RADIO NEWS

MARCH
1943
25c
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The Saga of the Vacuum Tube

★ GERMAN AIRCRAFT RADIO EQUIPMENT
★ A THYRATRON TUBE TESTER

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Hallicrafters Model S-27 FMAM receiver, 15 tubes, 3 bands, cover 27.8 to 46 mc., 45 to 84 mc., 81 to 143 mc. Switch changing from FM to AM reception.

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CHICAGO, U.S.A.

Volume 29 Number 3

RADIO NEWS

March, 1943

★ *Leading the Industry Since 1919*

The Technical Magazine devoted to Radio in War, including articles for the Serviceman, Dealer, Engineer, Experimenter and Student.

FOR THE *Record* BY THE EDITOR

AFTER many months of debate, the *War Manpower Commission* has finally certified that repair and hand-trade services are essential to the support of the war effort. Included within this certification, appears "radio repair." Thus under the Occupational Bulletin issued by *Selective Service* and known as bulletin No. 42, radio repairmen now have the status of a critical occupation, eligible for occupational deferment, until a replacement can be trained. To receive consideration for occupational deferment, the serviceman or the employer of a serviceman will have to fill out Form 42A. Such deferment will place a person in class 2A.

Servicemen who seek such deferment are not evading their duty, says the *War Manpower Commission*. A balance of manpower in the military and home fronts is essential, they say. This viewpoint is best expressed in a statement by Paul V. McNutt, Chairman of the WMC, which declared, "Occupational deferment usually indicates that a man is making a more valuable contribution to the war right now than if he were in uniform . . . it is the *War Manpower Commission's* job to see that the nation's manpower is properly allocated."

Coast-to-coast networks have already begun a campaign outlining the importance of radio maintenance. Newspapers and magazines have also swung into the program. Such effective cooperation further proves the importance of the home receiver and the man who keeps it working.

THE serviceman has been receiving some excellent promotion these days on the air. With stations from coast-to-coast stressing the importance of the serviceman and his work, everyone has become more conscious than ever of his value to a community. Perhaps the most effective air tribute to the serviceman was made by Frazier Hunt recently during one of his broadcasts. Said Mr. Hunt . . . "to the list of hard-working public serv-

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DEPARTMENTS

On the Cover: Radioman-Gunner in Heavy Bomber. (U.S.A.A.F. Photo.)

Member of the Audit Bureau of Circulations

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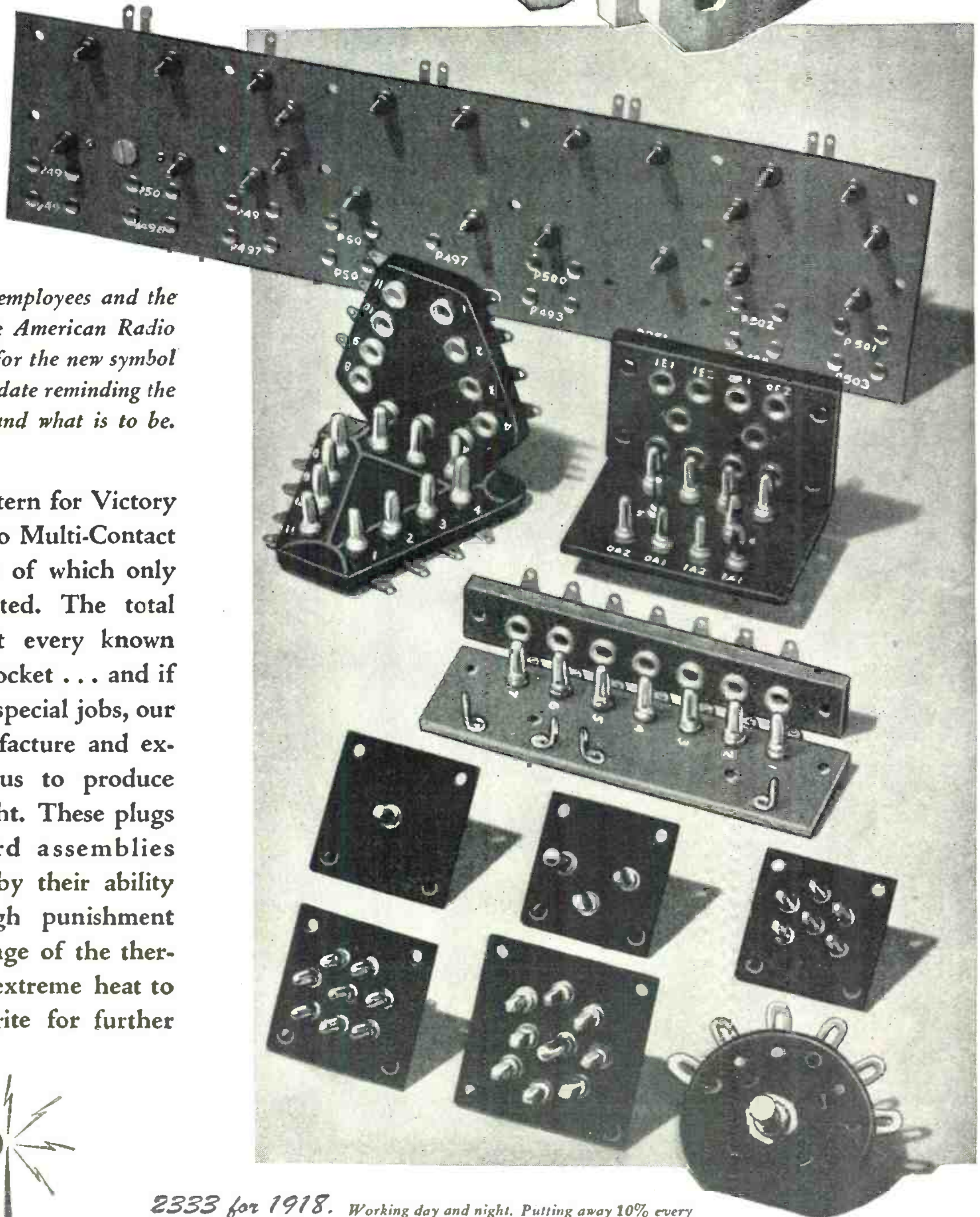

2333 for the 325 employees and the 2008 products of the American Radio Hardware Co. 1918 for the new symbol of Victory . . . fateful date reminding the enemy of what was and what is to be.

Partner in the pattern for Victory are American Radio Multi-Contact Plugs and Sockets of which only a few are illustrated. The total line covers almost every known type of plug and socket . . . and if the need arises for special jobs, our flexibility in manufacture and experience permits us to produce practically overnight. These plugs and socket board assemblies are characterized by their ability to withstand tough punishment over the entire range of the thermometer . . . from extreme heat to extreme cold. Write for further information.

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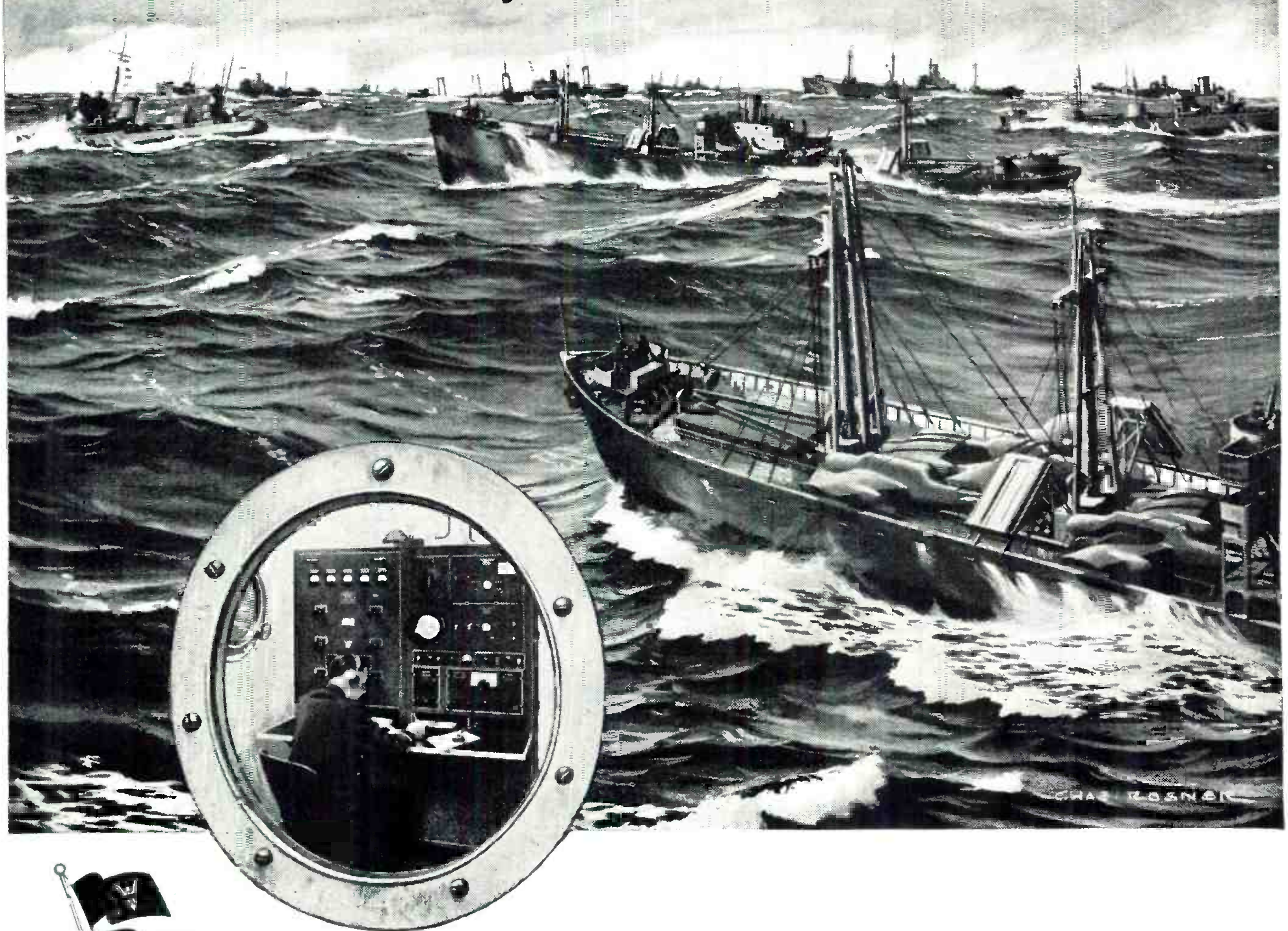

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Is helping save the manpower hours
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AN **IT&T** ASSOCIATE

IRC *"Here's How"* VOLUME CONTROL *Contest*

Pays $500.00 in WAR BONDS

Do you know how to make a sick radio sit up and *sing?* Would you swap a few minutes' time for a $100 U. S. War Savings Bond? O.K. . . . if you live within the boundaries of the United States—you're qualified. Not only one, but FIVE, $100 Bonds are offered! Let's go!

Nobody knows better than you how important the radio is to a democracy at war. And nobody knows better how difficult it is sometimes to get a radio into working order . . . what with the difficulty of getting exact replacement parts, etc. The question is: HOW DO YOU DO IT? IRC is going to pay a $100 Bond each for five answers. Don't you agree one of them might as well be delivered to YOU?

HOW TO WIN A BOND!

All that's required is a simple account, told in your own way, and your own words, describing:

How you were able to replace a volume control and get the 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.

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 and/or electrical changes in the circuit.

IRC suspects that in these times radio service men are displaying more ingenuity and inventiveness and resourcefulness than most of us have any idea of. We'd like to uncover some of these stories.

It's the IDEA that Counts

Remember, no one expects you to submit a literary masterpiece. Your spelling makes no difference; grammar doesn't matter. Just "let yourself go" and tell us how you licked the volume control problem you faced (it may have been as simple as filing down a shaft, or making a special shaft), and send the story in.

You May ALREADY Have Won a Bond

What we mean is that some Volume Control job you've already done may be the one to cop one of those Bonds. It may be only a matter of putting down the detailed facts and mailing your entry!

IDEAS to be Shared

In entering this contest you have the satisfaction of knowing that worth-while ideas will be publicized for the entire service profession. You yourself will benefit from the information made available by the results of this contest. This exchange of ideas is certain to help you keep radio sets going, through the use of standardized controls. These same sets might otherwise be kept out of service and become lost jobs for you.

The Judges

Judges, whose decision will be final as to the five winning entries, include IRC's Chief Engineer, Jesse Marsten, and two "outside" experts—Joseph Kaufman, Director of Education of the National Radio Institute, and William Moulic, Service Editor of "Radio Retailing Today." If, in the opinion of the judges, winning ideas of equal merit are presented, duplicate awards will be made. It is understood, of course, that all ideas submitted become the property of IRC.

WHAT HAVE YOU GOT TO LOSE?

Don't say, "Aw, the Volume Control job I'm thinking of was too easy—any good radio man would have done the same as I did." Remember this: ANY job looks easy when you know the answer. . . . And besides, even if someone else did have the same idea, HE may not tell us about it. So get busy yourself—surely a crack at one of those $100 Bonds is worth *some* trouble! All entries must be in IRC's hands by April 10, 1943 when contest closes.

FILL OUT THE COUPON

—and send it in with your entry this week—TODAY if possible. Don't put it off. Five men are going to be richer by a $100 Bond—make one of them YOU!

Uncle Sam's Men, Too

If you're now in Government service, in or out of uniform, you're still eligible in this contest. Maybe the job you did was handled before you went into the service.

CLIP THIS—FILL IN—SEND IN WITH YOUR ENTRY

RN

INTERNATIONAL RESISTANCE COMPANY
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• Gentlemen: Here is my entry in your $500 U.S. War Savings Bonds Contest.

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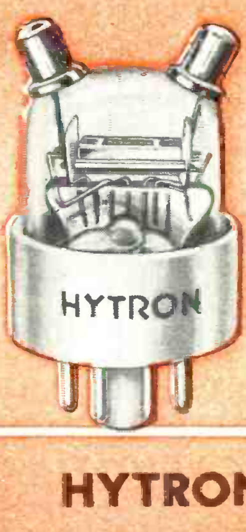

HYTRON CORP., Salem and Newburyport, Mass.

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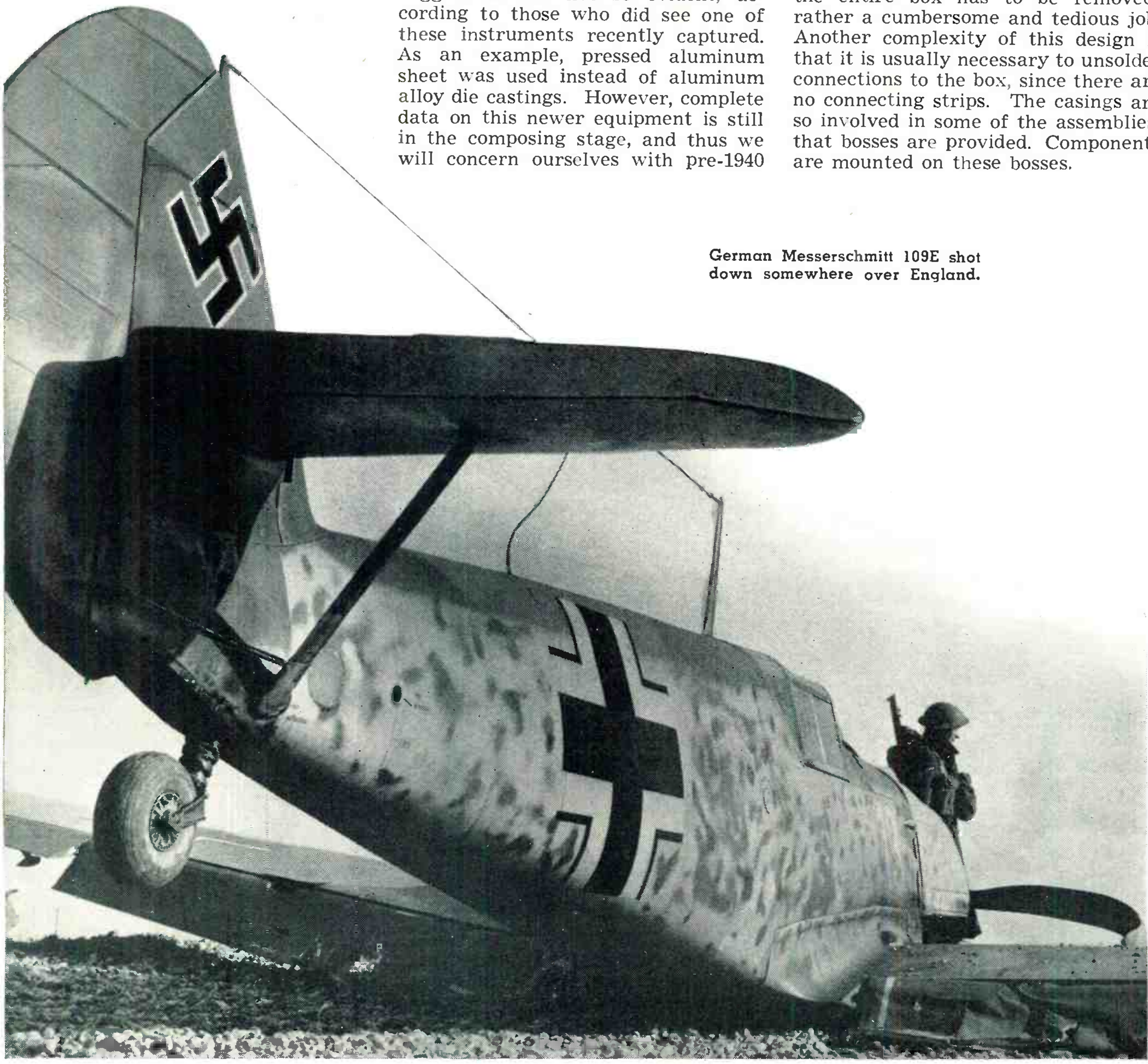
GERMAN AIRCRAFT

By
LEWIS WINNER

A revealing study of the radio receiving and transmitting apparatus found on captured Nazi planes in recent weeks.

THE recent release of data on German aircraft equipment by the *British Air Ministry* has capsized many theories and suppositions. Probably the most important of the revelations was that the Nazi equipment was not as inferior as we had all imagined. The equipment found on captured planes shows that it is extremely durable, more than truly requisite, and its design is good . . . not superior to ours . . . but equal in many respects. The material employed is of the highest order, with practically no thought given to economy. Of course, it must be remembered that this apparatus was made prior to 1940. Today, the rigidity and ruggedness are not so evident, according to those who did see one of these instruments recently captured. As an example, pressed aluminum sheet was used instead of aluminum alloy die castings. However, complete data on this newer equipment is still in the composing stage, and thus we will concern ourselves with pre-1940 equipment, on which information is quite complete.

In the earlier equipment, the rotor plates in the variable condensers were milled out of a single solid aluminum alloy sheet. All housings and chassis were also aluminum die castings. In some of the receivers, the chassis consisted of an intricate die-cast framework, bolted to the panel casting. Onto this framework, the various stages, consisting of cast boxes, were bolted. Thus the components were fixed within these cell-like units. This method has its good and bad features. It does provide rigidity but it hampers servicing. For it is almost impossible to get to the components in the box, and thus the entire box has to be removed; rather a cumbersome and tedious job. Another complexity of this design is that it is usually necessary to unsolder connections to the box, since there are no connecting strips. The casings are so involved in some of the assemblies, that bosses are provided. Components are mounted on these bosses.



German Messerschmitt 109E shot down somewhere over England.

RADIO EQUIPMENT

The method of wiring is quite unique. In some instances, it is bunched to form a so-called snake formation. A grooved recess provided in the casting and lined with copper foil, houses this snake wiring, thus providing protection and shielding.

In the components were found many interesting features. For one thing, silvered ceramic trimmers are used almost universally, instead of micas, even at audio frequencies. Oddly enough these ceramic type condensers, which are now so popular here, were introduced several years ago in Germany. In the transmitters, molded bakelite mica condensers are used, in addition to the wax-paper *Mansbridge* type of condensers. Laminated bakelite is used in some instances for resistor and condenser mounting. Soldering strips are of ceramics.

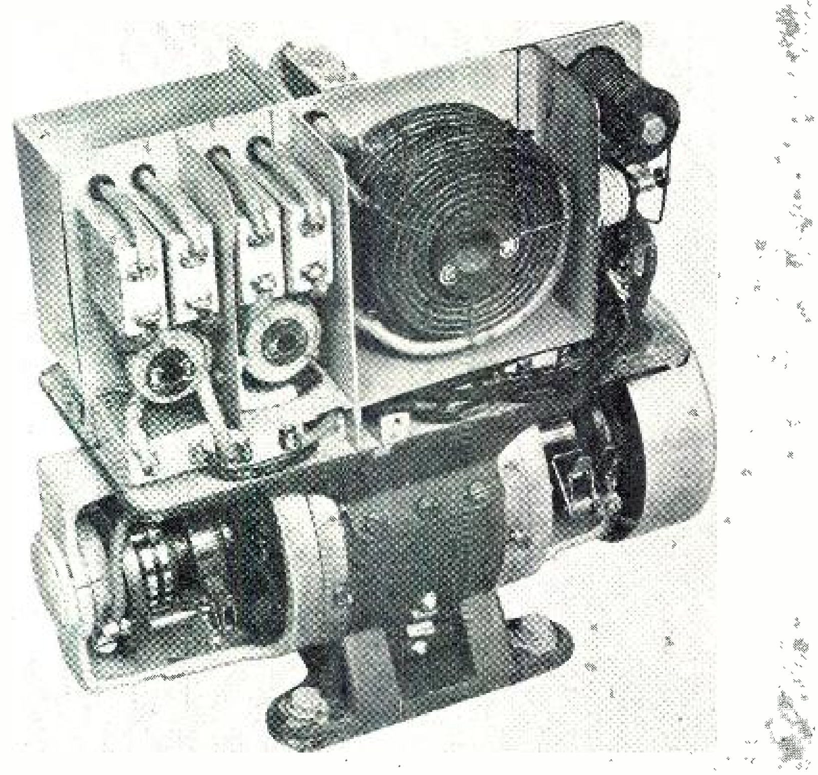
As was pointed out in a previous paragraph, the rotor plates of the variables are machined out of a die cast piece. They are mounted onto a ceramic spindle. Similarly made are the stator plates, they being clamped to two ceramic rods. Tracking is provided with a two-rotor and three-stator master oscillator condenser. In both the doubler and amplifier circuits, a rotor and two-stator unit is used, in addition to a trimming plate. This plate is mounted on the rotor and meshes with the rotor. A serrated edge provides movement of the plate.

Spiral grooved ceramic forms, with silver deposits in the grooves to form turns, are used in most of the instruments. This deposit, applied by electrolysis rather than spraying, affords stability, low capacity between turns and additional surfaces for the ultra high currents.

Iron dust cores are used rather extensively. In one coil construction studied, a plastic, three-section bobbin fitting over an iron core and molded in one piece served as an r-f and i-f unit. To provide adjustment, a screw action is employed.

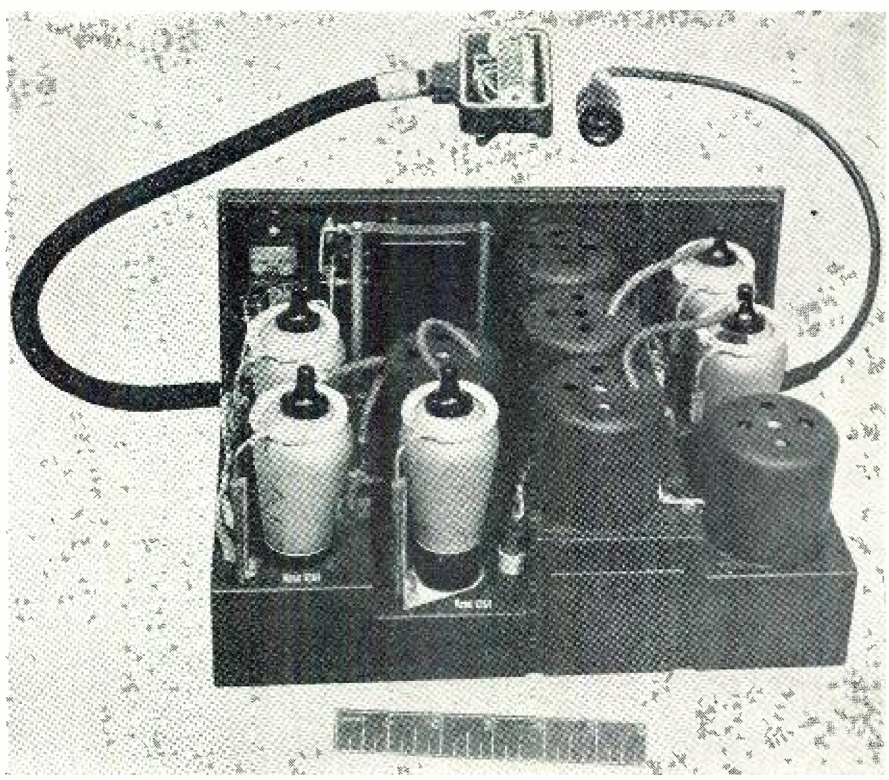
Let us now see where some of these parts were used. One was the *Junkers* 88, which is a bomber. The transmitter here, a voice type, and the receiver, a nine-tube superheterodyne, provided coverage of from 38.6 to 42.2 mc. The operator cannot tune the device, since there is no remote mechanism. Instead, either of four frequencies are selected, and the equipment set to these predetermined frequencies. In the intermediate frequency, 3.15 mc. is used.

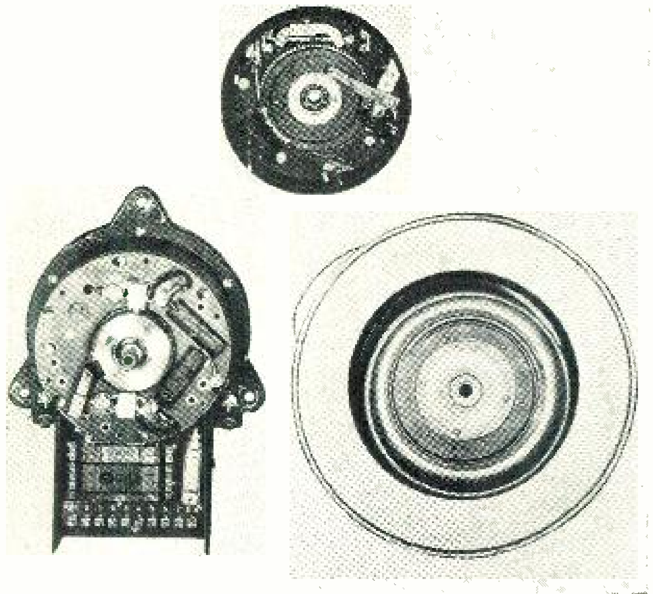
Two pentode tubes, one in a Colpitts oscillator operating at half the carrier frequency with a frequency doubler, and the other a power amplifier, are used in the transmitter. The



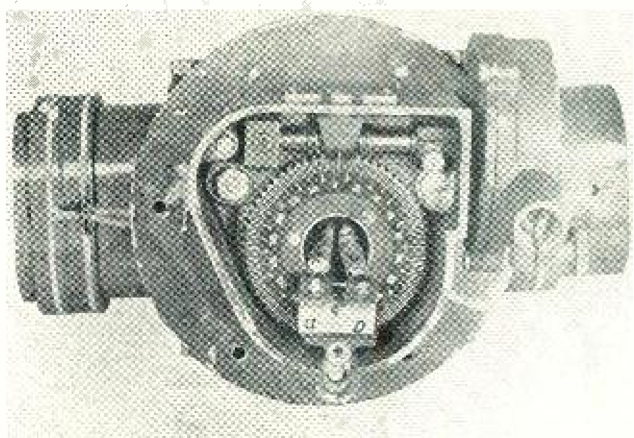
Power Unit and associated filter circuit components for the transmitter and receiver removed from Nazi aircraft.

This German radio receiver was found intact upon being removed for inspection by British radiomen in England.





The trailing winch of a dissected antenna system. Note the automatic reel and drum assembly units.



An underside view of a direction-finder loop, a part of the Telefunken direction-finding equipment.

modulator tube is a standard type receiving pentode, and thus grid modulation is used.

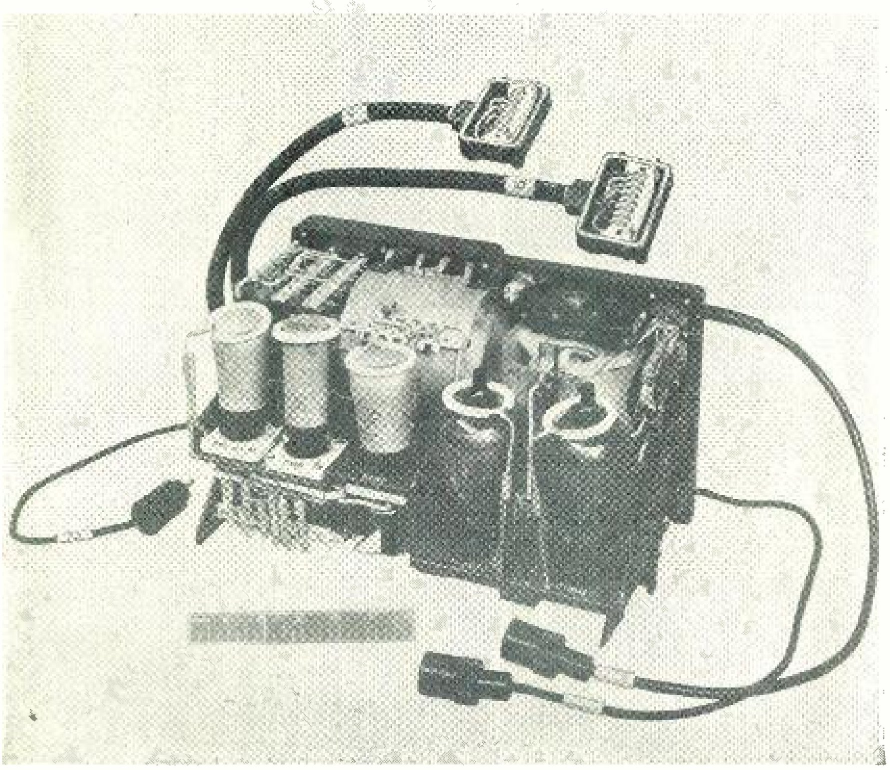
Dynamotors supplied with three commutators supply energy for the 24 volt direct current motor supply, anode supplies and grid bias, respectively.

A single wire, 6 feet 11 inches long suspended from a deck type insulator to a point on the tail, and matched to a concentric feeder by means of a T network, serves as the antenna.

Of unique design is the equipment installed on the reconnaissance and more recent bombers. This consists of apparatus that affords four fixed-frequency short and long wave lengths, a direction finder, intercommunication system, and a blind landing approach unit. A separate direction finder receiver, combined with a compass repeater, is used for navigation by the navigator. Pulses from the long wave transmitter provide hearings from the ground, that are free from night errors.

On these instruments, electrical remote control is used. An intermediate frequency of 140 kc. is used for the long waves and 1.4 mc. is used for the short waves. Here again we find the free use of the ceramic condensers and powdered iron core transformers. In the compact superheterodyne receivers (8 x 8½ x 7 inches), acorn type pentodes are used. They have ring seals. When the tubes are used as triodes, the suppressor and screen grid are connected to the anode. And incidentally no automatic volume control is provided for in these receivers.

This is one of the transmitters taken from Nazi aircraft. Note the intricate multi-point plugs.



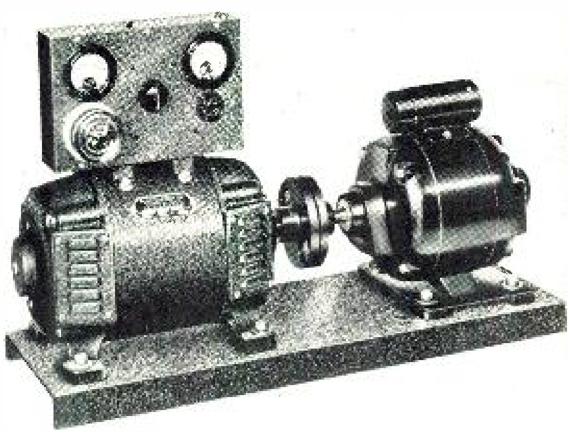
In the short wave transmitter, which has been designed for continuous waves only, a master oscillator is used to drive two power amplifier tubes in parallel. In the grid circuit of the master oscillator circuit, the keying system prevails. The master oscillator system is also used in the long wave transmitter.

Remotely controlled tuning circuits, fitted to a special base, are used in association with fixed and trailing type antennae. A remote controlled antenna winch provides a choice of two trailing lengths of antenna.

In the fighter plane captured, a *Messerschmitt* 109, a transmitter and receiver built only for voice and operating between the frequencies of 2.5 and 3.75 mc. was found. A master oscillator is used in the transmitter, with grid modulation and two output tubes in parallel. As in the *Junkers* 88 unit, preset operation is used here too. A single antenna is used for the receiver and transmitter, with a variometer tuning the antenna for the transmitter. An output of 2½ watts is available from the transmitter. The receiver, a superheterodyne, uses pentagrid tubes, and an intermediate frequency of 509 kc.

Probably the only transmitters that can be classified as quite unusual from an electrical and mechanical stand-

(*Continued on page* 77)



Motor-Generator set with control box.

DYNAMOTOR FILTERING

by **HARRY GOLDBERG**

Chief Eng., Pioneer Gen-E-Motor Co.

Increased use of motor generators makes it necessary to understand the correct means for the removal of unwanted interference.

DRAWINGS shown are intended to indicate a method of effectively filtering a dynamotor. Figure 1 and Figure 4 indicate respectively an ungrounded unit and a grounded unit. This type of filtering should be used for sensitive receivers or when exceptional filtering is desirable on a transmitter dynamotor. Fig. 2 and Fig. 3 indicate a less effective filter (ungrounded and grounded) although in many applications such a filter will serve sufficiently.

In regard to condensers, it should be noted that air, mica, oil, and good quality paper types are theoretically desirable in this order. However, practical considerations eliminate the air type. In r.f. circuits, only mica or oil condensers should be used. In the audio filter, any good capacitor may be used.

Shielded compartments around individual filtering units are highly desirable; a unit is a reactor and its associated capacitor.

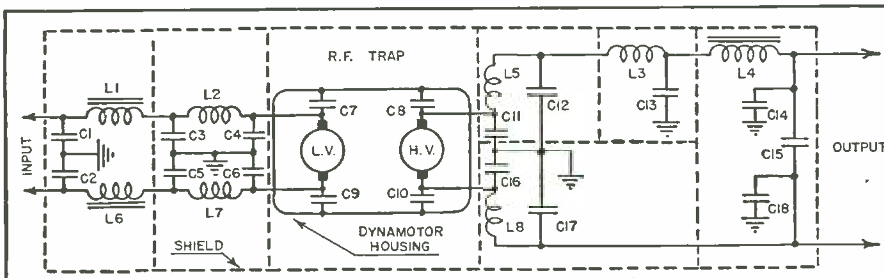
Condensers C_7, C_8, C_9 and C_{10} are transient condensers. They must be mounted as near to the generating source of radiation as is physically possible. This source is at the surface of the brush in direct contact to the face of the commutator. Condenser ground connections must be direct and as short as possible. The term ground in this application shall be considered only as the dynamotor housing or frame. All condensers in the radio frequency trap shall be grounded to one common point if possible and practical. Avoid long ground leads or high resistance grounds. When necessary to make ground connections at several points, be sure to reduce the high frequency ground current to a minimum by a proper bond.

When strong ground currents are present due to r.f. condensers discharging into the ground, such ground currents can couple into other circuits of a radio receiver, and when such is the case, such a condenser discharging frequency into the ground will be tunable to its corresponding frequency and its harmonics, resulting in audible noise.

The function of condensers C_4, C_6, C_{11} and C_{16} is to suppress any coupling that may be picked up by the leads from within the dynamotor. These condensers shall be connected to the leads as they emerge from the frame to its shortest possible dimensions. Once r.f. filtering starts they must run their course so that no coupling exists, namely, the l.v. going in one direction while the h.v. goes in another direction and away from each other.

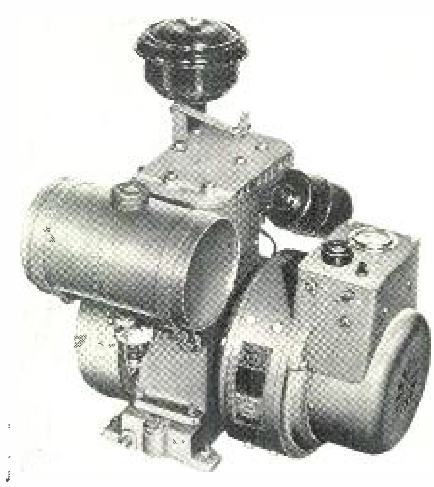
Only thoroughly filtered wires can be re-grouped together again or the result will be in vain. Condensers C_1, C_2, C_3, C_5, C_{12} and C_{17} are to suppress

(*Continued on page* 58)



L_1, L_4, L_6—Iron core reactors
L_2, L_3, L_5, L_7, L_8—Single layer R.F. chokes
C_1 to C_{14} inc., C_{16}, C_{17}—Low loss condenser mica or oil
C_{15}—Audio filter condenser of good quality

Fig. 1. Best ungrounded system.



Model RA-10 single-cylinder, 1 kva. unit.

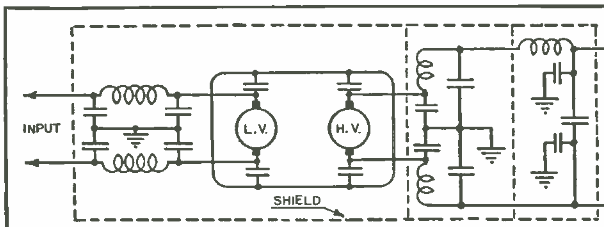


Fig. 2. 2nd best ungrounded system.

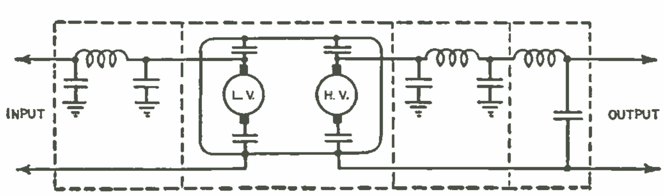
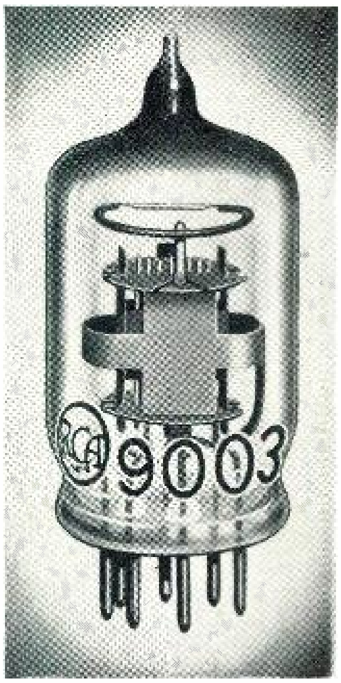


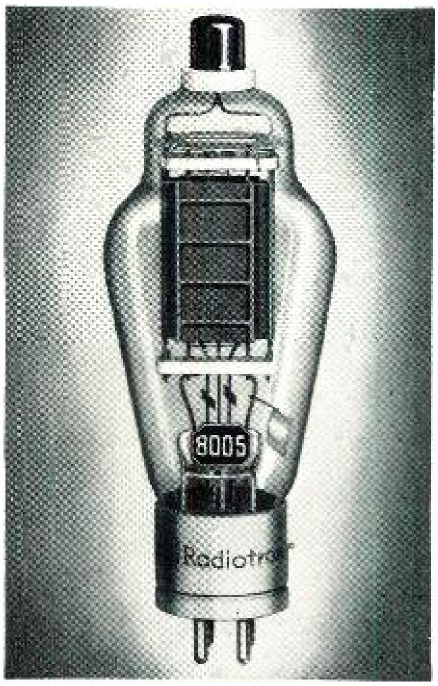
Fig. 3. 2nd best grounded system.

ELECTRON CONTROL METHODS

Dual beam-power tube.



U.H.F. Pentode.



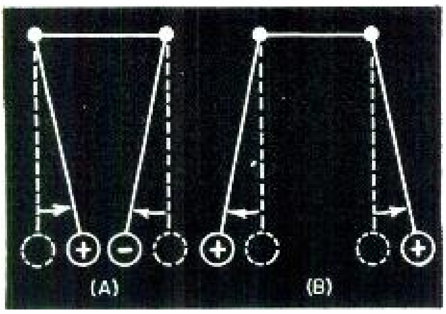
Transmitting triode.

by C. D. PRATER
Bartol Research Foundation

This continuation of Fundamental Atomic Physics explains the characteristics of vacuum tubes and analyzes their behavior when subjected to changes of cathode potentials.

IN the last article the methods used to obtain electrons in a high vacuum tube were discussed. In order to utilize these electrons something has to be done to control them. Since electrons are *negatively* charged, they are affected by charges existing within the tube. These charges can be ions, other electrons, or the charges on the metal or the glass parts of the tube. If the charges on two bodies are of like sign, i.e., both negative or both positive, the forces acting between them will be such that the two bodies will repel each other and tend to move apart. If the signs of the charges are opposite, i.e., one negative and one positive, the forces acting will be such that the bodies will be attracted to each other. This is illustrated in Fig. 1 by means of two very light pith balls supported by a silk string.

Fig. 1.



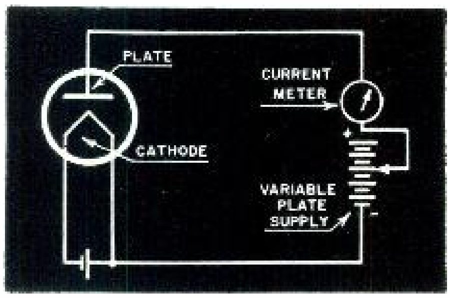
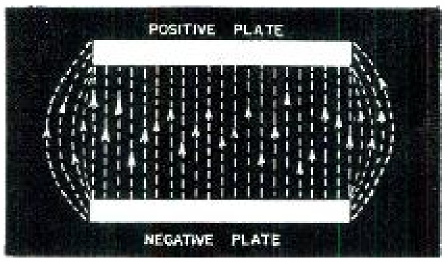


Fig. 2.

If a vacuum tube, containing one metal electrode and a hot cathode, is connected as shown in Fig. 2, a current will be observed flowing through the meter. This current is caused by electrons being attracted by the plate which is being operated at a positive potential with respect to the cathode. If the plate is given a negative potential with respect to the cathode, no current will be observed since now the plate is repelling electrons. If the potential of the plate is varied, and the current for the different potentials noted, a curve similar to the one shown in Fig. 4 will be obtained on plotting the results. During this experiment the cathode temperature was maintained at a constant value. It might seem surprising at first that a curve such as this should be obtained since on first thought it would seem as though the plate would remove as many electrons from the cathode as the cathode emits as soon as the plate potential was a small positive value. It might be thought a curve similar to curve X of Fig. 4 would be obtained, but this is not the case.

The reason for the more gradual rise in plate current as the plate po-

Fig. 3.



tential is raised is that the electrons, being negatively charged, shield electrons on the side of it away from the plate from the action of the plate. Since the electrons do not move from the region of the cathode to the plate instantaneously but require a finite time of transit, even though this time is extremely small, the electrons in

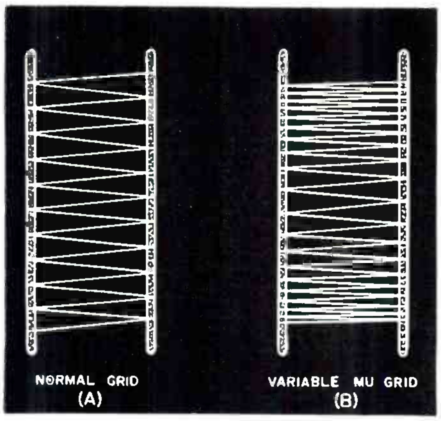


Fig. 6.

transit will tend to shield other electrons from the action of the plate and, therefore, if the transit time is not small enough there will be an accumulation of electrons in the region of the cathode.

The accumulation will cause electrons to be forced back into the cathode as rapidly as they are emitted because of the repelling forces between the electrons. The transit time of the electrons becomes less with greater plate potential, and, therefore, more electrons will feel the effect of the plate potential to a greater extent. More electrons will then arrive at the plate. This process will be continued

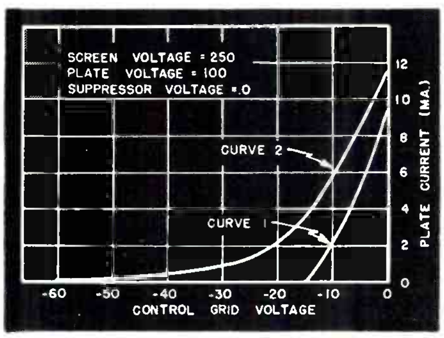


Fig. 7.

on raising the plate potential until the electrons are accelerated to such an extent that all electrons emitted by the cathode at this temperature will move towards the plate as rapidly as they are emitted.

When this point is reached there will be no further increase in plate current with an increase of plate voltage. This is represented by the section, cd, of the curve in Fig. 4. When there is an accumulation of electrons in the region of the cathode due to an insufficient rate of removal of electrons by the plate, the tube is said to be operating under a space-charge lim-

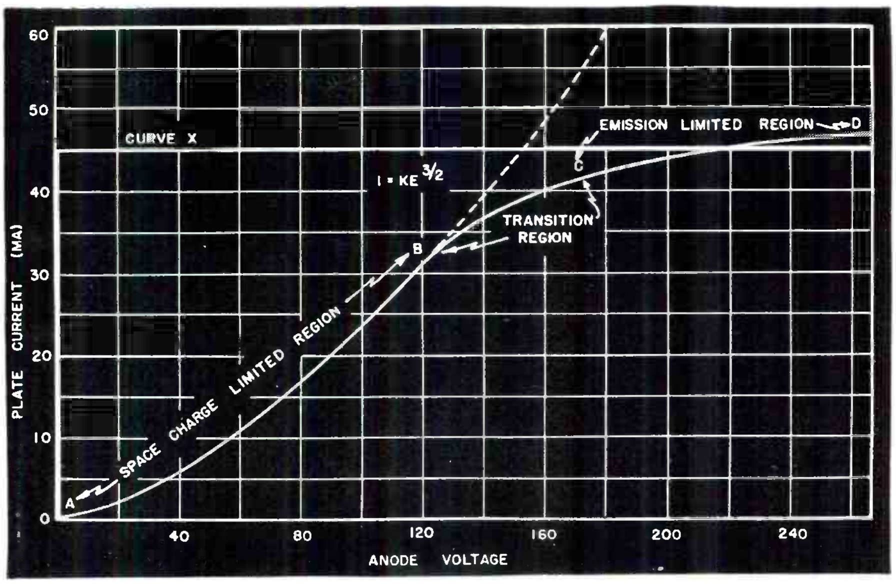


Fig. 4.

ited condition. The term space charge comes from the fact that the accumulated electrons in the region around the cathode have a negative charge. As long as the tube remains in a space-charge limited condition the plate current will be determined entirely by the geometry of the tube and the plate potential.

The relation between the current and the plate potential in a tube operating under space charge limited conditions is given by the equation

$$I = KE^{3/2}$$

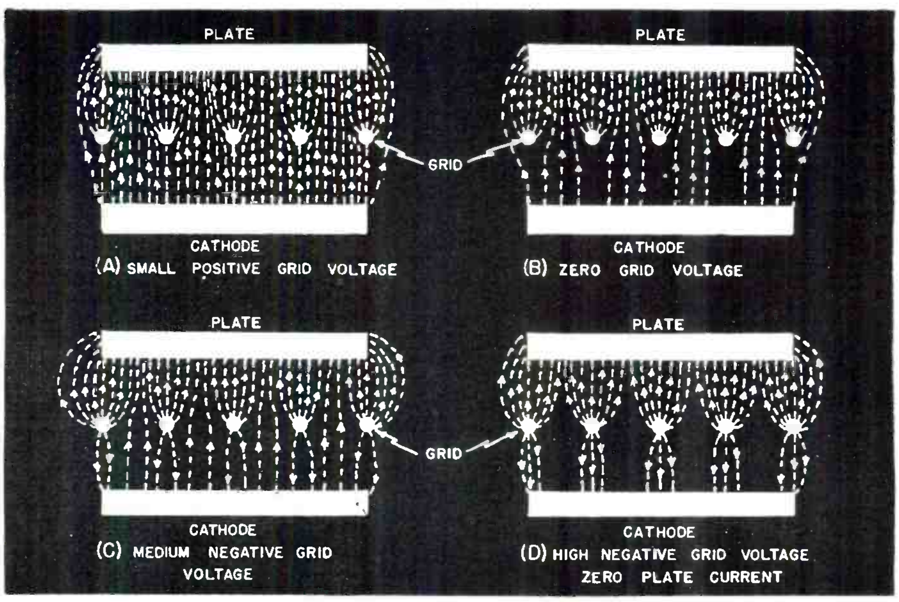
where I is the current flowing to the plate, K is a constant depending upon the shape and distance between electrodes, and E is the plate voltage. The first part of the curve shown in Fig. 4 is a graph of this equation and is shown continued by the dotted line. The flat part of the curve that depends upon the number of electrons the cathode will emit is determined by the temperature of the cathode, and is therefore governed by Richardson's equation given in the preceding article.

As the cathode temperature is raised the cathode will emit more electrons, and the emission will follow the 3/2 power law until some higher value of plate potential is reached which will now give the electron enough acceleration to remove all electrons from the cathode. When the tube is operated with the plate potential sufficient to remove all electrons from the cathode as fast as they are emitted, the tube is said to operate under emission limited conditions. A tube of this sort, having two electrodes, a plate and a cathode, is called a diode and as will be seen has the property that it will only conduct electricity in one direction.

In 1907, Lee de Forest placed another electrode in the vacuum tube which enabled him to exert much more control over the electrons than it is possible to obtain with the diode. This

(Continued on page 64)

Fig. 5.



MOBILE CRIME LABORATORY

The huge truck shown with tower in place ready for action. Note officer in turret.

Driver's position in truck. Control panel and handset are within easy reach.

by **CARL H. NICHOLSON**
Chief Eng., Illinois State Police Radio System

This specially-designed mobile laboratory contains the finest radio equipment and accessories.

THE advantages of radio communication and sound equipment have been fully realized in the new mobile crime detection laboratory and emergency unit recently placed into operation by the *Illinois State Highway Maintenance Police*.

This ingenious crime laboratory on wheels which also can be utilized as a mobile hospital, a combat unit tough enough to handle anything short of an army tank, an emergency electric power station and a fire fighting and life saving unit, was designed by T. P. Sullivan, director of the *Illinois Department of Public Safety* and Professor Leonarde Keeler, an internationally famous criminologist and inventor of the lie detector.

It is completely equipped with every conceivable scientific device and practical piece of police apparatus for emergency use. The idea of the laboratory was originated by Governor Dwight H. Green of Illinois and the final result of this work developed into a huge mobile unit 29½ feet long and 11½ feet high, armoured throughout with bullet-resistant steel, with windows and windshield of heavy bullet-resistant glass, and powered by a 131 horsepower Hercules engine.

It carries elaborate radio and audio equipment to provide the necessary communication and public address facilities needed in a modern police system.

The main radio transmitting equipment consists of a 150 watt crystal controlled transmitter capable of operating on five frequencies of the emergency, special emergency, zone, interzone and state police channels. It was built by radio engineers of the *Illinois State Police* radio system at the laboratory in Springfield, Illinois. The circuit consists of a 6L6 oscillator and an 813 amplifier operated class C. To modulate the 813 an audio amplifier employing a 6SJ7, two 6C5 tubes (one being an audio limiter) and a 6L6 is used driving two type TZ-40 tubes in Class B.

The tank circuits for the transmitter are all pretuned and the frequencies are selected by means of a selector switch. The transmitter may be operated remotely from either the driver's seat or from the rear of the vehicle if the regular operating position is not used.

The remote control panels allow the AC generator power supply to be placed in operation, controls the tube filaments, contains a microphone jack, receiver volume control and a switch to select either a front or rear loudspeaker or both. The microphone contains a press to talk switch which controls the plate voltage of the transmitter.

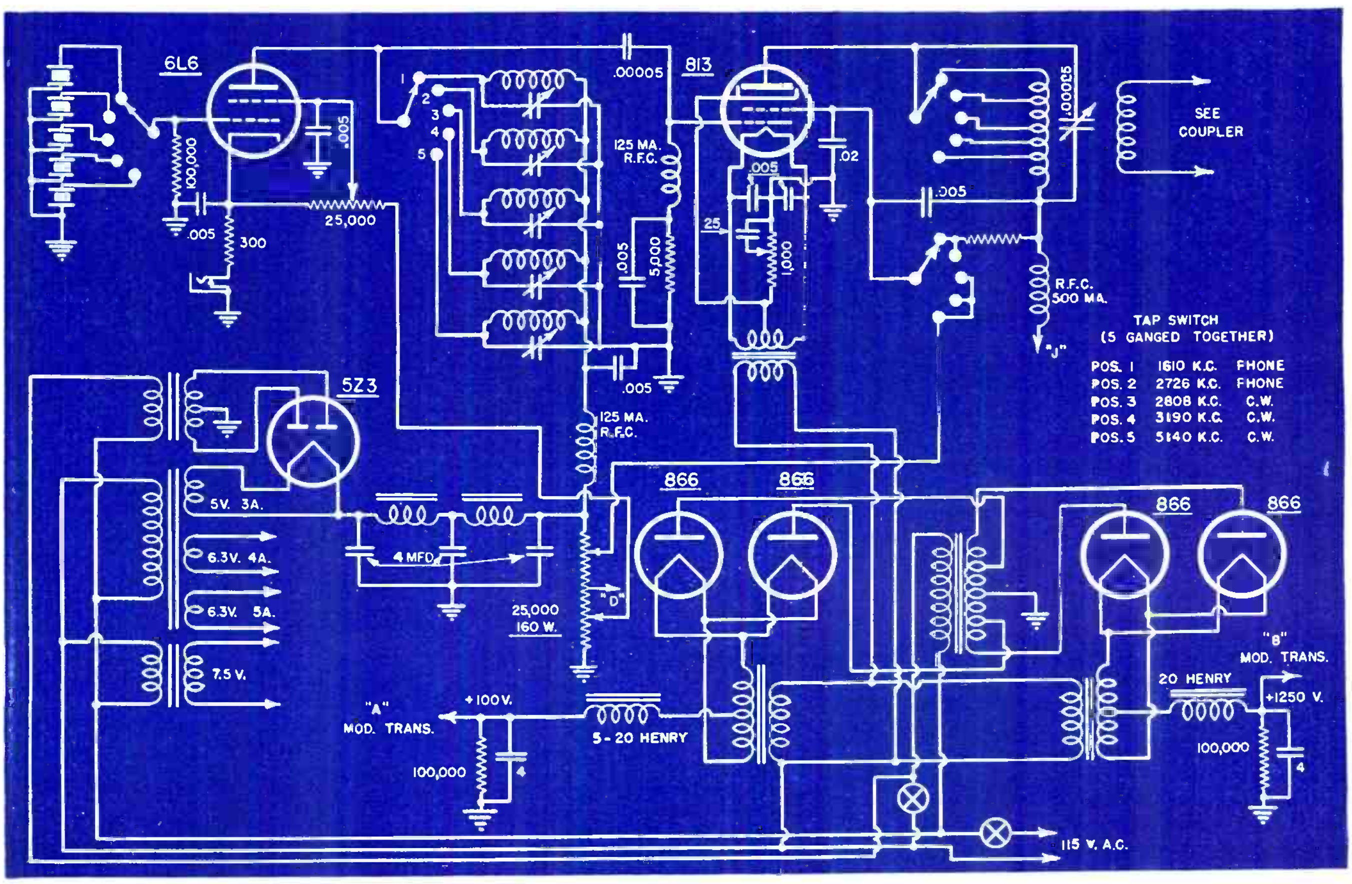
An ultra high AM 25 watt transmitter operating on 39.180 mc. is also available to be used in conjunction with small pack transmitters and receivers. These pack units are not completed at this time. However, they will be able to be carried on foot and will be of ample strength to cover walking distances from the vehicle.

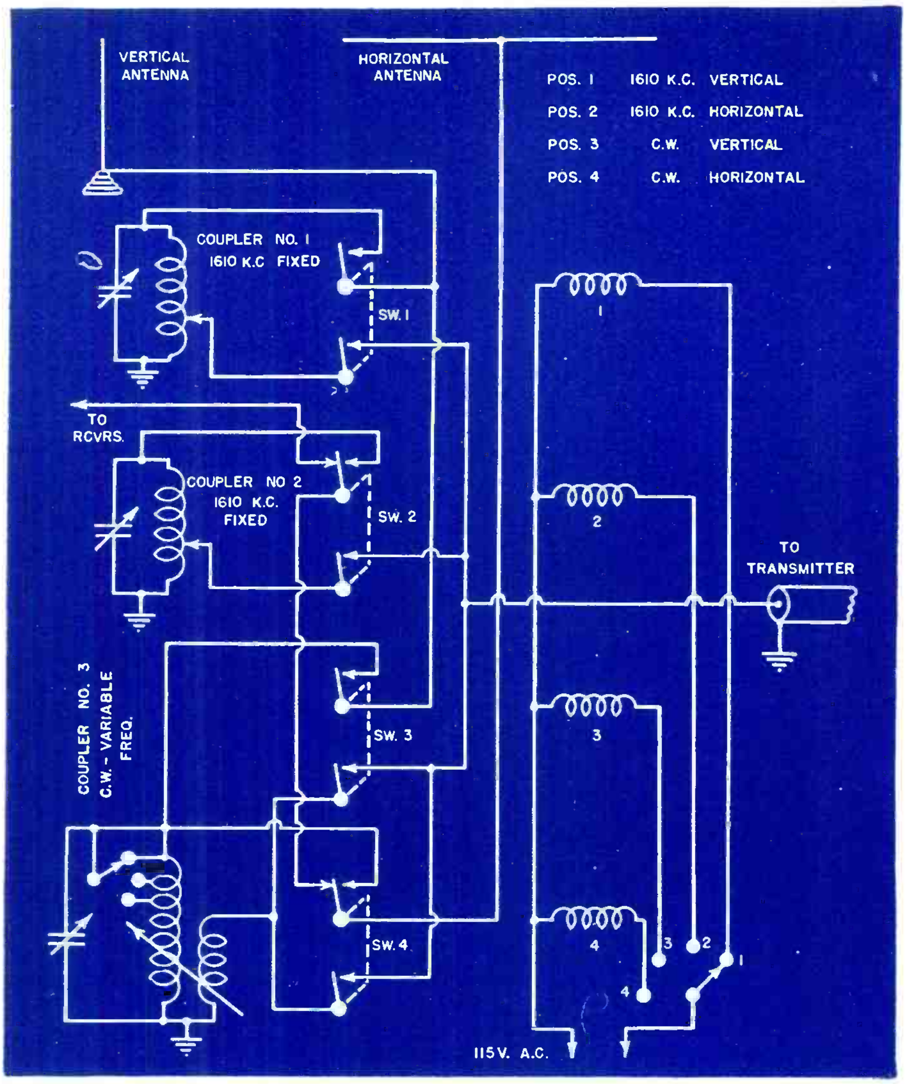
The receiving equipment consists of a *Hallicrafter* SX-28 communications receiver and a S27 AM or FM ultra-high-frequency receiver covering the entire spectrum of police frequency allocations. An *RCA* MI-7819 automobile receiver is mounted in the front cab and is fix-tuned to the 1610 kc state police frequency. With this receiver the state frequency is monitored at all times without using the AC generators.

All transmitters, receivers and high voltage supplies, with the exception of the 1610 kc. receiver in the front cab, are mounted on a single standard relay rack structure which is hinged to swing out for maintenance and service work. A hinged shield is attached at the proper height on the rack for use as an operating table to hold a telegraph key, typewriter and microphone when necessary, and adjacent compartments are furnished for message forms, telegraph key, spare parts, microphone and tubes.

Lt. Stuper speaks through the elaborate PA system which is an important part of the complicated radio system.

Schematic diagram of the 150 watt phone and cw transmitter with power supply.





An elaborate antenna coupler was designed for the special transmitters.

Two transmitting and one receiving antennae are provided on the vehicle. Two horizontal insulated railings twenty-five feet in length mounted on the roof are utilized. One is used for transmitting and the other for receiving while the vehicle is in motion. A compressed air operated telescopic vertical antenna is used to obtain maximum transmitting range when the vehicle is in a fixed position. This vertical antenna, which extends to a height of 35 feet above the top of the laboratory when fully extended, is a custom built affair. It consists of five sections of brass pipe, the bottom section being about 1½ inches in diameter, each section of reduced diameter to about ⅝ inch at the top. The vehicle's engine supplies air pressure through the regular air brake supply tank. It is so constructed that it will remain vertical even though the engine is not running.

The proper transmitting antenna is selected by a rotary switch controlling relays for selecting one of the three antenna couplers. Number one position connects the main transmitter to the vertical antenna through a coupler fixed at 1610 kc. only. The second position selects a second coupler for the horizontal antenna. The third and fourth position selects either vertical or horizontal antennas for radio telegraph through adjustable couplers for all other frequencies.

The public address system is an *RCA* type MI-4117 50 watt audio amplifier with four channel inputs with individual mixer controls. It is mounted under the armoured turret accessible from the radio operating position. This amplifier may also be controlled from the remote control position.

Two narrow beam trumpet type speakers are mounted concealed in front of the vehicle for maximum projection of sound directly ahead of the unit. Two non-directional high fidelity waterproof cone type speakers are mounted on the rear of the unit. These speakers allow a wide coverage for addressing assemblies and the microphone may be used in the cab, rear compartment or turret if desired.

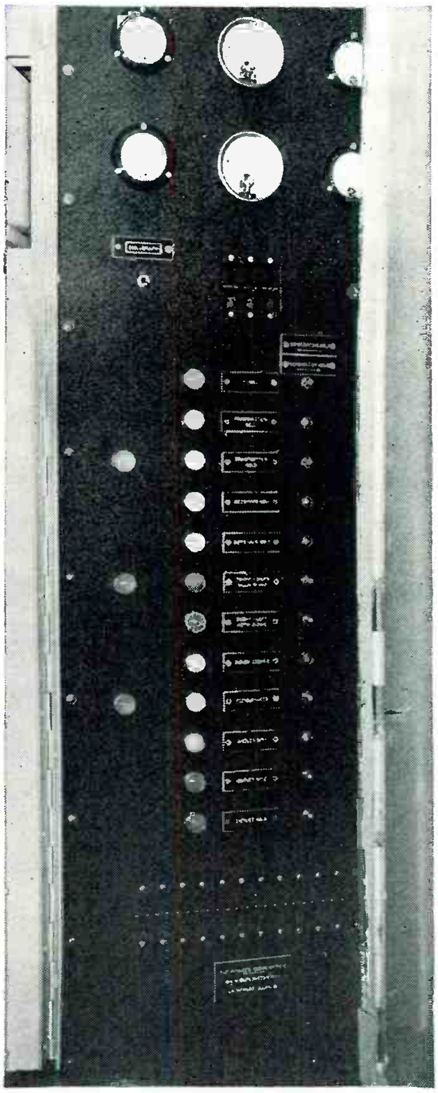
A portable *Presto* 12-inch recorder is used for recording confessions, statements, etc. By means of jacks and patch cords the following combinations can be obtained. The radio receivers may be fed into the recorder, the PA system may be fed into the recorder or the recorder may be played back through the PA system. The radio receivers may also be placed on the PA system.

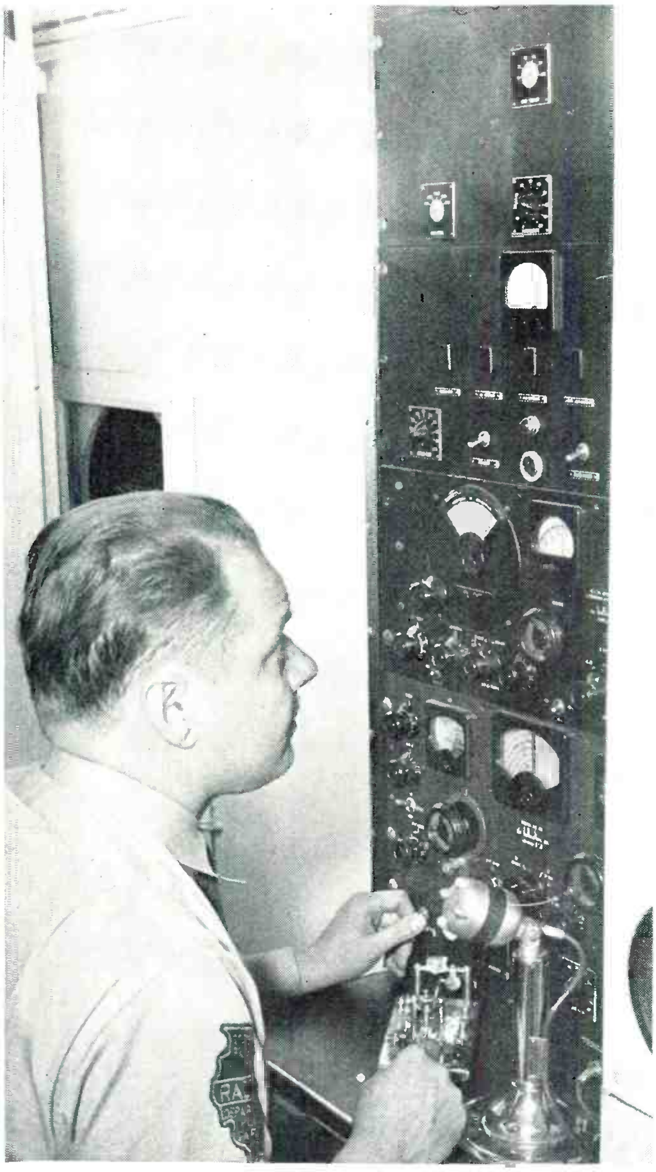
In conjunction with the recorder and lie detector, a portable rotary converter is used in which 110 volts AC is obtained from a 12 volt DC supply. This DC supply consists of two 6 volt storage batteries placed in a carrying case. The converter and batteries have a compartment of their own in the laboratory, however, they may be easily carried out if portability is desired.

The purpose of this rotary converter is two-fold. One reason is to obtain a noise and vibration free source of power for the lie detector. This sensitive instrument cannot be operated on the 3 kw. motor generator supply without picking up vibration from the unit. The other reason is to enable either the lie detector or recorder to be taken out in the field where no AC supply source is available.

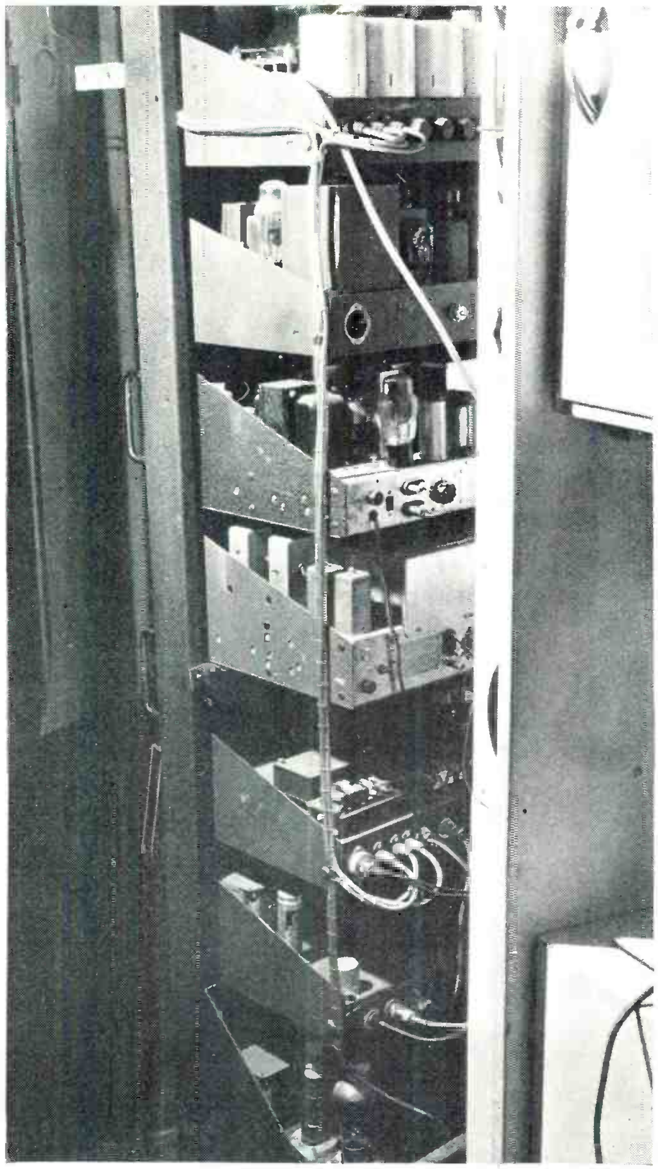
Power to operate the radio and audio equipment is furnished by two 3000 watt 60-cycle 115 volt single phase gasoline driven generators (*Continued on page* 78)

Master control panel has full complement of indicator lamps.



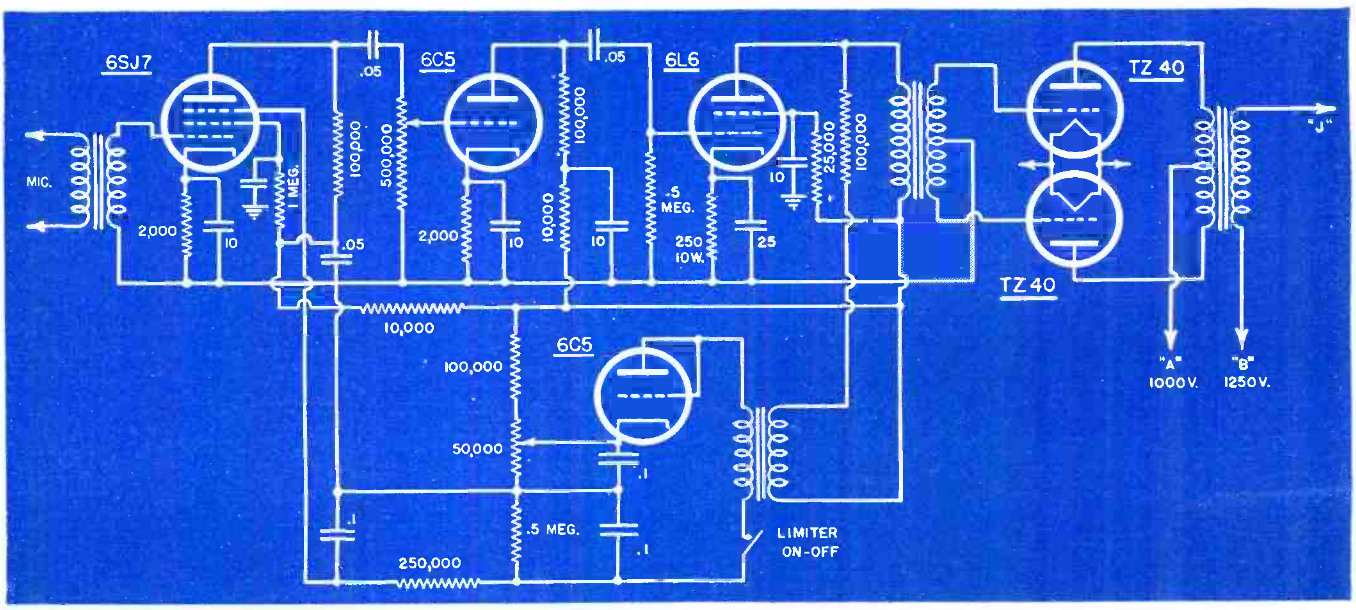


E. Erickson, Supervising Operator, at the key in front of the receiver position.



Rear view shows the Hallicrafters sets and speech amplifiers. Note cabling.

The modulators for the transmitter are a pair of TZ 40's.

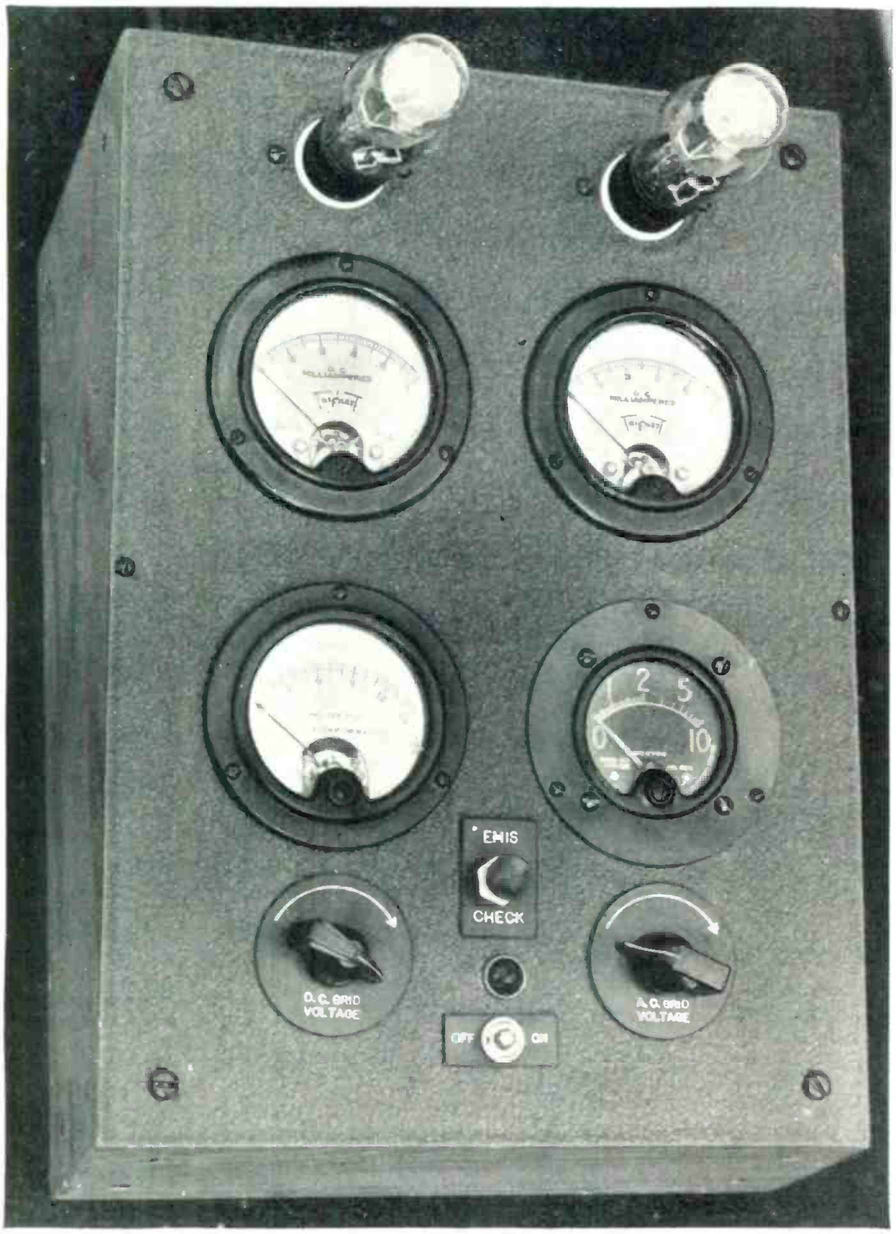


A THYRATRON TUBE TESTER

by WILLARD D. STEWART

Tubes used as shield-grid thyratrons must be checked for emission and matching characteristics in order to insure best performance.

All parts of the tester are mounted on the panel.



GRID-CONTROLLED rectifier service where the operating frequency is relatively low is an important phase of electronic applications. For this medium of control, the 2050 and 2051 inert or hot gas tetrodes, or more popularly known as shield-grid thyratrons, are used very effectively. So as to assure the utmost in tube efficiency, it is necessary that these tubes be checked for emission and matching characteristics, particularly after they have seen some constant service. To provide such a checking service, the test device shown in Fig. 1, was developed.

The structure and resultant properties of thyratrons are quite unlike those of receiving tubes and thus the test instrument must include the necessary means of checking these properties. In the thyratron, for instance, because of the special electrode structure, the preconduction of gas-leakage currents to the anode are extremely small right up to the beginning of the conduction cycle. Once the plate current has started to function, its magnitude is determined by the plate supply voltage and the load of the plate circuit.

The plate current is independent of the grid bias value, but the initial bias starts the plate current. The plate current is stopped by opening this circuit or by creating a polarity reversal. In order to accomplish the latter, the condition must occur at a no-grid-bias interval. The value of the grid potential at which the plate current starts is called the critical value. It is this value that this test instrument checks, in addition to other necessary characteristics.

In these tubes, the grid current is very low (less than a microampere), so that a high resistance may be used in the grid circuit. This characteristic provides the tubes with a high sensitivity, permitting their operation directly from a vacuum type phototube. Since the 2050 and the 2051 have a very low grid-anode capacitance, they are not appreciably affected by line-voltage surges.

Either a direct current or alternating current source may be used to supply the anode voltage in a relay application circuit using the thyratrons. When the direct current supply is used, the circuit is said to have a lock-in feature, since the anode potential must be removed momentarily in order to restore the tube to a nonconducting condition. However, this so-called lock-in feature is not present when the supply is of an alternating current nature. However the average anode current may be controlled by the relative phase of the control-grid, shield-grid and anode potentials.

To match a pair of tubes with this test device or to compare a tube under test with a tube of known characteristics, three steps must be followed. First the tubes must be inserted in the sockets, power turned on and *ten* seconds allowed for normal operating temperature to prevail. Then the direct current bias is adjusted to two and a half-volts. This is regarded as an index value. Once adjusted it should not be changed during the test. This caution is emphasized because of the alternating current and direct current bias circuit arrangement. In the concluding step, the alternating current grid bias is increased to the critical point, so as to establish trigger action in the grid. This reaction is indicated by the meter showing the plate current.

The plate current meters used are of the zero-to-fifty ma type. The direct current bias voltage readings are supplied by a zero-to-fifteen voltmeter, while a zero-to-ten voltmeter supplies the alternating current bias voltage readings.

Thyratrons may be used in truly an endless variety of systems for control operations. At the present it appears as if only the imagination can be called the controlling factor in their application. If, for instance, the voltage or current to be controlled is quite low, the necessary amplifiers can be inserted to raise the impulses to a level that will activate the control grid.

In industry thyratrons have been employed successfully in such unique projects as seam welder controls. This tube is so efficient as a control device here because it controls with extreme accuracy the current flow producing each of the overlapping spots or spaced spots which comprise a seam weld.

By closing the circuit at precisely the same point on the alternating current voltage supply wave each time, transient currents are minimized. And these transients are quite troublesome and a cause of irregular welding. Essentially, the thyratron control is a precise timer controlling an electronic switch, with no moving parts. This governs the current to the welder.

Sequence timers are another popular user of the thyratron. Using the tube here in a synchronous system affords an accuracy of control that is better than plus or minus ½ cycle per second.

The use of the thyratron for control of motors, which today is an exceptionally important factor, is quite an old project for the thyratron. While it is true that today, the systems have been improved and streamlined, those adopted as far back as 1938 were quite successful, too. In a report made by G. W. Garman of *General Electric,* the value of the thyratron as an effective means of direct current motor control was shown. He pointed out that this tube when used as a phase-controlled rectifier could provide the necessary smooth control of the voltage applied to the armature or the field without materially increasing the losses or changing the load-speed characteristics. Another advantage, he explained, was in the fact that the desirable characteristics of the direct current motor could be used without requiring a direct current source of power.

Today we hear of many instances wherein the thyratron is used to control lighting. Its use for this purpose started many years ago too. In 1937, its use was adopted for scene fading systems, rehearsal systems and even a three-scene preset system. Today its use in the theatre is as essential as the lights, or bus wires that carry the current. When the three scene preset system was installed in the Metropolitan Opera House some six years ago, the innovation frightened the old-timers. However one performance convinced everyone that here was a new mode of light control that was destined to become a "must" throughout the theatrical industry.

Actually there are two types of thyratrons. One contains a heated cathode, control grid and an anode. The other, for which this test device was designed, contains the additional element . . . the shield grid. This shield grid, shields the control grid partially from the electron stream, permitting the use of higher grid impedances. It also shields the plate and cathode from each other, thereby affording more flexible control properties.

The inert gas in the tube reacts in a fashion similar to that occurring in a gas phototube. That is, it is ionized by collision with the emitted electrons, and increases the current many times. Since an ample supply of electrons is assured by the large cathode at operating temperature, the positive voltage of the anode will never appreciably exceed the ionizing voltage of the gas, of let us say, 10 to 20 volts, for any reasonable current. However, if current should be demanded before the cathode has reached the proper temperature, and this may require five minutes or more in the larger sizes, sufficient electrons to neutralize the heavy positive gas ions may not be available. Thus the ions may bombard the cathode at high velocity, chipping off the active material and damaging the surface. And the same action may take place if an excessive load, short circuit or other defect demands a current which exceeds the cathode rating.

As long as the thyratron is not conducting, as for instance, when the grid is held sufficiently negative to prevent current flowing, the anode may remain positive without current flow, exactly as in a standard vacuum tube. However as soon as electron current begins to flow to the extent that ionization may take place, the resulting ion sheath completely shields the grid and no further grid control is possible. The grid control can only be regained if ionization ceases and the current stops. If an alternating current power supply feeds the anode, the current will stop when the negative half-cycle is reached. And if the anode is supplied with direct current the current may be stopped by opening the anode circuit, connecting the anode to cathode for an instant, or driving the anode negative by a capacitor charge.

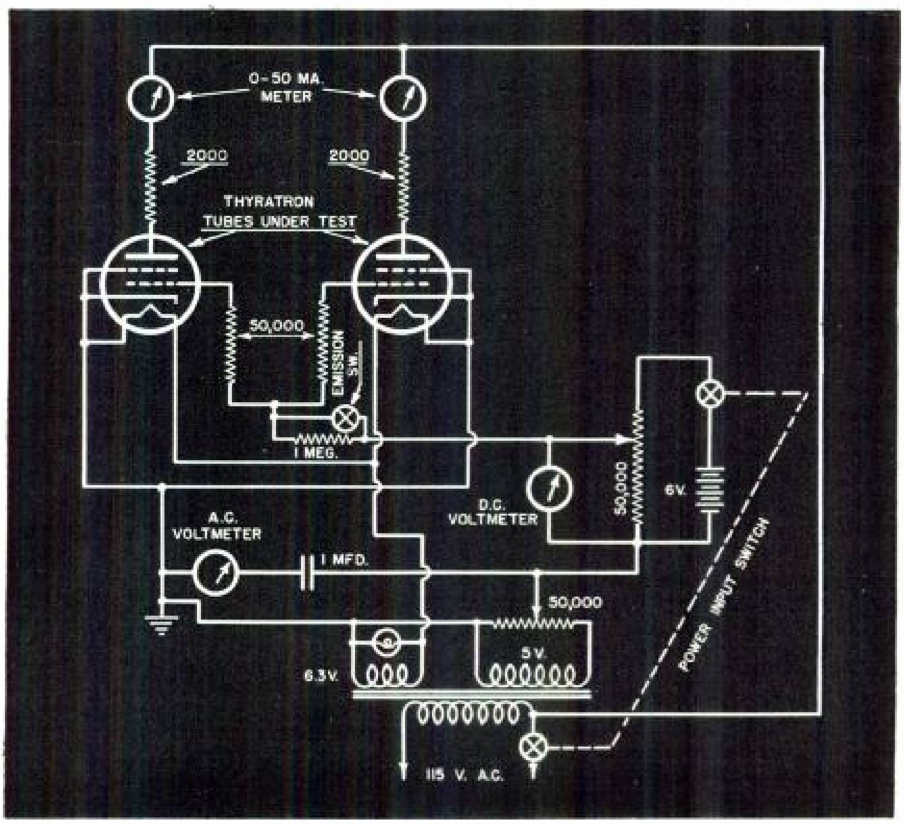
The use of thyratrons as a phase-control device offers students, engineers and experimenters a most fascinating subject and field, in which to dwell today.

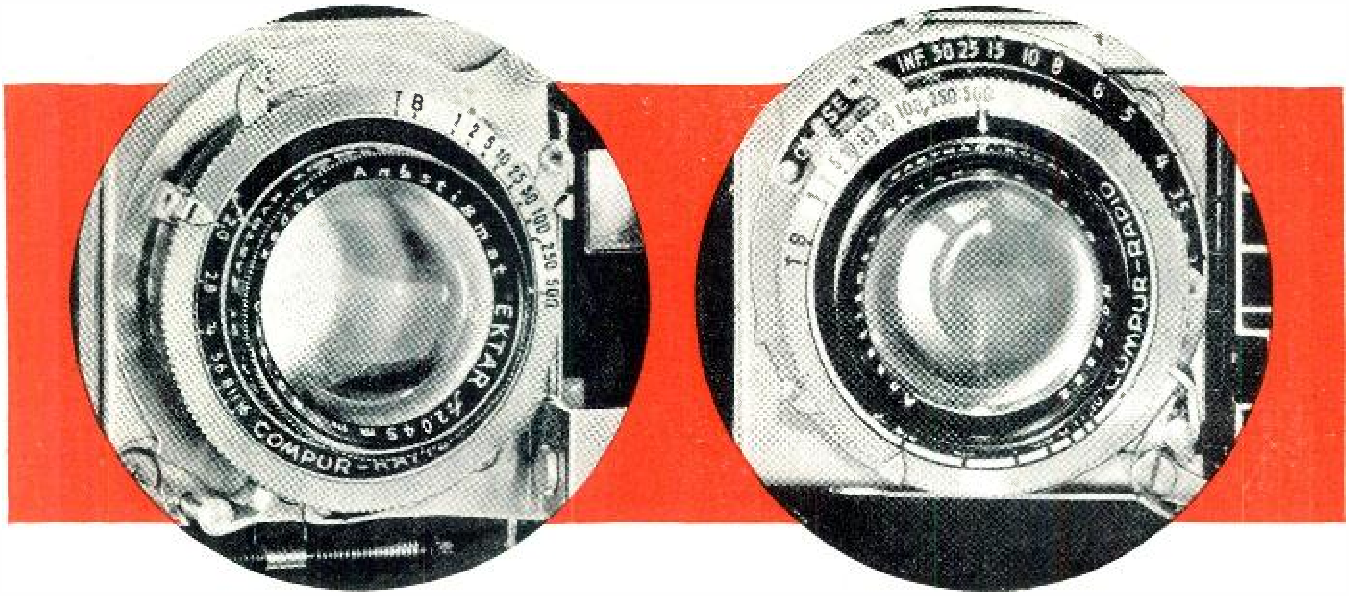
Acknowledgment

To Charles W. McKee, the author wishes to express his profound thanks for the kind assistance given in the preparation of this paper.

-30-

Fig. 1. Circuit diagram of the thyratron tube tester.





Camera lenses are ground for specific functions. Photocell units use several different types.

OPTICS FOR PHOTOCELL HOBBYISTS

by GUY DEXTER

The experimenter who deals with photocell equipment should understand the fundamentals of optics and associated lenses.

THE electronic experimenter who concentrates mainly on photocell applications soon discovers that the principles of light transmission and measurement are invaluable working information. He finds that transmission of light energy, reflection and refraction of light beams, and measurement of light intensity and the efficiency of optical systems embody more technical details than meet the eye. In order more effectively to utilize light as a link in electronic control, familiarity with the leading ones of these details is essential.

The basic principles of light, including basic technology of lenses, reflectors, prisms, etc., are encountered by every student of physics. However, it is unlikely that the radio man, who concentrated on another branch of physics — *electricity,* will remember much of his light physics. We present this review for the benefit of those, who having forgotten the principles, need a refresher and for those who, having never before encountered the subject, require a streamlined survey of the field.

Photometry is the art of measuring light intensity. The art of measuring light is older than that of measuring electricity.

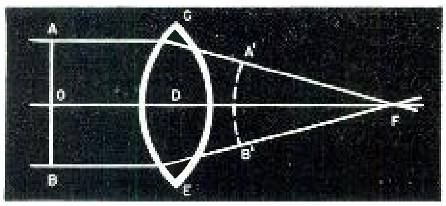
A number of the units and definitions for optical quantities are the contribution of photometric science. Photometry reduces to quantitative terms all reckoning regarding amount and intensity of light energy.

Photometry is not a difficult subject for radio and electronic experimenters to understand; since light, being of a vibratory nature, behaves very much like radio waves and we may accordingly fetch up many radio analogies in explaining light action.

Wavelength and Velocity

Like radio waves, light waves may be measured with respect to *wavelength.* Wavelength, as in the case of radio waves, is proportional to frequency or *vibrations per second.* Wavelength in light very conveniently reveals itself in visibility or invisibility and *color.* This brings up the point that there is more to the light spectrum than the human eye is able to detect—at either end of the visible band are the enormous invisible regions.

Fig. 1. Converging lens action (real image).



In the visible spectrum, light wavelengths extend from 7800 angstrom units (red) to 3800 angstrom units (violet). The angstrom unit, standard for expressing the wavelength of light, is equal to 0.0000000001 meter (one hundredth-millionth of a centimeter). Compare these wavelengths with those of radio waves — e. g., a radio frequency of 1000 megacycles equals 0.3 meter. Along the visible spectrum, lie red (7800-6300 A. U.), orange (6300-6000), yellow (6000-5600), green (5600-4900), blue (4900-4400), and violet (4400-3800). Beyond the red region, lie the infra-red rays; and beyond the violet region, lie the ultra-violet rays.

The velocity of light is identical with that of radio waves; 186,000 miles per second or approximately 300,000,000 meters per second.

Reference to the data supplied by manufacturers of photocells will reveal that some of these devices are especially sensitive in certain regions of this visible spectrum. *Spectral sensitivity* curves supplied show the response of the photocell (generally in microamperes output) for a given amount of light excitation at various wavelengths (colors). The wavelengths are generally stated on these curves in millimicrons. 1 micron is equal to 0.001 millimeter, or 0.000001 meter.

The Solid Angle

Since a number of the definitions of photometry are based upon the *unit solid angle,* we introduce here an explanation of that term. The solid angle is defined classically as the angular region enclosed by three or more planes meeting at a point, such as at the vertex of a cone. If we visualize a solid angle formed by planes which meet at the center of a sphere, we see that the planes describe an enclosed area on the surface of the sphere. If we assume the sphere to have *unit* radius, then we may say the solid angle is equal numerically to the aforementioned enclosed area on the surface of the sphere. Thus, any solid angle may be defined in terms of the

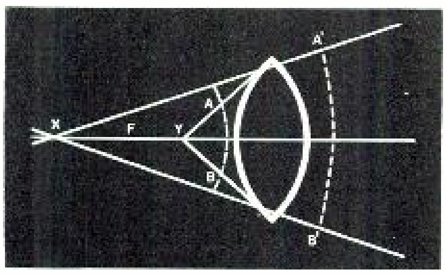


Fig. 3. Virtual image action.

sphere of unit radius, by determining the size of the section (which may be of any shape) that is enclosed on the surface of a sphere of unit radius.

The unit solid angle is the *steradian,* equal to the central solid angle intercepting a spherical area equal to the square of the radius. About any point, the *total solid angle* is equal to 12.56 steradians.

The solid angle becomes extremely useful to us in dealing with light which we conceive as composed of a number of rays in a solid section of space. This concept is analogous to that of magnetic flux, which we conceive as made up of numerous lines of force in a solid portion of space.

Terms and Definitions

Luminous intensity has to do with the amount of light impinging upon a surface, and is governed by the intensity of the source and its distance from the illuminated surface. The unit of luminous intensity is the *candle,* in which term the luminous intensity of any source may be expressed. Our universal use of the term *candlepower* results from the fact that candles were

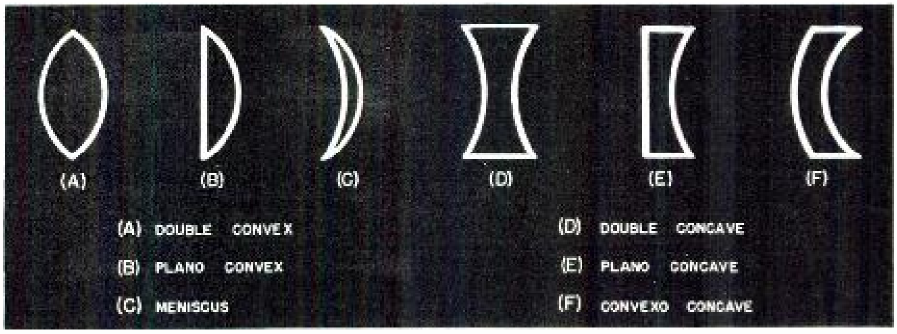


Fig. 2. Illustrated above are six types of lenses.

the established source of artificial light when the basic photometric standards were set.

Illumination describes the amount of light falling upon a lighted surface and is expressed in *foot-candles.* One foot-candle is the illumination given by 1 standard candle placed 1 foot from the illuminated surface. Similarly, 1 *meter-candle* (also called 1 *lux*) is the illumination produced by 1 standard candle at a distance of 1 meter.

Luminous flux has been defined as the "rate of flow of radiant energy." The unit of luminous flux is the *lumen.* One lumen is the luminous flux emitted in 1 steradian (unit solid angle) by a light source with average intensity throughout the solid angle of 1 candle. If the source has uniform candle power in all directions (such as would be true if the source were at the center of a sphere of reference) and is numerically equal to 1 candle, the emitted flux is 12.56 lumens.

From a slightly different viewpoint, the lumen may be said to be the amount of light which flows through an area of 1 square meter at a distance of 1 meter from 1 standard candle, or through 1 square foot of area at a distance of 1 foot.

Brightness expresses intensity per unit area and applies both to self luminous and illuminated objects or surfaces. Thus, brightness is expressed as the luminous intensity of the surface divided by its area. The unit of brightness is the *lambert.* It is also common to express brightness in candle power per square centimeter (1 c. p. per sq. cm. = 3.14 lamberts). The practical unit of brightness is the *millilambert,* equal to 0.001 lambert. The interrelation of the various brightness expressions may be seen from the following equations:

1 candle per sq. cm. = 3.141 lambert.

1 candle per sq. in. = 0.1150 candle per sq. cm. = 0.4869 lambert.

1 lambert = 0.3183 candle per square cm.

Luminous efficiency is expressed in lumens per watt, and is the ratio of the total light radiation in lumens to the total energy radiation in watts. The mechanical equivalent of light is shown by:

1 lumen = 0.001497 watt.

1 watt = 668 lumens.

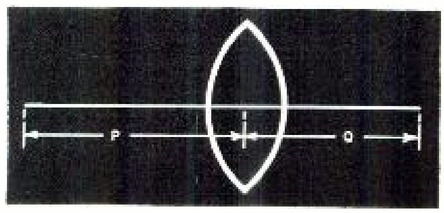
(From *Handbook of Engineering Fundamentals.* Eshbach. Wiley.)

Light Source	Brightness (candles/sq. cm.)	Eff. (lumens/watt)
Sun, outside earth's atmosphere...	200,000	100
At horizon..	600	....
Clear Sky (av.)	0.4	....
Black Body at 6500° K....	294,000	90
At 4000° K.	24,350	52.2
Electric Arcs		
Searchlight Arc	50,000 to 70,000	....
Crater of carbon arc	16,000	....
Mercury-vapor arc (glass)	2.3	14
Incandescent Electric Lamps		
1000 watts gas-filled tungsten ...	1210	20
500 watts tungsten ...	1000	18.1
100 watts tungsten ...	579	12.9
40 watts vacuum tungsten	203	10
Tantalum (2 watts per candle)	53.1	5
Treated carbon (3.1 watts per candle)	70.6	3.4
Untreated carbon (4 watts per candle).	54.9	2.6

Standards. The *international candle* is the international unit of luminous intensity. It is taken as the light emitted by 5 square millimeters of platinum at the temperature of solidification. The *international foot candle* is the direct illumination on a sur-

(*Continued on page* 75)

Fig. 4. Relations for lens equation.



WARTIME PROGRESS IN ELECTRONICS

by ROBERT EICHBERG
Electronics Research Engineer

New circuits for applications in military and civilian production are discussed.

HALF-WAVE voltage-doubling rectifiers have been widely used for a long time, particularly in inexpensive receivers designed to operate directly from the 115-volt A.C. lines without benefit of a power transformer. Yet it has remained for D. L. Waidelich of the University of Missouri and C. H. Gleason of *Westinghouse,* both Associates of the *Institute of Radio Engineers,* to analyze their operation and to compare the half-wave with the full-wave circuits. This is illustrated in a recent issue of the I.R.E. *Proceedings,* from which the accompanying diagram, Fig. 1, and the following information are taken.

At a glance, the connections will show that Tube T_1 conducts during half the A.C. cycle, while T_2 conducts during the other half; and according to the authors, condenser C_1 is charged to approximately the peak value of the supply voltage while T_2 is conducting while being discharged during the remainder of the cycle. For the purpose of simplifying the analysis, the authors assume that the A.C. supply has a sinusoidal wave-form of zero impedance; that the resistance of the tubes is zero when conducting and infinite at other times; that the condensers have the same capacity and zero power factor; and that the load resistance has zero inductance.

As these assumptions are made, the complete circuit may be broken down into three equivalent circuits: (1) with Tube T_1 conducting, (2) with neither tube conducting, and (3) with Tube T_2 conducting. With T_1 conducting, the effective circuit may be described as a D.C. circuit consisting of C_1 in series with R, with C_2 in parallel with R, and with the positive potential applied through C_1. With neither tube conducting, the equivalent circuit is merely C_2 in parallel with R, with potential stable so that current flows unidirectionally, in the same direction as during the conductive period of T_1, due to the charge on C_2. The third equivalent circuit (which, together with the second, described above, illustrates the conductive period of Tube T_2) shows C_1 inserted in a D.C. line of the same polarity as that in the previously mentioned circuits.

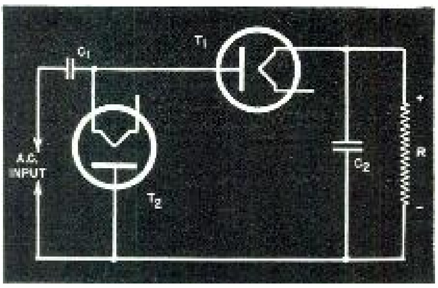
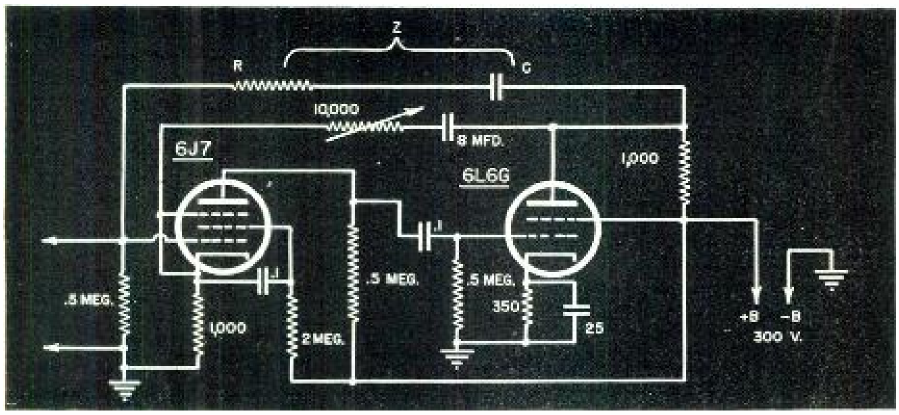


Fig. 1. Half wave voltage-doubler.

The input condenser, C_1, must be of sufficiently high rating to withstand the supply voltage; while C_2, the load condenser, must be able to handle twice that voltage.

According to the authors, both half-wave and full-wave voltage doubling rectifiers afford advantages and disadvantages. The full-wave, they say, affords higher input power factor, lower peak tube currents, output voltage with somewhat less ripple (and that ripple of higher frequency) and slightly better voltage regulation. The half-wave provides lower peak inverse tube voltages, lower effective input currents, and permits grounding of both load and input source, for one lead is common to both.

Fig. 3. A new circuit for producing negative resistance.


The article in *Proceedings* goes into considerable detail as to the design of the circuit and an analysis of its characteristics, but space does not permit a more complete discussion here.

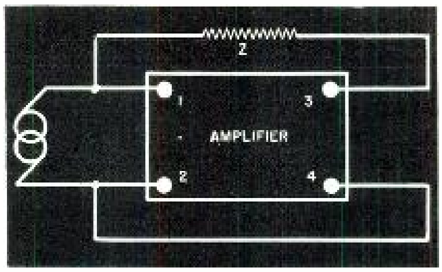


Fig. 2. How negative resistance is obtained.

In the same issue, a couple of engineers discuss the use of positive feedback in conjunction with inverse feedback to secure high stability in a two-stage amplifier of this sort. The writers are Cledo Brunetti, formerly Assistant Professor of Electrical Engineering at *Lehigh University,* now a Radio Physicist at the *National Bureau of Standards* in Washington, and Leighton Greenough, Byllesby Research Fellow at *Lehigh.*

Assuming that a negative resistance is necessary in certain oscillators, tuned parallel circuits and special networks, they have designed one which is independent of frequency, normal supply voltage and tube variations. It is possible, they point out, to couple part of the output of an amplifier back to the input, so adjusting the positive feedback and degree of amplification that the amplifier's input impedance becomes a pure negative resistance.

In Fig. 2, which shows the basic method of obtaining negative resistance, the impedance Z is connected between one of the input and one of the output terminals of a two-stage amplifier. With an extremely high impedance of the input grid of the amplifier, if Ei is the input voltage and A the amplification, the resulting current will be Ii = (Ei —AEi)/Z. From this, the input impedance, Zi, is seen to be Zi = Ei/Ii = Z/(1—A). Thus if A has no phase shift and is greater than unity, say the authors, Zi = Z(—X), where —X is a negative number. Zi may be varied by changing either Z or A—preferably both—for altering the feedback resistance, Z, affords large-step variations in Zi, while changing the amplification affords finer control. However, keeping amplification low increases stability, pro-

(*Continued on page* 70)

THE SAGA OF THE VACUUM TUBE

by GERALD F. J. TYNE

Born at Binghamton, N. Y., 1899. Attended Canisius College & Rensselaer Polytechnic Institute. Served at latter as instructor, 1921-29. Since then has been engaged in development work in one of largest research and engineering organizations. Was ham 1912-15. Started collecting tubes in 1923 and studying tube history in 1932. Has to call in serviceman when anything except a blown fuse develops in his own home set.

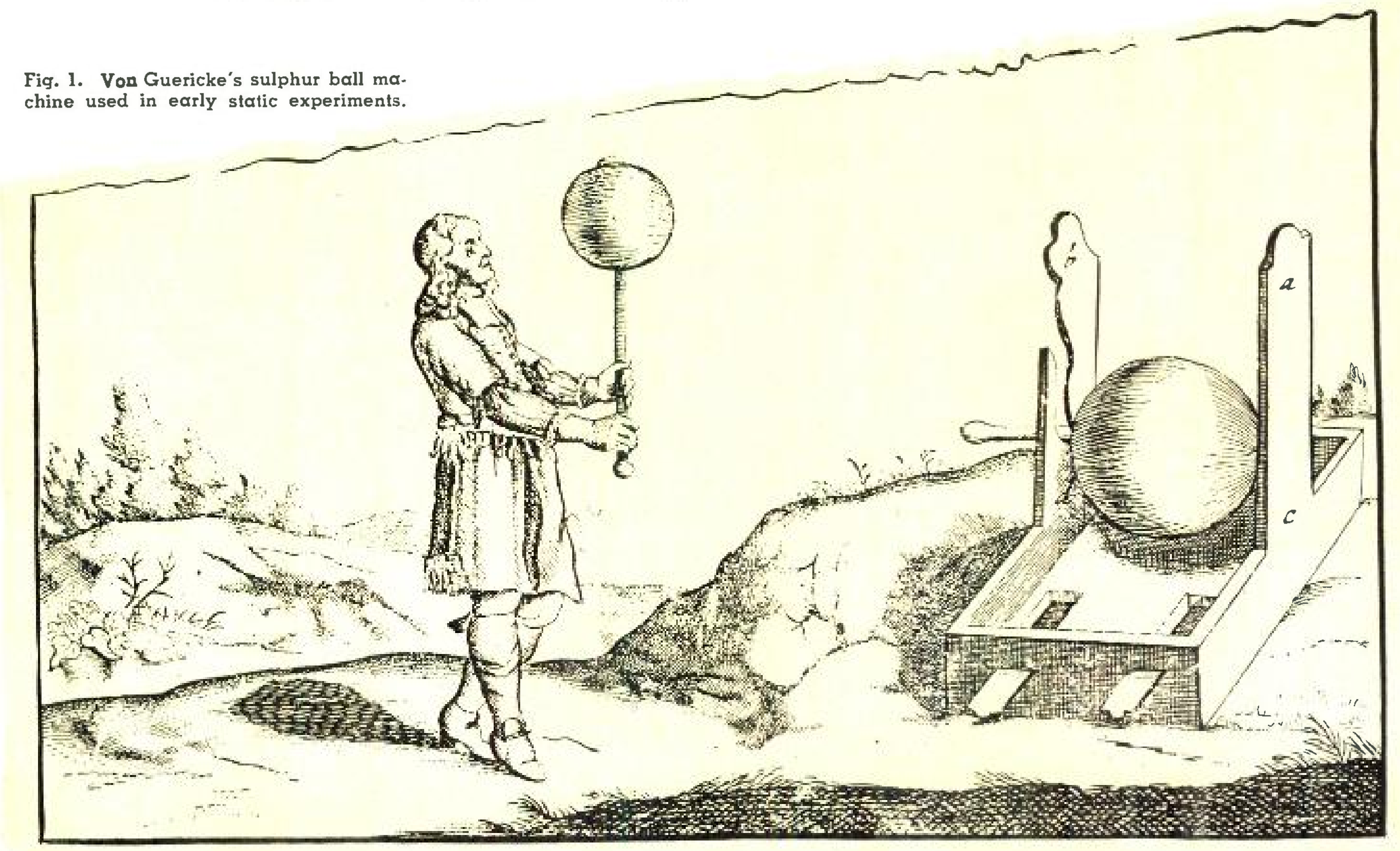
THE modern vacuum tube may well be regarded as the goal toward which scientists were groping for approximately two hundred and fifty years. The early scientists were seeking an explanation of known electrical phenomena, trying to extend the scientific knowledge of the world, and their contributions to later investigations became of great importance. Actually two centuries of scientific research went into building the foundations of the science of thermionics. Another fifty years elapsed before scientists and technical experts produced the tube which in one generation affected everyday living for people all over the world. Around this tube great industries have been built, great fortunes made and lost. In the short space of fifteen years after its first practical application the tiny glow from this tube lighted up endless paths for study in communication, medicine, and other fields. It shed light on some of the darkest mysteries of nature. The culmination of this two hundred and fifty years of tireless searching, studying, and experimenting was the modern Aladdin's lamp, the vacuum tube.

These men of science spent lifetimes spurred on by the conviction that if the electrical phenomena could be understood, this great force in nature might be harnessed and utilized. The solving of the mystery of the combined effects of heat and electricity was one of the greatest challenges science had ever faced. The story of these men who took up the challenge and through sheer heroic persistence mastered the task is a saga as thrilling as any epic of ancient or modern times.

To a great extent we will see that the results attained by scientists and technical experts responsible for the evolution of the vacuum tube reflected the tempo of the ages in which the men lived. In 1672 and the two centuries following, research was geared to a slow pace, partly because of the lack of adequate support for the effort and lack of an efficient system of communication. For what work was done,

Part I of this especially-prepared series of articles giving the complete history and development of the radio vacuum tube.

Fig. 1. Von Guericke's sulphur ball machine used in early static experiments.



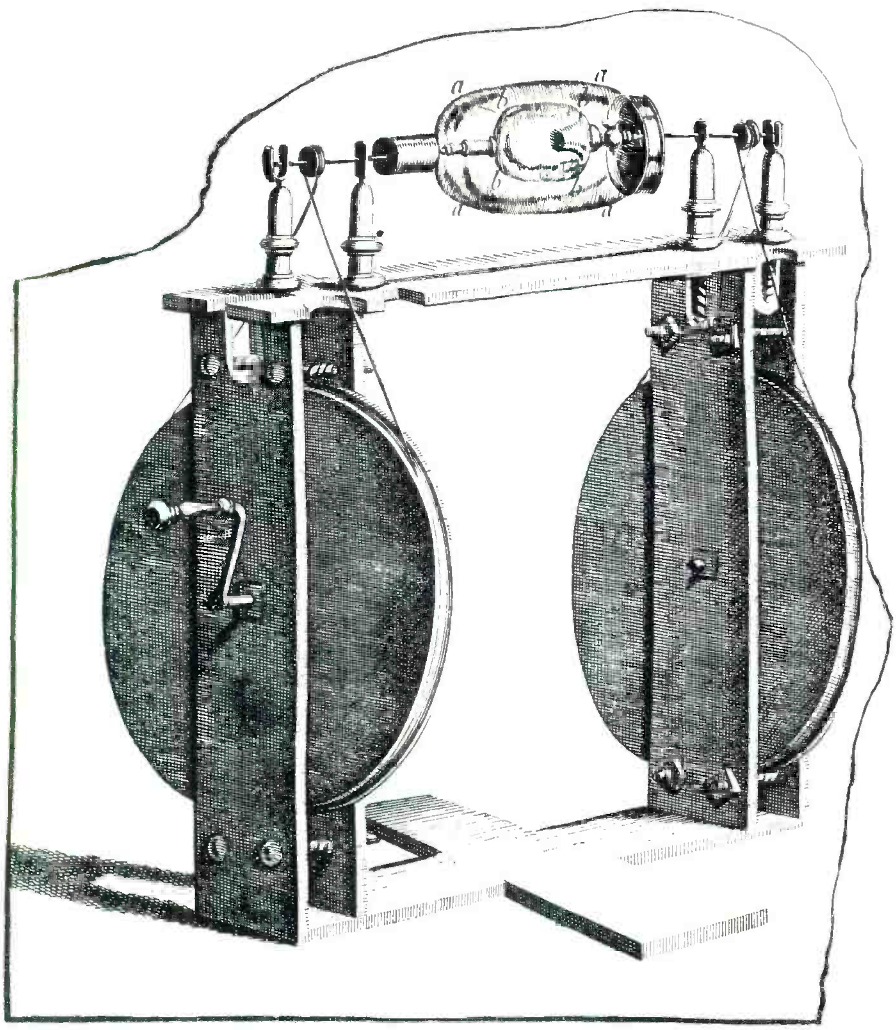
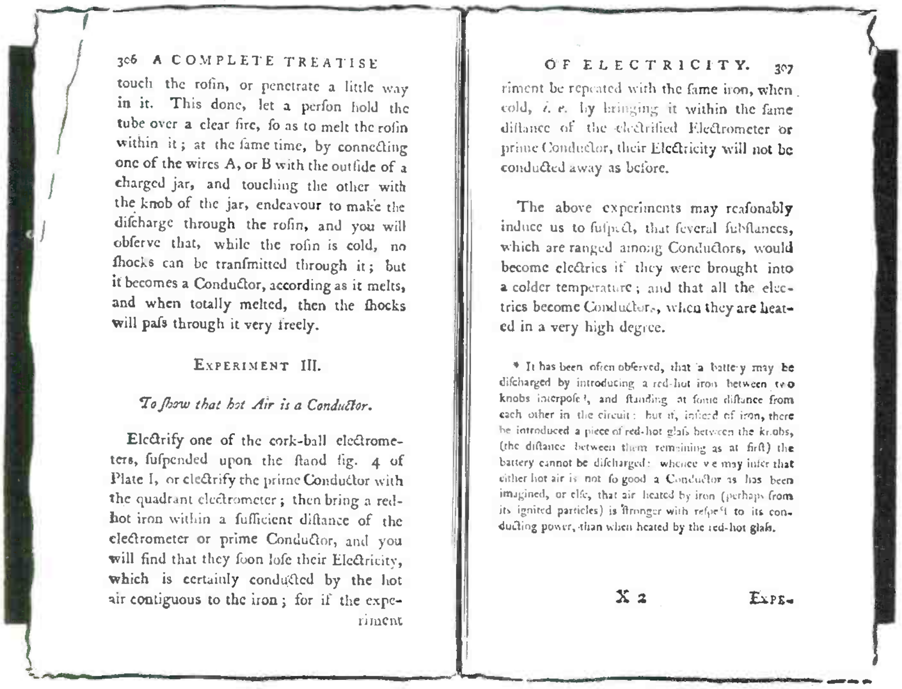


Fig. 2. Cylinder Machine as used by Hauksbee in his early experiments. Note the belt drive to increase speed of rotating elements.

Fig. 4. A reproduction from "Treatise of Electricity in Theory and Practice" (1st edition, London, 1777).



306 A COMPLETE TREATISE

touch the roſin, or penetrate a little way in it. This done, let a perſon hold the tube over a clear fire, ſo as to melt the roſin within it; at the ſame time, by connecting one of the wires A, or B with the outſide of a charged jar, and touching the other with the knob of the jar, endeavour to make the diſcharge through the roſin, and you will obſerve that, while the roſin is cold, no ſhocks can be tranſmitted through it; but it becomes a Conductor, according as it melts, and when totally melted, then the ſhocks will paſs through it very freely.

EXPERIMENT III.

To ſhow that hot Air is a Conductor.

Electrify one of the cork-ball electrometers, ſuſpended upon the ſtand fig. 4 of Plate I, or electrify the prime Conductor with the quadrant electrometer; then bring a red-hot iron within a ſufficient diſtance of the electrometer or prime Conductor, and you will find that they ſoon loſe their Electricity, which is certainly conducted by the hot air contiguous to the iron; for if the experiment

OF ELECTRICITY. 307

riment be repeated with the ſame iron, when cold, *i. e.* by bringing it within the ſame diſtance of the electrified Electrometer or prime Conductor, their Electricity will not be conducted away as before.

The above experiments may reaſonably induce us to ſuſpect, that ſeveral ſubſtances, which are ranged among Conductors, would become electrics if they were brought into a colder temperature; and that all the electrics become Conductors, when they are heated in a very high degree.

* It has been often obſerved, that a battery may be diſcharged by introducing a red-hot iron between two knobs interpoſed, and ſtanding at ſome diſtance from each other in the circuit: but if, inſtead of iron, there be introduced a piece of red-hot glaſs between the knobs, (the diſtance between them remaining as at firſt) the battery cannot be diſcharged: whence we may infer that either hot air is not ſo good a Conductor as has been imagined, or elſe, that air heated by iron (perhaps from its ignited particles) is ſtronger with reſpect to its conducting power, than when heated by the red-hot glaſs.

X 2 EXPE-

long periods might elapse before men in Germany or France appreciated what was being done by a scientist in England, though all might be working on the same problem. Better communications no doubt would have accelerated the study of thermionics.

The period from 1850 to 1880 was notable chiefly for the investigations of men who were duplicating, but with better facilities, the work done by their predecessors in the field.

News of the discovery of the "Edison effect" spread rapidly to other countries. This and further development of the incandescent lamp served as an impetus to stimulate scientific investigation. With the improvement of both transportation and communication at this time we find the picture of research and development quite changed. Sir William Preece visited America. Having heard of the work of the great Edison he witnessed demonstrations of the "Edison effect" and took back to England not only his notes on the demonstration but also samples of the magic lamps. Sir John Ambrose Fleming, who was at that time Electrical Adviser to the Edison Electric Light Company of London, studied Preece's work of repeating the experiments he had seen in America and continued investigation in this field, using the same types of lamps.

By 1895 scientists in the United States, England, and on the Continent had carefully studied the phenomena, seeking an explanation.

Five years later men coping with the problems of the wireless telegraph began to investigate the possible use of this device as a detector of electromagnetic waves.

While we will present evidence that Lee de Forest and his co-workers had conceived the idea of using a heated rarefied gas as a sensitive detecting medium in wireless telegraphy, which idea was later developed into the "Audion," it was actually Sir John Ambrose Fleming who obtained the first patent for the application of a thermionic device, as a rectifier, to wireless telegraphy, in 1904.

Even at this stage of the game few saw the possibilities of the device which was the grandfather of the present day detector, amplifier, and oscillator tubes. Several years later, when highly trained physicist-technicians attacked the problem, having at their command all the facilities which only large capital could provide, the full potentialities of this "bottle" began to be realized.

Who really started the ball rolling toward the modern vacuum tube? As we examine the foundations of the science of thermionics we find that the first stones were placed securely in position by such men as von Guericke, Gray, du Fay, Nollet, Winckler, Bose, von Kleist and their successors. To the casual observer these may be no more than a list of names picked out of a physics book, and placed in chronological order. Viewing the evolution of the vacuum tube from present day knowledge, however, we realize the significance and importance of each man's contribution.

Looking closely at these scientists they begin to live again. We see von Guericke poring over his books, working in his laboratory, proclaiming his discoveries to any one who would listen; Gray, experimenting prodigiously, for years jealously guarding the products of his struggles; du Fay "the interloper," performing his so-called "tricks," an expert at coming to the wrong conclusions; Abbé Nollet, the exhibitionist, in his curled wig and black skull cap, with his black gown barely concealing the richly laced coat and rapier beneath, demonstrating the fruits of his genius with one eye on the gallery of the lords and ladies of the French nobility; and Bose, giving superhuman demonstrations, to the awe and wonder of the populace.

They were all real men, the prototypes of men who played a prominent part in the feverish activity surrounding the final forging of the link between the scientific discovery of the "Edison effect" and its practical applications.

Probably no electrical discovery of major importance ever was made but that the honor of discovering it was claimed for more than one person. The origin of the Leyden jar was claimed for von Kleist, van Musschenbroek, and Cunaeus, and there are those who credit de Romas rather than Franklin with the discovery that lightning is an electrical phenomenon. The invention of the electromagnetic telegraph is ascribed to Steinheil by the Germans, to Wheatstone in England, and to Morse in the United States. Reis, Drawbaugh, Gray, Dolbear, and Bell all claimed the invention of the electrical transmission of speech. In the field of the incandescent lamp we have the conflicting claims of Edison, Sawyer, and Mann. In the field of the thermionic tube we have von Lieben, the de Forest-Fleming controversy, and that of Arnold and Langmuir. The scientific forefront from which these advances flowed truly is of international scope.

In the days of the philosophers these disagreements were largely confined to the annals of scientific societies, but in the past half century the commercial interests at stake have been so large that invention disputes have been the subject of long drawn out actions in the civil courts. This is partly the result of the patent system. Whether in the annals of the learned societies or in the courts of the land, these controversies are productive of a wealth of material for the historian. In modern times, when much development work is done in the research laboratories of large commercial organization, such actions bring out and place on record many of the details of interest which would not otherwise become generally known.

In the earlier days of which we shall treat it will be seen that a device produced by a philosopher was improved and adapted by those in other countries, and the use of the improved device brought about still further discoveries or resulted in more fruitful work in still a different country. A barrier to this free interchange of knowledge and ideas is found in the language differences involved. That this was recognized in the early days may be seen from the preface to the second edition of Priestley's famous "History and Present State of Electricity," published in 1769. In this work Priestley says:

"It is certainly to be regretted that philosophers have not one common language but neither the theory of language in general, nor the nature and analogies of things to be expressed by it are sufficiently understood to enable us to contrive a new and philosophical one, which might be easily learnt and would be completely adequate to all the purposes of science;—These circumstances make it the more necessary, that there should be in every country, persons possessed of a competent knowledge of foreign languages, who should be attentive to the progress of science abroad, and communicate to their countrymen all useful discoveries as they are made."

In addition to the language barrier it should be realized that the downfall of feudalism and disintegration of the Holy Roman Empire had resulted in sweeping changes in the social and political system of Europe, which were in progress during this period. Countries were torn by internal strife and external war. While this had its bearing on scientific development and research, consideration of it belongs more to the field of social than electrical science. We need consider only the disastrous effect of these factors upon possible intellectual unity. The rise of nationalism frequently resulted in the negation of honestly attributing the truth where truth was due. The resultant dissen-

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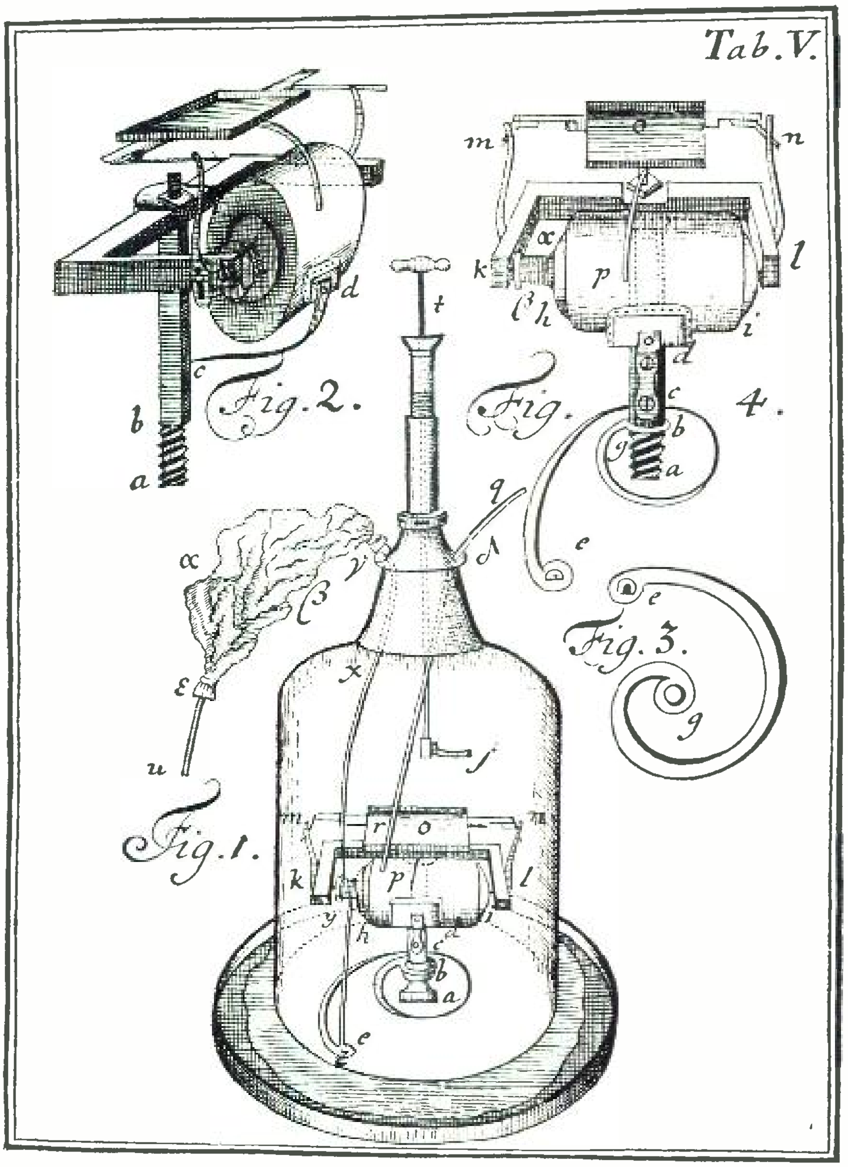
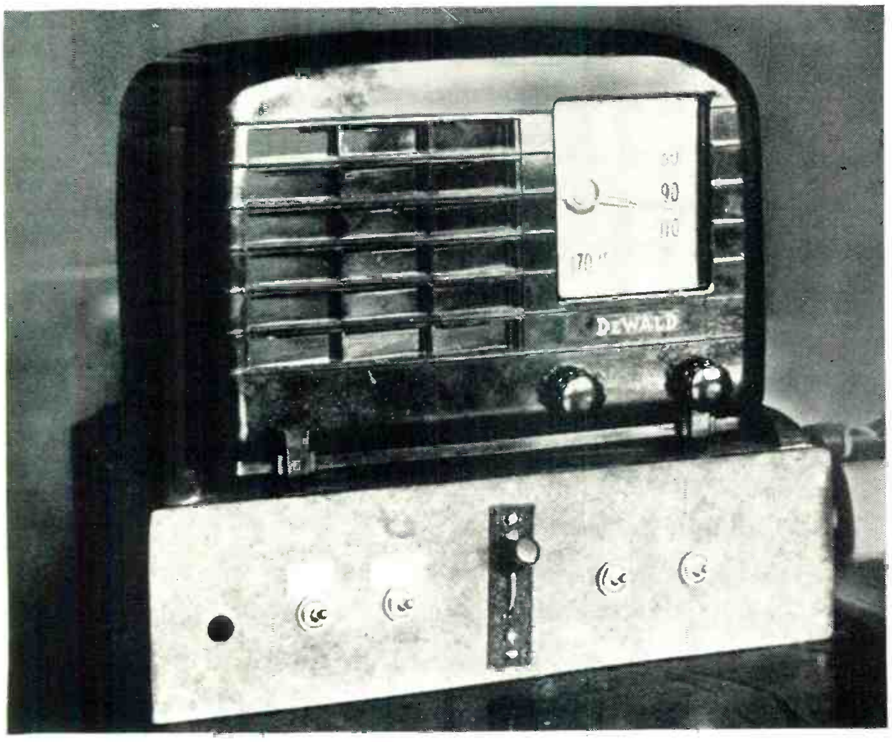


Fig. 3. Details of Winkler's Machine. Fig. 1 shows the machine set up for operation within a vacuum in glass jar.

Priority-Free Radio Intercomm

by ROBERT F. SCOTT, ex-W4FSI

The small AC-DC sets made during the past several years may be converted to excellent intercommunicators for home or office.



Front view of the Master Station, built from DeWald midget receiver.

This front view of a remote station shows the selector switch mounted on unit.

WITH the advent of National Defense and priorities, there are many small business firms that are in dire need of interoffice communication equipment and call systems but are unable to get them because of the priority ratings that are necessary for the purchase. A1-J ratings or better are often required. Perhaps all of you know of some small diner, store or business office that is in need of this equipment.

The only immediate answer to this problem is to convert radios already on hand to do double-duty. The market is open to those who want to purchase small AC-DC radio receivers. There are many radio-bargain counters that have numerous permanent magnet dynamic speakers and assorted switches that are available. With a radio receiver and a speaker to be used in each sub-station and a few switches, you can have a first class radio, intercommunication set and call system.

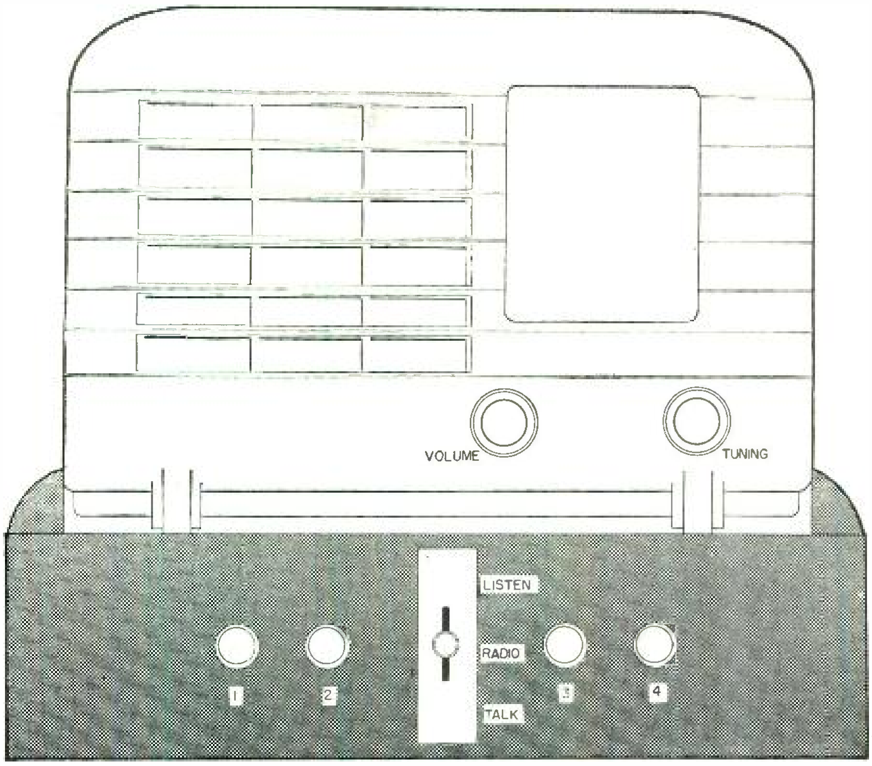
The receiver that was converted was a six-tube AC-DC table model. The tube line-up in the audio circuit includes a 12SQ7 as second detector and first audio, 12SQ7 as second audio, 35L6GT as audio output tube. The system used here has four remote stations and a master station. The equipment purchased was: 1 radio receiver, 9 switches, 4 speakers (permanent magnet dynamic). A roll of shielding braid and hook-up wire completed the purchases.

With this system the master station is able to call all of the sub-stations at once or may call the stations individually. The sub-stations may answer the master or originate a call to him. Radio programs can be broadcast to all of the sub-stations or to any one of them. If a radio program is being received at a sub-station, the station or stations receiving the program may interrupt the program to call the master position.

The Master Station

The master station is the station that controls the selection of stations and the radio programs and is the key position for the call system. The equipment at the master station is composed of a radio receiver (superhet-) and a control box (for mounting the switches). The switches at the master position are four SPST toggle switches, and a Push-to-Talk switch. The latter switch is a two pole-three position, lever type, positive action switch. This switch changes the various stations through the various positions. The switch is shown in two parts on the drawing. The toggle switches SW2 to SW5 inc. are used to select the stations that are to be placed or removed from the circuit. There is a six terminal, terminal strip mounted on the back of the control box. The three wire cables, that run to each sub-station, are connected to this strip. It is not advisable to use a 3-wire cable where the wires are interwound as the capacity between wires will reduce the voltage output considerably. Use 3 wires strung loosely side by side, between the sub-stations and the control panel. The control box is 3½ inches deep and is just large enough to support the radio that is mounted on the control box. The control box is so wired that the sub-stations may originate a call at any time regardless of the position of the toggle switches.

One terminal from each toggle switch is connected to one of the terminals on the strip. The other poles of the switches are connected together and a shielded wire run from this point to one of the movable blades of Sw1. Positions 2 and 3 on the same side of the switch are joined together and wired to positions 1 and 2 on the other side of the switch. The remaining positions, 1 and 3, on opposite sides of the switch are wired together and a shielded wire run from this point to the grid of the first audio tube. The jumpered positions, 1 and 2; 2 and 3, are connected by shielded wire to one end of the high impedance winding of T2. The other end of this winding is grounded. The remaining blade of switch Sw1 is wired to the high impedance winding of T3, the other end



Front view and layout for the Master Station. A three-position vertical switch is centered on the front of the sub-chassis.

of which is connected to a common ground point. The voice coil of the master speaker is connected to the voice coil winding of T3. The voice coil windings of T1 and T2 are connected together. T1 is the transformer that is mounted on the receiver speaker.

Transformers T2, T3 and T4 are bargain counter output transformers designed to match a 35L6GT to voice coil. (3000 ohms to voice coil impedance.) They cost less than 25 cents each. It was originally planned to replace T1 with a plate to 500 ohm transformer. T3 was to have been a voice coil to grid transformer. T2 was planned as a duplicate of T1. T4 to T7 inc. were to be 500 ohm line to voice coil transformers. We later found that these could not be purchased without a priority rating. Suitable substitutes have been found in the present transformers. The matching seems very

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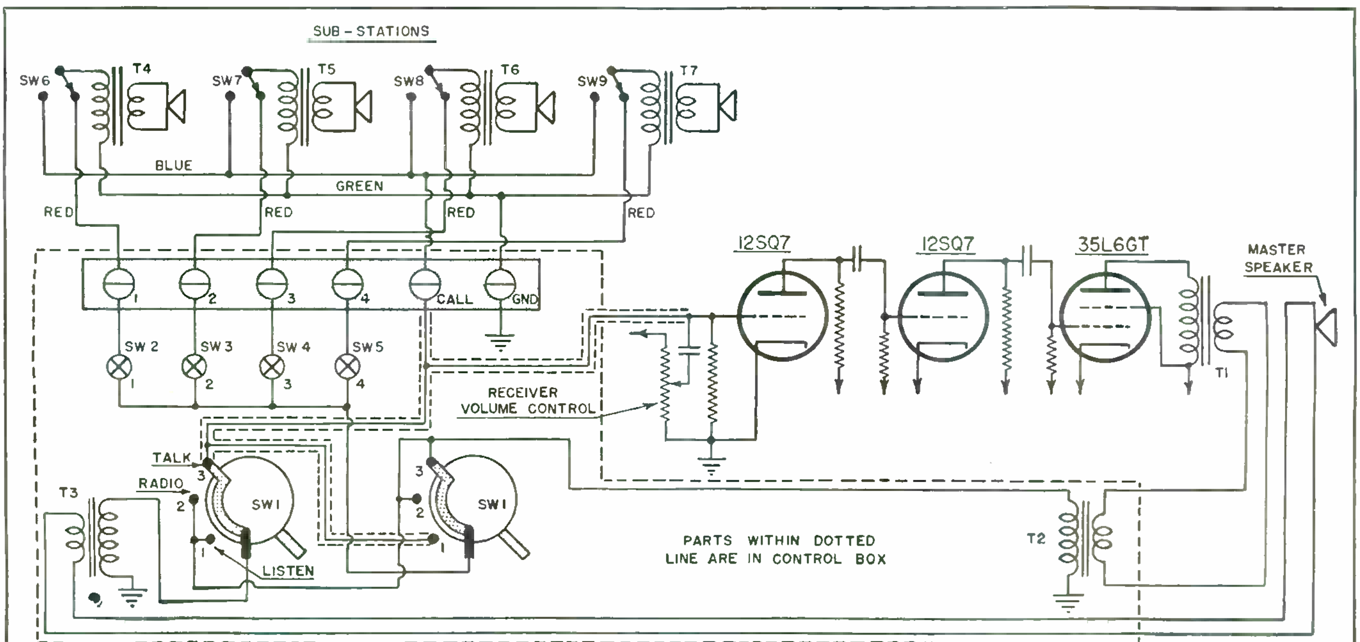
Wiring diagram of the converted receiver, now adapted for use as an intercomm.



T_1—Output transformer (on receiver)
T_2, to T_7 inc.—Output trans. 3000 ohms to v.c., Stancor
Sw_1—2P3T Lever type switch, Centralab
Sw_2, Sw_3, Sw_4, Sw_5—SPST toggle switch, H & H
Sw_6, Sw_7, Sw_8, Sw_9—SPDT spring return toggle switches H & H
Speakers, four P.M. dynamic, Utah or Jensen

PRACTICAL RADIO COURSE

by ALFRED A. GHIRARDI

Part 12 of the present series tells what tubes are best suited to specific circuits and shows their behavior under various conditions.

IN ORDER to intelligently select the proper tube for a particular application it is necessary to know the desirable characteristics for that particular application. The tube manuals published by the various manufacturers give a brief description of the recommended applications along with the characteristics, but in order to obtain optimum performance from the circuit it is necessary to select each tube used with particular attention to the circuit needs. Of course considerable latitude in this respect is possible as there are a great many types which are electrically similar, differing only in base connections, filament voltages, and physical size and construction.

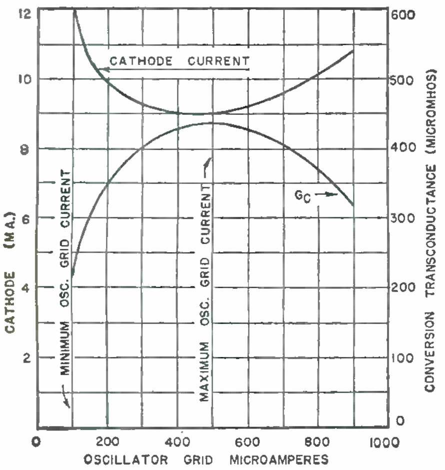


Fig. 1.

Tubes for R-F Amplifiers

If for example, a tube were to be used as an r.f. amplifier, we would select one with high gain, low interelectrode capacitances and ability to handle various signal voltages without crosstalk or modulation distortion. An examination of the various types listed shows that these requirements are best met by the variable-mu pentodes such as the 6D6 or 6SK7 in the six-volt series or the 1P5G in the battery type. There are other tubes of the same general type listed in the tube manuals for other supply voltages which would serve equally as well with slight circuit modifications. Components generally available for home construction are usually listed in the manufacturers catalogs for use with various groups of tubes of the same general type.

Tubes for Frequency Converter or Mixer Service

The selection of a tube for use as a frequency converter or mixer in a superheterodyne offers considerably more difficulty. First, the signal frequency range the receiver is to cover has an important bearing upon the tube selected. For general broadcast and medium range coverage any of the pentagrid converters such as the 6A8, etc., are satisfactory, as they offer the necessary conversion gain and transconductance. However at high frequencies such as are encountered in so-called "all-wave" receivers the frequency stability of the oscillator section of these tubes is poor and the output of this section is too low for efficient conversion, or ceases entirely. The only remedy for this condition is to either use a separate tube as an oscillator, coupling it into the normal oscillator grid of the converter, or use a tube designed to give efficient operation at these frequencies (such as the 6K8 or 6SA7). For the best all around operating results the separate oscillator offers the best solution. However in commercial construction of receivers it is necessary to temper optimum results with costs so the usual choice is a tube of the 6K8 or 6SA7 variety. Both of these tubes function fairly well at these frequencies.

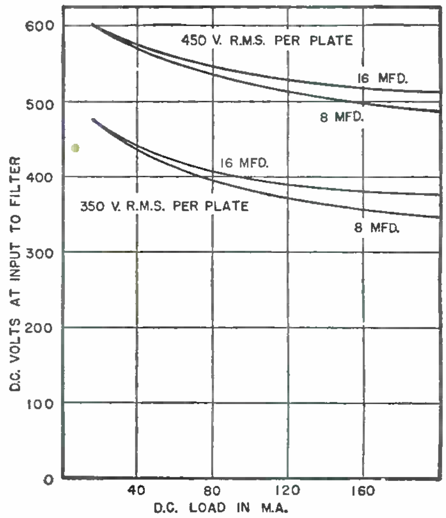


Fig. 3.

Tubes for I-F Amplifiers

In general the requirements for a tube to use in an i.f. amplifier are the same as those for r.f. stages as the only difference lies in the signal level

Fig. 2.

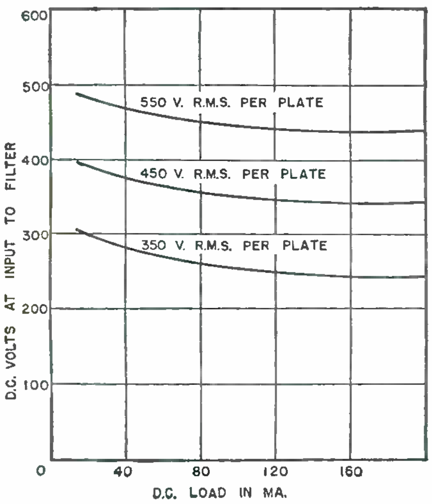
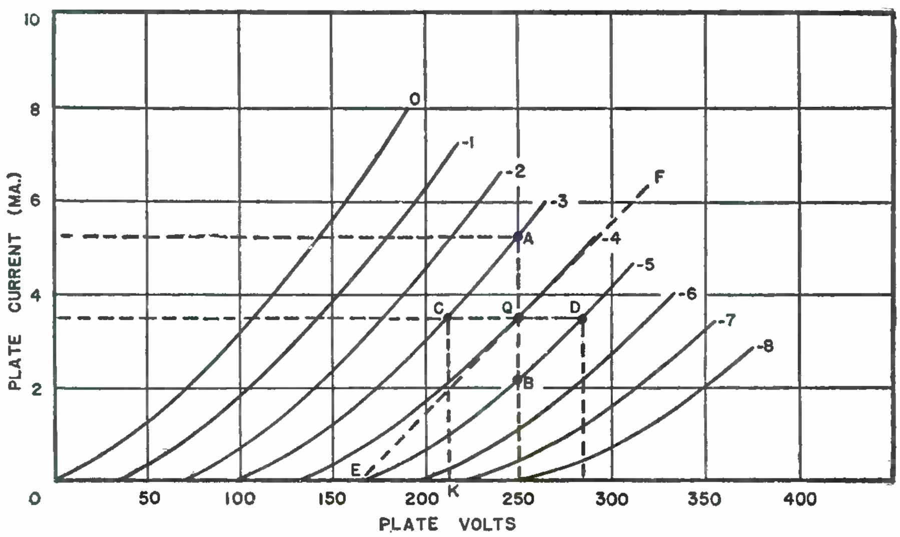


Fig. 4.



and frequencies at which the circuits operate. For most broadcast receiver applications sufficient gain is furnished by one stage of amplification using a tube of the 6D6 or 6SK7 type. However in receivers of the communication type the need for greater selectivity and gain requires the use of two or sometimes three stages of i.f. amplification. The i.f. amplifiers used in f.m. receivers must be capable of considerable gain as well as have a broad band width, so to satisfy this requirement with a minimum number of tubes and a minimum of components special tubes such as the 6AC7 and 6AB7 have been developed. By use of such tubes it is possible to get as much as four times the gain per stage as is obtained with tubes of the 6SK7 type. Naturally with such tremendous gains it is necessary to take special precautions in construction and wiring to prevent undesired regeneration and oscillation.

Detector Tubes

Tubes for use as detectors can be of several different types depending on the results desired. For use as a grid leak detector a tube such as a 6C5 or equivalent is often used, in simple receivers, as it is possible to use headphones directly in the plate circuit of

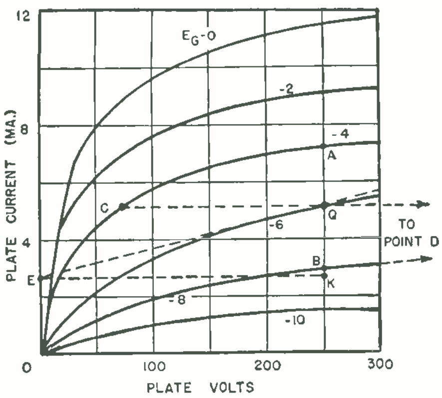


Fig. 5.

such a tube. The plate resistance is low and a good impedance match is obtained. Where an audio amplifier is to be used following the detector the usual practice is to use a tube such as a 6C6 or 6SJ7. Considerably more gain and sensitivity can be obtained from a tube of this type than from a simple triode, and the following amplifier furnishes the proper plate load for the tube. As the power handling capabilities of a grid leak detector are poor, when fidelity and output are important, recourse to some other type of detector is necessary and either the plate detector or diode is used. For use as a plate detector either a triode such as a 6C5 or a pentode 6C6 or 6SJ7 is satisfactory. While a plate detector does not load the tuned circuit feeding it, and does contribute considerable gain, it has the disadvantage that A. V. C. is not possible unless a separate tube is used. Consequently in most receiver designs the usual practice is to use a diode such as a 6H6 for a detector, or

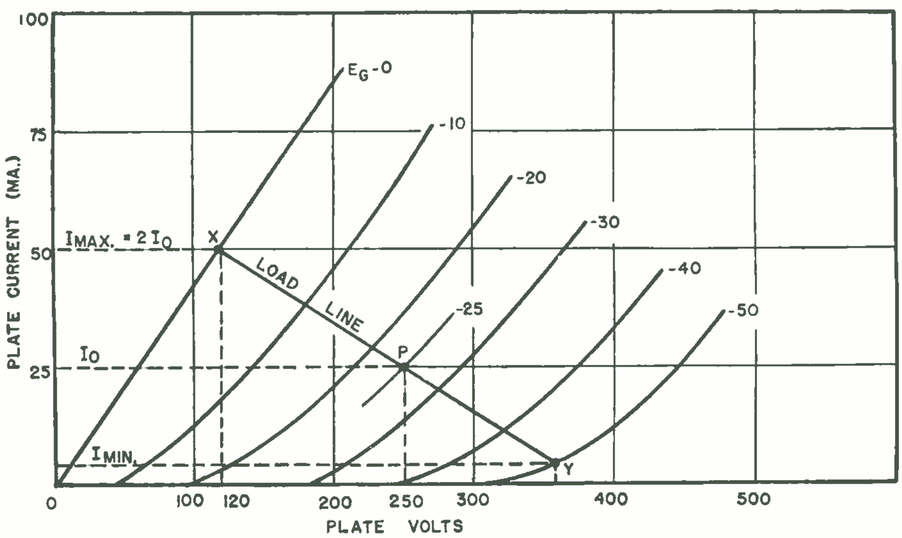


Fig. 6.

a combination diode-triode or diode-pentode such as the 6Q7 or 6B8 respectively. In an application such as this the triode or pentode section is used as an audio amplifier and coupled to the output of the diode.

Tubes for Audio Amplifiers

The choice of a tube for the input stage of an audio amplifier varies widely, depending on the gain necessary and the input voltage available. Where high gain is needed with small inputs either a remote-cutoff pentode of the 6C6-6SJ7 type or a high gain triode such as a 6F5 is used. In receiver applications the practice is to use a diode with a high gain triode in the same envelope.

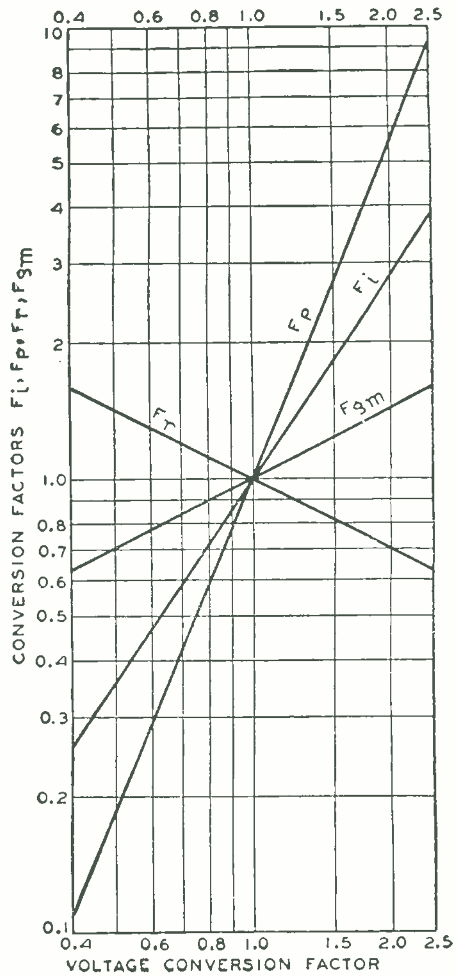
The audio stage following the input in most cases does not require a great deal of gain and can be a fairly low gain triode such as a 6C5 or 6J5. If this stage is used to drive the power output stage either of these may be used as a phase inverter or a twin triode 6C8G or 6F8G depending on which type of phase inverter is desired.

Tubes for use as output amplifiers must be selected with regard to the output power desired, the voltage available to drive the grids, the type of load the stage is to feed, the plate voltage available, and the fidelity desired. The greatest fidelity is obtained with low-mu triodes such as 45's and 2A3's but they have the disadvantage of low plate efficiency, high grid bias, and require a large grid driving voltage. However, where cost and other considerations will permit it, their use is justified as they are much less critical as to circuit conditions than tetrodes and pentodes.

The present trend is to use either beam power tetrodes, or pentodes for the output stage, either singly or in push-pull. They require little grid drive, low grid bias, and have a high plate efficiency, giving considerable power output at low plate voltages. Their greatest fault is the high harmonic distortion, and critical load requirements. The impedance of a loudspeaker varies considerably with frequency and this varying load is reflected back to the output tubes. Much of this variation can be eliminated by the application of inverse feedback. Inverse feedback also serves to reduce the harmonic distortion considerably, although it does reduce the overall gain of the amplifier, in some cases enough to require the addition of another stage. The more commonly used beam power tubes are the 6V6, 6L6, and 25L6 while

(*Continued on page* 60)

Fig. 7.



POCKET VTVM'S

by RUFUS P. TURNER
Consulting Engineer, RADIO NEWS

A Vacuum Tube Voltmeter need not be of complicated design in order to make numerous circuit measurements.

OUR new unprecedented military radio needs and current war-industrial requirements have struck a keynote in the mobilization of electrical equipment. Test equipment of late design displays this trend. Wherever possible, test instruments are being made portable in type in order to satisfy the demands for ready movement, adaptability to field use, and minimum storage space.

Among the laboratory instruments which traditionally have been bulky in size is the vacuum-tube voltmeter. Seldom have these instruments been made less in girth than the size of a midget receiver. Only recently has one of the leading radio instrument manufacturers offered an entirely portable v. t. voltmeter for field use.

Working to reduce the dimensions of simple, but immensely operable v. t. voltmeters to pocket size, we have carried on a number of tests with minimum-component circuits, selecting the parts with great attention to overall dimensions. The results of these tests we present herewith in circuits and information for the guidance of military and civilian radio technicians who have need of completely portable v. t. voltmeters. Unfortunately, time did not permit exploration of all possibilities. However, it is felt that the circuits presented are representative of others which will occur readily to the ingenious technical reader.

A. C. Midget

The first meter, shown in circuit schematic in Figure 1, is a completely a.c. operated instrument based upon a 6P5GT triode and a 0-1 d.c. milliammeter.

The small size of this instrument is made possible by operation of the triode at a low plate potential—12 volts, which permits the use of an ultra-midget power supply.

The 12 volts required for the triode plate are obtained from a compact voltage doubler which employs a miniature 6.3-volt filament transformer, a type 6H6 tube, and a dual 20-μfd. electrolytic capacitor. In addition to furnishing plate voltage, the miniature 6.3-volt transformer, a *Thordarson* T19F80 (measuring only 2″x1⅝″x1⅞″ overall), supplies heater voltage to both 6H6 and 6P5GT tubes.

The drain imposed upon this power unit is unusually low, and the unit consequently runs sufficiently cool to permit its inclusion in the close quarters of the small instrument case. A low-voltage electrolytic doubler capacitor is employed with the greatest safety, since the peak voltage impressed upon it will never exceed about 18 volts. However, it will be observed that this component must, in addition to having the smallest possible overall dimensions for the desired capacitance, be provided with independent leads for each section. One capacitor recommended for the application is *Aerovox* PRS-B 20-20, which measures 1 inch in diameter and 2¼″ in length and is provided with a handy metal mounting bracket and long leads.

The a.c. model v. t. voltmeter utilizes a conventional plate rectification type triode circuit, with approximately 1 volt of grid bias obtained from a point on the voltage divider R4-R5-R6.

It will be seen that the 0-1 milliampere d.c. indicating meter operates in a four-arm resistance bridge in the 6P5-GT plate circuit, one arm of this bridge being the tube plate resistance. The adjustable arm is composed of the variable resistor R7, a 2,000-ohm *I. R. C.* type W-2,000 wire-wound control, and the limiting resistor R8. The milliameter is initially set to zero by means of R7 which balances the bridge

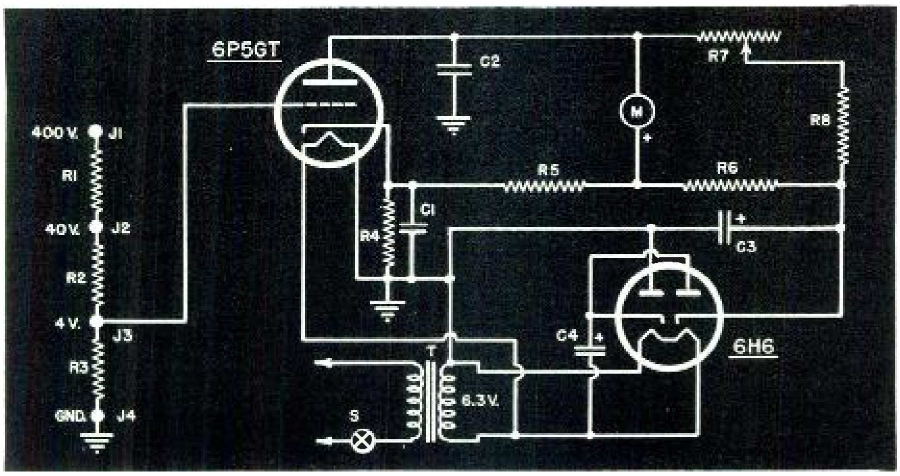
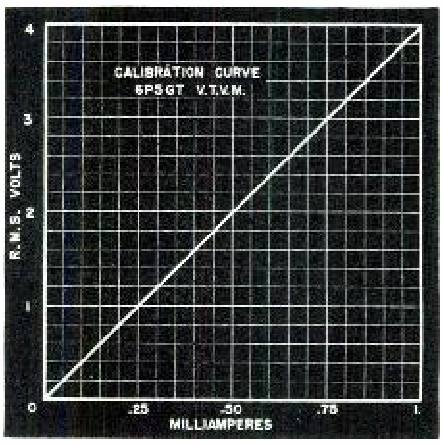


Fig. 1. A simple, but extremely accurate VTVM circuit.

C_1, C_2—0.1 μfd. 200 v. tubular, Aerovox 284
C_3, C_4—Dual 20 μfd. electrolytic, Aerovox PRS-B 20-20
R_1—9 megohm miniature 1 w. resistor (see text), Aerovox 1098
R_2—900,000 ohm miniature 1 w. resistor (see text), Aerovox 1098
R_3—100,000 ohm miniature 1 w. resistor, Aerovox 1098
R_4—1000 ohm miniature 1 w. resistor, Aerovox 1098
R_5—10,000 ohm miniature 1 w. resistor, Aerovox 1098
R_6—500 ohm miniature 1 w. resistor, Aerovox 1098
R_7—2000 ohm miniature wire-wound volume control, IRC W-2000
R_8—3000 ohm miniature 1 w. resistor, Aerovox 1098
J_1, J_2, J_3, J_4—Insulated banana jacks, Gordon
S—SPST toggle switch, Arrow
T—Midget 6.3v. filament transformer, Thorardson T19F80
M—0-1 d.c. milliammeter (2″), Simpson

Fig. 2. A calibration curve for the 6P5GT tester.



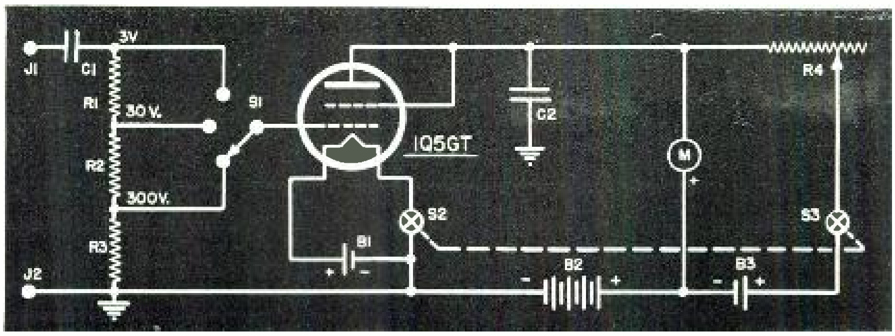


Fig. 3. An easily-built battery-operated VTVM uses only 1 tube.

C_1—0.02 µfd. mica (two 0.01 µfd. units in parallel), Aerovox 1467
C_2—0.1 µfd. 200 v. tubular, Aerovox 284
R_1, R_2, R_3—Same resistors as in Fig. 1
R_4—10,000 ohm wire-wound rheostat, IRC W-10,000
M—0-1 d.c. milliammeter (2"), Simpson
J_1, J_2—Insulated banana jacks, Gordon
B_1, B_3—1½ v. pen-size flashlight cells, Eveready
B_2—7½ v. flat battery, Eveready No. 773
S_1—SP3P rotary switch, Centralab
S_2, S_3—D.P.S.T. toggle switch, Arrow

with respect to the steady triode plate current. The use of a series combination of fixed and variable resistance in the adjustable arm permits a larger amount of the variable member to be used during balance adjustments and removes any tendency toward "hair-trigger" zero adjustments.

The indicating meter is a 2-inch 0-1 d.c. milliammeter *(Simpson* Model O-1). With this instrument, the fundamental full-scale deflection of the v. t. voltmeter is 4 volts RMS. A curve showing meter deflection versus a.c. input volts is given in Figure 2.

The normal 0-4-volt range of the instrument is increased by the input voltage divider R1-R2-R3, made up of small carbon resistors, which afford additional full-scale deflections of 40 and 400 volts.

R1 is made up of one 5-megohm and one 4-megohm resistor connected in series between jacks J1 and J2. R2 is one 500,000- and one 400,000-ohm unit connected in series between jacks J2 and J3. These resistors are mounted well back from the metal case of the instrument as possible, in order to reduce ground-capacitance effects. The jacks are mounted through and along the front edge of the instrument case, which is really a chassis, and as close together as the resistor length will permit.

With every cubic inch of space utilized to the fullest in the instrument, no room was available for a rotary voltage-range switch. So input jacks have been provided instead. J1, J2, J3, and J4 are insulated banana jacks *(Gordon)* into which the test-probe leads are plugged.

Due to the low plate voltage employed in this v. t. voltmeter circuit, zero drift is almost totally undetectable on the 0-1-milliampere scale.

The scale of the author's instrument was replaced with a new dial made of stiff white Bristol board on which was drawn a special 0-4-volt scale in accordance with calibration points. It is strongly recommended, for complete ease of operation, that the reader make a similar scale. Reference to voltage curves or tables necessarily slows down measurements considerably, and the outstanding virtues of the special scale are quickly realized.

The circuit of Figure 1, like those of the other v. t. voltmeters described in this article, will be found useful for power-frequency, a.f., and r.f. measurements. However, the upper radio-frequency limit will be somewhat limited by the capacitance of the input jacks to ground and to each other and by the length of the test leads. A series of measurements made by the author with standard multimeter test leads indicates that objectionable voltage errors enter at about 4 megacycles. But these effects may be reduced satisfactorily by employing short, heavy wires not more than one inch long as test leads between input jacks and voltage source during high-frequency measurements, i.e. the shorter and heavier the input test wires, the greater is the H.F. accuracy.

If the specified components and the layout as intended are employed, the complete a.c.-operated pocket v. t. voltmeter may be constructed into a 5"x6½"x2" chassis as a "flat" instrument case. With some ingenuity, the builder may reduce these dimensions still further.

Battery V. T. V. M.

For complete portability, battery operation is recommended. And by keeping voltage requirements low, as in the case of the a.c. instrument, small-size batteries may be employed and the instrument size kept down to pocket dimensions.

The first of the battery circuits with which we experimented is shown in Figure 3. Plate voltage in this instrument is 7½ volts. Built around a 1Q5-GT tube and a 0-1 d.c. milliammeter, this v. t. voltmeter is powered by two pen-size flashlight cells (one for filament heating and one for suppressing the steady plate current and a flat 7½-volt battery for plate potential (the latter battery is an *Eveready* No. 773 which measures 4"x2¾"x1³⁄₁₆").

The 1Q5-GT tube, a beam power model, is arranged as a triode by connecting together its screen and plate terminals directly at the socket. This

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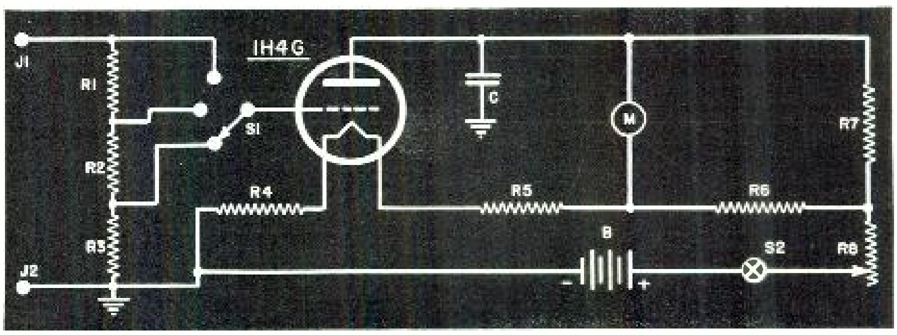


Fig. 4. Another single tube battery-operated meter.

C—0.1 µfd. 200 v. tubular, Aerovox 284
R_1, R_2, R_3—See same resistors as in Fig. 1
R_4—18 ohms wire-wound, made up from Nichrome wire, wound on small dowel
R_5—150 ohms, 1 w., Aerovox 1098
R_6—20 ohms, 1 w., Aerovox 1098
R_7—10,000 ohms, 1 w., Aerovox 1098
R_8—150 ohm wire wound rheostat, IRC W-150
J_1, J_2—Insulated banana jacks, Gordon
B—Flat 7½ v. miniature battery, Eveready No. 773
S_1—SP3P rotary switch, Centralab
S_2—SPST toggle switch, Arrow

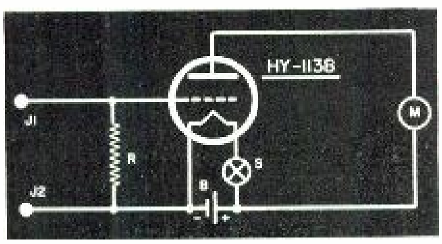
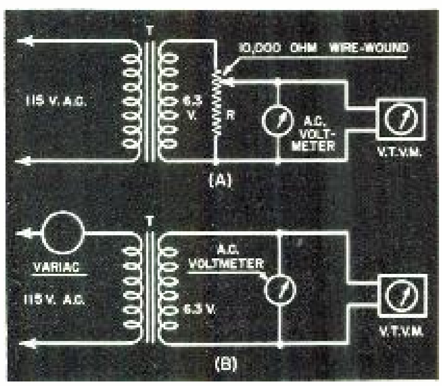


Fig. 5. A real pocket meter.

R—2 megohm 1 w. resistor, Aerovox 1098
B—Pen size flashlight cell (1½ v.), Eveready
J_1, J_2—Insulated banana jacks, Gordon
M—0-50 d.c. microammeter, Simpson
S—SPST toggle switch, Arrow. (May be slide-type switch if flashlight case is used as voltmeter probe.)

Fig. 6. Calibration set-up for basic meter.



SEVERAL more members are in line for entrance into the Tube Collectors Club. Many letters are being received from individuals giving a list of tubes available for cash or trade. This information is being compiled and will be presented in an early issue. We want to hear from any reader having one or more of the tubes listed below. Send us your lists, giving full information on the condition of the tubes and we will see that members are notified as to what is available. Address all letters to the Tube Collector, RADIO NEWS, 540 No. Michigan Ave., Chicago, Ill. The following are needed:

Amrad "S" tubes, both cylindrical and pear shaped
Audiotron
Bartley
Connecticut Detector
Corcoran tube
De Forest Audion-spherical bulb single grid single plate type-candelabra base
De Forest Audion-spherical bulb double grid, double plate type-candelabra base
De Forest Audion-cylindrical—Type T—with or without adapter
De Forest Audion-pear shape—"Singer type"—Shaw base
De Forest Oscillions
Donle B6, B8, BA2, BP71, BR4
Electro Importing Company Audion
Emerson Multivalve
Fleming Valves
Liberty Valve
Lieben-Reisz "LRS" Repeater
Marconi V24, Q, QX
Margo Detector
Moorhead Electron Relay (cylindrical, unbased)
Moorhead Electron Relay—Shaw Base
Moorhead cylindrical tube with external grid
Moorhead A-P Amplifier
Rectobulb R3, 6EX
Roome Thermotron, Oscilaudion
Sovereign AC
Strongson Copper Plated Tube
WRC 20, WRC 22
Wunderlich
Kellogg (top-heaters)
All foreign tubes, modern or antiques
Thermo Tron
Electron Relay (single fil.)
Electron Relay (double fil.)
De Forest RJ9 detector
Audio Tron (National Elect.)
Audio Tron (double fil.)
Moorhead (Pacific Lab's)
Ultra-Audion (1916)
Tigerman Detecto-Amplifier
Donle Type C
Telefunken 1919
TeCo Audiotron adapter
Vacuum Rect. (Wireless Equip. Co.)
A-P Electron Relay
A-PVT Amplifier-oscillator
Moorhead transmitting (1920)
Moorhead Amp-Osc (1920)
De Forest VT21 (Signal Corps)
De Forest ¼ kw. Oscillion
De Forest 12.5 w. transmitting
Edison Swan Elect. ES2, ES4
UV203 (early)
UV204 (early)
A-P rectifier (shaw condensite base)
Kenotron UV217 (early)
Kenotron UV216 (early)
De Forest 20 rectifier

(*Continued on page* 81)

24 YEARS AGO in RADIO

{ CONDENSED FROM RADIO NEWS, 1919 ISSUES }

Radio Vacuum Tube Litigation Is Settled

DURING World War I, litigation over rights for the manufacture and sale of vacuum tube detectors for radio work was suspended by common consent, and tubes or "bulbs" for government use were made at various plants. As the situation stood at the close of hostilities, an attractive market for bulbs was in prospect, but patent rights prevented any one manufacturer from entering the field independently. The Marconi Company held rights covering the use of a two-element bulb, Dr. deForest's patents protected the use of the third element, and the Moorhead Laboratories in San Francisco had patented still other features also essential to the commercial production of the best tubes, among these being the use of a chemical process for exhausting air. During the war, the Moorhead Company had developed manufacturing facilities rapidly, and bulbs were being turned out for the Allied governments at the rate of 30,000 per month.

Early in May representatives of the Marconi, deForest and Moorhead companies held a conference in San Francisco and agreed that patent rights of all three should be extended to the Moorhead Company, for which the latter should make payment to the other two on a royalty basis. In this connection it was noted that this company was only permitted to make receiving and amplifying tubes, the Western Electric Company having the rights to manufacture the transmitting tubes. It was also agreed that the Marconi Company would become the sole sales and distributing agent for the Moorhead output. The tube produced under the agreement is to be known as the Moorhead audion. Government contracts still operative will call for 15,000 bulbs per month, and within sixty days after the date of the contract, the Marconi Company, in the capacity of main distributing agent, is to receive bulbs at the rate of 50,000 per month.

Wireless Questions—1919

A. ALBERT SMITH, Hoboken, N. J., asks several questions on radio matters.

A. 1. We cannot understand why the mere adjustment of a detector should necessitate such a great change in the inductance used in tuning. You must have made some change in the capacity of your aerial to cause this marked effect, as detectors have little or no effect on the wave length.

Your suggestion for a new loose coupler is not exactly new and possesses no advantage over modern types. In winding the two coils so close you practically destroy all selectivity which is the secret of the operation of the loose coupler. The plan will work, we admit, and the coupler will produce louder signals under certain circumstances, but for all around work use your present loose coupler.

The adopted method of shortening the wave length of an aerial is to connect a variable condenser in series. This is done on shipboard when the "distress signals" are sent out and all stations with the long wave require a series condenser to pick up short waves. We know of no instruments which will eliminate excessive static without also weakening to a certain extent the wireless signals. The only way this static may be done away with to an appreciable extent is to shunt a variable condenser across the coupler secondary, which dissipates considerable static. The Rogers Underground Aerial is perhaps the best present method to eliminate static.

Combination Code Practice Instrument

REMOVE the gong and hammer from an ordinary bell. Mount an ordinary battery binding-post on the frame between the two binding posts of the bell, insulating it from the frame by rubber washers. The key is a 6-inch girder from a model engineering set, fitted with a knob at one end. The other end is fastened to where the gong was, using the same hole, nut and screw. This time be sure connection is made with the frame.

To make the buzzer hy-tone insert a piece of match stick between the armature and the vibrator.

All that is necessary now is to connect one wire from the battery to the magnet binding-post, and the other to the insulated one, which serves as the contact for the key. Connect the phone terminals to the unused post and to the vibrator point. Pressing the knob so that it touches the contact will cause the buzzer to operate.

Reviewing American Radio History

THE Great War, just ended, has given us many renewed reasons for pride in our country, pride in what America has accomplished in scientific achievement as well as in noble self-sacrifice for the common cause of liberty. We all are justified, therefore, in reviewing what contributions in invention has been especially the work of Americans, in what fields of work we have been pre-eminently pioneers, and not only pioneers, but, better yet, have kept at the head of the procession, says Lee deForest.

The world admits that two American boys, the Wright brothers, were the first of all mankind to fly, to wrest from the birds the secret which baffled human ingenuity since the beginning of history. But, to our shame be it said, we Americans did not follow up this splendid beginning as we should have done. The French and British sportsmen, perhaps because of more enthusiastic and far-sighted support by their governments, learned the lessons which Wilbur and Orville Wright first taught, better than did Americans, so that at the beginning of the war the Allies' bird-men knew far more about aviation, about planes, about engines, than we did. They were far ahead and had we not swallowed our pride and diligently gone to school to the Allied aviators, we would never have been able to make even the belated showing which during the last weeks of the war began to prove our American-trained aviators and our American-made planes of use to General Pershing's mighty army.

So it was with especial pride that we hailed the big Navy NC-4 seaplanes the first aircraft in history to cross the wide Atlantic.

U. S. to Drop Radio Station

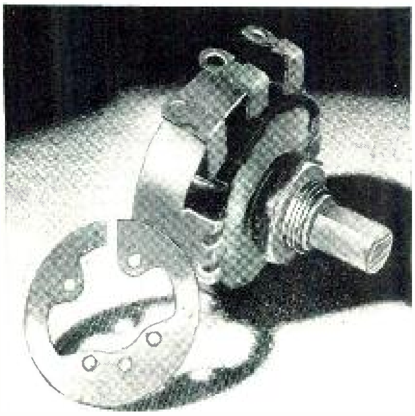
ORDERS have been received by Ensign W. C. Finch, in command of the naval radio station, to withdraw all the naval forces on August 1 and to return the New Brunswick, N. J., station back to the Marconi Wireless Company, from whom it was taken over in the summer of 1917.

The station will be closed for six weeks or more, as all the naval equipment is to be removed, according to the instructions from Washington, and the Marconi people will have to install new apparatus before they will be able to take up commercial work. —30—

WHAT'S NEW IN RADIO

Non-Wire-Wound Potentiometers

Important developments in the processing of resistive coatings have resulted in potentiometers and rheostats claimed to be virtually on a par with wire-wound units in matters of



resistance permanence, immunity to climatic conditions and wearing qualities.

Clarostat Series 37 controls employ the new stabilized element developed after years of intensive research and exhaustive tests. This element takes the form of a resistive coating on a bakelite base, being practically as smooth and hard as glass. The element is chemically treated during processing to eliminate all further changes in its composition. It is likewise heat treated to stabilize its temperature and humidity characteristics.

Controls incorporating the new stabilized element were quietly introduced to the trade many months ago, so as to get the reaction of users out in the field. Users have been prompt to spot the new element. Accurate resistance values first and last, even after months of continuous usage under adverse conditions, have been noted.

Series 37 controls with the new stabilized elements are made by *Clarostat Mfg. Co., Inc.*, 285-7 N. 6th St., Brooklyn, N. Y.

Solenoid Contactor

Among five types of approved solenoid contactor units announced by *Guardian Electric Manufacturing Company*, Chicago, the B-5 series has a contact rating of 50 amperes continuous and operates on 24 volts d.c., producing a coil current of 210 milliamperes. It has double pole, single throw, normally open contacts. Weighs 11.2 ounces.

The B-5 Solenoid Contactor, like the balance of the series, is built to U. S. Army Air Force specifications and can be adapted for numerous applications of heavy current control in aircraft and other products.

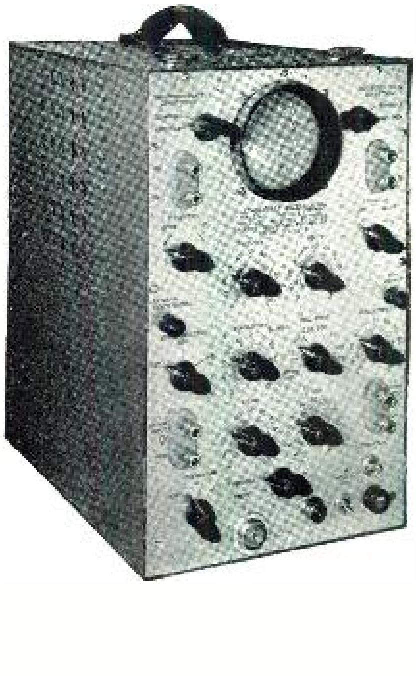
Unit is said to resist acceleration and vibration over 10 times gravity, that it operates in any position and is so constructed that it may be disassembled with pliers and screwdriver. Metal parts are plated to withstand 200-hour salt spray test. Full details obtainable by writing to *Guardian Electric*, Dept. B-5, 1630 West Walnut Street, Chicago, Illinois.

New Oscillograph

Critical wartime requirements are responsible for a new cathode-ray oscillograph characterized essentially by a greatly extended frequency range, more versatility in the handling of applied signals, and special pickup means whereby input capacitance is reduced and stray pickup eliminated. Removable front cover protects panel, controls and tube screen, and also holds the shielded-cable test probe, when instrument is not in use.

Known as *Du Mont* Type 224, this new oscillograph is now offered as a standard instrument by *Allen B. Du Mont Laboratories, Inc.*, Passaic, N. J. One of its outstanding features is the Y-axis or vertical deflection response which is uniform from 20 c.p.s. to 2 million cycles. It has a comparably faithful square and sinusoidal wave response. The X-axis or horizontal deflection amplifier has a uniform characteristic from 10 c.p.s. to 100 kilocycles. Both amplifiers have distortionless input attenuators and gain controls.

The widest variety of signal input connections are available. In addition to the conventional amplifier connections, signals can be applied directly to the deflection plates of the 3-inch cathode-ray tube, when it is desirable, by means of terminals at the front



panel of the unit. The Y-amplifier has an input connection for the Shielded-Cable Test Probe Type 242A, supplied with the instrument. This reduces input capacitance and eliminates stray pickup. All high-voltage electrolytic condensers are eliminated from circuit.

Type 224 Oscillograph weighs 49 lbs., and measures 14⅛" high, 8⅜" wide, 15⅛" deep. It operates on 115 volts, 60 cycles a.c.

Manufactured by the *Allen B. Du Mont Lab., Inc.*, Passaic, N. J.

Inter-communication System

Illustrated is the Super-Chief model in the *Talk-A-Phone Mfg. Co.* of Chicago's new line of inter-communication systems.

As noted by the diagram, the "Super-Chief" has incorporated in its

design many new exclusive features never before used in inter-communication systems. Outstanding among these is "Conference Traffic Control." This enables any number of stations to hold a private conference without interruption or eavesdropping from other stations outside of the conference group. When one of the conference group is being called, he is signalled by a light so that he knows that the call is waiting. Working in conjunction with the Traffic Control is the "Busy Signal Light." This light is illuminated when the line on another station you are trying to reach is busy and so remains lighted until that station is ready for a new conversation.

Other new features include "Uni-Trans" or one way automatic transmission, especially effective for the dictation of letters and the complete recording of conferences. When "Uni-Trans" is used, the "Talk-Listen Switch" does not have to be operated.

The Super-Chief also uses the latest type finger-tip pushbutton control which utilizes in its construction the "Hold-O-Matic Switch." In the con-

(Continued on page 82)

A group of foreign radio equipment and shortwave set built in Denmark.

MAINTENANCE OF FOREIGN MARINE RADIO

by CARL COLEMAN
and
J. T. DONNEL
Arnessen Elect. Co., New York, N. Y.

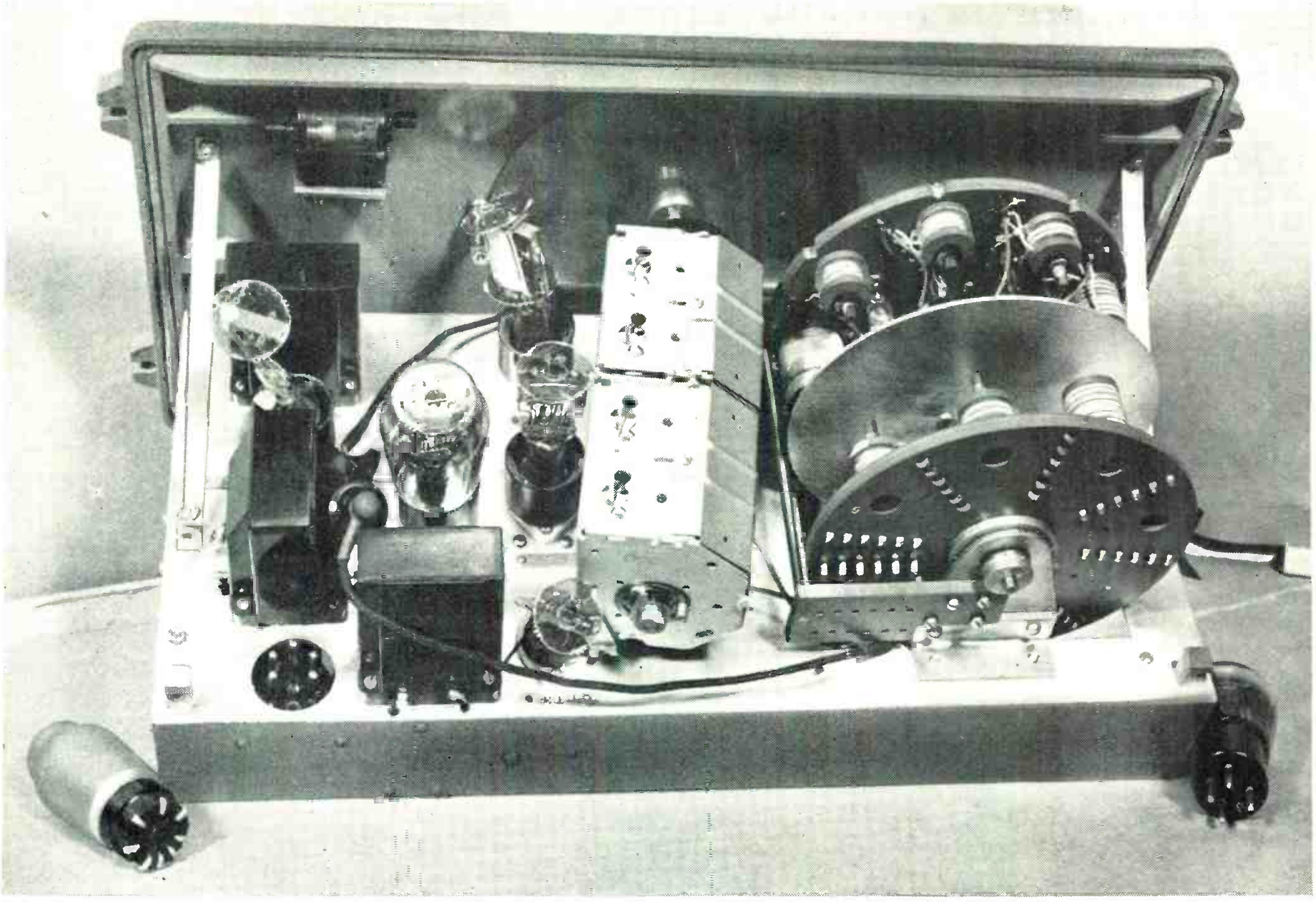
A little-known radio subject is covered by two specialists in this unusual profession.

ONE of the most difficult situations that has arisen in the marine radio maintenance service as a direct result of the present world conflict is the maintenance of radio equipment aboard foreign vessels. This is especially true aboard the ships of the United Nations whose countries are now occupied by Axis forces, thus making it impossible for these ships to obtain standard material for repair and maintenance of the ship radio stations.

The necessary radio equipment aboard steamships today is usually composed of a main transmitter, emergency transmitter, automatic alarm system, radio direction finder and short wave transmitter, together with the main receiver and short wave receiver. There is also the motor generator, batteries and the battery charging equipment and various antenna systems required, which complete the ship's radio station equipment, all of which must be inspected thoroughly and repaired when necessary before the ship can proceed to its next port.

The repair and maintenance of foreign equipment aboard ship required a complete study of the various items manufactured. This must be done in order that the best possible advantage may be taken when it becomes necessary to replace defective equipment with substitute equipment, made in this country, when the standard replacement parts are no longer available. When one considers that there are in Europe alone more than forty concerns engaged in the manufacture of marine radio equipment for use in the ships' radio stations, together with the material made in other foreign countries, the magnitude of such a task becomes apparent. A detailed study of these various items made by the foreign companies discloses that while the basic circuits used are of standard type, tube design is considerably different and various ideas are used which are not common in this country.

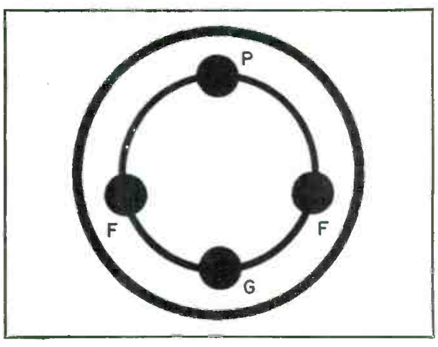
Tube replacements must be made because many European types are of course no longer available under the present conditions. Tubes used in commercial marine radio receivers,



This smashed up all-wave receiver was taken from a torpedoed ship and arrived at the shop in this condition.

while of the same general characteristics as most of those manufactured in this country, are fitted with pins to fit an entirely different type of socket than that used in the United States. The common triode and pentode tubes use a pin and socket combination such as that shown in Figure 1; the tube cap, if any, is connected to the plate within the envelope rather than the grid, as is common with our type of tube. Another common type of socket and tube arrangement is shown in Figure 2. This arrangement is used in the double purpose type tubes. To compare with our present octal—eight pin type tubes—the foreign manufacturers have designed tubes fitted with small flat pins, as shown in Figure 3, which fits a socket with a spring-wiping contact. Most

Fig. 1. Foreign triode and pentode socket.



receiver tubes operate at either two or four volts on the filament, very few are manufactured for six volt operation, as is the case with many of our common types.

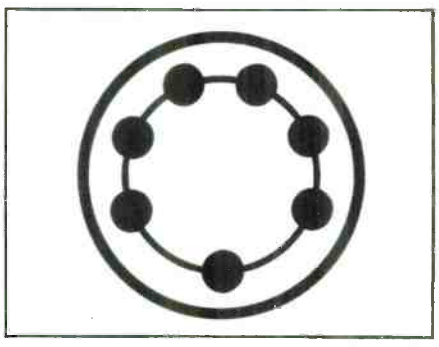
The tubes used in transmitters are also fitted with different types of sockets and holder arrangements, with the exception of one or two, which are interchangeable with American designed tubes. Most transmitting tubes of foreign design are also operated at different filament voltages from tubes of similar American design, running on twelve and a half, fifteen and twenty-two volts. Plate voltages are likewise higher for a similar power rated tube, running as high as ten thousand volts on tubes of five hundred watts.

One common type used in medium powered ship transmitters has neither pins nor prongs, being fitted with holes in the lower end for the filament and grid leads of the socket and a similar hole in the opposite end for the plate pin on the socket arrangement. Another type is fitted with pins similar to our layouts but has a screw connection binding post fitted at the top of the envelope for the plate lead. This tube happens to be a one-kilowatt pentode of a design entirely different from any manufactured in this country, and if no replacement is available, an entirely new tube layout for the transmitter must be designed —together with the necessary socket, resistor and condenser changes.

Transmitter design of equipment built prior to the war was quite a bit different from that made here in a similar period. Most intermediate frequency band transmitters were designed to use a single oscillator tube, although there were a few more modern types designed around the master oscillator power amplifier type circuits. Many of these master oscillator power amplifier types of equipment, however, are designed to use radiotelephony as well as continuous wave and modulated continuous wave transmission, whereas it is not common to find radio-telephone equipment incorporated in the same transmitter on American designs used as

(*Continued on page* 76)

Fig. 2. Socket for dual-purpose tubes.



TECHNICAL BOOK & BULLETIN REVIEW

"PRINCIPLES OF AERONAUTICAL RADIO ENGINEERING" by P. C. Sandretto, Superintendent of the Communications Laboratory, United Air-lines Transport Corp., published by *McGraw Hill Book Company,* New York, N. Y. 406 pages plus index. Price $3.50.

This book is intended for those having basic knowledge of the fundamentals of radio and electrical engineering. In order to derive full benefit of its contents, it is essential that the reader have a fundamental knowledge of radio and at least understand the terms used in describing the characteristics of apparatus. To the practical man, this book may seem too mechanical, but the mathematician will recognize the limited depth of its derivations. Mathematical formulae are frequently used, and are presented in such a manner that references may be made by the serious mathematicians. The book is filled with a liberal treatment of the history and philosophy behind developments in aircraft equipment, devoted chiefly to the military aviation angle. It illustrates and describes various units, particularly from the standpoint of continental commercial airline operation.

The author states in his preface, "Although the information contained in this book may not be sufficient for military use, it should, however, serve the purpose for which it was written; that is, as a basis to which additions can be made by the student . . . the factor of secrecy has come into many of the discussions. For both commercial and military reasons, some of the facts cannot be published." Partial contents of the book are devoted to application of radio to aeronautics, the radio range, the ultra-high-frequency radio range, aircraft direction finders, markers, instrument mounting, absolute altimeters, direction finding from ground stations, medium-high-frequency communication, ultra-high-frequency communication, and chapters including aircraft power supply systems, considerations in aeronautical radio systems design and an appendix containing mechanical requirements for aircraft radio equipment.

This book is entirely up-to-date, having just been published. The material it contains is of current vintage. Students of aviation radio will find this book a valuable addition to their libraries.

"COYNE REFERENCE ENCYCLOPEDIA" (Volumes 1, 2 and 3), published by *Coyne Electrical School,* Chicago, Illinois. 1212 pages. Price $12.00 per set.

Designed especially for the student of electricity and radio, this reference

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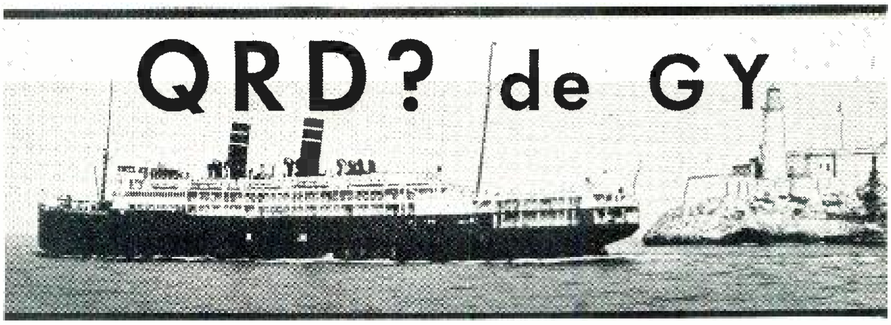

by JERRY COLBY

OUR mail these days is like the ebb and flow of the ships that are going and coming to and from all parts of the globe. Here a radiop has just arrived from around Midway, there a chap sends in greetings on his return from North Africa and others send in 73 from Australia. All of them have seen action of one sort or another. Some have been so close to it that the heat of battle seems to remain in the descriptions of the written word. As one publisher said recently there won't be a depression after this war is over because a million books will have to be published recounting the experiences of all those who have been in it. And some of the best storytellers are radiops . . . or shouldn't we know.

BROTHER HC Craig, Chief radiop USN, who has just returned from the North African coast tells us "when I wrote you my last letter it was just before we shoved off for the assault on Morocco. It was quite an adventure, my ship was in the group that went into action at Safi, a small port about 125 miles south of Casa Blanca. While our group did not meet the stiff opposition that the boys did at Casa Blanca. Fedala and Mehdia and up around Oran and Algiers we had our troubles. We suffered no losses in ships or personnel. Our forces knocked out the French shore batteries which were 155's and 75's and machine gun positions. It was a thrilling sight in the early dawn of November the 8th to see the flight of shells with tracers from our supporting ships which included a battleship, a light cruiser and a number of destroyers and smaller craft. We made good speed in unloading and got out of there. As you have read in the papers you know that five of our transports were torpedoed around Casa Blanca."

"It's interference from that Indian reservation!"

HC continues: "Upon my return to the states I was detached from the ship to shore duty here at——. My billet here is with the radio school where I am in charge of the radio section of group two. This is a very interesting place but I am not at liberty to tell you a great deal about our training program. Suffice to say that we are turning out some pretty good operators in the short period that is allotted. Many of our students have had no previous training and learn the code for the first time. Of course, once in a while an ex-Ham or some fellow with previous experience does pop in. Incidentally, the Navy is training Negro recruits in practically all classes of naval ratings. They are at Camp—and the first group of radiomen, yeomen, storekeepers, Quartermasters and signalmen graduates on January 4th. But I want you and the gang to know that although I had understood that this was a large training base, I had no idea that it was as large as it is. They make the claim that it is the largest of its kind in the World. 70,000 persons are supposed to be attached here . . . which is quite somethin'. Radiomen are going to tops after this shinding is over, so the more the better.". . .

HAL STYLES, Prexy of the Los Angeles-Hollywood Chapter of the VWOA, has this to say on the closing days of 1942: "The closing of 1942 marks the ending of a period in which we in America have made great strides towards total mobilization of our industrial, economic and manpower forces. As an indispensable factor in the war effort, Wireless has made a great contribution of which we veterans can be especially proud. Not only because many of us have hearkened to the urgent call of Uncle Sam, but because of the influence our Association has lent toward awaken-

(*Continued on page* 58)

Spot Radio News

IN DEFENSE AND INDUSTRY

Presenting latest information on the Radio situation.

by LEWIS WINNER
RADIO NEWS WASHINGTON CORRESPONDENT

IT ISN'T NECESSARY TO RACE to Washington anymore to get WPB assistance on radio production problems. For branches or "local field-service units" of the radio and Radar division of the WPB have been established in several cities thus far. In the New York office, Frank Mistlery has been appointed as head of this division. He is being assisted by a staff of six. The Chicago office is headed by Ray C. Woodford, who was formerly in charge of sales and production of Stewart Warner.

In charge of the complete division is Frank S. Horning. Mr. Horning has had extensive engineering and production experience in the radio and allied fields and is thus fully familiar with the maze of problems that cross a manufacturer's desk today. Among the problems that the new division will solve are those, for instance, involving available materials. One such instance came up recently. A manufacturer required a rarely used alloy. The public utility industry, the chief user of this material, was canvassed. The alloy was found and with the aid of the RFC, financial assistance was also arranged to provide the funds for this purpose.

That the opening up of these service branches will shortly be a haven of help is quite evident. Washington hopes to expand this service into a nation-wide network that will increase production by leaps and bounds.

YOU CAN STILL INVENT, even if you are in the Army. A new Army regulation now permits men to contact the Chief Signal Officer when they have a new invention. Thus far many important contributions have been made. While new developments have not paralleled the commercial equivalent of quantity, the inventions have been of vital import and have contributed materially to the war effort.

WE HAVE HAD MANY ALTERNATES for materials, but now component alternates are being adopted. This is particularly true in the case of meters. The demands for meters are great and in many instances in excess of production. Accordingly, it has been found necessary to use other means of indication of circuit action. The Material and Pre-service Tests Branch of the Signal Corps is studying and making rapid strides on this phase. Lamps, fuses and our good friend the vacuum tube are playing a major role in this work. The use of the vacuum tube as an indicator is well known to many radio set owners as the "magic eye." It will be recalled that before the magic eye, tuning meters were frequently used. While no complete development data is available on the alternate indicating devices produced in the Signal Corps, it is simple to see from the magic eye applications, that the possibilities are many.

Incidentally on the material alternate front appears friend solder. In an effort to save solder and its scarce ingredient, tin, solderless type terminals are becoming more and more a specified requisite in Signal Corps specifications.

THE IMPORTANCE OF RADIO IN ENGLISH WARFARE has been emphasized with the appointment of Sir Stafford Cripps as Minister of Aircraft Production. In his new post, Sir Stafford will be in charge of a special group whose sole purpose will be the development of radio for the war effort. Sir Stafford is able to take on such an important assignment for he is a trained scientist and fully familiar with the communication problems of the aircraft units. Heretofore the administrators of the Ministry of Aircraft Production have not been of a scientific type. They have been more familiar with the production and labor problems. In Sir Stafford, England has the ideal administrator. For being a lawyer, an able executive and an expert in science, he can cope with the variety of situations that have bogged down the others.

According to reports released from Washington, technicians were elated over this appointment for it was a first official government implication of the importance of radio.

TURNING IN THE OLD FOR THE NEW has become an official radio practice now. You will recall that some seven months ago we told of several retailers and associations who organized campaigns highlighting the necessity of turning in an old part, before a new one could be purchased. The plan worked well. It spread throughout many communities and even a few states. Now, the WPB has adopted the plan. Thus far only tubes are concerned. But it won't be long before the trade-in practice extends to the complete scope of parts.

This trade-in practice should receive wide application in the service shop-distributor-manufacturer setup. For there are plenty of components idling away in corners that could be easily turned in to usable apparatus. This material should not be characterized as plain scrap either. There are an endless variety of pieces that have refinishing and reprocessing value, such as choke and transformer cores, i-f cases, lugs, wire strips, etc. Dismantled from their basic unit. these salvaged pieces can be readily reclaimed and used effectively. This is a practice which both the service man and manufacturer can follow effectively. Of course, we do not mean to imply that the service man should go into the business of manufacturing.

There is no harm, however, in his utilizing every available method to expedite the replacement of effective components. This procedure assisted by the coming Victory allotment of parts should provide the service man with an effective source of supply of replacement items. This Victory line, by the way, appears now to have gained real headway. The Spring should see its inauguration. All of the V line of parts will not, of course, be available at the opening gun of the inauguration. But there should be an attractive allotment that will at least tend to alleviate the situation. The members of the various standardization committees are to be congratulated on their efforts in bringing this outstanding plan to a practical and effective completion.

NEW TYPE WATERPROOF BAGS enclosed the radio equipment that was taken ashore in the North African campaign. The bags, which were designed and developed by Quartermaster Corps technicians and industrial experts, were manufactured in sufficient quantities for the campaign, within a period of only two weeks. The bags are so sturdy and so resistant to water that the equipment shows no signs of any immersion even after having been hit by waves of salt water. Some of the bags are so large that tackle is necessary to hold them.

So unusual is the design of this bag that many have requested permission to use it for other than the military purpose for which is was designed. In view of its military importance, this permission may not be granted. However, this interest further proves that we will certainly see countless unusual military developments applied to peace-time equipment, when the war is over and the restrictions have been removed.

THE F.M. FRONT SEEMS TO BE GROWING rapidly. In the latest tally of F.M. outlets, there were 36 on a regular commercial basis, with nine others continuing as experimental ventures. The 36 stations maintain operating schedules ranging from six to a maximum of twenty-four hours daily. Some curtailment of the longer schedules may be expected as 1943 proceeds, due to the scarcity of replacement tubes and parts. Shutdowns, however, are not expected, in spite of what the rumors may say. In the F.M. roll call of 1942, we find one station in California (Los Angeles), two in Connecticut (Hartford), four in Illinois (Chicago), two in Indiana (Evansville and Fort Wayne), one in Louisiana (Baton Rouge), two in Massachusetts (Boston), two in Michigan (Detroit), one in Missouri (Kansas City), one in New Hampshire (Mount Washington), nine in New York (New York City with four, Schenectady with two and one in Rochester and Binghampton), one in North Carolina (Clingham's Peak), one in Ohio (Columbus), seven in Pennsylvania (five in Philadelphia and two in Pittsburgh), one in Tennessee (Nashville) and one in Wisconsin (Milwaukee). In addition, there are experimental transmitters on the air in Worcester and Springfield, Massachusetts; Washington, D. C.; Rochester, New York; Kansas City, Missouri; Superior, Wisconsin, and New York City, where there are three operating.

According to latest statistics, there are approximately a half-million receivers that tune in to F.M. programs. In Chicago, there are 30,000 F.M. owners and in New York City, there are 80,000. That's quite a growth for a comparative newcomer and interesting evidence of the strides F.M. will take when the production lines roll again. Veteran A.M. will have quite a sprinter to keep pace with!

WITH THE CESSATION OF THE RECRUITING OF MEN (except those above 38 and below 18), the drive for women to enter the Signal Corps has become quite an affair. In New York City and other cities, a steady stream of applicants has appeared before the Civil Service and Army officials to apply for positions as assistant radio engineers, assistant wire engineers and assistant senior draftsmen. Although these women do not actually become fullfledged members of the Army as the WAACS, they do have to serve the Signal Corps for at least one year and must accept assignment in any portion of the United States. The minimum requirement for this position is four years of high school, and eighteen years of age minimum. There is no top limit for age. During the first six months of training, they are paid $1440 a year, after which the trainees are eligible for promotion to $1620 a year.

A special training school has been set up in Long Island for those in the New York area. After the training period, these women engineers will move on to Fort Monmouth, to join the staffs of men engineers, previously recruited in similar campaigns.

EVERYONE IN WASHINGTON from administrator down to clerk is all astir about the indictment of a wire manufacturer for presenting false claims on $1,000,000 worth of wire manufactured for this country and the lend-lease countries. The charges say that for an insulation test the company installed transformers and a vacuum tube device, that reduced the test voltage to one-fifth of the amount required by the government. Thus the wire broke down not only in field tests because of the voltages used, but because of the climatic conditions which this wire was supposed to tolerate. Another practice that was used to deceive the inspectors said the Justice Department, was the substitution of specially prepared saturation compounds used in waxing the wire and preventing it from becoming damaged in the event of dampness or immersion in water. A specially prepared wax which met all of the specifications required under the contract was substituted in the test, for the actual wax used in manufacture.

This is the first instance of such wartime misrepresentation in manufacture, that appears to have been prompted by an unfortunate series of "personal" incidents. In the indictments announced by Attorney General Francis Biddle, branches of the company in two states, where the defective wire was made, were included.

TWO ADDITIONAL FREQUENCIES FOR INTERNATIONAL BROADCASTING were granted by the FCC recently, at the request of the Board of War Communications. The two frequencies, 7805 and 7935 kilocycles, that were allocated, actually belong to the police station zone and inter-zone communication systems. However, since the intended transmissions are for reception outside of continental United States, and since most the police work is during the daylight hours, interference is not expected. Thus the police will be allowed to use these frequencies, too. Of course, if interference does prevail, it will be necessary to make corresponding changes. And from the importance that the BWC attaches to international broadcasts, the changes will not be in the international transmission setup.

This problem of allocating frequencies serves to further the efforts being made to use the ultra-highs more and more, for this international broadcasting media. Propagation problems are present in the ultra-highs, but sufficient knowledge of frequency behavior and control is available *now* to provide solutions to most of these difficulties. The recognition of the value of the spectrum of ultra-highs has been not only established by engineers but by many administrators, such as chairman Fly of the FCC and BWC. As a matter of fact, in his last address before the IRE, Mr. Fly stressed the fact that most transmission will probably be in the upper regions, now if possible, but certainly at the conclusion of war. We hope it will be possible to begin now, at least with the international broadcasts.

THERE'S A TENTH YEAR CELEBRATION awaiting that vital link in television . . . the iconoscope. During the latter week in June 1933, Dr. Vladimir K. Zworykin announced his now-famous magic electric-eye that established television as a practical instrument. The tube developed then provided an image of 4 x 5 inches. We know today that 9 x 12 inch images and even larger are possible and with a clarity that is truly amazing.

In his television prophecy of 1933, Dr. Zworykin gave the first hint of development of the now famous electron microscope. Said he at that time, "And there is the possibility of a radio-vision microscope, an extremely sensitive, all-seeing device that will peer into the realms beyond the reach of the most powerful microscope."

With the development of the iconoscope came the possibilities of outdoor televising. And with outdoor televising came the beginning of a television era. For the ability to televise outdoor scenes effectively gave television a scope of usefulness that could only be classified heretofore as a Jules Verne dream. It is unfortunate that the present emergency has necessitated the curtailment of widespread television activities for Mr. and Mrs. Public. But, as mentioned before, television progress has not ceased. Not only are the military racing ahead with developments, but many a university and personal laboratory is delving into the uncanny properties of television. Yes, the world owes Dr. Zworykin a debt of gratitude for his great invention, the possibilities of which are beyond the scope of imagination and time alone will show its many possibilities.

WHEN ARTHUR VAN DYCK AT THE LAST IRE banquet mentioned the fact that radio may have to be retitled "radionics" to parallel our good friend electronics, everyone stopped to ponder a bit. For the new term did sound strange. It seems, however, as if a new word or title was coined that night and that hereafter we may see many references to this term. Among the first to use this new nomenclature is Zenith. Advertisements exploiting radionics as "the miracle industry," have appeared from coast to coast. As a matter of fact, an electronic division of Zenith has been formed to engage

OHMITE RESISTORS

function under all variations of climatic conditions . . .

Extremes of climate are an old story to Ohmite Resistors. These rugged wire-wound vitreous enameled units have proved their worth in both the freezing cold of the arctic and the heat and humidity of the tropics. Often the same resistors face both extremes as they go from one climate to the other, yet they keep doing their job accurately, dependably, *because* they are built right. Ohmite Resistors are used today in endless variety and number in war and industry, and are ready to aid in the development of new devices for tomorrow.

SEND FOR THESE HANDY AIDS

Ohmite Ohm's Law Calculator—*Helps you figure ohms, watts, volts, amperes—quickly, easily. Solves any Ohm's Law problem with one setting of the slide. All values are direct reading. Available for only 10c. (Also available in quantities.)*

Free Quick-Reference Catalog 18—*Gives helpful information on Ohmite stock resistors, rheostats, chokes and tap switches for all types of applications.*

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Foremost Manufacturers of Power Rheostats, Resistors, Tap Switches

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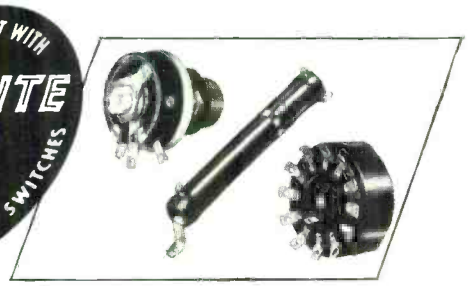

in the manufacture of "all types of electronic, *radionic radio,* radar television and electric apparatus and sound detecting."

Other similar units are being organized to produce the unusual in equipment that can already be anticipated, as the result of our war development efforts. We can truly expect an unparalleled wealth of miracle products in radio or "radionics" when the peace has been won.

FOR THE FIRST TIME, A MANUFACTURER OF A PRODUCT, other than radio, has entered the network scene. A tire company has purchased the Yankee network and six stations with the consent of the FCC. In the decision that made this unusual sale possible, two commissioners of the FCC, Mr. Walker and Mr. Durr, dissented. Commissioner Walker pointed out that broadcasting is of such public interest and importance that an effort should be made to keep it separate from other businesses. "If a transfer of chain broadcasting interest may be granted to a tire company," he said, "may it not likewise be granted to a motor company or to a public utility? The precedence having once been established of transferring licenses controlling a network to other interests . . . where can the line be drawn? Chain broadcasting is of such vital public consequence and public interest, that it should be a business in and of itself and disassociated from any other business."

A similar viewpoint appeared in the statement of Commissioner Durr. He implied that an acquisition of this type tends to make broadcasting an adjunct of private commercial enterprise, instead of the independent medium of entertainment and expression which it must be if it is really to serve the public interest.

"Unless some limitation is imposed," said Commissioner Durr, "they may embark on a program of station acquisition which will force their competitors and even concerns in entirely different lines of business to follow the same course in order to survive."

Notwithstanding these dissentions, the approval for the sale was granted. It is understood that no material changes are contemplated in the operation of the network or of the stations. Nor are changes in personnel contemplated. Even John Shepard 3rd, who is the operating head of the network, will remain as president and general manager under a five-year contract. This arrangement served in a large way to secure the necessary permission for the sale.

INTERCOMMUNICATIONS SYSTEMS ARE JUST AS POPULAR in Sweden as they are here. Advertising literature received here recently indicates that these office aids are becoming essentials in most businesses. Smartly designed, in attractive plastic cases, these intercoms resemble our streamlined midget receivers. Unlike the models here, though, the front and rear of the cabinets carry the design through. Ventilation is afforded by a series of attractively designed louvres that also serve the speaker-microphone. Pushbuttons, a couple of suitable signal lights and a moderne-handled switch are all that appear on the cabinet. Where additional speakers are required, a triangular shaped device that fits onto a stanchion or pillar is available. The unit is handsome enough, too, for the office, and like the other units offers surprising evidence of strides in design and production.

LICENSES FOR RECEIVERS IN ENGLAND are on the rise again. In 1941, there were 8,625,579 licenses issued. On August 31, 1942 (the latest available date from which these data are available), the number of granted licenses had jumped to 8,836,724. In 1939, when the war began, there were close to nine million licenses issued. This information was released during a debate in the House of Commons, during the first week of December of last year. This increase, of nearly a quarter of a million is most encouraging and tends to indicate the upward march of morale in England.

OVER A THOUSAND-PERCENT INCREASE in deliveries to the Signal Corps was reported for the month of November 1942, as against January 1942. The month of November itself was 30.5% ahead of October. This consistent production rate of increase will be maintained throughout the year to provide the greatest output of radio apparatus the world has ever seen . . . radio apparatus that is also the world's most efficient . . . as our enemies are finding out daily!

AN IMPORTANT PRIORITIES AMENDMENT that will unravel many knotty problems has just been issued. This basic document provides that, if for any reason, material obtained with priority assistance, or by allocation, cannot be used, as first intended, the material owner may . . . (1)—use it to fill purchase orders placed with him which bear a rating of AA-5 or higher, or a rating at least as high as that upon which the material was obtained, provided such use is permitted by other regulations and orders controlling the production or distribution of the particular material or item . . . (2)—use it for his own needs, if he has been authorized to obtain material for such use by applying or extending a preference rating of AA-5 or higher . . . (3)—re-deliver the material to the person from whom he purchased it . . . (4)—if it is impossible to use the material or dispose of it, he may then file a report with the regional WPB office, which will assist in the redistribution of the property.

Thus, if it becomes necessary to wait

(*Continued on page* 74)

IN the manufacture of precision instruments for the Armed Forces we strive for short cuts in production—but not in *quality*. There can be no expediency, no compromise, no half-way measures. The success of the bomber's mission depends as much upon the efficiency of the instruments as it does upon the skill of the officers and men.

Meeting the specifications of the United States Armed Forces is in itself an eloquent testimonial to the *quality* of DeJur meters, potentiometers and rheostats. However, we do not rest upon these laurels alone. Behind DeJur workers is the stern tradition of New England . . . honesty of craftsmanship, pride of skill, the deep, personal delight in doing a job and doing it better than anyone else—anywhere.

in war as in peace... *nothing takes the place of quality.* *Your inquiries are invited.*

DeJUR-AMSCO CORPORATION

SHELTON, CONNECTICUT

Manufacturers of DeJur Meters, Potentiometers, Rheostats and other Precision, Quality Electrical Instruments

Saga of the Vacuum Tube
(Continued from page 27)

tion in the scientific world, however, gives a multi-faceted picture which, even though it sometimes defies evaluation, gives to the historian much additional factual information.

The story of the development of the vacuum tube may be approached along two different paths, one of which leads us through the study of high voltage-heat phenomena, the other the study of high voltage-vacuum phenomena. Much has been written concerning the evolution which took place along this latter path, hence we shall confine ourselves to travel along the former.

Glazebrook's "Dictionary of Applied Physics" defines the word "thermionics" as the term "applied to the phenomena associated with the discharge of electricity from hot bodies." While we usually think of thermionics only in connection with electron emission in vacuo, the term as defined is much broader than that, and includes phenomena taking place under atmospheric conditions, such as the ionization of air by emission from hot bodies, flames, etc., and it is in this broader sense that we shall use the term.

The early work in thermionics is inextricably bound up with the work done by the philosophers of the seventeenth and eighteenth centuries on static electricity, and usually the experiments were conducted in air at atmospheric pressure. Under these conditions ionization phenomena become observable only where high voltages are available, which was the case during this period, the era of so-called *static* electricity. Knowledge in any field becomes greater as the tools available for use in investigation become perfected; hence it will be seen that as better tools and higher concentrations of energy became available, knowledge of thermionics grew apace. This era of static electricity was the era of high voltage.

Beginning around the turn of the nineteenth century with the work of Galvani and Volta the emphases in electrical research shifted to the field of galvanism and voltaic electricity, which was essentially a technique of low impedances. Hence we find little done in the field of thermionics during this era. Not until the tools of galvanism were developed and perfected, and higher voltages and greater energies were available from low impedance sources, could any great amount of work be done in the high impedance field of thermionics.

Early Investigators

The earliest reference in literature to the beginnings of thermionics is to be found in the work of William Gilbert of Colchester, physician to Queen Elizabeth, as recorded in his famous "De Magnete, Magneticisque Corporibus—." In this book[1], in discussing the effect of heat on amber, he says:

"Moreover the spirit of the amber which is called forth is enfeebled by alien heat—"

and later he makes the statement:

"It is manifest indeed that the effluvia *(charge)* are destroyed by flame and igneous heat; and therefore they attract neither flame nor bodies near a flame."

After Gilbert we find little of importance recorded until Otto von Guericke, Burgomaster of Magdeburg, entered the scene. Von Guericke is one of the few of the early workers to have made contributions to both the paths of research which led to the development of the modern vacuum tube. For, as every high school physics student knows, he was the inventor of the air pump, a device which has proved to be a most useful tool in many branches of research. He also, literally, started the ball rolling, with the invention of the friction type electrostatic generator, the first electrical machine. This machine is shown in Figure 1. It consisted of a globe of sulphur mounted on trunnions and rotated manually. The hand of the operator was used as the friction device. With this machine as a power source von Guericke made many experiments. During the course of his work he observed[2] that a body once attracted by an "excited electric" was repelled by it, and not again attracted until it had been touched by some other object. He also observed that if the repelled (charged) body came near a flame it could again be attracted by the electric without having touched any other body.

While von Guericke was delving so assiduously we know now that over the Alps in Italy similar observations were being made. Some of the members of the Accademia del Cimento, which was founded by the Medici family, and flourished from 1657 to 1667, were making their contributions to the advancement of various branches of human knowledge. We find that they observed[3] that if an electrified amber was presented to a flame it lost its "attractive power," that is, its electric charge.

Over in England Francis Hauksbee published, in 1709, a book[4] of interesting experiments on electricity. He improved on von Guericke's machine by substituting for the heavy sulphur globe a hollow glass globe, with which higher rotational speeds could be attained. A reproduction of an engraving showing Hauksbee's machine, as used in one of his experiments, is given in Figure 2. It will be noted that this machine also uses a pulley and belt drive system to enable the attainment of higher speeds of rotation.

With the work of Hauksbee there came a hiatus in the development of the electrical machine, for what reason we do not know. Many philosophers went back to the use of the glass tube, excited by friction of a piece of cloth, as a source of electricity.

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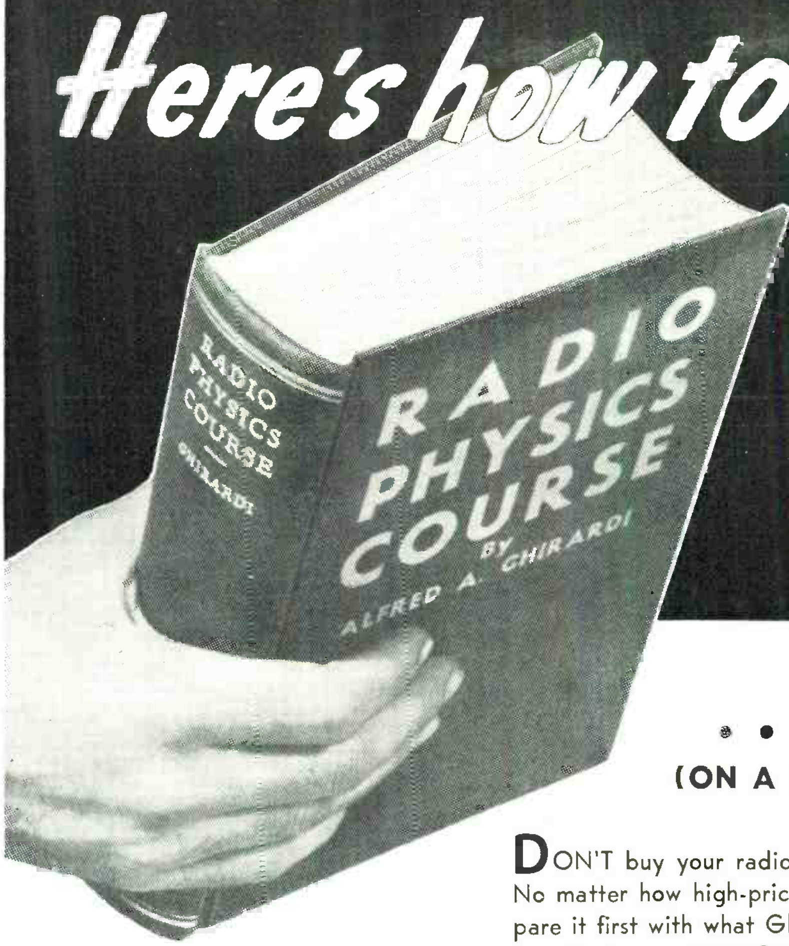

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Shortly after Hauksbee's book was published the work of another Englishman, Stephen Gray, began to attract attention. Unfortunately the records of Gray's life and work are hidden in the early annals of the Royal Society. When we first hear of him in 1720, he was about fifty years of age and a pensioner in the Charter House of London. Even then he was described as a crusty and testy old gentleman, to whom life had not been kind. He had no wealthy sponsor in his early years. Truly in his case "Necessity" was the "Mother of Invention." His apparatus was built of materials readily available to the poor. And yet with this crude experimental equipment he determined that the electrical conductivity of bodies depended on the substances composing them, and gave to the world the first practical and useful information on electrical conduction and insulation.

Gray's contribution to thermionics was an indirect one, and consisted of stimulating others. One of these was his co-worker, Mr. Granville Wheeler, who introduced the element of heat into some of his experiments. Another of those influenced by Gray was du Fay, of whom we shall hear more in a short time. Gray's early experimental work was unpublished for some time probably, according to Dr. Desaguliers[5], writing some years after Gray's death, because of his intolerance of opposition and fear of contradiction. In his later years he seems to have changed this attitude, perhaps with the improvement in his economic security which took place. This we deduce from the fact that he contributed a number of papers[6] to the Royal Society, and even while on his deathbed, dictated[7] some of his conclusions to the Secretary of that august body.

Across the Channel in France, Charles François de Cisternay du Fay began, in 1733, his famous work in electricity. At this time he was thirty-five years of age. While it is possible that Gray's temperament prevented philosophers in England from entering the field as competitors, it is evident that neither awe nor fear of this genius crossed the water to frustrate the working of du Fay. As we read of Charles du Fay he becomes a vivid, vital person. To his heritage of culture had been added the gifts of a brilliant mind, keen wit, and charming personality. He used these gifts to win the friendship and co-operation of Gray.

Du Fay's work merited being recorded in the annals of the French Academy. He wrote on every subject considered worthy of public discussion by philosophers. He was the only member of the French Academy who contributed to all six fields into which science was divided by that body. His tastes were catholic and his interests profound.

In the spring of 1733 du Fay learned of the work done by Gray and Wheeler. He immediately set about checking their findings; and determined to continue the experiments along somewhat different lines. During this year and the year following he wrote six Memoires[8] recording his experiences while conducting experiments on electrical phenomena. In one of these Memoires he set forth his theory of electricity, which was known as the two-fluid theory.

It is curious to note that although the electrical machine of von Guericke and Hauksbee must have been known to du Fay and his contemporaries, they did not use it. In all their experimental work they used glass tubes excited by rubbing with silk.

In his Fifth Memoire du Fay describes experiments on the effect of hot air, compressed air, and rarefied air on the electric effect. Another experiment, which was described in his Second Memoire, is especially worthy of note. He observed that the flame of a candle could not be electrified at all, and that it is not attracted by an electrified body. He adds the following:

> "This singularity merits a close examination, in which we will perhaps enter into the question of leakage; but of this we can assure ourselves, for the present, that this (phenomena) is not due to the heat nor to the burning; for a red hot iron and a glowing coal, placed on the glass table, become it (electrified) exceedingly."

Du Fay never examined the effect further, probably because of his interest in other electrical phenomena. He died in 1739 at the age of forty-one and his last Memoire, which was a summary of his concepts of the great phenomenon, was published in 1737.

Du Fay, in December 1733, wrote a brief synopsis of the Memoires which he had published in the annals of the French Academy and sent it to the Duke of Richmond and Lenox for presentation to the Royal Society[9] and to Gray "who works on this subject with so much application and success, and to whom I acknowledge myself indebted for the discoveries I have made, as well as for those I may possibly make hereafter, since it is from his writings that I took the resolution of applying myself to this kind of experiment." This is probably the handsomest recognition of the work of another investigator that has ever been published, and completely won Gray's heart. From that time on Gray and du Fay maintained communication with the greatest of friendliness. It was this which led Fontanelle to remark that he wished that such relations might always typify the intercourse between great nations.

All the experiments of the lonely Gray in England and the spectacular demonstrations of du Fay were soon repeated and publicized by Abbé Jean Antoine Nollet, who might have been as successful in the theater as he was in the field of science.

Nollet, because of his charm and

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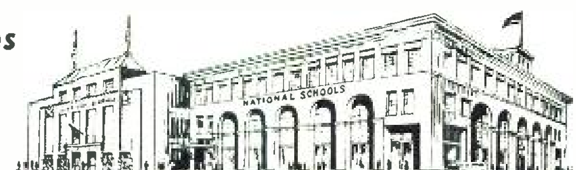

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wit, his talent for simplifying and explaining his theories, entertained the gay French court with his dramatic revelations. The public clamored for the theatricals of the intriguing French philosopher. Contemporary scientists recognized his genius.

Nollet carefully repeated the experiments of du Fay and came to conclusions which contradicted the findings of du Fay, particularly those pertaining to the effect of heat on the electric virtue. Nollet felt[10] that if his friend had lived long enough to study the relationship as exhaustively as he had planned, he would have contradicted himself. Du Fay stated briefly that the application of heat to an electrified tube had little or no effect on the electric virtue. Nollet, after performing many experiments meticulously[11], found that a white hot piece of iron dissipated the virtue very quickly, and that the result was the same when the iron had cooled to a red heat. As the temperature of the iron decreased the dissipation of the virtue was slower. He noted further that when the cooling iron had resumed its brown color, the electricity showed no sign of dissipation.

While Nollet was pursuing his researches in France, scientists in the Germanic states were improving the tools of electrical science.

Johann Heinrick Winckler conceived and brought to execution the idea of using a fixed cushion to provide friction on the electrical machine, instead of the hand of the operator, as originally used by von Guericke and Hauksbee. On March 21, 1745, Winckler communicated to the Royal Society[12] a description of his machine, which is shown in Figure 3. With this device he could obtain much more energy than before. This was later improved by John Canton of England[13], who applied to Winckler's cushion an amalgam of mercury and tin by means of which the excitation was increased.

George Mathias Bose, Professor of Philosophy at Wittemburg, about this time introduced[14] the *prime conductor*, in the form of an iron tube or cylinder, which increased the energy storage capacity of the machine. Figure 3, of Winckler's machine, also shows a prime conductor in the form of a rectangular plate.

About the same time Andreas Gordon, a Scotch Benedictine monk who was Professor of Philosophy at the University of Erfurt, substituted[15] a glass cylinder for the globe used by his predecessors.

With these improved devices much higher voltages could be obtained and greater energies could be stored. By this time the friction type of electrical machine had been developed to nearly its peak, and it seemed as though the time had arrived for some great advance. This came in 1745, when the discovery of the Leyden jar was announced.

The origin of this utilitarian device has been variously attributed to von Kleist, Dean of the Cathedral of Comin in Pomerania; van Musschenbroek, of the University of Leyden; and N. Cunaeus, a burgess of Leyden. It is now established that it was first announced[16] by von Kleist in a letter to Doctor Lieberkuhn, dated November 4, 1745, in which was described an elementary form of the device. His explanation of it was so obscure, however, that it was of little use. Von Kleist felt that the human body contributed part of the force of the jar.

The Leyden Jar, because of the increased energy and storage capacity it provided, was seized upon by the philosophers of all countries as a most versatile and useful tool. Large quantities of energy, with which spectacular experiments could be performed, could be obtained by connecting numbers of these jars together to form what was called a "battery."

The addition of these instrumentalities aided greatly in the progress of research in electrical science.

While this development had been going on, other scientists, such as Delaval, Canton, Watson, and Wilson of England, and Franz Aepinus of Germany were seeking further explanation of the effects of heat on electricity.

While it was customary for the philosophers to repeat experiments made by each other, for the purpose of verification or contradiction, we may attribute the unusual interest in the effect of heat to the fact that in 1756 Franz Aepinus made an important discovery. This celebrated German philosopher reported[17] his results in the study of the tourmaline to the Academy of Sciences and Belles Lettres in Berlin. He found that he could electrify this substance to a high degree by heating it to somewhere between 99½ and 212 degrees Fahrenheit. Up to this time very little was known concerning the necessity of heating the tourmaline to excite electricity.

It is not difficult to understand what followed the publication of his report. Immediately heat was applied by other scientists, not only to the tourmaline, but to all other experiments being conducted. The controversy of the tourmaline stimulated not only the study of this phenomenon but also the exchange of ideas.

Mr. Delaval set forth the results of his studies in this matter in a paper read to the Royal Society on December 17, 1761[18]. Mr. Delaval's explanation of his results was not satisfactory to Mr. Canton, who was similarly interested. Mr. Canton attempted to supply his own explanation of Mr. Delaval's results in a paper which he presented some three months later, on February 4, 1763, to the Royal Society[19].

Mr. Delaval expounded the theory that stones, tourmalines, and similar earthly substances were convertible from electrics to non-electrics by different degrees of heat. Mr. Canton claimed, in his paper, that the substances were conductors when they

were cold because they contained moisture (which is the bane of all experiments in static electricity); that when the moisture was evaporated by heat they lost their conductivity; that when they were made very hot, the hot air at or near their surfaces would conduct and the substances only *appeared* to be conductors again. Mr. Canton then proceeded to prove this contention. He says:

"Hot air may easily be proved to be a conductor of electricity by bringing a red-hot iron poker, but for a moment, within three or four inches of a small electrified body; when it would be perceived, that its electric power would be almost, if not entirely destroyed; and by bringing excited amber within an inch of the flame of a candle, when it would lose its electricity before it had acquired any sensible degree of heat."

We mention this particular incident in the history of thermionics for a very important reason.

Abbé Nollet had performed this same experiment using the heated iron to prove that heat dissipated the electric virtue in a glass tube, arriving at the conclusion that, since the virtue was dissipated, the heat was responsible for the dissipation.

Mr. Canton repeated the experiment to prove that hot air was a conductor of electricity. Since the electric virtue was dissipated, he concluded that hot air was a conductor of electricity.

Apparently, what they found depended on what they were looking for, a condition which is not peculiar to the ancients by any means.

But when Mr. Wilson made experiments[20] discharging electrified tubes by means of heated glass, Mr. Canton, who seemed to be always looking over someone else's shoulder, observed that perhaps Mr. Wilson did not discharge the tubes by means of the hot glass, but rather by means of the heated air on the surface of the material.

In 1777 the next important link in our chain was forged by Tiberio Cavallo. In his book,[21] published in that year, we find instructions for performing an experiment. Because of the significance of the explanatory note which he attaches we are here reproducing (see Figure 4) the pages of his book on which it is given. In reading these pages the student should bear in mind that the "battery" of Cavallo's day was a bank of charged Leyden jars as previously described, and not the chemical device which is today termed a battery.

We see that Cavallo contradicted not only Wilson but Canton. Cavallo realized that some element other than heat or hot air was responsible for the discharge. "Perhaps from its ignited particles" is the keynote of the essential difference between his explanation and that of his predecessors.

The term "thermionic emission" was many years in the future.

(*Continued on page* 52)

CATHODE-RAY TUBE CHARACTERISTICS

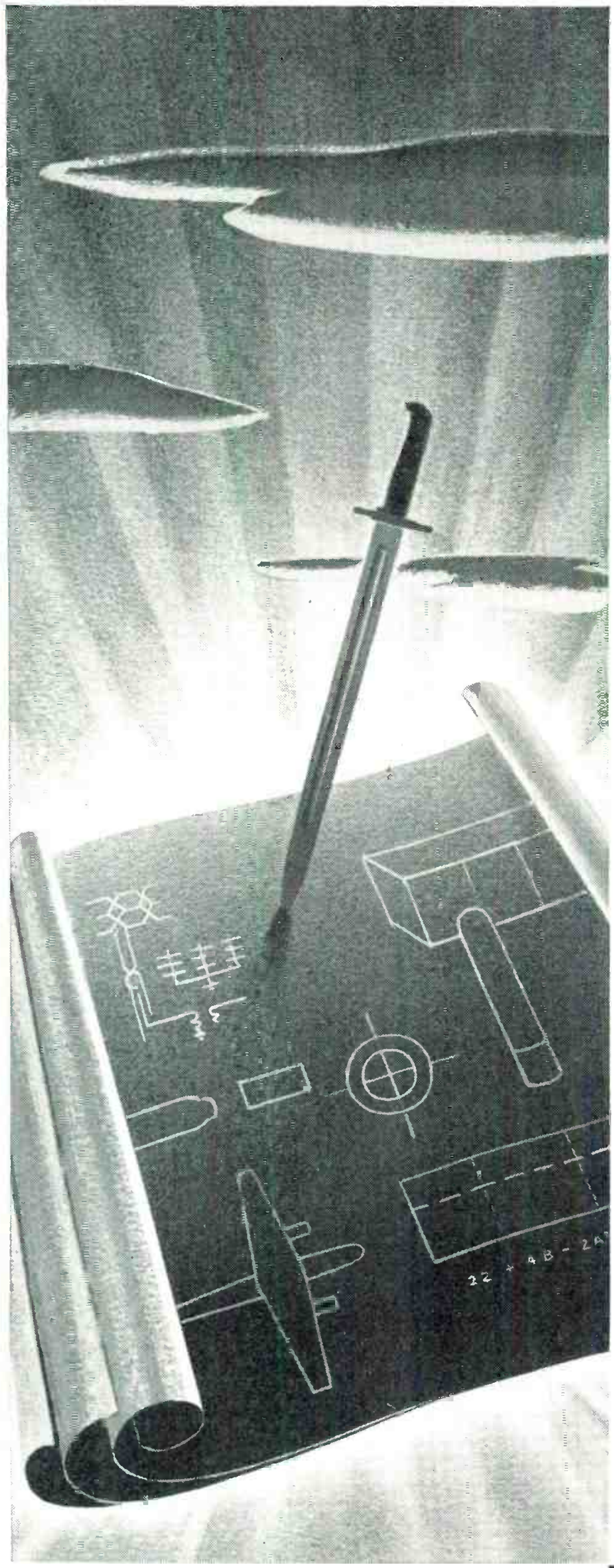
THE electron beam in a cathode-ray tube may be deflected by either magnetic or electric means, but by far the most common type of deflection is electrodynamic. Magnetodynamic deflection is seldom employed for oscillographic purposes since the impedance offered by the deflection coils varies with frequency, varying the deflecting field and therefore producing indications difficult to interpret, according to Du Mont engineers.

Deflection voltage requirements for electrodynamic deflection systems increase directly with increasing accelerating potential. It is thus necessary to investigate the signal voltage available in conjunction with deflection requirements of the cathode-ray tube to be used. At the same time if an amplifier such as, for example, the deflection amplifier provided in a cathode-ray oscillograph is to be used to amplify the signal for deflection of the cathode-ray tube, care must be taken to insure that the output voltage available is sufficient for full-scale deflection of the tube.

All *Du Mont* instruments, it is pointed out, are designed so that the overload point of their deflection amplifiers is off the screen. This consideration is especially important when it is desired to employ commercial oscillograph amplifiers for deflection of a cathode-ray tube different from that provided with the instrument, since in most cases only sufficient deflecting voltage has been provided for the standard tube supplied with the instrument while operating at potentials available in the instrument. If this precaution is not observed, the overload point of the amplifiers is likely to occur on the screen, thereby seriously distorting the unknown signal.

Electrodynamically deflected cathode-ray tubes are manufactured with either one or two plates of a deflecting-plate pair available for external connection. In the former case one plate of each pair is connected within the cathode-ray tube to the second anode. The free plate of each pair is brought out to a connecting terminal for deflection. Such operation is permissible at low accelerating-potentials but, when it is desired to operate a cathode-ray at high accelerating potentials, the high deflecting voltage required is likely to develop an axial as well as radial acceleration to the beam, which may cause a certain amount of defocusing to appear on the screen edges.

When both plates of a deflecting-plate pair are available for external connection, higher accelerating potentials such as are necessary for satisfactory operation of long-persistence screens and for high brilliance, may be used. —30—



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Saga of the Vacuum Tube
(Continued from page 50)

Up to this point we have been concerned with showing a continuity in the study of thermionics. Many scientists not mentioned here were studying the electric phenomena from other angles, and it is true that some considered the factor of heat in some of their experiments. Our purpose has been to show an unbroken chain in the study of the relation of heat and electricity in the early days.

Just as we have traced the foundations of thermionics along the high voltage-heat path, so also we might trace the development along the high voltage-vacuum path, from the work of von Guericke in the development of the air-pump, and the study of the attractive power of electrified bodies in vacuo by Robert Boyle in 1670,[22] and by the Accademia del Cimento.[23]

Following the above, an unbroken chain of experiments with vacuum in connection with electricity may be seen by tracing the observations of Hauksbee,[24] Gray,[25] du Fay,[26] Nollet,[27] Allamand,[28] Ludolph,[29] Hamberger,[30] Waitz,[31] Canton,[32] Watson,[33] Grummert,[34] Wilson,[35] and others.

Up to this time little had been heard from America. Suddenly in the middle of the eighteenth century a voice from this side of the Atlantic was heard.

In 1750 the remarkable discoveries of Benjamin Franklin startled the scientific world. More amazing do the achievements of Franklin appear when we consider his background and contrast it with that of the foreign scientists. Franklin, born in 1709, had very little formal education. At the age of seventeen he arrived in Philadelphia from Boston. He was penniless and had worked for his transportation; at the age of forty he was Philadelphia's leading citizen. Those twenty-three years were spent in work during which time he founded schools and libraries, established a newspaper, organized civic affairs, and founded the Philosophical Society. He always had a desire to study natural sciences but never had the time. Franklin knew nothing of the environment of the European philosopher who spent his time in slow deliberation and contemplation of the causes and effects of the universe.

Yet scarcely five years after he met Doctor Spence and saw his crude electrical experiments in Boston Franklin received world acclaim for his discoveries in electricity. So revolutionary and conclusive were his findings that they almost stunned his contemporaries abroad. His experiments were many, his writings on the subject prolific. At once he was recognized as a genius. He charmed the world with his directness and simplicity, his ability to say "I don't know." With him worked such men as Ebenezer Kinnersley, Thomas Hopkinson, and Philip Sing, all brilliant men.

While they did not contribute directly to the science of thermionics, their work was important enough to make our friends abroad realize that a new era had begun. Their own new date line was "Since the time of Ben Franklin."

The achievements of Ben Franklin are of particular significance today. Thousands of boys in the armed forces are being trained for work in communications. They are required to absorb present day knowledge of radio in the briefest possible time. Many of them have no more technical background than did Franklin. From some of them we may expect inventions and discoveries never thought of by the engineers designing the communications systems. History shows how frequently the men using a device will adapt it to their own needs in ways completely overlooked by the man who, because of his absorption in developing the device, has become a channeled thinker.

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The SPRAGUE TRADING POST

EXCHANGE—BUY—SELL

A WARTIME SERVICE TO THE RADIO PROFESSION

Is there something pertaining to Radio that you want to Buy—Sell—or Swap? If so, send us your advertisement today. We'll schedule it for appearance in the Sprague Trading Post as soon as possible—*AT NO COST TO YOU*, and providing only that it seems to us to fit in with the Trading Post plan. Our aim is to cooperate with our friends throughout the trade with the object of helping keep the nation's radios working during these shortages of wartime days! *Address your ad to: SPRAGUE PRODUCTS COMPANY, North Adams, Mass.*

Your Own Ad Run FREE!

WANTED—Two 865 tubes. Also, one 6 amp. battery charger. General Radio, 701 E. Las Olas Blvd., Ft. Lauderdale, Fla.

WILL TRADE OSCILLOSCOPE—Will swap 2 in. Supreme Oscilloscope, Model 535 in excellent condition, for Vacuum Tube Voltmeter, or new radio tubes, or will sell for $20 cash. Buck's Radio Service, 291 Home Avenue, Mansfield, Ohio.

FOR SALE—Jensen 12 in. series X speaker with 6 volt field coil; Wright Decoster 10 in. speakers (two) with 6 volt field coils; Triplett Model 1210 A Tube Tester in oak carrying case; also Jannett Type C6 Rotary Converter, 110 volts a.c. to 110 volts d.c. All used, but in fair to good condition. Howard F. Wampole, P.O. Box 45, Gwynedd, Pa.

TUBES WANTED—Will pay list less 40% and shipping charges on small quantities of following tubes: 50—50L6GT; 50—35Z5GT; 25—35Z4 GT; 50—12SA7 (or GT); 50—12SQ7 (or GT); 50—12SK7 (or GT); 25—No. 80; 15—5Y3 (or GT); 25—35L6GT. Any good brand. Write soon as possible. Pine Radio Service, 44th & Spruce Sts., Philadelphia, Pa.

WANTED FOR CASH—"RME" LF-90 low frequency expander, 90 to 600 kc. Radio & Electric Repair Service, 315 Beechwood Ave., Trenton, N. J.

WANTED FOR CASH—Solar, QCA or Exam-eter; Triplett 1200 VOM, 1000 ohms per volt. Also need 12S tubes, 5Y4G, 5Y3G, 50L6GT. Will pay cash for any or all. Seymour Radio Service, 20 New St., Seymour, Conn.

RECORDER FOR SALE—Complete, professional, heavy duty type, 2-speed turntable with cutter and pickup. 2-channel amplifier with tuner, crystal microphone. In perfect condition. Will demonstrate. Best cash offer takes it. Coronet Radio Shop, 224 Thompson St., New York, N. Y.

WANTED—Do you have a 4 in. diam. 3-jaw self-centering lathe chuck with or without face plate to fit ½ in., 24-thread spindle? Have phono motors and tube testers to swap or sell. Miracle Radio Shop, 1901 Lexington Ave., New York, N. Y.

WATTMETER FOR SALE—Weston Model 432 in bakelite case. Range 0-150 & 0-300 watts. $30. Radio & Electric Repair Service, 315 Beechwood Ave., Trenton, N. J.

SELL OR SWAP—Will sell or exchange the following tubes: 32L7, 48, 199, 182B, 89, 25B6, 12A7, 12A5, 34, 40, 30, 31, 32, 33, 55, 25A7, 6A4, 6A6, 1A1, 1A5, 1A6, 1B4, 1C1, 1C5, 1C6, 1D1, 1D5, 1D7, 1D8, 1E5, 1F1, 1F6, 1G4, 1J6, 1P5, 1Y1, 1Z1, 2A6, 2A7, 2B7. Traveltone Radio, 2014 Broadway, New York, N. Y.

50L6GT TUBES TO SWAP for a Bridge Condenser Tester. Will pay part in tubes, part in cash. Leo the Radio Man, 4230 Lancaster Ave., Philadelphia, Pa.

ANALYZERS WANTED—Need Superior Channel Analyzer, and the All-Meter (Jumbo) 6 in. Meter in good condition. Also want Jackson Condenser Analyzer or similar apparatus. Dearth Radio Service, Augusta, O.

MANUALS WANTED—Want Rider's Manuals Vols. VII, IX, X, XI, XII, and XIII. Must be complete and subject to examination. State prices. Bannister Radio Service, 2119 Shawnee Ave., Scranton, Pa.

WANTED FOR CASH—Scott Philharmonic FM-AM Receiver; Triplett Signal Generator Model 1632; Presto Recorder. State price, condition, and how long in service. Jahn Radio Service, 240 W. Maumee Ave., Napoleon, Ohio.

VOLTMETER FOR SALE—Weston Milli-Voltmeter, Model 45, 5 in. needle sweep, scale in 10's graduated 0-1000. In wood case. Make us an offer. Mauk's Radio Service, 717 S. Brady St., DuBois, Pa.

TUBES WANTED—List your unused tubes according to types, prices, and quantity and mail to Rowse's Radio Sales & Service Co., 85 Robinson Ave., Pawtucket, R. I.

CHANALYST, VOLTOHMYST FOR SALE—Going into other business and offer following in first class condition for best cash offer: Rider Chanalyst; Senior Rider VoltOhmyst; Philco Model 050 Tube Tester; Philco 077 Signal Generator; Rider's Manuals Vols. 1 to 12. Farmon L. Newton, 2112 Picher St., Joplin, Missouri.

FOR SALE—100 tubes of various types, also condensers and transformers. Would like to swap a tube tester for a new one, and have some used radios (late models) for sale in good condition. L. W. Coleman, 29 Wellesley Drive, Pleasant Ridge, Mich.

SWAP OR SELL—Will sell or trade tube checker, channel analyzer, and over 300 tubes, parts and old radios. Need a Supreme or any good make oscilloscope. Joseph M. Ortiz, 52 E. 103 St., New York, N. Y.

USED CHASSIS WANTED—Will buy used chassis up to five years old in any condition. Send us a list of what you have. Columbia Radio & Phonograph Service, 1254 Amsterdam Ave., New York, N. Y.

MANUALS AND OHMMETER WANTED—Want Vols. 7-9 and 10 Rider's Manual, also ohmmeter. Name best cash price. Have Marlin 22 cal. rifle to swap or sell. Ristow Radio Co., 3608 Irving Pk., Chicago, Ill.

TUBES AND SIGNAL TRACER WANTED—Want 6F6M (G or GT), 35Z5GT, and 35Z3 tubes; also Philco Signal Tracer. Tubes must be in factory-sealed cartons. Advise what you have. Duncan's Radio Service, Longhurst, North Carolina.

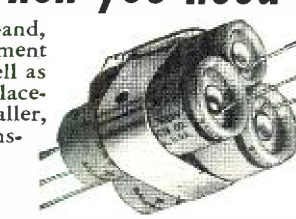
FOR SALE—Sets, chassis, and farm sets. Table models, combinations, etc. Write for details. Victory Radio & Record Shop, 1546 E. 53rd St., Chicago, Ill.

TECHNICAL BOOKS WANTED—Want Rider's Manuals Vols. 7 to 13, also late technical books on radio and refrigeration. State best cash price. Robison Radio Service, Ione, Wash.

WILL BUY—Oscillator, Ohmmeter and Manuals. Give details and price. Tube Tester for sale. John Honochick, 157 First St., Oneida Pa.

THE CONDENSER YOU NEED . . . *when you need it!*

Sprague Atom midget dry electrolytics are still available—and, with them, you can handle practically any condenser replacement up to their ratings. You can get Atoms in single-sections as well as in multi-capacity units—and you can make up hard-to-get replacements by strapping individual Atoms together. Atoms are smaller, cheaper, and fully as reliable as the big, old-fashioned condensers they replace. *Use Atoms UNIVERSALLY on all of your jobs!*



SPRAGUE PRODUCTS CO.
North Adams, Mass.

SPRAGUE CONDENSERS AND KOOLOHM RESISTORS

Obviously, Sprague cannot assume any responsibility for, or guarantee goods, etc. which might be sold or exchanged through above classified advertisements.

22. *Secondat de Montesquieu, Jean Baptiste, Baron de: "Historie de l'electricite." Paris,* 1750.

23. *See reference* 3 *above: "Saggi di naturali esperienza——." Third edition,* 1841, *pp.* 51-54. *"Essays on natural experiments." Benj. Alsop,* 1684, *pp.* 43-46. *See also Phil. Trans. Roy. Soc. Abridged, Vol.* 4, *p.* 275.

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26. *du Fay, Charles Francois de Cisternay: Fifth Memoire on Electricity. Memoires de l'Academie Royale des Sciences de Paris,* 17-34, *p.* 489.

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28. *Allamand, Jean N. S.: "Versuche und Abhandlungen der Natursforschenden Gesellschaft in Danzig." Danzig,* 1747. *Vol.* 2, *p.* 426. *(Danzig Memoires.)*

29. *Ludolph, C. F.: Danzig Memoires, Vol.* 3, *p.* 495.

30. *Hamberger, George Erhard: Danzig Memoires, Vol.* 2, *p.* 426.

31. *Waitz, Jacob Sigismund von: Danzig Memoires, Vol.* 2, *pp.* 380, 426. *See also "Recherches sur les differentes mouvements de la matière electrique." Paris,* 1760.

32. *Canton, John: "Attempt to account for some of the phenomena of electrical experiments." Phil. Trans. Roy. Soc., Vol.* 48, 1754, *p.* 356.

33. *Watson, William, M.D.: "On the phenomena of electricity in vacuo." Phil. Trans. Roy. Soc., Vol.* 47, *pp.* 362-376. *Paper read February* 20, 1752.

34. *Grummert, Gottfried Heinrick: Danzig Memoires, Vol.* 1, *p.* 417.

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(To be continued)

Pocket VTVM's

(Continued from page 33)

tube need not be electrically shielded.

The circuit is a grid rectification arrangement which functions in the same manner as an input diode rectifier followed by a d.c. amplifier. The input circuit is isolated by means of the 0.02-μfd. mica blocking capacitor (made up of two paralleled 0.01-μfd. units).

The plate-circuit by-pass capacitor C2 (*Aerovox* type 284) is a 0.1 μfd. tubular which acts to by-pass any alternating current passed through the tube interelectrode capacitance.

The initial steady plate current of the tube is bucked out by the single cell B3, which delivers current in the reverse direction through the meter through the zero-set rheostat. This variable resistor must be a midget wire-wound, such as an *I. R. C.* type W-10,000. 10,000 ohms full value is recommended.

This v. t. voltmeter has a normal full-scale deflection of 3 volts RMS which may be multiplied to 30 and to 300 by the input voltage divider R1-R2-R3 which will be seen to consist of the same resistor components as the multiplier in Figure 1. By using a miniature 3-position rotary disc-type switch, the selector mechanism may be kept small in size.

The entire 1Q5-GT instrument may be enclosed within a 4"x5"x2¼" metal chassis pressed into service as a case. The chassis bottom plate completes the enclosure.

Single-Battery Model

The circuit of Figure 4 embodies a unique arrangement for obtaining filament, plate, and bias voltages all from a single *Eveready* No. 773 flat 7½-volt battery. In this hookup, the slow deterioration of the operating battery does not change the operating characteristics of the instrument beyond control, since the 1H4-G tube is normally operated at lower than regular filament voltage. And as the battery voltage declines with use, the original operating voltage is restored by adjustment of the rheostat R8. In actual adjustment, R8 is simply set to zero the meter M. When the meter is thus set to zero, all three voltages have automatically been restored to normal.

The indicating meter is a 2-inch 0-1 d.c. milliammeter (*Simpson* Model 0-1.) With this instrument, the normal full-scale deflection is approximately 2 volts RMS. The input voltage divider R1-R2-R3 enables multiplication to 20 and to 200 volts.

Due to the few components required in the construction of this battery-operated v. t. voltmeter, the instrument overall size may be kept within 5"x5"x2". If the fundamental full-scale deflection is satisfactory to the builder, and the higher ranges are not required, the input voltage divider may be dispensed with, the tube placed on the end of a cable as a portable probe, and the size even more materially reduced.

1.5-Volt Model

An interesting circuit, based upon a popular European design and permitting almost unbelievably small size is shown in Figure 5. This unit may be made so small in size, provided a small-size meter of sufficient sensitivity may be obtained, that it might even be termed a *vest-pocket v. t. v. m.!*

Built around a *Hytron* HY 113-B baby bantam tube (which, including its socket measures only 2¼" long by 13/16" in diameter), this v. t. voltmeter employs a single 1½-volt pen-size flashlight cell for filament and plate voltages. Plate potential is ingeniously obtained by connecting the plate circuit back to the positive terminal of the 1½"-volt filament battery.

Due to the low plate potential employed in this circuit, a highly sensitive indicating meter is required. This is the lone disadvantage of the compact instrument. Recommended for this purpose is the meter employed in our own experiments—a 0-50 d.c. microammeter (*Simpson* Model 0-50). Only the 3-inch case size could be obtained in this sensitivity. However, a "thin" shallow cabinet for the meter will hold all of the circuit components. In one of our breadboard test arrangements of this circuit, we mounted a basic set of parts minus the input voltage divider in a 1-inch-diameter short test probe. The leads from this probe ran directly to the microammeter. The pen-size cell within the test probe handle was switched on by means of a sliding-type flashlight switch.

Unless an additional cell or bridge circuit is employed, the meter zero must be suppressed mechanically either by "backing up" the meter zero-set screw or bending the pointer gently backward using a pair of tweezers.

Normal full-scale deflection of this circuit is 5 volts RMS which may be extended to 50 and 500 volts by substituting for R1 one of the input voltage dividers described in the outlines of the previous circuits.

Calibration

Calibration of any v. t. voltmeter is a relatively simple process. However, the simplicity of the operation must not tempt the operator to spare any pains in the making of observations and marking off of deflections. The process consists of impressing a known a.c. voltage (at any convenient frequency within the frequency range of the instrument) across the input terminals of the v. t. voltmeter and noting the deflection of the milliammeter or microammeter. The value of the input voltage must be continuously variable in order that a large number of points may be obtained directly.

Several calibration hookups are shown in Figure 6. In (A) the calibration voltage is obtained from the low-voltage winding of a standard filament-type transformer, T. A 6.3-volt unit is recommended for calibration of the v. t. voltmeters described in this article. A 10,000-ohm wire-wound potentiometer is connected across the secondary of the transformer to enable adjustment of the calibration voltage to various voltages at will between approximately zero and full secondary value. A good, dependable AC voltmeter monitors the calibration voltage.

The potentiometer is set at a particular value and the milliammeter deflection noted. If the meter scale is to be marked off directly, the meter case is removed and the position of the pointer on the scale indicated carefully for each voltage by a light pencil dot. After all points along the scale have been thus pointed off with the aid of the input AC voltmeter, the milliammeter scale may be removed and lines inked in at these points. In this operation, the sensitive milliammeter movement must be protected against drafts, including those arising from the operator's breathing, in order that erroneous deflections of the pointer are not occasioned.

The 60-cycle calibration thus obtained will hold for other frequencies as well, provided that the operation is carried out with care. The monitoring AC voltmeter will read RMS values, so that these values may be transcribed directly to the meter scale or its calibration curve if the v. t. voltmeter is to read RMS volts. The voltmeter values must be multiplied by 1.41 if a peak-reading v. t. voltmeter scale is desired, or by 0.9 if an average-reading scale is desired.

Operators possessing variacs will prefer to use this variable transformer in place of the potentiometer and may employ the circuit of B (Figure 6).

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For the Record

(*Continued from page 4*)

ants on the home front, the hundreds of thousands of air raid wardens, the millions of men and women on the industrial front, a new name deserves to be added. It's the radio serviceman. The patient skill that radio servicemen gained during peace suddenly became a vital military resource. These are the men entrusted now on the fighting fronts with manning and maintaining America's electronic weapons. Thus, the ranks of the radio serviceman have shrunk as one after another went into the armed services. Those left are working far into the night, taking up the slack. Because in this total war, they know that the 50 million home radios may be as vital in an emergency as the radios on the warships, planes and tanks. Your serviceman is doing a real job!"

LETTERS have been pouring in from readers interested in "The Tube Collector" which we began in the February issue of RADIO NEWS. Many individuals who do not consider themselves to be bona fide collectors have one or more collectors' items available, and for the most part have been perfectly willing to dispose of them, providing they reach those engaged seriously in the collecting of antique specimens. We are compiling lists of all tubes available, and these will be included from time to time in "The Tube Collector" column. Some readers feel that they have enough types to start a collection. We shall attempt to help these people in every way possible.

THE Editors of RADIO NEWS are still receiving many complimentary letters regarding the November Signal Corps Issue. Upon receiving the official *War Department, Office of the Chief Signal Officer,* Information Letter No. 1, Vol. 2 for January 1943, we found a full page containing reproductions of letters received by the *Signal Corps* commenting favorably on that issue. We are proud that we have been able to portray the history and activities of that branch, at a time when the information was so greatly needed . . . both in military circles and by civilian personnel.

LITTLE information has been given as to the quality, durability and design of radio equipment used by our enemy. The article "German Aircraft Radio Equipment" which begins on page 10 of this issue will be most enlightening to you radiomen, who have been wondering how foreign equipment compares with that used by the U. S. Army Air Forces and her allies.

Another scoop is the article on the new *Illinois State Police* "Mobile Crime Laboratory." Radio equipment designed especially for this unit plays an important role by permitting its personnel to maintain contact with both fixed and other mobile stations.

As promised, RADIO NEWS presents, beginning with this issue, a series of exclusive articles prepared by a top-ranking engineer who is a member of the staff of one of the largest development laboratories in the world. His treatise on "The Saga of the Vacuum Tube" is the result of years of painstaking research. It will give in complete form the entire history and development of the vacuum tube. With thousands of new students now studying radio, it is extremely important that they be given factual data on the many types of vacuum tubes together with sufficient background in order to obtain a full appreciation of the amount of painstaking effort that our scientists have made to give us the so-called "heart" of our receivers and transmitters and other electronic devices.

A CORRESPONDENT from far off Malta wrote to us recently stating that he had not been able to procure copies of RADIO NEWS for many months. He wished to know "how we were doing" back home.

The following are excerpts from Mr. Scidman's letter:

*Hello Mr. Editor: Here's an echo from far off "Malta." How are you and your staff? Is the famous "*RADIO NEWS*" still being published? Have been unable to get a glimpse of your magazine for over a year though I have tried many times. Thanks to the fine recent events created by your people and ours, we shall get in regular contact very soon. . . . Best wishes to your staff and the radio community, and tell them that 1943 is surely a victorious one for people of the shattered island. They are all stout-hearted, and they shall soon join hands with their friends across the sea. The radio business is absolutely flourishing here, and for this reason I am eager to get your latest developments of the radio world.*

My sincerest wishes to yourself,

Yours,

(Signed) *Joseph Scidman,*
Island of Malta.

Our reply contained the assurance that when final victory was won by the United Nations that he would again be able to complete his RADIO NEWS file. We extend his best wishes to all of you readers, particularly to those of you now engaged in wartime jobs or in military service.

We look forward to the day when it will be possible once more for him to receive his copy of RADIO NEWS every month.

73, OR . . .

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NEXT MONTH!
FIRE-FIGHTING AM NETWORK

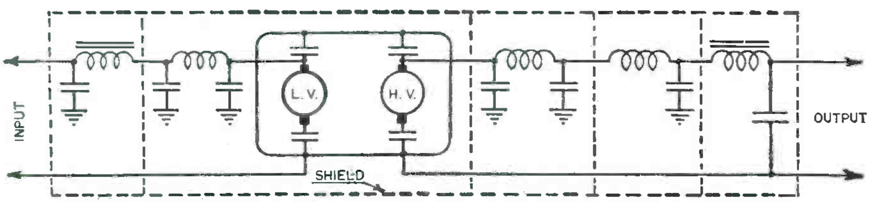
Dynamotor Filtering
(*Continued from page* 13)

strays. L_3 and C_{13}, when and if necessary, shall be used to react and suppress remaining r.f. interferences. C_{14} and C_{18} may be used in case the outgoing leads may have picked up some radiation immediately prior to their exit. In most cases L_3 and C_{13} will not be required. L_4 and C_{15} shall be of such value to reduce the audio frequency to a low value. L_1 and L_6 are very important reactors and will suppress commutator and slot ripple surging back into the source of power supply, the big offender to the radio receiver. C_1 and C_2 are the associates to L_1 and L_6 and should be used as such.

Never allow a filtered wire to come even close to an r.f. circuit. The entire filter must be thoroughly shielded and only thoroughly filtered wires shall make their exits from same. When space is limited for a good filter sequence layout, good judgment must be used in making shielded compartments so as to prevent coupling. Properly designed filters will more than pay for themselves on the production line. A machine designed for hairline decisions puts production and other departments into difficulties, and is a source of argument between manufacturer and user.

—30—

Fig. 4. Best grounded system.



Coming Next Month

PRACTICAL U.H.F. OSCILLATORS

(New Ideas for Improved Performance)

QRD? de Gy
(*Continued from page* 38)

ing youth to the possibilities of our art, which has now emerged from its swaddling clothes to longies.

"Special tribute is due and is hereby paid to the benign and kindly interest of our own Dr. Lee de Forest, National Honorary President and Father of Radio, without whose enthusiasm we would not have been inspired to grow. I am sure I express the hope of each one of you when I wish for him many, many more years of fruitful endeavor. (He recently celebrated his 69th birthday.)

"In this coming year it is the earnest hope of your Board of Directors that we can bring to a realization a dream to establish a West Coast Monument in McArthur Park in Los Angeles, to be dedicated to the memory of wireless operators who have lost their lives in the performance of duty, since Pearl Harbor.

"May I take this opportunity to thank each and every one of you for your loyal adherence to the purposes of our organization and especially Sections A and B which are (a) to foster and extend an esprit de corp among wireless operators and (b) to promote a fraternal and comradely sentiment between and among its members. And in closing may I add that while the future may look dark to some of us, it is nevertheless very bright indeed. For our good bark has ridden safely and speedily during the past years as we emulated 'the way is long, the night is dark, the hidden shoal may wreck the bark, so give the signal and the sign, that marks the true fraternal line. This may we do 'ere we are gone . . . we speak, we hail, and then, pass on.' "

INCIDENTALLY, Brother Styles is trying to locate Leo Glassberg, Elwood Welch, S. J. Minnikin, Glen Litten, Lewis D. Chilson, Sidney J. Fass, Price, Garner and Ernest Roberts. Their mail, he sez, has all been returned and they have no forwarding address. So shoot in the dope on these radiops. This assignment should be easy after being able to find a chap in South America for a fan in Bangkok, Siam (Thailand, to you, now).

AS we go back with the VWOA gang we remind ourselves of a bit of verse that George H. Clark, former RCA boss donated to all and sundry. This, sung to the tune of The Old Oaken Bucket, goes rather well. "How well I remember, the first days of wireless, when home made receivers were all we could own. We built them and used them, with energy tireless, and thought them the finest and best ever known. The old slide wire tuner, the crystal detector, the headphone receivers as clear as a bell. But most I remember, the fly in the nectar, the old broken static that came in so well.

The loud, rattling static,
the strong summer static
the old broken static that came in so well.

Today we have stations, of great super-power. Much stronger than static, we normally get. And, winter or summer, we hear every hour the signal we wish, on our new super-het. Our modern receivers are ultra-selective. Our broadcasting stations, efficient and strong. And these are the reasons we now make effective, our broadcast reception the whole summer long.

Our local reception,
long distance reception
our broadcast reception, the whole summer long."

WE understand that Tom Gardner is being heckled by the Navy who are trying to get him to go to Chicago . . . that Harry Austin (who is turning in a swell job for RCA Communications out here) tells us of a letter he received from a radioman (a private somewhere in England) whom he had given a lift one night as he was returning from the Code School. The Yank wrote that he appreciated Harry's kindness and the pep talk he had given him. . . . And if going to sea these days means spending time ashore like George Newton does . . . boy, lead us to it. The latest letter from NE says . . . "I should have written some time ago, but you know how it is in New York with nothing to do, a new girl and plenty of money to spend. Well, three weeks waiting for a new ship, on pay, and all bills paid, wasn't so hard to take. While on the subject of the new girl (who is a dancer, has the looks of Miss America and a figure to go with it), if I should decide to bring her out that way, do any of youse guys know how I could get her a screen test? You know how it is when you get your women mixed up . . . and that is just what happened to me. But anyway, I'm having the time of my life. I am now in the Flag Ship for big fleet . . . and it's a dandy. . . .

And that's all for the nonce . . . so chins up and cheerio . . . with 73 . . . ge . . . GY.

—30—

Next Month
A DISTORTION METER
For P.A. Men

Practical Radio

(*Continued from page* 31)

the power pentodes are represented by the 6F6, 6K6 and 25A6. One important consideration in the output stage of any audio amplifier is the selection of the proper output transformer to match the output tubes and handle the power developed by them.

Selection of Rectifier Tubes

In the selection of rectifier tubes due consideration must be given to the load current, the R. M. S. plate voltage, and the inverse peak voltage. The load current can be calculated easily by adding the plate and screen currents of the various stages together with the various bleeder currents. This will give the total drain and a satisfactory tube may be selected by consulting the tube tables in a tube manual. The R. M. S. voltage is that developed in each half of the high voltage secondary of the power transformer, or the line voltage in the case of an "a.c.-d.c." receiver. Inverse peak voltage is calculated for full wave rectifier circuits with choke input to the filter by multiplying the R. M. S. plate voltage by 1.4. This formula will only hold true for sine wave input and if no means are available to measure the actual voltage it will be necessary to allow some safety factor. For most ordinary applications the normal run of rectifier tubes have a sufficiently high peak inverse voltage rating to take care of conditions usually encountered. One other factor that must also be considered in selecting a rectifier is the peak plate current. If choke input to the filter is used the peak plate current will not be much larger than the load current, but, if an input condenser is used on the filter, the peak current may be many times the safe value. In the absence of instruments to measure this current accurately, it is best to err on the side of safety, operating the tube well below its ratings and using as small a filter condenser in the input to the filter as is compatible with output voltage and filtering requirements.

Interpretation of Tube Operation Characteristics Graphs

The tube characteristics graphs offered in the tube manuals are exceedingly confusing to the beginner with the result that they are usually passed by with a casual glance. However their proper interpretation makes the selection of tubes much simpler as they make it possible to predict the final circuit performance with reasonable accuracy. Among the various graphs commonly published are the operating characteristics, average plate characteristics, and control characteristics in the case of tuning indicator or "magic eye" tubes.

Operation characteristic graphs are usually published for converter tubes and rectifiers. A typical graph for a converter is shown in Fig. 1. The common practice is to indicate the operating conditions directly on the graph and show separate graphs for two or more operating voltages, to allow the designer some latitude in circuit conditions.

By examining this graph we see that the cathode current varies as the oscillator grid current is varied, while the conversion transconductance reaches a maximum and then falls off as the recommended oscillator grid current is exceeded. For optimum performance it is necessary to adjust the oscillator grid current to within the recommended region. This may be accomplished by inserting a O-1 milliammeter in the grid lead of the oscillator section where the connection to the cathode is made, and either varying the plate voltage on the oscillator or reducing or increasing the number of turns on the feedback winding, as may be required. In general this type of graph is self explanatory and little description of its use is required.

The operation characteristics graph for a rectifier tube shown in Fig. 2 is the usual one of output voltage vs. current for various values of a.c. plate voltage when choke input to the filter circuit is used. It can be clearly seen from a graph of this nature that choke input to a filter offers definite advantages insofar as regulation of the d.c. output voltage with various loads is concerned. By comparing this graph with that of Fig. 3 which shows the conditions with condenser input to the filter it is apparent that the output voltages with the same a.c. voltages are considerably lower for choke input.

In Fig. 3 we have an excellent illustration of the effect of various sizes of filter condensers on the voltage output, although it is readily apparent that the regulation with the smaller condenser is much poorer in each case. For ordinary receiver design where the load on the power supply is relatively constant, it is advantageous to use condenser input to the filter, as there is little need for excellent regulation and the cost of the power supply will be somewhat less.

In Fig. 4 we have an average plate characteristics graph for various values of grid voltages, for a triode. By examining this graph we may determine the plate current for various combinations of grid and plate voltages. The graph as shown in Fig. 4 is a typical characteristic curve of a triode vacuum tube. Similar curves of any tube may be obtained direct from any one of the many tube manuals.

Most tube manuals list the plate resistance of a tube. However, if it were desired to determine this value, the procedure would be as follows:

We will assume that the tube is to be operated at a plate voltage of 250 volts and a grid voltage of —4 volts. By drawing a vertical line from the 250 volt point on the plate voltage scale we find that it intersects the —4 volt grid curve at a point *Q*, which indicates that the plate current under those conditions will be 3.6 ma. Now, by drawing a tangent *ef* to the point *Q* we see that it intersects the plate voltage scale at 165 volts. The plate resistance at point Q is then the voltage between e and 250, or 85 volts divided by the plate current at point Q (3.6 ma.) or 23,611 ohms. To find the plate resistance at any other operating conditions we would use the same procedure, selecting the desired plate and grid voltages.

To determine the amplification factor (μ) of this same tube we draw a horizontal line CD through Q to points C and D which represent −3 and −5 grid volts respectively. These points are used because they represent an equal grid voltage change (1 volt) in either direction from the initial grid voltage of −4 volts.

By referring to the plate voltage scale we find that these points represent plate voltages of 220 and 285 volts respectively. The amplification factor or μ is then 285 minus 220 divided by the total change in grid voltage (−5 minus −3, or 2 volts), or 65/2, or 32.5.

As the mutual conductance is the change of plate current for a constant plate voltage divided by the change in grid voltage, to find it we draw the line AB through the point Q. Point A represents 5.2 ma. plate current while point B represents 2.2 ma. or a difference of 3. ma. Since these points also differ by 2 volts grid bias the mutual conductance is 3. ma. divided by 2 volts, or 1,500 micromhos.

In general the same method is used in determining the characteristics of a pentode, as illustrated in Fig. 5. However due to the high plate resistance of a pentode the portion of the curve above the bend is very flat and it is necessary to draw extension tangents to the curves as may be seen by examining the graph. Although the graph appears different the method of using it remains the same. In this case for a plate voltage of 250 and a grid voltage of −6 the plate resistance would be EK/QK or 250/0.0025 or 100,000 ohms. The amplification factor, or μ, would be CD divided by the change in grid bias or $\frac{530}{4}$, while the mutual conductance is AB divided by the change in grid bias, or;

$$\frac{.0072 - .003}{4} = \frac{.0042}{4}$$

or 1,050 micromhos.

By proper use of the plate family graph it is possible to calculate the proper plate current, grid bias, optimum load resistance, and power output of tubes. Referring to Fig. 6 we have a plate family graph for a triode power tube. Our first step is to determine the proper load resistance for our operating conditions which we will assume to be 250 plate volts. By following the same procedure we used in Figs. 4 and 5 we determine that the μ of the tube is 6.8. The point P (zero signal bias) is found by the formula

$$P = \frac{.68 \times Ep}{\mu} = \frac{.68 \times 250}{6.8}, \text{ or } 25.$$

Drawing a vertical line from the 250 volt on the plate scale we find it intersects the minus 25 volt grid line at the 25 ma. point. The point *X* is located on the zero grid voltage line at a point which is twice the plate current of *P*. The line *XY* is then drawn, the point Y being located on the —50 volt curve, or twice the grid voltage of *P*. Vertical lines are then extended from *X* and *Y* and the plate voltage at these points read on the plate voltage scale. A horizontal line is also extended from *Y* to the plate current scale and the *I* min. read. The load resistance is then the line *XY*, or expressed in ohms is equal to (E max-E min) divided by (I max-I min). In this case it is $\frac{360-120}{.050-.004}$, or 5,217 ohms.

To determine the power output we assume that the peak alternating grid voltage is sufficient to swing the grid from the zero signal value to a value twice this on the negative swing. On the positive swing both the plate voltage and plate current reach values of E min. and I max. As power is the product of voltage and current the power output is

$$\frac{(I\ max.-I\ min.)\ (E\ max.-E\ min.)}{8}$$

or 1.38 watts. The reason for dividing the product of EI by 8 is rather involved and requires the use of trigonometry to properly explain its action.

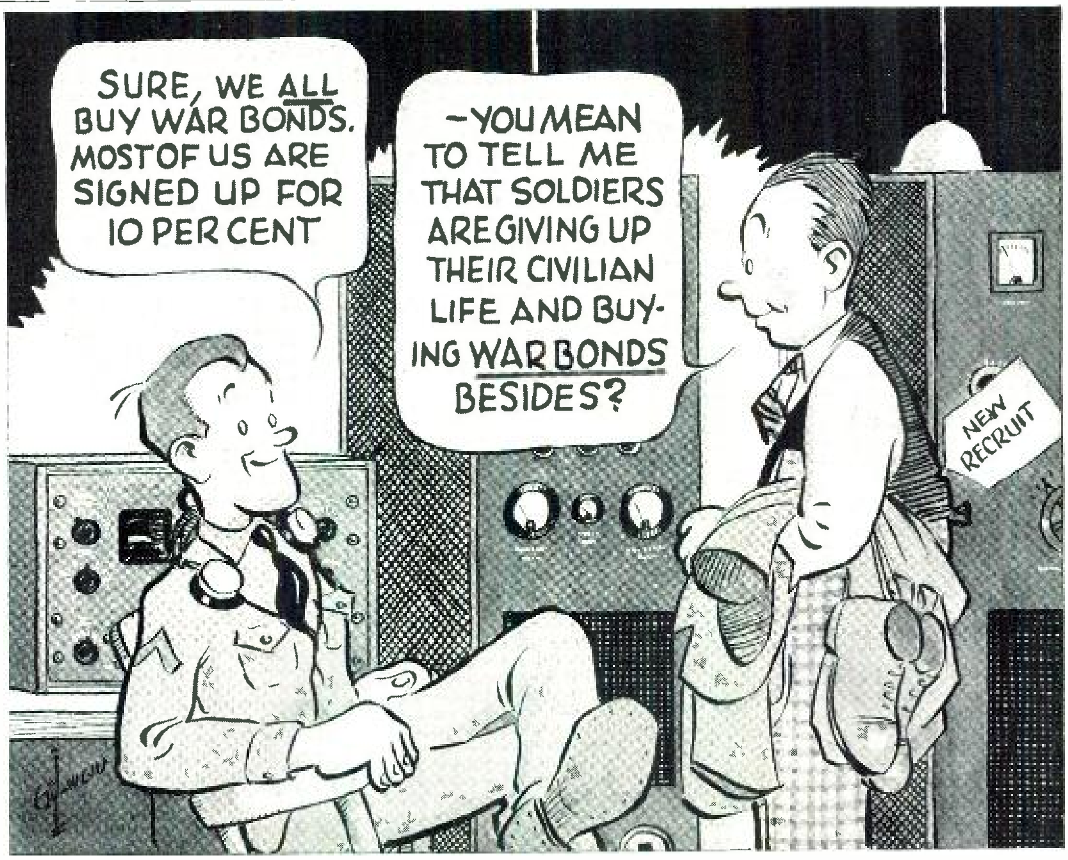
The fundamental principle for calculating power output, load line, etc., is the same for beam power, pentode, and push-pull tubes. However the discussion of these steps would be repetitious here and little would be gained by it.

The conversion curve shown in Fig. 7 is generally used for power tubes but can be applied to tubes in general. For example if we desired to operate a 6F6 pentode at a plate voltage of 150 volts, we could determine the correct operating conditions by use of the chart. The nearest published figures for a 6F6 are 250 volts, or a conversion factor of 225/150, or 0.6. If we follow the vertical line corresponding to 0.6 to the point at which it intersects the four heavy lines we may obtain direct readings of the new values. The normal values for a 6F6 at 250 plate volts are: plate and screen 250, grid —16.5, plate current 36 ma., screen current 10.5 ma., output 3.2 watts, plate resistance 80,000 ohms, plate load 7,000 ohms, and transconductance 2,500 micromhos. The new values for grid bias and screen voltage may be found by multiplying the old values by the conversion factor of 0.6.

The new values for plate and screen current are determined by the point at which the line F_i is intersected on the vertical scale or in this case 0.47 of the original figures. The same procedure is followed for power output, plate resistance and load resistance, and transconductance, using F_p for power output, F_r for plate and load resistance, and F_{gm} for transconductance.

By proper application of the tube characteristics graph described in this article a much clearer interpretation of the characteristics of vacuum tubes may be obtained, and design of equipment begun with an excellent forecast of the final results.

(To be Continued)



Electron Control
(*Continued from page* 15)

electrode is called the grid. It consists of some sort of metal wire lattice in which the metal parts of the lattice occupy but a small fraction of the space, leaving large openings for the electrons to pass through. This electrode is placed between the plate and cathode of the diode. The tube is then called a *triode*. If the grid is given a charge of electricity, it is capable of influencing the motion of electrons within the tube while at the same time the grid, due to the small area of metal present, will allow electrons to move more or less freely without striking the metal part of the grid if the plate is operated at a much higher positive potential than the grid.

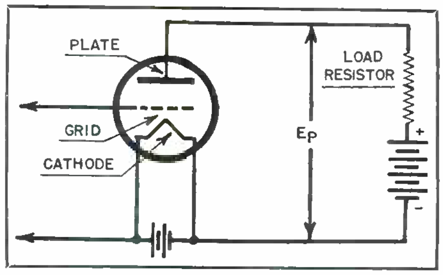


Fig. 8.

The grid acts very much as if it were a variable layer of electrons at this point within the tube. When the grid is positive it might be imagined that, in the region occupied by the grid, there is instead of the grid a region in which there are fewer electrons than there should be in normal diode operation. If the grid is positive enough, the electrons can be imagined to be replaced by positive ions. This enables the plate to affect electrons much deeper in the space charge, and since the grid serves only to neutralize or to partially neutralize the shielding effect of the electrons under their influence while these electrons are continuing their motion towards the plate, the plate current will consequently be increased.

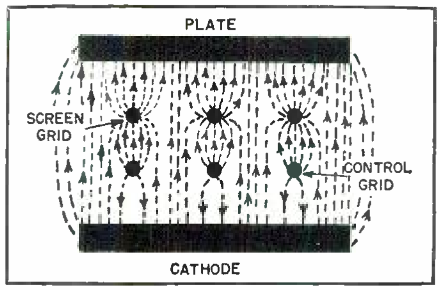


Fig. 9.

The amount of area the grid effectively neutralizes will depend upon how positive the grid is. When the grid has a negative charge on it, it will have the same effect as if more electrons existed in this region than would be expected in normal diode operation. This causes an increase in the shielding action on the electrons on the side of the grid away from the plate, thereby reducing the number of electrons going to the plate.

There is another and perhaps better way of visualizing the effect of the grid upon the behavior of the electrons in the triode. This is by maps of the lines of force between the tube electrodes. If a charged particle having no weight is placed in the region between two plane parallel plates with a potential difference between them, this charge will move in the electrical field between the two plates. The path that this charged particle will take when it is placed just in front of the plate having the same sign as the charge on the particle defines a line of force running from one plate to the other.

Fig. 3 shows how the lines of force between two parallel plates will appear. These lines of force should not be thought of as any real lines that exist between the plates but only as lines drawn to show how a massless particle will move in the region of this line. Since an electron has mass, if it is moving rapidly in the electrical field, it will not follow the lines of force if these lines make too great a bend. Where the lines bend they will follow a path somewhat different because of their inertia.

Fig. 5 shows the lines of force that exist in a triode for different values of grid voltage. The arrows on these lines indicate the direction in which the electron will be urged. It will be seen that when the grid voltage is positive that electrons from the entire cathode will be urged toward the plate and grid. Only one line is shown terminating on the grid in Fig. 5a. This is because the grid is only slightly positive. At this very low positive potential only a few electrons will be collected by the grid.

As the grid is made more positive more lines will terminate upon the grid, and more electrons will be collected by the grid causing a rather large grid current to flow. When the grid is at *zero potential,* electrons from the entire cathode surface now go to the plate exclusively. As the grid is made *negative,* lines of force will run from the grid to the cathode. Electrons in the region of these lines will be forced back into the cathode, but over the remainder of the cathode the lines run from the cathode to the plate and urge electrons towards the plate. Only the electrons from this part of the cathode are collected by the plate. This represents a decrease in the plate current.

As the grid becomes more and more negative, a point is reached where the entire cathode surface lies in regions on which lines running from the grid to the cathode terminate, and no lines run from the cathode to the plate. When this condition is reached no electrons can get to the plate, and no plate current will flow. The value of grid potential for which this occurs is called the cut-off value of the grid voltage. The cut-off value of a tube is one of the important characteristics of a vacuum tube. Its value depends on the electrical and mechanical properties of the particular tube and can be obtained from any tube characteristic chart. Some tubes are chosen for their cut-off value for particular applications, such as in grid bias detector, A.V.C. circuits, etc.

There are three constants in general use which give considerable information about what a given triode will do. If the grid voltage is changed by a certain amount $E_{g1} - E_{g2}$, and the change in plate current noted, then, the grid voltage held constant and the plate voltage changed until the plate current is changed by the same amount as before. The ratio between the voltage changes $\frac{E_{p1} - E_{p2}}{E_{g1} - E_{g2}}$ is called the amplification factor of the tube where E_{g1} and E_{g2} are the grid voltages, and E_{p1} and E_{p2} are the plate voltages. This factor measures the relative effectiveness of the grid and plate as electron controlling agents.

This, as the name implies, measures the voltage amplification of a tube. It is represented by the Greek letter mu, written μ.

This constant depends upon the size of the grid wire, the distance between the grid wires, the placement and shape of the grid, and the placement and shape of the plate, and also to a certain extent upon the potentials of the plate and grid.

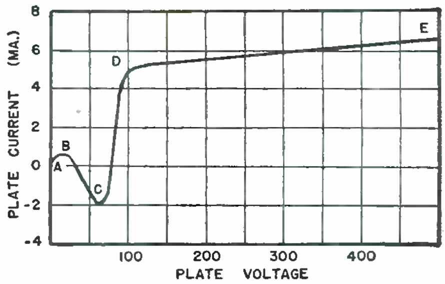


Fig. 10.

It is sometimes advantageous to have the mu of a tube much more variable than it normally is under changes of potentials of the elements. This is accomplished by varying the spacings of the grid throughout its length. Fig. 6 shows an ordinary grid and variable mu grid. It will be seen on examination of the method of grid control illustrated in Fig. 5 that the closer the spacings of the wire the more effective the grid potential is as a control. The cut-off value will be reached much sooner under the closely spaced part of the grid than under the coarse part of the grid.

This leaves the more widely spaced parts of the grid controlling electrons going to the plate after the close space grid cut-off has been reached, and since these grid wires are much more widely spaced, their control of the electrons is much less. This means that the mu of the tube is varying. A comparison of the curves of plate current versus grid voltage for the two types of grids is shown in Fig. 7. It will be noted that the cut-off voltage for the variable mu grid is more than three times as great as for the normal grid.

Tubes having normal grids, and therefore characteristics similar to curve 1, are said to have a sharp cut-off, whereas, tubes having variable mu grids and characteristics similar to curve 2 are said to have a remote cut-off.

When the grid voltage is varied by an amount $E_{g1} - E_{g2}$ the plate current varies by an amount $I_{p1} - I_{p2}$. The ratio $\frac{I_{p1} - I_{p2}}{E_{g1} - E_{g2}}$ is called the grid to plate trans-conductance or mutual conductance and is denoted by the symbol g_m. The ratio $\frac{E_{p1} - E_{p2}}{I_{p1} - I_{p2}}$ where $E_{p1} - E_{p2}$ is the change of plate voltage which produces a change of plate current $I_{p1} - I_{p2}$, is called the plate resistance of the tube and is denoted by the symbol R_p. These three constants are related by the formula $R_p \times g_m = \mu$.

The plate to grid transconductance and the plate resistance are determined by the same factors that determined the amplification factor.

The triode has two faults which limit its uses for certain operations. When a load having resistance is used in the plate circuit as shown in Fig. 8 the plate potential will vary as the amount of current flowing in the circuit varies. This variation is caused by the IR drop in the resistance which subtracts from the plate potential. This variation of plate potential with plate current due to the IR drop in the load resistance always tends to counteract the effect of variations of grid potentials.

The second fault encountered in a triode is the capacity of coupling between the plate and the grid that exists in the tube. Since the grid and the plate constitute two charged bodies at different potentials separated by a dielectric, i.e., the vacuum, they will constitute a condenser having a small capacity. This will allow any alternating component on either electrode to be felt by the other electrode. The plate will affect the grid in this way since the plate will often have very large alternating components upon it. This effect is called feed-back.

Feed-back will interfere with the normal grid operation of the tube. These two faults of a triode can be corrected at the same time by placing in the tube a second grid, called the *screen grid,* between the control grid and the plate. This grid is normally operated at a potential somewhat lower than that of the plate but of the same order of magnitude. This grid, because of the small area of the grid wires, will not interfere with the collection of electrons by the plate. The potential of this grid will remain constant at all times, thus subjecting the electrons to a constant acceleration almost independent of any variation of the plate potential. This means that the plate current will now be almost independent of the plate potential, thus removing the first fault.

The number of electrostatic field lines originating on one electrode and terminating on another at a given potential difference between the two electrodes will determine the amount of capacity of coupling between these electrodes. Fig. 9 shows the electrostatic field that exists in a tetrode. It will be seen on comparison with Fig. 5c that when the screen is placed in the tetrode, lines that ran from the grid to the plate now terminate upon the screen grid, and there are no lines (actually there are some, but they are not shown since only the few more representative lines are shown) run directly from the control grid to the plate. This constitutes a reduction in the grid-plate capacity.

Since the variation of plate current with the variation of plate voltage is very small in a *tetrode*, the plate resistance will be very high, and since the plate current no longer varies with plate voltage, the same change of grid voltage as in a similar triode will produce a correspondingly larger change of plate current, thus causing the tetrode to have a much higher mutual conductance than the triode. This means then, that the amplification factor will be greater for the tetrode than the triode since the product of the plate resistance and the transconductance is equal to the amplification factor.

The introduction of the screen into the vacuum tube corrects the two major triode faults but introduces a new one that was not present before to any extent. If during the operation of the tetrode, the plate potential falls, due to the IR drop of the plate load resistance, to a value lower than that of the screen grid, the secondary electrons emitted from the plate by the bombardment of the plate by the primary electrons coming from the cathode will be collected by the screen grid. This will constitute a current flowing from the plate to the screen grid and will be opposed to the current flowing from the cathode to the plate.

This current can become so large in normal operation that it can make the instantaneous plate current drop to a very low value and can even instantaneously reverse the flow. It is obvious though that this condition is very transitory in nature because as soon as the plate current falls, the IR drop in the plate load is less, causing a rise in the plate potential which eliminates the effect. This change of plate current due to secondary emission causes distortion.

Fig. 10 shows a curve for constant grid potential and constant screen grid potential but with varying plate potentials plotted against the plate current. The part of the curve bc can be put to a practical use as an oscillator since an increase in voltage causes a decrease in current. This property is called negative resistance. A triode with a negative resistance can be made by placing the screen grid close to the plate and operating this grid at a higher positive potential than the plate. Tubes operated in this way can also be used as voltage and current amplifiers as well as oscillators. Tubes using this principle of secondary emission are called dynatrons.

In order to correct for the detrimental action of the secondary emission from the plate in normal tube operation, a third grid is placed between the plate and screen grid. This grid is operated at the same potential as the cathode and is called the suppressor grid. These tubes having five electrodes are called *pentodes.* The electrons coming from the cathode will be accelerated by the screen grid until they have sufficient energy to get through the retarding field existing between the screen grid and the suppressor grid, and as soon as they are through the suppressor grid they will be subjected to the accelerating field existing between the suppressor grid and the plate. The addition of the suppressor grid will have little effect on the number of electrons going to the plate, but the secondaries emitted from the plate will be subjected to a large retarding field and will, consequently, be forced back into the plate again which results in no loss of electrons by the plate. The additional shielding effects of the suppressor grid result in plate resistance and amplification factors that are even greater than those for a tetrode.

Pentodes designed for large power outputs will have some distortion present when the plate voltage falls to a too low value because of the unevenness of the electrical field between the wires of the suppressor grid. In order to eliminate this distortion a suppressor grid is formed in a tetrode by a space charge formed, by correctly placed electron beams, when the plate voltage falls below that of the screen grid.

This space charge acts in the same way as the suppressor did before in the suppressing of the secondary emission from the plate, but now the field is uniform since the space charge is evenly distributed. When the plate potential swings higher than the screen grid potential the space charge disappears, but it is no longer needed to suppress any secondary emissions from the plate since there is a retarding field for secondaries now existing between the screen grid and the plate. As was stated above, this formation of space charge in the region depends upon a correctly formed electron beam of greater intensity than is normally necessary in pentode operation. This type of tube is called a *beam power* tube. And as stated above, even though it has only four actual electrodes, it nevertheless, behaves as if it had an additional grid part of the time. This tube has also an additional advantage in that the beams are formed in such a way that the screen grid wires are almost entirely missed by electrons, thereby making the screen grid current much lower than in the normal pentode or tetrode.

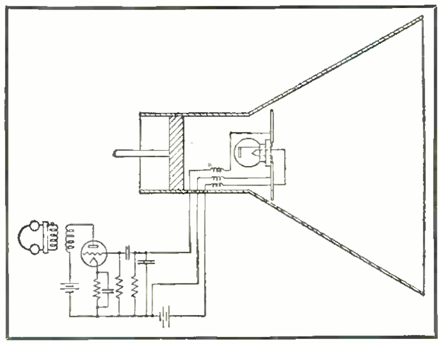
(To Be Continued)

Wartime Electronics
(*Continued from page 24*)

vided it does not approach unity too closely.

The authors' circuit for producing negative resistance is shown in Fig. 3, in which the basic conventional amplifier has both positive and negative feedback added. The degree of amplification is controlled by means of the 10,000 ohm variable resistor which is connected from a cathode of the 6J7 to the plate of the 6L6-G through the 8 μfd. fixed condenser. A graph which accompanies the article in *Proceedings* shows the degree of amplification for various settings of this resistor; for example, about 2:1 at 1000 ohms, 3:1 at 2000 ohms, 5.3:1 at 4000 ohms, 9.9:1 at 8000 ohms, and 11.5:1 at full resistance. It is stated that at an amplification of about 10, "the actual amplification variation is less than 2½% from 200 to 30,000 cps. Below a value of 8, the variation is less than 2½% from 100 to 50,000 cycles."

Too low a resistance value, however, in the resistor forming a portion of Z in the positive feedback circuit will result in undesirable phase changes produced in the associated blocking condenser; raising the degree of amplification does likewise, but to a lesser extent.

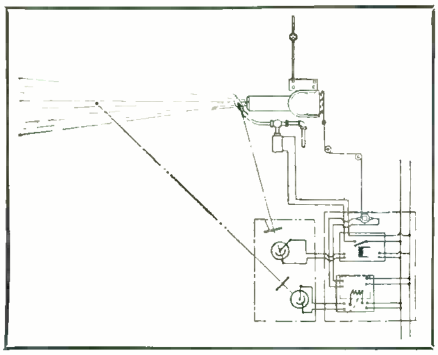


Pat. No. 2,307,012.

In summarizing, the authors state that values of negative resistance from 1 ohm up to an unlimited value may be secured with this circuit, either as shown or with minor modifications, and that stability is good with respect to frequency and supply voltages.

The Patent Parade

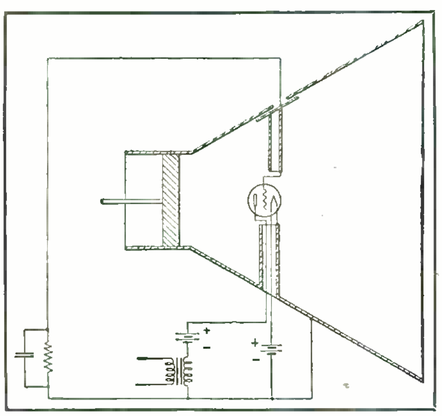
Roy A. Weagant (remember the famous Weagant circuit of yesteryear?) appears in the patent parade again with something new in superheterodynes. His receiving circuit, granted Patent No. 2,304,977, and assigned to RCA, includes a regenerative stage, the plate and grid of which are coupled through a fixed condenser. This tube, operating at intermediate frequencies has its plate supply fed through the secondary of an I.F. transformer, and feeding I.F. energy through a fixed condenser into the stage preceding the dual diode demodulator. The grid of the regenerator hooks into the AVC bias lead through a fixed resistor. While the claims of this particular patent read a bit like scientific double-talk, one gathers that two carrier frequencies—one modulated and the other unmodulated, but both different from the received frequency—are produced, the modulation being secured through the sidebands of the incoming carrier, and combining two locally produced waves in the demodulating (double diode) stage. From a study of the circuit, as shown in the *Official Gazette* of the *U. S. Patent Office,* the circuit would appear to afford greater over-



Pat. No. 2,306,073.

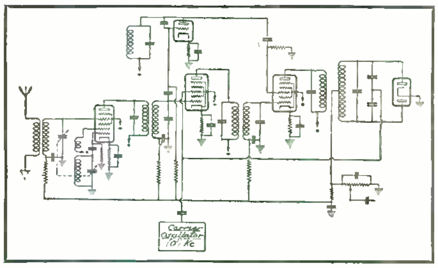
all gain than more conventional designs, but its tube-for-tube efficiency could not be estimated by this reviewer.

Relatively little has been printed in preceding articles concerning the reproduction of recorded music, although there is appreciable activity in this field, which now comes under the category of electronics rather than accoustics. It was, if memory serves, in the early 1920s, that the metamorphosis took place. Prior to that, a phonograph recording instrument consisted of a large horn into which the sound



Pat. No. 2,307,011.

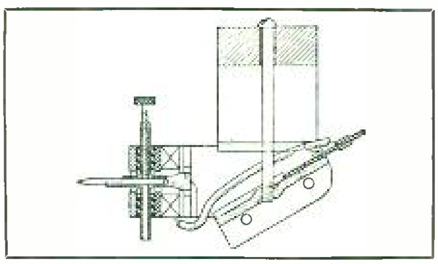
was directed, the alternating compressions and rarefactions of the air (comprising the sound wave) being finally impressed upon a diaphragm which, through a system of simple levers, drove the needle which cut the wax of the record. In reproduction, the process was reversed, the needle, vibrated by the corrugations in the record groove, imparting its motion to the diaphragm which drove the air column in a horn. Then, when radio amplifiers came into common use, cutting heads modeled upon electro-mag-



Pat. No. 2,304,977.

netic principles were invented, as were pick-ups acting in the same way. In the magnetic pick-up, the vibrating needle is mechanically connected—usually directly—to an armature around which is a coil, and which has its poles adjacent to those of a powerful permanent magnet. As the pick-up and the cutting head were highly similar, RCA, as long ago as the early 1930's, brought out a combination recording and play-back instrument which used a single head with a 7-ohm coil (an unusually low impedance) for both purposes. In recording, the pick-up was connected to the secondary of the output transformer in place of the voice coil of the dynamic speaker; in reproducing, it fed into the amplifier grid circuit through a matching transformer.

Now a head especially designed for both recording and reproducing has been invented by B. F. McNamee, and

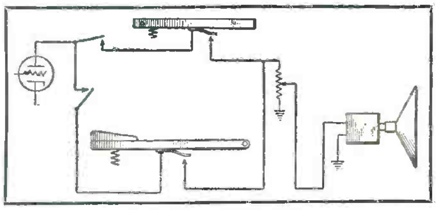


Pat. No. 2,305,182.

the patent, No. 2,305,182, assigned to the *United Acoustigraph Corporation.* In this head, there is a permanent magnet which acts as part of the structure supporting the armature. The magnet's ends lie in the same plane. The supports which contact them have their ends turned down to hold the shaft on which the armature vibrates. The poles of the magnet are extended along these supports, so that they come close to the armature. The same supports also hold the coil in which the armature vibrates.

As can be seen, an audio frequency electrical current passing through the coil will make the armature vibrate to provide a cutting head, while vibrations produced in the needle traversing the groove in a record will produce audio frequency currents in the coil when the head is used for reproducing. This is the standard electro-magnetic means of reproducing and recording; but what is unusual in this invention is the method of construction, which should provide relatively simple manufacture, yet produce a high degree of efficiency, for it would appear that the pole pieces could be made to come close to the armature without any great need for extremely fine adjustment.

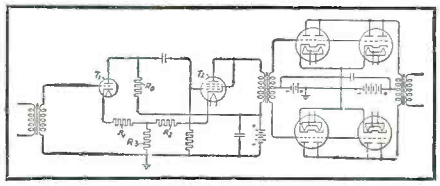
The *Central Commercial Company* of Chicago has also acquired patents in the field of electronic music. Two of these are the invention of J. A. Koehl, of the same city. One, No. 2,305,574, deals with the electro-mechanical production of musical frequencies in an electronic circuit, and the translation of these electric waves into sound. The circuit, as shown in the *Patent Review,* has a number of toothed discs revolving between polepieces which are surrounded by coils, each disc providing a frequency which is a multiple of the fundamental, the MM progression being 129+, 258+, 387+, etc. According to the first claim, sources of relatively different impedance produce simple and complex wave forms of alternating potentials. A means which includes a constant speed alternator is provided for controlling the frequency of one of these potentials, which is used to synchronize the frequency of the other potential. There is also means for "mixing" the generated frequencies. Finally, either of the alternating potentials is amplified and fed into a loud speaker. The effect, it would appear, should be much like that of an organ.



Pat. No. 2,305,575.

The other of Mr. Koehl's inventions, No. 2,305,575, is more in the nature of an electronic piano, for a keyboard and action are used to set up vibrations in tuned strings. Keys and pedals are provided not only to cut any of the vibrations into and out of the circuit but, through the pedals, to control the volume of any particular note.

There has long been a great deal of interest in the electronic production of musical frequencies, and several commercially successful applications will come to mind. In fact, until the earliest electronic musical instruments had come into being a few years back, though there had been such inventions



Pat. No. 2,306,749.

Largest and smallest water-cooled tubes for CBS video transmitter.

for *reproducing* music as the player piano and the phonograph, there had been no important addition to instruments for the *creation* of music since the invention of the saxophone by Adolphe Sax in Belgium nearly a hundred years ago.

A photo-electric switch to control heating equipment is another new and rather startling development, for heretofore most devices performing this function have been thermostatic in nature. Yet the switch invented by A. G. B. Metcalf and assigned to Photoswitch. Inc., is capable of analyzing the color of a flame in, say, an oil burner, and adjusting the mixture to provide for most efficient combustion.

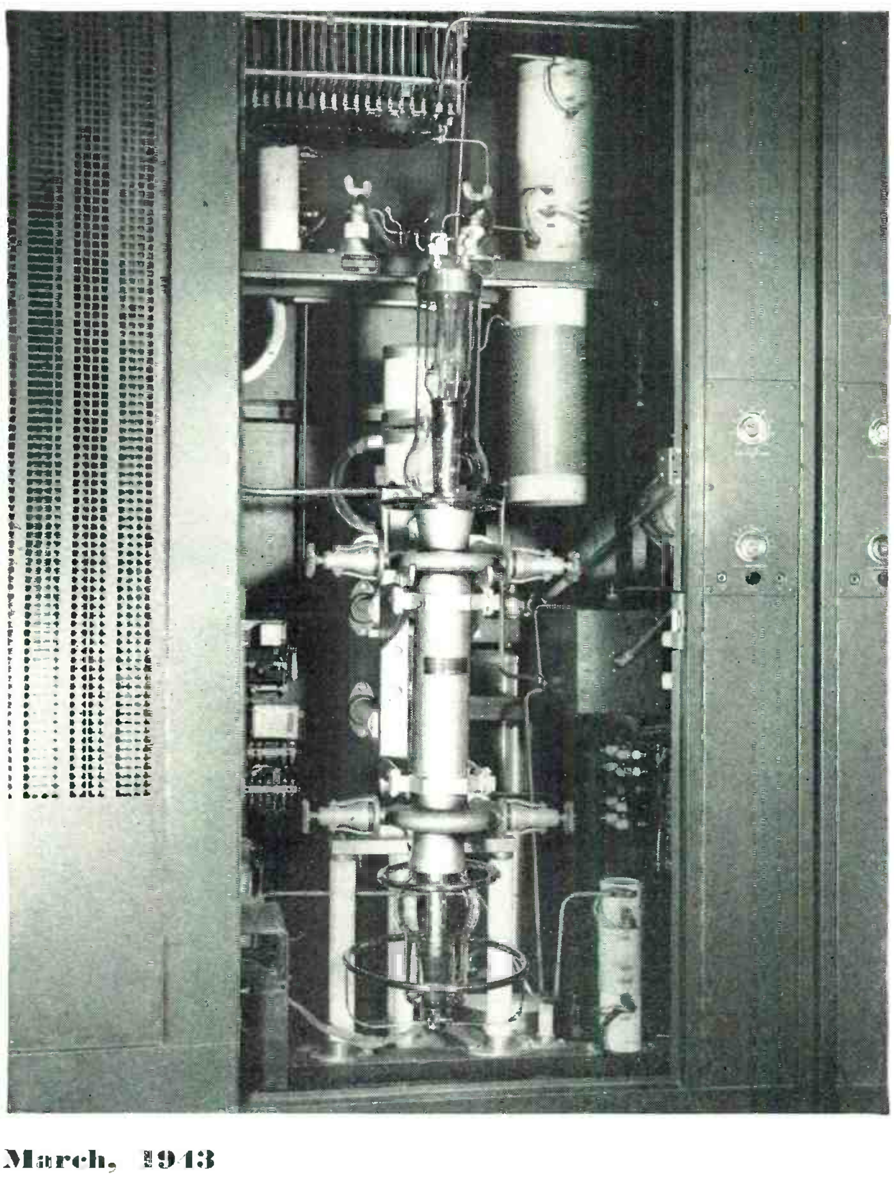
As disclosed in Patent No. 2,306,073, the principle utilized is that the light emitted from the burner and the igniter in a combustion unit will change in color in accordance with the heat produced. The burner and the igniter are each controlled by a separate photo-cell and associated circuit. The patent drawing shows two cells, each with a light filter before it; one is focused on the flame close to the igniter, the other at a more remote portion of the burning mixture. The function of the filters is to make the photo-cells color selective. When the flame is of the incorrect color (and, therefore, temperature) the light impinging upon the emissive plate of the photo-cell is altered, and consequently the electron output of that cell is changed. The change is used to control the output of the burner if it affects the cell focused upon the remote portion of the flame, or to control the igniter if it is detected by the other photo-cell.

One advantage of this type of control is that it can be used to provide the maximum heat with the minimum consumption of fuel—a rather desirable characteristic as those who found it impossible to convert to coal last winter will be the first to admit.

Something a bit different in the way of regenerative feedback amplifiers has been acquired by *General Electric* from J. L. Potter. As shown in Patent No. 2,306,749, the amplifier, which comprises a push-pull-parallel output stage, preceded by two driver stages, has several novel features.

The tubes in the first and second

This 50 kw. tube at WHN costs $1650. It's water-cooled.



stages have internal plate resistances of R_{p1} and R_{p2}, and amplification factors of μ_1 and μ_2, respectively. One of the coupling resistances (that in the plate circuit of the first stage) is R_0, while R_1 and R_2 are degenerative feedback resistors common to the grid and plate circuits of these tubes respectively. R_3 is the regenerative feedback resistor, and is common to the grid and plate circuits of both tubes. When the resistance values are in balance as determined by the formula:

$$R_3=[R_{p1}+R_0+(R_1+R_3)(\mu_1+1)]\ [R_{p2}+(R_2+R_3)(\mu_2+1)]/\mu_1\mu_2R_0$$

the circuit is in balance, and the gain through the amplifier is substantially independent of the output load impedance on the second stage.

It will be interesting to compare this circuit with that described by Brunetti and Greenough, earlier in this article.

While much has been written on the use of tuned horns for the propagation and interception of radio waves—particularly those of very high frequency —the one which is described in patent No. 2,307,012, assigned to *Research Corporation* by W. L. Barrow, seems to have several desirable features. The horn is, in effect, more like a funnel, in that it is a cone terminating in a cylinder. Positioned in the conical portion, near the small end, is an antenna, in this case a dipole, together with the final stage of a transmitter, or the first stage of a receiver. Behind that, movable in the cylindrical portion of the system, is a reflector which can be correctly positioned from the antenna to afford maximum efficiency. When used for transmission, antennas of the horn type direct a great percentage of the output in a beam, and so lay down a good directional signal. As part of a receiving system, they are similarly efficient, picking up energy from one direction only, and therefore rejecting much atmospheric and man-made interference. They may be compared to an electromagnetic megaphone when transmitting or an electro-magnetic ear trumpet when receiving.

Another variation, with the same patentee and assignee is described in Patent No. 2,307,011. It is similar in principle, though it varies in detail.

(To be Continued)

Spot News

(*Continued from page* 42)

several months for the delivery of material and at that delayed date, conditions make it impossible to sell the material, no loss need be suffered.

THAT POPULAR MAGAZINE . . . The Beam . . . of the No. 1 wireless school of the RCAF (Royal Canadian Air Force) will no longer be published, due to a new law that has been issued. The law forbids the appearance of advertising in station publications, and since it is impossible to continue without the financial assistance provided by advertising, R. O. Norman, flight lieutenant and editor-in-chief, has reluctantly declared the demise of the publication. Everyone will miss this cheerful, educational journal!

SO URGENT IS THE NEED for the technically-trained, that the U. S. Office of Education is advertising free war courses that are being given at the thirteen colleges and training centers in the metropolitan area of New York. Minimum requirement for these courses is a high school education. The same procedure is being adopted by the local divisions of the USOE in many other states, where these courses are also available. Here is an outstanding opportunity. Don't miss it!

AN INTENSIVE DRIVE is now under way by the employment service of the government to recruit workers with any of twenty-five special skills. And included within these skills is radio chassis assembler. Apply at once if you can perform this work . . . or tell others who can help.

Personals

The resignation of **James S. Knowlson** as Director of Industry Operations of the WPB shocked Washington. Unfortunately, Mr. Knowlson had to return to his desk as head of Stewart Warner. Mr. Knowlson's record in Washington was one that constantly merited the highest praise. . . . We have just learned of the passing on of **Alva J. Carter**, founder and directing head of the Carter Motor Company, Chicago. Many of us in the industry knew him well and deeply regret his death. . . . Two outstanding radio scientists were honored at the recent meeting of electrical and radio engineers in New York City. From the IRE group, **Dr. William Wilson**, who has just retired from the Bell Laboratories, received the Medal of Honor for 1943. The Edison medal was presented to **Dr. Edwin H. Armstrong** at the AIEE meeting, for his noteworthy contributions. . . . One of the world's most celebrated scientists passed away in January . . . **Nikola Tesla**. Few could parallel his distinguished work. . . . **Gaetano Greco**, the man who invented a static eliminator back in 1924, died in New York City recently. . . . **Robert S. Wood**, former radio editor of the old New York World, is now with CBS as director of public affairs in Washington. . . . **A. M. MacLennan**, advertising manager at I. T. & T. now becomes an assistant vice-president. . . . **Dr. H. A. Jones**, who managed the sales of electronic tubes for nonradio applications at General Electric has been commissioned a Lieutenant-Colonel in the Signal Corps. . . . A Christmas greeting was wired in to the Hallicrafters' employees by **General Douglas MacArthur** . . . **Rear Admiral Stanford C. Hooper** recently made an inspection tour at the **Hallicrafters** plant. . . . Congratulations to **Meissner** for winning the coveted Army-Navy E award.

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Photocell Hobbyists

(*Continued from page* 23)

face everywhere one foot from a uniform point source of 1 international candle (such as on a spherical surface with the international candle at the center of the sphere).

Relationship of illumination units:

1 lux = 0.0929 foot-candle = 10^{-4} phot.

1 foot-candle = 10.76 lux = 0.001076 phot.

1 phot = 10^4 lux = 929 foot candles.

Reflection and Refraction

Both reflection and refraction are phenomena well-known to electronic experimenters. We, therefore, will not enter into a qualitative discussion of those effects. It is sufficient to point out that a basic law governs the behavior of both reflecting and refracting devices; namely, that light rays leave the reflecting or refracting body at the same angle at which they reach the bodies. The angle of striking (*angle of incidence*) always equals the angle of leaving (*angle of reflection—or refraction*).

Reflection, as is well known, takes place most effectively from highly polished surfaces. These surfaces may be flat or curved. The flat (plane) reflector enables us to send rays back in the same direction from which they were directed; or to change their direction by appropriately adjusting the angle presented by the reflector to the rays. Curved reflecting surfaces enable the concentration of all light rays to a single point of influence—an operation properly termed *focusing.*

Refraction, or the bending of light rays, takes place as light rays pass through a transparent material. The velocity of the waves is reduced by the material through which they pass and the wave-front curvature is changed. The result is that the rays travel at a different angle while passing through the material.

The most familiar of the useful devices employing the principle of refraction are lenses.

Lenses and Lens Action

The common types of lenses are shown in Figure 2. These are (A) double-convex, (B) plano-convex, (C) meniscus, (D) double concave, (E) plano-concave, and (F) convexo-concave. Types A, B, and C are thicker in the middle than at their edges as seen in cross section and are of the *converging* type. Types D, E, and F are thinner in the middle than at their edges and are of the *diverging* type.

In all lenses, typical action upon light rays is the result of refraction through various portions of their volumes. Figure 1 illustrates the action of a converging lens—the double convex type. In explaining the action, we will assume that the source of light is small and at an appreciable distance removed from the left-hand surface of the lens. Taking the light to be radiated in rings or spheres from the source, these rings will grow to a considerable size by the time they reach the lens. The result is that small portions of each wave front will closely resemble a straight line (or plane). Such a line-shaped wave front is represented by AB in Figure 1.

Since the rays will travel at a different speed through the lens glass than through air, they will be refracted by the lens. Furthermore, since the glass of the lens offers various thicknesses to different rays, those passing through the center will travel at a different speed from those which pass through the edges. The speed of the ray passing through the center will be reduced more than that of the rays passing through the thinner edges. Consequently, the wave-front will not emerge straight as at AB, but curved, as at A′B′. The wave-front will contract to the point F, which will be an image of the *object,* or distant source of light. Any image formed in this manner on the side of the lens opposite that on which the object is located is the result of converging rays and is said to be a *real image.* The distance DF, from the center of the lens to the image is termed the *focal length* of the lens.

If the source or object is placed at some point, such as Y, Fig. 3 within the focal length of the lens, the object distance has been so reduced that the wave-front AB is strongly curved as it enters the lens. The lens, as a result, can exert little refractive influence upon the wave-front, and it emerges from the other side, as at A′B′ with little or no change in curvature. The rays spread out on that side and, consequently, no image is formed on the right-hand side of the lens. But the image does appear to an observer (on the right-hand side of the lens) to be on the opposite side at X, which is the center of a sphere described by the wave-front A′B′. Images which only *appear* to be at a point, as in this case, are the result, as has been shown, of diverging rays and are said to be *virtual images.*

Lens Relationships

In any lens system:

Size of image/size of object = dist. from lens to image/dist. from lens to object.

The *lens equation* is:

$1/p + 1/q = 1/f$.

When the object is distant, $1/p = 0$, and $q = f$, which is another way of stating that the image is at the focal distance from the lens.

As the distance between object and lens decreases, $1/p$ increases and $1/q$ decreases, causing the image to recede.

When object and image are at equal distances from the lens; $2/p = 1/f$ and $p = 2f$. Both image and object are at a distance 2f from the lens; which is to say, object and image are at a distance 4f from each other. This makes both equal in size.

When p is less than f, q becomes

negative, since then $1/q = 1/f - 1/p$. When q is thus negative, the image is *virtual.*

Lens Power is measured by opticians in *diopters,* and is proportional to the reciprocal of the focal length (1/f). The power of a lens may be determined in diopters by finding the number of times the focal length (in centimeters) may be divided into 1 meter of length. Thus, lens power in diopters = 100/f (cms.).

Lens Aperture. This is the ratio of lens diameter to focal length, and is a gauge of the amount of light a lens collects and concentrates into the image. In the standard language of this rating, a lens aperture of f/6 states that the lens diameter is 1/6 of its focal length—as in the case of a 2-inch lens with 1-ft. focal length.

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Foreign Marine Radio

(Continued from page 37)

the ship's main radio transmitter. Push-pull power oscillators for intermediate frequency transmitters are not uncommon. Most master oscillator type transmitters are designed with an audio oscillator, which modulates the final amplifier for I. C. W. transmission.

One very common practice on foreign built equipment, designed for both intermediate and high frequency bands, is to use a simple oscillator using a large tube on intermediate waves and having a switching arrangement whereby the same becomes the amplifier tube when using short wave, in conjunction with a separate oscillator tube.

When substituting American tubes, it is often necessary to install a new power supply for the filament circuits. As a rule, the foreign tubes being designed to operate on less current at a higher voltage than our similar rated tubes. Transmitters of these types operate on the regular ship frequencies, but specific details of frequencies, power and use of this type of equipment cannot be given for obvious reasons under present day conditions.

Radio direction finders designed by foreign manufacturers are seldom made with automatic compensation, to correct for deviation, as most of those made here are designed with. Most types are otherwise similar to our design except for some which still use iron core radio frequency transformers, in their several r.f. stages.

A short summary of the different automatic alarm systems could well be used as an example of the various diversified methods used in foreign equipment. The automatic alarm systems used aboard ship operate on a received signal consisting of four-second dashes separated by a one-second interval which is sent from the steamer in distress. This signal operates the mechanism of the automatic alarm selector which upon completion of the sequence of the received signals, rings several bells aboard the ship, calling the operator to the radio station at times when he is not "on watch."

In view of the above, it can be seen that an accurate timing device is essential in order to select the proper sequence of the signals and at the same time reject other signals, static, etc., which are not properly spaced. The different methods used for timing are composed of the following systems: condenser-resistance, solenoid dash-pot-spring, geneva clock movement, motor-driven magnetic clutch, motor-driven relay, ratchet-controlled, electrically, operated relay, some of which have more than thirty relays.

The condenser-resistance timing system works on the principle that, when a potential is placed on a condenser and resistance in series, a current will flow through the circuit until the condenser is fully charged and then the current will stop flowing. It can easily be seen that the time of current flow can be controlled by either changing the condenser capacity or the value of the resistance; raising either will lengthen the time which the current will flow.

The solenoid dash-pot-spring arrangement works on the principle that the solenoid pulls an arm down against the spring and releases it, allowing it to return to its original position, closing the contacts. The return time is controlled by the air control valve in the dash-pot. The geneva clock movement times the mechanism by means of the escapement movement as used in regular clock movement. The motor-driven types are controlled by the use of a constant speed motor.

In many instances, diagrams and specifications of equipment are not available, making it necessary to trace complete wiring of the specific equipment being overhauled, and drawings and blueprints made of same. Instruction books, when available, are, of course, all printed in the native language of the country from which these ships originally sailed, which adds to the difficulties encountered. The marine radio serviceman must, therefore, be familiar with many languages and able to translate same. Screw type plug fuses of an entirely different design from those in common use in this country will be found aboard foreign vessels. These are manufactured exclusively by this firm at our Clifton, New Jersey plant for use aboard ships with European electrical and radio equipment. All electrical sockets, plugs, etc., used in the electrical and radio circuits made in Europe, are of different design from those made in America and are not interchangeable. This is also true of phone tip jacks, plugs, etc. The European type incandescent lamps also use a different base, most being of the bayonet type, using two pins, rather than of the screw type. Lamps, plugs, sockets and adapters for these types of fittings used in the radio station, therefore, must be made in this country.

Most foreign-made radio receivers for marine use are designed to use tubes of the filament type, operated by either a two or four volt storage battery. These batteries are usually not obtainable on the commercial market here and have to be made up on special order when replacements are required. The charging resistors used to charge these low voltage batteries when defective must be rewound for the particular ship as they are not of standard size obtainable here. Intercommunication systems used on these foreign ships vary from speaking tubes to modern public address systems. In many cases the telephone system from the bridge to the radio station required repairs or part replacements. These being of foreign make and design, special parts must be manufactured in order to properly repair this type of equipment.

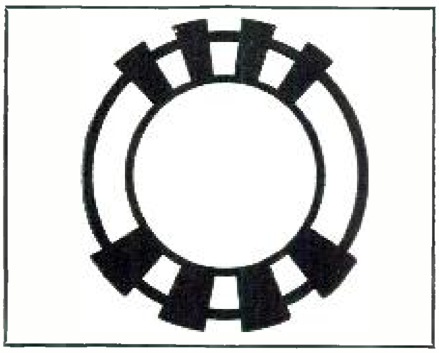

Fig. 3.

Motor generator units used in the radio transmitters, automatic alarm systems and other items in the radio station are often defective and must be overhauled, or at times completely re-wound, to be placed in proper condition for serviceable use. Often these machines are designed for frequencies and voltages which are in common use in this country. Other items manufactured by the various foreign firms include condensers and wire, both of which are marked in centimeters rather than our system of microfarads and gauge size. Machine bolts and nuts are likewise of a different thread from our manufactured types.

Such repair and maintenance work calls for a large stock of materials to be held on hand at all times for the rush calls which are always present in this type of service. International regulations forbid a vessel to sail without proper radio equipment. If a ship calls in port for a short stay of only a few hours, and radio equipment is not in proper condition, the marine radio serviceman often has to work against time in order not to hold the vessel in port beyond the scheduled sailing time which, of course, would otherwise become very expensive for the steamship operating company.

We have given an outline of some of the problems which must be overcome in the maintenance and repair of foreign marine radio equipment prior to the start of the present conflict. It might be well to call attention to the fact that we cannot, of course, go into specific details, frequencies and power ratings of the latest types of equipment and aboard these ships, which, at present, are our life-line to the various war fronts.

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German Radio Equip.

(*Continued from page 12*)

point are the emergency portable units, used for forced landing. One of these units uses a five section aluminum tube antenna, five meters long with an umbrella type top, and a 165 foot steel wire antenna wound on a reel and held aloft by a box kite. Both of these antennas are stowed away in a separate container, with the receiver, which itself is in a weatherproof container, approximately 18 x 18 x 10 inches. The power for this transmitter is supplied by four batteries of 120-volt power. The heaters are powered by a 4-volt storage battery.

The second transmitter is the more unusual of the two, in that, first, it is the only one that is crystal controlled, and, second, it has a range over water of some 250 miles. It is designed for use on the emergency rubber boats and is only 11 x 10 x 7½ inches. An alloy accessory container, with a kite, two balloons, two filling tubes, and two hydrogen generators, is supplied with the transmitter. Some 260 feet of stainless steel wire is used for the antenna, that is carried by the kite. However, when the wind is less than 13 miles an hour, a balloon, inflated by a gas generator, is used. A hand driven generator supplies the power. This power supply also drives an automatic keying device that transmits distress signals.

The frequency of this unit is 500 kc., while the frequency coverage of the other emergency unit is from 320 to 532 kc., with 500 kc. as the spot-tuned frequency.

Quite a power output is available from the rubber raft unit, the power output to the antenna being 6.2 watts with .9 of a watt being radiated.

Many of these transmitters were on exhibit at the recent annual meeting of the *Institute of Radio Engineers* at Rochester, New York. It was difficult to realize that they had been taken out of a plane that had crashed, so perfect was their appearance. They looked more like units that had come just off the production line. This superstructure, while an appropriate feature of careful design, is not so essential in wartime practice. For after all, the average life of a wartime plane is seldom more than a couple of hundred hours. These units could have lasted several thousand.

This additional painstaking design and the consequential use of abnormal quantities of materials, could well have been put to other more effective uses. This lesson seems to have been learned by the Germans now, for their newer equipment is much less sturdy. As a matter of fact, it is actually frail in comparison. Even the wiring is makeshift now. Foresight on the original designs would have provided sufficient materials to produce present equipment more efficiently. Of course, the extended length of the war hasn't been too kind either to supply sources. And thus, the Nazi methods of design and planning seem to have defeated its very purpose . . . fortunately.

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Radio Intercomm

(*Continued from page* 29)

satisfactory. The sub-stations can answer the master by talking from over twenty feet from the unit.

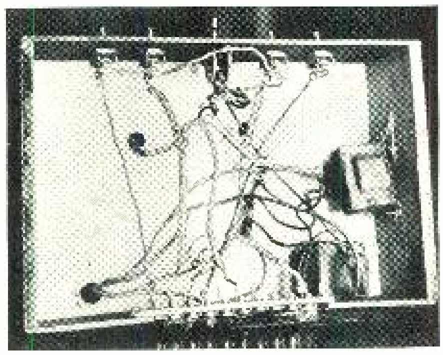
A wire is run from the CALL terminal on the terminal strip to the grid of the first audio tube through a hole drilled in the bottom of the cabinet and through the top of the control box. These holes are drilled just under the grid of the tube so that the lead is as short as possible.

The Sub-Stations

The sub-stations consist of a permanent magnet dynamic speaker with transformer and a SPDT, spring return rotary, switch. This switch is equipped with a bar knob for ease of operation. The three wire cable is run to a tie point on the speaker cabinet to relieve any strain that may be placed on the switch. The cable should be color coded for ease of installation. The cable from each sub-station is brought to the terminal board in the back of the master. The wire that was used here was in three colors, red, green and blue. One end of the BLUE wire is connected to the switch at the sub-stations, on the normally open position. The RED wire is connected to the normally closed position terminal. The GREEN wire is carried to the grounded end of the output transformers. The other end of this winding is connected to the blade of switch in each sub-station. At the terminal strip, the BLUE wires are tied together to the CALL terminal. The GREEN wires are tied together to the GROUND terminal. The RED wires are run to the numbered terminals that correspond to the numbers that have been assigned to sub-stations. Corresponding numbers are also assigned to the toggle switches on the front of the control box. The windings of T2 and T3 that are grounded to a common point are also connected to the GROUND terminal.

This radio intercommunicator can be adapted to suit your own needs by adding or removing sub-stations. These sub-stations operate most efficiently in an area with a low noise level. If a higher output is required the same system may be applied to radio receivers having an audio output up to fifteen watts. The speakers can be placed in the children's play room so that you can monitor the conduct of the children without leaving the bridge table. This is accomplished by throwing the play room switch ON and placing the TALK-RADIO-LISTEN switch, Sw1, in the listen position. The same idea may be used to guard the priceless gasoline and tires that you have on the family bus in the garage.

The speaker is placed in the roof of the garage over the car. The only change that is made from the equip-



Bottom view of the Intercomm.

ment of the original sub-stations, is that the spring is removed from the sub-station switch and the switch left in the talk position. It is then possible for the slightest sound that is made in the garage, by an intruder, to be heard at your bedside where you will be aroused by the foreign sounds.

Why not place a small speaker in the vestibule of your home or at a hole cut in the door or door casing to take the speaker. No call switch is needed on this speaker. A 3-inch permanent magnet dynamic speaker or one of the Quam speaker-mike will suit the purpose. If you have a speaker at the front door, don't forget to keep the selector switch for that outlet in the OFF position when you are listening to the radio. If you don't you will be sending the radio program to the neighbors and they might not like it.

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Mobile Crime Lab

(*Continued from page* 18)

mounted in the rear of each side of the vehicle and well away from the operating position.

The total drain of all radio and audio equipment is only 1300 watts and one of these generators would provide ample power. The purpose of utilizing two of these units is to provide power for emergency use if necessary as in the case of a fire, tornado or bombing or other catastrophe where local power lines have been damaged.

At the rear of the vehicle a panel board with three power outlets is provided together with 300 feet of cable in three sections. One outlet allows the whole mobile unit to be operated from an external 110AC power source, and the other two units provide the outputs for the two motor generators. Another interesting device is the *Otis* control unit for the motor generators. This unit enables the generator to start automatically as soon as a load of 50 watts or more is placed on the output of the generator. A receiver need merely be switched on and the motor generator supplying its power will start instantaneously.

A power control panel containing meters and switches controls and distributes all power sources including the generators, battery power and power from or to an external source.

Although the radio and sound equipment is only a small portion of the huge amount of emergency gear carried, it is indispensible if complete efficiency of the laboratory is to be achieved. No matter where located in the state, the unit can always maintain communication with one or more state, county or municipal police radio stations.

At the scene of a train wreck, tornado, explosion, mine disaster, etc., it may direct the work of a fleet of squad cars in the vicinity by radio, or messages may be relayed to other parts of the state. A commercial radio operator may handle this emergency traffic by radio telegraph to the nearest state police radio station where it will be delivered through the Illinois police radio networks.

In case of a riot, the mobile unit can stand off an armed mob while a member of the crew speaks to the rioters over the public address system.

At the scene of a military bombing, the unit may be used advantageously to control restoration work. Since it also has radio contact with power companies, telephone companies and pipeline stations through the emergency frequency channels, it can handle any type of emergency traffic direct from the scene of the disaster.

In many instances blockades are set up in certain areas in the state in an attempt to apprehend criminals. In such cases the laboratory can be sent directly to the area and the blockade controlled by radio communication with all the police cars in the vicinity.

Another use for the unit is to act as an emergency state police station should the transmitters in any of the nine state police stations break down, due to a defective part which cannot be replaced immediately. The unit can be rushed to the inoperative station and the push-to-talk microphone be set up on the operating desk and communication maintained in the usual manner.

It is a well known fact in modern police systems that radio communication is very essential in all phases of police and emergency work. With this thought in mind, the engineers of the *Illinois State Police Radio System* have provisioned the crime laboratory with the necessary radio and audio equipment to handle any problem that might arise.

★ INDUSTRIAL ★ MAN-POWER BUREAU

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

Of interest perhaps is some of the equipment available in the laboratory for crime detection and for use in emergencies.

The unit is equipped with a darkroom for developing photographs of a crime scene or developing x-ray plates. There is a complete chemical complement for nitrate tests, blood stain tests, seminal fluid identification, restoration of numbers on metals. There are microscopes, magnifying glasses, photomicrograph cameras, a refractometer, and ultra violet lamp, moulage equipment and an x-ray unit which includes a 200 foot extension for examining suspected bombs at a safe distance.

There is a good assortment of small and large hand tools, hydraulic and screw jacks, spades, shovels, rope, wrecking tools, etc., together with dip and seine nets, grappling hooks, a diving suit and helmet and a four passenger rubber boat.

The unit carries a lie detector and sound recording apparatus. Finger prints can be taken, classified and radioed immediately to identification bureaus.

A well stocked arsenal is available together with bullet proof vests, shields, gas masks, handcuffs, leg irons and a straight jacket.

Other emergency equipment includes a *Harrington-Richardson* lifeline gun with cartridges and coils of lifeline, climbing irons, pike poles, cant hook, door openers, tow chains, blocks and tackles, kerosene and electric lanterns, carbide torches, dog net, binoculars and other items. The medical and surgical outfit is designed for first aid and emergency surgery on the spot, and to replace or supplement supplies and equipment of hospitals in emergency areas.

The rear compartment of the unit is the office or interview room. In it is a bench for first aid treatment or surgery. A drawing board for sketching crime or accident scenes slides out from one of the desks. The second compartment from the rear is the chemical and physical laboratory including an ice refrigerator for preservation of specimens and perishable drugs or serums, a sink with running water, sliding shelves for auxiliary work benches and a permanent laboratory bench which can be used as an operating table in an emergency.

Immediately behind the drivers compartment is a bullet proof turret which can be elevated to a commanding position four feet above the roof by means of an engine operated hydraulic hoist. It is 5 feet deep and 52 inches in diameter, large enough to accommodate two or three men and equipped with hinged steel lid and gun ports.

There are four 12 volt searchlights mounted on the turret and four 115 volt floodlights mounted on the roof in front of the turret. Another feature is the hydraulic jack system comprised of four jacks, one at each cor-

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ner, for leveling the unit when parked on other than level road surface. Each jack operates separately actuated by controls from within, and will raise its wheel a maximum of 18 inches from the ground.

With this remarkable unit in operation, the *Illinois State Police* has made a great stride forward in the field of crime prevention and apprehension. The people of Illinois can well be proud of their state police system and of its ambitious leaders.

—30—

Tube Collector

(*Continued from page* 34)

Marconi (British) MT and MT4 valves
Marconi (British) AV24 Amp.-osc.
Donle rectifier (1923)
Marconi MR4
Dietzen 1½ volt tube (1923)
Schickerling S200
Silvertone 201-A
Bazoni nitrogen tube (1924)
Birk-Morton B-M 201A
Royaltron type 200
Magnavox Type A
De Forest DV3
Harp 200 DA
Magnavox (110 v. fil., 1924)
Russian types
Teletron 201-A
CeCo types A, B, C (1925)
Neon-filled rectifiers (1925)
Luminotron (1925)
Daven MU20, MU6
Gehrke tube (1925)
Sylfan 501A, 499A, 499 (1925)
Siemens-Schottky double grid
English double grid (1925)
Musselman Mogul 5 VC
Magnatron DC-199, 201-A, DC-199
McCullough AC
Lucien 110 v. (filamentless tube)
Loewe tubes (1926)
Quadrotron
Loewe multiple tube (1926)
Perryman double fil. (1926)
QRS full-wave rectifier (60, 85, 400 ma.)
Magnavox 3-element duplex grid
Raytheon A rectifier
Raytheon BA rectifier
Ruben VT Relay
CeCo D-G rectifier
Sulfotron (1927)
Globe G-100 rectifier
Raytheon type R
GE types PJ1 and PJ5

(*To be Continued*)

Book Review

(*Continued from page* 38)

set has been prepared to take the prospective student through the various phases of step-by-step instruction in the quickest possible time. The first volume lays the necessary groundwork in order that the student become familiar with simple terms and expressions, laws and rules of electricity, upon which any of the installations, maintenance and service jobs are based.

Chapters included in the three volumes are: Elementary Electricity, Signal Systems, Alarms and Telephones, Electrical Construction and Wiring for Light and Power, Armature and Stator Winding and Testing, Direct Current Power and Machines, Alternating Current, Principles and

Calculations, Storage Batteries, Automotive Electricity, Diesel Engine Operation and Maintenance, Electric Refrigeration and Air Conditioning, and Radio and Television.

These volumes will provide handy reference for students in electricity and radio. Wiring diagrams and illustrations are used profusely, and complicated formulae are purposely avoided.

—30—

What's New in Radio

(*Continued from page* 35)

struction of this switch all mechanisms are nickel silver plated and are of the self-cleaning constant pressure type which assures quick positive action.

Units have amplifier of super-sensitive design which delivers an undistorted output of five watts and permits operation with undiminished power and efficiency with the units as far as 3000 feet from one another. Each station is equipped with individual volume control so that incoming volume may be adjusted to suit individual requirements.

Optional equipment is privacy earphone. When earphone is used, Talk-Listen switch does not have to be operated and unit works exactly the same as telephone. Volume for earphone may be adjusted.

Super-Chief is available in systems consisting of from 2 to 10 or 20, 30, 40, 60, 80, etc., stations.

Literature Available: Catalog *"Talk-A-Phone Systems,"* eight-page description and explanation of All-Master and Combination Master Inter-communication Systems as well as paging systems, are available from the *Talk-A-Phone Mfg. Co.*, 1219 W. Van Buren St., Chicago, Ill.

New Coil Winding Bobbins

Much higher corrosion resistance in bobbins for coil windings has been achieved by *Precision Paper Tube Company*, Chicago, Illinois, by construction in which cellulose acetate is embodied in the bobbins.

Cellulose acetate is used in combination with the spiral-wound dielectric fish-paper core and vulcanized fiber flanges. Spiral wound laminations of cellulose acetate are made over a die to the o.d. of the core and then with a press-fit, slipped over the core to form a spacing tube. The length of the acetate determines the winding area. The inside faces of the fiber flanges are laminated with cellulose acetate before die-cutting, the core then swaged, locking the flanges in place onto the core carrying the spacing tube. Acetate cement is brushed over the joinings.

Further information will be furnished by *Precision Paper Tube Co.*, 2033 W. Charleston St., Chicago, Ill.

—30—

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Next, they have an understandable pride in themselves, in their equipment, in their management, in the ability of their technicians and in the skill and loyalty of their workers.

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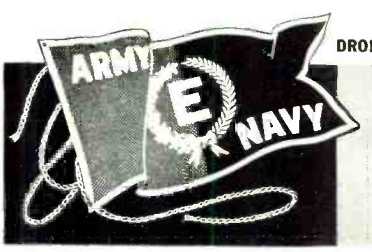

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