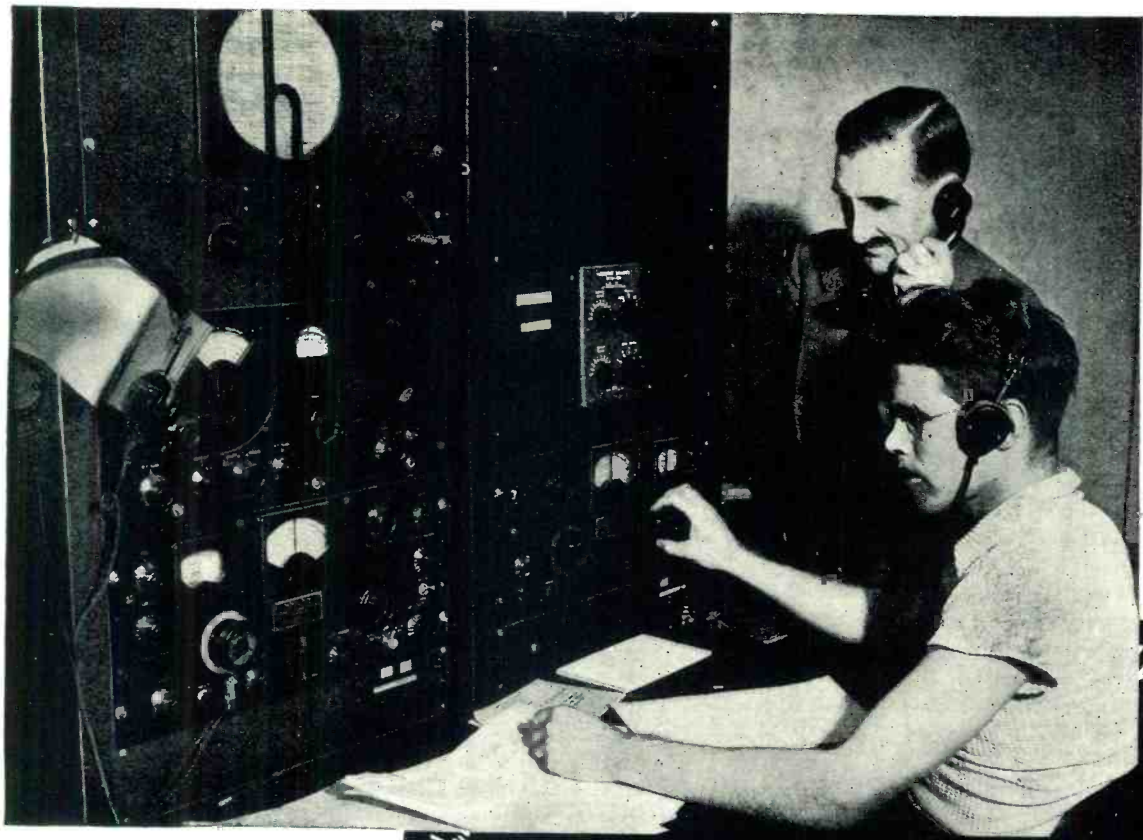
If you do not know his name, get in touch with us.

P. R. MALLORY & CO., Inc., INDIANAPOLIS, INDIANA

P. R. MALLORY & CO. Inc.

MALLORY

Approved Precision Products



Listening Posts!

You will find Hallicrafters Communications Equipment working three shifts at our Country's "Listening Posts"... searching the airways for illegal programs and espionage messages.

Hallicrafters Communications Equipment is engineered to "take it" on this constant operating... there are no rest periods, no time out, it's constant performance!

The Hallicrafters Equipment you can buy—when communications equipment may again be sold for Civilian use—will incorporate all of the endurance and top quality performance you will ever demand.

Illustration—typical view of Hallicrafters Communications Equipment is a monitoring (listening in) station—somewhere in the U.S.A.

WORLD'S LARGEST EXCLUSIVE MANUFACTURER OF SHORT WAVE RADIO COMMUNICATIONS EQUIPMENT

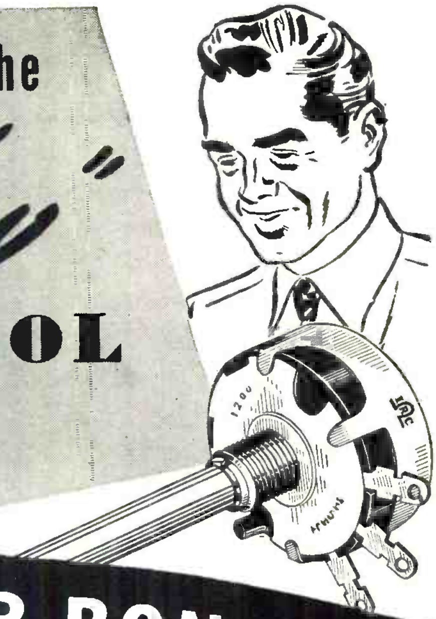
ARMY E NAVY

hallicrafters

CHICAGO, U.S.A.

There's Still Time to Qualify in the

IRC "Here's How" VOLUME CONTROL Contest



SHARE IN $500.00 WAR BONDS!

Closing Date April 10th

Yes, there's still time to put yourself in the running for one of those FIVE $100 U.S. War Bonds, as announced in last month's issue of this magazine. *But there's no time to lose!*

If you saw the original notice and have been putting it off . . . well, this is the LAST CALL! Contest closes and entries must reach IRC by April 10.

If you have overlooked this "golden" and patriotic opportunity . . . if you are a radio man living within the United States . . . if you would like to have one of those $100 Bonds inscribed with your name and delivered to you, the field is still wide open and you stand as good a chance as anyone!

HERE'S WHAT TO DO

IRC feels that radio service men today are doing a fine job in keeping the Nation's radios functioning in the face of unprecedented difficulties. Often unable to get exact duplicate replacement and repair parts you would ordinarily require for the job in hand, you are showing amazing resourcefulness.

All right—write IRC an informal, simple letter telling in your own words—

How you were able to replace a *volume control* and get the radio set working satisfactorily—when you couldn't obtain the volume control you would ordinarily have considered necessary for that particular make and model of radio.

Please be specific. Name the make and model instrument you were working on. Tell what the VOLUME CONTROL trouble was. Describe exactly what you did, and why: whether you made certain mechanical changes in the substitute control to adapt it to the set, and/or certain electrical changes in the circuit.

BONDS for IDEAS

It's your factual story that counts in this contest—not your spelling, your "literary style" or anything else. What we're after is a straightforward account of a VOLUME CONTROL problem you ran up against, and how you licked it. *Your* story, unexciting as it may seem to you, may be the very one to cop one of those awards!

PRIZES WILL BE AWARDED

by an impartial board of three—Joseph Kaufman of the National Radio Institute, William Moulic of "Radio Retailing Today" and IRC'S Chief Engineer Jesse Marsten. The judges' decision as to the five winning entries will, of course, be final and if in their opinion winning ideas of equal merit are presented, duplicate awards will be made.

RADIO INDUSTRY TO BENEFIT

Though all ideas entered in this contest become the property of IRC, contestants have the satisfaction of knowing that their worth-while ideas will be passed along to the entire service profession. Thus, while you extend a hand to others, they too will help you to keep radio sets in operation that might otherwise be retired from service and become lost jobs for you.

HAVE YOU WON A BOND ALREADY?

Some VOLUME CONTROL jobs you have already done may be good enough to win a $100 Bond, if you write us about it NOW.

DON'T PASS UP THIS CHANCE!

Remember, you have as good a chance to win as the next fellow. Fill out that coupon right now! Write your letter tonight! Don't put it off—and later kick yourself for passing up an opportunity. A $100 bond would sure come in mighty handy at maturity, wouldn't it? O.K.—*let's go!*

Uncle Sam's Men, Too

If you're now in Government service, in or out of uniform, you're eligible in this contest too. Maybe the job you have in mind was done before you went into the Service.

CLIP THIS—FILL IN—SEND IN WITH YOUR ENTRY

BN

INTERNATIONAL RESISTANCE COMPANY
401 N. Broad St., Philadelphia, Penna.

• Gentlemen: Here is my entry in your $500 U.S. War Savings Bond Contest.

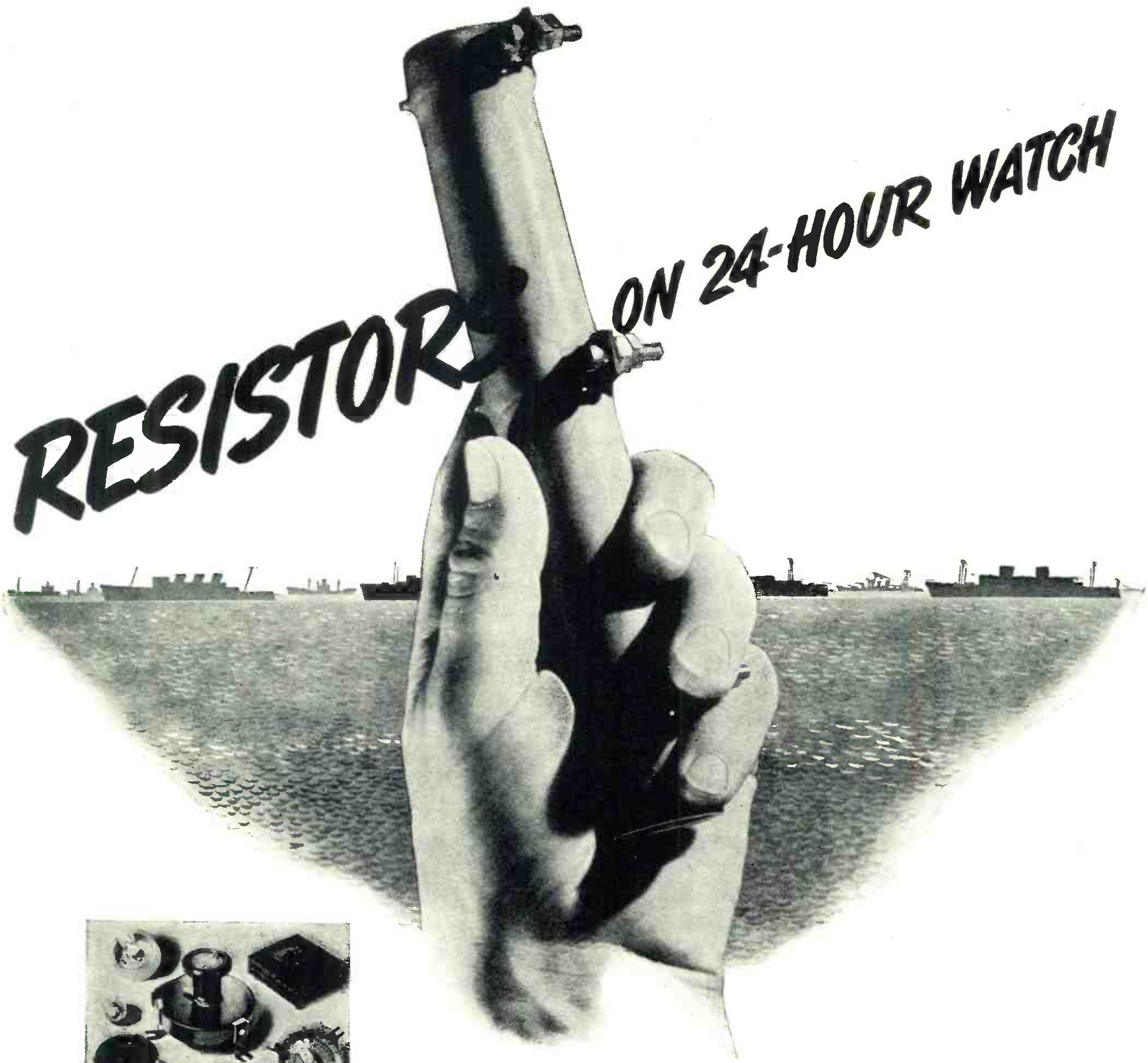
MY NAME ____________________

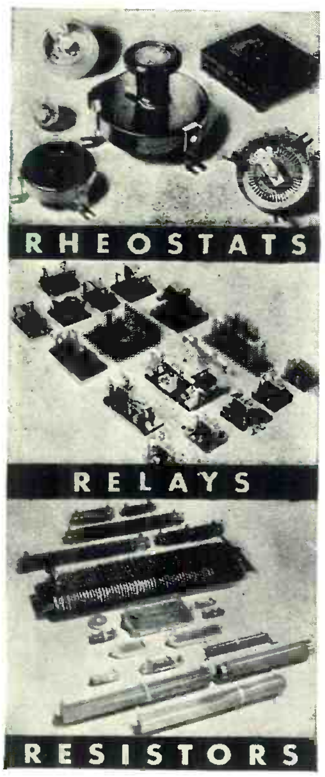
COMPANY ____________________

ADDRESS ____________________

CITY ____________ STATE ____________

MY REGULAR DISTRIBUTOR IS ____________________





Electrical equipment aboard ship has no off-duty time. Radio, inter-communication, air conditioning, ventilation, refrigeration, deck machinery, gun operation and innumerable other vital services employ resistors in their control circuits. These resistors must be dependable to function at all times. Ward Leonard Vitrohm Resistors have measured up to their responsibilities. Their ability to withstand moisture, temperature change, shock and vibration makes them particularly well fitted for sea duty. Resistors with the same ruggedness as those used by the Navy and Merchant Marine are available to all industry engaged in victory production. Send for data sheets.

ARMY E NAVY

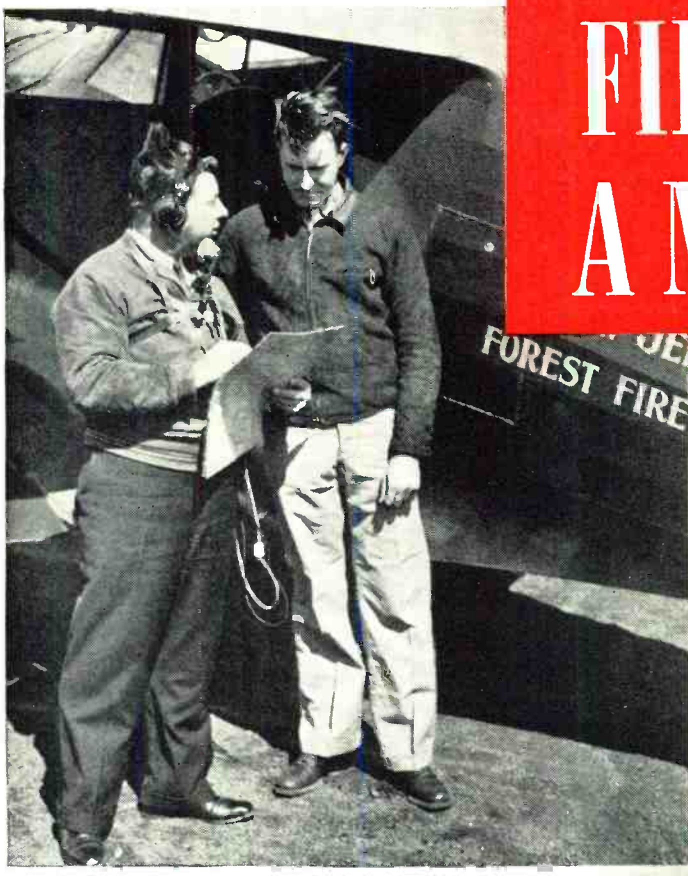
WARD LEONARD

Electric control (WL) devices since 1892.

WARD LEONARD ELECTRIC COMPANY, 47 SOUTH STREET, MOUNT VERNON, NEW YORK

The FIRE-FIGHTING AM NETWORK

Special radio-equipped aircraft are used effectively for spotting fires.



by
LEWIS WINNER

Uncle Sam takes no chances in having his forests destroyed by fire. Radio is protective medium

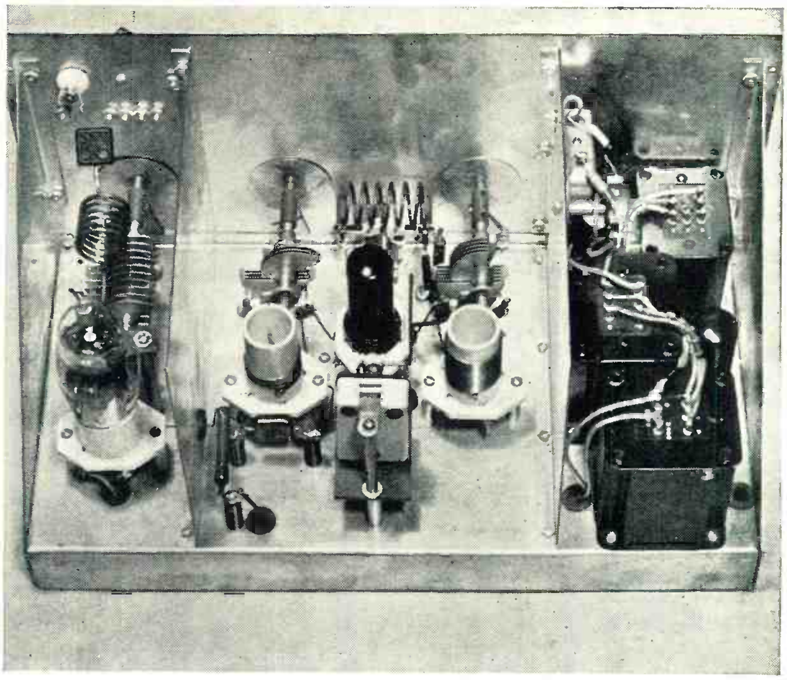
FIRE is a ruthless enemy. It knows no bounds. It must be fought and destroyed quickly. And one of the most formidable weapons for such warfare is radio. In city and country, radio has shown its unparalleled usefulness as a fire-fighter. And in the forest areas, it has become the most vital instrument of combat. This is particularly true in the mountainous and wooded areas where mobility of coverage is a prime requisite.

One of the first mountain range-studded states to recognize the need for radio in its fire-fighting service was New Jersey. With some five million acres of land of which two million acres are forest and another million of contiguous brushland, grassland and salt marsh to patrol for possible fires, the problem of coverage was truly one of many complexities. The only plausible solution seemed to lie in some form of a radio system that would permit fire wardens either on the mountain tops or in cars to communicate with each other, report on the fires and thus secure the necessary help required to combat the flames quickly.

Experiments to establish such a system began several years ago, with Dr. Carleton D. Haigis as the consulting radio engineer on the project. The first efforts resulted in setting up simple radio links between two fire lookout towers and testing with mobile units in the field from these points. These experiments demonstrated that only random communication was possible this way. Therefore this system

Always ready for action is the tower lookout and radio operator. Each transmission is logged.

Interior of one of the mobile radio units, which is in close touch with the main control headquarters.



This top view of one of the twelve-watt mobile transmitters shows baffle shield arrangements.

could not be used effectively to handle all communications between various points with the speed required to meet emergencies. Nor could this system effectively handle a quantity of messages that would have to be filed on those days when many fires were burning at one time. It was therefore decided to install a state-wide system whereby it was possible to establish instant communication between all of the strategic points of the state.

In this unique arrangement eighteen observation towers, three division headquarter offices, state headquarters, a fire service observation airplane, thirty mobile units, and twelve back-pack sets for use on fire lines, are now used.

In each of the three tactical divisions into which the state is divided is a control tower. The transmitter at this point is capable of transmitting to each of the auxiliary towers of the division, the observation airplane and also to the division headquarters as well as state headquarters. The transmitters at the auxiliary towers division and state headquarters all transmit on a second channel which is picked up by a receiver at the control tower. At this point a relay device is actuated, putting the control tower transmitter on the air and thus rebroadcasting any received signal. In this way, any tower of a division can communicate instantly with any other tower in its division and also with its division or state headquarters. But two channels are required to provide this service, the only limitation being, of course, when full time operation of the control power transmitter will no longer handle the message traffic.

There are six channels used, two in each division, to provide independent intercommunication throughout each of the three divisions and to state headquarters where three receivers are located, each of which is tuned to the control tower of a division. The transmitter at the state headquarters can be operated on any of the three division auxiliary tower channels by a push-button control on the operator's desk. In this way the operator can communicate with any desired division without causing interference to the message traffic coming from the others.

At each auxiliary point, there is also a second receiver that is tuned to the channel used by the mobile units. Therefore when a mobile unit goes on the air, its signal can be received by every station within its range. In New Jersey, it is quite impossible to find any location from which communication cannot be maintained with at least one lookout tower.

Captain LeRoy S. Fales, State Fire Warden of New Jersey, at telephone which connects to all radio units.

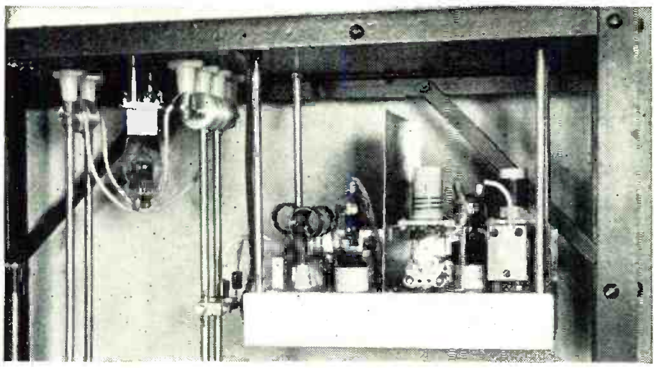
Thirty cars are used by fire wardens to cover an area ranging from fifty to a hundred-thousand acres. When a fire occurs and a mobile unit warden sights it, the nearest lookout tower is radioed. This tower receives information on the location and size of the fire, when it was discovered, how hard it is burning, and the approximate number of men that are required to control or extinguish the flames. Since all of the division and state headquarters have receivers tuned to the mobile transmitter frequency, they, too, receive this important information. The mobile unit also reports from time to time the condition of the fire; then a control tower operator radios the nearest district warden. The warden proceeds with whatever material and men are required to combat the fire.

When it appears as if the fire will burn fifty acres or more, and the condition seems difficult, the warden on the ground radios the division warden to determine if aerial study is necessary to successfully quench the fire. If a plane is required, he is radioed and on arriving at the scene of the fire maps the fire progress and radios this information to the ground warden. Many times the plane as an observer, hovers above the scene to guide the ground fighting crews.

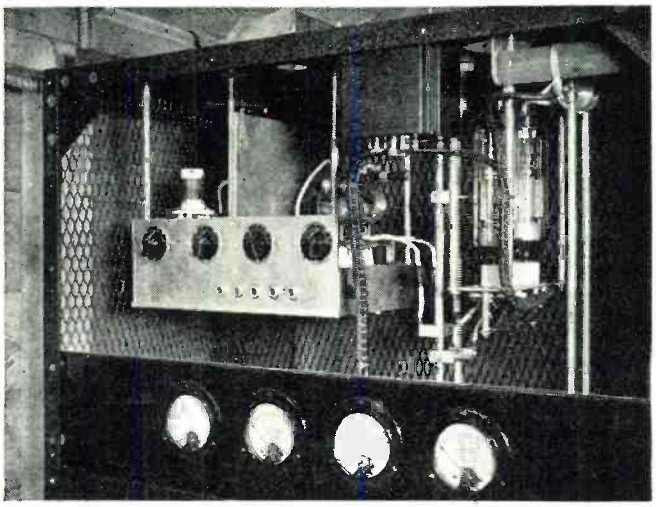
Amplitude modulation is used by all of the stations. At the time this system was developed, frequency modulation had not been applied practically. However, the results from the amplitude modulation equipment have been so outstanding that it doesn't appear as if frequency modulation will be necessary.

The equipment used is unique in many respects. For instance, all of the receivers are equipped with squelch or silencer circuits. These of course are not affected by noise. In this way a field sensitivity in the receivers can be maintained equal to that obtained in the shop.

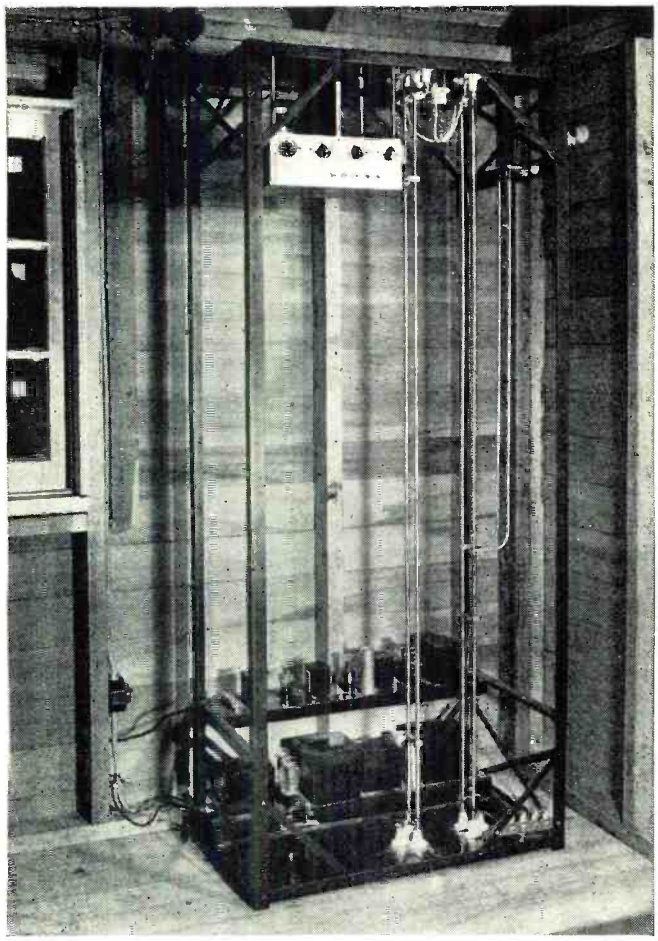
(*Continued on page* 59)



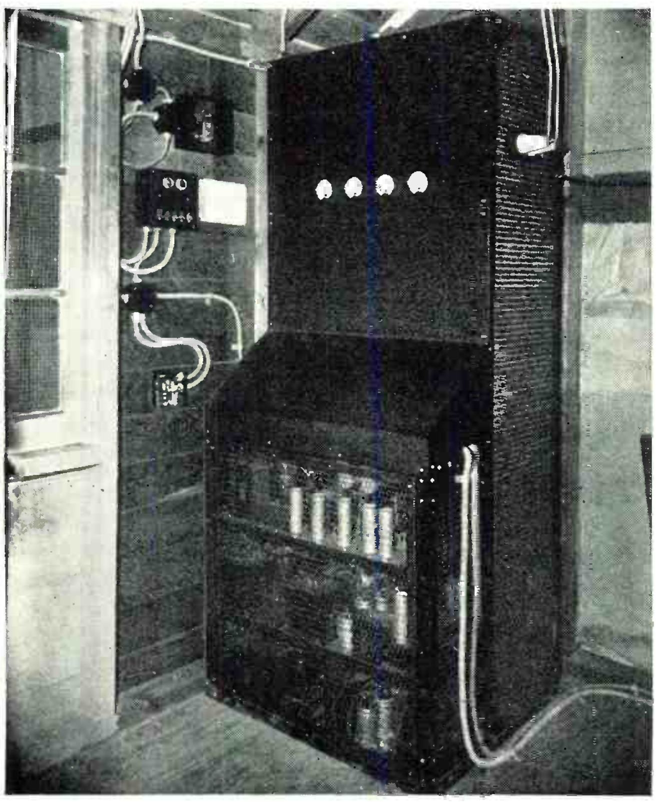
Crystal unit and 15 watt long-line oscillator.



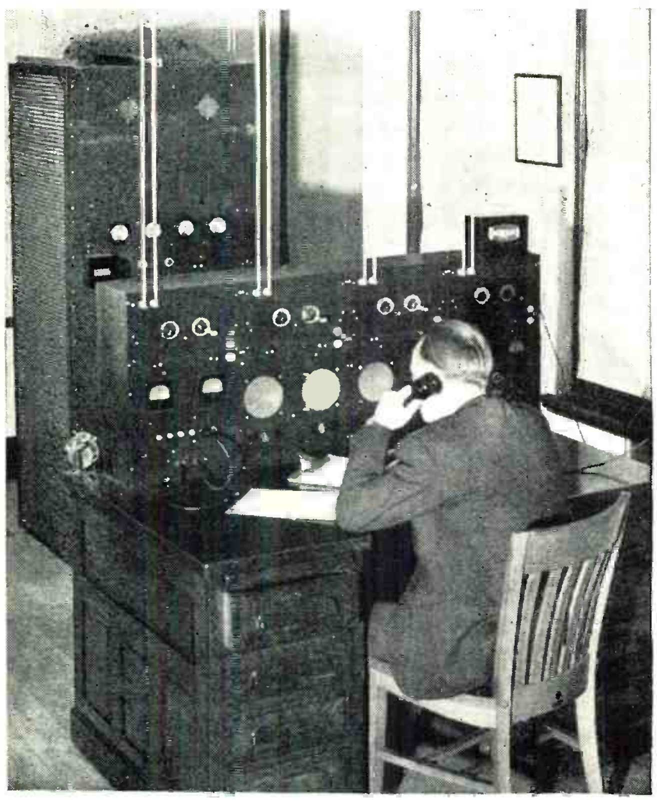
Crystal-control unit and final amplifier of the 50 watt transmitter. Tubes on right are RK 28's.



The long vertical rods are tuned to exact resonance. Note connections for transmitting antenna.



Every precaution is taken to insure trouble-free performance and to protect equipment from fires.



The Master Radio Control panel in State Headquarters used to contact mobile units, towers and portable sets.

A FLIGHT RECORDER

Newest device records the complete flight performance of aircraft while undergoing test flights with complete pilot safety.

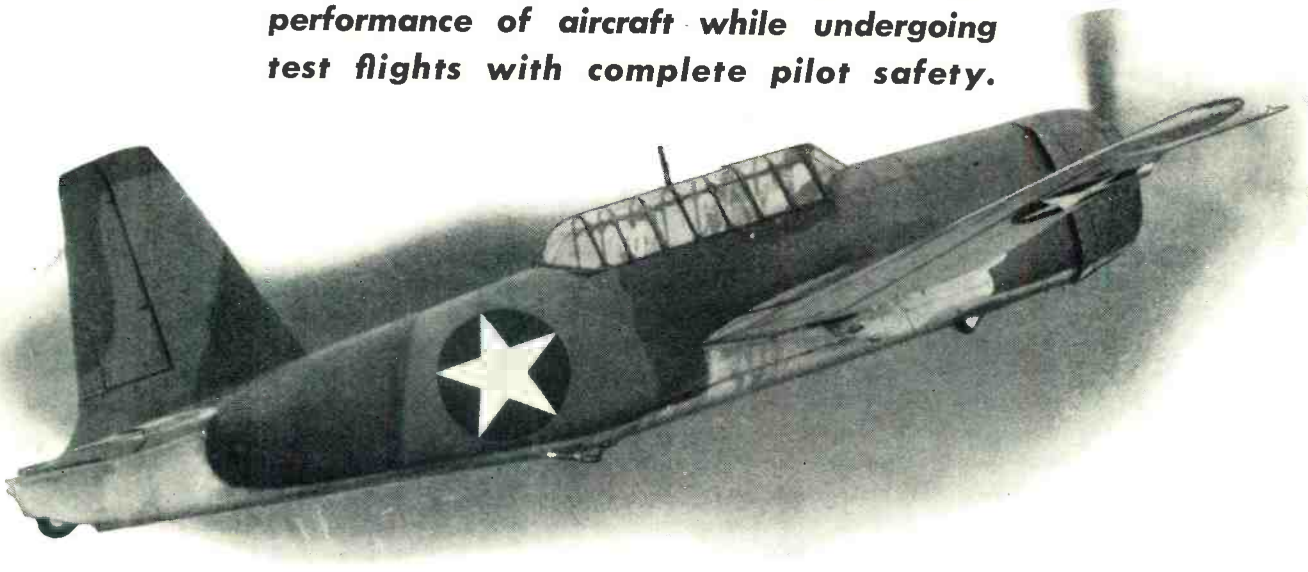


Fig. 1. The performance of this Vultee Vengeance Dive Bomber is being recorded by radio thousands of feet below.

Fig. 2. Flashed to the earth by radio, the stream of reactions is picked up by the ground unit and recorded on discs.

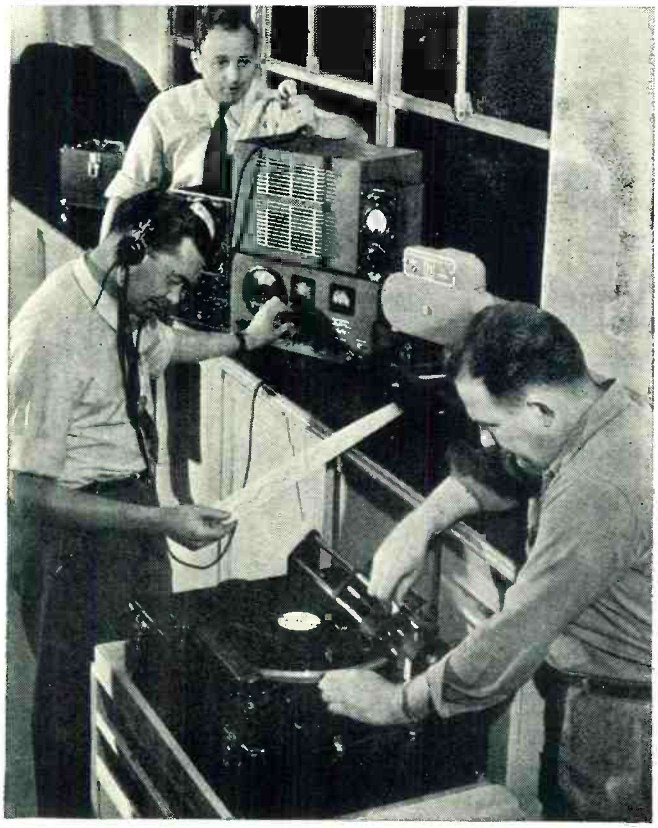


Fig. 3. An endless belt of 72 charts is used in this pen recorder. After decoding is complete, charts are cut apart.

FOR AIRCRAFT . . .

by HARVEY D. GIFFEN
Radio Engineer, Vultee Aircraft, Inc.

PRESSED by time and cramped by lack of space, particularly in small fighting planes, aircraft manufacturers must test prototypes as rapidly as possible yet obtain accurate and permanent records.

The *Vultee Radio Recorder,* designed and built by *Vultee Aircraft, Inc.,* not only makes possible high-speed recording; it also makes possible quick analysis of those records.

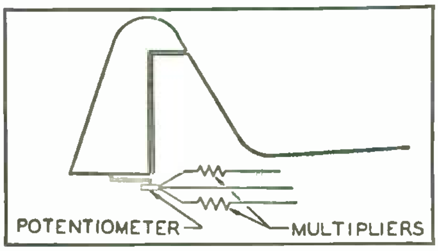


Fig. 4. How control surfaces are measured with potentiometer.

This system serves the following functions:

1. It responds to a variety of stimuli from pressures, temperatures, strains and movement by means of special pickups.
2. It scans these pickups as rapidly as 100 readings per second.
3. It transmits these indications to the ground by radio.
4. On the ground, recordings are made on paper charts, wax discs and film.

Necessity for such a system is immediately apparent. Pilots testing warplanes are faced with the necessity of controlling their planes during severe gyrations, and cannot be expected to record faithfully the many instrumental readings. Because the many factors of atmospheric conditions, vibrations, fuel flow, etc., are often variables, frequently changing by split-seconds, readings and recordings must be taken very rapidly.

One reason alone is adequate to provide radio transmission for these readings. Should the plane crash, valuable data would otherwise be lost. What caused the failure? Very likely we never would learn the answer. As it is, however, those records are safely in the keeping of engineers on the ground at the very moment those in the plane are lost.

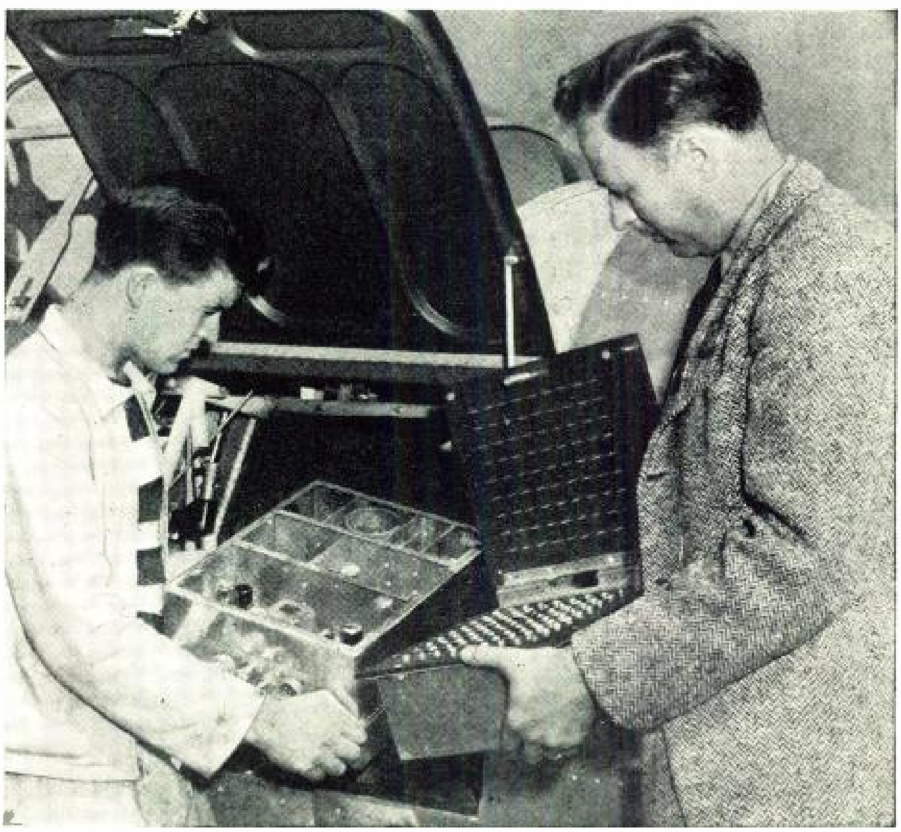
In the past radio recording has met difficulties under certain conditions by fading, decreased range of operations and interference caused by static. We have overcome the latter two problems by confining the flights to a distance of about 100 miles, over which range normal radio communication can be maintained easily, and by employing limiting circuits similar to those employed in Frequency Modulation receivers. As for fading, this is overcome by converting the amplitude readings of the various pickups into audio frequency modulation, which can't be altered by amplitude variations in the radio carrier. It might be interesting to add that either the plane's transmitter may be used, with the pilot switching alternately from normal communication to recorder instrument signals; or, an auxiliary transmitter on any band suitable for voice communication may be used when space for installation permits.

For purposes of clarity, let us consider the equipment in the following divisions: that installed in the airplane, that employed on the ground, and the scanning switch which passes the signals along from air to ground. Finally, we shall explain how the system is calibrated.

Plane equipment consists essentially of pickups, scanning switch, and converter. The pickups, specially designed, are so constructed that they cancel out automatically all variable factors, except the one we wish to measure. Each pickup with its leads forms two arms of an A.C. bridge. Temperature pickups Fig. 15, by way of example, are of the resistance type which follow rapid changes in the medium being measured. These consist of a thin copper tube, a thermal insulator of special cement, the resistance wire winding and a thin copper plating over the winding. Similarly, other units made of stainless steel and platinum wire measure high temperatures, as in exhaust gases.

Standard type wire-wound strain gages Fig. 14 measure strains. An unstressed dummy gage is mounted adjacent to each, and this gage with the leads forms two arms of the bridge to cancel out the effects of temperature. Leverage systems operating a potentiometer measure positions of controls and control surfaces Fig. 4. Standard diaphragms are employed in all pressure units Fig 9, movement of each diaphragm causing a small armature to move between two coils which form two arms of a reactance bridge. We find other uses for reactance bridges, also, as measuring the deflec-

Fig. 5. The network of special instruments and gages that connects with this unit of the Vultee Recorder reacts at lightning speed to all conditions during flights.



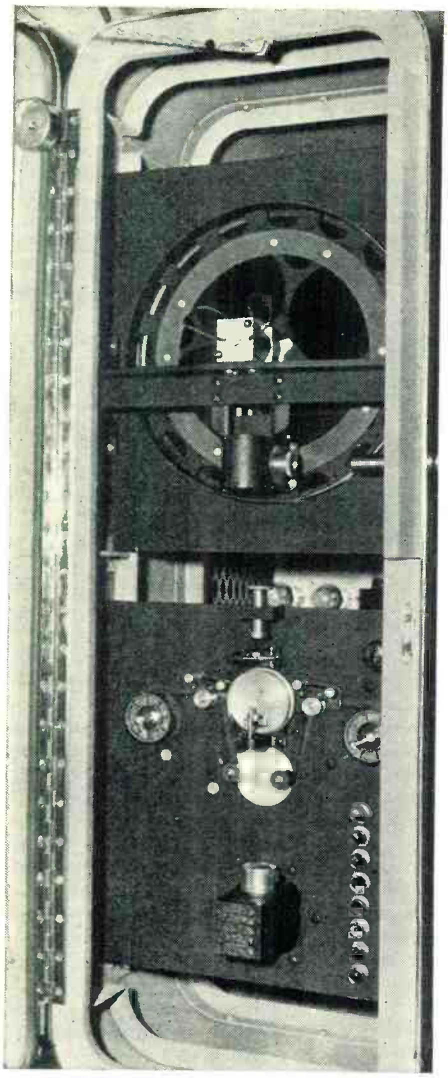


Fig. 6. The scanning mat, mounted on a revolving drum, consists of a transparent film on which is recorded a continuous sound track of 500-5500 c.p.s.

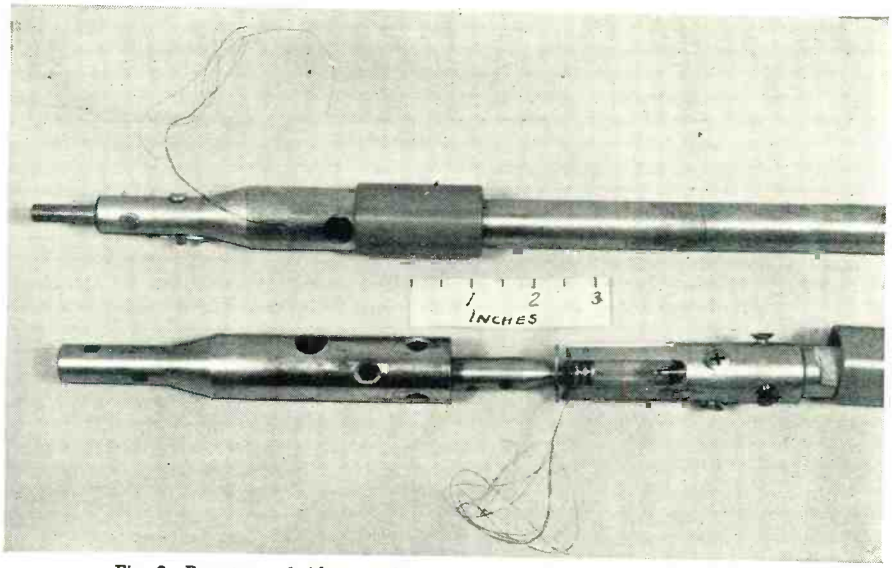
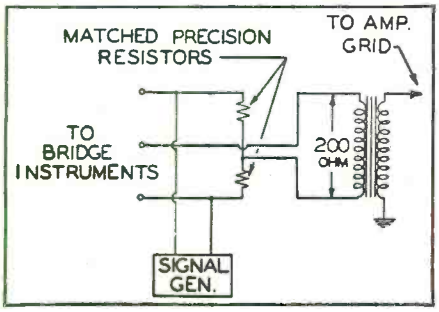


Fig. 8. Reactance bridge used in pressure units for measuring deflection of a spring in a push-pull control rod. Note compact assemblies.

tion of a spring in a push-pull control rod Fig. 8. Each of these pickups and its leads form two arms of a bridge which is connected by the switch to the other two bridge arms built in the converter Fig. 7.

Reference to the schematic wiring diagram Fig 13 will show graphically how the plane's system operates. An A.C. generator (C) energizes the many pickups, while the switch (B) scans

Fig. 7. Each pickup and its leads form two arms of a bridge which is connected by the switch to the other two bridge arms that are built in the converter.



them. The amplitude of the bridge carrier is changed or modulated by the gage under influence of the stimulus being measured, causing a change in amplitude of the bridge carrier (D), which is amplified at (E) and rectified at (F), producing a large D.C. amplitude change corresponding to the change in gage (A). The D.C. (B) is then fed into the control grids of a pair of reactance tubes which act as part of the capacity and inductance of an oscillator circuit (H) which varies in frequency between 4,000,500-4,005,-500 cycles per second in accordance with the amplitude of (B), giving a frequency modulation (G) as shown. This varying frequency beats against the fixed frequency of oscillator (K), which causes a beat note (J) between 500 cycles and 5500 cycles. This audio signal (J) is then fed into the microphone line of the airplane's transmitter.

The above equipment weighs approximately 27 pounds, including the 12-pound switch and the 15-pound converter unit.

Of equal importance is the ground equipment, for transmission of signals would avail us little were we not able to record them properly. For this purpose, a disc recorder is employed to cut a master record, which is available instantly for use should any of the other units mal-function. Simultaneously, the signals are decoded electronically and recorded on moving paper charts. Width and accuracy of this chart depend almost entirely upon the speed with which the scanning switch operates. Readings may be made as slowly as one per instrument, during powerplant studies, or as rapidly as 100 per second, to record load distributions during strain studies. The signals may be recorded simultaneously on both disc and film, or the film can be re-recorded from the disc.

As indicated by Fig. 17, our radio recorder analyzer automatically decodes the recorded signals and plots the readings of each pickup on a separate chart by projecting each image of each signal through an optical scanning system. This system both determines the frequency of the signal as recorded, and plots the related amplitude with pen and ink on a chart. Further, the analyzer shifts the proper chart for each pickup into the recording position when the film image of that pickup is moved into the decoding system. By this means, changes in stimulus for each pickup are plotted separately, requiring about 3 seconds.

Three seconds seems a long time

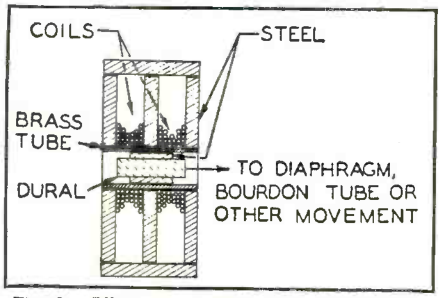


Fig. 9. All pressure units use standard diaphragms. Their movement causes a small armature to move between two coils which form two arms of a reactance bridge.

compared to the instantaneous electronic conversion from changes of stimuli to changes of frequency in the converter unit. This lag in decoding and plotting by the optical analyzer is controlled, however, by the time element imposed by the mechanical devices used. The sequence of charting operations involves five steps:

Without contact, the recording pen moves across the chart in relation to the rotation of the scanning mat. A matching surge causes the pen to strike the paper. Next, the pen returns to zero. Fourth, an endless belt moves ahead to the chart for the next instrument. The film moves ahead to the next instrument frequency. The cycle starts over when the fourth and fifth steps are completed. Interlocking relays prevent

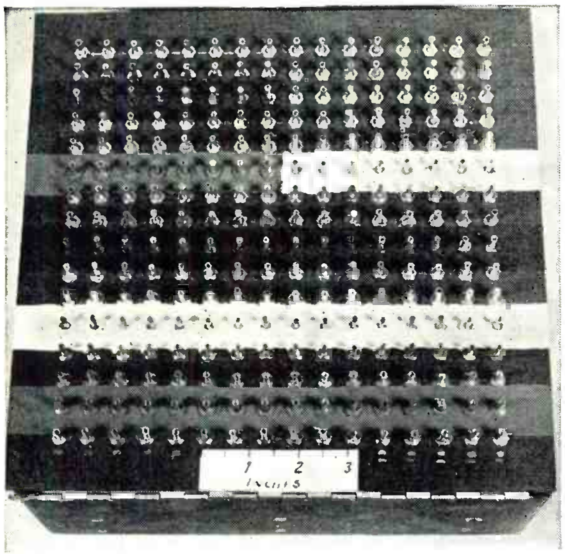


Fig. 10. All contact points of the switch are wired so that any desired sequence of readings may be made.

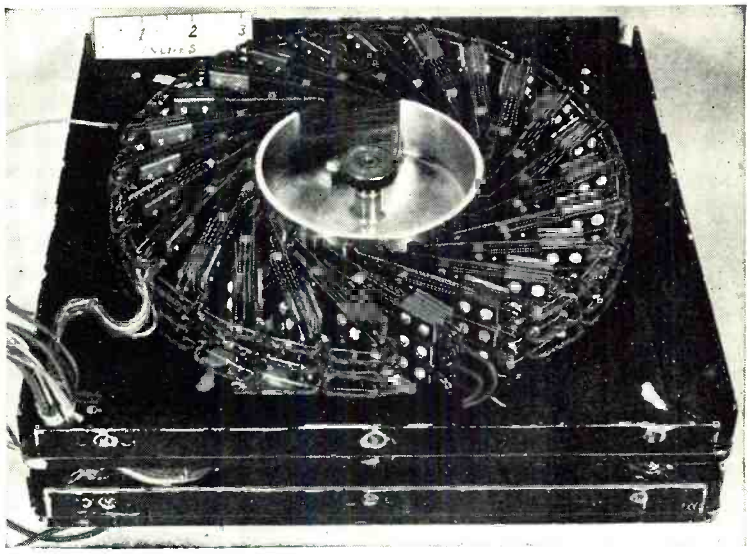


Fig. 12. The elaborate scanning switch, shown above, consists of many leaf-type contacts. They are operated in proper sequence and by a special cam.

premature operation of any part of the analyzer. When 72 instruments are scanned, an endless belt of 72 charts is used in the pen recorder. Following decoding, the charts are cut apart, giving us a separate chart for each instrument. All charts match as to the same flight time element.

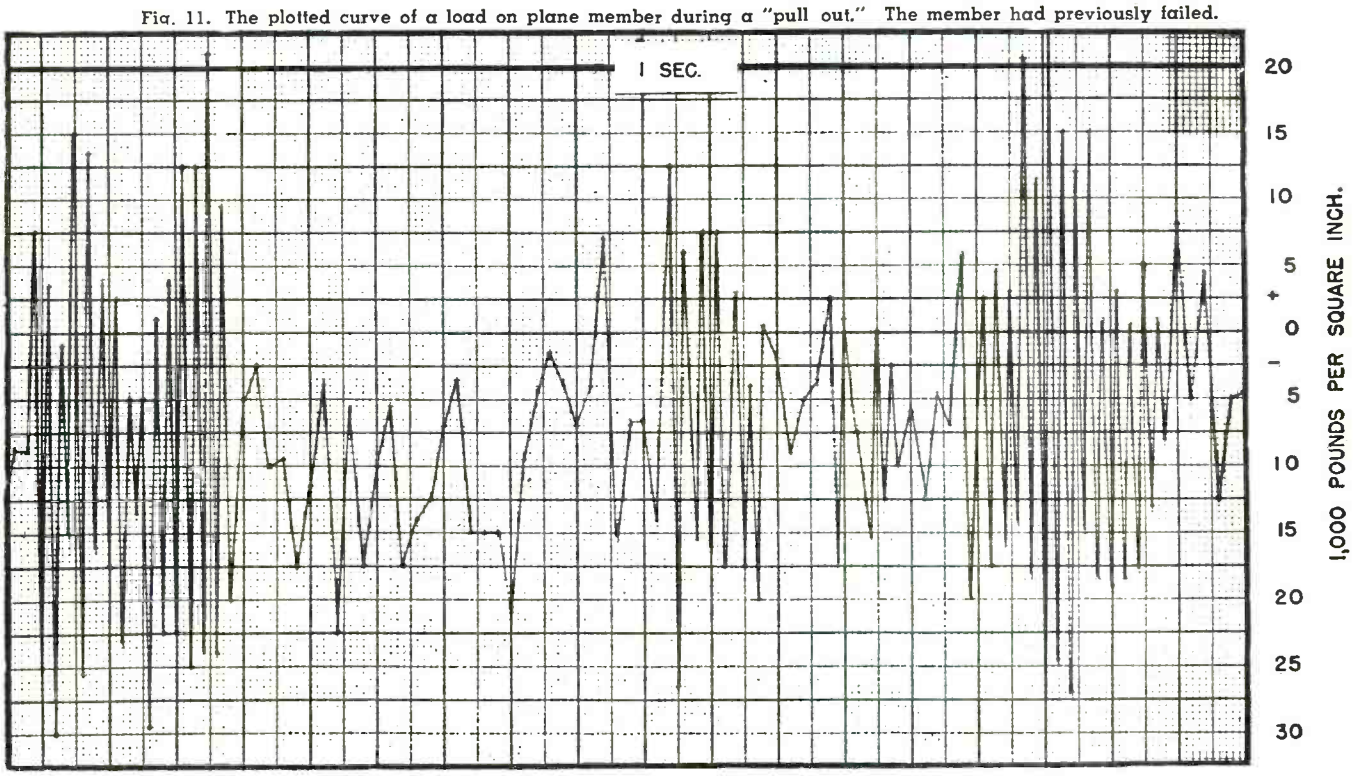
Instantaneous graphic recording and cutting of the disc records follow orthodox methods. An intervalometer is used in connection with these devices when we desire to record instrument readings at definite time intervals, as, say, readings every half-minute during a climb. Controlled by cams and selector switches, the intervalometer starts and stops the recorders and withholds the signal until proper recording speed is reached. It is also equipped with an override button to permit continuous recording.

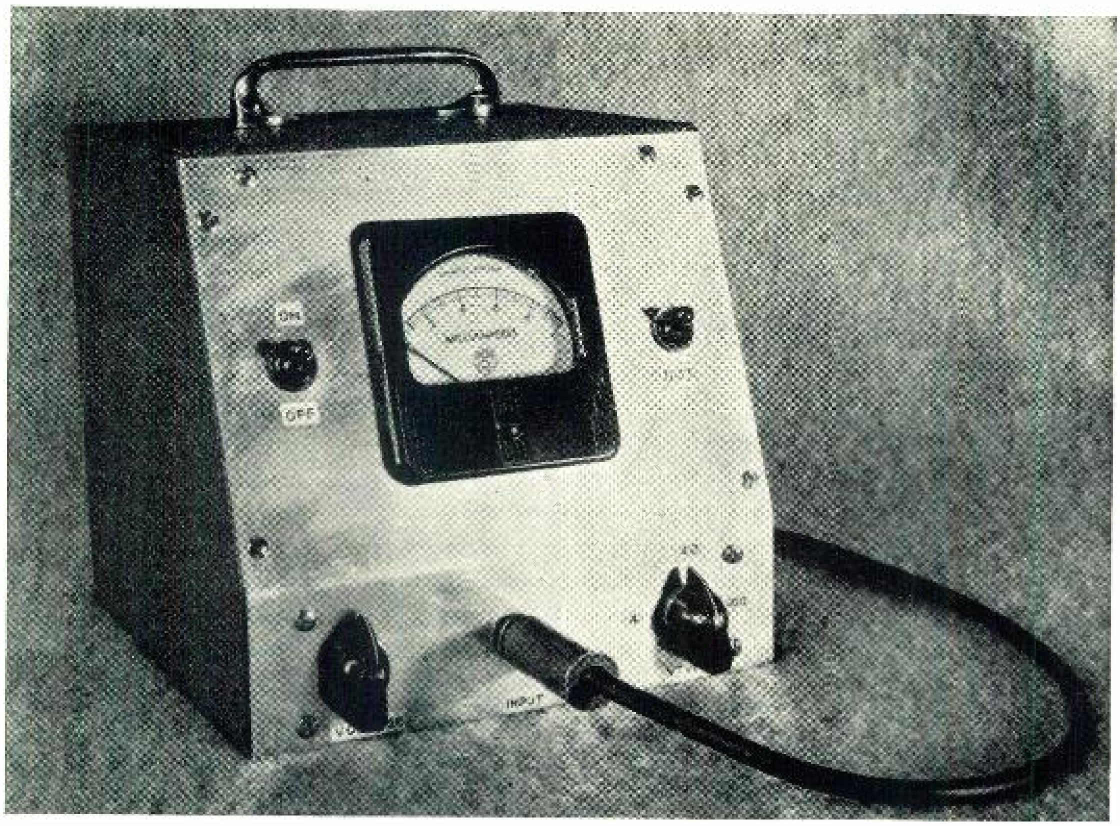
You may look upon the scanning switch, Fig. 12, as the brain which actuates the entire system. The device as now used has reached a high degree of efficiency because of the considerable research which has gone into its development. It consists essentially of leaf type contacts actuated by a cam. One arm and the amplifier input of each bridge pass through the switch, while the opposite arm is connected directly to a converter connection common to all pickups. All leaf switches are so adjusted that the arms of the bridge are completed before the amplifier input contact is made, thereby preventing overloading in the amplifier while the bridge is open on one arm. Vibration and bouncing are avoided by the arrangement of the switches with respect to the cam, which is so arranged as to put uniform pressure on the switch during contact. Electrical controls and changeable gears govern speed changes in scanning. Any one, or two or all three of the 24-contact-set banks may be scanned, individually or in succession. Gear trains and electric plug-in-jacks govern the scanning sequence.

As an added feature, other gear trains and contact points enable the switch to halt the signal from the converter between each instrument reading, Fig. 17, thus providing divisions between instruments to facilitate later analysis. Special contacts make pos-

(*Continued on page* 42)

Fig. 11. The plotted curve of a load on plane member during a "pull out." The member had previously failed.





The completely assembled distortion meter, showing the front panel layout. Meter is 0-1 DCMA.

A DISTORTION METER FOR P.A. MEN

by **RUFUS P. TURNER**
Consulting Engineer, RADIO NEWS

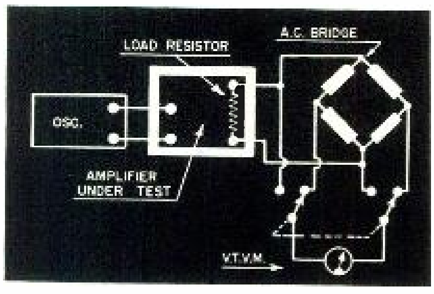
This instrument, while not possessing extreme accuracy, is well suited for measuring the harmonic distortion in amplifier circuits.

THERE are several well-known systems now in general use for measuring the distortion percentage of audio-frequency amplifiers, audio oscillators, lines, and associated equipment. These instruments place "quality" determinations on a quantitative basis. Most such apparatus is at present to be found only in broadcast stations and in well-equipped scientific laboratories. Few P. A. servicemen own distortion meters of any type, although it is readily admitted within their craft that such meters, if they could be inexpensively produced, would greatly enhance their trouble-shooting operations.

This article describes a simple, readily portable distortion meter which may easily be built at little expense from spare radio parts by any amplifier technician engaged in military or civilian work.

This instrument is not elaborate in design and does not require for its calibration special equipment not likely to be found in the average radio shop. Likewise, it is simple in principle and accordingly is easy to operate. Direct-reading, it does not require calculations. With the best quality parts, the meter will not cost more than fifteen dollars to build—in fact, it may easily be made up from spare parts commonly found in any radio "junk box." The design is recommended to industrial laboratories that find it difficult because of the present emergency to obtain commercially-built instruments without high priorities and long waiting periods.

Fig. 1. Functional block diagram.



With this distortion meter, the audio technician may rapidly determine the actual percentage of distortion in a complete amplifier or in a single amplifier stage, through coupling devices, or through modulation processes. The total harmonic content of various a.f. voltages or currents may be measured quickly and directly, and the total harmonic content of output voltages from audio oscillators, generators, and the like likewise be determined. The instrument has a high-impedance input circuit and, as a result, presents a negligible load to the device under test, thereby drawing little power for its operation. It is self-contained.

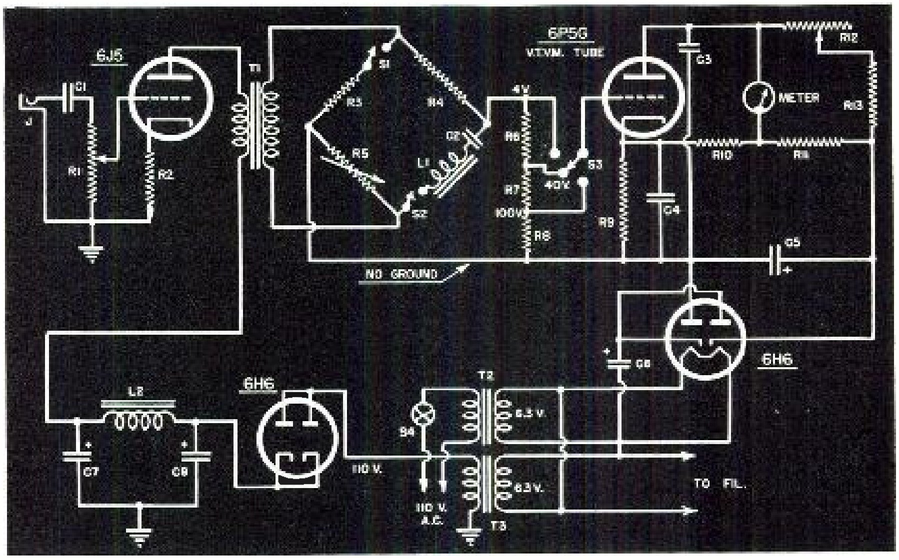


Fig. 4. Circuit diagram of the completed Distortion Meter.

C_1—*0.02 µfd. mica, Aerovox*
C_2—*See text*
C_3, C_4—*0.1 µfd. 200 volt tubular, Aerovox 284*
C_5, C_6—*Each 16 µfd. midget electrolytic, Aerovox PRS-B*
C_7, C_8—*Each 40 µfd. midget electrolytic, Aerovox PRS*
R_1—*1 megohm potentiometer, I. R. C. Type CS*
R_2—*8500 ohms, 1 w., Aerovox 1098*
R_3, R_4, R_5—*See text*
R_6—*900,000 ohms, 1 w., Aerovox 1098*
R_7—*60,000 ohms, 1 w., Aerovox 1098*
R_8—*40,000 ohms, 1 w., Aerovox 1098*
R_9—*1000 ohms, 1 w., Aerovox 1098*
R_{10}—*10,000 ohms, 1 w., Aerovox 1098*
R_{11}—*500 ohms, 1 w., Aerovox 1098*
R_{12}—*2000 ohm rheostat (wirewound), I. R. C., W-2000*
R_{13}—*3000 ohms, 1 w., Aerovox 1098*
L_1—*See text*
L_2—*Miniature broadcast filter choke, Thordarson replacement*
T_1—*Shielded interstage broadcast type transformer*
T_2, T_3—*Midget 6.3 volt filament transformer, Thordarson T-19F80*
J—Closed circuit miniature jack, Mallory
S_1, S_2—*D. P. S. T. toggle switch, A. H. & H.*
S_3—*3-position, single-pole rotary switch, Centralab*
S_4—*S. P. S. T. switch, A. H. & H.*
M—0-1 d.c. Milliammeter, Simpson

Defective transformers, improper by-passing, impaired coupling devices in general, and faulty tubes, as well as incorrect values of load impedance are only a few of the factors contributory to poor tone quality that may be revealed by distortion tests with the meter. At the same time, the efficacy of certain circuit refinements, such as degenerative feedback, may be measured in comparative distortion tests made with the meter.

Operating Principle

Common distortion meters in general present use include (1) wave analyzers of both the heterodyne and resistance-tuned amplifier types, (2) filter-type meters, and (3) bridge-type meters. Wave analyzers are tunable devices which cover the entire a.f. spectrum and are capable of indicating successively the amplitude of each individual harmonic component in a complex waveform. These instruments are usually highly complex in operation and if home-built, may be adapted to full a.c. operation only after prolonged and painstaking developmental work.

Filter-type and bridge-type meters are harmonic totalizers in that they indicate, in most cases directly, the total harmonic voltage present in a complex waveform. In virtually all P. A. work, it is this harmonic total that is of importance to the technician. It is only on rare occasions that he is concerned with the relative amplitudes of each harmonic component. These latter type distortion meters are considerably simpler in arrangement than the more advanced wave analyzer.

The filter-type meter makes use of a wave filter, generally of complex configuration, to separate the fundamental frequency of a test-oscillator voltage from the output of an amplifier under test. The only voltage remaining in the output will then be that due to the total harmonics present, and this may easily be measured with a vacuum-tube voltmeter. If the voltage ahead of the filter is first measured and used as a reference value, a ratio may be struck between this value and the voltage after the filter to show the harmonic (distortion) percentage. Likewise, the meter may accordingly be made direct-reading in harmonic percentage. A disadvantage of the filter-type meter, as far as home-building is concerned, is its requirement of an accurately-designed and closely-adjusted filter circuit which demands considerable ingenuity in filter engineering and calibration.

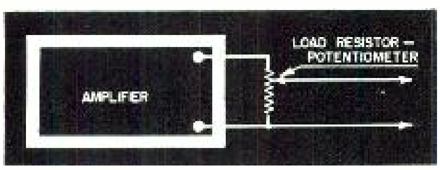


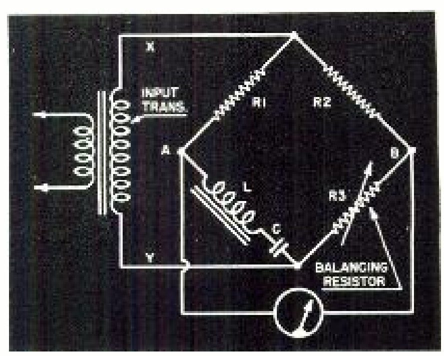
Fig. 2. Calibrating circuit.

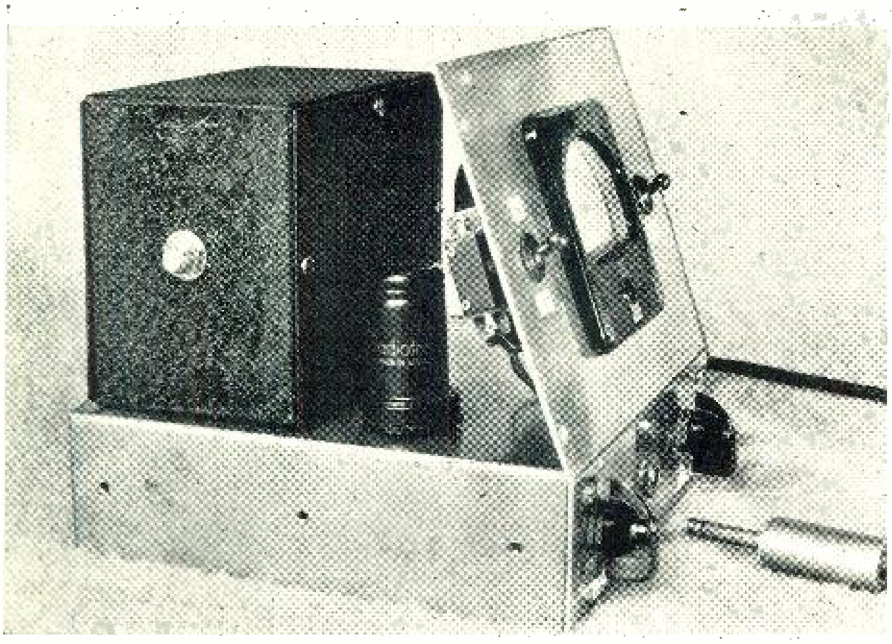
The last system, the bridge-type meter utilizes a simple bridge, rather than a filter, to remove the fundamental frequency from the output of the device under test. Its operation is decidedly straightforward and understandable: an amplifier under test, for example, is supplied with an input voltage at a standard test frequency from a low-distortion audio oscillator. In the output circuit of the amplifier, in place of the speaker or across the speaker or resistor load, is connected the bridge which is then balanced to null at the fundamental frequency. At null, any voltage remaining is that due to the total harmonic content and this is measured with a vacuum-tube voltmeter. Thus, the bridge becomes a simple harmonic totalizer which contains relatively few components and is both easy to build and operate.

This principle of operation is illustrated by the functional block diagram of Figure 1. It will be observed that the v.t. voltmeter in this arrangement is connected to the circuit through a double-pole, double-throw switch. When this switch is in the left-hand position, the meter is connected across the output of the amplifier under test and thus is made to read the total amplifier voltage—fundamental plus all the harmonics. This reading we will call the reference voltage. When the switch is in the right-hand position, the v.t. voltmeter is connected to the bridge output and the bridge may then be balanced until the minimum reading of the meter shows null. If there were no harmonics present in the output voltage, the meter would read zero at this point, since the bridge has been balanced for the fundamental frequency. The chances are that there will be a definite readable voltage at minimum dip (null), indicating the actual total harmonic amplitude. By comparing this voltage with the reference voltage obtained formerly with the switch in the left-hand position, the ratio of the harmonic voltage to the total output voltage (or the percentage) may then be obtained.

Several bridges suggest themselves for use in such simple distortion meters. The most satisfactory for this purpose is the familiar *resonance bridge,* long employed in laboratory table set-ups for distortion measurements at audio frequencies. The resonance bridge has been called clumsy by some authorities, since it requires a large amount of bulky equipment when a number of frequencies must be covered, or when individual harmonic amplitudes are to be deter-

Fig. 3. Basic bridge arrangement.





Compact assembly of the Distortion Meter. Sloping panel aids in reading meter.

mined. However, this circuit will be entirely satisfactory for amplifier measurements, since in this work *harmonic total* rather than individual amplitudes is the important factor.

A typical resonance bridge is shown in Figure 3. It is this circuit which is the basis of the distortion meter described in this article. The arrangement will be recognized as a simple four-arm bridge with transformer input and v.t. voltmeter detector (null indicator). The one salient difference displayed is the presence in one of the bridge arms of a series resonant circuit comprised by the capacitor C and the inductance L. The same mode of bridge operation is obtained when L and C are arranged in a parallel resonant circuit.

Operation of the resonance bridge is simple: L and C are so chosen in value that they form a resonant circuit at the fundamental frequency which is to be eliminated. At this resonant frequency, the inductive reactance and the capacitive reactance cancel each other and there is nothing left in the resonant arm but resistance. The bridge then balances as a four-resistor bridge. However, the bridge is balanced only for the resonant frequency determined by L and C and not for the various harmonics of that frequency. With the v.t. voltmeter at points A and B, as shown in the diagram, the voltage indicated at null is that due to the total harmonic contant. But when the voltmeter is at points X and Y, the full voltage (fundamental plus harmonics) is indicated. If this latter voltage is designated E1 and the null voltage E2:

$$\text{Percent Distortion (total)} = \frac{E2}{E1} \times 100$$

It may be well to mention here that this distortion percentage is the total, i.e., the output voltage in reference to the total input voltage. The total input voltage will be comprised of the fundamental, second, third, etc., harmonic. This total is not a vectorial sum of all these various waves, as these separate waves form a single wave which is in a complicated form.

It is seen that a number of L-C combinations will be tunable to the fundamental frequency and that the builder may use any choke coil available as long as he connects the proper capacitance at C to make the L-C combination resonant at the fundamental frequency. Chart I lists the common inductance values of choke coils that are apt to be found around a radio shop against the condenser values required to resonate at the common audio test frequencies of 400 and 1000 cycles per second. Either test frequency may be employed, as both are standard for audio-frequency test work, although 400 cycles is most generally used.

In choosing a choke coil, only one precaution need be observed: that the ratio of reactance to resistance of the coil be greater than 10. The reactance of the coil may be determined from the equation: $X_L = 6.28 f L$, where X_L is the inductive reactance in ohms; f, the frequency in cycles per second; and L, the inductance in henries. It should be borne in mind, however, that the inductance of power supply choke coils, as commonly stated by manufacturers, takes into consideration the flow of some d.c. through the coil and the inductance is apt to be somewhat different when no d.c. is present, as is the case in the bridge circuit. It will be advisable to measure the inductance of the choke at the fundamental frequency because of this fact.

It is obvious that the simple bridge of Figure 3 might be adapted still further to the task of distortion measurements by providing a high-impedance input circuit in place of the simple transformer (in order to load the tested device as lightly as possible) and a potentiometer at the bridge output to enable full scale adjustment of the voltage. These additions are shown in the circuit of Figure 5.

The high-impedance input is afforded by the simple triode amplifier and the high-resistance control R1. In order that this tube shall introduce as little distortion as possible, its cathode resistor R2 is made very high in value and is left un-bypassed for degeneration. Variable input to the v. t. voltmeter is obtained through the second potentiometer R3. Actually, R3 may be dispensed with, since the input control R1 will permit the operator to adjust the full voltage to full-scale on the v.t. voltmeter. It will be noted that the high cathode resistance will reduce the gain of the amplifier stage considerably; however, this is of no importance, since the tube is introduced merely to provide a high input impedance for the distortion meter with minimum distortion, and amplification is not desired.

In all of the arrangements shown, a v.t. voltmeter is indicated. This type of voltmeter is essential to proper operation of the circuit both because it offers high input impedance and is unaffected by the frequency of the applied voltage. A high-resistance copper-oxide rectifier type of a.c. voltmeter is unsatisfactory because of its inherent frequency error.

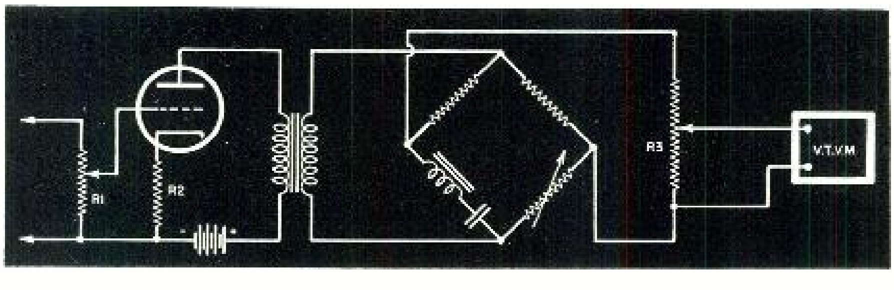
Distortion Meter

The distortion meter shown in the photographs combines the principles and circuit arrangements discussed thus far to give a self-contained instrument consisting of (1) input degenerative single-stage amplifier, (2) resonance bridge, (3) direct-reading v.t. voltmeter, and (4) power supplies for the amplifier and v.t. voltmeter.

The complete circuit diagram of the instrument is shown in Figure 4, and the instrument is shown in external and internal views in the photographs.

(*Continued on page* 64)

Fig. 5. This arrangement enables full-scale adjustments to be made.



entation by T. K. Miles of the National Roster of Scientific and Specialized Personnel War Manpower Commission, the scientific manpower problem was effectively analyzed. Of the 280,000 professional engineers that are registered to date, but 7,000 are engaged in radio engineering, according to Mr. Miles. Every effort is now being made to increase this percentage with thousands of electrical engineers taking on radio engineering work.

A paper by Dr. George C. Southworth of the Bell Telephone Laboratories, pointed out the importance of wave guides for conveying microwaves. Dr. Southworth said that these wave guides are decidedly useful since they contain no insulating material and so are entirely immune to moisture. In addition, he said their waves can be radiated by simply flaring out the tube into a horn. By blocking one end with a metal plate and closing another partially by a plate with a hole in it, a wave guide may also be made into a resonant chamber, he explained. Its precise frequency can be determined by varying the length of the chamber. It is possible to locate a detector at precisely the right spot in a pattern for maximum response because the wave pattern in a resonator is fixed, said Dr. Southworth. And incidentally, sound waves are strikingly similar to electric waves since they too can be guided down a tube. Of course, any hole in the tube will let out sound energy. On the other hand, one of the most useful forms of the electric wave is that it can be so oriented, in a hole in the tube or even to a long slot, that no energy escapes. Thus it is possible to insert an electrical probe and move it along the tube. The detection of any irregularities is thus made possible.

With wider channels becoming more and more essential for such developments as television, frequency modulation, and so on, the micro region is becoming more and more an important factor. There is no doubt according to Dr. Southworth that microwaves will see one of their most important, if not their most important, period of use in the post war era.

BATTERIES FOR FARM RADIOS AND HEARING AIDS will be available in accordance with production schedules previously announced, but flashlight and other similar types of dry cell batteries will no longer be available in the usual quantities. In an amendment to battery limitation order L-71 the production of flashlight cells are cut to 35% of the 1941 rate.

Since batteries for farm radios are considered so vital, but are nevertheless not as plentiful as heretofore, the consumers durable goods division of the WPB has issued a bulletin covering battery conservation. The bulletin, which is free for the asking, is known as WPB 2332. There are very many helpful hints provided. We thus urge you to write for a copy, particularly if you own a farm type radio set.

PROBABLY THE MOST IMPORTANT PLAN OF THE DAY on the homefront is the controlled materials plan, or better known as the CMP plan. It has been the subject of discussion not only in many industrial circles, but in all forms of meetings in Washington among a variety of groups. With the recent retirement of Ferdinand Eberstadt, interest in the plan assumed front page prominence. It was indicated at that time that the plan might be changed. However according to a statement issued by Charles E. Wilson, who is executive vice-chairman of WPB, no change is contemplated. The plan is a sound one providing distribution of critical materials, said Mr. Wilson.

"For example," said Mr. Wilson, "the B list, which covers specific items not included in the A list, is being interpreted and classified better to assist manufacturers notwithstanding, into which category, A or B, the products which they make, fall. Class B products are items normally sold on the open market."

Claimant agencies provide information on the allotment of controlled materials to prime manufacturers of class A products. Class B product manufacturers receive their allotment data from the WPB Industries Division.

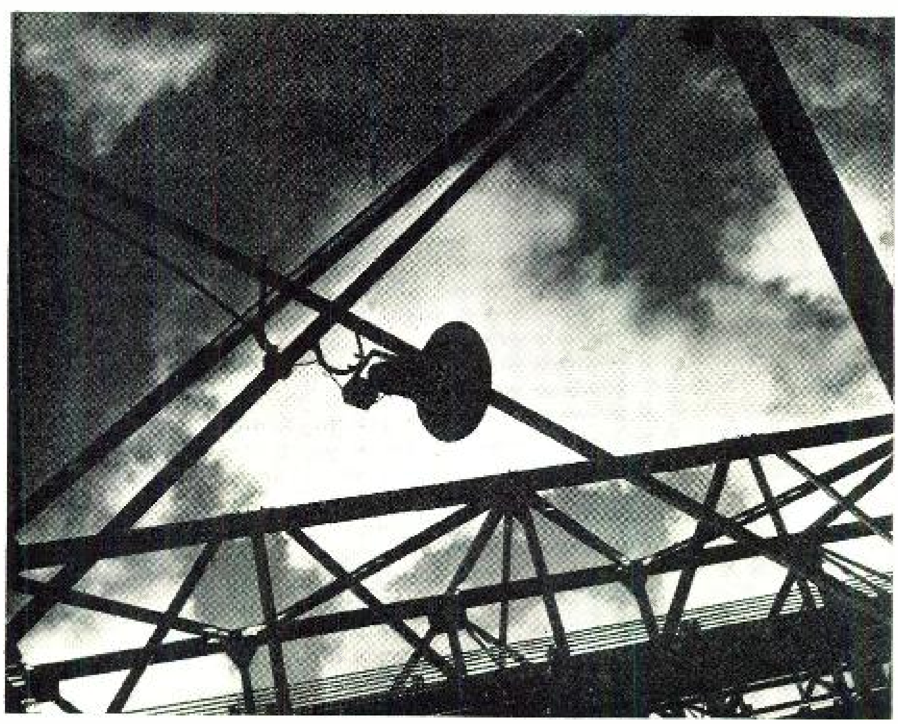
If any manufacturer is in doubt as to the class into which a product falls, he should write or wire the controlled Materials Division, War Production Board, Washington, D. C. providing a full description of the article in question. To assist manufacturers, many government engineers are being sent around. Many a radio plant has received a welcomed visit from a CMP man during the last few weeks. And according to these visited manufacturers, and others who have put the plan into operation, the plan is a most effective one that will be of material assistance in providing greater production than ever before.

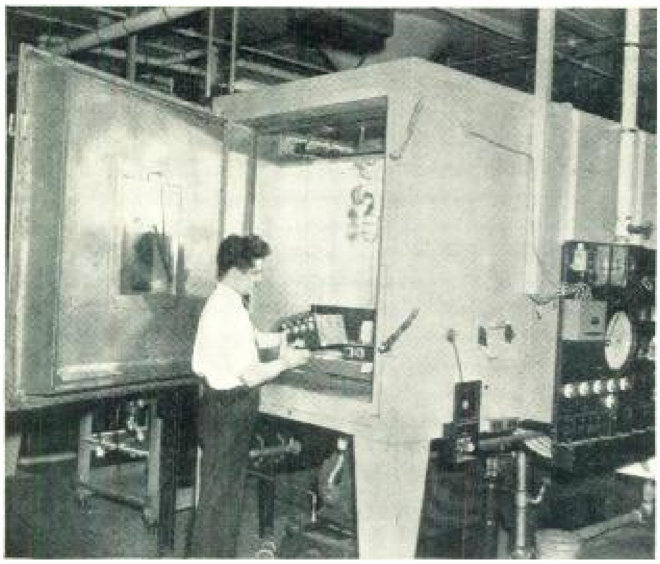
IT TOOK A YEAR'S SEARCH TO FIND that a high resistance taped-connection was the cause of a persistent reduction in volume along the line of one of our nation's leading network stations. Every time this reduced signal effect was noted, the telephone company troubleshooter would apply the usual test means and find nothing wrong. Yet shortly after the test was completed, a decided drop in signals again occurred. After an exhaustive study of this puzzling situation, it was found that a circuit in which the lines were tied together in a very solid way, but without the aid of solder, was causing the trouble. It appeared that every time the troubleshooter applied the test circuit, the resultant voltage delivered by this instrument, broke down the residual resistance which was causing the loss in the circuit. Since because of physical difficulties, it was impossible to change the method of contact on the line, it was decided to devise a system whereby rejuvenating voltages would be fed into the circuit on a predetermined schedule. With this unusual arrangement in operation, the program levels have been maintained and listeners no longer complain about signal fades. Strange what problems small things can cause!

TO HELP REPAIRMEN AND DEALERS LOCATE parts and tubes or equipment, a unique classified advertising service has been begun by Sprague Products Company. The service which is offered

(*Continued on page* 78)

This speaker is installed in the steel framework on ways for new battleship U.S.S. Alabama.





Testing aircraft receivers in a special humidity chamber.

Members of Royal Canadian Corps in communications room.

away from the home front, coordinated programs, wherein those that have remained behind, assisted by newcomers in the way of women and men, have been most effective. Service men and dealers have established training programs that have been most successful in providing new talent. While these "freshmen" cannot participate in all forms of servicing, they are performing many tasks that serve to expedite the servicing of receivers.

The victory line of replacement parts will also be of material assistance in providing an effective maintenance of receivers. In this respect it must be remembered that most receivers have an operating life of up to eighteen months before repairs are required. Thus there are quite a percentage of receivers that will require no repairs. And in many of the receivers of the past year or two that require repair, but minor adjustments will be required. In most instances, the repair will revolve about tube replacement. In this respect, the trouble may be a more complex one. For tubes do offer a problem today. Every effort is being made to provide a supply for most receivers. There will be unfortunately some types of receivers for which tubes will not be available. In many instances the ingenuity of the repairman will come to the rescue. According to estimates from dealers, it does appear as if the retirement of receivers will be, in most instances, due to lack of proper tubes.

THE CHIEF SIGNAL OFFICERS OF THE NATION presided at one of the most interesting meetings ever held, some weeks ago. The occasion, the eighteenth annual dinner of the Veteran Wireless Operators' Association brought together for the first time all of the directing leaders of the communication services of our military units. In attendance were Major General Dawson Olmstead, Chief Signal Officer of U. S. Army, Captain Carl F. Holden, Director of Naval Communications; Captain E. M. Webster, Director of Coast Guard Communications; Colonel A. W. Mariner, Director of Air Corps Communications; Colonel Berkeley, Director of Marine Corps Communications, and Captain Thomas Blau, Commandant U. S. Maritime Service. Each received a Marconi memorial reward for their outstanding contributions to the art. Acceptance comments were broadcast over coast-to-coast networks. During the broadcast messages, tributes were paid to the valiant efforts of radiomen of this nation. The outstanding work of the radiomen in Guadalcanal was also a featured topic of discussion by the celebrated military authorities.

Another highlight of this dinner was the unveiling of Ted McElroy's code-chart. This chart, contains for the first time, every known code which includes the Arabic, Russian, International Morse, American Morse, Japanese, Spanish, Flag Signals, "Q" signals, "Z" signals and many others.

Another outstanding celebrity in attendance was Major General J. O. Mauborgne, retired, former Chief Signal Officer, who spoke of the work done in the Signal Corps during the first World War. Incidentally it was General Mauborgne who was responsible for the installation of radio equipment on a plane in 1912, that provided the first concrete evidence of the importance of aeronautical communication. Major General Follett Bradley, Commanding General, First Air Force, who recently returned from the epic trip to Moscow, and who in 1912 participated with General Mauborgne, was also present. He received a special commemorative medal.

Radio, according to these celebrated gentlemen, has become a vital link in our military might . . . a tribute of which we are exceptionally proud!

THE SIGNAL CORPS MEN are doing an excellent job in the Asiatic theatre of war, under supreme difficulties, said Colonel Samuel S. Lamb of the Signal Corps, during a recent return to Washington. Colonel Lamb, who is now in India, pointed out that radio is truly one of the most essential implements of war in China, Burma and India, where the distances are so great and communications by means of wire are practically impossible. In Australia, New Caledonia and the Fiji Islands, radio is also a most important factor, said Major A. V. Wharton of the Signal Corps who also recently visited Washington. Major Wharton spent some two months studying the communications systems in these remote outposts. He found the boys in the Signal Corps accomplishing the impossible. With the most unfavorable conditions to combat, the men of the Signal Corps completed every mission assigned to them, to provide effective communications between a variety of inter-island and battle-position posts.

PRACTICALLY THE ENTIRE FORCE OF THE SIGNAL CORPS are now housed for the first time in one building . . . the vast Pentagon Building. Here we will now find Major General Dawson Olmstead and his staffs, together with the staffs of the Chief of Army Communications.

THE YEAR'S TEN OUTSTANDING MEN IN RADIO were recently honored with fellowship awards at the one-day winter conference of the IRE. Receiving these honors were Andrew Alford, International Telegraph & Telephone Company, for his design of shortwave antennas; Peter C. Goldmark, Columbia Broadcasting System, for his color-television contributions; Lieutenant Colonel Metcalf, U. S. Army, for his vacuum tube development work; Irving Wolf, Radio Corporation of America, for centimeter-wave research, and Ivan S. Coggeshall of Western Union; Captain Jennings B. Dow, United States Navy; Dorman D. Israel, Emerson Radio; Axel G. Jensen, Daniel E. Harnett and Lee A. DuBridge for their achievements in radio engineering.

Several interesting papers were presented at this conference. In a pres-

Spot Radio News
IN DEFENSE AND INDUSTRY

Presenting latest information on the Radio situation.

by LEWIS WINNER
Radio News Washington Correspondent

THE ACTUAL PARADE OF V LINE radio parts has begun, with transformers as the grand marshal. As we stated a short time ago, a comparatively few transformers will be included in this new program. However, those that will now be available, have been chosen since they provide a greater variety of applications than other types. Six types of power transformers, two chokes, two interstage transformers, a driver transformer and three types of output transformers are included in this new allotment of victory parts, at the present time. We say, at the present time, for while these types have been selected for the first production run, sudden emergencies may arise and cause a consequent production change. Nevertheless, as the program stands now, the power transformers that will be available are of the dual center-tapped filament winding type, 2.5-6.3 and 2.5-5 volts, with secondaries ranging from 0-350 and up to 200 milliamperes. In the chokes, we will have the six and fifteen henry types. The interstage transformers will be of the usual standard style. The driver transformer will have a voltage ratio of 1-1, 1.5 to 1 or 6-1. Output transformers available will have ratings of from 4 to 15 watts and primary impedance of 2500 to 15,000 ohms for two, four, six, eight and fifteen-ohm voice coils.

Since the transformers finally chosen will fit most receiver designs, the problem of practical replacement will not be a difficult one. There will, of course, be instances where some redesign will be necessary. This will be particularly true in those receivers that have been custom-built or produced in very limited quantities. A careful study of the circuits requiring such redesigning will reveal in most instances that the assignment is really not too difficult. However, since many of those who will be engaged in such servicing may not be too experienced, some manufacturers are planning to release data that will show how to make the necessary changes.

At this writing, it appears as if the V line of fixed paper condensers, dry electrolytic condensers and volume controls will soon be formally adopted, too. The data sheets now available are still subject to change, because of manufacturing and material problems. However, before the next month rolls around, there is every assurance that a standardized group of these components will also be available.

When last we mentioned the V line parts, we also stated that a lapse of some time must be expected between the date of approval and final release to the public. This cannot be avoided because of customary manufacturing and distributing problems. Manufacturers promise however that this "delay-gap" will be kept to a really low minimum of time.

Replacement coils, ballast tubes and resistance cords are also expected to be included in an additional allotment of victory line parts that should be announced within the next sixty days.

WHEN THAT HISTORIC LIMITATION ORDER curtailing consumer receiver manufacture was issued last June, consumers were stunned. They felt that now it would be impossible to buy a new receiver. Then to add to this problem, there was a sudden dearth of replacement parts. And to make the situation still worse, the ranks of repairmen were being depleted by the draft and recruiting campaigns. However, surveys made some thirty days later seemed to show that all was not as black as anticipated. And a succession of surveys made since that time has further shown that the situation is far from hopeless.

For instance, even though receiver manufacture was halted by everyone within about thirty days after issuance of the limitation order, dealers throughout the country, in the larger centers, of course, report that receivers are still available. The variety is not as great. And it is not possible to satisfy the individual demands, but there appeared to be sufficient receivers to maintain listening response at a substantial level. The smaller type receivers, popular with so many, may be classified as the real victims of the limitation order. In view of their popular price and convenient size, the rush to buy these types was greater than the larger consoles. Accordingly dealers' shelves are not too plentiful with table model receivers or portables. While the exact quantities of these types available now has not been tabulated, the survey seems to indicate that the supply should last at least until the summer months. In the console and larger table model type of receiver, the picture is much brighter. Dealers report that if there is no sudden surge of buying, and it doesn't appear as if there will be, the present stocks should last until next autumn and even perhaps into the winter.

A British mobile wireless van in action in the Western Desert.

There are still warehouses with close-out stocks stored away in some large centers. Every now and then releases of these lots are made and dealers have an opportunity to replenish their shelves.

While there are not too many of these sources of supply, those that do exist may serve to provide a supply of receivers for many months beyond the anticipated "end-of-supply". Consolidations of small and large stores are providing another source of supply for many dealers. Many dealers are also closing up their shops for the duration and selling out. This source of supply has been an effective one, particularly in the small communities where the shelves have not been too full at any time. The smaller community store unfortunately has been the greatest sufferer of receiver availability. Plans are afoot now to equalize distribution, using a metropolitan area as a focal point of such distribution. Washington hopes that with such a plan, whatever receivers are available can be made available to these isolated sections.

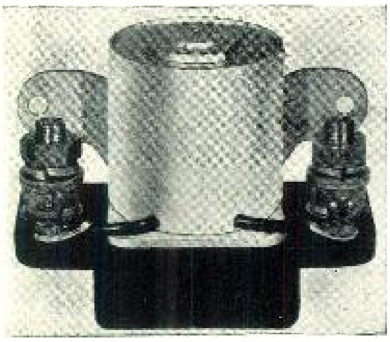
Although new receivers may not be available to any extent by the beginning of 1944, American listening will be far from seriously affected, thanks to the service man and woman. While it is true that the draft and enlistments have taken many service men

WHAT'S NEW IN RADIO

Solenoid Contactor Aircraft Control

Guardian Electric, Chicago manufacturer of relays and electrical control assemblies, announces production of five types of approved solenoid contactor units built to U. S. Army Air Forces specifications for remote control of electrically actuated aircraft armaments, instruments and devices. Among these, the B-4 type illustrated, originally designed for airplane starting motors, may be used for other applications of heavy current control.

The B-4 Solenoid Contactor operates on 24 volts producing a coil current of 300 milliamperes. Contacts are rated at 200 amperes at 24 volts D.C. Unit has double pole, single throw, normally open contacts. It is claimed that unit resists acceleration and vibration over 10 times gravity and operates in any position. May be disassembled with pliers and screwdriver.

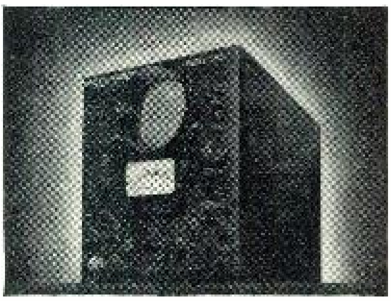


Metal parts are plated to withstand 200-hour salt spray test. Weight of unit, 31 ounces. Descriptive circular and full details available from *Guardian Electric,* Dept. B-4, 1630 West Walnut Street, Chicago, Illinois.

R.C.P. Announces New Cathode Ray Oscilloscope

Radio City Products Company, Inc., announces its new Cathode Ray Oscilloscope Model 555. This new instrument is introduced in line with R.C.P.'s policy of meeting industry's requirements for extended frequency measurements. The Oscilloscope uses a 5" Cathode Ray Tube operating on 2,000 volts. Permissible input voltage to amplifiers is 600 V. and direct to deflection plates 500 volts, rms. Input impedance is 3 megohms. Frequency response is ± 3 db from 20 cycles to 2 megacycles. Voltage gain is approximately 275 times. Sweep frequency is from 40 cycles to 750 kc. in 10 uniformly linear steps. Unknown peak input voltage can be read on a direct indicating multirange voltmeter. This is accomplished by a unique comparison method with an internal voltage source. Instrument operates from standard 115-230 volt, 50-60 cycle AC power supply.

Model 555 is housed in a black crackle, non-corrosive, steel case, 14"

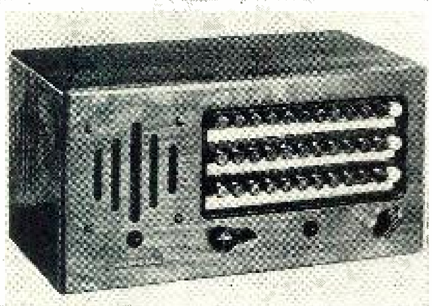


high, 12" wide, and 19" deep with convenient carrying handle.

Details on the new R.C.P. Cathode Ray Oscilloscope may be obtained from the manufacturer, *Radio City Products Company, Inc.,* 127 West 26th Street, New York City.

New President's Model Convers-O-Call

A new development in inter-communicating systems is announced by *Fred E. Garner Company,* Chicago. The new President's Model Convers-O-Call (illustrated herewith) provides a combination all-master system that greatly facilitates factory and office inter-communication for the busy executive. It is so simply operated, you can page an entire factory or communicate privately with one or more departments instantly and easily. There are no switches to push while talking. All conversations are strictly private—no one can listen in. Voice transmission is clear and easy to hear. Calls go through even if the power of the station you call is turned off. It's a tube life-saver, too—increases the life of tubes 200% to 300%. Can easily be installed by your plant elec-



trician or local electrical or radio shop.

The new President's Model Convers-O-Call takes the strain off the telephone switchboard, helps to keep it open to important incoming calls. At the same time, it provides the privacy so essential in industrial operations today.

Extremely simple in design—highly efficient in operation. Engineered to highest standards. Attractive in appearance—built for long life and trouble-free service. Easy to operate. Especially useful for factories, offices and training centers. System can be utilized for music transmission to employees.

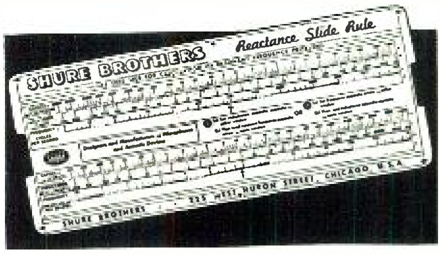
Available for 10 to 30 stations. Prices for each President's Model Master Station range from $29.50 to $69.50 net. Earphones available.

For further information, write to *Fred E. Garner Co.,* 53 E. Ohio St., Chicago, Ill.

New Shure Reactance Slide Rule

A handy new Reactance Slide Rule that speeds up the solution of reactance and resonant frequency problems has been devised by *Shure Brothers,* designers and manufacturers of microphones and acoustic devices.

Electronic and electrical engineers, physicists, radio service men, radio amateurs, teachers and students find this accurate Slide Rule useful in their every-day work. It saves time solving resonant frequency problems, capaci-



tive reactance problems, inductive reactance problems, coil "Q" problems, and dissipation factor problems.

On one side of this new *Shure* Slide Rule, resonant frequency problems are solved with one setting of the slide, using

$$\omega^2 LC = 1$$

with ranges of 5 cycles to 500 megacycles, .001 $\mu\mu$fd. to 1,000 μfd., and .00001 mh. to 10,000 henries.

On the other side of the *Slide* Rule, reactance, dissipation factor and coil "Q" problems are solved with one setting of the slide, using the following formulas:

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

$$Q = \frac{2\pi fL}{R}$$

$$D = 2\pi fCR$$

The ranges on this side are 0.1 cycle

(*Continued on page* 82)

TECHNICAL BOOK & BULLETIN REVIEW

"TESTING RADIO SETS," by J. H. Reyner, Consulting Engineer. Published by *The Sherwood Press,* Cleveland, Ohio. 3rd edition. 236 pp. plus index. Price $4.50.

The testing of radio sets covers a very wide field, for testing enters into every phase of modern radio technique. First of all, in the design stages, tests are required to ascertain the extent to which the designer's calculations have been carried out in practice. When he has completed a satisfactory model the whole organization of routine testing comes into operation. Every component must be systematically tested, and, in addition, the assembled receiver must again be put through a form of test, the severity of which depends upon the thoroughness of the tests on the component parts.

A second class of testing becomes necessary after the set has been put into commission. The best of sets will develop trouble sooner or later and the technique of "trouble-shooting" is a highly specialized art.

Success in this latter form of testing depends essentially upon a methodical approach to the problem and hence the first part of this book is concerned with a detailed analysis of the methods of attack. A great deal of the first section has been rewritten to bring it in line with modern technique, while still preserving the aim adopted in previous editions of presenting a reasoned statement of the basic principles rather than a collection of rule-of-thumb tests.

The second section of the book treats in detail the testing of receivers in laboratory and factory. This portion has been much enlarged and necessarily includes many references to matter of pure design. This widened scope has been made necessary by the welcome change in policy of radio manufacturers in the six years since this book first appeared. Scientific testing of receivers is now the rule instead of the exception, and the technique has, therefore, been thoroughly reviewed.

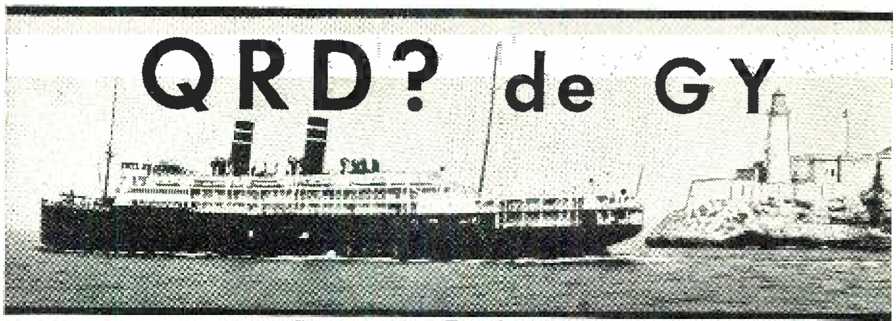
This book serves as a handy reference for students, laboratory workers and servicemen, covering as it does practically any conceivable circuit test. It may be referred to when setting up equipment and in determining operating characteristics from the information supplied.

"A GUIDE TO CATHODE RAY PATTERNS," by Merwyn Bly. Published by *John Wiley & Sons, Inc.,* 440 4th Ave., New York City. 39 pages, 8x10½. Price $1.50.

This book presents under one cover the summary of cathode ray pattern

(*Continued on page* 68)

QRD? de GY



by JERRY COLBY

BROTHER Joe Dessert breaks down and admits that he has been reading this old yarn for the past many years and sez that this is the first time he has ever dropped us a blurb. Now whinell doesn't some one tell these guys that a word dropped herein, whether good or good and insulting, is what ye ed kinda craves. He sez, "it used to be quite a treat to hear you 'peglarize' some of the boys who had their own ideas about how to change the good old 'American way of life.' I have one person in mind. I also think the way you do about such things. . . . I see in your last issue that Harold Craig got hitched. Please convey my best wishes to an old shipmate who used to take the boys around the San Pedro Local No. 2 to task. Tell him I came here immediately after the Wilmington Transportation Co. let us go in December, '41. Am now transmitter technician at KECA. Do you know how much math the different services require for commissioned officers in their Radar divisions? Have had calculus but forgot most of it . . ." May we suggest to Brother Dessert that he should contact Lieut. Schwartz, USA, Radar Division, Ft. Mason, San Francisco, Cal., for his info. We believe that with his math background he shouldn't have any difficulty.

BROTHER Charley Bolvin (CB) broadcasts from LaGrange, Illiniy, that there's one way of getting the dope (he's our super-snooper).

"I've just received a message C.O.D.!"

Just slip up once on having the right story and they all fire in the correction. He sez it wasn't the poor ole Nyvy which closed down WMW. It turns out that it was a combination of this'n'at. The FCC started pressure regarding the handling of tfc ptp on the low freqs. So Pere Marquette withdrew from the partnership operation of WMW. The Ann Arbor hung on for a while but the combination of the final order killing all ptp on the low freqs increased cost of operation ending finally in QRT. That was April, '42. In June WMX, Manistique, Mich., and WDM, Menominee, Mich., followed on the QRT list. The ops of these stations are really scattered to the four winds as is the case of the car-ferry ops. Of the WMW crew, Biesmeier and Honold have gone to work as electricians in the Manitowoc shipyard, Orville Kiester is down near Akron with the Akron, Canton & Youngstown R.R. as a Morse op, Larry Vaclavik is supposed to be somewhere in the Gulf area with Pan-Am. He left WDM when it closed, spent a short hitch on the ferries and then scrammed to warmer climes. Noble from WMX is back on one of the boats. As for the boat men, Baruth of WDCL is now located here in LaGrange and is holding down a berth with Northwest Airlines at Chicago Municipal Airport. Anderson of WDCK is with Consolidated, San Diego, Cal., on flying duty. Harold Jacobson who took WDCN when I shoved off is also there. Dick Olson, one of the Pere Marquette ferry ops, after trying Pan-Am, Eastern Air, Michigan S.P., is also flying for Consolidated. (Boy, take a look at those names and tell me where that Norwegian navy is now!) 'T would seem transpacific duty pays purty money. The shortage of ops on the ferries was taken up by a couple of Frankfort boys who used to hold commercial tickets and have taken out the new "duration" licenses.

Baruth tells me that Northwest Air is on the verge of being taken over by Mid-continent which will make this one of the biggies. If their Army contract route to Alaska develops into a commercial one and if the CAA approves a Washington, D.C. hop it will be a big thing for the radiops. NWA ops are signed in the airlines union and the pay scale is pretty fair. Also, the line has a policy of taking its dis-

(*Continued on page* 71)

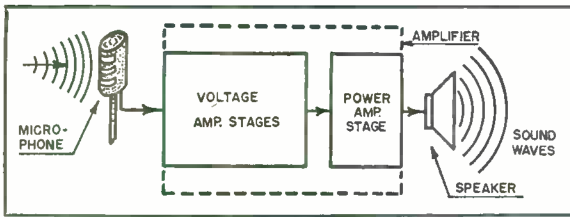


Fig. 4.

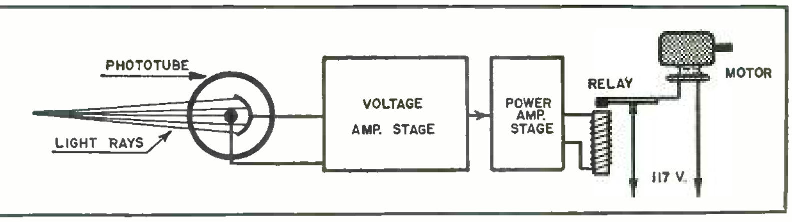


Fig. 7.

with which it is to be directly associated.

If the amplifier tube and circuit are so chosen and designed as to develop the maximum *voltage* across the load, the amplifier thus constituted is called a *voltage* amplifier. Voltage amplifiers usually produce very little power output.

Nearly every amplifier tube produces a power output that is greater than the power delivered to its grid and is, therefore, in the strict sense of the word, a *power amplifier,* but this term has been generally reserved to describe an amplifier tube and associated circuits that are so chosen and designed as to give the greatest possible electrical signal *power* (current as well as voltage) output. The actual *voltage* step-up produced in the power amplifier stage is usually of secondary importance, and is usually sacrificed somewhat in order to improve the power-handling capacity of the stage. Tubes supplying signal power to loudspeakers, radio transmitting antennas, relays, etc., are examples of applications where power amplifiers would be used.

The essential difference between a power amplifier stage and a voltage amplifier stage lies in the tube type, magnitude of the load resistance, and the plate voltage used. In amplifier stages which are called upon primarily to produce as high a *voltage* amplification as possible, tubes designed to have a high mu are employed and the load resistance is made as high as possible

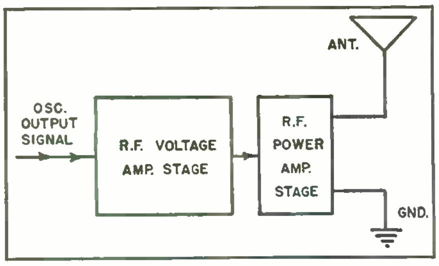


Fig. 6.

to obtain maximum voltage gain from the stage (see formula 1). In amplifier stages designed primarily to release as much signal *power* as possible to the plate load, amplifier tubes capable of controlling appreciable plate currents at reasonably high plate potentials are employed and a lower value of load resistance is used (as we shall see later) than in voltage amplifiers. Also to obtain larger power outputs for a given tube size and plate voltage, the power tubes are often operated as Class AB or Class B amp. Tubes designed to have such large power-handling characteristics are called *power amplifier* tubes. However, because of the design features necessary to produce these high power output characteristics, such tubes have relatively low values of amplification factor and fairly low values of plate resistance. Consequently a tube type that is designed to be an excellent tube for the output stage where power output is the prime consideration, is usually not the most desirable tube for use in the voltage amplifier stages, where maximum signal *voltage* amplification is the prime requirement, and not much power needs to be handled.

Other tube types designed especially to provide high voltage amplification factor will provide much higher voltage amplification than is available from the so called *power* tubes. Conversely, these high-mu tubes, because of their construction, generally have a high a.-c. plate resistance and low plate current and must be operated into a load of fairly high impedance. Consequently they do not make good power output tubes.

In practice, a compromise is effected, utilizing each type of tube to perform the function for which it is best suited. As many successive voltage amplifier stages as are required are generally used to build up the signal voltage to an amplitude sufficient to excite or drive the grid of a suitable power-amplifier tube (or tubes) which will release the required plate-circuit power to the load. A complete audio amplifier usually contains one, two, or three stages of voltage amplification followed by a single power-amplifier stage.

Referring back to our example of the practical use of vacuum tube amplifiers, Fig. 4 shows the basic arrangement used in sound amplifier systems. In order to provide sufficient gain, several stages of amplification are employed. Those immediately following the microphone are designed as efficient voltage amplifier stages, since they are merely required to produce as much *voltage* amplification as possible, so as to build up the microphone or phono pickup signal voltage output to an amplitude sufficient to excite or drive the grid of the tube (or tubes) in the power amplifier stage which follows. The power amplifier stage releases sufficient plate circuit power *(watts)* to properly operate the load (loudspeaker).

Fig. 3 illustrates the amplifier arrangement commonly employed in an ordinary tuned radio-frequency type radio receiver. The feeble modulated r.-f. signal voltage impulses generated in the antenna circuit are first amplified by the several voltage amplifier stages comprising the r.-f. amplifier. These amplified r.-f. signal voltages are detected by the detector, and the resulting a.-f. signal voltages are further amplified by a.-f. voltage amplifier stage (usually one). The signal has now been built up sufficiently to excite or drive the grid of the tube (or tubes) in the power amplifier stage that is to deliver signal *power* to operate the loudspeaker.

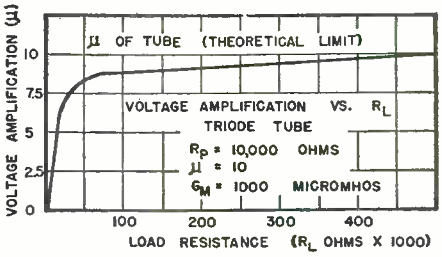


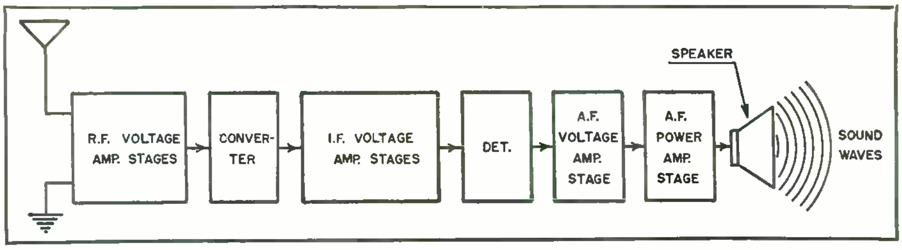
Fig. 8.

Fig. 5 illustrates the successive amplifier stages in a superheterodyne receiver. Here, the signal undergoes one additional change, that of being converted to an intermediate value of frequency by the *converter* tube. It is then amplified at this frequency in the i.-f. amplifier. Notice that the last amplifier stage just before the loudspeaker is a *power* amplifier stage. All the others are *voltage* amplifier stages, designed to produce maximum *voltage* amplification.

Fig. 6 illustrates the use of vacuum tube amplifier stages to amplify the

(*Continued on page* 44)

Fig. 5.



PRACTICAL RADIO COURSE

by ALFRED A. GHIRARDI

Part 13 in the series. The actual applications for the tube circuits given previously are described in easy-to-understand language.

CONTINUING our study of vacuum tubes, we are now prepared to learn how they may be put to work to perform certain desired, useful functions in radio equipment. One of the most important of these is that of amplification of a given input signal so that its *voltage* level or its *power* level is raised sufficiently to enable it to properly actuate a given device, even though this device may require substantial amounts of power for its operation.

Fundamental Operation of the Vacuum Tube as an Amplifier

The circuit for a simple-stage amplifier is illustrated at Fig. 1a. The alternating signal voltage E_g is applied in series with the control-grid-cathode circuit and the steady grid-bias voltage supply E_c. This causes the plate current to vary similarly. This varying plate current flows through the load impedance R_L which is in series with the resistance r_p of the cathode-plate electron path (inside the tube) and the plate voltage supply. The alternating signal voltage developed across, and the energy dissipated in the load impedance R_L, varies with the plate current.

Let μ be the amplification factor of the tube. Then, since the grid of the tube is μ times as effective in controlling the plate-current flow as is the plate, an alternating signal voltage of E_g volts when impressed on the grid will have the same effect on the plate current as would a voltage of μE_g acting on the plate—or in the plate circuit. Consequently, insofar as the signal is concerned, the tube circuit of Fig. 1a may be considered as being electrically equivalent to the simplified circuit of Fig. 1b in which the alternating signal voltage μE_g acts in a series circuit composed of the internal plate-cathode resistance r_p and load impedance R_L.

The signal current flow through the plate load impedance R_L is, then,

$$I = \frac{\mu E_g}{r_p + R_L}$$

The signal voltage developed across the plate load impedance is, therefore,

$$E_{RL} = IR_L = \frac{\mu E_g \; R_L}{r_p + R_L}$$

The *voltage amplification*, or voltage increase, or *gain*, produced by the amplifier stage is the ratio of the amplitude of this output signal *voltage* developed across the plate circuit load to the input signal *voltage* applied to the grid circuit (both expressed in like units). It is therefore,

$$A_v = \frac{E_{RL}}{E_g} = \frac{\mu R_L}{r_p + R_L} \quad \ldots\ldots\ldots\ldots (1)$$

(This expression also represents the voltage gain if a pentode tube is used instead of a triode.)

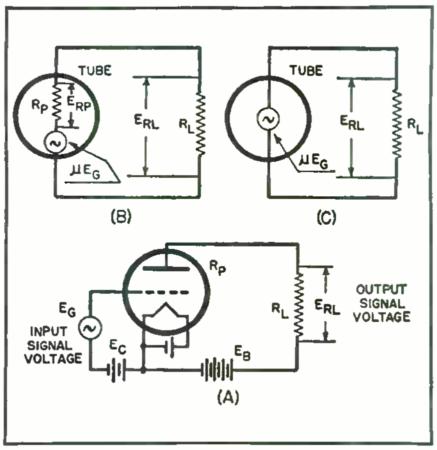


Fig. 1.

The electrical signal *power* delivered to the load impedance R_L is

$$P = I^2 R_L = \frac{(\mu E_g)^2 \; R_L}{(r_p + R_L)^2} \quad \ldots\ldots\ldots (2)$$

The *power* amplification produced is defined as the ratio of the output signal *power* developed across the plate circuit load to the signal *power* applied to the grid circuit.

In either case, the signal voltage or power level is increased primarily by the action of the grid in controlling the flow of power from a local "plate supply" source to the output circuit. Dry-cell batteries, a battery-driven vibrator type power pack, a dynamotor, or the 110-volt a.c. or d.c. socket power supply line are usually employed as this local source of plate circuit power.

By properly impressing the output signal voltage of one amplifier tube on the grid circuit of another amplifier tube through a suitable coupling device, thus allowing the second tube to further amplify the output signal of the first, a 2-stage amplifier is produced as illustrated in Fig. 2. Other additional stages may be added (within practical operating limits) to raise the signal level still further if required. Such multi-stage voltage amplifiers, and the arrangements employed to couple the plate circuit of one tube to the grid circuit of the next, will be studied in detail in the next lesson.

Need for Voltage Amplification and Power Amplification

Before further discussing the details of the operation of vacuum tube amplifiers, a few common examples of their use will be instructive for an understanding of what they must accomplish. Then the reasons why *voltage* amplification must be used in some cases and why *power* amplification is required in others will be more easily understood.

Fig. 4 represents the basic arrangement employed in a sound amplification or public address system. The microphone translates the sound waves of the speaker into very feeble a-f voltage impulses. These are impressed on the amplifier which must amplify them so that sufficient electrical signal *power* will be available to operate the loudspeaker which, in turn, must radiate considerable acoustic power into the auditorium to actuate the hearing organs of the assembled listeners.

Voltage Amplifiers and Power Amplifiers

Because of these conflicting requirements, there are two fundamental types of vacuum tube amplifiers—the one that is used for any specific purpose is governed, of course, by the requirements of the circuit or device

Fig. 2.

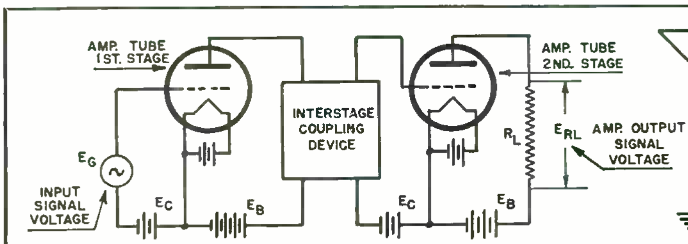
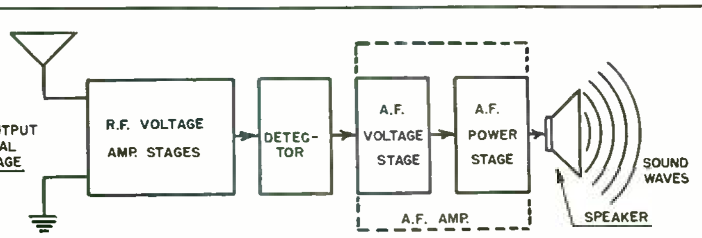


Fig. 3.



The success of this department has been most encouraging. We invite participation by all of our old and new readers.

THE most valuable function of the Tube Collector has been to make it possible for serious-minded collectors to gather antique specimens from old-timers. They are selling or trading valuable types when they learn of the urgent need on the part of many members for those tubes which are scattered about the attics and basements in hundreds of homes. These hidden tubes are eagerly sought in order that members may complete their collections and gather historical data prior to making them ready for exhibition. We urge individuals to check the lists of tubes wanted and to write to the Tube Collector, RADIO NEWS, 540 No. Michigan Ave., Chicago, Ill., giving complete information on those available for swap or for cash. We begin a Treasure Hunt this month. Readers and collectors are asked to search for the specimen illustrated on this page. It was made about 1920 in this country.

WANTED

Amrad S tubes, cylindrical and pear shaped
Amrad A-3000-1, B-3000-1, C-5000-1
A-P Electron Relay
A-PVT Amplifier-Oscillator
A-P rectifier (Shaw condensite base)
Arcturus 38A, PZ
Audio Tron (National Elec.)
Audio Tron (double filament)

Bartley tubes
Bazoni nitrogen tube (1924)
Birk-Morton, B-M 201A
British Marconi V24, MT, MT4 valves
Burgess Radiovisor bridge

Canadian Marconi MT-1, MT4
CeCo, DG rectifier, Types A, B and C (1925)
Connecticut Tel & Tel, Detector, Electron JR3
Corcoran tube

Daven, MU6, Television lamp
Dietzen 1½ v. tube (1923)
Donle Rectifier (1923), BA-Z, BP-71, BR-4, and type C
De Forest Round Audion Detector (1) Hudson filament, (1) Tantalum fil.
De Forest Round Audion Amplifier (1) Hudson filament, (1) Tantalum fil.
De Forest Type T, (tubular with candelabra base, wire out of other end)
De Forest Modified T (tubular, candelabra base, wires out of base end)
De Forest Modified T (tubular, candelabra base, wires out of envelope near base end)
De Forest Tubular (2 wires out of each end)
De Forest Navy Audion (tubular with Navy 3 element base)
De Forest Navy type Round Audion (round with Navy 3 element base)
De Forest RJ9 detector
De Forest Ultra Audion
De Forest VT 21 (army)
De Forest Oscillion ¼KW
De Forest Oscillion ½QW
De Forest 20 Xmtr. tube
De Forest Electron Relay style with base (std.)
De Forest Amplifier styles with base (std.)
De Forest Types D, D2, D 01 A, Demi, D 400 A, D 401 A, D 410, D 412, D 416B, D 471, DL 2, DL 3, DL 4, DL 5, DL 7, DL 9, DL 14, DL 15, DR, DV 1, DV 2, DV 3, DV 3A, DV 5, DV 6, DV 6A, DV 7, DV 8, DV 9 (power tube), DV 9R (rectifier), HR (rectifier), H, OT 3, P 2, P 3, Q 15, S, 56, 102 D, 205 D, 210, 224, OT 1A battery

Electro Importing Co. Audion
Edison Swan Elec. ES-2, ES-4
Electron Relay (single fil.)
Electron Relay (double fil.)
Eveready Raytheon ER-LA, Photocell, Kino lamp
English double grid (1925), Stenotube
Epom D-18-1 rectifier
Electrodyne rectifier (round envelope)
English types (modern or antique)

Fleming valves (all types)
French tubes (modern or antique)

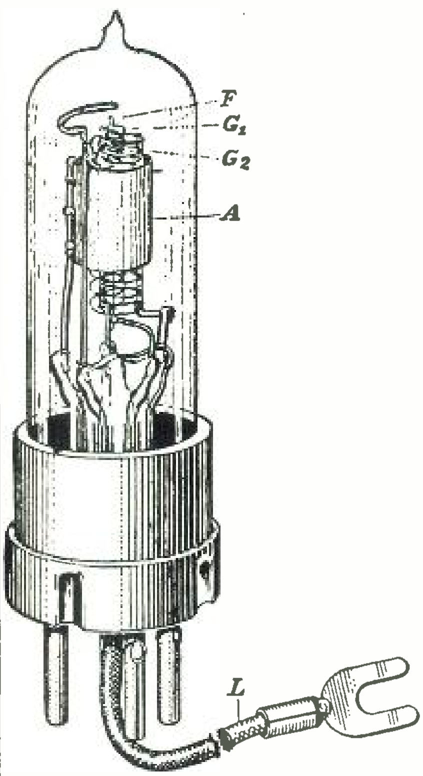
G.E. PJ-1, PJ-5
Gehrke tube (1925)
Globe G-100 rectifier

Harp 200 DA

Jays 201-A
Johnson 550, 560, 570 (xmtg.)

Kenotron UV 217 (early), UV216 (early)
Kylectron Ballast tube

Treasure Hunt



Edison Swan Electric V.T. with extra grid connected to flexible lead and clip.

Liberty valve
Lieben-Reisz "LRS" repeater
Loewe tubes (1926) multiple-grid (1926)
Lucien 110 volt (filamentless)
Luminotron (1925)

Marconi V24, Q, QX, MR-4
Magnavox 110 volt fil. (1924)
Magnavox 3-element, duplex grid
Magnatron DC-199, 201A
Manhattan rectifier (1927)
Margo detector
McCullough AC tubes
McCullough power tube
Moorhead tubular audion (2 wires one end—one wire other end, grid-clamp)
Moorhead cylindrical, unbased (electron relay)
Moorhead Electron Relay (Shaw base)
Moorhead cylindrical tube with external grid
Moorhead (Pacific Labs)
Moorhead Xmtg. (1920)
Moorhead Amp-Osc (1920)
Moorhead SJ-1 detector
Musselman Mogul 5VC
Myers DIA, DIX

National R3, R4 (rectobulbs)
National 203, 6EX, N65
Neon-filled rectifier (1925)

Perryman (double fil. 1928)
Phillips Dutch valve (metal ends, cylindrical shape)

QRS 60, 85, 400 ma. rectifiers
Quadrotron

Raytheon A, BA, BA 300 ma., R (rectifiers or regulators)
Rectobulb R3, 6EX
Roome Thermatron, Oscilaudion
Royaltron 200
Ruben VT relay
Russian tubes (new or antiques)
RCA UV210, UV213, UX213, UX216B, UV886, UV217A, UV217C, UV206, UV217, UV111 (special) WX12, 863, UX864, UX867, 868

Schickerling S200, S300, S400, S500, S700
Siemens-Schottky double grid
Silvertone 201A
Sonatron 201A, 199, 227
Songbird 80, WD12, WD11 (brass contacts), WD11 (silver contacts)
Sonora S01
Strongson copper plated tube
Sulfatron (1927)
Supertron SX112, 99

TeCo audiotron adaptor
Telefunken (all types)
Teletron 201A
Thermo Tron (all types)
Tigerman Detecto-Amplifier (all types)

(Continued on page 70)

genious and clever experiments. His explanation of these results was that the electricity was due to the animal organism.

Similar observations had been made many years before by a Dutch naturalist Jan Swammerdam. In a book[36] published in 1737-8 experiments which he made in 1658 were described. During these experiments he obtained muscular contractions in frog's legs by means of combinations of silver and copper wires connected with the ends of the nerve. Also in a book[37] published in 1767 Johann Georg Sulzer had recorded the "galvanic taste" obtained by putting his tongue between two plates, one of silver and the other of lead, connected together by a wire.

After some years of investigation Galvani published an account of his work. No sooner did it appear than the philosophers in different parts of Europe entered with eagerness into the examination of this action—some to confirm, others to challenge.

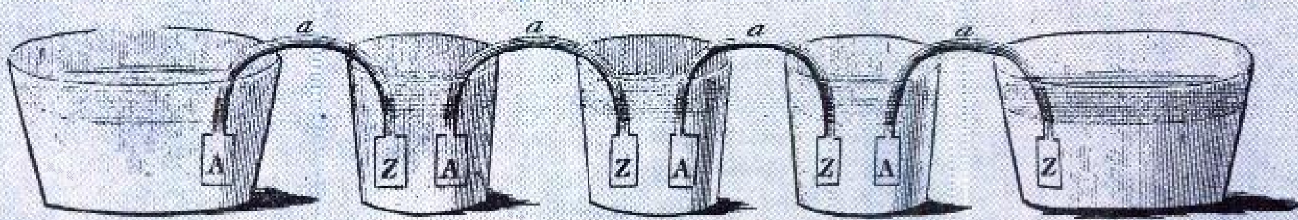


Fig. 6. Volta's revised voltaic pile (battery), called the "couronne des tasses."

Among those who did not accept Galvani's explanation was Alessandro Volta, of the University of Padua. In the relations of Galvani and Volta we see another excellent example of the combination of the amateur and the trained scientist—the value of the unchanneled thinker whose observations and discoveries open new doors for the mind of the trained scientist to enter. Volta, being Professor of Natural Philosophy at the University, was such a trained scientist. In fact he was the first of the scientists to confine his activities to that branch of physics dealing with electricity. Of necessity he was interested in allied subjects, but he devoted his life to the specialized field of electricity. Volta knew his theory. For this reason the great French scientist, Arago, said "There is not a single one of the discoveries of Professor Volta which can be said to be the result of chance. Every instrument with which he has enriched science existed in principle in his imagination before an artisan began to put it into material shape."[40]

Volta having read of the work of Galvani, repeated the experiments with his usual precision. Knowing his theory he could not accept Galvani's explanation of the twitching nerves in the frog's legs. He combined his observations with his experience and theory, and possibly with the experiences of Swammerdam and Sulzer in mind, he finally concluded that the nerve was merely a wet conductor between two pieces of metal, dissimiliar in nature, causing a flow of electricity which produced the reaction that Galvani had observed.

Volta communicated the results of his discoveries to the Royal Society of London, at the end of 1792, in the form of letters to Tiberius Cavallo.[41] He gave an excellent account of Galvani's discovery and added many experiments and observations of his own. In these letters he successfully laid down the basis for the theory of voltaic electricity.

Volta continued to actively investigate these phenomena and perfect his theory. He wisely concluded that, although the effect of one pair of plates or wires was small, it could be multiplied indefinitely by a plurality of such devices. He accordingly obtained a number of silver coins and pieces of zinc of similar dimensions; disposed them in pairs, and placed between adjacent pairs a card soaked in water. Thus came into being the famous *voltaic pile*, the first galvanic battery. See Figure 5. The effect of the combination fully justified his expectations. He found that electric shocks could be obtained from the pile as long as the pasteboard between the metals remained moist. These shocks were of the same kind as those produced by the electric machine.

Volta afterwards constructed another apparatus, or rather arranged the elements of the pile in a different fashion. It consisted of a set of small glasses, placed adjacent, and containing water or some saline solution. A number of metallic loops, with one end of zinc and the other of copper or silver, were inserted in the glasses in a uniform order, each glass having the zinc leg of one loop and the copper or silver leg of another loop, immersed in the liquid. Volta called this arrangement the "couronne des tasses" in his description of it in a letter to the Royal Society.[42] This arrangement is also shown in Figure 6.

Volta seems to have completely overlooked the changes which took place in the solution in the cups.

With the work of Volta electricity ceased to function as a series of jolts, and began to flow smoothly and controllably from pole to pole. A new day had dawned.

No sooner was the discovery of the voltaic pile announced than the English experimentalists began to use it, and almost immediately made some interesting and important observations. William Nicholson and Anthony Carlisle,[43] while conducting some of their experiments, made part of the circuit, connecting the extremities of the pile, of water. They noticed that gas was evolved where the connecting wires came into contact with the liquid. Subsequently the apparatus was arranged so that the gases given off from the two electrodes were kept separate, and it was found that (1) they consisted of oxygen and hydrogen and (2) that they were generated in the proportions that they occur in water.

About this time the relation in which the voltaic pile stood with reference to the Leyden jar and the electrical machine began to be perceived. In the Leyden jar a quantity of electricity under high tension is accumulated on the surface of the glass, and is held there in equilibrium. When communication is established between the two surfaces an almost instantaneous discharge takes place, and equilibrium is soon reestablished. A sudden, instantaneous, and violent effect is produced in whatever bodies are exposed to this electrical discharge in transit. The Leyden jar is a high voltage storer of electricity, quickly discharged. The voltaic pile, by contrast, is a generator of electricity in a continued current. It discharges not suddenly, but with a moderate, continued, controllable action. It is a comparatively low internal resistance device.

The experiments of Nicholson and Carlisle attracted the attention of Sir Humphrey (then Mr.) Davy, who was at that time starting the labors in chemical science which were later to surround his name with so much lustre. He repeated[44] their experiments and found that no decomposition could be obtained when the water was pure, i.e. that conduction depended on the presence of some impurity in the water. He continued his experiments and later demonstrated to the *Royal Society* that other substances than

(*Continued on page* 48)

THE SAGA OF THE VACUUM TUBE

by GERALD F. J. TYNE
Research Engineer, N. Y.

Part 2 of this authoritative series, shows the tremendous amount of preliminary work that led to the discoveries of the radio tube.

UP TO about 1800 the science of electricity was that of static electricity, the electricity which was developed in the electrical machine of that day, and stored in the Leyden jar.

Beginning at that time with the work of Galvani and Volta the emphasis in electrical research shifted to the field of galvanism and voltaic electricity. The technique of this work was essentially a technique of low impedances. We find little done during the next few decades which had any direct bearing on the field of thermionics. Not until the tools of voltaic electricity were developed and perfected, and high voltages and greater energies became available from the low impedance sources could any great amount of work be done in the high impedance field of thermionics.

The names of Galvani and Volta are inseparable in studying the development in this new field. The lives of these men are perfect contrasts in their approach to the study of this branch of science. Each man was a genius. As a result of their conflicting theories, there arose another of the controversies which provide such a wealth of material for the historian.

Luigi Galvani was an amateur in this field in the real sense of the word. He was a physician and anatomist by profession. His studies in the comparative anatomy of animals were responsible for his interest in electricity. A true scientist, his work was done with the utmost care. His powers of observation were so keenly developed that no detail passed unobserved or unrecorded. When he noted certain phenomena of animal electricity, he began to study the effects of electrical currents on animals. As a result of these experiments Galvani soon was convinced that muscular motion depended on electricity in the body.

At this critical time in his study the historical accident, which seemed to substantiate his theory conclusively, occurred. While we find several conflicting reports of exactly what took place, substantially the following occurred.

Galvani's wife, a well educated woman who was deeply interested in her husband's work, spent much time in his laboratory. When she became ill Galvani proceeded to prepare for her a soup of frogs which, according to the custom of the country, was considered a restorative. After he had skinned and cleaned the frogs he placed them on a table near an electrical machine. At that moment he was called away from the laboratory. While the machine was in action an attendant happened to touch, with a scalpel, the crural nerve of one of the frogs that was not far from the prime conductor of the machine. At the touch of the scalpel the frog kicked, and the kick of that dead frog changed the whole face of electrical science. When Galvani returned his wife called his attention to what had happened. It appeared to confirm his hypothesis and he proceeded to investigate the phenomenon at length.[38]

In the course of these investigations, Galvani attempted to determine what part, if any, atmosphere electricity played in this reaction. Accordingly he prepared some frog's legs, inserted brass hooks in the spinal marrow, and hung them on an iron trellis outdoors. He noted that under these conditions the frog's legs showed occasional convulsions even when the weather was fine, and the atmospheric electricity supposedly quiescent. In the course of his observations he happened to press the hooks against the iron trellis and found that the convulsions were produced whenever these dissimiliar metals were in contact. This was followed by many in-

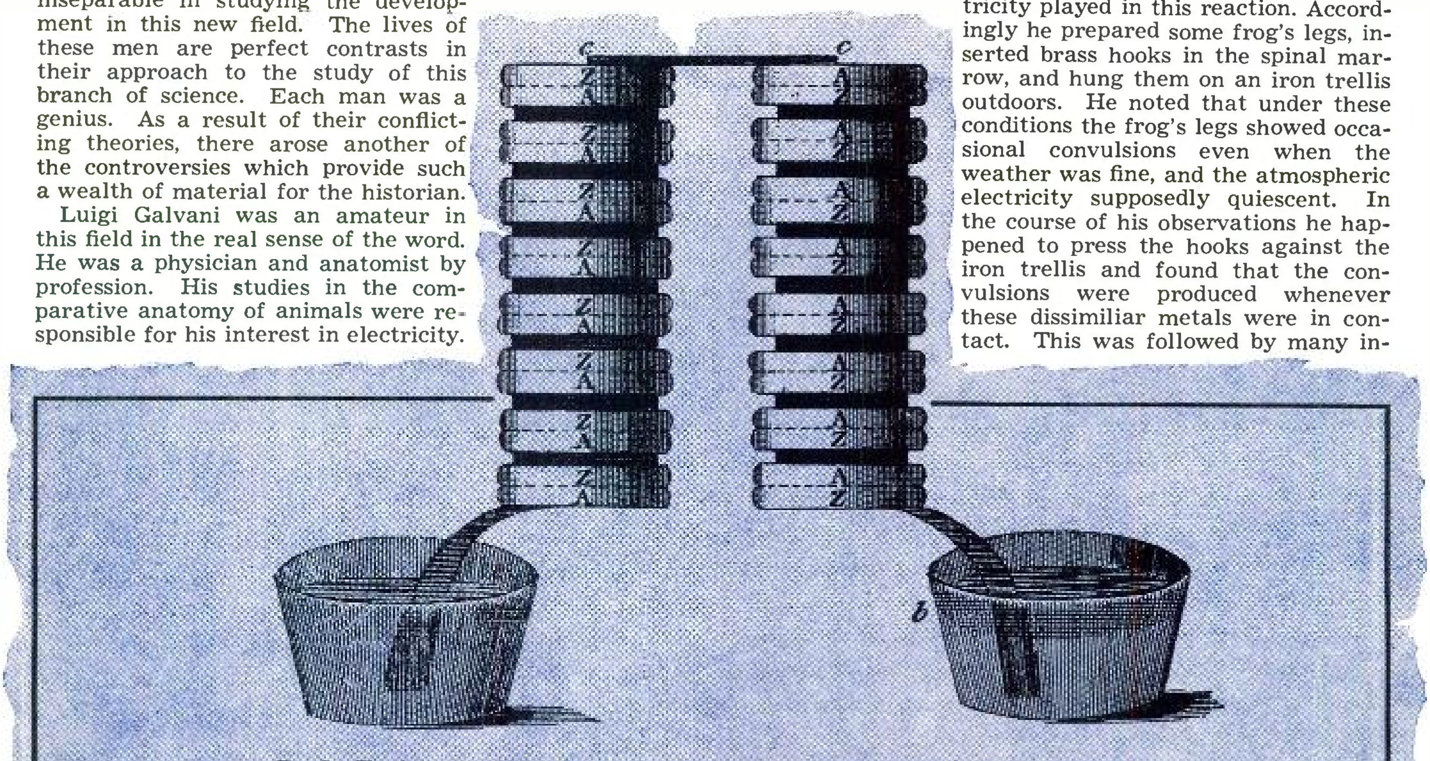


Fig. 5. The famous voltaic pile, made from layers of zinc, silver and water-soaked cards.

24 YEARS AGO in RADIO

{ CONDENSED FROM RADIO NEWS, 1919 ISSUES }

A Low-Priced Radio Telephone Set at Last!

AMATEURS are about to realize one of the dreams which has fascinated them ever since, in the early days of the war, when they began to read about the wonderful little oscillion radio telephone transmitters which the U. S. Air Service was introducing for interplane work and for communicating between planes and ground. A set very similar to this elaborate Government radiophone has at last been produced, but its design is so simple that it can be acquired for a sum of money which will be within the reach of thousands of amateurs. It operates on a 60 cycle 110 volt alternating current—no motor generator is required. Plug the power leads into any lamp socket; connect to the antenna and earth. Connect a small battery for the microphone and talk away. The wave length is from 200 to 600 meters. The articulation is surprisingly clear, decidedly better than over an ordinary wire, and the circuit is so cleverly designed that no troublesome noise whatever is experienced from the 60 cycle supply at the transmitter. The telephone range of the set is from 10 to 20 miles, depending on the various conditions, heights of masts, nature of terrain, etc.

The transfer switching is affected by means of a little relay with a push button in the microphone base, so that when two parties are each equipped with this new transmitter and any good audion receiver, it is possible to telephone back and forth as rapidly as over a land wire.

The entire outfit is mounted on a bakelite panel 14"x20" and on a baseboard attached thereto. Two rectifier bulbs and four small transmitter or oscillator bulbs are employed. If shorter distances of transmission are sufficient, then two oscillator bulbs only are needed. A Morse key is provided with the set so that it can be used as an undamped wave telegraph transmitter as well. When so used with an ultraudion receiver, distances up to 100 miles can be readily covered. The entire transmitter weighs less than 50 lbs. With the introduction of this practical low price radio telephone we will shortly expect the formation of radio telephone clubs in many localities.

Tuning Qualities of Shunt Condenser

J. M. BERNER, Mt. Washington, Pa., asks: Q. 1. Why is it that at times the variable condenser which I have shunted across the primary of my loose coupler fails to furnish any tuning qualities; can it be an open circuit in my receiving primary or in the condenser? A. 1. The trouble you experienced with your shunt variable condenser to the primary has been a mystery to some of the uninitiated and from the following you will readily understand the cause. It is possible that the condenser circuit has an opening in it, but it would not be possible to receive signals were the primary at fault. There is a very curious phenomenon which presents itself in the tuning of the primary circuit when employing a variable shunt capacity. At times this condenser and the primary inductance act as two separate circuits in parallel and in which case the condenser robs energy from the primary and while the tuning qualities of the primary circuit is as critical as usual, it will be found that the condenser variations have a very small effect upon the circuit as a whole under these circumstances. It is always best to employ an inductance in the form of a loading antenna coil to increase the wavelength of the primary circuit beyond the range of the primary windings.

Grand Opera by Wireless

A RECENT newspaper report from Chicago brought the not at all surprising news that grand opera music had been transmitted by wireless telephone for over one hundred miles. Sensitive microphones placed on the stage of the opera house caught the sound waves; the impulses then being stepped up in the usual manner by means of a transformer were then led into an amplifying vacuum tube. Here the current was impressed upon the radio telephone transmitter in successive stages and then sent out over the aerial on top of the opera house. Wireless amateurs all about the surrounding country were thus able for the first time to hear grand opera. While this was only an experiment, grand opera by wireless will soon be an accomplished fact.

During the next few years it will be a common enough experience for an amateur to pick up his receivers between eight and eleven o'clock in the evening and listen not only to the voice of such stars as Caruso, Tetrazzini, McCormack and others, but also to the orchestra music as well, which is picked up by the sensitive transmitters along with the voice of the stars. The surprising thing is that it is not being done now.

The reason probably is due to the fact that as yet no means has been found to reimburse the opera companies for allowing everyone to listen in. Of course listening to the music is not as satisfying as seeing the performance in person.

Value of Wireless Demonstrated on Trip of R-34

THE epochal voyage of R-34 demonstrates fully the inestimable value of directional and ordinary wireless.

Never during the whole journey were we out of touch with either side of the Atlantic—this with a comparatively small wireless set makes the possibilities of larger sets on larger craft apparent. The wireless functioned all the way across, easily reading the messages from the powerful stations at Bar Harbor and Boston.

In the first ten hours of the trip we did fifty-five knots an hour, a wonderfully favorable thirty-five knot tail wind aiding us. We were using only two engines. We talked with the battleships in New York as we circled over brilliantly lighted Broadway and Times Square.

The only mishap of the trip came Saturday when the pistons flew thru the cylinders of one of the engines. This slightly lessened our speed. Otherwise it had no effect. The breakdown was so bad that it was not possible to make repairs.

I saw two ships on the way over, the San Florina, bound for Mexico, and the Cumberland, bound for England. The wireless operator on the Cumberland picked our call and asked, "Who are you?"

We answered: "We're a British airship."

The operator apparently was so dumbfounded and surprised that he was unable to reply for several minutes.

We carried a message from President Wilson to King George, one from the governor of Newfoundland to the king and another from the Mayor of New York to the Lord Mayor of London.

A world's record for long distance wireless from an airship was established on this trip. We talked with the air ministry in London Friday midnight from a distance of 1,600 miles.

—30—

Manufacturers' Literature

Our readers are asked to write directly to the manufacturer for this literature. By mentioning RADIO NEWS and the issue and page, we are sure the reader will get fine service. Enclose the proper sum requested when it is indicated. This will prevent delay.

Technical Standards Booklet

Mr. Sidney Gould, president of *Gould-Moody Company,* manufacturers of the *Gould-Moody* Black Seal Glass Base discs, has just published one of the finest little helps that the Radio Engineer can hope to find in a year of Sundays. "Technical Standards and Good Engineering Practices,"

printed on a tough, durable stock; able to handle plenty of punishment, done in 2 colors, contains the 14 pertinent facts as established by the *National Association of Broadcasters.*

It may be obtained free of charge by writing to Mr. Sidney Gould, *Gould - Moody Company,* 395 Broadway, New York City.

Handy Radio Troublefinder

Extremely helpful in the Wartime training program today is this ingenious radio troublefinder devised by the well-known radio expert Alfred A. Ghirardi.

In handy pocket-size form and consisting of eight 4¾"x7" printed cards arranged to swing on an eyelet, this clever Ghirardi "gadget" is proving to be a very valuable aid to students learning radio troubleshooting and repair work. For any of the 8 common radio receiver trouble symptoms such as "Dead" receiver, "Intermittent" Reception, "Fading," etc., it clearly lists all of the probable causes of the trouble in the 7 main portions of the receiver and also suggests the remedy for it. New servicemen will also find it a valuable source of information in their work.

These Troublefinders are available

(*Continued on page* 69)

to use the medium frequency crystal oscillator and double or triple up to the desired frequency in a superhet receiver. It was a very good engineer indeed who could get a stable superhet receiver to work with doublers or triplers with a minimum of image reception and maximum sensitivity. This type of receiver also covered only a very narrow band without using band switching. The other oscillators used were chiefly acorn tube oscillators of various kinds. Using an acorn tube had its disadvantages, since as previously mentioned in paragraph two, the mechanical spacing of the elements (Gm) more or less determines the range of frequencies the tube would oscillate over.

This meant that much experimentation went into the manufacture of each television or high frequency receiver. On some commercial receivers, it was noted that the 75 megacycle calibration drifted 5 megacycles or more overnight, indeed it was very rare that any commercial receiver was calibrated correctly above its 30 megacycle range. Doubling or tripling means extra tubes and circuits, while the acorn type of tubes meant extra space and careful mechanical construction in addition to the disadvantages previously mentioned.

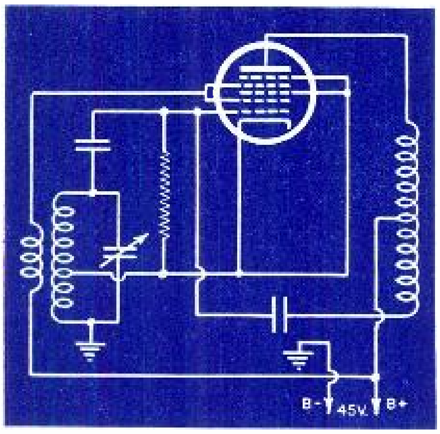


Fig. 4.

The writer maintains that a fundamental premise has been either overlooked or disregarded in designing oscillators, for frequencies up to 150 megacycles anyway. Let us refer back to paragraph two of this article . . . "assuming that (t) of ωt (t) being transient time, is the limiting factor of the apparent conductance of the tube, then the apparent conductance of the tube goes up in proportion to the square of the frequency (F), and $F^2 = Gm$." What happens then when you use a tube as an oscillator with a high Gm, and how high can one get such a tube to oscillate?

There are a half dozen commercial tubes that work very well as U.H.F. oscillators, among them were tried, 6SJ7, 6L7, 6K7 and others. In recent experiments with the circuit as shown in Fig. 3, curves were plotted up to 70 megacycles on fundamentals with a 4:1 tuning ratio under several conditions. The graph will be referred to later in this article. The tubes worked well, and the outputs were about the same. The ease in working with them would place their usefulness in the order that they are listed above. The 6SJ7 was the tube chosen to make the final tests.

Construction of the R-K Oscillator

The oscillator can be constructed with the following components, plus one of the tubes mentioned, some No. 18 enameled wire, a tuning condenser from a broadcast receiver, a 50,000 ohm grid leak, .0005 fixed condenser, midget condenser for the feedback condenser (can use a broadcast condenser here by trimming the plates) and if desired, a 10$\mu\mu$fd. padder condenser, .05 by-pass condenser and a power supply. Fig. No. 3 illustrates the wiring diagram. The small padder is used to tune up the low end of the band.

(a) The grid coil is wound with three turns of wire about ¼" in diameter. It is center-tapped. The tap on this coil is critical and experimenting must be done to show what portion of the center turn is tapped, particularly on the first of these oscillators you build. Keep the leads to the tube very short, if possible solder directly to the tube socket.

(b) The plate tank coil is surprisingly found to have from 30 to 50 turns (40 turns used on last oscillator of No. 18 enameled wire depending on the frequencies you wish to cover. This coil is center tapped also, but the tap is not so critical as on the grid coil. If a padder is used (10$\mu\mu$fd) for the low end of the band, you can pick out the approximate center. Iron cores can be used to tune the bottom half of the tank coil providing a large amount of a.c. is not desired from the oscillator. Note also that the iron core will act as an attenuator as it is moved into the coil.

Operation

Note that due to the peculiar characteristics of this oscillator, very little capacity is added to the grid circuit by the coupling condenser (Cl) or the distributed capacity and padder in the tank circuit. Tests made showed that this added capacity even at the higher frequencies can be neglected since it is so very small. Refer to the graph accompanying this article and you will note results of several conditions recorded approximately. The plate feedback can be entirely disconnected and you will find that the tube is still oscillating. This is possible, due to the shielding effect of the screen on the plate, and explains how we get, in effect, the sum of two conditions in which we can assume that the plate circuit and the grid circuit are oscillating separately but adding up to give us our high a.c. output. The output is so high in fact that we can use attenuating devices to level off our output and give us a flat power output curve over the entire tuning range.

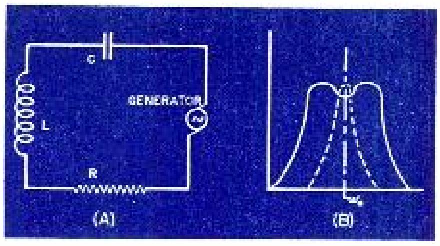
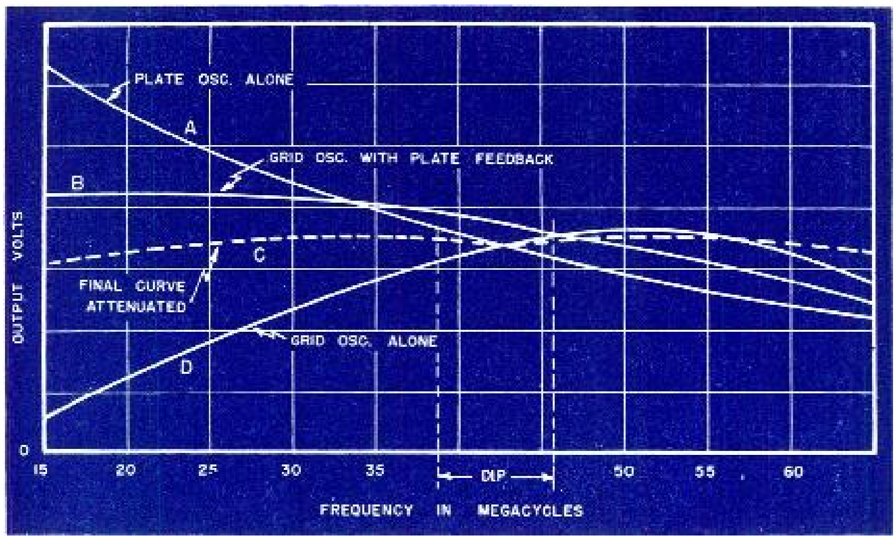


Fig. 5.

Referring again to the graph, we have several conditions illustrated as to the operation of this oscillator. Curve A shows the output over the band with just the plate oscillation condition. Curve B shows the effect of the combined grid oscillation, and the plate feedback. Curve D shows grid oscillation alone, without plate feedback, while Curve C shows the effect of some attenuation, nearly approaching the linear power output we desire over the band. Note the dip still showing in the center; with a little more attenuation, we would eliminate this condition and get a perfectly flat curve. Limiting circuits were tried to aid in getting the proper attenuation, but at these frequencies the limiting circuits with conventional

(*Continued on page* 56)

Operational data for the performance of the U.H.F. Oscillator.



PRACTICAL U.H.F. OSCILLATORS

by ROBERT RICKETTS

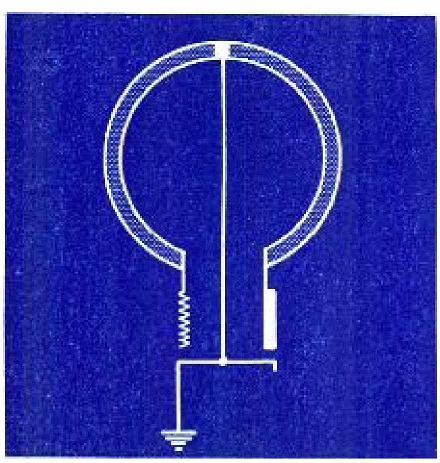
A revealing study of U.H.F. oscillator performance when changes are made in LC ratio.

☆

MOST experimenters make a practice of accumulating old parts and salvaged items from receivers and other apparatus that they have constructed. Even old broadcast sets are filled with parts that may be used for the construction of high-frequency equipment providing alterations are made, and further, that the insulation is adequate for the frequencies to be employed. This article will show how to construct highly efficient oscillators covering from 70 to 100 megacycles on fundamentals and possessing a stable linear output over the entire range. We will discuss just such an oscillator in this article together with a general review of several other types used in recent years, in order to more fully explain the advantages of the R-K Oscillator.

First, let us review the U.H.F. oscillator field and bring our knowledge up to date. Without exception, most attacks on the oscillator field in the last seven years have followed a general fixed pattern of three types, the first being the "Negative Grid Oscillators." The minimum capacities were considered fixed by the tubes construction. The inductance (1) was decreased to increase the frequency. Let us express the critical value at which the tube will resonate as (ωt). One observes that the (t) or transient time is the limiting factor to the apparent conductance of the tube as an oscillator, and the conductance of the tube goes up in proportion to the square of the frequency (F). Then note, that $F^2 = Gm$ at high frequencies. When practical limits were reached, smaller tubes were designed such as the acorn tubes. U.H.F. oscillators with fair outputs were designed up to 150 megacycles. Note, however, that the engineer or experimenter had to be very careful of mechanical layout and the characteristics of the tubes to get oscillators working smoothly even at 70 megacycles.

Fig. 1. Typical negative-grid osc.



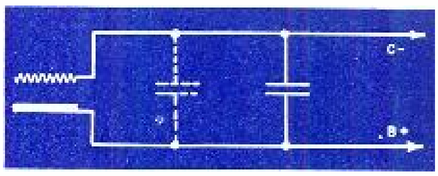


Fig. 2. Typical transmission line type osc.

The illustration (Fig. 1) shows a typical negative-grid oscillator, which no doubt the engineers and the experimenters are familiar with, since it is a rather old circuit.

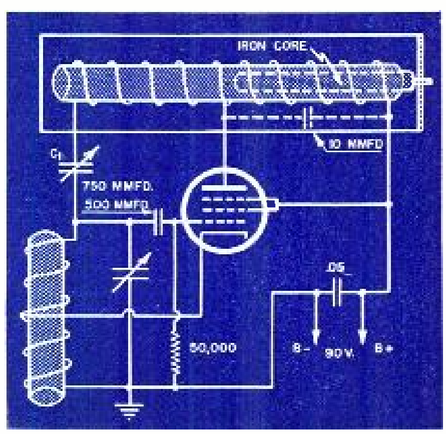
The second big step in oscillator work began with the trend towards transmission line networks and "coaxial" tuners. Transmission lines have worked out very well indeed and are very popular, although many newer and more efficient types of oscillators have been designed on which there is little quantitative data. For general reference on the newer fields, this writer recommends the latest book by the *D. Van Nostrand and Company* on U.H.F. Technique. The effective Q of a transmission line circuit is very high, the illustration (Fig. 2) showing how one could analyze such a circuit. Theoretically, it is viewed as a parallel resonant circuit. A condenser is shown as a shorting bar, since it will serve to isolate the d.c. current, but at high frequencies act as a short for the a.c. component of the current. The dotted lines to the condenser near the tube terminals indicate the capacity of the parallel feeders, as well as the internal capacities of the tube.

Coaxial tuners present more of a problem to construct, and operate somewhat like the transmission line circuits described above, with one interesting difference. If we use a coaxial grid-plate tuner and coaxial filament lines, the impedance of the filament lines may load up the oscillator circuit to such an extent that they actually may have more to do with determining the oscillator frequency than the grid plate coaxial tuners.

In summary, let us say that the previously mentioned oscillators are very nice, but for frequencies up to 150 megacycles, such as for receivers, the above mentioned types of oscillators, whichever one we choose, will present difficulties in electrical and particularly in mechanical construction. The large amount of space needed for such an oscillator as the coaxial tuner, also makes this type of oscillator undesirable.

Previous to the war, much progress had been made by several private laboratories, and television companies in U.H.F. design, but it also followed stereotyped lines. One method used by hams and some manufacturers was

Fig. 3. Diagram of 4-16 m. oscillator.



The vacuum tube voltmeter is one of the most versatile of all radio test instruments when used properly. Step-by-step procedure is covered in this article.

tained with manufacturer's or design data on the oscillator under test,

6. Repeat the voltage measurements at a number of frequencies, if the oscillator is a variable-frequency device, noting any variation of output voltage with frequency changes. Compare these results with manufacturer's or design data,

7. Note that the v.t. voltmeter possesses a certain amount of input capacitance, determined mainly by the input capacitance of the voltmeter tube and the stray input-circuit capacitance, and that this small capacitance will exert some detuning effect upon high-frequency r.f. oscillators. Generally, this will result only in a slight shift of the oscillator frequency as indicated by the control dial, and the oscillator may be re-trimmed at the desired dial frequency to compensate for the detuning effect,

8. When voltage vs. frequency tests are made on a variable-frequency audio oscillator, voltage readings may be plotted in a graph against corresponding frequency settings to give a response curve which may be compared with the one supplied by the manufacturer of the oscillator.

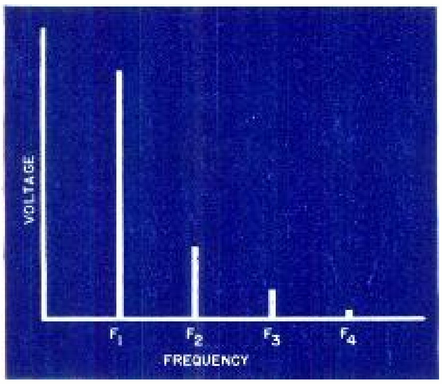


Fig. 3. Response obtained with circuit (Fig 2).

Measurements in Receiver R. F. Stages

The a.c. v.t. voltmeter is invaluable for checking alignment and gain in all types of receiver circuits. In all such tests, the receiver (or receiver stage under measurement) is supplied with a signal at the desired operating frequency from a standard r.f. oscillator, and the voltmeter is connected successively to various output circuits in order to study the amplification or reduction of the signal:

1. Measure the r.f. voltage at the input of the stage, using the lowest permissible voltage range of the instrument,

2. If the signal voltage is too low for measurement on the lowest voltage range, it will be necessary to follow the oscillator with a radio-frequency amplifier, preferably tuned to the signal voltage. In most cases, this will be more satisfactory than preceding the voltmeter with a similar amplifier, since it would then become necessary to know the gain of the amplifier very precisely for all frequency settings,

3. Measure the signal voltage at the output of the stage, noting whether the required amount of amplification has taken place within the stage. An increase in voltage, as readings are taken at input and output, indicates amplification in the ratio of the two voltages; no increase or decrease shows that the stage operates merely to pass the signal along without gain or loss; and a decrease in voltage indicates loss in signal amplitude through the stage,

4. Due to the inherent input capacitance of the voltmeter, allowance must be made for detuning of r.f. stages when the meter is in the circuit by retrimming the circuit under measurement at the indicated dial frequency,

5. In all receiver r.f. measurements, the extended-tube probe of the instrument must be employed, in order to keep lead length at the lowest value,

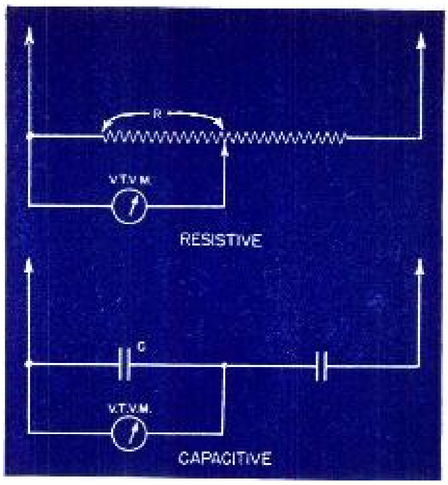


Fig. 4. Shunts for voltmeter adaptation.

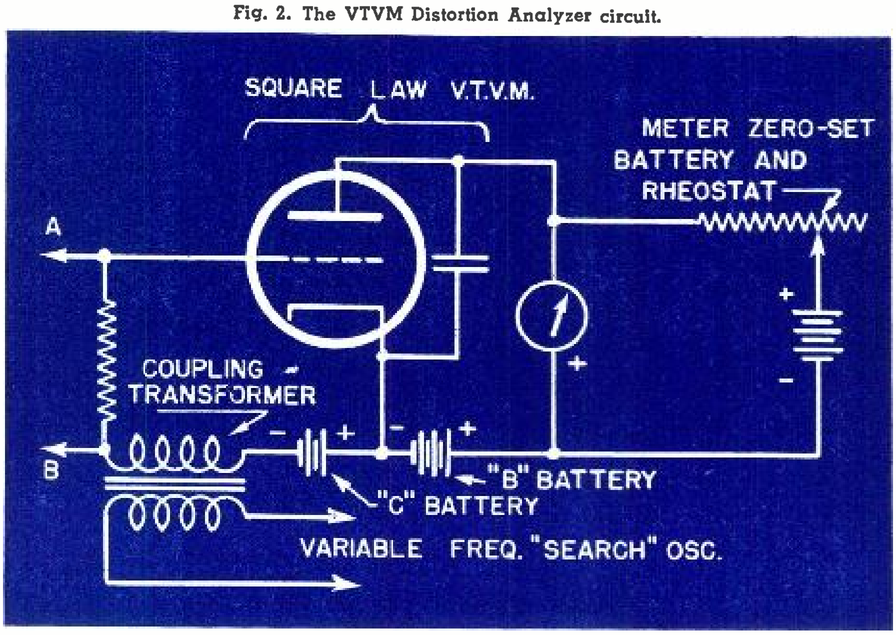
6. Where input and output measurements must be made in circuits carrying d.c. as well as r.f. components (such as plate voltage and grid bias), the input circuit of the voltmeter should be isolated, by means of a small series mica condenser, to prevent d.c. from reaching the grid of the voltmeter tube,

7. Conversion gain in superhet receivers may be measured by measuring first the signal voltage at the grid of the first detector and then at the grid of the first I. F. amplifier. The reference point is ground,

8. If the input capacitance of the v.t. voltmeter is unusually low (1 to 5 μμfd.), the receiver stages may be inspected for proper alignment during these tests by adjusting each trimmer as voltage measurements are taken across the trimmed circuits. Here, resonance is indicated by maximum upward swing of the meter pointer. If the input capacitance of the instrument is appreciable, however, these alignment indications will be erroneous, since alignment will then be cor-

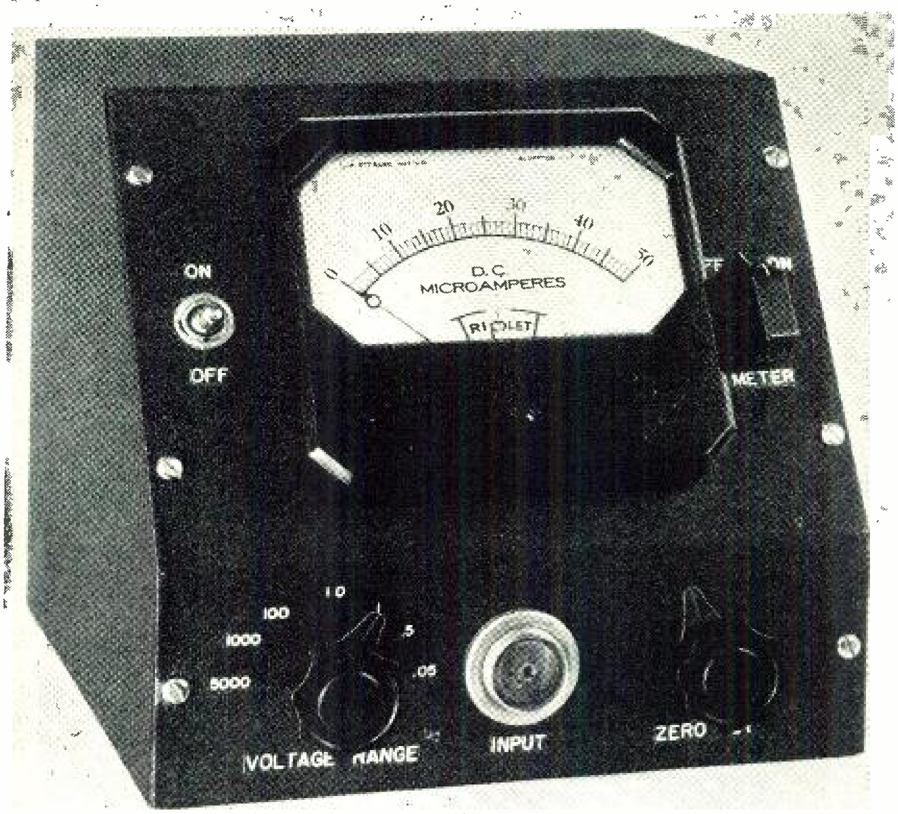
(*Continued on page* 72)

Fig. 2. The VTVM Distortion Analyzer circuit.



How to Use
VACUUM TUBE VOLTMETERS

by GUY DEXTER



The RADIO NEWS VTVM is an example of a highly-accurate instrument with wide range.

THE inherent frequency-voltage error of the oxide rectifier-type of a.c. voltmeter and its relatively large input impedance and shunting effect render that type of instrument totally unsatisfactory in measurements at other than powerline frequencies. In high-frequency testing, there is no entirely satisfactory substitute for the vacuum-tube voltmeter. In spite of these well-known facts, however, the electronic voltmeter is perhaps one of the most maligned of radio test instruments. Any undeserved ill repute, we feel, is due chiefly to lack of complete information regarding the utility of the instrument and noticeable tendency on the part of some authors to exaggerate the virtues of the instrument plus a leaning toward incomplete treatment on the part of other authors. This is why we believe so many v.t. voltmeters gather dust on instrument shelves, although they have excellent operating characteristics and were originally built with feverish enthusiasm.

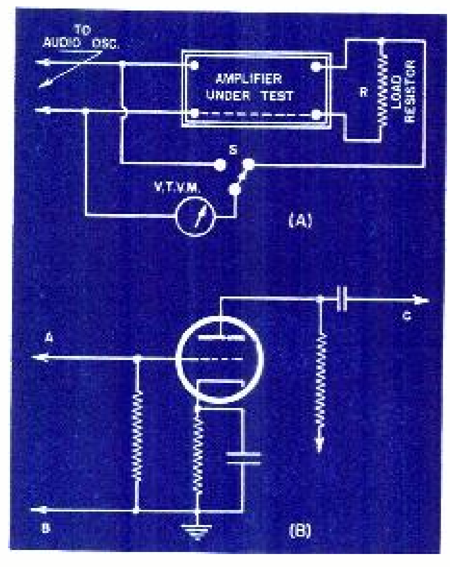
In order to point out the real utility of the a.c.-type v.t. voltmeter and to give proper directions for its use in a variety of radio and electrical measurements where this instrument is indispensable, we are presenting herewith a definite set of directions for specific operations. Space limitations make it impossible to describe every measurement that may be made with the instrument, so a careful selection has been made of those examples which are typical, and the radio electrician may readily employ the same technique to the solution of other measurement problems of the same types. It should be noted that in some cases a common a.c. voltmeter might be used, and commonly is employed. However, greater accuracy and speed are to be obtained even in these cases with the electronic instrument.

Oscillator Voltage Output

The voltage output of both radio-frequency and audio-frequency oscillators of all types may be taken as a gauge of oscillator efficiency in transmitter and receiver work. In each case, voltages must be measured at high frequencies beyond the limits of accuracy of common a.c. voltmeters, making the v.t. voltmeter imperative for this test. When making such measurements, it is desirable that the oscillator be permitted to feed its normal load circuit, in order that the test may be made under dynamic operating conditions. The test is performed in the following manner:

1. Connect the input circuit of the voltmeter to the actual output circuit of the oscillator under test, keeping all connecting leads as short as possible,
2. At audio frequencies up to 15 kc., the lead length to the instrument may be as much as several inches. However, leads must be extremely short to r.f. oscillators. Wherever possible, all r.f. measurements must be made with an extended-tube v.t.v.m. probe, in order that the grid of the voltmeter tube may be placed right at the point of measurement,
3. Set the voltmeter range selector to the highest voltage range,
4. Switch on the oscillator and note the voltmeter deflection, switching to lower voltage ranges for closer reading,
5. Compare the voltage readings ob-

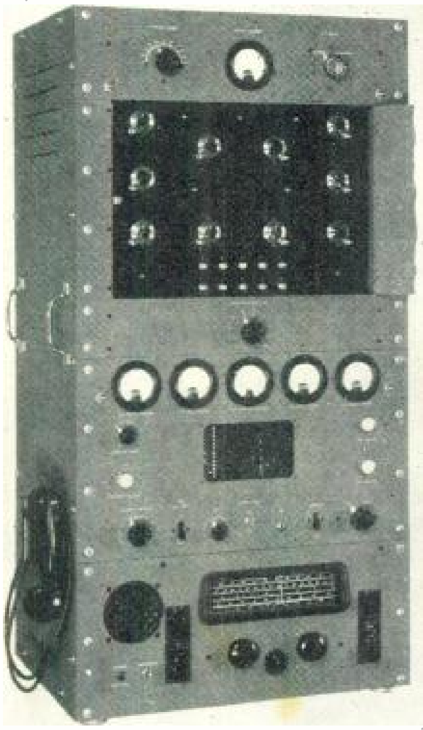
Fig. 1. Circuit for amplifier measurement.



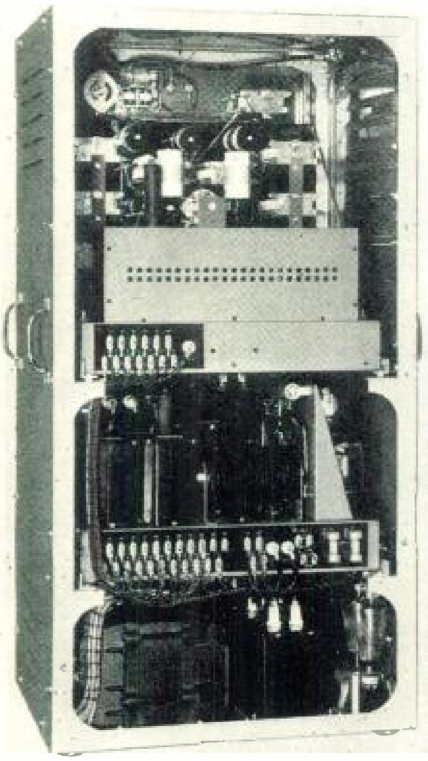
AVIATION RADIO COURSE

by PAUL W. KARROL

Concluding the series of articles on Aviation Radio. This final installment shows the importance of U.H.F. radio systems.



Above: Front view of modern airport transmitter. Below: Rear view of unit shows neatness of its construction.



IT has been conclusively proven that ultra-high-frequency (U.H.F.) aviation radio equipment, if designed, constructed, and employed properly, offers many decided advantages over the lower or medium frequency equipment now preponderant.

Because the advantages are sufficient in number, many corporations and governmental agencies have spent much time and money in research to perfect certain systems which will increase the safety factor in flying to a very high degree and simultaneously increase the efficiency of ground communications to the point where consistency of contact and utmost dependability are assured.

It was predicted sometime ago by this writer that U.H.F. systems would come into greater prominence as the equipment could be produced and installed. As was stipulated, the change must be a gradual transition from the low and medium frequency bands to the ultra-highs. It is evident that the change is taking place but at a decreased rate due to certain exigencies.

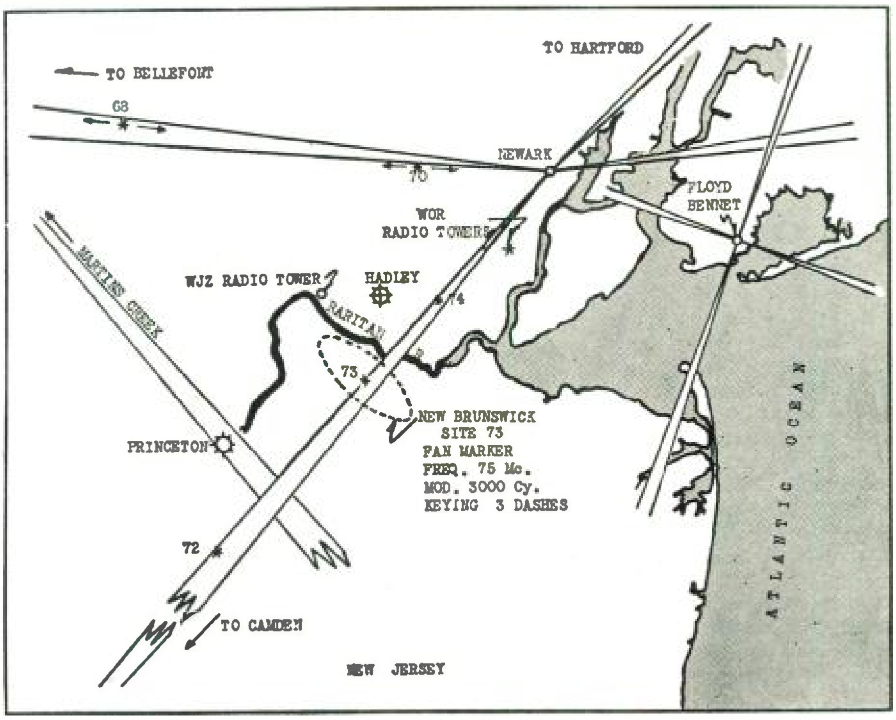
U.H.F. waves are said to lie in the frequency bands above 30,000 kilocycles (30 mcs.) and extend into infinity. These waves after transmission do not behave as do the lower frequency waves under a set of similar circumstances.

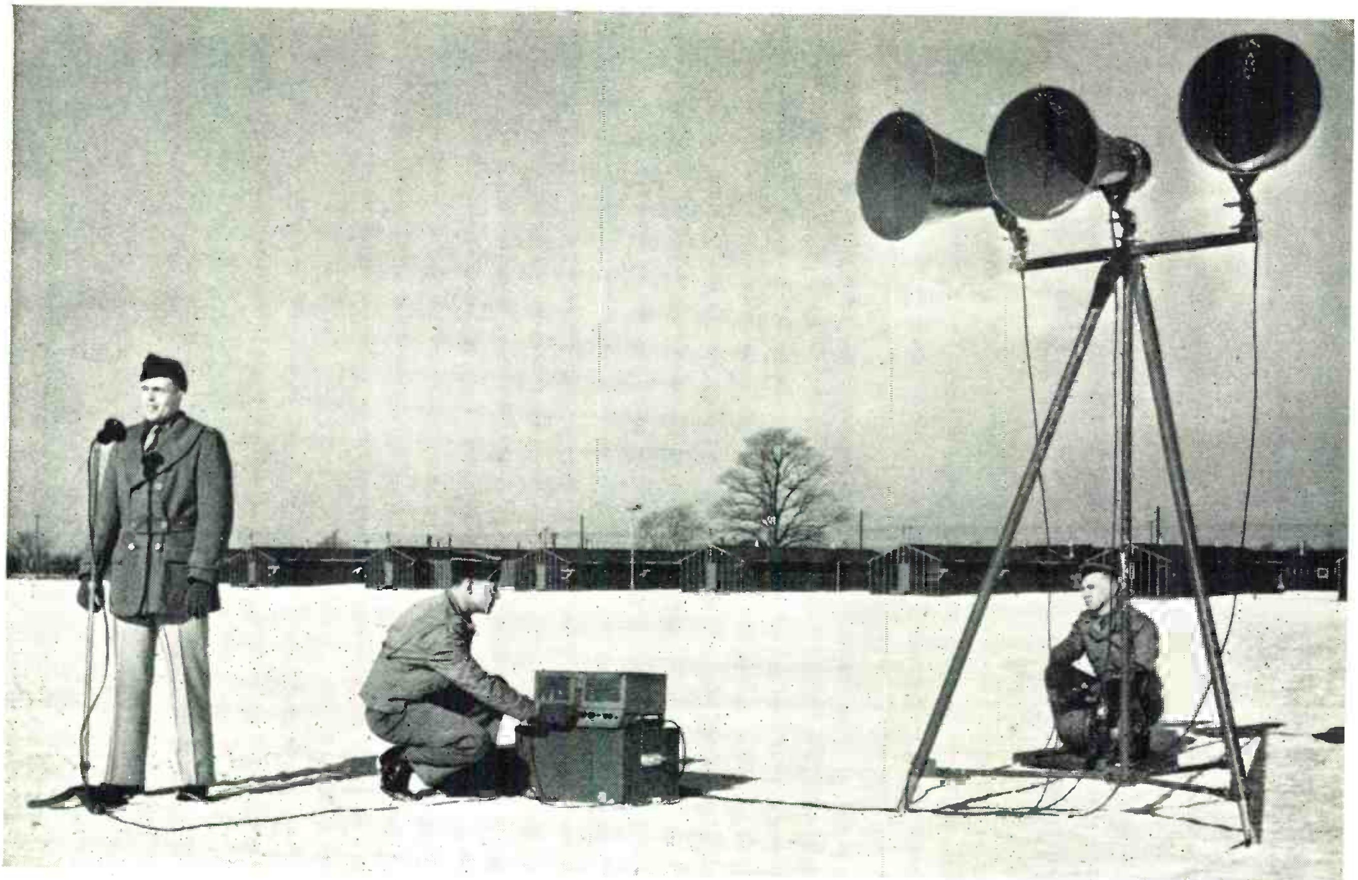
Those waves whose frequencies are 30 mcs. or over when transmitted pass through an ionized layer of the Heaviside, are not refracted back to the earth and are of course lost. Too, the ground wave component of the U.H.F. wave disappears because of ground absorption or ground losses. In mobile systems which depend upon the ground wave to any large extent, the lowest frequencies in the U.H.F. spectrum are utilized; and then consistent communication is not always assured because of improper positioning of the vehicle. Explained: in case the car was located near the base of a mountain whose ore content was high (even on lower frequencies decided signal changes would be apparent), beneath a steel bridge or near a steel structure, near tall buildings, etc., and the distance from the receiving station was not in "proportion" to the power of the transmitter (that is, the power of the transmitter could not overcome losses, absorption and reflection would take place reducing the signal to a point where it could not be heard at all or to a point where it was just audible.

Certain police radio station operators have heard patrol cars thousands of miles away at certain times of the year whose signals were much louder than those within only a few miles of the station's antennae systems.

(Continued on page 75)

Fan-type marker at New Brunswick, N. J. showing its position with respect to airways.





Lt. Richardson demonstrates use of portable PA equipment on Parade Grounds.

The OP-6 remote amplifier has a center tap on the output transformer and this is utilized for simplexing a phone on the remote station end of the loop. Each remote loop has its own row of jacks and also two rows are provided for the console units in the station. Should the occasion demand it is possible to send seven different signals through the system simultaneously. It is possible, for example, to present one band selection to one area, and an entirely different band selection to another area, at the same time. The turntables may be operated, each as an independent unit, or both combined as one unit giving a continuous program. Often, cued records for marching, have been played from one table to the other without missing a step in cadence.

After leaving the "low level" stage the signal is amplified with regular broadcast voltage amplifiers, which in turn are driving fifty watt power amplifiers, and which are also driving banks of speakers in each area. Each power amplifier feeds its own bank of speakers, and in the event of trouble, each unit can be "patched around" by an ingenious arrangement of patch cords, so that speakers in any specified area can be driven by an amplifier which had been serving another area. Volume indicator meters and a monitor speaker give a double check on the signal going through the system and level of sound going to the speakers.

A schedule of a typical day's routine vividly illustrates the complexities in the operation of the station. . . . *First Call* sounds at 5:30 in the morning which is followed by *Reveille* at 5:40 and *Assembly* at 5:45. Breakfast is at 6:15 when *Mess Call* is sounded. *Sick Call* is sounded at 6:50 and the students get information to attend school at 7:30 when *School Call* is sounded. The next call is not sounded until 11:30 when *Recall* is played to bring the students back from school for the noon meal.

During this morning interim, however, we will assume for example, that a musical transcription is to be made of the Company Band. One of the PA operators takes an OP-6, a phone, a microphone or two with all the necessary cords and plugs to the theatre where the Band starts rehearsing at 9:00 o'clock. The remote amplifier and other equipment are made ready for transcribing by the operator.

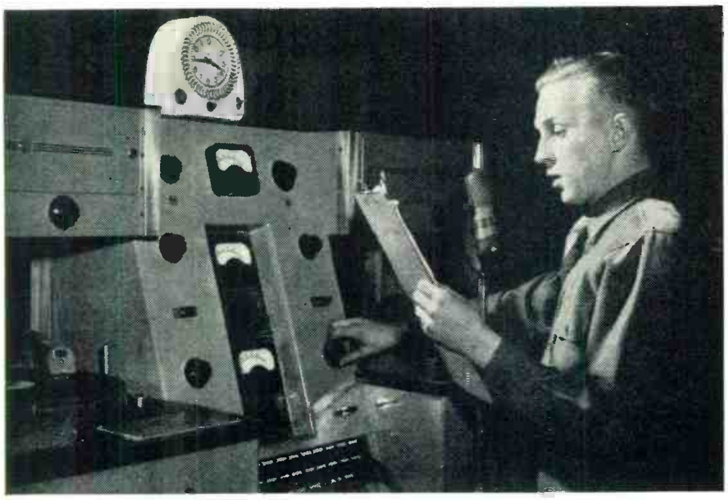
After the amplifier is plugged in, phones connected and microphones set up, the PA operator at the main station is contacted by phone to check everything for the cutting of a record. The blank disc is on the turntable, the cutting device is mounted, and already a "test cut" has been made. The "board" has been trunked up and everything is in readiness for taking a "level." The Band starts to play, the needles on the VU meter begin to swing and adjustments are made for the proper readings. The "levels" are taken and the Band, which has been stopped, is put in readiness to play.

At this point the main station is again called on the phone to double check before the PA operator at the remote station gives the order to "stand by" and then "start cutting." Next the table at the main station is set into motion and the cutting head is placed on the disc. The "go ahead" sign is given the Band leader and the volume control is "cranked up" to the point on the dial that was selected during the test level. The Band continues to play until the selection is completed and the same procedure is repeated until the desired selections have been recorded. When it is about time for the noon meal the PA operator returns to the main station and at 12:00 noon, *Mess Call* is played.

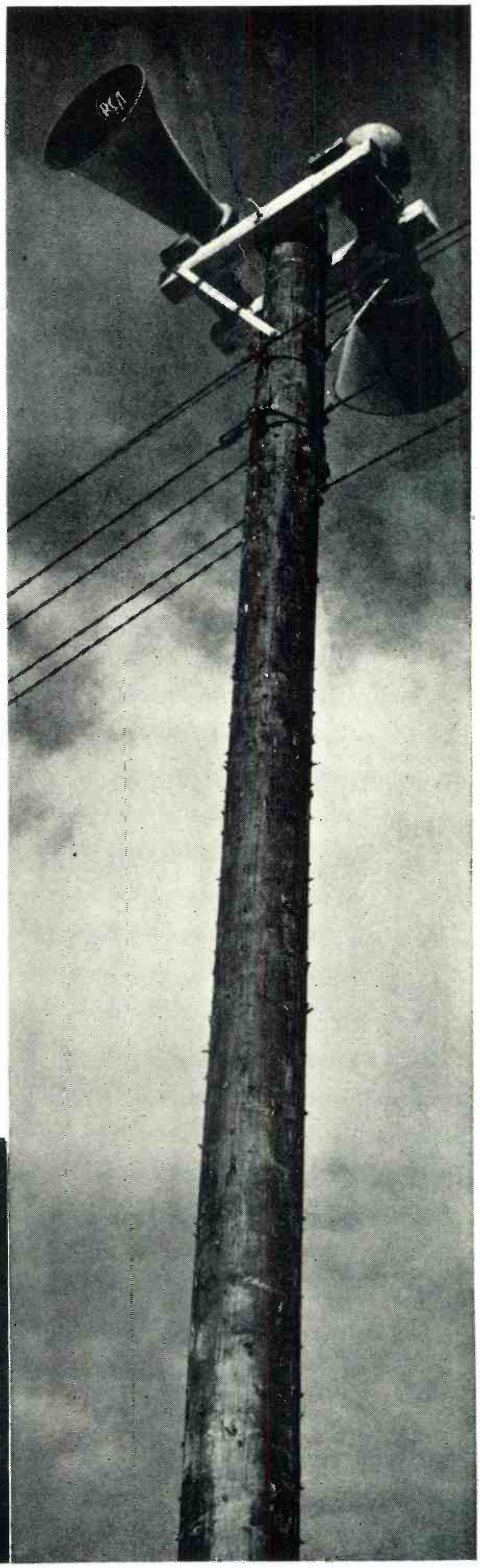
After the mid-day meal the *News of the Day* is broadcast over the entire camp system. A microphone is set up in the main station and the "signature music" record is placed on the turntable. At 12:15 the music is played and the "opening fanfare" reaches the speakers, the music is cut back to a softer level and the voice of the announcer comes in with *News of the Day*. The music is then brought up and out and the announcer continues with the news announcements proper. At the end of this feature the events of prime interest to camp personnel are given and it is ended with the *Correct Time* to the second. This signal, checked daily with the *Bureau of Standards* time signal station at Washington, D. C., is picked up by an all-

(*Continued on page* 62)

BUGLER ★ ★ ★ ★



Many important announcements and special broadcasts are sent out over the public address system to every corner of the post.

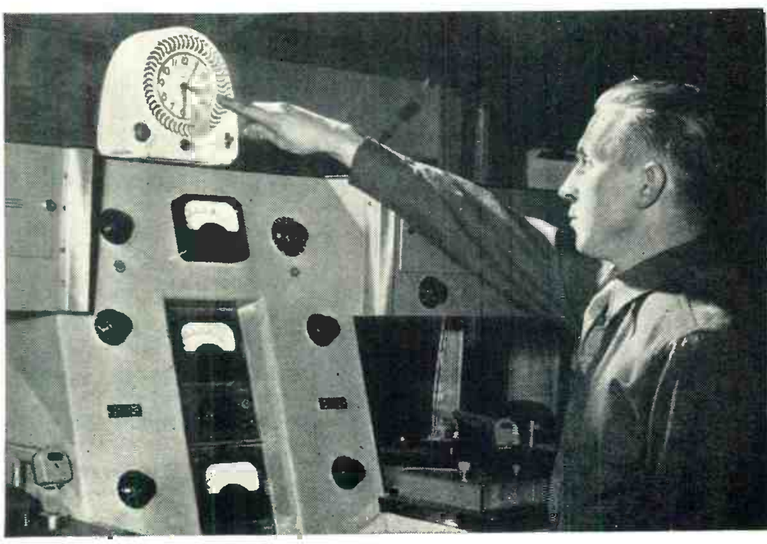


is constructed of practically all standard parts. Two turntables which will rotate at either 78 or 33⅓ rpm, and will accommodate any record up to and including one of 16 inches in diameter, are mounted on the right and left top sections of the console. The entire "low level" side is built similar to radio broadcasting station equipment. In the station console there are provisions for two microphone inputs. The two microphones and the two turntables, or any combination of the four, can be mixed together. For making transcriptions this enables both the music and voice to be blended. This mixing feature is employed daily except Sunday in presenting the *News Broadcast*.

The remote equipment includes the RCA OP-6 remote amplifier and the OP-7 microphone mixer. Remote lines are run to line matching transformers used at the PA Station. From there the signal is transmitted to rows of jacks with resistors across each so there will be no volume drop in the amplifiers already carrying the signal. Telephone communication between the main station and remote station is accomplished by simplexing the remote lines. A phone is connected across all the center taps of the line transformers in the main station so that no matter what remote circuit is in use, communication is available.

Right: Bank of speakers mounted on a tall telephone pole.

Below: Operator is pointing to a special clock on console.



ARMY USES ELECTRONIC

The bugler is being replaced by electronic gadgets in many Army Camps.

by KENNETH R. PORTER
Washington, D. C.

One of the most elaborate of all installations of PA equipment is described herein. Built by personnel of Camp Wood—the system has been designed for maximum flexibility and quality.

AN ELECTRICALLY controlled robot in the form of a monitorial phonographic public address and recording system has taken the place of the much maligned bugler in many of the nation's Army camps.

No more can he be verbally "murdered" or cussed, as an individual, for his daily instrumentations. His danger now lies, not so much in bodily harm, as in the possible filching of the needle or shutting off of the power. And of what good is a record or even a phonograph without these two items?

A centralized public address station in an Army camp, now that many successful ones are in use, is the logical method for the transmission of bugle calls, important messages, vital instructions, radio programs, local entertainment announcements and for innumerable other applications. Following in sequence a general description of the many and varied uses of a typical *U. S. Army Signal Corps* system; the operation, the programs handled and, finally, the more technical details pertaining to the equipment and installation, one realizes its many advantages.

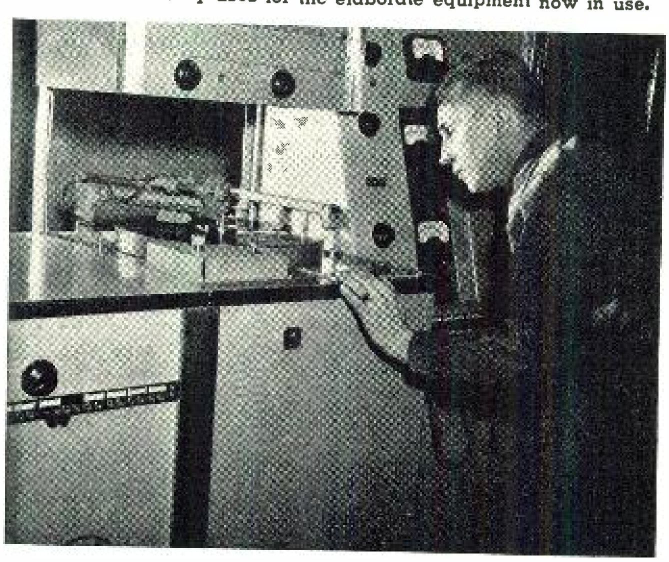
This particular PA Station, at Camp Charles Wood, N. J., a sub-post of Fort Monmouth, consists of amplifiers, turntables, meters, monitor speaker and time indicators housed in a console designed for maximum flexibility of operation. From this station any or all of the speaker groups throughout the camp areas can be driven. The sound is controlled by fingertip knob and dial operation. Indicator meters and a monitor speaker are used to determine the volume of sound going to any particular area of the camp.

The Station is in operation 24 hours a day, seven days a week. The system handles the complete course of recorded bugle calls every day, from *First Call* in the morning to *Taps* at night. Although the playing of bugle calls is the primary purpose of the system, there are other important uses served by the system.

Aside from the routine bugle calls and marching music handled daily, programs originating from the Post Theatre, Post Chapel, Post Headquarters, Parade Ground or Athletic Field may be "piped in" to the PA Station on remote circuits and then, having been amplified, may be sent to one or more of the speaker groups.

The equipment in the main station

Cutting transcriptions of selections played by the post's band is one of the many uses for the elaborate equipment now in use.



The operator examines a finished disc which has just been cut. All controls are within easy reach in order to insure compactness.

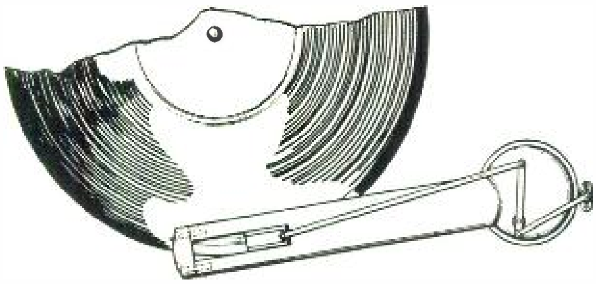


Fig. 1

Pickup cartridge is towards center of arm when in the outside position as shown in this illustration.

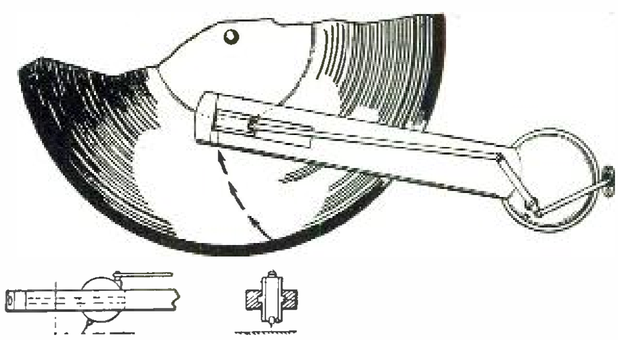


Fig. 2

The needle swings in proper relationship to the groove as the arm moves towards the turntable hub.

A SELF-ADJUSTING PICKUP

Of particular interest to recordists and sound operators is this new tone arm, designed to maintain proper tangency.

by RALPH B. DAVIS

NOW that it is possible to construct pickup heads with a very low distortion in their output, which has been made possible by careful and diligent research, it has become necessary to eliminate another source of distortion, i.e., the needle not being tangent to the groove. Before the introduction of the high fidelity pickup this distortion was not so noticeable due to the fact that distortion is more apparent in the high-frequency spectrum than in the low. The only way in which this distortion can be eliminated is by keeping the needle tangent to the groove.

There is one serious drawback to our present type of pickup arm. In our present type the needle is stationary, and as a result, cannot be kept tangent to the groove. If we expect the utmost from a high fidelity pickup head it will be absolutely necessary to keep the needle tangent to the groove as it traverses the record. In the past this distortion has been tolerated and no simple means has been available to remove it. There have been several attempts in the past to overcome this faulty tracking, but all have fallen short of their intended purpose. In the design of these pickup arms it would seem that the pivotal base had been disregarded while bringing the needle into tangent relation with the groove.

It is a well known fact that if the needle pressure is greater on one side of the groove than it is on the other, distortion is sure to result. Not only is distortion introduced due to this unequaled pressure, but the needle scratch is also greater. To obtain quality from a recording, both of these conditions must be eliminated. Of course, only a portion of the scratch can be overcome by making the needle tangent to the groove. But the distortion due to improper tracking can be completely eliminated.

If we expect to eliminate the distortion due to improper tracking, the needle must be kept tangent to the groove from a point in direct line with the pivotal base of the arm. This condition can be satisfied in only one way, that is, by varying the distance of the needle from the point where the arm is pivoted. There may seem to be other means of accomplishing this unless careful consideration is given. For example, it may seem at first thought that all that would be necessary to bring the needle into a tangent position with the groove would be to offset the needle in the head of the pickup arm at an angle which would cause it to be tangent and then locating the pivoted end of the arm at such a position that it would continue to keep it in this relation as it traversed the record. This can, of course, be accomplished. But on more careful inspection it will become obvious that the condition which we expected to

(*Continued on page* 46)

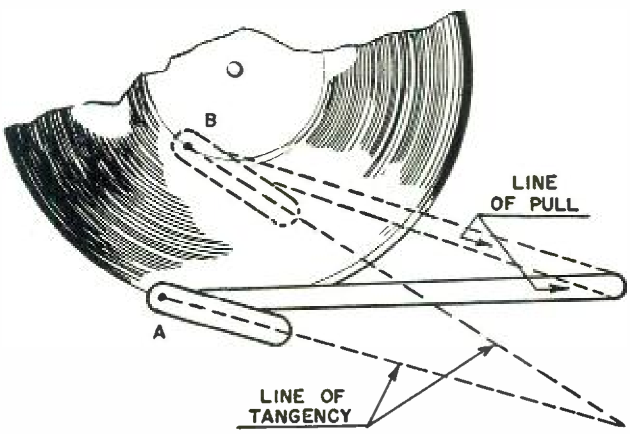
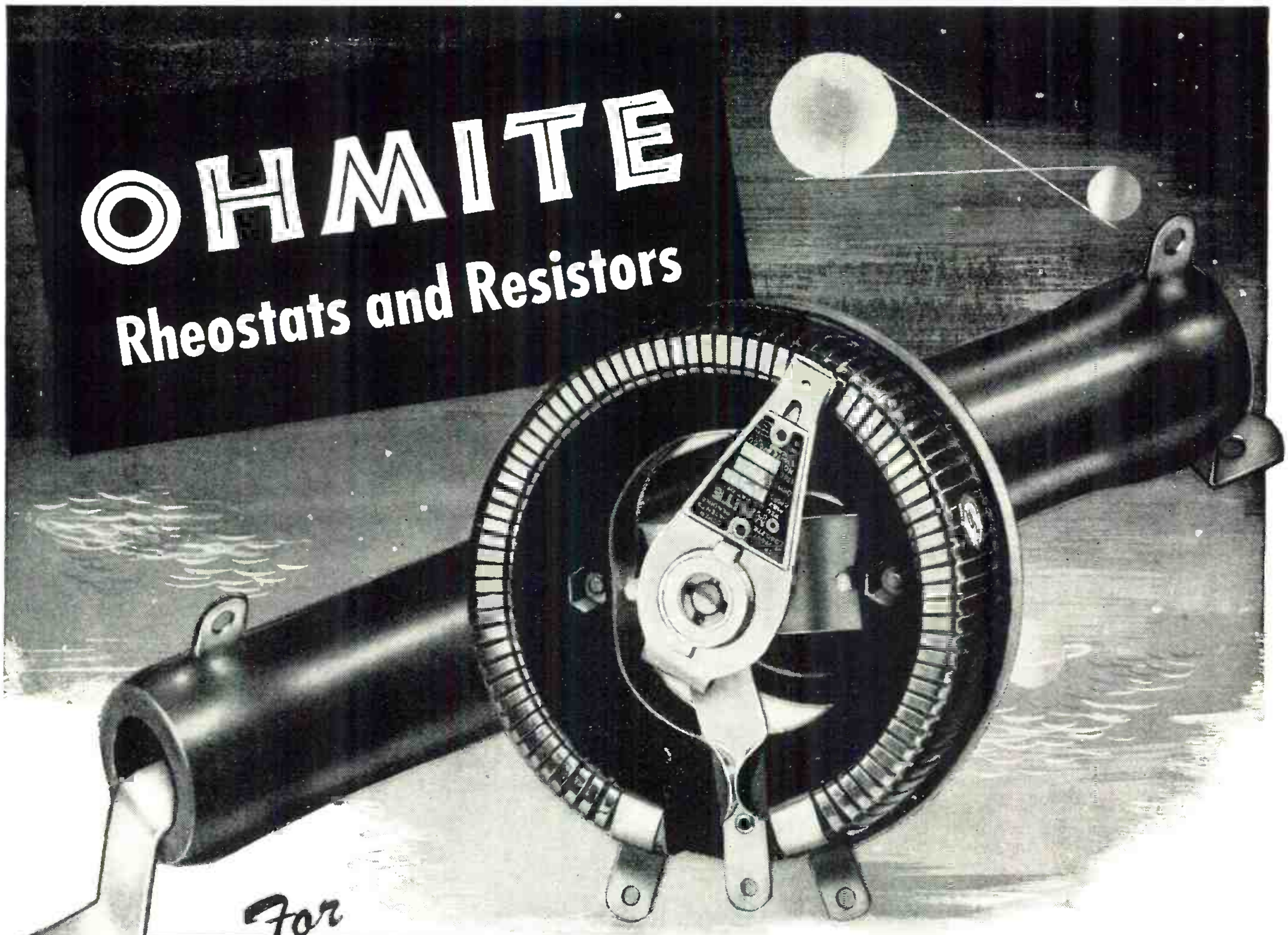


Fig. 3

Illustrating the change of angle, with respect to the groove, with conventional pickup.



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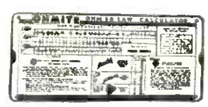

OHMITE MANUFACTURING CO., 4883 Flournoy St., Chicago, U. S. A.
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Aircraft Flight Recorder

(*Continued from page 17*)

sible opening the line while a tachometer signal is coming through. In order that any desired sequence of signal readings may be arranged, contact points of the switch are wired to one side of a plug-and-jack terminal board, Fig. 10.

Calibration obviously is of extreme importance to the accuracy of this system. Prior to operations, all pickups are laboratory calibrated in relation to fixed gages. Any changes occurring later in other parts of the equipment are corrected at the analyzer so that the fixed dummy gages appear on the charts in their correct ratio. This assures the correct ratio for all other pickups. What we have done, to be somewhat more specific, is set a band of 0 to 5,000 cycles per second as our full scale of range, and relate the output of the various gages to it.

Each pickup causes a 5,000 c.p.s. change in the convertor unit when the pickup is subjected to the maximum change in stimulus it is required to measure. Our graphic recorders are used as frequency meters, and respond full-scale to 5,000 c.p.s. change. The dummy gages included among the active gages in the plane give a check and a control on the entire system. Should any variation occur in the plane's equipment due to changes in power supply, temperature or weak tubes, our charts will show the change, which can be corrected immediately by an adjustment on the analyzer. Therefore, all variables in the pickups, the converter unit and the analyzers have been cancelled out or recorded so that both time and amplitude of their occurrence are known.

Because space does not permit, we shall omit some of the more searching details. It will be of interest, however, to consider the more important elements. Strain gages, for example, have a resistance of 88 ohms and vary two ohms over a range from 60,000 to 60,000 p.s.i. stress in 24 ST AL. When we desire to measure small loads under special conditions, the converter unit can be made to swing through its entire range by increasing the gain on the bridge amplifier so that strains can be read over a total range of approximately 3,000 pounds.

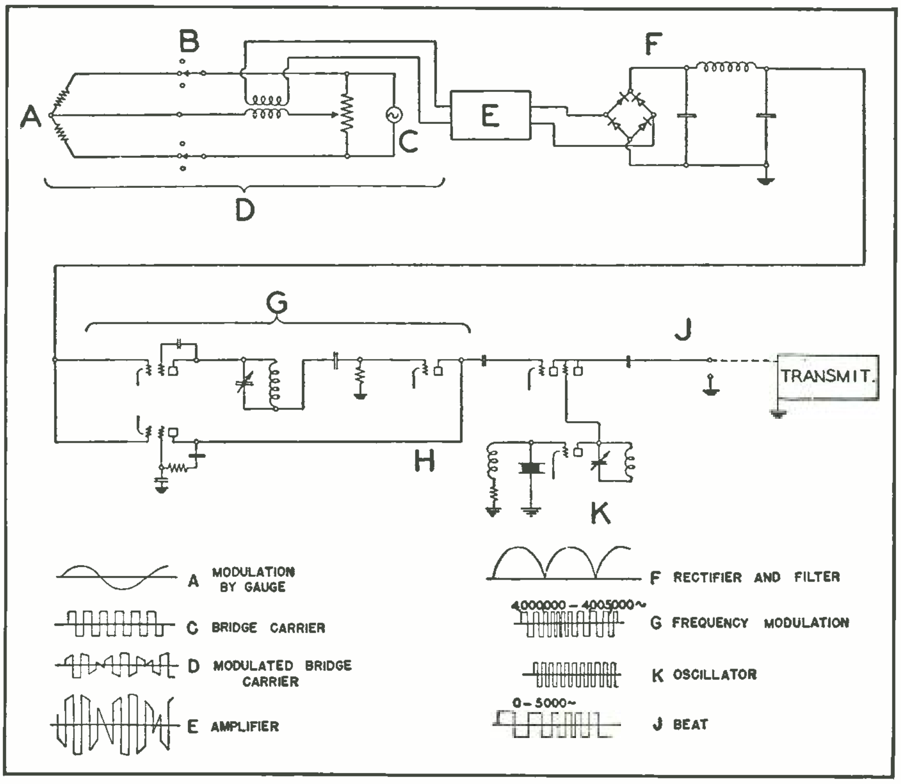
Other types of pickups being more sensitive than required, shunts or multipliers are used in normal operations to control their ranges. In the case of temperature measurements, Fig. 15, the units are made to approximate specification ranges, and then the ranges are adjusted as desired by the use of proper multiplier resistances in series with the unit.

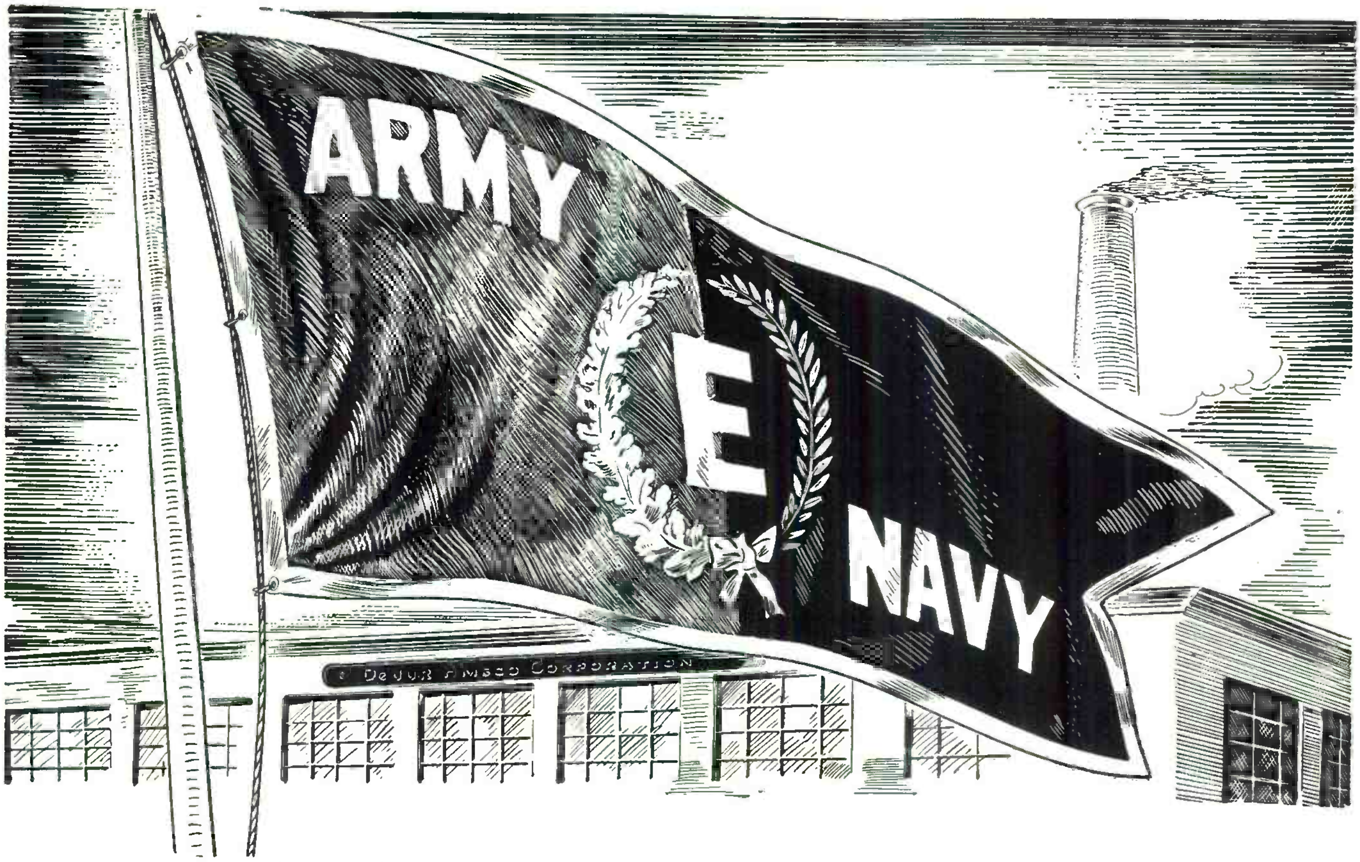
Calibration of positions indicators may be accomplished both mechanically and electrically. Wire wound potentiometers of suitable values are employed with multiplying resistors to give us the correct range, while mechanical systems are designed to use half or more of the available rotation of the potentiometers.

The r.p.m. of tachometers must be converted into a related range of c.p.s. falling within the established frequency swing of the radio recorder, accomplished by designing the tachometers as multipole alternators. Output of the tachometer unit is fed through the scanning switch to the transmitter as audio modulation.

Converting r.p.m. into c.p.s. involves

Fig. 13.





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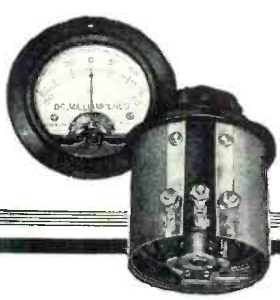

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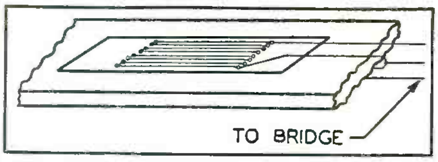


Fig. 14.

no particular trickery. The number of poles on the tachometer unit is determined by the range of r.p.m. to be scanned. Suppose we want records of engine speeds between 500-4000 r.p.m. Because the tachometer shaft rotates half as fast as the engine, a 120-pole generator would, at an engine speed of 1000 r.p.m. produce 1000 c.p.s. This generated signal then will be recorded and analyzed by the same methods used to record and analyze signals from the converter unit. Frequency

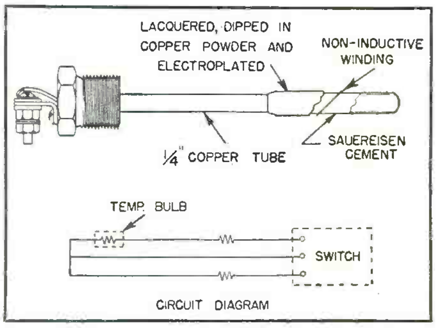


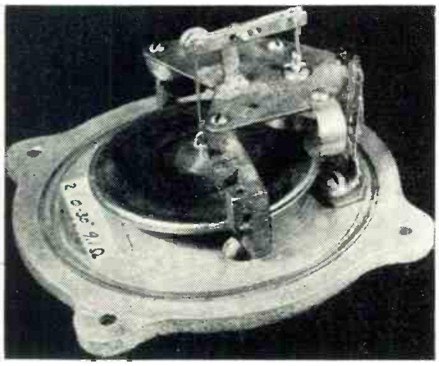
Fig. 15.

generators used with the recorder consist of a steel gear whose teeth pass the pole of a permanent magnet.

As for calibrating the converter unit, since all pickups are set to a common denominator it is necessary only to set the gain of the bridge amplifier to produce the desired frequency range. To simplify calibration, this "common denominator" has been fixed as the amount of change on the output of an equal arm bridge (100 ohms in each arm) when one of the arms is changed two ohms. Since the normal frequency swing of the converter is set at 5000 c.p.s., we can operate the automatic analyzer at any points between 500-6500 c.p.s.

As for actual operations of the system, these have been confined largely to date to tests. We know that its use reduces materially the number of hours of test flying necessary to ob-

Fig. 16.



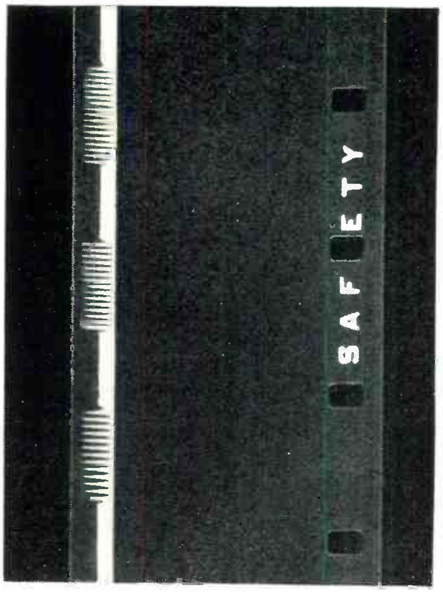


Fig. 17.

tain performance data on planes and engines. The automatic analyzer likewise saves considerable engineering time in plotting charts. Perhaps even more important is the fact that with this equipment we can obtain data previously impossible to obtain, due to rapidly changing conditions during flight.

Following is a list of present pickups, indicative of applications already possible: strain gages, altimeter, air speed, manifold pressure, tachometers, fuel flow, acceleration, liquid pressures, liquid temperatures, air or gas temperatures, air or gas pressures, pressure differentials, suction, exhaust gas temperature, control surface positions, control cable or rod loads, positions—flaps, throttle, etc.

As for the future, these proposed pickups will open an even wider range of studies: thermocouples, angle of pitch, angle of attack, angle of yaw, angle of airflow, ground speed-wheels, hydraulic pressures, hydraulic valve positions, vibrations, etc.

—30—

Practical Radio
(*Continued from page* 35)

output of the r.-f. voltage generated in the oscillator circuit of a radio transmitter. The output end of the amplifier is called upon to deliver maximum electrical power to the transmitting antenna circuit, so it is a *power* amplifier stage designed especially for this purpose.

Fig. 7 illustrates a commercial application of the vacuum tube amplifier to amplify feeble output voltage impulses of a phototube so that sufficient electrical power will be available to operate the magnetic relay that controls the operation of the electric motor circuit. Notice the use of a *voltage* amplifier stage driving the grid circuit of a power amplifier stage designed

to release maximum signal power to the relay coil connected in its plate circuit.

Effect of Plate Load Value on Voltage Amplification Produced

Formula (1) for the voltage amplification produced shows at once that the gain actually obtainable from the tube is some value less than the tube's amplification factor μ, but that by making R_L so large that r_p is negligible in comparison with it, the voltage amplification produced by the stage will rise towards a theoretical maximum equal to μ, the amplification factor of the tube. This can be visualized by inspection of Fig. 1b. As R_L, becomes larger and larger in comparison to r_p, a greater and greater proportion of the voltage μE_g applied to the circuit appears across R_L. Under maximum conditions, when R_L is large enough, all of the signal voltage appears across it, that is, $\mu E_g = ER_L$ (see Fig. 1c). The amplification produced by the stage is then equal to

$$\frac{\mu E_g}{E_g} = \mu.$$

Therefore, for voltage amplification, it is desirable to use as large a plate-load impedance as practicable, so that a large amount of effective gain can be obtained from the tube. In practical voltage amplifiers the plate-load impedance that can be employed is limited by considerations involving the plate supply voltage (E_b of Fig. 1a) available and the actual direct plate voltage the tube is designed to operate at. The direct voltage reaching the plate is equal to the plate supply voltage minus the direct voltage drop of I_pR_L which occurs in the load resistance. Thus, if the plate current, I_p, of the tube is 2 milliamperes and $R_L =$ 50,000 ohms, then the direct voltage drop in the load resistance will be $E = I_pR = 0.002 \times 50{,}000 = 100$ volts. If the tube should be operated with 90 volts actually on the plate, the total voltage applied by the plate supply source (batteries, rectifier, etc.) must be $100 + 90 = 190$ volts. Naturally, in battery-operated amplifiers it is important that the B-battery voltage required be kept low, so the value of R_L used in them must be chosen with care. Even in amplifiers powered from the electric light lines, the value of R_L must be kept within reasonable limits for, otherwise, a rectifier and filter unit delivering higher voltages must be used for the plate supply. This makes it more expensive and more subject to breakdown.

Fig. 8 shows the values of stage-gain obtained with various values of load resistance R_L for a triode having $r_p = 10{,}000$ ohms and $\mu = 10$, (assuming that r_p is constant). It will be noticed that there is little additional voltage amplification to be gained by making R_L greater than about four or five times r_p, i.e., referring to the curve where R_L is equal to about 50,000 ohms. In general, this is true for such voltage amplifiers.

(To be continued)

Self-Adjusting Pickup

(Continued from page 21)

improve has been made somewhat worse.

Let us refer to Fig. 3 for a more complete picture of this method to bring the needle into a tangent position within the groove. It is, of course, obvious from looking at A and B in Fig. 3, that the needle is tangent to the grooves, but the line of tangency is not in the direction of the point of pull, which is the pivoted base of the arm. It is, therefore apparent that the pull exerted on the needle is at an angle, and as a result, would increase the distortion due to the added pressure on one side of the groove. It is evident then, that the distortion which this arrangement would seem to eliminate has in fact been increased.

Now let us turn to an improved method for keeping the needle tangent to the groove, a method on which there has just recently been issued a patent. In this arrangement every trace of distortion has been eliminated by varying the needle longitudinally by the arm. The mechanical arrangement of this arm is exceedingly simple in design, and as a result, it presents an appearance like that of an ordinary straight arm pick-up. By referring to Fig. 1 and 2, we can see the mechanical arrangement of the actuating mechanism which keeps the needle in tangent relation with the groove as it traverses the record. When the pick-up arm is placed in the starting position as shown in Fig. 1, the pickup head is in the rear position and tangent to the peripheral groove.

As the record is played and the pick-up arm continues across, the pickup head is slowly moved at the correct speed to the opposite end by the mechanical arrangement. The speed of the head toward the front of the pick-up arm is at the correct rate to cause the needle to be tangent to each groove. It is, therefore, obvious from this arrangement that any distortion due to uneven pressure on either side of the needle has been completely eliminated.

When the needle is not kept tangent to the groove as in the ordinary pick-up arm the distortion produced in the high-frequency range is far more pronounced than in the low frequency. This high frequency distortion is usually reduced to a point where it is not objectionable by the attenuation of the high-frequencies. But when the high-frequencies are attenuated the harmonics of words and music are lost. This condition cannot be allowed to exist if high fidelity reproduction is our aim.

-30-

APOLOGIES!
The co-author of the article "MAINTENANCE OF FOREIGN MARINE RADIO" in our March, 1943 issue was J. T. Donnelly

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Saga of the V.T.
(*Continued from page* 32)

water (such as the fixed alkalis) could be decomposed in the same way, and thus laid the foundations of the science of electrochemistry.

In 1806, Paul Erman of Berlin wrote an elaborate memoir[45] on the conducting power of different bodies, which was awarded the prize of the *French Academy*. In this memoir we find the first mention of the action of flames in connection with the phenomena of voltaic electricity. He divided all bodies into five classes; perfect conductors, perfect non-conductors, imperfect conductors, positive conductors, and negative conductors. The nature of the first three classes requires no explanation; the fourth and fifth classes of bodies act as perfect conductors when applied to either of the two poles separately, but when placed between them, insulate either the positive or negative pole respectively and do not form a communication between them. The flame of a spirit lamp is described as a positive conductor; if it be applied to each pole separately it conducts the electricity; but if placed between the two poles it will not form a communication between them in consequence of its insulating the negative electricity. Although flame is a conductor, it does not conduct as perfectly as the metals. Flame is, however, a very different substance according to the body from which it is procured. The above observation refers to the flame of a hydrocarbon. The flame of sulphur insulates both the poles; that of phosphorus insulates the positive and conducts the negative.

William T. Brande, in 1814, reexamined Erman's work[46] and performed additional experiments with flames. He attempted to explain Erman's results on the basis of Davy's electrochemical theory. He postulated that some chemical bodies were naturally positive and some negative, and that they would be attracted toward the negative and positive poles of the pile respectively. Brande found that the flame of a hydrocarbon was attracted to the negative; and the flame of phosphorus which would contain a quantity of phosphoric acid, was attracted toward the positive. Here the bodies seemed to follow the then known laws of electrochemical attraction.

Meantime experimenters were improving on the voltaic pile and developing other forms of primary batteries. The evolution of this device, from the time of Volta to the present day, would fill volumes, hence we can only touch on it briefly.

In 1803, Hachette and Desormes substituted[47] starch for the liquid in the common voltaic pile, and in 1809 J. De Luc invented[48] the so called "dry pile," consisting of a column of alternate disks of paper gilt on one side, and zinc. This was not in reality *dry;* the paper imbibed and retained moisture enough to activate the pile. These modifications all produced a device which gave a high voltage but which had a high internal resistance.

Mr. John G. Children worked along somewhat different lines. Starting with Volta's "couronne des tasses" he increased the size of the elements, in order (as we now see it) to increase the current or quantity output. He first constructed a battery of twenty cells, with plates four feet by two feet, the cells being filled with a mixture of dilute nitric and sulphuric acids, with which battery he performed numerous experiments. He next made a battery of two hundred pairs of plates, each two inches square. From the experiments he performed with these batteries he deduced[49] that the *intensity* of the electricity is increased with the number of cells and the *quantity* with the extent of the metallic plates. He subsequently built[50] another battery of twenty-one cells, with plates six feet by two feet eight inches in size. This battery was first used in July 1813. Later a battery of two hundred cells, with multiple plates per cell, was installed at the Royal Institution. With the ouput of this battery many substances were fused and the electric arc between charcoal points was publicly demonstrated. This arc, or "arch," was described as follows by one of the historians of that day:[51]

"A singularly beautiful effect was produced by placing pieces of charcoal at the two ends of the wires in the interrupted circuit; when they were brought within the thirtieth or fortieth part of an inch of each other, a bright spark was produced, above half the volume of the charcoal, which was rather more than an inch long, became ignited to whiteness; and by withdrawing the points from each other, a constant discharge took place through the heated air, in a space equal to at least four inches, producing a most brilliant arch of light, this light constituted the sphere of activity of the instrument."

From this demonstration came the subsequent development of the arc lamp as a commercial source of light. Since it was so brilliant later scientists attacked the problem of making the unit smaller, that is, of "subdividing the electric light." This eventually led to the development of the incandescent lamp, and the modern vacuum tube. But this was far in the future, and the development of the tools with which it was finally accomplished went on.

The functioning of these early batteries was none too good, especially those containing acid electrolytes. Investigation by de La Rive showed[52] that this was due in part to "local action" caused by impurities in the electrode material, especially in the zinc electrode. Kemp,[53] followed by Sturgeon,[54] drew attention to the fact that this action could be reduced by amalgamating the zinc plates. In 1836

came the Daniell cell,[55] and in 1839 the Grove.[56] These were the first cells to use depolarizers in a practical way. The principles underlying depolarization had previously been recognized[57] by Becquerel, who also described cells similar to the Daniell, which however were not very much used. The Smee cell appeared in 1840 and the Bunsen cell in 1841.[58] This Bunsen cell was a modification of the Grove. The bichromate type cell usually referred to as the Bunsen cell did not appear until 1875.[59]

We have followed the development of the battery. While our source of electrical energy was growing from the abrupt discharge of the Leyden jar to the steady unidirectional flow of electric current, fortunately for us the age-old question of the relationship of electricity and magnetism still held the attention of some scientists. To these men the voltaic pile and its successors opened a new avenue of investigation. As we look into this phase of electrical research we shall see how their patience was rewarded.

In 1820 Hans Christian Oersted of Denmark, after spending thirteen years seeking some evidence of a physical interaction between magnetism and electricity, was suddenly rewarded for his perseverance. In this year he announced[60] to the world his discovery of the magnetic effect of the electric current. This discovery caused unqualified astonishment throughout Europe; more especially since all previous attempts to connect electricity and magnetism had proved unavailing. As might be expected, the experimental resources of every laboratory were brought to bear on the pursuit of the consequences of this newly-enunciated relation, so long suspected. The inquiry was taken up by Ampere, Arago, Biot, Savary, and Savart in France; Davy, Cummings and Faraday in England; de La Rive, Berbelius, Seebeck, Schweigger, Nobili, and others elsewhere in Europe.

Within less than three months after Oersted's announcement, Andre Marie Ampere communicated[61] the first of a series of Classic memoires on the subject of electromagnetism to the *French Academy*. In these memoires Ampere gave a far more complete exposition of Oersted's discovery than Oersted himself had done. He gave a definite rule concerning the direction in which the magnetic needle deflected when influenced by the passage of the electric current in a nearby wire. This is still known as *Ampere's Rule*. He disclosed the attraction and repulsion of parallel wires carrying electric currents, and proved that the force between them was directly proportional to the product of the currents and inversely proportional to the square of the distance between them. It was Ampere who decided that the direction of the current is the direction in which we imagine the positive electricity to move, and who introduced the term "galvanometer" to describe a current measurer which worked by means of the magnetic effect as it appeared.

While Galvani and Volta supplied the means for this development Oersted pointed out the main road to the application, and Ampere gave this application a fixed form, which is serviceable today. Later Faraday added to it something new and important both in form and matter.

Ampere succeeded because of his analytical mind and fertile imagination. Up to his time even the idea of the electric current was undefined. It was difficult for the philosophers to grasp exactly what happened when the wire was connected to the voltaic pile. We find that Volta used the term "courant electrique"[62] and Gray had previously spoken of the flow of electricity. Ampere decided, in 1820, to call the whole process in the discharge wire an *electric current,* and the direction of the current to be defined as the direction in which we imagine the positive electricity to move. This gave a pattern and terms to the study of electricity. We can understand the importance and significance of this when we note that even Oersted referred to the phenomenon as an "electric conflict" in the title of the book which announced his discovery.

Ampere was the first to make a clear distinction between *electric tension* and *electric current*. He realized that the phenomenon of electric tension existed in the voltaic pile before the circuit was closed, and could be measured by the electrometer, while that of electric current was absent until the circuit was closed. He felt that the current could best be measured by its magnetic effects.

Ampere was also the first to distinguish between *electrostatics* (the science of stationary electricity), and *electrodynamics* (the science of moving electricity). He also named these two branches of the science.

The names of Ampere and Oersted became linked for all time with the study of the mutual effects of electricity and magnetism. Oersted appears to have been the pure scientist. Apparently he gave no thought to the possible practical applications of his discovery. This was in line with his statement before the *University of Copenhagen* in 1814 that "The real laborer in the scientific field chooses knowledge as his highest aim." Oersted appreciated the utilitarian in science, but it took a flash of the genius of Ampere to see the practical application of Oersted's discovery. He thought immediately in terms of an electric telegraph. Ampere was not only a scientist but also an engineer.

Claude Servais Matthias Pouillet, in 1837, developed [63, 64] the sine and tangent galvanometers, which were later improved by Helmholtz. These were all moving magnet type of instruments. The first elementary form of the moving coil type was devised[65] by Sturgeon in 1824, and termed by him an "electrodynamoscope," improved by others until in 1882 it was modified by d'Arsonval to use a mirror and beam

of light as a pointer. This instrument has ever since been known by his name.

The development of the tools proceeded. Sources of controllable energy and better instruments and methods of measurement became available. Along with them grew knowledge of the phenomena. Sir Humphrey Davy, as has been previously stated, laid the foundations of electrochemistry. His work was supplemented by that of Guyton-Morveau, Berzelius, and others. This work was rounded out by that of Michael Faraday, of whom we shall speak later.

With the discoveries, clear terminology, and clear cut laws established by Ampere we might think that the next link, Ohm's Law, would be readily seized upon by the scientists. This was far from what actually happened. As Ampere disclosed his findings the philosophers followed him step by step. They found that they could repeat the experiments, but their cold reception of Ohm's Law shortly after showed that, with the exception of Davy, the electrical scientists did not really understand what Ampere was doing. Both Ampere and Davy had conceived the idea of the *resistance* of a conductor. They noted that the strength of the current depended upon the nature of the circuit.

It was Georg Simon Ohm who found the answer to the questions raised concerning the work of Davy and Ampere. Though he had none of the recently developed tools to work with he cleverly improvised apparatus which would give the desired effect. After deep study and repeated experiments he settled forever the question of this distribution of the electromotive force in the circuit and also the strength of the current. So comprehensive was his knowledge of the phenomena that he was able to enunciate,[66] in 1827, the law which bears his name, and which is the keystone of all work in direct current engineering. This was done in a book in which was stated that the current in a circuit was directly proportional to the electromotive force and to the cross-section of the conductor, and inversely proportional to the length of the conductor. His book was ignored. Instead of fame and fortune, it brought its author misery and contempt. Not until 1841 was the importance of this work recognized, when the Royal Society awarded to Ohm the Copley Medal.

Michael Faraday was much more fortunate than Ohm in the matter of prompt recognition for his achievements. His early association with the great Davy placed him in a very advantageous position in announcing his discoveries to the scientific world. The searching mind of this great experimentalist was guided by his motto "It must be tried. Who knows what is possible?" He would spend years delving into the mysteries of science, making excursions into the unknown, with comprehension far beyond that

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TUBES WANTED AT ONCE—Types 12SA7 (or GT/G); 12SQ7 (or GT/G; 3525GT; 50L6GT; 24A: 47; 75; and 80. Write, giving quantity and price. Frank H. Farrington. Wilmington, Vt.

TUBES TO BUY OR SWAP—I need 3525GT, 12SA7GT, 50L6GT tubes. To swap, I have 6SK7GT, 12SJ7GT and 117L7GT. Jules Walicki, Jr., 3818 Butler St., Pittsburgh, Pa.

WANTED—Precision Model 912P portable tube tester, 4½ in. meter, 1941 or 1942 type. Also want a 3-in. or 5-in. RCA, Hickok, or Dumont Oscilloscope. Will sell or trade an RCA station allocator, also a Stancor auto radio test pack. Paul Capito, 637 W. 21 St., Erie, Pa.

OSCILLOSCOPE WANTED—Will buy 2-in. or 3-in. instrument, any good make. State price. E. E. Johnson & Son, Shelter Island, N. Y.

FOR SALE—110 D.C. Amplifiers, 8-tube phono type, used. 48's P.P.P. Output tubes supplied. Equipped with special relay which keeps filaments warm 'til ready for use, then applies full voltage to plates and fils. at flip of switch. Sold "as is" or reconditioned. Reasonable. Will swap 3 for 225 watt rotary converter. P. F. Alphen, 6 Halifax St., Jamaica Plain, Mass.

RADIOS WANTED—Will buy table model radio receiver and combinations not over five years old. Economy Radio Service, 1009 S. Mint St., Charlotte, N. C.

WANTED—Triplet signal generator; Solar condenser checker, Model BQC; and a late model tube tester. John Chulick, P.O. Box 55, Winters, Calif.

VOLTOHMYST WANTED—Will pay $35 for good used VoltOhmyst, Jr. or $55 for senior model. J. N. Gilbert, 2805 Ontario St., Knoxville, Tenn.

WILL SELL OR TRADE—Hammarlund Comet Pro receiver; also Peak preselector, both in good condition. Want 3" oscilloscope, late model tube tester, and new radio tubes. E. W. Edwards, 4740 Johnson Ave., Hammond, Ind.

EQUIPMENT FOR SALE—Having sold business and joined the Navy, I offer: One Solar capacity analyzer and resistance bridge Model CB-1-60, 110 volts, 60 cycle, complete with leads. Also offer one Hickok tube tester, model AC-51; also one Sangamo portable watthour meter type F, 5 amps. 115 volts, 60 cycles. L. A. Maples, 76 Chestnut Ave., Dansville, N. Y.

WANTED—One Volt-Ohm-Milliameter. Will pay cash. Require this immediately. Describe in detail and name price. Gilbert C. Carlson, Austin, Penna.

MANUALS WANTED—Rider's Manuals Nos. 8 to 13 for cash. Also want RCA Junior VoltOhmyst and pocket voltohmmeter. Al's Radio Shop, 2027 W. Division St., Chicago, Ill.

WANTED—Superior Channel-Analyzer in perfect condition. Will pay good price for a good instrument with full instructions. Describe fully. Joseph K. Peffer, Box 66, Mt. Holly Springs, Penna.

FOR SALE OR TRADE—Weston tube tester IV—120 v. tubes, V-O-MA meters; Hickok tube tester and ma meters; radio chassis, parts, precision resistors and shunts. Need amplifier, also 8" or 10" circular saw. Make offer of swap or cash. Send your lists. Satisfaction guaranteed. C. Demeter, 933 Emma St., Elizabeth, N. J.

TUBES AND PARTS FOR SALE—Have many types of new home radio receiving tubes that are slow sellers. Also overstock of new parts, etc. Will swap for other tubes, etc. that I need or will sell wholesale. Send your list and I will mail mine. All letters answered. Dolan Radio Service, 187 Union St., Randolph, Mass

WANTED IN A HURRY—A signal generator suitable for set or receiver aligning; also small size AC-DC voltohmmeter. Jerry Havard, Burke, Texas.

MANUALS FOR SALE—Rider's Manuals from 1 to 12, for sale at $80. Harold's Radio Store, 46 Brattle St., Boston, Mass.

WANTED—any kind of test equipment at reasonable prices—also any odd meters you might have available. Give list of same and price. Rolen P. Woods, CEM, Training Center Force, U.S.N.C. T.C. S-3, Camp Endicott, Davisville, R. I.

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of his contemporaries. And yet when a discovery was made, Faraday's explanation of it would be simple, concrete, and of such a nature as to add something practical to scientific knowledge.

Faraday had followed closely the work of Oersted and Ampere. They had obtained magnetism by means of electricity. He determined to investigate the possibilities of obtaining electricity from magnetism. As a result, mutual inductance, the phenomenon on which all transformer action is based, was discovered.[67] He was also the first to obtain continuous mechanical motion by electromagnetic means, and the first to use the terms "anode" and "cathode."

In 1838 Faraday observed that when an electric discharge is produced in rarefied air the negative electrode is covered with a glowing layer which is separated by a dark space from a glowing column extending from the positive electrode. Later this separation became known as the *Faraday dark space*. Subsequent investigation by Geissler, Plucker, Hittorf, and others, using higher vacua, but with cold electrodes, provided knowledge along the high voltage-vacuum path to the modern radio tube. Since we are confining ourselves to the approach along the high voltage-heat path (as previously stated), these phenomena will not be discussed. The student who wishes information along this line of research is advised to consult the work of Thomson,[68] Townsend,[69] and Loeb,[70] is which this branch of development is discussed at length.

Wilhelm Weber spent a long and industrious life adding to the knowledge of electricity. We have seen the work of brilliant men elsewhere in Europe making great strides in this field. Weber, to whom order was Heaven's first law, began his career by carefully studying what had been done by others. He summarized their work and proceeded to utilize the principles which they had enunciated. He devised more and better measuring instruments, which are the tools of the scientist. Among his achievements may be listed[71] the earth inductor and the electrodynamometer, the latter of which is the fundamental measuring instrument for all low frequency alternating current work. The accuracy of his measurements on newly discovered phenomena was such as to provide in the science of electricity a picture of harmony in which no gap remained. From the exact measurements of Weber stemmed the mathematical development of the electromagnetic theory, first worked out by James Clerk-Maxwell. Weber was also the first to define *unit current* and *unit tension*.

What was being done in America during these years of industrious investigation in Europe? Almost a century after Franklin we find the brilliance of another American star rising in the firmament of this science. Space does not permit us to go into detail concerning the work of the man after whom the unit of inductance was named. Suffice it to say that Joseph Henry constructed[72] the first electric motor embodying an electromagnet and a commutator. He discovered[73] the property of self-induction of an electric circuit, and produced currents in distant circuits by means of an oscillatory discharge.[74] It was from Henry that S. F. B. Morse learned how to make electromagnets for his telegraph. Henry also showed how to properly proportion the coils of a mutual inductance so as to give voltage step-up or step-down, which is to say that he began the work on transformer theory.

With the tools which had thus been developed by workers from all parts of the scientific world, let us see what progress was made in the science of thermionics.

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(To Be Continued)

U.H.F. Oscillators

(Continued from page 29)

tubes seem to have very little effect.

The screen grid acts as an effective shield, as mentioned previously, and must be hooked up as illustrated in Fig. 3. No R.F. chokes are to be used under any conditions in the filament or power leads, since at these frequencies the distributed capacity together with the inductance of such a choke would combine to give a parallel tuned circuit which would change the characteristics of the oscillator and possibly stop it from oscillating. Note remarks of this effect under discussion of coaxial tuner in "Ultra-High-Frequency Techniques" by the D. Van Nostrand Co.

Oscillator Calibration

Experimentally, this oscillator was first constructed on a breadboard, so that the component parts were readily available to change and experiment with. To check the frequencies at which this oscillator works, an F.M. tuner was first used, then with the F.M. tuner and harmonics from a strong local station, a wavemeter was constructed and calibrated. Some difficulties were encountered in the first breadboard construction which should be pointed out since they probably will appear regardless of the mechanical construction used. The first of these was the appearance of harmonics above and below the fundamentals that were very strong. The second was the appearance of spurious frequencies that were not multiples of the fundamental frequencies. This latter condition was quickly traced to poor dressing of power and filament leads. These should be dressed away from the grid circuit and the filament leads should be twisted neatly to get the proper "bucking" action.

The harmonics and spurious oscillation conditions can be checked very easily. Disconnect the bias condenser from the tube and the plate feedback lead. Tune over the band with your wavemeter and look for apparent strong peaks. If any are noted, this indicates that you still have strong oscillation nodes or points that do not belong there. Check your mechanical construction and observe the previously mentioned conditions for power and filament leads. A common ground point should be used . . . a piece of copper makes an excellent ground medium.

After you are generally satisfied with the output of the oscillator, check the output and you may find several miniature peaks with the dip in the middle of the band. The question of attenuation to get a flat power output curve has been discussed previously. You will find that by using a heavy duty carbon resistor you can attenuate the output to get this flat curve. After finding the proper value of resistor, the carbon can be replaced with a good non-inductive resistor or if resistance wire is available you can wind your own.

History of the Circuit

This circuit was first used experimentally by Bernard Berger of New York City, a young radio engineer in 1936. He had excellent success with the first version of it on an all wave receiver design and is now working with this writer on a laboratory test oscillator for experimental use after the war.

The latest work done with this oscillator has shown it to work well up into the 100 megacycle range. Since it is difficult to get equipment to accurately check the output above 60 megacycles at the present time, our test has been with a wavemeter with which we are approximately checking the higher frequencies. We do not yet have the quantitative or qualitative data available up to 150 megacycles but the ease with which it oscillates above 70 megacycles and its constant output at these frequencies leads us to believe that it will work well into the 150 megacycle band. We hope to have more information at a later date. Remember that we are using a very large value of C in the grid circuit and large values of L in the plate circuit.

Receivers with the R-K Oscillator

The last five years have found airport traffic control receivers swinging towards U.H.F. ranges. Several types of receivers for different channels usually are used covering fixed bands. Obviously a stable trouble free receiver could be designed for such operation. Investigation would reveal that trick oscillator circuits or crystal oscillators with doubling or tripling stages have both been used.

We suggest the use of the R-K type of oscillator to avoid extra tubes and circuits. We could change the L & C combinations somewhat and make a compact oscillator section about 2″ square using coaxial tuning condensers. We could impregnate the whole oscillator section in wax or pitch to make it moisture proof and keep the circuits constants from changing, leaving the tube socket and tube free from the wax so that the tube can be replaced. The adjusting screws from the coaxial condensers would protrude from the front or rear making them available for readjustment. Note that this unit would be using commercial tubes which would always be available and cheap to replace. Remember also that all the additional circuit elements we eliminate, the less are our maintenance problems.

If portable equipment is desired, the circuit, Fig. 4, works very well on very low plate potentials such as 45 volts, but is more difficult to construct.

Transmitters

The circuit, Fig. 3, or the modified version of it in Fig. 4 will work very well with low power transmitters. If tubes with a high enough Gm can be had medium power transmitters should also work well.

Circuit, Fig. 3 is ideal for use with variable frequency receivers and low power transmitters. The two main advantages besides its simplicity and ease of operation are rather obvious:

a. It uses a broadcast tuning condenser; many precision condensers about the same capacity have been manufactured and are still available.

b. The tuning ratio can be as high as 4:1 without excessive attenuation over the whole range.

Fig. 4 shows an oscillator that works very well on low plate potentials. This is a modified version of the first oscillator, but it presents many more difficulties than does the original design previously discussed.

The K (coupling coefficient) between the screen grid coil and the grid coil serves to make LC designs and ratios very difficult to analyze.

In this circuit if we analyze the grid and screen circuits, the transformer (R.F.) we use would break down somewhat as Fig. 5A indicates, and assuming that R_p is large,

$$\alpha = \frac{\alpha_0}{1 + j\frac{x}{q} - x^2}$$

we then get the illustration, Fig. 5B, where the ω_0 is the resonant frequency, which would be the product of two curves tuned to the same frequency. For the experimenter, therefore, this type of oscillator will offer too many difficulties but may be of some interest to the engineer.–[30]–

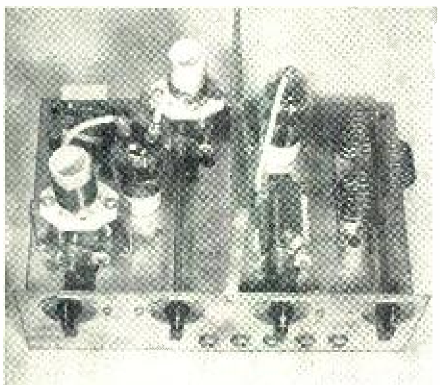
Fire Fighting Network

(*Continued from page* 12)

In the thirty mobile units in service, twelve-watt crystal controlled transmitters and two-channel superheterodyne receivers are used. The receivers use an 1851 r.f. amplifier with three tuned r.f. circuits, a two-stage intermediate-frequency unit tuned to approximately 4,000 kc., a diode detector and two stages of audio-frequency amplification. In addition, there are, of course, the silencer and noise limiting circuits. The total number of tubes in this receiver are nine. The tube service provided, however, is approximately 25% more, since many of the tubes serve dual purposes.

A simple two-position switch on the receiver panel affords operation of either of two frequencies permitting reception of the relay station or any of the auxiliary stations of a division.

The mobile transmitters consist of a dual triode, one section of which acts



Chassis layout showing crystal unit

as a crystal oscillator with the other section operating as a tripler, which in turn drives the final amplifier capable of supplying twelve watts to the antenna.

A change-over relay connects the antennas on the units to the receivers and transmitters by way of a flexible concentric transmission line. The antennas are resonated to a quarter-wavelength by base loading coils. The body of the car acts as a counterpoise. It is not uncommon, and depending on location, to obtain forty to fifty mile two-way communication with a fixed station. Ranges of from twenty to thirty miles are practically always possible from the mobile units. It is interesting to note that in northern New Jersey where the terrain is semi-mountainous, the intervening ridges have little effect on transmission. Thus it is possible to use fifteen watt units very effectively. And even though the mobile units may be located in valleys during a transmission period, reception in the towers has been most effective.

In many of the fixed stations, super-regenerative receivers installed in 1935 are still working as well as the day they were put in. They would have

been replaced with superheterodyne receivers except for the present critical situation which, of course, prevents such an installation. It was the intention of Dr. Haigis to place the new superheterodyne receivers in the towers to provide greater selectivity, and to use the older super-regenerative receivers as listening posts in many of the wardens' homes. The super-regenerative receivers used but three tubes; a type 37 quenched oscillator, a type 36 r.f. amplifier, and a type 41 audio-amplifier. These receivers have been designed especially so that they are practically non-radiating. Thus they can be operated side by side when tuned to frequencies that are closely adjacent.

With the exception of the transmitters at the state headquarters station, and the relay stations in the central, northern and southern sections, the fixed stations all use fifteen-watt transmitters. At the four above mentioned points, fifty-watt transmitters were installed because of the distance that had to be covered.

The fifteen-watt transmitters consist of a crystal unit employing one section of an RK-34 as an oscillator, and the other section as a tripler driving an RK-56 as a buffer, which in turn drives the final amplifier, an RK-34. The transmitter is modulated by two 6A6's in push-pull parallel. These are driven by a 41 which in turn is driven by a type 37 speech amplifier. The final amplifiers are tuned by parallel-rod resonant circuits which results in a very high state of efficiency, as well as ease of tuning.

In the fifty-watt transmitters the same crytal unit is used to drive two RK-47's in push-pull. These are modulated by two RK-31's in class B, with suitable pre-speech amplification. At the relay stations automatic control relays are installed, employing unique circuits which are fool-proof in operation. They do not depend on the use of any sensitive relays. Whenever a station is received, the receiver supplies a controlled voltage which is applied to a vacuum tube having a relay in its plate circuit. The contacts of this relay close and activate the transmitter relay, so that the message is automatically rebroadcast at the relay point.

In the r.f. system of the fifteen-watt transmitters, there are three tubes; four tubes in the modulator system and two type 83 mercury tubes for the power supply.

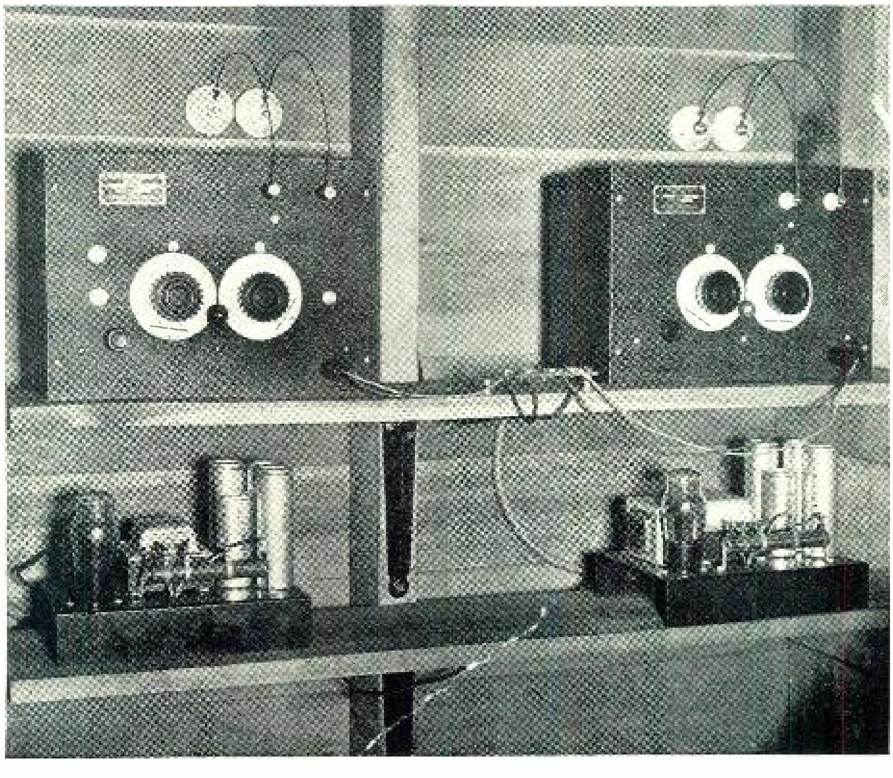
In designing the equipment, Dr. Haigis included mechanical and electrical improvements that provided ease of servicing. This is quite evident from the various illustrations of the equipment shown on these pages. Excess plates are available on the front of the panels, behind which are jacks.

The equipment was designed especially to provide reliable communication under all weather conditions as economically as possible. All transmitters incidentally, both fixed and mobile, are crystal controlled and are held to within .02%, independent of temperature.

So that the State fire warden, Captain LeRoy S. Fales, can communicate with any mobile auxiliary tower, control tower or airplane, a special handset was designed. It is only necessary for Captain Fales to flip a switch and then talk to whatever location necessary.

The control towers rise as high as thirteen hundred feet in some in-

Super-regenerative receivers like these are in use at various observation towers.



stances. They are all glass enclosed, heated and quite comfortable, notwithstanding the terrific gales which usually snap across the cabin. From these towers miles of terrain can be observed. Because of their visibility range, these towers often serve as guides to the ground crews during a fire-fighting session. Only when they are unfortunately cloaked by smoke and dust, do they have to bow out and depend wholly on the airplane as their only means of contact.

The New Jersey system which uses ultra-high frequency transmission is very flexible and can thus be applied to other states with similar terrain characteristics. For instance, the transmission paths in some parts of the state to the control tower range from fifteen to thirty - five miles. A forty-mile circuit exists from the most southerly control tower to the state headquarters, while a fifty-mile range is required to reach the northern control tower.

In the older installations, open-wire transmission lines have been used. In the later installations, two - wire concentric tube transmission lines are used to provide perfect balance for feeding.

During the past six years that radio has been used in New Jersey, it has afforded a reduction of approximately 65% in the total area burned. When it is realized that during the extreme period of a year covering some six weeks, as many as ninety fires have burned daily, it is easy to see what a tremendous saving in life and property radio has afforded.

The importance of radio in forest-fire fighting has also been recognized by the *Office of Civilian Defense*. In the new "forest - fire fighters service," radio will be an important accessory. In all states where radio material is available for fire-fighting, the auxiliary units now being organized by the OCD will find their work greatly facilitated. In those areas where equipment may be scarce, cooperation on the part of the *War Emergency Radio Service* units will become an important contributing agent. As a matter of fact, plans are now being discussed whereby the WERS will become quite active in the new FFFS Division of the OCD.

Radio, newspapers, magazines and other printed material will be headlining the FFFS during the next few months, seeking volunteers for this very important service. Your local defense council will supply you with full details. If you cannot join yourself, pass the message on to your neighbor. The protection of the forest

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PHOTOGRAPH

resources of a nation are today more important than ever before. We cannot afford to lose timber, homes or lives. According to statistics from Washington, close to two-hundred-thousand forest fires usually attack the fire resources during peacetime. In wartime with a possibility of incendiary bombing and ground sabotage as added threats, the need for widespread civilian participation in the fight against fire is even more imperative. By becoming a part of the "forest fire-fighters service," you can contribute your share toward the protection of these forest resources which are so vital to the war job today.

The author wishes to acknowledge with grateful thanks, the kind assistance and cooperation of the following, who provided invaluable information for this article: Captain LeRoy S. Fales, William J. Seidel and Dr. Carleton D. Haigis.

—30—

NOW IN PREPARATION!
Special AVIATION COMMUNICATIONS Issue FOR JUNE

Electronic Bugler
(Continued from page 24)

wave *Hammarlund* HQ-120 receiver which is incorporated in the console unit.

With the completion of the news broadcast the PA operator takes a remote amplifier, telephone, microphones, and other miscellaneous equipment to the camp parade grounds. By 1:30 the apparatus is all set up and the system is ready for use. The announcer who is to use the system speaks into the microphone, the meter needle swings, and the signal is transmitted to the main station. The signal is here amplified and is returned to the large outdoor loudspeakers, mounted two to a pole in banks of three; the hundred watt speakers facing the parade grounds, the other twenty-five watt directed toward the barracks, located on the edge of the parade grounds from which the program originates. The same arrangement of remote equipment handles this "pick up" as was used for the recording made from the theatre during the morning. The system is used as a regular public address unit exclusively for the parade grounds but no disc is cut.

By 3:00 o'clock the system is prepared for a *Retreat Parade* to be held at 4:15. In the meantime, *Recall* has been played over the entire camp system and *Drill Call* has also been sounded. Troops in the various sections of the camp are lined up, the Band is set up and the remote equipment is again in readiness for the parade. The order "sound retreat" comes over the system and the Band starts to play the regular bugle call Retreat. The "gain" is "cranked up" and the entire camp is "patched in" at the main station, so the total camp area is covered. The cannon is set off and the flag is lowered while the Band plays the national anthem, which is also carried over the entire camp. After this is finished the "gain" is "cranked back" and the system is "dead" until *Mess Call* is sounded from the main station at 6:00 P.M.

After the evening meal is completed the portable equipment is loaded into a truck, along with the portable gasoline generator, as no AC is available for the *Training Schedule* which is carried throughout the training area during the entire evening. *Tattoo* is played by the main station at 10:00 P.M. and *Call to Quarters* at 10:45. The day is ended with *Taps* at 11:00 P.M. and the operators are finished for the day. They sleep with the phone next to their beds and are ready for *Fire Call* or any other such emergency that might require the use of the PA system during the night. *Pay Call,* perhaps the most appreciated record played, is the least used.

Other uses of the PA equipment include proper coverage of areas for orientation lectures, the addressing of troops on welcoming occasions, presentation ceremonies and other such formalities. On these particular assignments the more portable equipment is used. The AC needed to operate the amplifiers is furnished by a gasoline powered generator or, if the program takes place near a mess hall, a rubber covered AC cable is run from the amplifier to a receptacle.

The flexibility of the unit was recently demonstrated when a complete Battalion Parade was handled by the PA station. The Post Band was on a special assignment away from the camp and the PA system was called upon to "dub" in the musical parts of the *Retreat* and *Parade* ceremonies. A field telephone was set up at the parade grounds and connected by a remote line to the main station. Through close coordination, an attendant, using the phone at the parade grounds, contacted the operator at the main station and "cued" him for the various calls and marches. Each attendant had a script for the complete ceremony. The marching selections were determined in advance, the more brief portions of the ceremony being played on 10 or 12 inch records while the troop movements were handled by a 16 inch recording at 33⅓ rpm turntable speed. The parade ground speakers were the only speakers used during the major part of the ceremony. However, during the playing of Retreat and the national anthem, all areas were covered. Special Armistice Day, Thanksgiving Day, Christmas Day and other holiday programs are also broadcast over the PA system.

The entire system was designed, built and is operated by military personnel of Camp Charles Wood, New Jersey, with the assistance of Major G. L. Martin and the cooperation of various departments. The PA station is in charge of Lt. J. W. Richardson. Sgt. H. Neumann, Cpl. M. T. Koleda and Cpl. O. Hoffman, who assisted in constructing the outfit, handle the daily operation of the system, which they claim anyone can duplicate.

The rack framework is ¾" x 1½" welded angle iron. The metallic appearing surface is fibreboard, painted to a high lustre. The equipment consists of *RCA* stock parts including OP-6, 83-C, and MI 4288-G amplifiers. Volume controls are *Daven* Ladder Pads and an OP-7 microphone mixer is used. The system is not a factory designed unit in any respect, but rather the development of the operating personnel, who designed, drew plans and did the actual building of the system. Extreme care was taken to design the equipment for ease and flexibility of operation.

Many features of the most modern and extravagant public address systems are to be found in this station and it is expected that other army camps may soon equip their posts with similar apparatus.

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Meter for P.A. Men

(*Continued from page 20*)

Examination of the illustrations shows the degenerative 6J5 input stage serving as an isolator and high-impedance input; resonance bridge consisting of T1, R3-4-5, L1, C2, S1, and S2; three-range v.t. voltmeter based upon the 6P5-G tube; a novel double power supply comprised by the two filament transformers, the two 6H6 tubes, and associated components; and the meter indicator M. This circuit has several unusual electrical characteristics and the instrument has a number of mechanical features that warrant separate discussion.

Electrical Features

Input to the instrument is isolated, in order that measurements may be made in d.c. circuits without short-circuiting. For this purpose, the 0.02-μfd. mica blocking capacitor C1 is provided. Input is through an open-circuit jack, J. The input potentiometer ("gain" control) is R1, a 1-megohm volume control type component. This input amplifier feeds the resonance bridge through transformer T1 which is a standard interstage unit.

The resonance bridge is composed of three resistive legs, one of which is variable for balancing the bridge, and one resonant leg composed of L1 and C2. The values of R3, R4, and R5 will be governed by the inductive and resistive values of the choke coil L1. It is suggested that a bread-board bridge circuit consisting of the four legs be set up with the choke chosen for use in the instrument and that the correct values determined experimentally. A 400- or 1000-cycle signal is fed into the bridge through the input transformer from a good quality audio oscillator and the various resistors adjusted for bridge balance. The experimenter who wishes to save time may incorporate into each of the resistive arms of the bridge 50,000-ohm wire-wound potentiometers instead of fixed values. He may then locate the proper settings by adjusting the three successively to simultaneous values until a null is obtained, whereupon two (R3 and R4) are left permanently set, and only R5 is subsequently varied when the bridge is rebalanced. The entire bridge assembly must be built finally into a separate shield-box. Into this compartment are enclosed T1, the entire bridge circuit, and the v. t. v. m. tube (6P5-G). The range switch S3 is located directly under this compartment, under chassis, and is adjusted by means of a long shaft extending through the front panel. In the interior photograph, the bridge shield box is seen to the rear of the chassis, with the screwdriver-adjusted variable resistance arm (R5) seen as the slotted control in the center of the box.

The v. t. voltmeter circuit is unique, but has been described by the writer previously in RADIO NEWS. It is a highly stable circuit in which the tube operates at a plate voltage of 12 volts obtained from the 6.3-volt winding of the filament transformer T2 through a 6H6 voltage doubler circuit. This circuit is so stable that the zero adjustment rheostat has been placed inside to conserve front-panel space. The voltmeter, the indicating instrument of which is a standard 0-1 d.c. milliammeter, has a full-scale deflection of 4 volts RMS and this is extended by means of the selector switch and the multiplier resistors R6-7-8 to 0-40 and 0-100 volts.

Plate voltage for the 6J5 input tube is likewise uniquely obtained. Another filament transformer, connected backward, is the source of this voltage. T3 is shown with its 6.3-volt winding connected directly to the same winding of T2. This makes available 110 volts from the high-voltage winding of T3 which is then rectified by the second 6H6 tube and applied to the 6J5 stage.

A feature of the instrument is the switch arrangement for changing over the v.t. voltmeter from the bridge output to the secondary of the input transformer. The changeover switch for accomplishing this operation is the double-pole, single-throw toggle switch S1-S2, which is seen along right center of the front panel in the external photograph. In the SET position, this switch is opened, removing the bridge from the circuit and connecting the v.t. voltmeter across the secondary of the bridge input transformer. When in the DISTORTION position, the switch is closed, placing the v.t. voltmeter at the output of the bridge.

It will be seen that small tubes and transformers are used throughout. The filament transformers and the bridge input transformer, as well, are miniature components, as will be seen from the list of apparatus. The selection of small components is made possible by the low power requirements of the instrument.

Mechanical Features

The entire distortion meter is built on a 7" x 7" x 2" chassis with 7" x 7" sloping front panel. The two photographs show the mechanical features of the instrument very clearly.

The various controls pass through the front panel and front edge of chassis. The left-hand knob labelled VOLTAGE rotates the input control R1, while the right-hand knob labelled V.T.V.M. rotates the voltmeter range switch S3. The input jack occupies the lower center portion of the instrument panel. The ON-OFF switch to the left of the meter is S4, and the SET-DIST. switch to the right of the meter is S1-S2.

It is not hard with an instrument of this type, employing small-size components to place all parts where they are "active" in the circuit, thus keeping leads short. The transformers T2 and T3, as well as the filter choke L2 and the two 6H6 tubes are mounted below chassis. The entire bridge circuit, including the input transformer T1 and the resonant choke L1, is mounted along with the 6P5-G V.T.V.M. tube in the 5" x 4" x 3" metal shield box which is in turn mounted rigidly to the chassis along its rear edge.

No elaborate shielding of leads has been worked out, since such shielding tends to by-pass certain of the higher-frequency harmonics and give erroneous results when taking distortion readings. Rather, pains were taken in the building of the meter to keep critical leads well away from sources of hum fields.

The name plates seen on the front panel are made by lettering on medium white Bristol board with black India ink and securing these plates to the panel with transparent Cellophane adhesive tape.

A metal base plate, carrying rubber mounting feet, is fastened to the bottom of the chassis to complete the job of electrical isolation.

Calibration and Operation

When the instrument has been completed and its wiring carefully checked, it is ready for test and calibration. First calibrate the VTVM.

Remove the lead extending from the top of the VTVM multiplier to the bridge connecting this lead to a reliable 0 to 4 volt a.c. source, which is monitored by an accurate a.c. voltmeter. This may be connected as shown in Fig. 2 by connecting the input of the amplifier to an audio oscillator.

CHART I

Inductance of Choke (Henries)	Resonating Capacitance (μfd's.) 400 Cycles	1000 Cycles
1	.1583	.0253
2	.0791	.0127
3	.0528	.0082
5	.0317	.0051
6	.0247	.0042
8	.0198	.0032
10	.0158	.0025
12	.0132	.0021
15	.0106	.0017
18	.0088	.00141
20	.0079	.00126
22	.0072	.00115
25	.0063	.00100
30	.0053	.00085
35	.0045	.00072
40	.0040	.00064
45	.0035	.00056
50	.0032	.00051
75	.0021	.00034
80	.0020	.00032
100	.0016	.00025

With the range switch S3 in the 4-volt position, vary the input voltage, noting the meter deflections corresponding to various values of input between 0 and 4 volts. A calibration is given in Chart II; however, it is strongly urged that the reader substitute a plain white scale for the regular milliammeter scale and graduate this new scale directly in volts as he adjusts his input voltage. He will thus obtain a direct-reading voltage scale which will greatly facilitate distortion measurements.

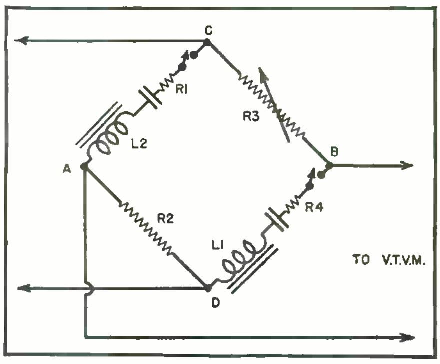

Fig. 6.

When the 0-4-volt calibration has been completed, the range switch may be changed to the 0-40-volt position and input voltages up to 40 volts introduced, watching carefully to see that all readings are exactly 10 times the 4-volt scale indications. If these readings are not in the proper proportion, the resistors R6-7-8 have not been selected with sufficient care and must be changed for units of closer value.

After the v.t. voltmeter calibration has been completed, the lead from multiplier to bridge is reconnected.

CHART II

V.T. Voltmeter Calibration

RMS Volts	Milliamperes
0.5	0.14
0.8	0.20
1.0	0.26
1.2	0.30
1.5	0.38
1.6	0.40
1.8	0.50
2.0	0.52
2.4	0.60
2.5	0.64
2.8	0.70
3.0	0.78
3.2	0.80
3.5	0.90
4.0	1.00

The reader has already been advised to select his bridge components in breadboard test, so it is assumed that these proper values have been installed and that only the balance of the bridge need be inspected at this time.

Feed a signal from a good grade audio oscillator into the jack J. The switches S_1 and S_2 should be in their open position putting the total secondary voltage across the VTVM. Vary the input voltage to the distortion meter by varying R_1 until maximum reading is obtained on the 100 volt scale of the VTVM. This reading will be the reference point for all future measurements. Connect across the secondary of T_1 a fairly accurate a.c. voltmeter, and note the output voltage.

We will assume for simplicity that the resonant frequency of the bridge circuit has been chosen as 400 cycles. Now close S_1 and S_2. Insert an audio frequency of 400 cycles into the jack J. Note VTVM reading and vary R_5 until a minimum reading is obtained. This minimum value should drop to a reading of 0 unless there is some distortion in the first amplifier stage made up of 6J5 tube. Increase audio oscillator frequency to 800 cycles per second, and vary the voltage across the secondary of T_1 until the same voltage is obtained as measured previously. This will indicate a distortion of 100%. Note the position of the needle of the VTVM and mark by inscribing a pencil mark on the scale directly above this needle.

Decrease the voltage across the secondary of T_1 until you have obtained only 80% of that which was measured above. The VTVM will now indicate a distortion of 80%. Calibrate the VTVM for various percentages of distortion from 100 down to 0. When lower voltage readings are to be measured change the switch S_3 to its lower voltage scale. It may be advisable to take the lower part of the scale in steps of 1% while that at the higher end could be taken at 10 or 20% steps.

The calibration should be made in this manner inasmuch as when a second harmonic or a third is employed across the bridge, the relationships between R_3, R_4 and R_5 and the tuned circuit will determine the voltage impressed across the VTVM. If R_3 and R_5 are made equal, for an example, the VTVM will actually indicate only 50% of that which would normally apply. Therefore the calibration at this point under this condition would indicate 100% distortion when the VTVM indicates 50% of the full scale reading.

A more accurate but more costly circuit could be employed as shown in Fig. 6 where two tuned circuits are utilized. The values of the component parts that are used in this circuit are chokes L_1 and L_2, 20 henries 100 ohms each. R_2 is 100 ohms, R_3 is a 200 ohm rheostat. R_1 and R_4 represent the d.c. resistance of the choke. However, the available chokes may not be of the same resistance and under these circumstances, the proper amount of additional resistance may be added as R_1 and R_4 to balance the resistance of the two resonant arms.

At the resonant frequency of 400 cycles, the tuned circuits will be at resonance, and therefore at 0 impedance. You will note at resonance that $R_2 = R_1$, i.e., approximately 100 ohms each while at the second harmonic at 800 cycles, the tuned circuit will have an impedance of approximately 75,000 ohms, thereby making the tuned circuit arm large in respect to R_2. This will give you a calibration result where the 100% indication is practically near full scale deflection whereas in the prior circuit it came closer to the 50% deflection point, depending upon the component parts that were utilized in the bridge circuit.

It is very convenient that the bridge need be balanced only once, perhaps only upon the initial calibration of the instrument, whereupon it is only necessary afterward when making distortion measurements to take voltage readings with the change-over switch S_1 and S_2 in both positions.

In using the meter, supply a signal of proper frequency to the amplifier being tested. This signal must have the absolute minimum of distortion, being produced by a low-distortion audio oscillator such as described in prior issues of RADIO NEWS. Connect the jack J to the output load resistor (or speaker voice coil). Adjust R_1 until the v.t. voltmeter reads maximum. Now, close S_1-S_2 and note the meter reading, which will indicate the percentage of harmonic distortion.

In making distortion measurements in a single stage, connect frame of J to chassis of the amplifier and top of J to the plate resistor or plate transformer in the stage and proceed as described before.

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Book Review

(*Continued from page* 36)

types encountered in the usual cares of laboratory and test bench work. Its format has been kept as nearly like a pictorial reference chart as practicable. For more detailed theory and analyses, the reader is referred to sources in the Reading List, as well as to the many other excellent works available. With some exceptions, practically all the patterns appearing in this guide may also be found in many other books. In fact, most of them are as old as the oscilloscope itself. There has been a definite need for a correlated presentation in quick and convenient form. It was also felt that, in addition to some new methods and material, certain ambiguities in presentation, often encountered, have been avoided in this guide.

Patterns produced for this book are developed with conventional amplifiers and oscillators and viewed on a small oscilloscope, using standard circuits.

The value of graphics and mathematical analyses is in no way underestimated, and a section on simple graphic analyses is included. It is to the oscilloscope operator who would rather check the charts than plot the points, however, that this little guide is dedicated.

The illustrations are drawn in clear

and concise manner, and are easily interpreted.

"THE INDUCTANCE AUTHORITY," by Edward M. Shiepe, B.D., M.E.E. Published by *Gold Shield Products,* 350 Greenwich St., New York City. 50 pp., 9x12. Price $2.50.

This new publication dispenses with any and all computation for the construction of solenoid coils for tuning with variable or fixed condensers. It includes the ultra frequencies to the border line of audio frequencies. Accuracy to 1% may be attained. There are 38 charts, of which 36 cover the number of turns and inductive results for the various wire sizes used in commercial practice (Nos. 14 to 32), as well as the different types of covering (single silk, cotton-double silk, double cotton and enamel), and diameters from ¾" to 3" inclusive. Each terms chart for a given wire has a separate curve for each of the 13 form diameters. The book contains all the necessary information to give the final wire on coil construction to servicemen engaged in replacement work, home experimenters, short wave enthusiasts, amateurs, engineers, teachers, students, etc. Ten pages of textual discussion by Mr. Shiepe, graduate of the Massachusetts Institute of Technology and of the Polytechnic Institute of Brooklyn, are included.

"MORSE CODE MADE EASY!", by Pvt. Alfred E. Johns. Published by the *Sessions Printing Company,* 210 W. 9th St., Sioux Falls, S. D. 14 pp. Price 25c.

This booklet is a device, by means of which the average person is able to memorize the International Morse Code in even less than an hour, which, otherwise, takes several days to master. While not a new method for mastering the code in a few lessons or acquiring the speed of 30 words per minute in a few hours, it is merely a psychological device by means of which one is able to memorize the characters in the shortest possible time. It is called mnemonics.

In this brief, but clear and concise booklet, the author presents his simple method for memorizing the characters and digits in the shortest possible time. Having demonstrated his system to hundreds of students at the Technical School, A.A.F.T.T.S., Sioux Falls, S. D., it can be categorically asserted that it will take the average time stated above for memorizing the entire alphabet.

"SYLVANIA TECHNICAL MANUAL." Fifth printing, published by *Sylvania Electrical Products, Inc.,* 500 Fifth Avenue, New York City. Price 35c. A new printing of Sylvania's 5th edition of the Technical Manual is now ready for distribution to radio technicians. One section of the Technical Manual has been devoted to listing all new types of tubes released since the previous issue, and a section pertaining to panel lamps has also been added. Plastic binding has been employed which allows the book to lie flat and remain open at whatever page is to be consulted. The general arrangement of the technical data of the reprinted Manual remains the same, and index tabs are still supplied, glued and marked for easy installation on the proper pages.

The new revised Technical Manual sells for the pre-war price of 35c per copy, and may be secured from Sylvania Distributors or by ordering direct from *Sylvania Electric Products, Inc.,* Emporium, Penna.

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Mfrs. Lit.
(Continued from page 30)

through radio jobbers, or can be secured by writing directly to the *Radio & Technical Publishing Co.,* 45 Astor Place, New York City. There is one designed specifically for Home Radio Troubles and another for Auto Radio Troubles. They are priced at 50c each.

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KEEP 'EM PLAYING!

Tube Collector
(*Continued from page 33*)

Ultra-Audion (1916)

Valvo (Italy) (modern or antique types)
Vacuum rectifier (Wireless Equip. Co.)
Volutron 201, 201A (brass base)

Wireless Corp. AC227
WRC20, WRC22

Miscellaneous

Modern Transmitting (air-cooled): 800, 801, 802, 803, 804, 805, 806, 808, 809, 810, 813, 814, 830-B, 831, 832, 833, 834, 835, 837, 838, 841, 842, 843, 844, 850, 851, 891-R, 892-R

Modern Transmitting (water-cooled): 207, 520B, 846, 858, 862, 887, 888, 891, 892, 893, 898, 1652

Rectifiers: 217-A, 217-C, 836, 857-B, 869-A, 870, 871, 872-A, 1616

Cathode-Ray: 902, 904, 905, 906 (3AP4 and P4), 907, 908, 909, 910, 913, 914, 1802-P1 (5BP4 and P4), 1849, 1850 (12AP4), 1803-P4, 9AP4, 1804-P4, 1899

Rectifiers—Cathode-Ray: 2V3G, 878, 879, 884, 885

Phototubes, 868, 917, 918, 919, 920, 921, 922, 923

Miscellaneous: 840, 864, 954, 955, 956, 957, 958, 959, 991, 1602, 1603, 1608, 1609, 1610, 1612, 1613, 1614, 1619, 1620, 1621, 1622, 6123, 1851, 6AC7/1852, 6AB7/1853, VR105/30, VR150/30

Sylvania Transmitting: 210, 830, 203A, 830A, 205D, 29, 69, 863, 264B

Arcturus: 47/PZ, GA, PZH, Wunderlich Detector, 2Y2, 5X3, G56H5, 1ZZ5, 25B5, 25Y5, 1C5G, 1G4GT, 1G6GT, 5W4G, 6A5G, 6AD5G, 6AF6G, 6B6G, 6K8G, 6Q6G, 6R6G, 6SA7GT, 6W5G, 12A8GT, 12B8GT, 12F5GT, 12J7GT, 12K7GT, 12Q7GT, 25D8GT, 25N6G, 25X6GT, 32L7GT, 35L6GT, 35Z4GT, 35Z5GT, 45Z5GT, 50L6GT, OZ4, 5Y3, 6N6, 6SA7, 6SC7, 6SF5, 6SJ7, 6SK7, 6SQ7, 12C8, 12SA7, 12SC7, 12S17, 12SK7, 12SQ7, 7A6, 7A7, 7A8, 7B5, 7B6, 7B7, 7B8, 7C5, 7C6, 7Y4, 35Z3, 35A5

(To Be Continued)

Tubes Available for Trade

Amperex, 866-A
Arcturus, 31
CeCo, M26
Cetron, 872
Cunningham, C-301A, CX-301-A, CX-300-A
De Forest (Marconi) audion
De Forest DV-3
De Forest VT11 (NR6)
Duratron, 201A
Eimac, KY21
French Fotos tube
GE, 199 (old tip style—brass base), C-299
Kellogg, 401 (top Heater)
Marathon AC608
Mazda (foreign), H210
Myers, RAC-3
Navy, CG890
Navy, CG, 1162
National Union, 32, 57, 45, NY-224, 24-A
OK, X-201-A, X-200-A
Phillips, GMB-250 (Holland) transmitting tube
Radiotron, UV 199 (bakelite base), 201A (early) WD12
Raytheon, BH, B
Sodion, S-13
Sovereign AC tube
Standard Cables, 4282-B (England) transmitting tube
Sylvania, 31, 866
Western Electric, VT-1 (1915)
Western Electric, VT-1 (1916)
Western Electric, 101-D, 216-A, 215-A peanut, 205-D (metal base), 205-D (bakelite base), 101B (metal base)
Westinghouse, WD-11
Wunderlich (Arcturus)
Zetka, Z-201-A

The RADIO NEWS Collection

Aerotron, S-319561, WB800
Airline, 201A, AX201A
Amplion, D
Arcturus, 6C5G, 127, Wunderlich, 28
Aurex, Triode
Cardon, 479, 585-P, 450, 281, C-182-B
CeCo, AC Pentode
Cetron, 110 PE
Conn. Tele. & Elect., Sodion S13, D21, Donle B8
Continental Chicago, 401, 403
Cunningham, CX-330, C-301, CG1787, CX-326, C-302, C-301A, CX-374, CX-381, CX-322, C-327
Daven, MU20 (UV base), MU20 (UX base)
De Forest, Tubular Audiotron (single fil.), Tubular Audion (dbl. fil.), OT-1A, DV3A, DV2, DV3, DV5, DV20, VT11, Type 20, VT21, DV1, Audion (1908)
DuMont, 128
Duratron, 201A
Electrad Diode
Emerson, Multivalve, Triple Triode (Van Horne 5VCX) or (Cleartron)
Eveready-Raytheon, E-245, ER-224, BR
Ewing, Microtube
G.E., 199, FX-H, PJ2
G.M., 0Z4G
Hytron, 7C7, HY615, HY114B, HY125, HY113, HY115
HyVac, D, SG
Kellogg, 401
KenRad, 46, 83, 2A5, 38, 6A7, 25Z5, 2A6, 56, 1T4, KR1
Luxtrom, L
Magnavox type A
Majestic, G-6A7, AP
Marathon, AC608R, AC608, MX-201-A
Marconi (De Forest), 547001, 236010
Monotron, 01A
Moorhead, SE-1444, A, 201793, VT219013, SJ-1 detector
Musselman, 5PD
Myers, RAC-3, RA3
OK, X-112
Philco, 47
Pliotron, CG1162, CG890
QRS (HV Rect.), Red Top
Radiotron, Exp. Triode (735), UV-200, Exp. Triode, WD-11, UV-201A, WD-12 (brass base), WD12 (bakelite base), UX-199, UX-120, VR-150/30, 868, UV202 (tip), UV202 (no tip)
Raytheon, 5Z3, 6L6G, 6A3, 237, 1F6, 5Z4, 6F6, 6L6, 1G4-G, 1N5-G, 1H5GT, BH, B, 0Z4G
RCA, UX280, 59, 6E5, 6H6, 5W4, 6SA7, 117Z6GT, 6J5GT, 9001
Schickerling, SSCO, S4000, S900, S100, S1100
Sovereign, AC
Speed, 257, 295, 230
Standard Radio & Light Co., Vacobulb
Supertron, 99
Sylvania, 43, 25Z6, 77, 6K7, 82, 69 (Wunderlich)
Taylor, 866Jr.
Van Dyke, 171-UX, X222
Weagent, Diode valve
WE, 216A, 101-B, 101-D, 101-F, 102-D, 102-F, 102-G, 104-D, D-86327, D-90278, 205-E, 277-A, 269-A, 205-D, 101-F, 323-A, 244-A, 235-D, 253-A, 247-A, 272-A, 274-A, 256-A, 262-A, 246-A, 300-B, 245-A, 283-A, 259-A, 300-A, 290-A, 310-A, 293-A, 275-A, 262-B, 292-A, 294-A, 314-A, 215-A, 346-A, 333-A, 231-D, 239-A, 264-B, 264-C, 239-A, 257-A, 311-A, 336-A, 215-A, 2221, VT1 (1916), (1915), VT1 (1916), 104-A, 208-A, 217-A, 313AA, 313C, 7631, 246A, 352A, 373A, 374A
Zetka Process, Z-201-A
Cables Flamingo (Holland)
French Fotos, R-36, French "R" Valve
Le DeLuxe VM77
Marconi, BTH (France)
Mazda, H-210 (England)
Mullard, ORA, PM24B, AC084, AC044, CL-4 (German)
Osram, HL-610, DE-5, DEP-610, R (Eng.)
Oxytron, DS-2 (Denmark)
Phillips, 505, KBC1 (Holland)
SFR, TA-31 (France)
Standard Tele. & Cables, 4033A (England)
Stenode Quartz Plate Det. (Canada)
Telefunken, AB-2, RE144-ACHI, CF7, AL4, AD1 (Germany)
Triotron, W412 (Austria)
Tungsram, KC1 Barium tube (Denmark)
Valvo, AB-2, AM-2, AZ-1, AF-7 (Italy)
Welsh, WT501 Peanut, Dollar Detector

(To be continued next month)

QRD? de Gy

(*Continued from page 36*)

patchers and such from the operating personnel, thereby giving the op a chance to move to bigger things.

Crooks, formerly op at WLOG, Logan, W.Va., is in the Navy now as RM2C. Karl Pearson, formerly police op at Villa Park, Ill., is now with the US Army Sig Corps as an Inspector. Wes Bell, one time op at almost any BC station you can name in the state of Washington and late of the staff at WUE, Ft. Wright, Wash., did a short hitch with NWA and then moved to the Signal Corps School, Scott Field, Ill., as a Senior Instructor.

WE ARE hearing from a lot of the old gang about their doings but we were certainly pleasantly surprised to learn that Jim Delaney, the founder of the ARTA, is now monitoring officer in charge for the FCC at Lanai City, T. H. Jim, it will be remembered, spent considerable time and money in founding the ARTA (known for a few months at first as the American Radio Association and later incorporated under the laws of New York State as the American Radio Telegraphers' Association). A bunch of us used to meet in Jim's hotel room at 94th and Broadway in New York. Gerald Travis is still Chief of the Seminole, John McManus is Second, and William Leyh, an old-timer just returning to the game, is Third. Frank Balck, former chief of the Cherokee, is now on a new Liberty ship. Returning from Iceland, Frank surprised company officials by walking into the main office with a full beard which he had nurtured during the voyage. Benny Beckerman, former president of the old U.R.T.A., left the Madison when she was tied up and turned over to the government and is now reportedly engaged in private enterprise ashore. Edward F. Samaha is doing a little broadcasting up in Pennsylvania, but thinks he may ship out again soon. Samaha still smokes those good cigars. Frank Tally lost his life when his ship went down some weeks ago in the Gulf of Mexico. Joe Davis was lost returning from a long foreign voyage. Arthur B. McKinley was reportedly lost on the Archangel run. Tom Cerio is still with the U. S. Lines after 25 years of continuous service. Tom is doing his stuff on the American Packer, one of the new C-type boats. Oscar Goertz, who expects to retire in a few more years with a life pension, is also with the U. S. Lines.

"Captain" Thomas L. Brewster has left Press Wireless and gone into the broadcasting game. Jim Abernethy left the F.C.C. and took out the La Salle of the Waterman Line. Arthur Albright, a former U. S. Lines radio officer, is teaching in the Air Corps down Miami way. Art is an aviator in his own right. He once owned and flew his own plane, and expects to be flying again soon, with a commission. We wish him lots of luck. George M. Bartlett and Edward Banek, former Clyde Line men, are both in the Navy. Barth O'Loughlen, member of the ROU, is now captain in the Army at Camp Wolters, Texas. His last ship was an Esso tanker. Benjamin R. Moon has left the Martha's Vineyard Line and joined the Navy. Congratulations, Ben. You deserve great credit for your patriotism.

WELL, seein' as how ROU has finally come out on the stand declaring that radiops of the Merchant Marine should go ashore wearing their uniforms, it behooves us also to voice our approval on this subject. Inasmuch as these men are doing as much as or more than the men in the armed forces, their uniforms being no disgrace to them; radio officers' uniforms no less are a credit to the men who wear them. So hoping that notice be taken of this idea and with a chin up and cheerio . . . 73 . . . ge . . . GY.

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Keep 'em playing!

How to Use VTVM's

(Continued from page 27)

rect only while the meter probe is across the tuned circuit,

9. The degree of A.V.C. action may be inspected by monitoring the signal voltage at the input to the second detector in a superhet circuit and applying various amounts of signal voltage to the antenna and ground terminals of the receiver. Over the guaranteed A.V.C. range, there will be no change in the second-detector signal if the A.V.C. system is functioning properly,

10. The selectivity of receiver circuits may be inspected by employing the v.t. voltmeter as a resonance indicator across the tuned circuit under test, feeding a signal on the desired resonant frequency into the circuit, and noting the voltage readings at resonance and at points of equal frequency separation above and below the resonant frequency. Thus, the selectivity of the I. F. amplifier might be checked at resonance and at points 10 kc. above and 10 kc. below resonance by adjusting the test oscillator frequency successively to the three points and noting the voltage readings. By taking a number of such frequency-voltage readings, a selectivity curve for the amplifier (or receiver) may be plotted. In all such tests, either the receiver, or stage, may be tuned or the oscillator may be tuned. In each case, the voltage delivered by the oscillator must be maintained at the same value for all frequency settings.

Amplifier Gain

The v.t. voltmeter is indispensable for a.f. amplifier gain measurements because of its total lack of frequency discrimination in the audio spectrum. The apparatus set-up for this type of measurement is shown in Figure 1. The test procedure is as follows:

1. For overall amplifier gain, refer to Figure 1-A. The amplifier under test is supplied with an input voltage from a good quality variable-frequency audio oscillator and is terminated with a load resistor R which is of the recommended ohmic value for loading the output of the amplifier and of sufficient wattage capability to dissipate safely the maximum output power of the amplifier,

2. The vacuum-tube voltmeter is arranged with the single-pole, double-throw switch S so that it may be connected successively to the input and output of the amplifier and thus may indicate input and output voltages,

3. For the test, the oscillator output control is set (with the switch S in the left-hand position) to give a low value of amplifier input voltage at some desirable test frequency. This voltage is recorded as E1,

4. The switch is then thrown to the right-hand position and a reading taken of the output voltage, this value being recorded as E2,

5. The ratio of E2 to E1 (that is to say, E2/E1) gives the gain (voltage amplification) for the entire amplifier. If it is desired to express the gain in decibels, the following calculation may then be made:

$$\text{db gain} = 20 \log_{10} E2/E1,$$

6. If gain-per-stage, rather than overall gain is desired, the scheme shown in Figure 1-B is adopted. Here, the signal is fed into the grid circuit of the stage under test (as between points A and B) and the reading E1 taken here. The E2 voltage reading is then taken between points C and B. Each stage gain may thus be measured,

7. It is highly desirable in most amplifier testing to make overall and per-stage gain measurements at several frequencies, and in this case the procedure does not differ markedly from that just outlined. The only difference is that the operation is repeated entirely at several settings of the oscillator frequency dial.

Amplifier Fidelity Measurements

The tone-quality characteristics of a audio amplifier may be studied by means of fidelity (or *frequency response*) measurements, also made possible by the v.t. voltmeter and variable-frequency audio oscillator. The apparatus set-up employed is identical with that shown in Figure 1-A. The test procedure follows:

1. With the oscillator set to deliver a low input voltage at 20 cycles per second, measure this input voltage with the voltmeter switch S in the left-hand position. This is the *reference input voltage* which must be recorded, as we will return to it often during the test,

2. The switch is then thrown to the right-hand position, and an output voltage reading obtained, recording this value as E(20),

3. The oscillator frequency is then changed to 30 cycles per second, and the original reference input voltage restored by adjusting the oscillator output control with the voltmeter switch in the left-hand position.

4. At this new frequency, the output voltage is again checked, with the switch S in the right-hand position, recording this new value as E(30),

5. The operations just described are repeated at various frequencies extending from 20 to 15,000 cycles per second, always taking care to restore the oscillator voltage to the original reference value,

6. After the frequency run has been completed, the various output voltages are plotted in a graph against corresponding frequencies to yield a response curve. This curve should be drawn on semi-log paper for best results. The straightness of the curve will be a direct indication of the amplifier's fidelity—the straighter the curve, the more faithful is the amplifier response. Pronounced peaks in the curve will indicate resonant frequencies or pass bands, while pronounced dips will show decreased

fidelity at certain points, or attenuation bands.

Distortion Measurements

The v.t. voltmeter enables the audio technician to make highly satisfactory measurements of the amplitudes of the fundamental and each successive harmonic frequency in a complex wave-form. From this data, this distortion of an amplifier or oscillator may be readily studied. A special form of simple v.t. voltmeter circuit—the *square law v.t. v.m.*—is necessary for this application, and the apparatus set-up is illustrated in Figure 2. This is a simple wave analyzer consisting of a battery-operated square law v.t. voltmeter and variable-frequency audio oscillator.

The operation of the instrument is described briefly in this manner: The distorted signal (such as might be delivered by an amplifier being driven by a test oscillator, or by an audio oscillator under test) is applied to the input circuit of the square law voltmeter. A second signal is introduced through the coupling transformer into the same input circuit, this signal (termed the *search frequency*) being supplied by a good-quality variable-frequency audio oscillator. As the search frequency is "tuned" successively to the fundamental and to its various harmonics, it will produce a beat note with each of these signal components. As the beat note decreases in frequency, due to nearness of the search frequency to the component frequency, the pointer of the indicating meter will pulsate to indicate the slow beat note. If the latter is made only a cycle per second or less, the actual amplitude of the pointer swing may be read, and this will correspond to the actual voltage amplitude of the fundamental or harmonic frequency to which the variable-frequency search oscillator is adjusted. Thus, not only may the individual frequency components be identified, but their actual amplitudes may be measured as well. The percent distortion at any harmonic component may be determined from the ratio of fundamental voltage, as shown by the maximum upswing of the pulsating meter pointer, to the particular harmonic-component voltage.

1. When checking amplified distortion, connect the input terminals A and B of the square law v.t. voltmeter to the load device of the amplifier under test,
2. Supply a test frequency to the input of the amplifier at a voltage low enough to prevent blocking of the amplifier. This frequency may conveniently be any value, although it is customary to make amplifier measurements either at 400 or 1,000 cycles per second,
3. Vary the frequency of the search oscillator until it is set very close to the fundamental frequency (400 or 1,000 c.p.s., for example) and adjust the frequency closely until the pulsations of the pointer slow up sufficiently to read the maximum upward swings, and record this reading as the fundamental voltage,
4. Vary the search frequency in a similar manner successively to the second, third, fourth, fifth, etc., harmonics of the test frequency, noting in each case the voltage indicated by the slowest upward swings of the pointer,

Low distortion is indicated by small harmonic voltages with respect to the fundamental voltage. High distortion takes the opposite shape. The percentage distortion at any harmonic frequency may be calculated (with respect to the fundamental) by dividing the harmonic by the fundamental voltage and multiplying the result by 100.

The harmonic analysis may be repeated at several settings of the amplifier volume and tone controls to determine the effect of each of these components.

1. When checking oscillator distortion, connect the input terminals A and B of the square law v.t. voltmeter, to the output of the oscillator,
2. Take amplitude (voltage) readings at the oscillator frequency and at as many of its harmonics as desired, employing the search oscillator, as before, to locate these various frequency components.

For complete success in this simple method of harmonic analysis, several essential requirements must be observed: (1) the v.t. voltmeter circuit must be entirely square law in response (several such circuits may be obtained from texts on v.t. voltmeters), (2) the search oscillator must be capable of very low-distortion operation over its entire frequency range and must deliver uniform output voltage over that range, and (3) it will be desirable to make the entire set-up battery-operated (including the search oscillator) in order to eliminate harmonics from the line voltage of a.c.-operated units, unless the operator is careful to remember that response points are apt to be obtained at 60 cycles per second and at each multiple thereof throughout the range of the search oscillator.

Power Measurements

Radio-frequency and audio-frequency power measurements may be made by measuring the voltage, as indicated by a v.t. voltmeter, across an appropriate load device of known resistance impedance. For example: an amplifier or oscillator may be terminated by its usual load, as in Figure 1-A, the resistance or impedance of which is known. The voltage across this load when the oscillator is delivering full output or when the amplifier is being driven by a test oscillator is then measured with any a.c.-type v.t. voltmeter. Power output is then determined from the calculation:

$$P = E^2/R = E^2/Z$$

Where P is in watts,

E is the v.t.v.m. reading in volts,
R is the load resistance in ohms or,
Z is the load impedance in ohms.

Current Measurements

The a.c.-type v.t. voltmeter may be employed to measure a.f. or r.f. currents by providing the instrument with a resistive or capacitive shunt, as shown in Figure 4, measuring the voltage drop across a portion of the circuit and converting this value to current readings. For example, the current to be measured is made to flow through the total resistance in the resistive shunt or through the total series capacitance in the capacitive shunt. However, the v.t. voltmeter is shunted across a known small portion R of the resistive shunt or C of the capacitive shunt. Current flowing in the resistive shunt will develop a voltage drop equal to the product of the current and the resistance R in one case, or equal to the current and the capacitive reactance of the condenser C in the other case. The current level may be determined from the v.t.v.m. reading thus:

$$I = E/R = E/X$$

Where I is the current in amperes,
E is the v.t.v.m. reading in volts,
R is the resistance of the section in ohms,
X is the capacitive reactance of the section in ohms.

The resistive shunt will be satisfactory for a.f. and power-line-frequency measurements, while the capacitive type of shunt will be more desirable for r.f. work, particularly when the current measurements are to be made at high frequencies.

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For the Record

(*Continued from page 4*)

and will become even more so in the post war era, has become quite evident these past weeks. Not only have talks by such outstanding scientists as Dr. W. R. G. Baker, of General Electric emphasized this point, but the formation of special companies have also been contributing factors. An illustration of this appears in the announcement of the newly formed Scophony Corporation of America who will operate under the British patents of the Scophony system. The fact that two major picture companies are directly interested in this new organization, gives credence to the import of television. In the Scophony system a mechanical method rather than an electronic one is employed, with the supersonic frequency spectrum being employed. These waves are those above the frequency of most audible sound.

Some years ago the Scophony Company in England sent over a unit demonstrating this system. An effective presentation was made in a theater in New York City. The transmissions picked up from standard televised programs were shown on a large screen before an audience of several hundred. Since then, officials of the company state many improvements have been made. It is their belief that large screen television in theaters and at home is quite possible on a consistent basis.

Demonstrations of the latest designed equipment are promised soon. As soon as they are held, a complete report on the present virtues of the system will be made.

TODAY we talk of micro-waves, but nineteen years ago wavelengths of 28,000 meters were more of an accepted means of propagation. Take the case of Thomas E. Clark of Detroit, who, in 1925, invented a radio operated device that was supposed to stop speeding locomotives when danger prevailed. In explaining his invention he said . . . "The success of continuous control depends on the propagation of electromagnetic waves flowing the track rails, these waves being picked up by loop collector coils under the pilot. The waves are pumped into the rails by a roadside unit. They are transmitted on a wavelength of 28,000 meters to give a clear indication signal and at a wavelength of 22,000 meters to give a caution signal. The loop collector coils are equipped with variable condensers for tuning each coil to the wavelength propagated in the rails. These coils transmit the various wavelengths to the visual signal device in the engine cab. This consists of three lights: red for danger, yellow for caution and green for clear track ahead. These signals give the engineer advance information on the condition of the track ahead." Quite a device!

WITH the recent approval of a reserve pool to provide essential two-way police radio equipment, many law enforcement groups will now be able to complete installations of this very important home-front means of protection. During the first period of 1942, it did appear as if police radio would not be available for the duration. However, after a series of presentations of the problems to the WPB, the present plan was evolved. Each of several manufacturers has now been given an order by the Defense Supplies Corporation, a subsidiary of the RFC, to manufacture a specific quantity of police equipment. Individual cities are permitted to proceed in a peacetime manner in the selection of the manufacturers from whom they wish to purchase. They, of course, must not order any equipment unless the need is vital.

Some manufacturers have developed new compact, space and material-saving devices, for this emergency pool. According to a survey of both police and manufacturers, frequency modulation units seem to be the most popular.

Many communities have found the need for police communication more necessary than ever before, because of the lack of manpower caused by the present emergency. There is no doubt that one policeman with suitable equipment can perform the duties of many, not only because of the coverage permitted, but also because of the rapidity with which such coverage is possible. Police radio has become an important unit in our war program!

IT'S the Artificer Branch of the Navy in which we find most of our radiomen. The abbreviations for the classifications of the men in this group are quite interesting. The chief radioman is a CRM. A radioman, first class, is known as a RM1c; radioman, second class, is a RM2c; and radioman, third class, is a RM3c. A chief radio technician is a CRT, while a radio technician, first class, is known as a RT1c. A radio technician, second class, is a RT2c, and a radio technician, third class, is a RT3c. A radarman, second class, is known as a RdM2c, and a radarman, third class, is known as a RdM3c. We also have a sound man, second class, in this branch, whose abbreviations are SoM2c, while the sound man, third class, is known as an SoM3c. In the aviation branch, we also have radioman classifications. The chief radioman is an ACRM. Then there are three classes of radiomen identified as ARM1c, ARM2c and ARM3c. Wow!

ONE of the most unusual of all radio applications that we have seen is the use of radio frequency energy, generated at a 10kw. transmitter costing $60,000.00, which literally stitches together wood wing spars for training and liaison planes. This transmitter has been installed in a large lumber company at Alliance, Ohio, which specializes in aircraft woods. Nine thicknesses of wood are piled up, one on the other with a film of glue between the layers. The wood is then put into heavy presses which draw it up tight. Radio frequency energy penetrates the assembly with slightly distorted radio signals which set up friction which causes heat within the wood, drying it evenly, firmly and permanently within ten or fifteen minutes without warping the wood.

Radio has now gone to work in the lumber mills!

THE Radio Man-Power Bureau, which first appeared in last month's issue of RADIO NEWS, is serving a very definite purpose. Many a radioman is situated in a small town where he is unable to contribute to the war effort directly, using his radio knowledge to the fullest advantage. It is the purpose of the Bureau to seek out these men and to place them in industry where they can engage in the war effort.

OUR most recent trip took us to Camp Truax at Madison, Wisconsin, home of the Army Air Forces Technical Training Schools for radio mechanics. We witnessed many new innovations and instruction methods. Women are playing a prominent part, teaching radio fundamentals to future radiomen whose sole duty will be to install and maintain vital radio equipment for our military aircraft. Hats off to them . . . they're doing a bang-up job!

We were delighted to come in contact with a special department which has been set up by the personnel officers of the school, for the sole purpose of providing students with a shop where they can tinker, design or repair their personal sets on their own time. Once within the portals of this room, they are left unmolested to pursue their hobbies or wants. It is run strictly on an honor system, and no student is asked to account for the use of any equipment. We were told that the idea worked out 100% successful, and that none had ever abused the privilege afforded him.

WE ARE already hard at work on the preparation of our forthcoming June *Special Aviation Communications Issue*. It will be even larger in size, greater in scope and more profusely illustrated than the history-making *Signal Corps* issue of last November. New subjects are being prepared, most of which have never been revealed to the public heretofore. We'll have more to tell you about this next month!

MEMBERSHIP in The Tube Collector grows by the hour. Many prominent radiomen and engineers are finding considerable value in this new club. Even the boys in military service are cooperating wholeheartedly, and we find several collectors scattered throughout the states in various camps and posts.

We are looking forward to meeting many of these men personally after the war is won. We hope that will be soon!

73, OR. . . .

Aviation Radio

(*Continued from page* 25)

U.H.F. receiving distance is dependent on: 1. time of the year; 2. time of the day or night; 3. the frequencies used; 4. power employed; and 5. types of antennas used for transmitting and receiving. Station location should also be taken into consideration.

It can be seen then if all conditions affecting long distance U.H.F. transmission are analyzed that too much dependence cannot be placed on "natural" reflection phenomena nor on ground wave propagation but rather on "etheralized transmission" (transmission of waves through space only above the earth).

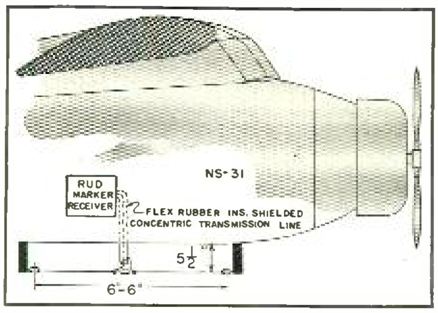
We have all heard of "quasi-optical" transmission and reception of radio waves, wherein the transmitter and receiver must be located within or near a definite line of sight. Because quasi-optical waves are usually above 150 mcs. they are classified as "micro-waves" in order to distinguish them from the longer short waves. Technically, quasi-optical waves are those which can be received only when the transmitter can be seen because beyond the line of sight reception is impossible due to power and frequency limitations. Even then, a transmission and receiving system utilizing frequencies of 2500 kilocycles at low power whose distance capabilities are limited to the line of sight, could be classified as a quasi-optical system. However, this would be wrong because the ground wave at the frequency mentioned would predominate depending upon the antenna system used. In case intervening terrain were present when a quasi-optical system was used, due to absorption and some reflection (depending upon the position of the receiving system) a signal may not be heard at all and then on the other hand the signal may "blast" in, due to correct reflection, but the latter is unlikely in most cases.

The aviation services do use frequencies above 150 mcs. for certain special services. These will be mentioned later.

At the present time U.H.F. bands as follows are assigned to the aviation services by the FCC: 33,420 kcs. to 143,880 kcs. U.H.F. radio ranges operate in the band, 63 to 125 mcs. and for airport traffic control work the 129 to 132 mc. band is used. In addition, marker beacons are operated in the 75,000 kc. band.

Because of the freedom from man-made interferences and natural static (electrical storms, sand storms, etc.), U.H.F. can be used effectively in certain types of control systems which would not function properly if low or medium frequencies were employed. Also when U.H.F. is used in inter-aircraft and aircraft to ground communications systems, especially the latter, consistent communication in bad electrical storms over short distances not possible sometimes with the "old frequencies" is made possible. If FM is employed, the signal to noise ratio would be much better than if AM were used; interstation interference would be practically eliminated if FM stations with proper power were placed strategically on desired communication lines.

One must not think that entire freedom from natural static is obtained by employing FM or U.H.F. apparatus; this mode of thinking is erroneous. There may be some but this will be reduced to a very large extent depending upon the choice of frequencies and method of transmission. Too, signal



Marker Radio Antenna.

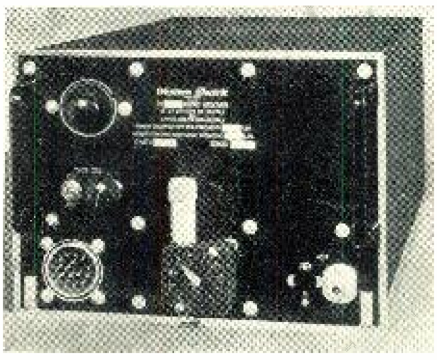
intensity has much to do with static levels. As the signal intensity increases the static will decrease and vice versa.

There are indeed few receivers on the market today which do not exhibit certain types of noise tendencies, which may be due in part to certain thermal conditions in various parts of the receiver. This is especially true of tubes and certain types of condensers and resistors. Inherent noises due to design are usually small and are negligible under most circumstances.

Radio receivers used in U.H.F. work are designed and constructed for specific service applications. They differ from the low or medium frequency receivers in that they contain tubes with low inter-electrode capacities; well insulated circuit connecting wires; condensers both fixed and variable which have been designed to hold their rated capacitance under extreme changes of temperature and humidity; coils which have been well insulated and carefully wound; voltage stabilizing circuits which prevent frequency drift or hold it within well defined limits; and critical tuning circuits which must be designed with but one thought in mind, "frequency stability." Of course, construction standards for aviation radio equipment are high for even the low or medium frequency bands. However, because of certain U.H.F. characteristics, it is necessary to "stretch" construction standards to the point where it is definitely known that not even the smallest or the most insignificant part in a circuit will influence overall efficiency.

Back-lash in tuning cables cannot be tolerated. This can be fully realized if one would just tune in any shortwave receiver capable of receiving 18 or 20 mc. stations. It's a cinch that higher frequencies (because they

WE 29A Communications Set.



are closer together) are more critical even though the receiver band width is taken into consideration.

Insofar as vibration is concerned, it must be held to a bare minimum just as it is with lower frequency equipment. If the "average of allowable vibration" (that vibration which, even though detrimental will not affect efficiency too much) is not taken into consideration when tuning circuits are designed (especially if many variable inductive tuned circuits are used), detuning is bound to take place.

This can better be understood by taking a transmitter's oscillator tuning circuit into consideration. What happens when the oscillator is detuned at the same time holding a simple wavemeter (coil, condenser and light) near the oscillator's main tuning inductance? If the wavemeter is tuned to a definite frequency and the oscillator's tuning condenser is rotated back and forth through the resonant frequency of the wavemeter, at the particular instant that both circuits are resonant the light will glow at full brilliance. As the frequency varies from the resonant condition to the non-resonant, the light goes out and from the non-resonant to the resonant, it lights up. The rotation of the oscillator's tuning capacitance can be likened unto the vibration encountered in an aircraft.

One can now see the undesired results of vibration, as it might affect frequency. If the coil of the wavemeter were vibrated so that it would change position, the intensity of the light would vary, proper coupling is disturbed. As the coil is placed nearer the oscillator's coil, the light gets brighter (surge of power); as it is taken away, power decreases. In transmitter (U.H.F.) circuits if conditions due to vibration as described above exist, one will quickly realize what the effects will be! And if in receivers, it is readily apparent that at U.H.F.'s one would be quite useless.

Spring and rubber shock absorbers used prolifically throughout an U.H.F. equipment installation will obviate the possibility of detuning due to vibration.

In the U.H.F. transmitter, as in the receiver, special tubes of low interelectrode capacities are used. However, insulation is stressed more especially in those circuits where much r.f. is present.

A word about tubes. Tubes designed specifically for U.H.F. applications do not usually have tube sockets but rather terminal connecting strips because they do not come equipped with prongs; short wire leads being used to affect connection. This is done to reduce terminal capacitance which influences tuning characteristics, and power distribution.

When examining an U.H.F. radio receiver or transmitter one will find that most connecting leads are short and are not routed for long distances. One will notice too that all parts have definite grouping for short connection. The average U.H.F. receiver or transmitter is usually quite small, a very big advantage when space requirements and weight must be taken into consideration when installation is to be made in an aircraft.

Crystal-controlled U.H.F. receivers have been used and are still being used by some services. However, if the receiver has been designed properly and all factors affecting frequency taken into consideration, there is no reason why tolerance limits cannot be fulfilled. This is especially true if inductive tuning (which incidentally has been holding its own with capacitive tuning) is utilized.

As in the low or medium frequency installations all power cables from junction boxes and dynamotors, etc., must be as short as possible.

Bonding and shielding doesn't present too many problems at U.H.F.'s but still must be taken into consideration. Advice already given should be followed.

Most transmitters designed for use at ultra-high-frequencies are crystal controlled. A few m.o.p.a. sets have been designed and operate well if tuning circuits are carefully adjusted. One will never find however, a transmitter designed for employment on many frequencies. (Switch tuning may be used as in *Air Associates* Model UHR140-G Receiver for example.) Doubler and tripler circuits are prevalent in order that maximum power can be carried to the final power amplifier at the correct frequency without too much interaction between circuits.

U.H.F. antennas can be found on nearly any modern aircraft because there is at least one piece of equipment which operates in the U.H.F. spectrum. Very few will be found on small private aircraft.

The design of an U.H.F. antenna for a specific service application is not a difficult job if all factors affecting ultra-high wave propagation are taken into consideration. In order to derive maximum benefit from any U.H.F. installation it is essential the antenna used must be given prime consideration.

The steps taken in designing an U.H.F. antenna for use on aircraft are as follows: 1. Determine whether it is to be a transmitting or receiving antenna or combination of antennas and/or reflector elements (insulation must be given a little more thought when designing the transmitting antenna); 2. Determine frequency or frequencies (usually not more than 2) to be used; 3. Determine mounting space (proximity of other antennas which may act as reflectors); 4. Determine pattern distortion of particular aircraft (this is the distortion caused by metal mass which does affect signal intensity and directivity and can only be figured by making field strength and pattern tests with portable antenna on aircraft and field strength meter and allied equipment); 5. Determine what material is on hand to affect actual construction and installation procedure.

Methods of feeding the antenna must be taken into the considerations under 2 and 3 above. Coaxial cable is used when possible because of its low loss characteristics and because it is easy to match and install.

The U.H.F. antenna can be made a pure resistance at the operating frequency without the aid of capacitive or inductive tuning elements, and it is quite possible to make the antennas comparable in dimensions with the wavelength of the specific frequency used. If a "locked" telescopic antenna (one whose length can be varied and that length maintained under vibration) is used the antenna can be "tuned" according to length for frequency.

The half-wave vertical rod antenna is considered by this writer as the best for general coverage. It is preferred because it does not exhibit those directional tendencies inherent in the horizontal types; does not present an exceptional amount of aerodynamic drag and is quite economical.

Those marker beacon receivers operating on 75 mcs. use various types of antennas, but the predominating type is an ordinary doublet; the horizontal di-pole usually mounted under the nose of the aircraft is the second preferred. The doublet is usually 78 inches long; 39 inches each side of the splitting insulator, is simple to install and maintain. Connecting to the antennas is accomplished by using twisted pair transmission lines whose length must follow those laid down by the manufacturer of the receiver. Concentric shielded transmission line is also used.

When the first commercially-manufactured fan type marker was installed in February, 1938 in the vicinity of New Brunswick, N. J., the CAA (then the BAC) made extensive tests and decided that the type tested was commercially practicable and out of the maze of experiments and research much was learned about U.H.F. wave propagation and the influence of terrain, structures, etc., on the U.H.F. marker patterns. As long as steel structures were in line with the ground antenna system and not placed to either side, nor the antenna installed so that it was flanked by steel structures which would naturally act as reflectors and cause undesirable distortion, satisfactory operation resulted. The antenna used with the receiver installed in the testing aircraft is shown. Another photo shows location of a station with respect to the airways.

The absolute altimeter which operates on frequencies in the 300 mc. band is one of the newest U.H.F. aids to aerial navigation. This equipment when properly installed and operated will indicate to the pilot from a direct reading meter (in feet) what the aircraft's altitude above ground is. The type of antenna used in the installation is a di-pole which resembles an inverted T, one leg of the T being smaller than the other. Little guesswork about altitude is indulged in by the pilot flying a craft equipped with the ARA (absolute radio altimeter).

As FM apparatus is introduced to the aviation radio industry it is believed that it will be given an immense amount of consideration because many stations may be accommodated on one frequency, power being the only hindering factor. It can be seen why. More stations occupying less space will afford better coverage. As the service area of one transmitter is left another transmitter serving another area will take up on the same frequency with no interference to the first station thus assuring continuous coverage and consistent service. The station with the strongest signal will take over just at the edge of the service area. In effect this could be called "modern radio relaying."

The U.H.F. field insofar as it concerns aviation is open, wide open. There are so many opportunities offered now and which will be open to those who look ahead and prepare, because the untrained man has no chance in this highly specialized field. As time takes its toll it will be apparent to those looking for opportunities that U.H.F. has everything to offer, especially to those engaged in aviation radio.

In order for the aviation radio technician to keep abreast with the latest developments it is necessary for him to depend more and more upon manufacturers. They are willing to proffer aid and give valuable advice to those who are in need of the latest information about the products and equipment they manufacture. For this, the technician is only expected to do his job well and properly take care of the equipment which may some day save one life which would more than pay for any vigilance he might have exercised.

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Spot News
(*Continued from page* 40)

free, provides the publication of 'Swap or Sell' advertisements of fifty words or less. The emergency requirements receive precedence although, according to Harry Kalker, Sprague sales manager, all classified advertisements that fit in with the spirit of the program will be scheduled for appearance. Congratulations, Harry, on a swell idea!

MUSIC WHILE YOU WORK has become a very important accessory in production plants throughout the Nation. The idea seems to have started nearly a score of years ago in a plant in Newark. At that time it was a novelty. However, today, it has become a requirement in most plants. Statistics show that production has increased as much as 25% in many instances with the 'music while you work' plan.

Many factories have installed a special sound division with a staff that is especially assigned to control machine loading, as well as volume for various parts of the plants.

The recent edict of Caesar Petrillo forbidding the production of any more records began to have a serious effect on this 'music while you work' plan, for it will be recalled that record making was officially stopped last July. However a recent statement issued by Mr. Petrillo indicates that records will be made again and there will be plenty for everyone again.

IN CANADA, AS IN THIS COUNTRY, THE SIGNAL CORPS is one of the most interesting branches of the service. This branch of the service, organized in a small way during the first World War, and then two years after the war, reorganized under what was then known as the Canadian Corps of Signals, has today become quite a formidable unit.

It wasn't until 1930 that radio equipment became a major factor in this division. In 1932 mobile units were first tried. Today, its equipment is of the latest and its usefulness to the services has been well established.

In 1936, the King of England conferred the honor of the title 'Royal' to the Corps. In the symbolic crest of the Corps, the Greek goddess 'Mercury' is employed, as a symbol of communications.

NEW FIRE PREVENTION REQUIREMENTS for receivers have been issued by the Underwriters Laboratories and accepted by the American Standard Association. The new rulings cover power operated radio receiving units, as well as television receivers, non-commercial or domestic phonographs, record players, recorders, and similar equipment.

This new devised format is the result of tests that began 17 years ago with the examination and testing of separate A- and B-battery eliminators. In the new standards, the features which are to be checked by means of tests, include power consumption, leakage currents, temperature, dielectric strength, strain relief and abnormal operation. The tests are most complete. For instance, in the strain relief test, supply cords must undergo a 35-pound test. All transformers used in receivers that will eventually pass the test, must contain impregnated coils. In addition definite limitations are placed on the ventilating openings in transformer enclosures.

These requirements, of course, are applicable only to civilian equipment, and as such will not be put into practice until civilian receiver manufacture is resumed at the conclusion of the war.

BATTERIES ARE NOW AVAILABLE IN ENGLAND under the lease-lend ruling. Approximately a quarter of a million are expected to be distributed. The 120-volt size, equipped with spring clips, are at the present writing, the only known type available there. Al-

★ INDUSTRIAL ★ MAN-POWER BUREAU

This section is designed to help the radio industry obtain trained, experienced, technical men to facilitate vital war production.

locations of these batteries are being made through the RMA of England. The Board of Trade in London, who arranged for the importation of these batteries, has stated that the distribution will be on a restricted quota basis.

Incidentally, although the tube situation has been believed to be critical in England, it appears, judging by the appearance of recent advertisements, that stocks are available again. One advertisement, in particular, stresses the increased production of American types and emphasizes the fact that stocks are available!

IN A RECENT CONVERSATION WITH COLONEL CARROLL O. BICKELHAUPT who directs the control division of the Signal Corps, he recalled an interesting historical fact of Communications that deserves mention here. Were radio available in 1812, he reminded us, the Battle of New Orleans would have been over two days sooner. For although the war of 1812 had actually ended the battle continued. Because of the lack of communications, it was impossible to convey this information to the armies and thus unnecessary bloodshed continued!

ALTHOUGH WE IMAGINE THAT BLIND FLYING and radio are quite new, it actually started nearly sixteen years ago. A recent talk by the famed Dr. E. F. W. Alexanderson revealed that in 1928, tests were made with radio echoes to measure an airplane's distance from the ground. Tests were also made to employ this echo as a warning to avoid flying, for instance, into a mountainside. To date, this form of control, which will permit a plane to be piloted through clouds and darkness, is still to be developed to a final form.

In his interesting talk, Dr. Alexanderson also revealed that a vacuum tube with a mercury pool and an igniter, was one of the first systems suggested for the amplification of signals. The function of the igniter he explained, was to control the power flow through the tube by a system of timing the spark. The development of the DeForest tube shelved this procedure. But ten years later this mercury-type tube was brought back again. At that time it was used to rectify alternating current into direct current. However, at that time, its application was limited since there was no way of controlling the rectification. The idea of the igniter with a timing control was returned to and Dr. Irving Langmuir developed the proper method to do this. By successfully developing this device, it was possible to not only change direct current into alternating current, but alternating current into direct current and thus the inverter was born. Its usefulness is still not yet too well known. However, it is interesting to note that at the present time such a device is operating a direct current power transmission from a 40-cycle water power plant on the Hudson River and delivering power at 60 cycles to a power house in Schenectady. Thus it may be possible to provide power transmission over perhaps distances of from 500 per 1000 miles.

There are countless other unusual developments, that have been left on a laboratory shelf because of other emergency demands, that may still be revived some day and provide us with many developments similar to those revealed by Dr. Alexanderson.

MANY INDUSTRY COMMITTEES have been appointed by the WPB to assist in the formulation of plans and methods that will increase production. During the last few weeks, committees on quartz crystal, fixed capacitors and mica have been formed. On the fixed capacitor committee will be found such radio personalities as Octave Blacke, Cornell-Dubilier Electric Corporation; Monte Cohen, F. W. Sickles Company; S. I. Cole, Aerovox Corporation; Wm. S. Franklin, John E. Fast & Co.; Paul Hetenyi, Solar Manufacturing Corporation; Gordon Peck, P. R. Mallory & Company; F. X. Rettenmeyer, RCA Manufacturing Company, Inc., and R. C. Sprague, Sprague Specialties Company.

DEJUR AMSCO AWARDED ARMY-NAVY "E". One of the most recent manufacturers to win the cherished Army-Navy "E" award is the *Dejur Amsco Company*. The master of ceremonies was Lt. Willis J. Goldert. Speakers were Ralph C. Booth, Mayor of the City of Shelton, while the award was presented by Lt. Col. Howard D. Norrie. Other participants were Mr. Peter Cassata, Production Manager of Dejur Amsco, and pins were presented by Lt. John D. Lodge, USNR. Representing Governor Raymond D. Baldwin, was Assistant Adjutant General, Lt. Col. Frank M. Green.

Personals . . .

The industry was shocked to learn of the deaths of **A. J. "Nick" Carter** and **I. R. Baker**. Both died suddenly while at work. Mr. Carter was a well known parts manufacturer and motor specialist. In 1922 he established what later became one of the largest parts manufacturing units. In 1928 he began the manufacture of motors. I. R. Baker was former head of the broadcast transmitter sales division of RCA and was recently engaged in electronic developments at that company. . . . For outstanding war production, the **De Jur-Amsco Corporation** has been awarded the coveted Army-Navy "E" award. . . . **General Radio, Electronic Laboratories, Cinaudagraph Corporation, Formica, and Thermador Electric** are also recent winners of the "E" award. . . . Congratulations to **Bill Halligan** whose company, the Hallicrafters, will soon occupy the entire building, where in 1936 they had but one floor. . . . Dr. A. W. Hull, the famous General Electric research scientist, who developed the magnatron, dynatron and screen-grid tube for r.f. amplification, was recently elected president of the American Physical Society. In 1930 Dr. Hull received the Morris Liebmann prize for his work on vacuum tubes. . . . Ed. C. Cahill has become president of the new RCA Service Company, a subsidiary of RCA Victor that will handle technical servicing and installation activity. W. L. Jones, former manager of RCA Victor Service, is vice-president and general manager of this company. . . . Ed. DeNike is back again with National Union, this time as public relations director.

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What's New in Radio

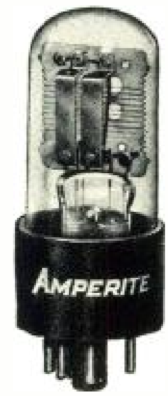
(Continued from page 37)

to 10,000 megacycles, 1 μμfd. to 100 μfd., and .001 mh. to 100 henries.

This new Reactance Slide Rule is available at a nominal charge of 10c in coin or stamps to cover the cost of handling and mailing. *Shure Brothers*, 225 West Huron Ct., Chicago, Ill.

New Amperite Voltage Regulator

The new type *Amperite* 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 providing 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%.



Engineers, write *Amperite Co.*, 561 Broadway, N. Y., for new eight-page illustrated folder, on your company letterhead.

—30—

Coming in the May Issue

Air Raid Alarm Circuits

Latest Electronic Devices

Printed in U. S. A.

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.

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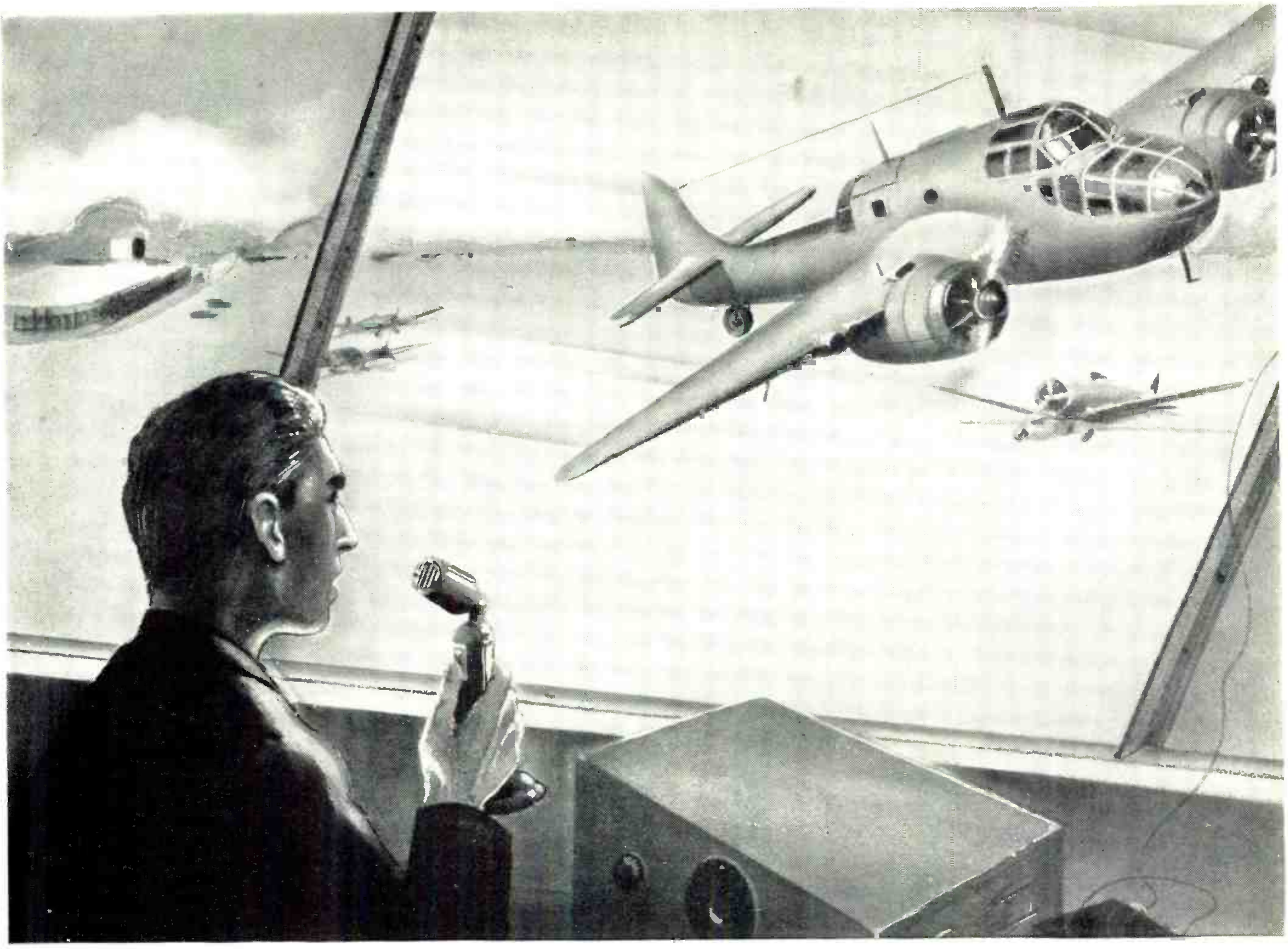


For a nation on wings

Built to Civil Aeronautics Administration specifications, CAA-515, the Electro-Voice Model 7-A microphone is widely used for airport landing control and is highly suitable for many other sound pick-up applications.

The smooth frequency curve, rising with frequency, gives extremely high intelligibility even under adverse conditions. Desk mounting incorporates easily accessible switch which can be operated by thumb of either right or left hand. Microphone may be moved without danger of pressing this switch. If you have a microphone problem, we invite you to consult our engineering department.

If, however, your limited quantity requirements can be met by any of our standard model microphones, with or without minor modifications, may we suggest that you contact your local radio parts distributor? He may be able to supply your immediate needs from remaining stocks. In all instances, his familiarity with our products and many of your problems will enable him to serve you well. Our distributors should prove to be vital links in expediting your smaller orders.

. . . Any model Electro-Voice microphone may be submitted to your local supplier for TEST and REPAIR at our factory.

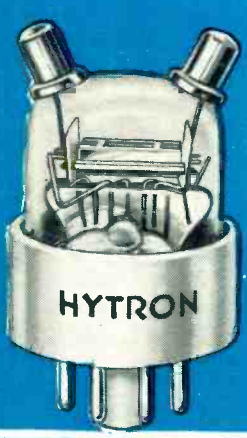
Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. 1239 SOUTH BEND AVENUE, SOUTH BEND, INDIANA

Hytron

DEDICATES *the* PRESENT *to* PRESERVATION *of the* FUTURE

HYTRON'S SOLE PURPOSE for the duration is to maintain an always-increasing flow of tubes into the radio and electronic equipment which is playing a vital part in winning this Radio War. It is our firm conviction that the torch of Liberty which Hytron is helping to keep burning will light the way to the unconditional surrender of our enemies and to an electronic age which will amaze a freed world.



HYTRON CORP., Salem and Newburyport, Mass.

. . . Manufacturers of Radio Tubes Since 1921 . . .