RADIO SCIENCE

VOL. 2.—No. 8

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AUGUST, 1949

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Microwave Communication Principles

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editorial

Television Standards Announced

The recent announcement by the Government on the standards to be adopted for Television services in this country has evoked considerable interest amongst the radio fraternity. Although such services are not likely to commence before another two years, it has been tentatively stated that a 625-line system with Frequency Modulation for the sound will be used.

Although the British system uses 441 lines, and that in America 525 lines, the adoption of 625 lines is in keeping with a policy to provide the best possible system and give the Australian public a high definition picture comparably better than that obtainable from either the British or American standards. To transmit a picture of high definition, i.e., one with more picture elements, requires an increased band-width, which is one disadvantage since it decreases the total number of possible stations for a given band of frequencies.

This latter consideration, however, will be of little importance in this country, since the present policy is to restrict T-V broadcasts to one station in each capital city. Whilst in the initial stages such a policy may be wise, especially from the economic point of view, it will certainly deny the benefits of the system to the large sections of population living in the major country towns. Because of this it seems feasible, due to public demand, that these areas will eventually be served by a relay system, using a single central transmitter.

In view of the high frequencies used, the normal range of a T-V station is restricted to a possible 1½ times the line of sight distance although under freak circumstances broadcasts have been received over much greater distances. Consequently to serve outlying areas beyond the normal service area of a T-V station, some form of relay system is necessary.

Up to the present time, three methods have been employed in overseas countries, namely, co-axial cable, microwave transmissions, or the use of aircraft flying around at high altitudes. Whilst co-axial cable has been used most extensively, this will not always be the case, and it is now being supplanted by microwave transmissions.

With this system, frequencies up to 7000 m.c., because of their directional properties, can be beamed to carry video signals from one antenna to another spaced approximately line of sight distances apart. The energy required for this is quite small, usually less than one watt, whilst the transmission quality and band-width passed are better than that obtainable with co-axial cable. From a utility and efficiency aspect, it seems highly likely that this type of system will be used in this country when required, especially in view of the current programme to instal microwave apparatus for trunk-line working between many areas.

Apart from the purely entertainment field, Television has numerous other important applications, not the least being those for military purposes. Both during and since the last war, there has been a continuous development with television-guided missiles and similar equipment, and these will undoubtedly play a large part in any future conflict. On the education side, television is now being installed in several large overseas hospitals to enable medical students, etc., to view intricate operations as clearly as though they were in the same room. In the commercial field, there is the recent introduction of Ultrafax, which is being used for the high-speed transmission of large quantities of printed matter. In use, pages are televised in rapid succession and photographed as they appear on the screen all at the tremendous rate of 20 full size books per minute.

In short, Television is the ideal technical medium for viewing distant or close events, and diverse though its present applications may be, it is still too early to indicate its possible ultimate uses. There is no doubt that its introduction will exert a tremendous and forceful influence on the already established mediums of entertainment, either as an incentive or threat, depending on the point of view. However, properly handled, and viewed in its proper perspective as one of the major miracles of our time, it must do much towards creating a new order of magnitude in entertainment, education and international affairs, leading to a better understanding between the peoples of the world.

RADIO SCIENCE

For the Advancement of Radio and Electronic Knowledge

Vol. 2, No. 8 AUGUST, 1949

EDITORIAL CONTENTS

OUR COVER: A view of the atomic clock developed by the National Bureau of Standards, U.S.A. The new clock has a face similar to a conventional electric clock and provides a new and amazingly precise method of measuring both time and frequency. Ihs potential accuracy is such that it would take about 3,000,000 years for it to gain or lose a second. Its operation was fully detailed in "Radio Science" for June, 1949. ... ...

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MICROWAVE COMMUNICATION

by F. S. MABRY, *Westinghouse Electric Corp.*

Traffic congestion is the order of the day, in communications channels as well as on the city streets. The growing need of industry for avenues of communication has outrun the available frequencies for short-wave radio and power-line carrier. This has led to the opening of a vast new territory in the microwave region, using tools and know-how gathered in connection with wartime radar.

The lives of people depend on the continuous functioning of public services—gas, oil, gasoline, water, electricity—and these, in turn, rely on continuity of communication. The demands for additional means of communication have become prodigious. In many cases it is impossible or uneconomical to expand further the present types of communication. Fortunately, new systems of communication, utilising microwaves, have been developed and can fill many of these needs.

The Growing Shortage of Channels

Present forms of communication cannot be expanded, or have room for only limited expansion. First, let's look at power-line carrier. Here is a highly reliable communication system. The power line is ruggedly constructed to withstand all kinds of weather and the conductors are almost ideally suited to conduct the lower communication frequencies.

Fig. 1.—Microwave communication borrows heavily from apparatus developed for radar and kindred wartime electronic systems. At left is a klystron, for generating small amounts of power at megacycle frequencies, centre is a lighthouse tube used at somewhat lower frequencies, and at right, a modern, synthetic crystal.

The available frequency spectrum is the limitation. Standard power-line carrier apparatus operates in the frequency band of 50 to 150 kilocycles, which means 100,000 cycles of frequency spectrum or bandwidth. Using the most modern single-sideband voice communication carrier with terminals employing the same frequency, which span 4,000 cycles of bandwidth for each channel, 25 channels would be the limit. Considering the functions of voice communication, telemetering, load control, supervisory control and carrier relaying, the number of channels is often insufficient.

Power systems are now so interconnected that these channels may have to be divided among several companies, because the interconnections may prevent use of the same frequencies in different parts of the composite system. Furthermore, many systems have grown up using older carrier equipment of the double sideband, two-frequency type, which uses 15 or more kilocycles of bandwidth per two-way channel. These conditions can be alleviated by using microwaves wherever applicable, generally for shorter distances, and using the power-line carrier for only the longer circuits.

Privately owned telephone lines are limited in their capabilities for carrying additional channels. New lines are expensive, not only in first cost but in maintenance. Also, because of the small conductor size and the closer spacing of the wires (as compared to power lines), they are more subject to disabling at the hands of the elements, and therefore are less reliable than the power conductors.

The Federal Communications Commission has recognised that microwaves offer a solution to many of these communication problems and has set aside a portion of the radio spectrum for this use. This section of the spectrum, which covers certain bands of wavelengths between 31 and 4 cm (frequencies between 950 and 6875 megacycles) opens the way to thousands of new channels.

Microwaves and Their Component Apparatus

Microwaves are simply radio waves having a higher frequency or shorter wavelength than most people are accustomed to, or know about. Prior to about 1935, tubes and circuit techniques for producing them were not available. The transmitting tubes, circuit components, and modern know-how techniques are by-products of wartime radar development. Lighthouse tubes, klystrons, crystal mixers and cavity resonators were actually developed to a high state of perfection during the war. Some are shown in Fig. 1.

A lighthouse tube is a simple triode radio tube having a cathode, a grid and an anode. It differs from a conventional radio tube only in slight design changes that minimise the inductance and capacitance of its elements. Much effort was given to adapting to it circuits in which energy is transmitted

through cavities instead of conductors, which makes the lighthouse tube useful at frequencies as high as 2,500 megacycles.

A klystron[1] is another special radio tube capable of generating frequencies many times higher than a lighthouse tube. It is useful as a transmitting tube and as a local oscillator in a superheterodyne receiver. The klystron is a cavity-resonator tube whose frequency depends on the dimensions of the cavities. Therefore, klystrons are available for different frequencies, since the cavities are adjustable over only a small range.

In any radio receiver the energy received must be amplified before it is of sufficient magnitude to be useful. Amplification is convenient, practical and advantageous at a different frequency than the frequency being received. Therefore a frequency changer is needed. The incoming frequency is mixed with a new frequency generated locally and applied to a non-linear impedance termed a "mixer", usually a rectifier, such as another tube or a crystal. One product of this mixer, being the difference of two frequencies, is a lower frequency, which can be processed by more conventional tubes and circuits less critical in their characteristics.

Crystal Mixer

At frequencies below about 1,000 megacycles, a tube makes the best mixer; for higher frequencies a crystal is most used. Known in the early years of radio as "cat's whisker" detectors, crystal rectifiers became obsolete until wartime developments gave them a new importance and raised their quality manyfold[2]. Several other components used in microwave transmission were also wartime developments.

The boundary between conventional radio frequencies and microwaves is not sharp. In general, we think of microwaves as all waves of less than 100 centimeters in length or higher than 300 megacycles in frequency. In this frequency region, conventional tubes reach the limit of their capabilities and cease to function as amplifiers, oscillators, etc. Also, in this region the techniques applicable to ordinary lumped-constant tuned circuits give way to those for tunable lines and cavities.

The microwave bands available for point-to-point use by power companies and other industrial services are shown in Fig. 3. These are called fixed operational bands. The ones used first will probably be the low-frequency bands 952-960 mc., 1850-1990 mc., 2110-22- mc., 2450-2700 mc., and possibly 6575-6875 mc. These frequencies are not available to government power agencies, whose assignments are made in the bands allotted to Federal bodies. These are also shown. In some cases they are adjacent to industrial bands.

At present, frequencies are reserved for industrial use on an experimental basis, pending availability of commercial equipment. The frequency assignment probably will be made as soon as suitable equipment is generally available and commercial application has been made of it.

Characteristics of Microwaves

Microwaves are not reflected from the ionosphere like frequencies below about 50 megacycles. Neither do they follow the curvature of the earth like signals in the broadcast and low-frequency bands. They tend to travel in straight lines. For reliable communication with microwaves large objects must not intervene between the transmitting and receiving antennas. Desirable antenna heights for different distances are shown in Fig. 5.

The line-of-sight path between the two antennas preferably should not even graze the surface of the earth at intervening points. A clearance of 50 feet or more is desirable, and Fig. 5 includes this allowance. This clearance minimises the amplitude of the variations in signal strength or fading due to storms or reflection from the earth.

In actual application, advantage should be taken of hills or high buildings to achieve the antenna heights required. The Bell Telephone Laboratories have conducted extensive tests on the reliability of microwave transmission and have concluded that "a high degree of reliability is practicable provided due allowance is made for the variations in the transmitting medium."[3] These tests showed that the longer microwaves were most stable and somewhat less subject to variations in the medium. By providing adequate transmitting power and using automatic gain controls in the receiving apparatus, strong and stable signals are received under all conditions.

Because of the short wavelength of microwaves, relatively simple antennas can be constructed that transmit them in a beam similar to the beam of a searchlight. The simplest method is to arrange the

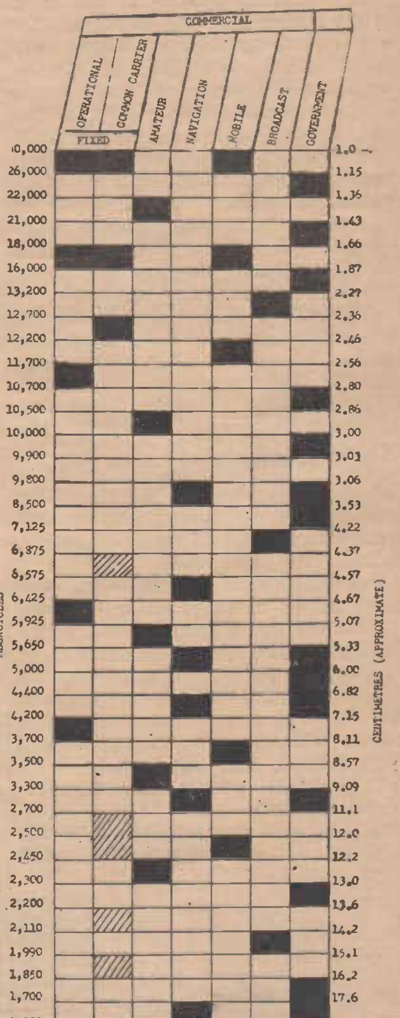


Fig. 3.—The spectrum of microwave assignments, with the bands more likely to be used for the early, point to point communications systems, shown in black and white.

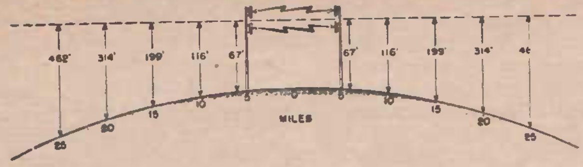


Fig. 5.—Height required for antennas for line-of-sight operation over different distances. They allow 50 feet for ground clearance.

antenna at the focal point of a parabolic metal reflector. The diameter of the reflector mainly controls the size of the beam—the larger the reflector the narrower the beam. Other factors, such as evenness of "illumination" also have an effect.

For example, Fig. 4 shows a typical parabola, 3.5 feet in diameter, that produces a beam only 20 degrees wide at 960 megacycles. To create a beam of this size in the broadcast band, say at one megacycle, would require a "dish" 2,700 feet in diameter. Concentrating the energy into a beam is equivalent to increasing the power of the transmitter by a factor equal to the gain factor of the antenna and increasing the sensitivity of the receiver a like amount.

Therefore, only a few watts of power are required for a communication circuit in the microwave bands. Many microwave channels in television relaying systems transmit powers of only a few milliwatts.

Both natural and man-made static is practically non-existent in the microwave bands. This is due partly to the use of small antennas, which are not readily influenced by electrostatic disturbances, and also to an absence of microwave frequency components in static discharges. The principal source of noise is in the receiving equipment itself, and is insufficient to concern the user. In any commercial equipment with suitable antenna and installation, the power output of the transmitter is sufficient to override receiver noise by a comfortable wide margin, even over the upper limit of distances indicated Fig. 5.

The Mechanics of Microwaves

A typical microwave link serving four telephone lines at each terminal is depicted in Fig. 6. One cabinet houses the microwave transmitter, receiver and power supply. Another cabinet houses the multiplexing or signal-combining equipment, and a third contains the telephone-line terminating apparatus. Separate antennas are used for transmitting and receiving. Where distances greater than line of sight are to be covered, the same kind of equipment can be used as a repeater.

When more than one conversation or other types of similar signals are transmitted simultaneously over a single pair of wires or over a single radio-frequency carrier, the circuit is said to be "multiplexed." To prevent "cross-talk" or interference between them it is necessary either to (a) share time among them, or (b) share frequencies, i.e., convert all but one of the various conversations to new frequencies separated in the frequency spectrum. The equipment that performs this function is called multiplexing equipment. Equipment employing scheme (a) is called time-sharing, time-division, pulse-time or pulse-code multiplex. Equipment using scheme (b) is called frequency-division multiplex.

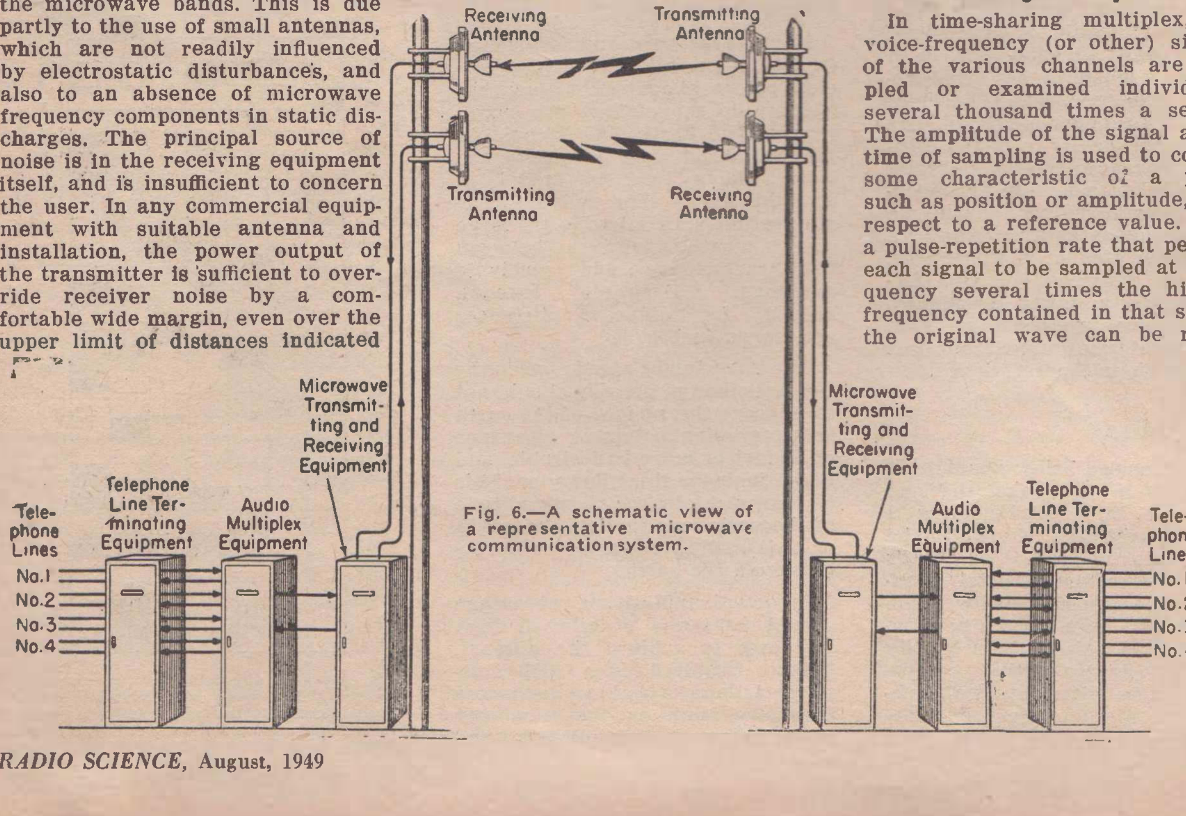


Fig. 6.—A schematic view of a representative microwave communication system.

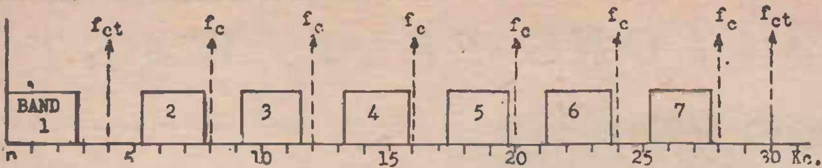
Where less than eight channels are required over a single microwave link, frequency-division multiplex appears to be more economical than time-sharing methods. It also spans less of the microwave spectrum. Where eight or more channels are required, one or more of the time-sharing methods appears to be more economical.

The multiplex scheme depicted in Fig. 6 is the frequency-division type. Equipment for four channels is shown, although the capability of the system is seven. Just how this scheme works is shown in Fig. 7. Carrier frequencies of 8, 12, 16, 20, 24 and 28 kc. are generated within the equipment. These are, in turn, modulated by the various signals to be transmitted, in a manner that eliminates the carrier and and upper sideband from the output.

The various outputs are then connected in parallel and the resulting complex wave is used for frequency modulation of the microwave carrier. At the receiving end the process is reversed and the signals are reconverted to their original form.

Time Sharing Multiplex

In time-sharing multiplex, the voice-frequency (or other) signals of the various channels are sampled or examined individually several thousand times a second. The amplitude of the signal at the time of sampling is used to control some characteristic of a pulse, such as position or amplitude, with respect to a reference value. With a pulse-repetition rate that permits each signal to be sampled at a frequency several times the highest frequency contained in that signal, the original wave can be recon-



structed from the received series of pulses with negligible loss of fidelity.

The telephone-line terminating apparatus shown in Fig. 6 consists of hybrid coils, line-balancing networks and ringing equipment, and line amplifiers when necessary. The hybrid coils, or transformers, as they are called, provide the ratio arms of an impedance-bridge circuit used to separate the outgoing from the incoming signals. Line amplifiers merely raise the level of the signals to suit the overall signal level requirements for the particular appreciation.

Microwave communication offers several distinct advantages over other forms. Paramount among these is channel reliability. It does not depend on continuity of power lines, pilot wires or telephone circuits between the two points. All of the elements involved can be located at the terminals where routine inspection and maintenance can be performed readily. Due to the directivity of the antennas, the line-of-sight characteristic and the spectrum space available, they offer great freedom from interference. Where communication is needed in highly industrialised areas or cities, the cost of digging up streets or stringing lines required for other forms of communication can be avoided.

Large-scale application of microwaves will probably be made in the near future. Most of this will be in the 952 to 960 megacycle band, for two principal reasons. Frequencies in this band are most stable in their transmission characteristics, that is, they are least affected by fading, weather, etc. The equipment for this band is simpler and more closely related to techniques employed in equipment for lower frequencies.

Uses of Microwave Communication

Some of the contemplated uses of microwave point-point communication are as follows:—

(1) **Power Radio Service** includes those activities concerned with generating, transmitting, collecting, purifying, storing or distributing by means of wire lines or pipelines, electrical energy, artificial and natural gas, water and steam for use by the public or by the members of a co-operative organisation.

(2) **Petroleum Radio Service**, having to do with prospecting for, producing, collecting, refining, or transporting by means of pipelines, petroleum or petroleum products.

(3) **Forest-products Radio Service**, such as for lumbering, tree farming, and related woods activities for the purpose of forest protection, safety of life and property, and efficiency of operations in remote areas where other means of communications are not available.

(4) **Special Industrial Radio Service**, which applies to all commercial or industrial operations that are predominantly rural in nature; commercial and industrial operations in which an element of hazard to life and property can be mitigated by radio communication; industrial or commercial operations that react directly on the public welfare or safety; and those services bearing on public health or well-being.

(5) **Land-transportation Radio Service**, such as inter-city buses and trucks, railroads, cabs and urban transit systems.

(6) **Public-safety Radio Services**, where spare radio communication is essential to either the discharge of governmental functions relating to the public

(Continued on page 40)

A TECHNICAL SURVEY OF LATEST OVERSEAS DEVELOPMENTS

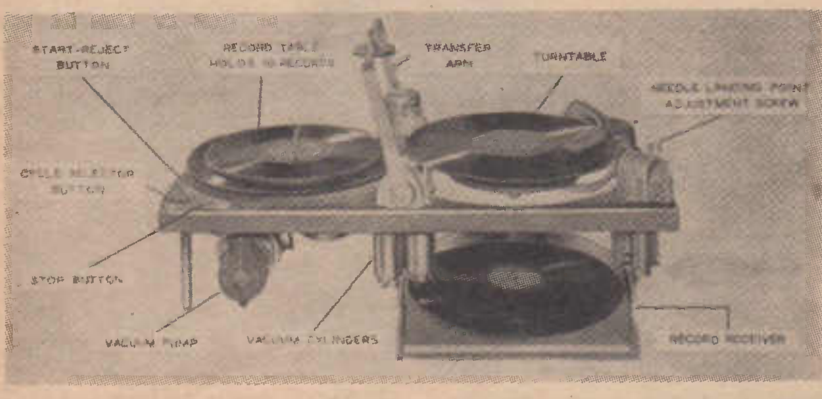
NEW RECORD CHANGER DESIGN

A new approach to the problem of record changing is shown in the accompanying photograph. This unit enables the playing of both sides of the record, and is said to eliminate dangers of record damage.

The basic feature of the design is the use of suction cups for holding the records, in place of place of grippers and clamps. This makes the handling of the records much more gentle, firm and positive. Although the changer handles 7, 10 and 12 inch records and operates at all three speeds now used, there is less machinery in this unit than in some of the changers that play one side at one speed.

The table at the left holds up to 16 records. These are picked up one at a time by a suction cup on on the transfer arm, and carried to the turntable at the right. After the first side has been played, the turntable, mounted on gimbals, is turned over, but the record is held in place by another suction cup until, at the end, air is admitted and the record is dropped to the tray below. There is no drive shaft, since the turntable is driven by a friction disc at the side. A control cuts out the turnover feature if it is desired to play the records on one side only at any time.

—Courtesy FM-TV.



In this turnover changer, suction cups are used in place of mechanical grippers to move and hold the records.

Insects Cause "Blips" on Radar Screen

Mysterious short-duration radar reflections called "angels" or blips" and which are observable most frequently below heights of 3,000 feet on radar screens, have now been identified as being due to flying insects.

In their attempt to synthesize the strange patterns on the radar scopes, Bell Telephone Laboratories scientists exploded a small charge of nitro-starch in the air 500 feet above the radar antennas. They flew a plane low over the radar and looked for reflection from exhaust gases. They built bonfires upwind so that the hot combustion gases and steam clouds formed by pouring water on heated rocks billowed into the beam. In all these experiments, the phenomenon were never observable.

In later experiments, working at night, they threw out a strong searchlight beam, and stationed observers at different levels of a 200 foot tower. While the observers counted insects, the radar operators counted the appearance of "blips" on their "scopes." They found that in one fifteen minute period twenty were counted, fifteen of which coincided with the sighting of an insect.

Insects fit most of the descriptions which have been applied to the mysterious reflections on radar scopes. They are small, they move at a speed comparable to wind velocity, sometimes with and sometimes against the wind, they are present both day and night, and there are more of them in warm weather than in cold.

Atoms Lay Cornerstone

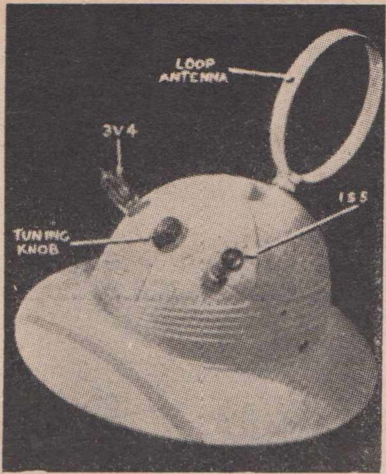
To symbolize efforts to put atomic energy to work for mankind, a miniature nuclear reactor was used to lay a 2 ton cornerstone for a new 19 storey building in New York City. Seven hundred persons watched as the huge granite stone dropped into place without the use of human hands.

Dr. J. R. Dunning, professor of physics at Columbia University, pressed a button to start the action. The miniature nuclear reactor split ten U-235 atoms in about 10 second. The cumulative electrical impulses activated a small magnesium flare embedded in a ceremonial ribbon. The ribbon parted with a flash of light and a loud explosion as the tenth fission was recorded. The stone then settled into position at the end of a chain attached to a motor atop a hoist, which also had been activated by the fissions. Each fission released 200,000,000 volts of energy.

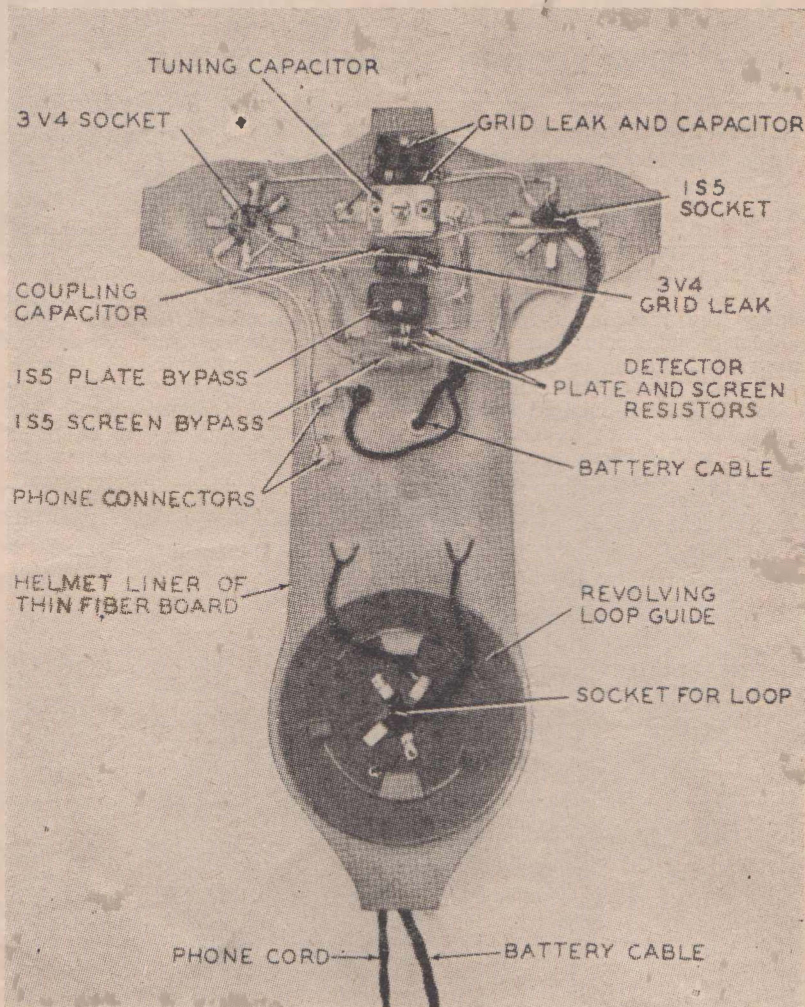
Dunning said that the event symbolized the "great advances man has made and the hope of the world that, rightly used, it will mean an era of peace, and help bring the better life to an ever-increasing fraction of the world's peoples."

THE RADIO HAT

Details of a new and novel receiver design now being produced in the U.S.A. Combining two miniature battery valves in an efficient circuit, it should be capable of good results when used in the vicinity of strong stations.



The external appearance of the new and novel receiver. Note the two valves mounted at the front, with the tuning control in between.



The chassis layout which fits inside the hat. To prevent damage it is covered and shielded with a foil-coated liner.

A new type of personal receiver in the form of a radio hat is now being marketed in the U.S.A. and is expected to prove very popular. It consists of a sensitive two valve receiver built into a tropical type helmet with the valves projecting from the front like two small horns.

Design Details

The tuning control is a small bar knob mounted between the valves, whilst the antenna (and tuning coil) is a five inch loop, ½ inch wide, mounted vertically on the rear of the crown. Due to the marked directional effects, this aerial fits into a socket that permits rotation through 90 degrees to ensure maximum signal pick-up. A single headphone is built into the inside of the hat just over one ear.

Power is supplied by a small battery pack, consisting of a 22½ volt B battery and two small A cells, which fit into the pocket and connects to the set through a thin 3 conductor wire. There is no switch, and the set is turned on by plugging the battery cable into the socket on the battery pack.

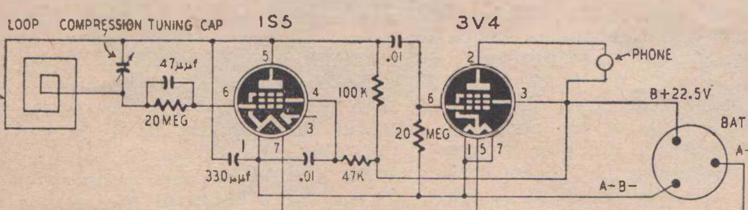
Efficient Circuit

In the circuit the 1S5 is connected as a modified ultra-audion detector. Its tuned circuit consists of the loop and a small compression type capacitor with the control knob on the front between the valves.

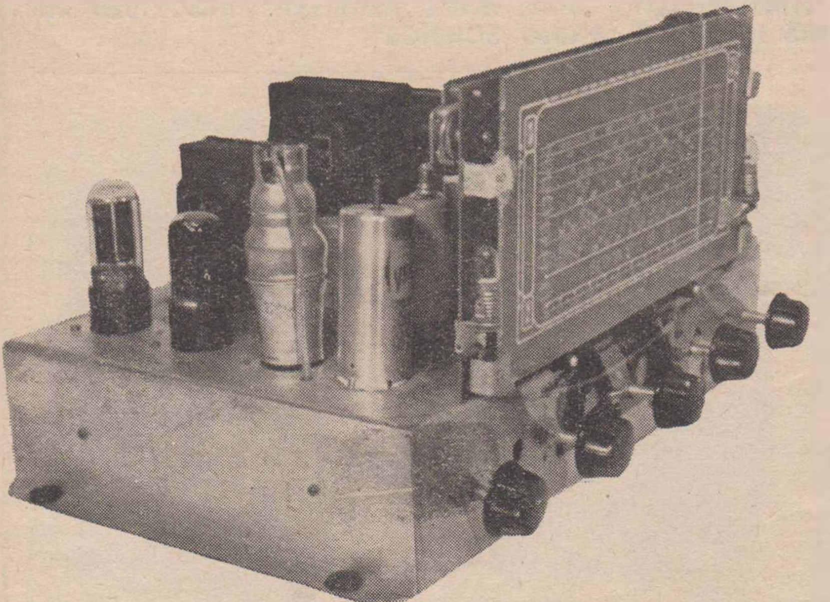
The audio amplifier is a 3V4 pentode, resistance coupled to the detector. Bias for the amplifier is developed across its 20 megohm grid resistor. The single phone is in the plate circuit of the 3V4, where it provides sufficient volume for local stations. Like most regenerative detectors, this one requires careful adjustment of the tuning control and antenna for best reception.

—Courtesy Radio-Electronics (U.S.A.)

The simple two-valve circuit which features an interesting detector circuit.



HIGH QUALITY DUAL WAVE RECEIVER



Front view of the completed receiver. Controls from the left to right are: Volume Control, Radiogram Switch, Tuning, Wave-change Switch and Tone Control Switch.

In the May, 1949, issue, details were given for constructing a high quality amplifier unit which featured a special tone control circuit. At the time it was pointed out that this design, whilst laying no claims to high fidelity, did provide a tonal response comparably better than that usually obtained with a single pentode output stage.

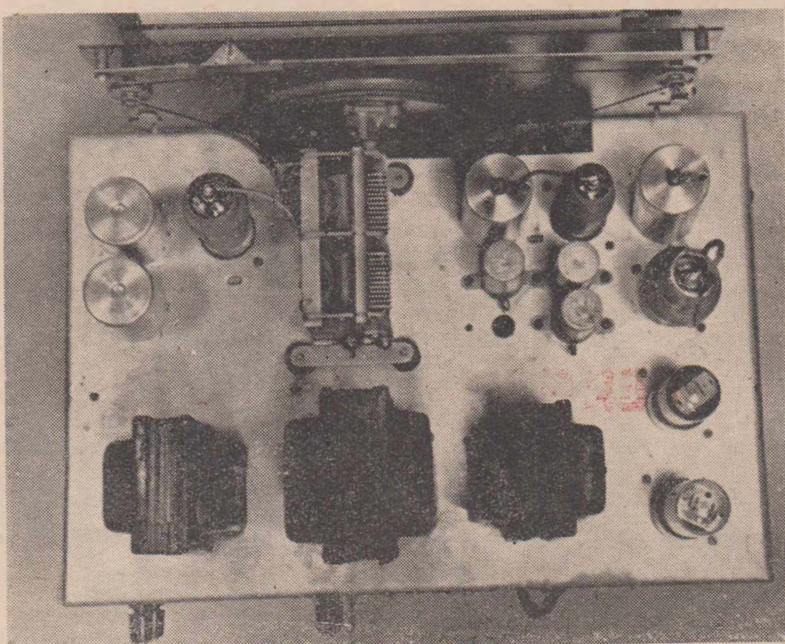
This improvement was largely due to the inclusion of a special tone control circuit, and a wide range output transformer having a separate secondary winding for the feedback loop. Now for those readers who have been interested in this design in view of the excellent tonal response, but did not have a tuner on hand to use it with, this description of a five-valve receiver incorporating this audio section should be of particular interest.

The output transformer is the special Ferguson type OP24, and this is available with secondary windings to suit speakers having either 2.2 or 6.5 ohms voice coils. For other V.C. ratings the two windings can be connected in either series or parallel arrangement, thus permitting its use with most speakers.

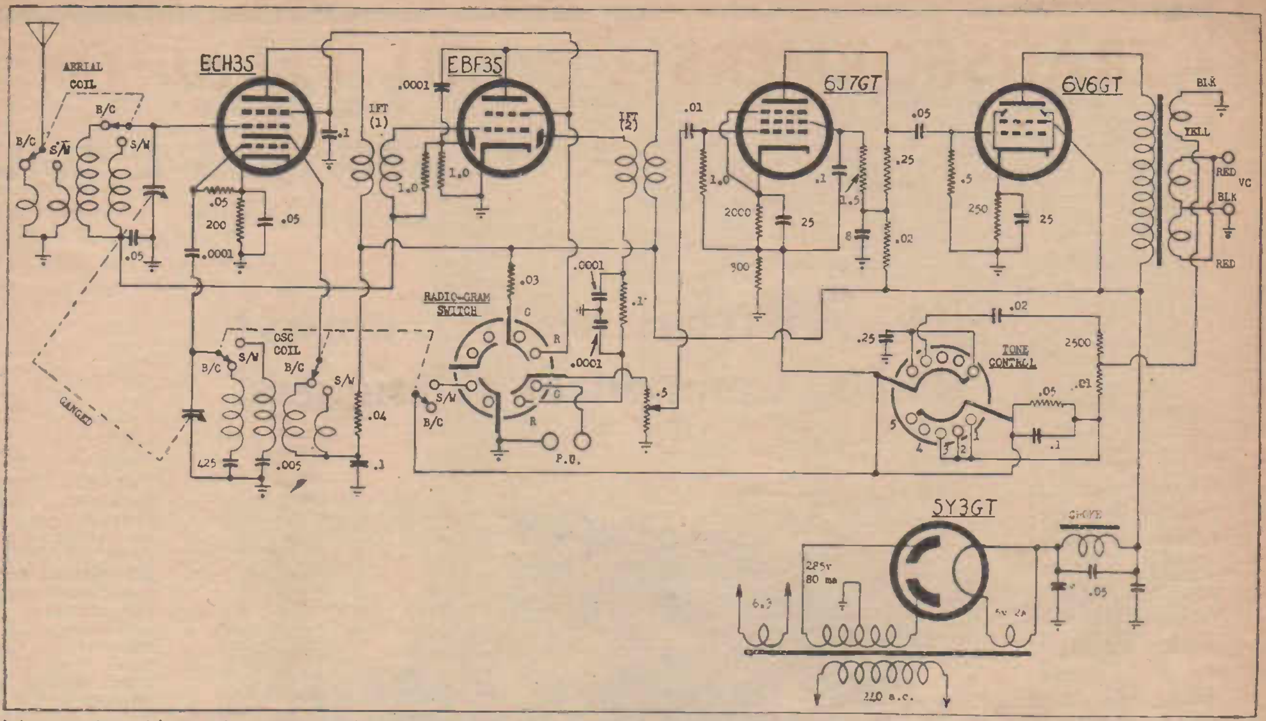
Circuit Details

The circuit consists of an ECH35 converter, an EBF35 combined i-f amplifier and second detector, a 6J7G audio amplifier, 6V6GT output stage and a 5Y3GT. Grid bias for the converter stage is obtained by means of the usual resistor and by-pass combination in the cathode circuit. In the case of EBF35, the cathode is earthed, with the requisite operating bias being supplied by the AVC line. The diode load consists of the .1 meg. resistor and .5 meg. volume control in series. The volume control is connected through the radiogram switch and serves the dual purpose of radio as well as gramophone pick-up volume control.

The audio signal is taken from this volume control to the grid of the 6J7G through the .01 mfd, condenser. The 6J7G is connected as a pentode audio amplifier, the component values being those recommended for this class of operation. Decoupling has also been provided in the plate circuits by means of the .02 meg. resistor and 8 mfd. condenser, to prevent any possibility of hum troubles, which are sometimes found in a high gain audio stage. The output stage is a 6V6GT and except for the output transformer, this stage calls for little comment.



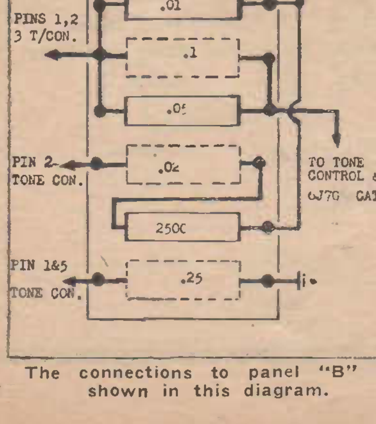
The top chassis layout can be seen in this photograph. The circuit progresses across the front of the chassis, with the power supply and output transformer being mounted along the rear edge.



Using modern high gain valves, this receiver will give excellent results on both radio and gramophone pick-up. Main feature of the circuit is the inclusion of the special tone control arrangement and feedback circuit which results in a high-quality output from a single PA valve.

Radiogram Switch

To enable the receiver to be switched from RADIO to PICK-UP and vice versa, a radiogram switch, consisting of a miniature 4-pole two-position rotary switch is fitted on the front of the chassis. The connections to this should be made as indicated in the schematic diagram. As can be seen, the screen dropping resistor for the ECH35 and EBF35 valves is connected through one switch section, enabling the screen voltage on these two valves to be disconnected when the receiver is being used with the pick-up. This arrangement prevents any possibility of the radio signal being heard at the same time as the gramophone unit.



The connections to panel "B" are shown in this diagram.

The .5 meg. volume control is connected across the second switch section, enabling its use on both gramo and radio, whilst the third section permits the earthing of the negative feed-back line on the short-wave band. Since gain is usually more important than quality on this band, it is advantageous to short out this circuit when listening to overseas stations.

The tone control circuit is similar to that used and described in the May issue, but for those who may not be able to refer to this issue the following details will clarify its use and operation. Reference to the circuit diagram will show that the output transformer (a Ferguson OP24) has a separate feed-back winding, and the feedback loop is taken into the cathode circuit of the 6J7G with a resultant reduction of the total harmonic distortion. This negative feedback loop is also taken through the five position 2-pole switch, and forms an effective tone control arrangement.

PARTS LIST

- 1 Chassis. (HQ,D/WR)
- 1 2-Gang Tuning Condenser.
- 1 Tuning Dial to suit.
- 1 Aerial, 1 Oscillator Coil (B/C and S/W).
- 2 455 I.F.T.'s.
- 1 Power Transformer, 285v. HT, 80 ma., 6.3v.; 5.0 windings.
- 1 Filter Choke, 80ma.
- 1 Output Transformer (Ferguson OP24).
- 4 Air Trimmers.

CONDENSERS.

- 3 8 mfd. Electrolytic, 525v.
- 2 25 mfd. Electrolytic, 40v.
- 1 .25 mfd. Tubular, 200v.
- 5 .1 mfd. Tubular, 200v.
- 5 .05 mfd. Tubular, 600v.
- 1 .02 mfd. Tubular, 400v.
- 1 .01 mfd. Tubular, 600v.
- 1 .005 mfd. Mica.
- 1 .000425 mfd. Mica.
- 4 .0001 mfd. mica.

RESISTORS.

- 1 1.5 meg., 1 watt.
- 3 1.0 meg., 1 watt.
- 1 .5 meg., 1 watt.
- 1 .25 meg., 1 watt.
- 1 .1 meg., 1 watt.
- 2 .05 meg., ½ watt.
- 2 .03 meg., 1 watt.
- 1 .02 meg., 1 watt.
- 1 .01 meg., 1 watt.
- 1 2500 ohm, 1 watt.
- 1 2000 ohm, 1 watt.
- 1 250 ohm, 3 watt WW.
- 1 200 ohm, 3 watt WW.
- 1 .5 meg. potentiometer.

VALVES—1 ECH35, 1 EBF35, 1 6J7G, 1 6V6GT, 1 5Y3GT.

SPEAKER—Permag. type.

SUNDRIES—5 octal sockets, 1 4-pin speaker socket, 5 knobs, 4 terminals, 1 6 x 2 switch, 1 2-pole 5 pos. switch, 1 4-pole 2 position switch, 4 small rubber grommets, 1 valve shield, Indicator knob card (I.R.P -160 49)

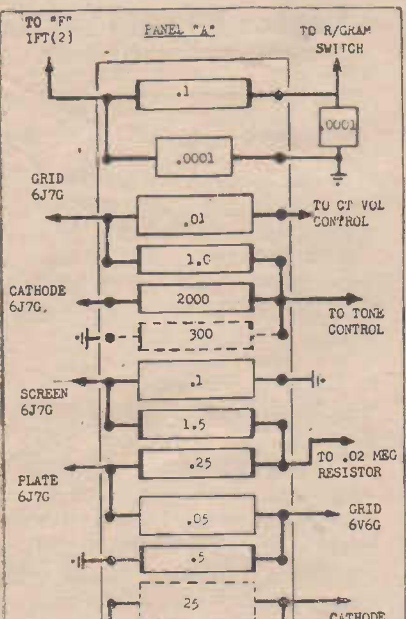
This switch provides the choice of five positions—Wide Range, Bass, Normal, Speech and Overseas. The connections should not prove difficult and to assist in this regard, it will be noticed that the switch positions have been numbered from 1 to 5, looking at the switch from the rear.

Switch Connections

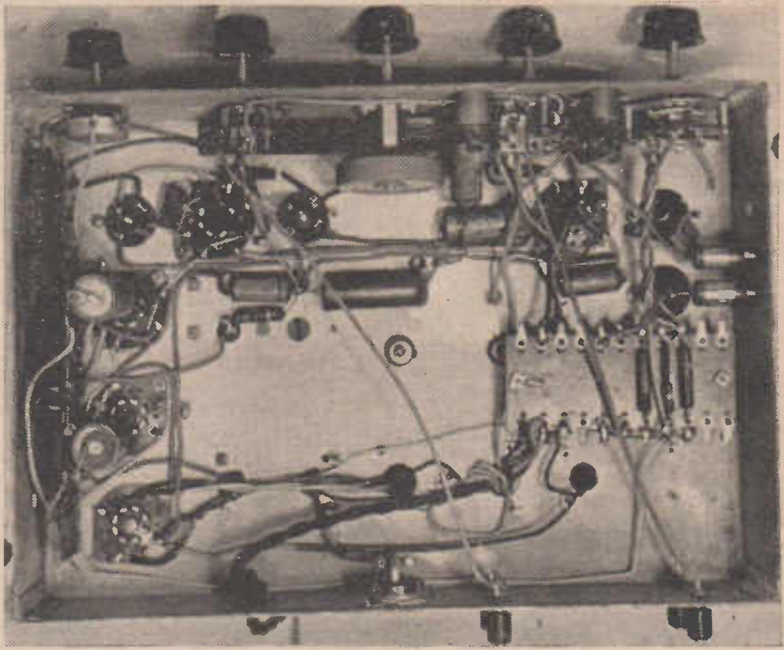
Taking the lower bank first, pins 1, 2 and 4 are wired together and connected to the "yellow" lead from the output transformer through a .01 meg. resistor. The two remaining switch positions on this section are left blank.

In the upper section, Pins 1 and 5 are connected together, with a 0.25 mfd. condenser, being connected from this point to earth. Pin 4 is taken to the feedback, winding through the .02 mfd. condenser and 2500 ohm resistor in series. These components, incidentally, are mounted as shown on the small panel marked "B."

Next, the two moving arms of the switch are wired together and connected across Pins 1, 2 and 3 of the lower section through a .05 meg. resistor and 0.1 mfd. condenser in series. A lead from the moving arm is also taken to the junction of the 2000 and 300 ohm resistors in the 6J7G cathode circuit, as well as to the shorting switch, to earth the feedback when the receiver is operated on the SW bands.



This diagram shows how to wire up panel "A." Make sure the various leads are left long enough for connecting to the valve sockets. Components marked with a dotted line are fitted on the reverse side of the panel.



The position of most components can be seen in this under-chassis photograph. Panel "A" is mounted along the left-hand chassis side, whilst panel "B" is at the lower right corner.

The operation of the switch is simple enough once the various circuits are traced through. Commencing with position No. 3, which is the normal position, it will be seen that the feedback winding is connected through the 0.01 meg. feedback resistor direct to the 300 ohm resistor in the cathode circuit of the 6J7G. Under these conditions, there is approx. 12 db of feedback and the frequency range using a 1 watt reference level is from 30 to 15000 cps. within plus or minus 0.5 db.

Moving the control to position 4—Bass Boost—this basic circuit is now modified by the inclusion of the 0.05 meg. resistor and the 0.1 mfd. condenser in series with the 0.1 meg. feedback resistor. This gives a bass boost of approximately 3 db below the reference level of 400 cps., down to the speaker cone resonance after which the effect rapidly falls off.

In position 5, the Wide Range position, the previous circuit is simply changed by the inclusion of the 0.25 mfd. condenser across the cathode bias resistor, thus effectively by-passing it, and increasing the high frequency response. Reverting to position 2, the Overseas position, the .01 meg. feedback resistor is now shunted by the 2500 ohm resistor and the .01 mfd. condenser in series. This results in a high note cut. The remaining position is for speech and this is basically similar to the normal position, except that now the 0.25 mfd. condenser is connected across the 300 ohm cathode resistor.

The leads from the output transformer are colour coded, and these should be wired into the circuit as shown to obtain the correct phasing. With the feedback winding the black lead is earthed, whilst the yellow lead is the feedback connection. The voice coil leads are obtained by twisting the two red leads and the two black leads respectively together, and these are connected to the four pin speaker socket mounted on the back of the chassis. The two black leads should be earthed at a convenient point.

Mounting the Components

A ready-cut chassis is now available for this receiver, and this will simplify the home constructor's assembly problem. The position of most components can be seen from the various photographs, and in each case these should be mounted so as to ensure the shortest possible leads between the circuits.

The two broadcast coils are mounted on the left-hand side of the chassis (looking from the rear), with the ECH35 converter immediately adjacent. The circuit then progresses across the front of the chassis, with the two I.F.T.'s and the EBF35 being mounted on the right-hand side. The 6J7G, 6V6GT and 5Y3GT are mounted along the right-hand chassis edge, whilst the power transformer, filter choke and output transformer are all mounted across the back edge of the chassis.

The tuning gang is mounted centrally on the chassis, using rubber grommetts. To provide an efficient earthing return, make sure the gang wipers are connected to the chassis as near as possible to the AVC return. This is especially important as regards operation on the short-wave band, otherwise undesirable coupling effects may take place.

To simplify the wiring up it will be noticed that many of the components, especially those in the audio section, and tone control circuit have been mounted on two resistor panel strips. One of these, marked "A," is bolted on the left-hand side of the chassis, whilst the smaller one, "B," is mounted at the lower right-hand side as shown in the under-chassis photograph. The two small drawings indicate how the various condensors and resistors should be wired up, those marked in a broken line being placed on the opposite side of the resistor strip.

It will be noticed that the two lugs at the end of the small panel "B" has been used as a convenient mounting spot for the two AC leads from the mains, as well as those from the transformer. In mounting these panels, make sure they are kept sufficiently clear of the chassis or any other metal so as to avoid any possibility of short circuits.

Dual Wave Unit

Although a standard 4/5 dual wave unit could be fitted in the tuning section of the receiver, we have preferred in this case to use the separate broadcast and SW coils, and wire them to a suitable switch. It will be found that this is not a particularly difficult undertaking, and providing care is taken with the leads there is no reason why the performance should not be equal to that of the ready-wired units.

All that is required is an aerial and oscillator coil for the broadcast and short wave band (make sure this latter coverage suits the dial markings) and a 6-pole two-position switch. In the original receiver we used the "Vega" type coils, which are now becoming available for the home set constructor, and found them quite satisfactory in operation.

The switch consists of six sections, each comprising a moving arm and two fixed contacts. By connecting the Aerial, Grid, Osc. Grid and Osc. Plate circuits to a moving arm, and wiring the respective leads from the broadcast and SW coils to the fixed contacts, it will be seen that the receiver can be switched to either band. Some of the leads, like common earth, AVC, padder and Osc. B plus leads, do not require switching, and these should be connected up as shown on the schematic diagram.

Trimmers must be fitted across each coil to enable the circuits to be aligned. The two air trimmers for the broadcast coils are mounted immediately below the two coils on the side of the chassis, whilst the short wave trimmers are mounted across the respective coil right at the switch bank.

After the wiring has been completed and checked over the only other step is to align the tuned circuits. Although the procedure for this has been mentioned in previous issues, the following remarks should be of assistance to many.

Alignment Procedure

First tune in a station at the high frequency end of the broadcast band and adjust the aerial trimmer for maximum output. Next tune in a station at the low frequqncy end of the band and adjust the aerial coil slug for maximum output. Loosen off the dial drum, and adjust the pointer to register correctly on a known station. Retighten the drum screw.

Retune the receiver to a known station at the high frequency end of the band and position it correctly by means of the oscillator trimmer. Check the aerial trimmer and repeat the low frequency adjustment.

The alignment on the short wave band is carried out in a similar manner, using the trimmers for the high frequency end of the band, and adjusting the aerial coil slug at the low frequency end. If the coils, tuning condenser and dial are matched, the stations should be received at the positions indicated on the dial glass.

Index for Volume 1

In response to many requests, an index of all the material which appeared in RADIO SCIENCE, Vol. 1, February to December, 1948, is now available.

Printed on a good quality paper, the price of this index is 6d., post free, and can be obtained by writing to the Subscription Dept., Box 5047, G.P.O., Sydney. In view of the limited number of copies printed, we would suggest you write off immediately for this copy and avoid disappointment.

Checking Crystal Frequency

With many types of crystals now becoming available through disposal and other sources the following simplified method of determining the frequency of an unmarked crystal should be of interest to all experimenters.

Simply connect the crystal in series between a signal generator and a V.T. Voltmeter. Set the VTVM to the three-volt range and tune the signal generator over its frequency range. The meter reading will remain very low until the resonant frequency of the crystal is reached, when it will move up sharply.

Reading the dial of the signal generator will then indicate the frequency of the crystal, although for greater accuracy it may be necessary to recheck with a frequency meter.

PRINTED CIRCUIT Techniques —

In this second article of the series, details are given for the surface preparation and methods of applying the various conductor paints.

C.—RESISTOR PAINTS

The resistor paint consists of the conducting pigments (such as carbon black or powdered graphite in carbon resistors or a metallic salt in resistors of the metal film type), a binder (such as phenolic resin in solution), a filler (such as mineralite) and a solvent (such as alcohol). These ingredients are varied in proportion to produce resistances varying in value from a few ohms to hundred of megohms.

They usually are printed in widths from 3/64in. to 3/32in. and in lengths from 1/8in. to 3/8in.

In the present state of the art it is not feasible to present a set of resistor paint formulations that one may use without special attention in the laboratory. Resistors may be painted readily only after careful practice. A paint formula that is successful to one experimenter may not work well for another because of the manner in which the ingredients are mixed, the quality of the ingredients, the amount of evaporation of solvent prior to application on any number of other small but important factors. However, the data of table 3 are presented as a compilation of formulas used to print resistors of the values indicated.

There is need for additional experimental work in developing improved methods of printing resistors and in clarifying the theory of resistor composition and performance. This is especially true with carbon resistors. At the present time the best resistor mixes are considered to be those in which the conducting element is predominantly or entirely carbon black dispersed in a suitable resin. However, carbon black is high in resistivity so that it has been necessary to add acetylene black or graphite to bring the average value within practical limits. There are many types of carbon black, each characterised by particle size, particle arrangement, the type of gas used in its manufacture and its impurities, particularly surface impurities.

Current knowledge points to the use of carbon blacks of relatively small size for resistor paints, those of particle diameter in the range 20 to 50 Mp. The carbon black

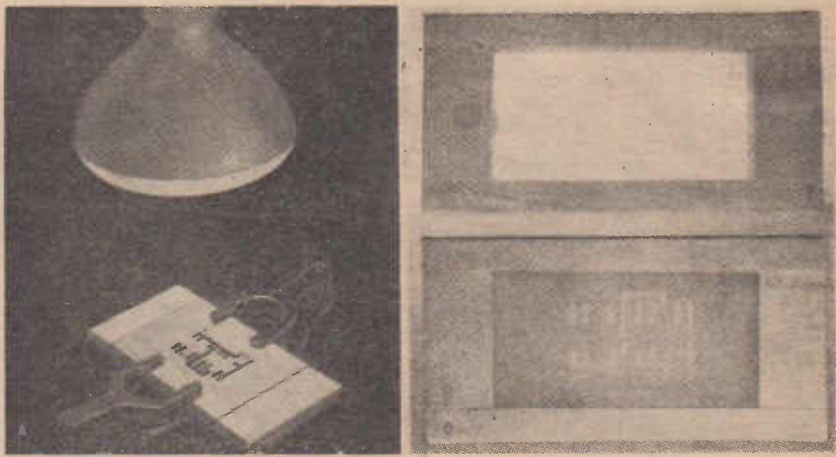


Fig. 1.—Preparation of stencilled screen. (A) Screen coated with photosensitive material is exposed to strong light through a photographic positive of circuit pattern; (B) Stencil screen before and after pattern is applied photographically.

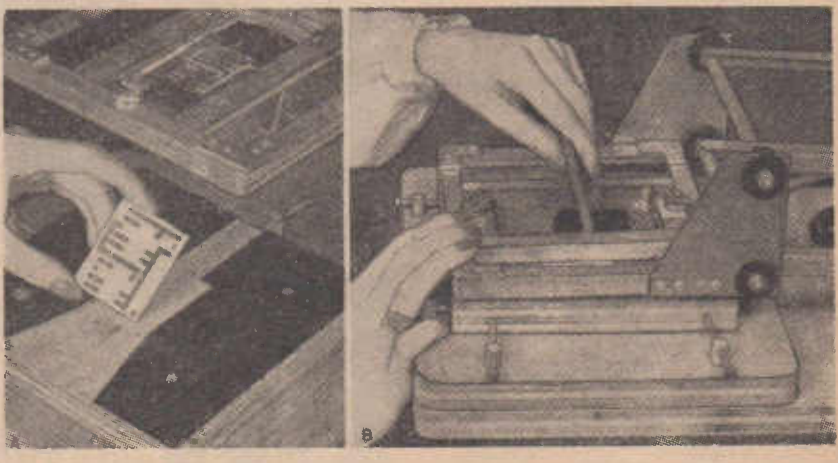


Fig. 2.—Stencilling Operations. (A) Retractible stencil holder for applying paint to insulated plate. Holder moves forward and down over plate held in platen. plate shown has just been removed from platen; (B) application of paint through stencilled screen. A single smooth stroke of the squeegee is required.

(9. Carbon black here is interpreted to mean carbon produced by impinging the flame of hydrocarbon gas on a metal surface such as a plate or channel. Also known as channel black, gas black or impingement black.)

TABLE 3.—*Resistor paint formulas*

[All percentages are by weight]

Approximate resistance	Approximate thickness[a]	Pigment	Binder	Solvent	Processing temperature
Ohms	*In.*				° *C.*
1,000	0.003	38% Graphite	62% Silicone resin		275
2,000	.003	3% Carbon black; 27% Graphite	70% Silicone resin		275
5,000	.003	4% Carbon black; 19% Graphite	77% Silicone resin		275
25,000	.003	12% Carbon black; 38% Graphite	17% Phenolic resin	33% Phenolic resin thinner	175
25,000 to 50,000	.0015 to 0.003	7% Carbon black	72% Silicone resin	21% Benzene	275
25,000 to 50,000	.0015 to 0.003	4% Carbon black	74% Silicone resin	22% Benzene	275
45,000—10 megohms	.001 to 0.004	12% Carbon black; 27% Graphite	20% Crystallite	12% Toluene; 29% Ethylene dichloride	50
50,000—10 megohms	.001 to 0.004	11% Carbon black; 23% Graphite	66% Ethyl cellulose lacquer		50

[a] All Resistors were approximately 0.10 in. wide and 0.40 in. long

should have its surface impurities, principally oxygen, removed by calcining. This is done by heating to a temperature of approximately 1050 deg. C. for 4 hours, preferably in a nitrogen atmosphere. The oxygen concentration is reduced to a limit of about one-half of 1 per cent.

After calcining the carbon black, it is best to disperse it in the binder by ball milling, using, for example, flint balls. The size and density of the balls and the speed of the mill are all important factors in this operation. The dispersion may be checked by measuring the resistance that decreases asymptotically with time as the milling proceeds.

When the resistance has reached a minimum, the milling should be stopped. A good ball milling technique applied for 12 hours usually assures adequate dispersion of the carbon in the resin. The resin plays an important part in the dispersion and considerable practice has been necessary to determine the best type of resin to use. It must have good solvent release.

2.—SURFACE PREPARATION

The insulating surface on which the circuits are to be printed may first have to be treated to improve the adhesion. The methods described herein are adaptable to all of the printing processes.

Adhesion to methyl methacrylate (Lucite, Plexiglass, etc.) may be increased by roughening the surface as by sand blasting. Roughening produces a minute granular surface to which better mechanical bonding may be had. When this is done, however, the surface becomes porous and the internal strength of the plastic may be reduced, causing the plate to buckle. In such instances, precautions should be taken to coat the surface after printing the circuit.

Glass surfaces may be prepared by etching with hydrofluoric acid fumes or sand blasting. Etching may also be used, if necessary, on glazed ceramic materials. Glass may be sand blasted or sprayed with other abrasive materials. Usually, suitable protective stencils or coatings are used to confine the roughening to that portion of the surface occupied by the circuit.

The next step is to make sure that the surface is absolutely clean, for the bonding or adhesion may be weakened considerably by the presence of impurities. The impurities prevent direct contact between metal and surface, and are a poor or useless base on which to form the circuit. The problem of cleaning is not difficult, and customary procedure may be followed, using standard cleaning materials[5,6,7]. In selecting the chemicals, it is important to consider the type of surface being cleaned. A material suitable for glass, for example, might produce undesirable effects if tried on plastics.

On hard surfaced material such as glass and ceramics, after washing the surface with water following by a rinsing with a suitable detergent, the surface may be swabbed with a dilute solution of nitric acid. If soap is used as the detergent, it should be rinsed off well with distilled water. Detergents such as aerosol are preferred because they form water soluble compounds with magnesium and calcium solids commonly found in tap water[10].

If the cleansing is carried out thoroughly, one operation should be sufficient. If desired, one may follow with a second operation by treating the surface with a dilute solution of potassium hydroxide[6,7]. The second operation, commonly followed in silvering mirrors, may not be necessary in printing electronic circuits. Glazed surfaces may be cleansed of paraffin and carbonised organic materials by using a mixture of chromic and sulphuric acid. In stubborn cases, the material may be placed in the solution and heated slightly.

(10. Dr. Carl Bosh, of Heidelberg, Germany, has described a procedure for cleaning glass, which is very good. He washes the glass with a potassium nitrate and sulphuric-acid solution. In this way, any chemical action taking place results principally in gaseous products which evaporate. Then follows a hot-water dip after which a blast of steam is played on the surface. The surface is dried while still hot in a water-vapour atmosphere. It dries instantaneously without forming minute water droplets, which on drying might leave nonuniform traces of materials dissolved in the water.)

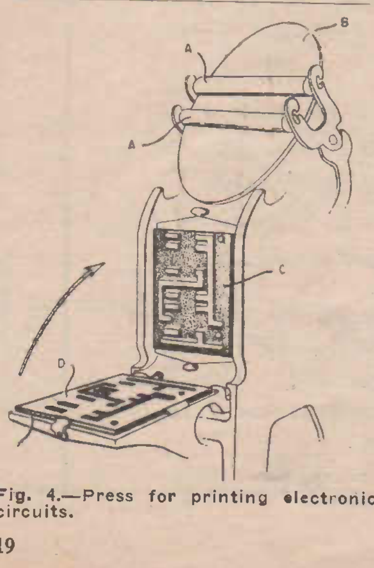


Fig. 4.—Press for printing electronic circuits.

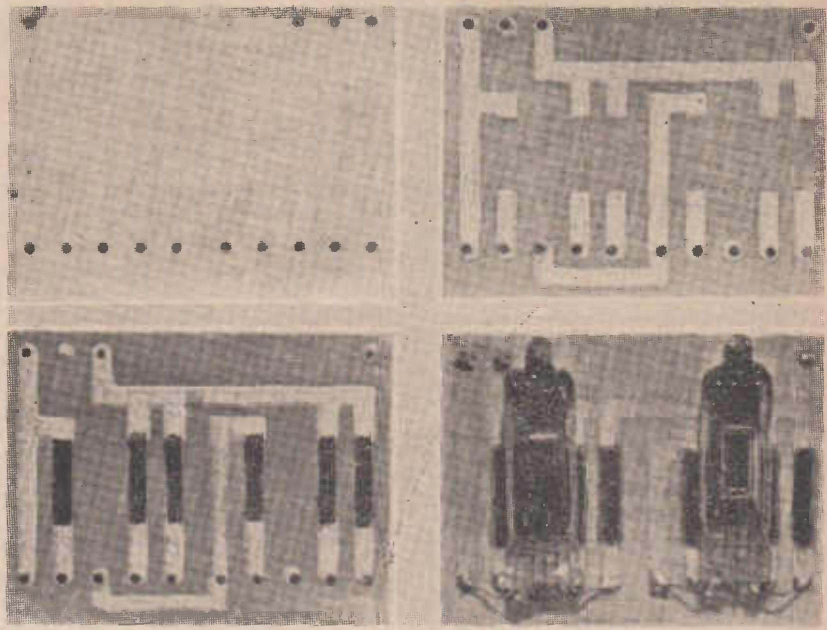


Fig. 3.—Stages in the printing of an electronic circuit onto a steatite plate. (A) Steatite plate after drilling and firing. (B) Circuit wiring deposited. (C) Resistor Strips added. (D) Miniature valves soldered direct to wiring completing a two-stage amplifier.

Thermoplastics such as Lucite or Plexiglas may be cleansed with a dilute solution of tri-sodium phosphate, then rinsed in water and dried to remove any oil. For certain types of plastics, such as the phenolics, the surface may be cleansed with ordinary carbon tetrachloride, followed by swabbing with a very dilute solution of potassium hydroxide or warm chromic acid. In one practice, this is followed with a quick dip in a strong caustic soda solution or nitric acid.

3.—APPLICATION OF CONDUCTOR PAINTS

A.—CIRCUIT DESIGN

In many applications the arrangement of the circuit can be chosen in any convenient manner. The circuit may be painted in the same way it would be drawn on paper. Eyelets would be placed where the tube elements are later to be attached. It will generally be found more convenient and economical, however, to lay out the printed circuit in such a way as to keep the length of leads to a minimum and to avoid cross-overs. Cross-overs are handled by going through the base plate and continuing on the opposite side, by going around the edge, or by cementing or spraying a thin layer of insulating material over the lead crossed.

It is important to emphasise that observation of good electronic wiring practice is as essential to the successful design of printed circuits as it is in standard circuits. In printed circuits the parts are usually placed closer to each other so that caution must be exercised to see that the components do not affect each other adversely while one circuit is in operation.

In one experience poor performance of a printed oscillator in the 150 megacycle range was traced to excessive grid-ground capacity, resulting from excess silver in a groove of the base plate. The heavy silver deposit in the groove being at ground potential and also near the grid terminal of the oscillator tube by-passed the RF current from the tank inductor. Reducing the width and depth of the silver line restored the electrical performance to normal.

Proper attention to circuit layout may produce many desirable advantages, such as the electrostatic shielding of leads from one another. A ground lead painted between two other leads acts as an electrostatic shield in a manner similar to the screen in a screen grid tube. This effect has been used to good advantage in providing hum reduction by shielding grid leads from the filament leads[8].

B.—BRUSHING

The paint may be applied to the surface in any one of a number of ways, depending upon the type of apparatus available and the electrical tolerances required. When close electrical tolerances are not needed, the paint may be simply brushed on.

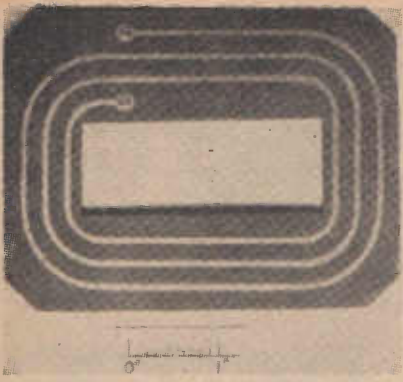


Fig. 5.—Loop antenna printed on a plastic sheet.

For brushing, an ordinary soft camel hair brush may be used. After the paint is stirred and the viscosity adjusted, it is applied in smooth, even strokes, care being taken to avoid air bubbles or films between the plate and the paint, or other imperfections that ultimately might result in blisters or cracks in the paint.

If the conductors are to be held to close dimensional tolerances, more care is necessary in applying the paint so as to maintain the necessary degree of uniformity between assemblies. There are, however, a large number of radio and electronic applications where, except for a few components, close tolerances in current-carrying capacity are not needed, nor is exact electrical duplication of subsequent assemblies important.

C.—STENCILLING

(a) Stencil Material

The simplest stencil is one in which the pattern is cut from a thin sheet of metal, plastic, paper, or cloth and the paint applied in a manner similar to that in which commercial packages are labelled. Uses of this type of stencil are limited.

Electronic assemblies for hearing aids, radios, etc., are produced uniformly at high rates of speed by using a thin screened stencil made of cloth or metal. The higher the quality of the screen and the finer the weave, the greater the uniformity in production. By employing a finer mesh, the edges are more sharply defined and the variation from assembly to assembly will be reduced.

Screens made of silk have found wide use in printed circuits work. Metals screens have also worked out satisfactorily, and in many cases have proven more practical than silk screens. They are prepared by the same process as silk screens. Either stainless steel, copper, phosphor-bronze or similar materials may be used.

It should be possible to use screens made of glass mash. The mesh size usually used varies from around 74 to 200 mesh[11]. Stainless steel screens of 300 mesh have been used to print silver leads. With screens of 120 mesh, it is practicable to print resistors of ±20 per cent. tolerance or better.

Separate stencils are used for the conductors and resistors, and in addition, stencils are often used for preparing the plate, that is, for cleaning and roughening, and for applying protective resin coatings to resistors and inductors.

(11. Mesh classifications are: 6xx, 74 mesh; 8xx, 86 mesh; 10xx, 109 mesh; 12xx, 125 mesh; 14xx, 139 mesh; 16xx 157 mesh.)

(12. Metal, plastic or other types of frames may be employed.)

(b) Preparation of Stencils

The screen is prepared by stretching it tightly over a wooden[12] frame. A photographic method is used to impart the circuit design to it. The screen is coated with a thin film of material such as gelatin or polyvinyl alcohol and photosensitized with potassium dichromate[13]. When subjected to strong ultra-violet light the film becomes insoluble in water.

To impart the stencil pattern to the film, a photographic positive of the pattern desired is held tightly against the sensitized screen and exposed to light as in Fig. 1. Those parts of the film which are not exposed to the light are water soluble and wash out in cold water, leaving the design of the pattern to be printed.

(Continued on page 39)

Basic Electricity & Magnetism

A further discussion on capacitors in which the mechanical forces involved in charged capacitors, as well as the difference between conductors and non-conductors, are dealt with in some detail. Some typical problems are also included to test your knowledge of the subject.

An electric field has two basic characteristics; it can electrically strain the medium supporting it and it can set up mechanical forces between bodies placed in it. The electric field established between the plates of a charged capacitor not only strains the dielectric separating the plates; it also produces a mechanical force of attraction between the plates themselves. This force exists because, basically, the plates are bodies in an electric field, one being negatively charged, and the other positively charged.

The magnitude of this attractive force depends on the strength of the field, which, in turn, is dependent on the p.d. between, and the capacitance of, the plates. This basic relationship provides a means for deriving an expression for calculating the magnitude of the force tending to compress the dielectric between the plates.

We have seen that when a capacitor is charged, the energy stored in it is given by,

$$W = \frac{CE^2}{2} \text{ joules} \qquad \ldots 9.1$$

but, C, you will remember, can be written as,

$$C = \frac{KA}{4\pi t} \qquad \ldots 9.2$$

and when we substitute this value for C, in expression 9.1 we get,

$$W = \frac{KAE^2}{8\pi t} \text{ joules} \qquad \ldots 9.3$$

Expression 9.3 is identical with 9.1, the only difference being that in 9.3 the energy W, in joules, is expressed in terms of the p.d. E, between the plates, the area A, of the plates, the dielectric constant K, of the material separating them, and the distance t between them.

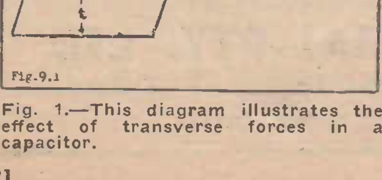


Fig. 1.—This diagram illustrates the effect of transverse forces in a capacitor.

Since the energy stored is equal to the work done in storing it, and work done, in the mechanical sense, is a product of force and distance, we can write,

$$W = F\,t \text{ joules} \qquad \ldots 9.4$$

and putting this value for W in the expression 9.3, we get

$$F\,t = \frac{KAE^2}{8\pi t} \text{ joules} \qquad \ldots 9.5$$

and dividing both sides of 9.4 by t we finally have

$$F = \frac{KAE^2}{8\pi t^2} \text{ dynes} \qquad \ldots 9.6$$

The force F is given in dynes in 9.6 when E is expressed in e.s.u. or electro-static units. There are 300 volts in one e.s.u. of potential difference, so that, if we want to express E in volts, we must divide 9.6 by $(300)^2$ or 9×10^4. Also a pound weight is nearly equivalent to 445,000 dynes.

By
A. L. THORRINGTON, A.S.T.C.

To express the force in lbs. when E is expressed in volts we must divide 9.6 by the product of $(300)^2$ and 445,000. If we include in this divisor the factor 8π we finally get the practical expression,

$$F = \frac{KAE^2}{10^{12}t^2} \text{ lbs. (very nearly)} \qquad \ldots 9.7$$

In most cases the magnitude of the forces involved when a capacitor is charged is too minute to warrant their calculation. However, in the final stages of powerful transmitters, potentials often rise to values which mechanically stress the dielectric of the capacitors used to a dangerous degree.

As a practical example, consider a case where the instantaneous value of the p.d. across a capacitor

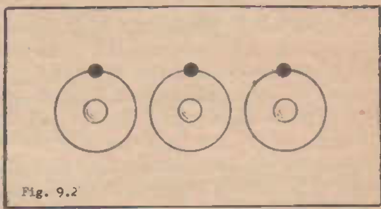


Fig. 2.—In non-conductors, the electrons encircling the nucleus of the atoms are restrained to their normal paths. ...

is 50,000 volts, and suppose the dielectric is mica 0.005" thick and has a dielectric constant of 8. Let the active plate area be 50 sq. ins. Then, in accordance with Equation 9.7, the force in tons will be,

$$F = \frac{8 \times 50 \times 25 \times 10^8}{10^{12} \times (.005)^2 \times 2240}$$

$$= 18 \text{ tons (nearly)}$$

In practice, of course, the dielectric would have to be a lot thicker than 0.005in., but this value has been deliberately chosen so as to emphasise how necessary it is to use capacitors of sufficient physical strength when they are used for heavy duty work. Your author still has vivid memories of a capacitor be made for the tank circuit of the final stage of a 1,000 watt transmitter. The dielectric was plate glass 3/16in. thick. With the first surge of r.f. the glass cracked and there was a spectacular display of sparks and smoke. After this, the magnitude of the mechanical forces set up was very carefully calculated.

It is important to note that the force in inversely proportional to the square of the distance between the plates so that if the force is great enough to compress the dielectric to half its original thickness the magnitude of this crushing force is increased fourfold, and this greater force, should it succeed in still further crushing the dielectric, will increase again so that the action is accumulative. If the initial forces are able to compress the dielectric at all they will increase in intensity until the capacitor fails because of mechanical crushing.

Transverse Forces

We have so far considered only those forces which act in a way that will pull the plates of a capacitor together. If we analyse the method we used to derive Equation 9.7 we will see that we have actually obtained an expression which yields the force required to pull the plates apart a distance equal to the thickness of the dielectric between them. There are also forces which tend to stop any sliding of the plates over the surface of the dielectric. These are called **transverse forces.**

Figure 9-1 represents a capacitor in which the upper plate B is free to slide mechanically over the surface of the dielectric. Let the length of this plate be x and its width be y, so that xy equals A, the area of the plate. Let the distance between the plates be t. Let us assume that, with the capacitor charged, we are able to slide the upper plate towards the right as shown, a distance equal to its length.

As the upper plate is slid toward the right, we can imagine the lines of electric force, representing the field between the plates as continually increasing in length, and, hence, in tension. As we pull the plate we must obviously pull against the forces set up by the electric field.

> **_IN OUR NEXT ISSUE . . ._**
>
> **Do you know that current does not flow; do you know that the term current flow is the most misleading ever used in the electrical terminology. The true idea about current is introduced in Part X of this series, which also discusses practical types of capacitors.**

When the upper plate has been pulled completely to the right, it has been pulled through a distance x against some force F so that the work done is,

$$W = Fx \qquad \ldots 9.8$$

The work done in dragging the plate to one side must clearly be equal to the energy stored in the charged capacitor. That is:—
Energy stored in capacitor,

$$W = \frac{KAE^2}{8\pi t} \text{ (from Eq. 9.3)}$$

And substituting from Eq. 9.8 we get,

$$Fx = \frac{KAE^2}{8\pi t} \qquad \ldots 9.9$$

Now, since $xy = A$
Then $x = \frac{A}{y}$
and putting this value for x in Eq. 9.9 we have,

$$\frac{FA}{y} = \frac{KAE^2}{8\pi t} \qquad \ldots 9.9$$

and

$$F = \frac{yKE^2}{8\pi t} \text{ dynes} \qquad \ldots 9.10$$

The transverse force is thus proportional to the width, y, of the capacitor plates, and inversely proportional to the thickness of the dielectric.

When y and t are each of unit length, Equation 9.10 reduces to,

$$F = \frac{KE^2}{8\pi} \qquad \ldots 9.11$$

Similarly, for unit area and thickness in the case of Equation 9.6 we obtain the same expression for the longitudinal force as is given by Eq. 9.11 for the transverse force.

The significance of this fact is

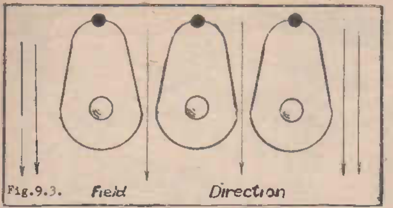


Fig. 3.—Under the influence of an electric field, the electrons shown in Fig. 2 are displaced from their normal orbits, the extent depending on the intensity and direction of the displacing field.

that both the longitudinal and transverse forces are the same per unit volume of the dielectric, and both act in a direction to reduce the volume of the field, or, what is the same thing, to increase the capacitance of the capacitor.

It is a fundamental characteristic of an electric field to tend to occupy the smallest possible space. Our knowledge of this tendency is often an aid in helping us visualise the shape and intensity of an electric field. Thus, a free charge in space must, according to this basic characteristic, establish a spherical field, because a sphere contains more volume per unit surface area than any other geometrical figure. It follows that the boundaries of all electric fields follow, wherever possible the contour of a sphere.

Conductors and Non-Conductors

All substances, insofar as electricity is concerned, are broadly classified into two groups—conductors and non-conductors. Conductors are characterised by their ability to permit the flow of electric charges along or through them: non-conductors have the property of resisting the flow of electric charge. There are no perfect conductors and there are no perfect non-conductors. Even the best conductors offer some resistance to the movement of charge, and no non-conductor can completely stop charges from flowing. The terms are thus relative opposites.

A good non-conductor for one purpose may be a satisfactory conductor for another purpose and vice versa. In general, all metals are good conductors when compared with non-metallic substances. Carbon and graphite fall between metals and non-metals, but have important applications.

The only requirement of a good conductor is that it conducts electricity readily with a minimum loss. On the other hand, non-conductors have three distinguishing properties. These properties are:—

1. Their dielectric constant.
2. Their dielectric strength.
3. Their dielectric resistivity or leakage.

The Dielectric Constant

The dielectric constant is somewhat analogous to an elasticity, although in the case of a non-conductor, this is an electrical elasticity, in contrast to the mechanical elasticity characterised by rubber or a stretched spring. It is this elastic property of a non-conductor which permits it to store electrical energy in the form of strain energy when it is used as a dielectric in a capacitor. To get the greatest capacitance per unit volume of space it is clearly necessary to use a non-conductor with as high as dielectric constant that we can get.

The mechanism which permits a non-conductor to store electrical energy is best explained in terms of the electron theory. In non-conductors, the electrons encircling the nucleus of the atoms comprising the non-conductor are apparently elastically restrained to their normal paths, as shown in Figure 9-2. Under the influence of an electric field these electrons are displaced from their normal orbits and pursue a path in conformity with the intensity and direction of the field which displaces them. The distorted orbits shown in Figure 9-3, which represents the electrons shown in Figure 9-2 under strained conditions, do not necessarily show the true paths that the electrons take.

We have already seen, when discussing the electron theory, that even the normal paths pursued by electrons are incredibly complex and we have no experimental evidence of what they do when displaced by an electric field. We do know, however, that electrons are negatively charged, so that, in accordance to the law of like and unlike charges, they must, when influenced by an electric field, be attracted in the general direction of any positively charged body in the vicinity.

The Potential Gradient Concept

The idea of potential gradient is best explained by means of an example. Suppose we have a two plate capacitor in which the plates are an inch apart, and also suppose it is charged with a p.d. of 100 volts between the plates. If we think of the upper plate as positively charged, we can imagine the p.d. decreasing uniformly through the dielectric between the plates, until, at the surface of the lower plate, the p.d. is zero.

According to this idea the fall in p.d. per inch (or unit length) is 100 volts. That is, for this particular case, the potential gradient is 100 volts per inch. If the dielectric had been two inches thick, the

TRY THESE PROBLEMS

The problems below are not exactly practical ones; they aim at making you think; they highlight some of the facts we have learned about electricity. You'll be surprised how basic notions will become clear after you have tackled a few problems similar to the ones below. You will find the solutions on Page 40. It makes little difference whether you look at the solutions now or later — it is more important that you know how the solutions are obtained. All answers were obtained by slide-rule, so may differ slightly from those you get by other methods.

1. How much energy is stored in a capacitor of 10 mfd. when the p.d. across it is 2,000 volts? Use ft. lb. units.
2. If the charged capacitor in (1) is connected across a 5 mfd. capacitor,
   (a) what is the p.d. across both capacitors when the 5 mfd. one is charged?
   (b) How much energy (in ft. lbs.) is lost to the system by the transfer of charge from the 10 mfd. to the 5 mfd. capacitor?
3. A force of 254.4 lbs. is exerted between the plates of a two-plate capacitor using a mica dielectric ($K = 8$), when a p.d. of 10,000 volts exists between its plates. If the area of one plate is 1,000 times the thickness of the mica—
   (a) What is the area of the plates?
   (b) What is the thickness of the mica?
4. A neon lamp just lights when a p.d. of 100 volts exists between its electrodes; if the internal capacitance of the neon is 4 ufd., to what p.d. must a 2 ufd. capacitor be charged so that it will light the neon when discharged through it?
5. From the basic relationship, $C = \frac{K'A}{t}$, it is evident that as t decreases, C increases. When $t = 0$, therefore, C equals infinity, but when $t = 0$, the plates of the that the capacitance is zero. Which is right? Is the capacitance infinite or zero when $t = 0$?
6. Three capacitors, A, B and C, are connected in series and charged. The charge given capacitor B is 500 micro-coulombs. If A is half the capitance of C, and C twice the capitance of B, what is the amount of charge given A and C respectively?
7. What is the TOTAL amount of charge in the case described in 6?

potential gradient would clearly be 100/2 or 50 volts per inch. Now,

$$C = \frac{KA}{4\pi t} = \frac{Q}{E}$$

and

$$Q = CE$$

so that

$$Q = \frac{KAE}{4\pi t}$$

and

$$\frac{Q}{A} = \frac{K}{4\pi} \cdot \frac{E}{t} \qquad \ldots 9.12$$

The ratio E/t is the potential gradient, and denoting this gradient by G we have

$$\frac{Q}{A} = \frac{K}{4\pi} \cdot G = K'G \text{ where } K' = K/4\pi$$

You will doubtless remember too that the ratio Q/A is actually the number of charges per unit area, or charge density D, so that we can finally write,

$$D = K'G \qquad \ldots 9.13$$

and

$$K' = \frac{D}{G} \qquad \ldots 9.14$$

It is clear from Eq. 9.14 that the dielectric constant of any material depends on the density of charges (or electrons) per unit volume. Further, we can see that the potential gradient G is mathematically equivalent to electric field intensity that we considered when dealing with electric fields. This confirms our earlier idea that the electric field, due to the potential gradient, stresses the dielectric and so produces a state of electric strain.

Dielectric Strength

Just as substances cannot be stressed mechanically beyond a certain point without mechanical failure, so non-conductors cannot be stressed electrically beyond certain limits since, beyond these limits, they are either "deformed" permanently or utterly destroyed. The dielectric strength of a non-conductor is its ability to resist electrical forces without suffering permanent deformation. In the same way as a spring, if stretched too far, is permanently deformed, so a non-conductor, if subjected to too great a p.d. between its surfaces, will be deformed permanently in the electrical sense, and may so change in character as to become a conductor.

The dielectric strength of non-conductors is expressed in terms of their ability to withstand a definite potential gradient, G, and is usually expressed in terms of kilo-volts per millimeter of thickness. Thus, mica has a dielectric strength of 150 kilo-volts (150,000) volts per m.m. (A m.m. is a little less than 1/25in). Any tabulated values of dielectric strength must be given considerable latitude because operating temperatures, humidity, duration of stress and previous use will all affect the dielectric strength of any given piece of material. It is extremely difficult to assess the exact dielectric strength of any substance, or predict how long it is likely to last under any particular set of conditions.

Dielectric Resistivity

The resistivity of a non-conductor is a measure of its ability to resist the flow of electric charges. All so-called non-conductors permit the flow of charges to a small degree. The resistivity of a non-conductor is sometimes called its insulating property, although resistivity and insulation are not exactly the same thing. Resistivity means the resistance of the substance per inch or cm. cube of that substance, while insulation implies the general ability of the substance to confine the flow of charges to a definite path.

Whilst all non-conductors are insulators, it must be emphasised that the insulation properties of a non-conductor are only one of its characteristics. Good insulators are not necessarily good dielectrics. Although a substance may adequately resist the flow of charges it may not be able to store adequate amounts of electrical energy; nor may it be able to withstand high potentials without breaking down.

The Choice of Dielectric for Capacitors

Any non-conductor used to separate the plates of a capacitor should have as high a dielectric constant as possible, as this ensures the greatest storage of energy in the smallest space. Its dielectric strength must also be high, because capacitors in service are often required to withstand high potentials and the dielectric used must be able to suffer such high potentials without failure.

The resistivity of the substances must also be as high as possible because otherwise there will be a continuous flow of charge through the dielectric so that the difference in the amount of charges on the plates of the capacitor will decrease. Since the potential difference depends on the difference in the amount of charge on each plate, the p.d. also decreases. Energy stored is converted to heat energy and so lost insofar as electrical

(Continued on page 40)

SIMPLE REFLEX CIRCUITS

Small receiver designs are always popular wih home constructors, and the three practical reflex circuits described here should prove no exception to the rule. Requiring a minimum of parts, each is capable of excellent results and could form the basis for a really efficient mantel or console receiver.

Although reflexing presents more problems than a straight circuit, they can be overcome with little difficulty and by using the principle in a small set, a considerable improvement in performance can be obtained with very little extra complication or expense. In most cases, all that is required is a few shillings worth of resistors and condensers.

Whilst there are quite a number of manufactured receivers which employ some form of reflex circuit to obtain increased performance from a minimum number of valves, very little in the way of practical circuits has been published for the home set builder. Consequently, the following description of three reflex circuits should prove of interest to all experimenters and set builders, since they can provide a much superior performance than obtainable with an equivalent straight receiver.

These circuits were developed after a considerable amount of experiment, and since then sets of each type have been built up and found to perform particularly well with no trace of instability or other troubles. One point to bear in mind at the outset is that the component values as shown are critical, and any departure from these may lead to poor performance and circuit instability.

Main Considerations

The main characteristic of the first two circuits is that the i-f valve serves a dual purpose, acting as both the i-f and a-f amplifier. In one circuit, only a low HT supply is used, requiring a 150v/150v power transformer, and this is particularly suitable for a small mantel receiver. In the second design, a 240/240v power transformer is used, resulting in a greater output and making it suitable for a console cabinet.

The third circuit is particularly novel, and to best knowledge has not previously been described in this country. Although requiring only three valves, it is a superhet. and makes a very successful bedside set.

by
E. B. CLAYTON

In using the i-f pentode for the two purposes—i-f and a-f amplification—it is not possible to utilise the valve's capabilities for both purposes, and consequently a compromise must be made in sacrificing gain in either one or the other of its capacities. If a high a-f gain is desired, then a larger plate load resistor must be used. This means lower plate and screen operating voltages with reduced i-f gain. Conversely, for maximum i-f amplification, high operating voltages and therefore a low plate resistor must be used, with a consequent loss of a-f gain.

I-F Gain Important

As i-f gain is the more important under normal conditions, the latter course has been adopted. With a low plate load, the high plate impedance of the valve becomes relatively unimportant and the value of the external resistance will be the practical deciding factor in calculating the stage gain.

In the first circuit, because of the low HT available the resistor is 10,000 ohms. This gives a stage gain of about 8—little when compared to a pentode's full a-f capabilities, but nevertheless giving a very worthwhile improvement in the place where most needed in a small set.

In the second circuit, the plate resistor is 50,000 ohms, giving a gain of approximately 40 and resulting in a set performance very close to that of a standard 4/5

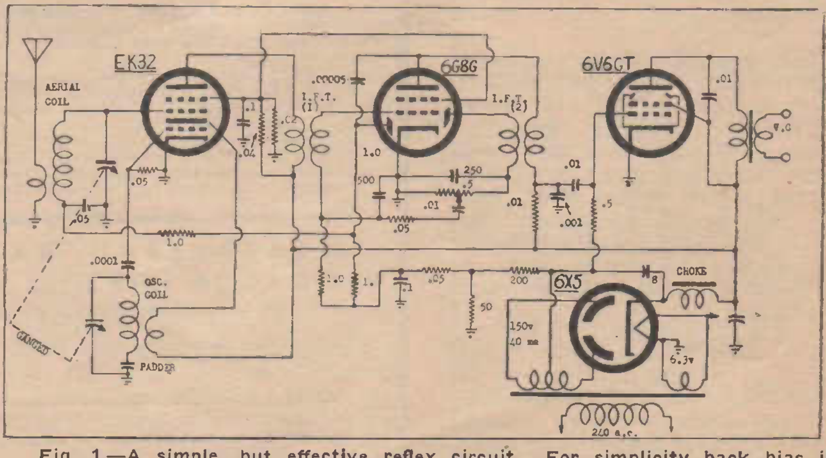


Fig. 1.—A simple, but effective reflex circuit. For simplicity back bias is used, enabling all cathodes to be earthed. As mentioned in the text care should be taken with the placement of the components.

receiver using a 6Q7 or 6B6 as the a-f amplifier. In both circuits very little i-f gain is lost, and since no A.V.C. is applied to this stage, the apparent sensitivity is about the same as a normal stage. The A.V.C. voltage is applied only to the converter, since it is liable to produce unpleasant effects on the grid of the a-f amplifier, but it will be found quite effective and prevents overloading of the reflex stage.

Residual Signal Effect

With regard to the manual volume control, it will be found that on strong stations this may not completely cut off the signal. This fault is common to reflex circuits, and is due to the fact that the pentode section still acts as an inefficient detector, thus passing some audio signal even though the diode output is cut right off.

In the first circuit, no remedy has been provided for this. The low plate resistor almost eliminates the defect, and as the strongest station is only a faint whisper with the volume control off, the effect is of no consequence. In the second circuit, feedback is applied from the 6G8G plate circuit to the bottom of the volume control, and this completely neutralises this residual signal effect.

General Circuit Details

Taking the circuits in turn, a short description of each will now be given. In the case of circuit No. 1 it will be seen that the valve line-up is EK32, 6G8G, 6V6GT with a 6X5 rectifier. The EK32 is used because its low screen voltage requirements makes it suitable for use with a common screen supply with the 6G8G. Also the lower HT voltage can be applied to the oscillator anode without the added complication of dropping resistor and bypass condenser.

Back bias is used for simplicity and this is used also to provide a delay voltage to the AVC diode fed from the 6G8G plate. Note that although the 6G8G grid is biassed from the same supply, it is connected short of the A.V.C. line. The three mica condensers in this stage—in the grid, plate and detector sections—all provide earth returns for the i-f current and should not on any account be left out.

The same remark applies to the .05 meg. resistor in the lead to the moving arm of the volume control and which carries the reflexed audio signal. This is to prevent i-f feedback along the line, and if it is left out uncontrollable oscilla-

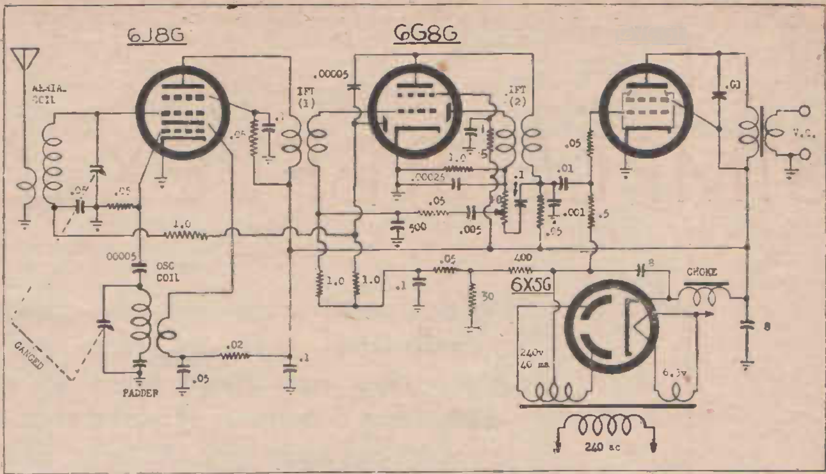


Fig. 2.—This circuit differs only slightly from that in Fig 1. The higher power transformer rating now requires the addition of the oscillator plate dropping resistor.

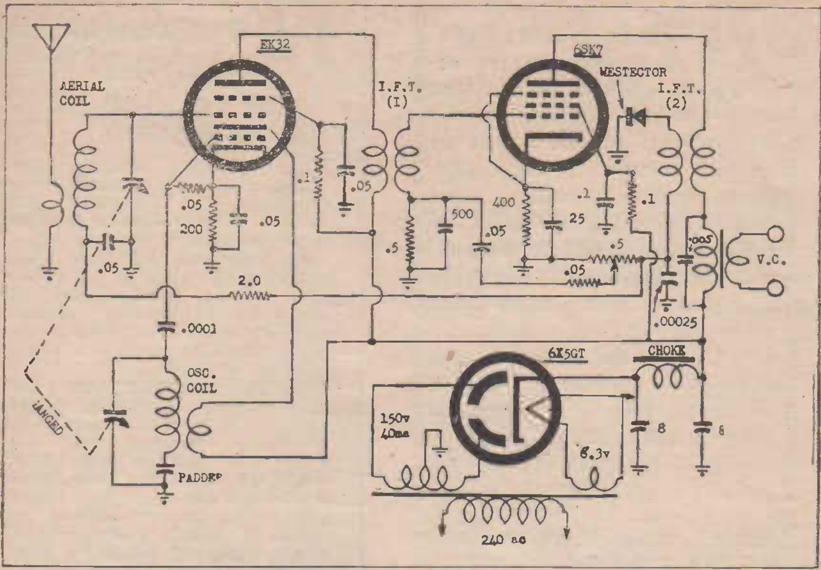


Fig. 3.—This is probably the simplest three-valve superhet. circuit devised. A Westector metal rectifier is used, and the 6SK7 provides sufficient output to drive the speaker. For local listening this would make an excellent "second" receiver for the home.

tion will occur. The output stage is conventional and needs no comment, except to point out if any other valve is used in place of the 6V6GT, different values for the bias resistor must be calculated.

With the exception of the electrolytic condensers, the condensers can be all 200 volt working. The two screen resistors should be 1 watt and the two bias resistors 2 watt, but all the others can be the ½ watt type. Standard aerial, oscillator and IFT's are used, and if these are of the iron cored types the results will naturally be much better. All plate leads to the IFT's should be kept short, and if the "hot" leads to the volume control are longer than a couple of inches, they should be shielded. The 6G8G will also require a shield, otherwise instability will result.

Set No. 2.—The 6J8G converter is used in this circuit, which, if desired, could be easily wired up as a dual wave receiver. For broadcast reception only, a 6A8G can be substituted if it is on hand, but in any case both the converter and i-f amplifier valves will need to be shielded.

For the remainder of the circuit, it is very similar to set No. 1 and the earlier remarks apply. As it is more sensitive, extra care should be taken with short leads and the shielding. A point to remember is that the bottom lead to the volume control is also "hot," and should be shielded. Although a tone control has not been shown this can be easily wired in if required.

All condensers are 400 volt working, whilst the two screens resistors, the oscillator anode resistors and the 6G8G plate resistor should all be one watt, and the bias resistors should be 3 watt. The remainder can be ½ watt. A 6X5GT rectifier is shown, but if you have a 5 volt winding on your power transformer, then a 5Y3GT can be used equally as well.

Set No. 3.—This is of a novel design utilising an EK32 converter, a 6SK7 as combined i-f amplifier and output valve, and a metal rectifier as the detecter (Westector). It has the sensitivity and selectivity of a superhet., and will be found a considerable improvement over the limitations of the ordinary reaction type two valve receiver.

Whilst the output from the 6SK7 is not comparable to a 6V6, it will be found ample for bedside or kitchen listening. Since the set is sensitive enough to give ample pick-up with a couple of feet of wire as an aerial, it can be moved easily from room to room. Using midget coils and tuning gang, it can be built into the smallest of the mantel cabinets, and makes a very efficient "second" set.

The circuit setup is similar to the other two designs, minus the output stage, but incorporating a metal detector. If size is not important a 6K7 or a 6U7 can be substituted without circuit changes for the 6SK7. An EK32 converter is used for simplicity, but a 6SA7 could replace it by using the correct type of oscillator coil and making the necessary changes in the screen resistor.

6SK7 Overbiassed

The 6SK7 is slightly overbiassed to reduce audio overloading and feeds into a high impedance output transformer—which should be at least 20,000 ohms, or higher if you can get one, owing to the valve's high plate impedance. A.V.C. is applied to the EK32 from the Westector, and this will normally prevent overloading of the 6SK7. If a long aerial is used, however, distortion may occur on strong signals, with the volume control turned right up. Consequently, the shortest aerial consistent with good results should be used, but in most cases sufficient volume will be available long before any overloading occurs.

The previous remarks concerning the construction and wiring up also apply to this receiver. The two screen and the 6SK7 cathode resistors should be 1 watt — the others can be ½ watt. All condensers can be 200 volt working.

In conclusion, these sets may be considered as a step in the experimenter's search for "something for nothing," although at the same time they will be found quite reliable and stable in operation. They are no more difficult to make up than a straight circuit except, perhaps, a little more care is necessary in the reflex stage wiring, but the results will more than justify the extra time spent on this.

CIRCUITS WANTED

Have you constructed or designed any unusual circuits that would be of interest to our readers? If so, we would be pleased to hear of your experiences. Just send along a short description of the equipment, together with a circuit diagram and photographs (if you have any) and we will publish those which we consider would have a wide reader interest. All material accepted will, of course, be paid for at our usual rates on publication.

Modern Amateur Transmission Techniques

In this article the author continues with the discussion of frequency control in the transmitter and details suitable oscillator circuits to achieve best results.

The previous article in this series detailed the various types of crystal oscillators which are in use to-day, and mention was made of the fact that immediately prior to the last war it was a matter of some pride to be able to state that one's station was crystal controlled.

In the period immediately following the war, however, there has been a definite trend towards the more extensive use of stable variable frequency oscillators as a means of frequency control. This has been partly due to the fact that during the war years many operators became accustomed to the use of equipment which could easily be shifted in frequency, and partly to the fact that it is now possible to obtain suitable components at much more reasonable prices than before. Another governing factor, no doubt, has been the necessity for the flexibility of operation, brought about, as stated last month, by the crowded conditions at present evident on our bands.

Basic Requirements

The first requirement of any self-excited oscillator used for frequency control purposes is that it must be most stable under all conditions of load and supply voltage. With modern receivers and their high inherent selectivity, it is not possible to tolerate any drift, or tendency towards frequency modulation of the carrier. As a result, it is necessary to employ some

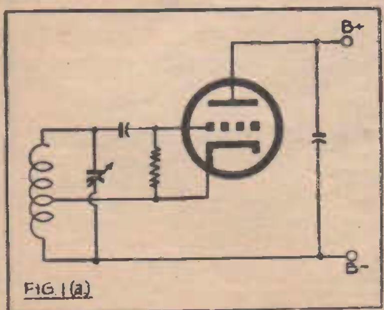


Fig. 1 (a).—A series feed Hartley circuit. See analogy in the EC oscillator.

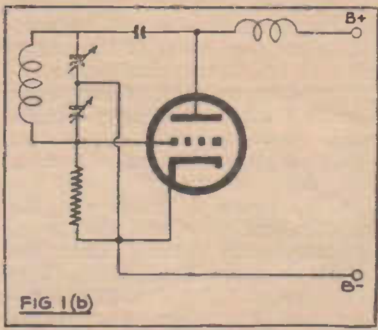


Fig. 1 (b).—The Colpitts oscillator circuit. This is similar to the Clapp oscillator described in the text.

form of oscillator circuit which exhibits these characteristics of stability, its power output being quite a secondary consideration.

In any type of oscillator, the oscillion is maintained by virtue of the fact that the amplification afforded by the tube allows the losses inherent in the tuned circuit to be overcome, the energy required to do so being drawn from

By
ALAN WALLACE

the power supply. There must be some feedback path from the output circuit back to the input circuit, and this feedback can be applied in various ways, as for instance, inductively, in the series fed Hartley oscillator (Figure 1a), or through the grid to plate capacity of the tube, as in the tuned anode tuned grid circuit (Figure 1c).

It follows that, in order to maintain oscillation, the phase relationships in the circuit must be such as to allow this feedback voltage to have some component in phase with the existing voltage in the grid circuit. In order for this to occur, any oscillator must function at a frequency slightly different to the resonant frequency of the circuit involved, but nevertheless, its frequency of oscillation will be determined largely by the circuit possessing the highest Q, normally the grid circuit.

It may be proved mathematically that the higher the Q of a tuned circuit, then the smaller need be this difference frequency (which is affected by changes in such factors as tube loading, etc.) and hence the more stable will be the oscillator. Therefore, our aim, if maximum stability is to be achieved, is to obtain as high a Q as possible in the oscillator circuit.

This is in keeping with the general desirability of having a low L/C ratio in the oscillator tuned circuit, in order that small changes in circuit capacitance will have a negligible effect on the output frequency. For this reason, most satisfactory results are normally obtained with an oscillator which has quite a low fundamental frequency, often in the 1,750 Kcs. band.

The frequency oscillation selected will be determined largely by the desired output frequency, and the complexity of the transmitter which is being used or designed. As a general rule, it is preferable to use as low a frequency as possible for the VFO, and obtain the desired output frequency by the use of a series of multiplier stages. However, in normal practice, quite good stability can be obtained using a fundamental frequency of

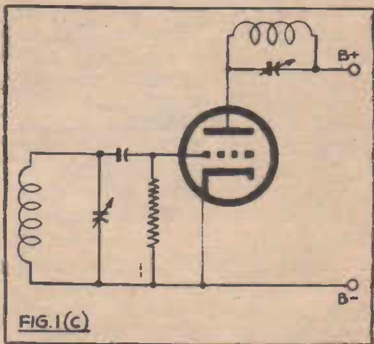


Fig. 1 (c).—The tuned plate/ tuned grid circuit has been widely used by many operators.

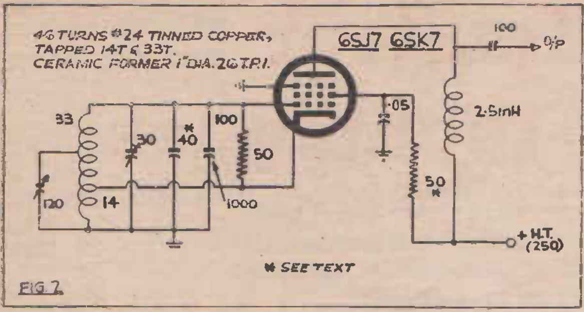


Fig. 2.—A practical electron - coupled oscillator circuit.

3.5 Mcs., although where extreme simplicity is desired, and 80 meter operation is not required, it is possible, providing the stage is carefully designed, to obtain satisfactory results using an oscillator frequency of 7 Mcs., particularly when using the Clapp oscillator circuit to be described later.

E.C. Oscillator

A very popular oscillator, however, is the familiar electron coupled oscillator which, when used with a properly designed tuning circuit (see "Radio Science," Vol 1, No. 10 and Vol. 2, No. 1), is capable of quite good stability, and is normally free from serious shifts in frequency due to small changes in either load or supply potential. We shall deal firstly with this oscillator before proceeding to a more lengthy discussion on the virtues of the Clapp oscillator.

A principle advantage with this electron coupled circuit is that by proper proportioning of the ratio of screen grid to anode potential (usually found to be at an optimum at 3:1), it is possible to obtain almost complete freedom from the effects of supply voltage variation.

The constants shown in the circuit of Figure 2 are for a fundamental frequency of 3.5 Mcs., but as has been mentioned in previous treatments on this oscillator, it is often desirable to adjust the position of the cathode tap for the best stability and freedom from the effects of drift. These two properties are very much interrelated, as will be appreciated when one considers that drift is only caused by the changes in circuit and tube capacities due to heating of the components, and if the oscillator permits only small changes in these constants, then quite good freedom from drift will be experienced.

It should be noted at this juncture that any form of variable frequency oscillator should be followed by an isolating stage, preferably with an untuned anode circuit. By this means, any interaction between the tuning controls of succeeding stages, and that of the variable frequency oscillator, may be eliminated, as well as minimising the possibility of the occurrence of frequency modulation.

Of recent months, there have been two other oscillator circuits which have achieved a certain degree of popularity, as well as a good deal of attention on the technical press. These are the Franklin oscillator and the Clapp oscillator, each named after the gentlemen associated with their development. The Franklin oscillator has no unique advantages which cannot also be claimed by the exponents of the Clapp oscillator, and as this latter arrangement has the advantage of a greater degree of simplicity, we shall only deal with this circuit, particularly as it is intended to incorporate it in some projected transmitters for future issues.

The Clapp Oscillator

The Clapp oscillator, shown in Figure 3 ,utilises a rather unusual arrangement whereby the input impedance and capacity of the oscillator tube are only connected across a small portion of the tuned circuit. In a normal oscillator circuit, of which Figure 2 may be taken as being typical, it will be noticed that the valve input capa-

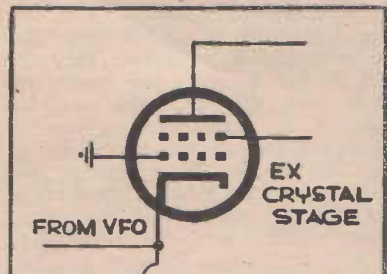


Fig. 3 (b).—This cathode driven stage prevents parasitic oscillation, since the control grid acts as an electrostatic shield between the input and output circuits.

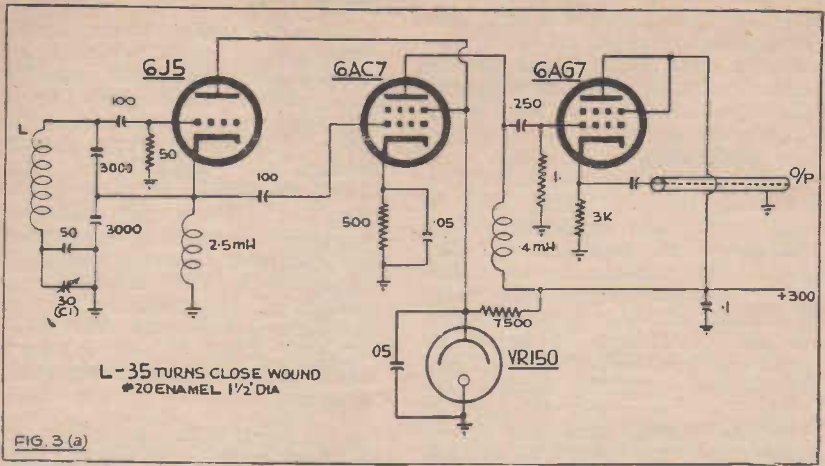


Fig. 3 (a)—The Clapp oscillator circuit which is now achieving a measure of popularity in overseas circuits.

cities are shunted directly across the tuned circuit. This means that the circuit is quite heavily loaded and hence requires a very low L/C ratio to be employed if the effective Q of the circuit is to be kept high and good stability obtained. Moreover, owing to direct connection, any variations which take place in the values of the various interelectrode capacities will cause appreciable variations in the output frequency of the oscillator.

However, in the Clapp oscillator, the tuned circuit is actually a series tuned arrangement, the actual variation in frequency being accomplished by the variation of C1 in Figure 3. Since the reactance of this condenser is much higher, at the operating frequency, than that of either of the two "divider" capacitors, it will be seen that a variation of even 20 uufd. in the capacity of one of these two large condensers will produce a negligible effect on the output frequency.

Therefore, since the valve capacities are shunted across one of these large capacitors, which has a capacitance out of all proportion to the order of capacitance of the input admittance of the tube, any variations in this latter quantity which may take place will produce a negligible effect on the tuned circuit. This will therefore eliminate not only drift during the warming-up period, but will also greatly improve the stability of the oscillator against the effects produced by changes in the supply potentialities to the tube.

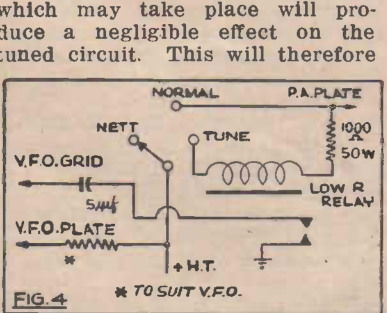


Fig. 4.—This circuit permits "netting" and tuning operations to be carried out without causing interference to the transmissions.

Higher "Q" Possible

Furthermore, since the input impedance of the tube is shunted across only portion of the tuned circuit, it is now possible to achieve a much higher Q in the tuned circuit, resulting in still further improvement in the stability of the oscillator. In practice, however, it will be found essential to employ an oscillator coil having the highest possible Q, since the tube is only connected across portion of the tuned circuit and the magnitude of the voltage applied is greatly reduced. If the efficiency of the coil is too low, then the voltage developed across it will not be high enough to provide the proper degree of feedback to maintain oscillation.

It has been found in practice that this circuit will key quite well at moderate speeds, and hence, providing proper biassing facilities are incorporated in the following stages, the transmitter may be keyed from the oscillator stage, thus providing break-in operation. In this regard, however, due care must be taken, as will be mentioned later in this series, to protect the receiver during transmission periods.

Exponents of this particular form of oscillator circuit claim, with some justification, that it represents the most stable form of L/C oscillator yet constructed, and it would seem to present some possibilities for use on the VHF bands. However, investigations are being made in this direction, and although the principle difficulty appears to be the rather poor Q of conventional circuits at frequencies above 50 Mcs., it is hoped to develop from this circuit a stable controlling oscillator for use on the 144 Mcs. band.

The circuit constants shown in Figure 3 apply for a fundamental frequency of 3.5 Mcs., and it will normally be found with the buffer or isolator stage shown, that the unit has sufficient output to drive a conventional crystal oscillator stage, used as a doubler. Since the stability of the oscillator under power supply voltage variations is quite good no regulation is provided, and only under exceptional circumstances, where the utmost of stability under abnormal voltage variations is required, will it be found to be necessary.

One feature which is very desirable when any new transmitter is being designed is provision for the operation of "netting," or, in other words, the facility to tune the transmitter exactly onto the frequency of the received station without radiating any signal, which would obviously cause interference. This facility is best provided by the incorporation of some switching device such as to allow normal operation of the VFO, without HT being applied to the final amplifier, and at the same time permit operation of the receiver. It should be borne in mind that, during this operation, the VFO connection to the transmitter should be made as normally to avoid any shift in frequency of the VFO due to a change in its loading.

Useful Circuit

A useful connection in this regard is that shown in Figure 4, and this permits the transmitter first to be "netted" to the desired frequency, and then, by switching to the "tune" position, to be tuned up without causing any interference to transmissions which are already in progress. This is made possible by the contact on the switch which, when bringing into circuit the dropping resistor to

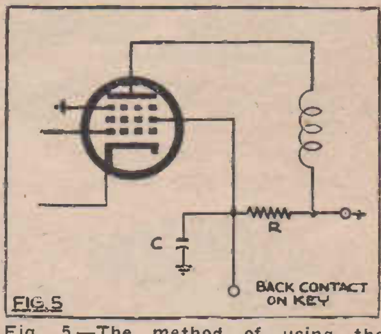


Fig. 5.—The method of using the "back" contact on the key to earth the screen circuit.

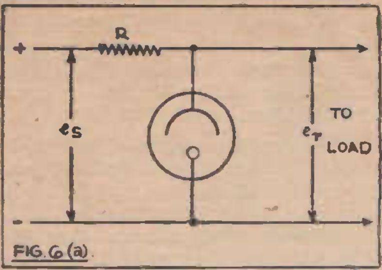


Fig. 6 (a).—A typical VR tube circuit.

allow safe tuning of the final, also brings into circuit a small, low resistance relay. Being operated by the final plate current, this closes and adds an additional 5 uufd. to the VFO tuning capacity, thus shifting the radiated frequency by about 10 Kcs. Consequently, providing this channel is not also in use, complete tuning may be accomplished, and when desired, immediate transmission may take place on the set frequency.

When it is desired to incorporate a "listening through" facility in the station, as is often very advantageous, permitting as it does immediate breaking of the transmission should any QRM be encountered, it is necessary to ensure that the oscillator is inoperative during the key-up period. This can be accomplished in three way. Firstly, the oscillator itself may be attached to the keying line in such a way that it's circuit is only completed on depression of the key. This system, however, has several disadvantages; the most important of which is its liability to the production of key-clicks and keying "chirps," particularly at higher operating speeds, although of course this disability is of little consequence for phone operation, providing reasonable care is taken.

Second Method

A second method is to completely enclose the oscillator stage, and its associate amplifier, in a completely shielded metal box, and key only the isolator stage. This prevents the radiation of any undesired signal from the oscillator, whilst at the same time removes any effects of the keying circuit from the frequency controlling stage.

This latter system is probably the most effective, for this reason, but it may not always be convenient to install such an elaborate system, particularly if the transmitter be of the more modest type, and in such an event, the arrangement shown in Figure 5 may be found useful. In this circuit, requiring the use of a double-contact key, a type which is in common use to-day, the "back" contact of the key is employed to "earth" the oscillator screen, thus preventing its operation.

Provided the circuit constants are selected accordingly, it will be found that the brief interval of time between the breaking of this contact and the making of the front contact is sufficient for the screen by-pass condenser to charge up and allow normal operation of the oscillator with no sign of any undesired effects. It will be realised, however, that the maximum speed of operation which can be undertaken when this system is in use is limited to about 20 wpm, as at higher speeds the time constant of the RC network becomes impracticably short, resulting in either insufficient screen by-passing or an excessive dissipation through the screen resistor during "key-up" conditions.

Voltage Regulation

One further point remains in this discussion of practical oscillator circuits, and that is the question of regulation. Since the power requirements of even a medium-power transmitter vary greatly between the "key-up" and "key-down" conditions, or under modulation, it is not usually advisable to attempt operation of the controlling oscillator from the same HT supply as the final amplifier, unless special regualting devices are employed to ensure that the voltage applied to the oscillator stage does not vary by too great an amount.

An exception to this rule may be found in the application of the previously described Clapp oscillator, but even in this instance too much reliance should not be placed on the characteristics of the circuit if the excursions of voltage to be expected are more than 50 volts or so, in normal operation. The best means of regulating the supply to any critical circuit such as an oscillator is undoubtedly the employment of one of the gaseous voltage regulators of the VR series, or their Continental counterparts.

(Continued on page 40)

W.A.Z. Boundaries

We R-gret . . .

It has been brought to our notice that the article W.A.Z. BOUNDARIES, which appeared on pages 39 and 46, "RADIO SCIENCE," March, 1949, is identical with one which is presented under the same title in "RADIO AMATEUR STATION LOG," published by the Mingay Publishing Company Pty. Ltd., 146 Foveaux Street, Sydney, and originally compiled by the staff of that company as a feature of the "Log Book."

In these circumstances, our re-publication of the article constitutes a breach of copyright, which is regretted, and due apologies are hereby made to the Mingay Publishing Company for the misuse of its material. In extenuation, we can only say that the article was submitted to, and accepted by, "RADIO SCIENCE" in all good faith as being an original contribution.

With the object of avoiding a similar occurrence in the future, we must stress to all intending contributors that articles submitted for publication in our magazine must be of an original nature and not previously published in any other journal.

SHORT WAVE LISTENER

Swiss Broadcasting Service

From Ken Boord (R. & T. News, U.S.A.) comes the following interesting information concerning the Swiss Broadcasting Corporation stations:—

"The Swiss Broadcasting Corporation maintains seven stations —in Basel, Berne, Zurich, Geneva, Lausanne, Lugano, and those of the short-wave service, also in Berne. All radio transmitter are being operated by the Federal Adminstration of Post, Telegraph and Telephone exclusively.

The centre of Swiss short-wave transmitters is Schwarzenburg, a prosperous village in the Canton of Berne. They are used both for overseas telephone service and for broadcasting. Schwarzenburg has eight short-wave transmitters, with powers ranging from 10 to 100 kw. For overseas service, rhombic antennas are being used, and for the European Service, circular dipoles are employed. Schwarzenburg is located some twenty miles south of Berne, capital of Switzerland, and works together with the receiving stations of Chatonnaye, in the Canton of Fribourg.

POLAND

We are indebted to two English correspondents to "Sweden Calling Dx'ers" for news of English transmission from Radio Polskie, in Warsaw. Programmes are given over the 9530 kc. channel daily except Thursdays and Sundays at 9.30 a.m. till 9.50 a m. The 6215 kc. channel is used on Thursday, Saturdays and Sundays (S.DX).

FRENCH INDO-CHINA

The station operating on 7205 kcs. for some time has been puzzling short-wave listeners as to its origin. It has at last been identified as "Radio Hue," at Hue, Annam, and it transmits three daily programmes from 9 a.m. till 11 a.m., 1 p.m. till 4 p.m., and 9 p.m. till 1.30 a.m. Australian Eastern Time.

Radio Hue relays programmes from Saigon at certain hours, and this created the impression that the transmissions were from a new outlet of Radio Saigon. The address to which reports should be sent is: Radio Hue, Boite Postal 65, Hue, Annam, French Indo-China.

Both Norway and Sweden are broadcasting very good programmes over several transmitters operating in 19.25 and 31 metre bands. These programmes are primarily for nationals abroad and for listeners in Sth. America, while Radio Sweden is heard on two frequencies, namely 15.155 kcs. and 10.780 kcs. with a very interesting DX session and answers to listeners' letters.

GERMANY

A "Voice of America" transmitter operating on a frequency of 15.280 kcs. comes on the air at 11.45 p.m. with the announcement that "this is the American station in Europe, and we are now signing on our transmitter on 15.28 mcs. News then follows in Russian. This station is believed to be Munich, with a power of 100 kilowatts. (R.A.).

Station Addresses

Addresses of Central American countries, stations of which are heard at good signal strength:—

COSTA RICA (TIPG)—La Voz de la Victor, Apartado 257, San Jose, Costa Rica.

CUBA (COBC)—Radio Progresso, San Jose 104, Havana.
(COKG)—Cadena Oriental de Radio, Apartado 82, Santiago de Cuba.

DOMINICAN REPUBLIC (HI2T)—Estacion de Onda Laiga HI3T, Apartado 23, Cuidad Trujilio, D.R.

GUATEMALA (TGWA) — Radio Nacional, La Voz de Guatemala, Cuidad de Guatemala.

HAITI (HH3W)—Rue Boun Fer, Box A117, Port-au-Prince, Haiti.

BRITISH WEST INDIES (ZQI)—The Government Broadcasting Station, 3 Seaview Avenue, Half Way Tree, Kingston, Jamaica.

MARTINIQUE (FNRI)— La Directeur du Service d'Information, Fort-de-France, Martinique, French West Indies.

MEXICO (XEWW)—La Voz de la America Latina Desde Mexico, Cadena Radiodifusora Mexicana S.A., Calle Ayuntamiento Nr. 54, Mexico, D.F.
(XEBT) — Las Emisoras de America, Calle Buen Tono Nr. 6, Mexico, D.F.
(XEQQ) — Radio Panamericana XEQQ, Jose Maria Marroqui No. 11, Mexico, D.F.
(XEHH)—Sal de Uvas Picot, Zempola, No. 77, Mexico, D.F.
(XERQ)—Radio Continental Corporation Mexicana de Radios ss Cordoba No. 48, Mexico, D.F.

TRINIDAD—Trinidad Broadcasting Co. Ltd., Broadcasting House, Port of Spain, Trinidad.

PANAMA (HP5K)—La Voz de la Victor, Apartado 33, Colon, Panama.

GOLD COAST

Station ZOY, located in Accra, African Gold Coast, is heard with quite a fair signal in programmes of news and music from 1 a.m. until 4 a.m. B.B.C. programmes are often used in relay and the frequencies are 4915 kcs. and 7300 kcs.

NEW STATION LOGGINGS

Callsign	Kcs.	Metres	Location	Time heard
MUNICH	15.280	19.53	Germany	11.14 p.m.
HCIAC	6.210	48.31	Ecuador	10.00 p.m.
YVKM	5030	59.64	Venezuela	9.00 p.m.
LRS	9310	32.21	Argentina	8.45 a.m.
LLH	9645	31.10	Norway	9.00 a.m.
CKOB	6090	49.26	Canada	8.00 a.m.
OAX4W	9375	32.00	Peru	3.00 p.m.

Listen For These Stations

PERSIA

A station from this country is heard now carrying out an early morning programme. Its call-sign is "Radio Tabriz," operating on a frequency of 6090 kcs., and according to the World Radio Handbook has daily programmes in Persian, Arabic, French, Russian and English. Operating times are given as 1 a.m. until 4 a.m., and signs off at 2.30 p.m. with a clock chiming eight. (R.A.).

This station is one of the regional broadcasting stations in Iran, and is situated in the province of Azerbajan.

NORWAY

Very good programmes have been heard over the last three months from several transmitters operating in 13, 16, 19, 25 and 41 metre bands. Now Radio Norway has a new transmission for listeners in South America over LLH, 9645 kcs.; LKQ 11735 kcs., and LKV, 15170 kcs. at times of 9 a.m. till 10 a.m.

According to Ken Boord, of Radio and Television News, U.S.A., they now use a new and beautiful tuning signal. Power used in these transmissions: LKQ, 11735 kcs., 100 kw.; LLH, 9645 kcs., 50 kw.; and LKV, 15170 kcs., 10 kw.

BELGIAN CONGO

Programmes in French, Flemish and Portuguese are heard over several transmitters operating for listeners in the Belgian Congo. Details are given of stations, frequencies and times as follows:—OTM1 on 6295 kcs.; power, 3 kw.; from 3 p.m. till 5 p.m. and 8 p.m. till 10 p.m., 2 a.m. till 6 a.m. OTM2 on 9380 kcs.; power, 7.5 kw.; from 3 p.m. till 5 p.m. and 2 a.m. till 6 a.m. OTM4 on 11720 kcs.; power, 7.5 kw.; from 8.15 p.m. till 10 p.m. OTH on 9210 kcs., with a power of 15 kw., from 3.30 a.m. till 4.30 a.m.

Address for reports is given as follows: Box 171, Leo Kalina, Congo Belge. (R.A.).

PORTUGAL

Emissora Nacional on 15160 kcs. now transmits a special daily programme from 1.30 a.m. until 3 a.m. to Goa, in Portuguese India. (R.A.).

BULGARIA

Signals from this country are also good when heard in the various language broadcasts over the frequency of 7670 mcs. and Radio Sofia, given news in German at 7.15 a.m., followed at 7.30 a.m. with French, and English at 7.45 a.m. All times mentioned are in Australian Eastern Time (A).

BECHUANALAND

ZNB, 5900 kcs., from Mafeking, was recently logged for the first time since the war. Identification announcement is: "ZNB at Mafeking calling," and the schedule is as follows: Week-days, 9 p.m. till 10 p.m., 3 a.m. till 5.30 a.m.; Sundays at 4 a.m. until 5a.m. (R.A.).

PANAMA

Stations from this country are heard with very good signals on opening, usually at 9.30 p.m. and HOLC, Radio Balboa, on 6060 kcs., is no exception, when it opens with Spanish news and music. (R.A.).

Readers' Reports

Readers desirous of submitting Short Wave reports for inclusion in these notes should ensure they reach our Short Wave Correspondent not later than the first of each month. Address all letters to: Miss D. Sanderson, 23 Elizabeth Street, Malvern, SE4, Victoria.

MADAGASCAR

By courtesy of Sweden DX'ers calling we have an item of interest on FIQA, operating on a frequency of 6060 kcs., at 6 a.m. Mondays to Thursdays, and closing at 5 a.m. on Fridays. Another transmitter on 7380 kcs. is heard in parallel, and these stations provide the best entertainment to listeners in South Africa, according to one of their correspondents.

MONACO

Some reference was made to the transmitter operating from Monte Carlo, and details were given as to its frequencies. We now have official information as to operating times and frequencies of the two transmitters. They are 4 p.m. till 6 p.m., 9 p.m. till 11 p.m., and 4 a.m. till 8.15 a.m. on 9785 kcs. and 7350 kcs., also 6035 kcs., with a power of 25 kilowatts each.

HUNGARY

Rex Gillett, of Adelaide, S.A., reports that Radio Budapest has sent on a letter of verification, together with three photographs, and the station stated that this report was the first received from Australia. As before mentioned, the transmissions are of an experimental character, and the programmes are heard from 11 p.m. until 8.40 a.m. A.E.T. relaying the medium wave stations, Radio Kossmuth and Radio Peton.

A ten-minute English bulletin of news is given daily at 8.20 a.m., and reports from listeners are welcomed, the address being: L. Barta, Head of the International Relations Department, Hungarian Broadcasting Corporation, Budapest, Hungary.

INDIA

Radio Pakistan has now changed the times of English language broadcasts. They are now presented at 12 noon, 4.10 p.m. and 12.45 a.m. over the 15.270 megacycle and medium wave outlets. Times are A.E.T. (R.A.).

ISRAEL

We made mention in a previous issue of short wave stations operating from the State of Israel, and news is to hand of a new transmitter operating in the 25 metre band on frequencies of 11.620 and 11.840 megacycles. Broadcasts have been irregular, but usually during normal broadcasting hours.

The current schedule of the transmitter operating in the 43 metre band on 6835 mcs. is from 1.45 p.m. till 4 p.m., 6 p.m. till 9.45 p.m., and 11.30 p.m. until 6 a.m. Australian Eastern Time. Call-sign of this station is Radio KOL-Y Israel, and English news is given at 9 p.m. and 5 a.m. daily. (R.A.).

TANGIER

Radio International operates on a frequency of 6200 kcs. and opens with an English programme at 9 p.m., has Spanish at 9.30 p.m., French at 10.15 p.m. A request programme at 11 p.m. till 2 a.m. in French and Spanish; Spanish programme at 5 a.m.; French at 5.30 a.m., and Spanish at 7 a.m.; then a cabaret programme till close down at 9.30 a.m. (Batten.).

ON THE BROADCAST BAND

NEW ZEALAND STATIONS

Stations in the Dominion of New Zealand are now being heard in this country at good strength. Here is the latest news of these stations together with suggested listening times so as to avoid interference from other stations sharing the same channel.

Reception of stations operating from the Dominion of New Zealand is as good at the present time as it is at any other period during the year. Signals come through at fine level around 5 a.m., while at night many stations are audible at good volume, although the presence of so many Australian stations prevents the clear reception of some transmitters heard during the morning.

Many National stations, namely 2YA, Wellington, 570k.c., 3YA, Christchurch, 690k.c., 1YA, Aukland, 750k.c., and 4YA, Dunedin, 780k.c., commence transmissions at 4 a.m. (6 a.m. in N.Z.) with their breakfast session, including recordings, station announcements, etc., with relays of news from the B.B.C., London, at 4, 5, and 6 a.m.

Stations carrying programmes of the National Commercial Broadcasting Service (accepting advertisements)—2ZB Wellington, 980k.c., 4ZB, Dunedin, 1040k.c., 1ZB, Auckland, 1070 k.c., and 3ZB, Christchurch, 1100k.c. —begin transmission at the same hour—6 a.m.—while N.C.B.S. station, 2ZA, Palmerston North, 940k.c., takes the air one hour later.

National stations taking the air at 5 a.m. with the B.B.C. news followed by recorded music include 4YZ, Invercargill, 720k.c., 1YZ, Rotorua (only opened in the last few months), 860 k.c., 2YZ, Napier, 860k.c., 3YZ, Greymouth, 920k.c., 3XC, Timaru, 1160k.c., another comparatively new station. This is unusual compared to others in N.Z., since it carries sponsored programmes up till 5.30 p.m. (AEST), then broadcasts National type features. Most other stations in New Zealand do not take the air until much later in the day and in some cases not until the evening.

Main Listening Times

Around sunset is generally a good time to listen for some of the stations not so easily tuned in at night, owing to interference from local stations. At this time, N.Z. stations begin breaking through, and some elusive signals may be heard before a local station takes the air or begins coming through on a particular channel. At night, however, it is possible at our listening post to tune 2YA quite easily, whilst 1YZ and 2YC (Wellington, 650k.c.) come through fairly well over interference from 6WN and 2BH respectively. 1YD, Auckland, 1250k.c., is quite fair at times.

Other New Zealand stations on the air at night, which some may be able to hear, include 1YC, Auckland, 880 k.c. (under 4WK, 3UL and 6PR, of course), 2YD, Wellington, 1130k.c. (under 2AD, 3CS and 6PM), 2XP, New Plymouth, 1370k.c., opens 6 p.m. (under 2MO, 5SE and 6GE), 2XN, Nelson, 1340k.c. (under 2LF and 6TZ), 2XG, Gisborne, 1010k.c. (under 7EX, 4MB and 4CA), 3YC, Christchurch, 960k.c. (under 3BO and 4AY), 4YC, Dunedin, 900k.c. (under 2LM and 7AD).

Most stations in this group leave the air at 8 or 8.30 p.m., EST, while the N.Z. "Listener" points out that 2XG, 2XN and 2YD open as late as 5 p.m., and the main Nationals sign or at 9.20 p.m.

by
ROY HALLETT

"The World To-day" Session

A presentation heard from 2SM on Wednesday evenings at 7.45, frequently contains news items of interest to readers of this page. Featuring talks, interviews and music recorded on wire by 2SM news editor, and former journalist, Tom Jacobs, items from studios of broadcasting companies in several Asiatic countries have so far been broadcast in this session, "The World To-day."

At the studios of "Radio Malaya," in Kuala Lumpur, Mr. Jacobs watched a variety show being rehearsed, whilst at the same time every entrance to the city was heavily guarded against attack by members of the rebel group at present operating in Malaya. Other items presented were those recorded at this organisation's studios, 250 miles from the Malay capital in Singapore.

The second programme in this series featured recordings made at the studios of "All India Radio," in the heart of Delhi. The familiar AIR identification signal was heard, and Mr. Jacobs described the studio installations as well as the general construction and equipment in use as being first-class.

Readers' Reports

One of our younger readers, Mr. R. E. Small, Eastwood, is particularly pleased with results he is getting from his four-valve superhet. Working with an aerial 70 feet in length, and using a 6J8 converter, 6G8G second detector, I.F. amplifier and reflexed a-f amplifier, 6V6GT power amplifier and a 6X5GT rectifier, this set is bringing in many of the weaker signals from overseas as well as, of course, the stronger ones.

By way of testing his set, our friend tuned to 2GB (870k.c.) near closing time, and turning the volume up following the close down of this station, was delighted to hear an American voice giving the news from WVTR, Tokyo. The "Voice of America," calling from Manilla, 920 k.c., in the Phillippines, is also heard consistently, relaying the usual programmes from New York.

All India Radio's outlet on 758k.c., operating from Tiruchy, is another good one, several other Indians being heard at weaker level, while the old reliable JOAK, Tokyo, comes through well on 570k.c. at 11 p.m.

This reader is anxious to hear from other readers using small sets, and suggests that his efforts may prove encouraging for owners of receivers of this type. We most certainly agree with this suggestion, and look forward to hearing also from other readers telling of their experiences, not forgetting, of course, the reports we also look forward to receiving from users of larger receivers.

5DN Celebrates Anniversary

On Saturday night, June 18th, a special variety programme was broadcast over Macquarie Network stations throughout Australia in celebration of the official opening of the new Radio Centre in Churchill Building, Gawler Place, Adelaide, installed by the "First Station in the State," 5DN, to commemorate its 25th year on the air. Many readers owning QSL cards from this station will need no reminder of this achievement, as most cards bear the phrase, "Established in 1924."

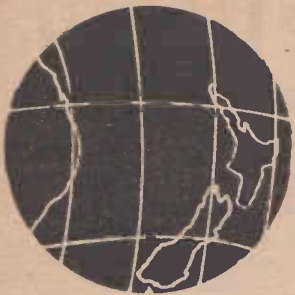
Broadcasts from 5DN came, originally from the music room at the home of its founder, Mr. E. J. Hume, at Park Terrace, where an occasional "live artist" programme was presented, whilst recordings broadcast were played on a gramophone placed in front of the microphone. 5DN was the first station in South Australia to use a pick-up—in 1927—whilst the station was the first in the state to relay a regular programme from Sydney in 1934. It is pleasing to note that Mr. Hume had no commercial ambitions when he began operating 5DN, making no profit from the station's presentations, his interests being in the education and entertainment value he saw in this new instrument of communication. The station did not become in any way commercial while he lived.

Programmes were scheduled originally from 5DN Tuesdays, Thursdays and Saturdays, 8 to 10 p.m., while today, running to 500 watts on 970k.c., the station is on the air at least 15 hours daily. Most programmes are relayed to 5RM, Murray Heights, on 830k.c.

Stations in Flood Areas

It was not until we tuned to broadcasting stations operating from the flooded areas along the Hunter River Valley, that we fully realised many of the difficulties facing residents of the district. We heard, for example, 2HR (operating from studios in High Street, West Maitland, where flood waters were at one stage reported some two feet deep and moving at something like 20 miles per hour) advise listeners that shelter was available in a particular school building for those unable to remain in their homes.

2CK, Cessnock was heard advising members of a particular family in the coalfields city that an absent member of that family was quite safe with friends in Newcastle. Quite a long list of firms which were forced to close down, largely as a result of the floods, was also read out. No doubt 2HD played its part during this disaster, whilst it is known that the A.B.C. sent observers to the scene to arrange special broadcasts.



TRANS-TASMAN DIARY

By J. F. FOX

(Special N.Z. Correspondent)

RADIO PIRATE TRANSMISSIONS

Despite heavy penalties provided for the illegal operation of transmitters, there are still instances of such misuse of equipment. Recently in N.Z. an operator using the tower frequency of Wellington Airport, gave false flight instructions, causing confusion to airline pilots in the vicinity.

In the early part of June, a radio pirate inconvenienced aircraft services in the Wellington district. Operating on frequencies used by the National Airways Corporation, a "ghost" voice was heard calling control towers purporting to be either Rongotai, Ohakea, Palmer ston North, Paraparaumu and other towers. The pirate would be heard using the following procedure: "Paraparaumu tower, this is Rongotai. Receiving you loud and clear. How are you receiving me? Out."

On one occasion the controller at Paraparaumu was interrupted for 10 minutes while giving pilots instructions. Pilots of airliners then relied on strict visual flying rules and disregarded any landing information received over their radios.

On Wednesday, June 1, Air Department notified the Post Office about the illicit transmissions on their frequencies. Immediately radio inspectors and the police swung into action. This was the beginning of an unceasing search wihch went on day and night till the unlicensed station was located.

Technical equipment for mobile use was installed in Post Office vehicles, and these mobile units were supplemented by some technical resources of Air Department. The detection was made difficult by the infrequent transmissions of short duration. It was also unfortunate that the news had to be released in the press, thus giving the culprit warning of the search.

Indications pointed to the Paraparaumu area, and the investigators concentrated on this district with the result that on Wednesday, June 8, the search had narrowed down to a single building half a mile from the Paraparaumu airport.

On entering a garage at the rear of a house the searchers found a young man of 17 years of age in communication with amateurs.

On June 17, Allan John Bull pleaded guilty in the Wellington Magistrate's Court to four charges of impersonating radio stations and operating an unlicensed radio transmitter. Bull was fined £25 one one charge (to be paid in weekly instalments), while on another charge he was placed on probation for two years. The remaining two charges were dismissed on payment of the costs.

The Postmaster-General, in a statement released on June 9, said, "I would like to pay public tribute to the ready co-operation and assistance afforded the Post Office in the location by the police, the Air Department and members of the Amateur Radio Transmitters' Association."

Another Illegal Station

During their search for the radio pirate, investigators located another unlicensed transmitting station. A radio inspector and a member of the police in the course of their investigations located in a shed at the rear of a house in Paraparaumu a quantity of radio equipment, including two ZC1 transceiving units. Except for connecting two wires from a transformer and plug in the microphone the set was ready for transmitting.

The owner admitted communicating from one set to another on the premises, but was not connected with the other uulicensed station. The fine of £20 was imposed for maintaining apparatus capable of transmitting wireless signals without a license.

Think Before You Act

At least six persons have been unable to resist the temptation of putting a signal on the air since the War Assets placed on sale ex-service radio transmitters at a very low cost. These transmitters ranged from the small walkie-talkie sets to the high-power transmitters in the 500 watt class. The ZC1 transceiver which was used by the 2nd N.Z.E.F. in the Pacific is a set capable of putting out a signal to be heard for thousands of miles.

CRIME DOES NOT PAY! This is also true in radio pirating, as can be read from the above two cases. Post Office radio inspectors are always on the alert for any suspicious signals. The penalty for operating an unlicensed transmitting station is a fine of up to £500, or six months' imprisonment.

Tarawa Operators Remembered

No doubt there are very few who have not heard of the epic battle fought at Tarawa, in the Gilbert Island, late in 1493. Very little has been told, however, of the small band of Post Office radio operators who, with their soldier companions, manned secret coast-watching stations in these islands in 1941 and who so successfully maintained vital communication links in that area until their capture by the Japanese the following year. These operators were later brutally murdered at Tarawa by the ruthless Japanese, while another, taken prisoner on nearby Ocean Island, later died of illness after having carried out very useful communication work.

In October, 1944, after the fate of the operators had been definitely proved, Mr. L. H. Steel, then Principal of the Radio Division, General Post Office, and formerly Controller of Pacific Communications, circularised all New Zealand radio stations and certain Pacific Island stations, as well as isolated radio staffs throughout

(Continued on page 38)

E.M.I. TELEVISION COURSE AVAILABLE

The various technical correspondence courses operated so successfully over the past few years by the E.M.I. Institutes Ltd., England, are now being made available in this country by E.M.I. (Australia) Ltd.

Of particular topical interest is the correspondence course in Basic Television, which has been written to give technical students a sound background in television techniques. The course consists of 15 lessons, each of which is equivalent to a chapter in a text book, thus giving the student at the end of the course, a text book on basic television which is far superior to anything yet on the market.

The course is almost non-mathematical and attention is concentrated upon circuits designed to operate in modern high definition television systems, with particular emphasis being given to receiver circuits. The printed matter in the lessons is supplemented as the course progresses, by the answers to the set lessons, together with comments and other notes provided by the tutors.

As this television course has been written assuming a sound knowledge of basic radio techniques as well as relevant mathematics and physics, intending students must provide evidence of satisfactory knowledge of these subjects. For those who may not have this necessary background, two other courses are available—namely, Preparatory Mathematics and Physics Course and the Basic Radio Course.

The cash price of the Television Course is £19/19/-, whilst the Basic Maths. and Physics and Basic Radio Courses are £10/10/- and £26/5/- respectively. In all cases arrangements can be made to purchase by instalments.

Further particulars, together with special leaflets describing each course in detail, can be obtained by writing direct to E.M.I. (Aust.) Ltd., 2 Parramatta Road, Homebush, N.S.W.

Table Radiogram

The new Table-Model Radiogram now available from Slade's Radio Pty. Ltd., should be of particular interest to all record enthusiasts.

Housed in an attractively designed, polished wood cabinet, this compact five-valve receiver will give excellent results on both radio and gramophone pick-up. The gramophone unit is conveniently mounted at the top of the cabinet, access being gained by the use of a large lift-up lid.

For those who may have a gramophone motor or other components on hand and would prefer to build up their own radiogram, this cabinet is also being made available as a separate unit. If desired, it can be purchased with a ready-cut chassis and matched dial unit, thus forming a basic kit with which a receiver to your own design can be easily constructed.

The prices of these components, which are now available, can be obtained by writing or calling on the manufacturer, Slade's Radio Pty. Ltd., Lang Street, Croydon.

HEAVY-DUTY TRANSFORMERS

A new series of heavy duty power transformers, specially designed for large receiver and amplifier applications has been released by Fergusons Transformers Pty. Ltd.

Of a particularly robust construction, they feature vertical mounting and are finished in black brocade. These are available in a wide range of secondary voltage and current ratings, and should be of interest to all designers and users of high voltage equipment. Filter chokes are also available to suit this range of equipment.

An illustrated leaflet has been prepared describing these transformers, and this is available from all distributors. Trade enquiries should be made to the wholesalers in each State, or direct to Fergusons Transformers Pty. Ltd., McMahon Street, Willoughby.

RADIOTRON 6AR7GT

Latest addition to the Australian-made Radiotron range of valves is the 6AR7GT, a duo-diode pentode which is intended to supersede the 6G8G in all future set production.

The 6AR7GT is a self-shielded, multi-unit valve containing two diodes and a remote cut-off pentode in the one envelope. This diode pentode is capable of providing high stage gain when used as an RF, IF or AF amplifier. It can also be used as a reflex amplifier with low distortion. In conjunction with the X61M and KT61, it could form the basis of a high performance "straight" 3/4 receiver.

A leaflet giving tentative operating data for this valve has been prepared, and is available on application to the Amalgamated Wireless Valve Co. Ltd., 45 York Street, Sydney.

NEW OCTAL SOCKETS

Of particular interest to all receiver manufacturers and home constructors are the two high quality octal sockets now being marketed by Wm. J. McLellan & Co.

The black socket known as the ST28G is moulded from a high grade powder and is suitable for all general receiver applications up to and including the medium frequencies. This mounts in a 1in. chassis hole, and has a 1 5/16in. mounting centre.

The second socket, known as the ST28L, uses the same mounting hole and centres as the ST28G, but has been designed for low loss applications. It is moulded from in a natural grade mica-filled powder, which makes it admirably suited for all high frequency applications. One recent application is its use in conjunction with the 6J8GX, which is fitted with a special mica-filled base to prevent any oscillator drift.

The price of the ST28G is 9d., and that of the ST28G is 1/2d. retail. Supplies of both types are now available from all radio stores, whilst trade enquiries should be made direct to Wm. J. McLellan & Co., 55 York Street, Sydney.

Please mention "Radio Science" when replying to advertisers.

Basic Electricity & Magnetism

(Continued from page 24)

energy is concerned. High leakage means that a capacitor is useless as a reservoir of stored energy.

The general effect on non-conductors, when subjected to high p.d. between their surfaces—as in the case when they are used as dielectrics in capacitors—is a decrease in their resistivity. That is, the leakage tends to increase as the capacitor ages. It would seem that dielectrics lose their electrical elasticity after service in somewhat the same manner as a spring loses its mechanical elasticity after long usage.

The electrical properties of a dielectric required for capacitor service are thus a high dielectric constant, a high dielectric strength and a high resistivity. Also, because they may be subjected to relatively high compressive mechanical forces, they should be able to mechanically resist these forces. They should also remain stable under conditions of high temperatures and humidities, and it is also desirable that they remain dimensionally stable because any change in dimensions will change the capacitance of the capacitor and may affect the balance of the circuit wherein the capacitor is used.

So far, a dielectric adequately fulfilling all these requirements has not been found, and a compromise is always necessary when selecting a substance for dielectric service. Thus, capacitors which are used under conditions of high temperature and/or humidity use dielectrics which will withstand these conditions even though the low dielectric constant and/or dielectric strength of such dielectrics makes it necessary to have a bulky unit. On the other hand, capacitors which are to be subjected to high potential surges use a dielectric with a high dielectric strength, and other requirements must be regarded as secondary.

Cost, of course, is another factor which governs the selection of dielectrics. In general, capacitors which are compact, which can withstand high potentials, and have a high capacitance with low loss are expensive. On the other hand, there is no point in deliberately using expensive capacitors when cheaper types will do a job satisfactorily.

Energy Storage in Dielectrics

It is simple to determine the amount of energy that any given dielectric will store by using data found in the usual tables.

We know that,

$$W = \tfrac{1}{2}CE^2 = \tfrac{1}{2}\frac{K'A\,E^2}{t}$$

Now, the volume of dielectric, v, is At, where A is the plate area and t is the distance between the plates.

So that

$$W = \tfrac{1}{2}K'(At)\,.\,\frac{(E)^2}{(t)} = \tfrac{1}{2}K'\,v\,.\,G^2 \quad \ldots 9.15$$

It is evident that for a given volume, v, of dielectric, the amount of energy which can be stored is directly proportional to the dielectric constant, and also directly proportional to the square of the potential gradient. Dielectrics with a high dielectric strength can store much more energy than those with a low dielectric strength.

Trans Tasman Diary.

(Continued from page 36)

New Zealand, suggesting that a permanent memorial might be established by the radio fraternity in honour of the operators who had lost their lives at Tarawa in such tragic circumstances. Operators were invited to subscribe towards a fund which would ultimately be used for the establishment of suitable memorials.

A bronze plaque measuring 24 inches by 18 inches and mounted on a wooden base of highly polished cedar was finished in February of this year. Besides the names of the operators, the following inscription was engraved on the plaque: "Erected by New Zealand and Island radio personnel in proud memory of nine radio operators brutally murdered at Betio, Tarawa and at Ocean Island during 1942 after their capture by the Japanese." At the bottom is the following: "In the service of their country they faced death with courage undaunted." The plaque has been erected in the main radio station at the administrative centre of the Northern Gilbert Islands.

At the same time, framed copies of a Roll of Honour were placed in the radio stations at Beru and Funafuti. In New Zealand, copies were placed in the aeradio and the various coast radio stations.

An appropriate gesture has been the presentation of a framed miniature Roll of Honour to the next-of-kin of the operators. The Roll of Honour, which have been delicately drawn and hand-painted in oils is of an attractive design.

The main border is of oak leaves, acorn motif interspersed with heraldic symbols of England, Scotland, Ireland and Wales, representing the Empire. The inner and outer borders are of Tawa leaves, while Mercury, representing the Spirit of Communications, with the New Zealand crest immediately below, is the central top figure. The lower centre of the rolls shows the Torch of Remembrance with the Gilbert and Ellice Islands Colony crest superimposed. The lower corners have coconut trees and coastal scenes with natives sailing Gilbertese canoes.

CLUB NOTES & NEWS

GLADESVILLE RADIO CLUB

Activities at this Club, which has shortened its name to the Gladesville Radio Club, during the past weeks have been mainly devoted to internal lecture programmes and other general club business. For the benefit of all members and intending members the programme for the coming weeks is as follows:—

1st August, 1949: J. Read, VK2JD—Ionosphere Predictions and Rotary Antennas.

18th August, 1949: Field Day, 144 m.c.—Direction finding and co-operation with other clubs.

9th September, 1949: Social Outing—Picnic to Eden Park.

The field day on 144 m.c. will be of the same type of direction finding contest as held last May, and which proved very popular.

The club's transmitter is being used every Tuesday evening on 40 metres and is becoming quite well-known on that band.

At a recent meeting some incapacitated amateurs, namely, VKS, 2AQQ, 2ANF and 2RR, were granted honorary membership—entitling them to all members' rights without financial obligation.

GEELONG AMATEUR RADIO CLUB

At the annual meeting of the Geelong Amateur Radio Club, on June 22nd, a report on the activities of the club during the past year was given by the Secretary, Bob Wookey (VK31C). At this meeting new officers were elected and are as follows:—President, E. Kosseck (VK3AKE); Vice-Presidents, W. Brownbill (VK3BU), A. Bell (VK3ABE); Secretary, B. Wookey (VK3IC); Publicity Officer, F. Freeman (VK3ALG); Committee, W. Barratt (VK3WT), Dick Heighway (VK3ABK), Peter Cartwright and J. Mitchell.

The Secretary of the club has been advised by the Wireless Institute of Australia that the club has been accepted as a "Member Club" of the W.I.A.

Printed Circuit Techniques

(Continued from page 20)

Figure 1 shows a typical screen prepared in this manner. Polyvinyl alcohol yields a highly satisfactory blocking material for the screen. Although gelatin has not proven as good, it usually gives acceptable performance. It is important that the blocking material be selected such that it will not be attacked by solvents in the paint.

Silk screens once stencilled may not be re-stencilled satisfactorily. To use the metal screens for new designs, the backlog material may be removed by soaking them in a hot hydrogen peroxide solution, containing 3 per cent. of H_2O_2 for 30 minutes to an hour. Scrub with hot water, dry and remove any remaining traces of organic material in an open flame.

(c) Stencilling Procedure

This practice is basically the same as any stencilling procedure, although certain precautions must be obesrved. For example, extreme care must be exercised to see that the screen is level and the mechanical assembly is designed to swing the screen clear of the plate after the printing operation.

The next step is to place the paint on one end of the top surface of the screen and bring the plate on which the wiring is desired into contact with the bottom surface. A neoprene bar or "squeegee" is moved across the top surface, forcing the silver paint ahead and through the open mesh of the screen pattern as illustrated in Fig. 2.

A uniform film thickness is thus obtained and very little paint is wasted. When the screen is removed, the plate bears a design which conforms identically to that of the stencil pattern. Figure 3 shows a steatite plate before and after stencilling operations.

Mesh marks will be left by the screen if the paint is allowed to get too thick or if too much pressure is exerted on the squeegee. It is not out of order to emphasise the need for checking the viscosity is maintained within close limits if uniform electrical performance is to be obtained. Other simple precautions are necessary, such as maintaining the underside of the screen free of paint during printing and to see that paint does not remain in the open meshes of the screen at the end of the day's operation.

If the impression appears smeared, it will be best to clean the screen by going through the painting operation a few times over a spare base plate rather than to attempt to wipe the screen. Silk screens may be cleaned by using specially commercially prepared solvents applied very carefully with a soft cloth so as not to rub off the blocking portion.

D.—OTHER METHODS OF APPLYING PAINT

Other methods of applying the paint are apparently limited only by the ingenuity of the user. Some which appear to have good possibilities include the use of decalcomanias, the application of ordinary printing, engraving and lithographing techniques, intaglio process and the special pencils, fountain pens and fountain type brushes. Printing electronic circuits by the decalcomania process is feasible and useful in applying the circuits to cylindrical and irregularly shaped objects, including vacuum tubes.

The procedure is to print the circuit on a thin film which may be transferred to the final surface. After transfer, the film is removed by firing. A firing operations may also serve to drive out residual solvents and binder from the paint and to fuse the metal to the final surface. The wiring may be applied to the decalcomania film by many of the methods described above, including stamping.

The material in this article is compiled with acknowledgement from the National Bureau of Standards Circular, C468—Printed Circuit Techniques. Readers desirous of obtaining this complete report should write direct to the Superintendent of Documents, Washington, 25, U.S.A. The price of the booklet is 35 cents, post free.

Attention has been directed toward developing and using methods of printing electronic circuits involving the standard processes of printing. Here also precedents have been set since, for example, metal designs are printed directly on china using rubber stamps. Exactly the same practice is applied to printing circuits by using a rubber stamp bearing the circuit wiring pattern on its face.

The stamp is first pressed onto a pad saturated with conducting ink, then onto the surface to be printed. If air-drying ink is used and the base material, for example, is plastic, the ink may be allowed to dry in air. Plating will increase the conductance is needed. If the base material is glass or ceramic, the paint may be fired after the impression and essentially the same steps followed as in the silk screen method. Although this practice is well suited to printing conductors, it may not work out well with resistors if close tolerances are necessary.

The printing press process has been used to print spiral loop antennas on the internal surface of radio cabinets. It is adaptable to any type of base plate. After the paint has been applied, the plate is subjected to the usual drying or firing procedure.

A paint that has proven successful for use in the printing press consists of a colloidal suspension of metallic silver, but with silver oxide and other inorganic materials kept to an absolute minimum. Up to 70 per cent. of silver may be used. The binder and solvent are volatile below 300° C.

This paint produces an even coating, which adheres strongly to the base plate after firing at 300° C. Coatings of fair conductance are obtained even after firing at 110° C.

Other variations suggested are the direct application of paint to the insulating surface by means of a rubber, metal or plastic block with the circuit design prepared as a cavity or deep etch to hold an appreciable quantity of paint. The primitive and seldom-used method of employing an ordinary lead pencil to draw a high resistance line on a sheet of paper should not be overlooked. The principal objection is the low conductivity and wide variation in resistance of the line.

To date, no satisfactory method of applying the paint by dipping the work into it has been found. The principal drawback to this method is the inability to control the thickness of the paint. Tear drops are formed and an uneven distribution of paint usually results. With plastics, dripping allows more of a chance for the solvent to attack the base material.

It is possible that a satisfactory means of employing it might be worked out, using glass, steatite and other hard base materials. Tear drops and fat edges may be eliminated by means of a recently described electrostatic method[12], which removes the excess paint, leaving a smoothly coated surface. Although this technique has not been tried in connection with printed circuits, it appears to have possibilities for printing circuits both by dip and flowing coating.

(To be continued)

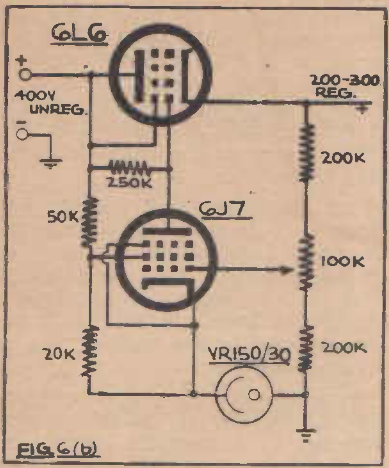


Fig. 6 (b).—An alternative arrangement which ensures a high regulation efficiency.

The principle of operation of these tubes is that, since they are filled with gas, the ionisation potential of which is constant, they will, once ionised, pass a current such as will endeavour to maintain a fixed potential, depending on the pressure of gas contained. Should the applied potential increase, then automatically more molecules of gas will be ionised, resulting in the passage of a heavier current, which, passed through the external resistance in the circuit, will cause a voltage drop such as to maintain the desired potential across the regulator tube.

Check Operation

Although these tubes are very versatile in their application, it is very necessary to ensure that they are operating on the correct portion of their characteristic. This entails proper calculation of the value of the series dropping resistor, taking into account the difference between the supply voltage and the regulator voltage, the normal load requirement, and any variations which may be expected in these factors.

It is advisable to proportion this resistor so that, with minimum supply voltage and maximum load a bleed current of 5 m/a is still permitted to flow through the regulator tube. If the regulator current should fall below this value, it is rather prone to set itself up as a relaxation oscillator, with unpredictable results on the circuit performance.

A suitable value for this resistor may be calculated from the expression:

$$R = \frac{E_s - E_r}{i_{max} + 5}$$

where R is the value of the dropping resistor in thousands of ohms, Es is the minimum supply voltage, and Im is the maximum load current, whilst Er is the voltage rating of the regulator tube.

Shown in Figure 6b is an alternative form of voltage regulator, which is capable of handling much larger variations in current and voltage than the shunt connected type. The principle of operation is that, under normal load conditions, the plate voltage of the 6J7 (and hence the grid voltage of the 6L6) is such that a voltage drop of the order of 75 volts occurs across the 6L6. In the event of the voltage applied to the load falling for any reason, the difference between the voltage applied to the grid of the 6J7 and its cathode voltage, as stabilised by the VR150 will be increased, thus applying more bias to the tube.

This reduces its plate current, and the resultant rise in anode potential decreases the effective anode resistance of the 6L6, thus compensating for the drop in voltage. In practice this scheme is found to be most efficient, for two reasons. Firstly, the degree of regulation obtained is high, being of the order plus or minus .5% for a change in load from 30 ma. to 60 ma., and secondly, a most flexible means of controlling the output voltage is provided by the use of a potentiometer in the 6J7 grid circuit, which determines the mean operating point of the circuit.

Whilst several types of oscillator have been discussed in this article, the foregoing general remarks do not apply in particular to all types. For instance, the circuit shown in Figure 3 will not normally require to be supplied from a regulated source and all factors taken into consideration this would appear to be the most satisfactory form of oscillator to fulfil the amateur requirements.

With regard to this circuit of Figure 3 it will be found that since the isolator stage has an untuned anode circuit no difficulty will normally be encountered with parasitic oscillations when this unit is employed to directly drive an ex-crystal oscillator stage. Should difficulty be encountered in this regard a useful expedient is to employ the arrangement shown in Figure 3b where the oscillator output is fed to the cathode of the driven stage which then becomes a cathode-driven stage with the control grid acting as an electro-static shield between the input and output circuits. The power requirements of this unit are quite modest, being a total of about 50 m/a at 200 volts, which can be supplied from either a built-in power supply or from the main transmitter power supply if the transformer ratings are such as to take the additional load.

THE MAILBAG . .

In view of the late publishing date of this issue of RADIO SCIENCE, the replies to letters which normally appear in these columns have been forwarded by ordinary mail, so as to avoid undue delay in passing on the required information.

The "Mailbag" will be included in the September issue once again, and consequently any reader having a technical problem dealing with any of our circuits or articles is requested to write in and a reply will be given through the columns of this magazine.

Microwave Communications

Continued from page 7

safety or to the alleviation of an emergency endangering life or property. These include police service, except international; fire service; forestry service; highway-maintenance service, and special emergency service.

References

(1. See "The Klyston-Radar-Receiver Oscillation," by Dr. Sidney Krasik, Westinghouse Engineer, Nov., 1946, p. 176.)

(2. See "Radar Receivers and Crystal Rectifiers," by Dr. S. J. Angello, Westinghouse Engineer, March, 1947, p. 54.)

(3. "Microwave Propagation Tests over 40-Mile Overland Path," by A. L. Durkee, Feb., 1948, Proceedings of the I.R.E.)

(Answers to Problems on Page 23)

1. 14.73 ft. lbs.
2. (a) 1,334 volts.
   (b) 4.9 ft. lbs.
3. (a) 100 sq. cm.
   (b) 1 mm.
4. 300 volts.
5. A simple case of when algebra fails. Algebraical relationships are true only within certain limits. Later we will introduce the notion of calculus, a branch of mathematics that makes provisions for the practical variations we find in everyday life.
6. A trick question to see if you have remembered our analysis on capacitors in series. When capacitors in series are charged, all receive the same amount of charge regardless of their individual capacitances. Charges given A and C are, therefore, 500 micro-coulombs; all capacitors are charged the same amount.
7. Tricked again? The TOTAL charge for the entire system is still 500 micro-coulombs.

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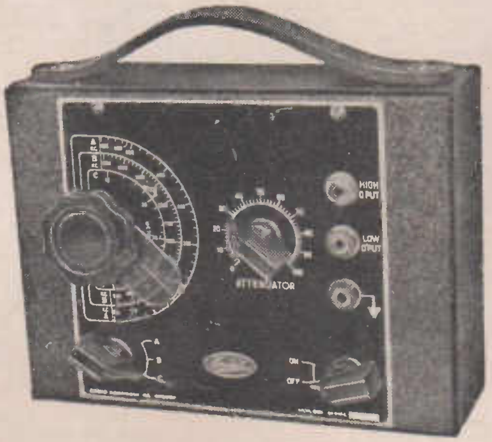
★ AND YOUR OWN PORTABLE

University



MODEL MK1 MULTIMETER KIT

The "University" Model MK1 is an AC-DC Multimeter Kit you can build yourself. Handy companion to the OK1 and the same neat size—6in. x 8in. x 2½in. Uses popular 4in. square type meter with clear multi scale. All wiring instructions and constructional details are given with the kit and photographs and circuit diagrams make assembly simple. All parts are prefabricated so that fitting is simple. Price £8 plus sales tax.

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For years of active service, yet simple to build at home with a few ordinary tools! The "University" OK1 Oscillator kit covers all fundamental frequencies in the average receiver—the dial is specially calibrated. Standard batteries are used and each OK1 Kit is complete with instruction book giving pictures and wiring diagrams and all parts. Price £8 (plus tax).

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The new PK4X Portable is a greatly improved radio incorporating all the latest technical advances. The kit set includes bantam type valves and Mini-max batteries. Genuine, leather covered carrying case is provided, all parts (including 5in. Alnico speaker), plans and illustrated instruction book are provided for easy assembly with a few simple tools.

University

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Secondary Z: .. .. 8 ohms VC
Insertion Loss .. .. 0.5 db
Primary L: 125 Hys. .. .. Leakage L: 22 mHY
Freq. Resp: +/- 0.2 db 20 cps to 30 Kc/s.
Base: 4 x 4½ x 4½" H .. .. Wgt 7 lbs.
Mntg; VII .. .. "S" is 1¾"

ITEM 53. TYPE No. AF10

Primary Z: 10000 ohms pp. .. .. Plus 34 db
Secondary Z: .. .. 500 and 125 ohms
Insertion Loss .. .. 0.4 db
Primary L: 125 Hys. .. .. Leakage L: 17 mHY
Freq. Resp: +/- 0.2 db 20 cps to 3 Kc/s.
Base: 4 x 4½ x 4½" H .. .. Wgt 7 lbs.
Mntg: VII .. .. "S" is 1¾"

ITEM 54. TYPE No. AF15

Primary Z: 10000 ohms pp. .. .. Plus 34 db
Secondary Z: .. .. 15 and 3¾ ohms VC
Insertion Loss .. .. 0.5 db
Primary L: 125 Hys. .. .. Leakage L: 19 mHY
Freq. Resp: +/- 0.2 db 20 cps to 30 Kc/s.
Base: 4 x 4½ x 4½" H .. .. Wgt 7 lbs.
Mntg: VII .. .. "S" is 1¾"

The "AW" range of output transformers listed in this section comprises units designed specifically for high fidelity audio systems. Their features are multiple interleaving of coils to confine leakage reactance within the limits permissible consistent with the upper frequency range covered; adequate primary open circuit inductances to maintain low frequency amplification;; and comparatively large core structure of high quality transformer steel to reduce iron distortion by the use of low flux inductions at the MAXIMUM R.M.S. signal frequency voltages incurred.

OCL values are measured at 5v AC at 50 cycles per second, representing an extremely low signal level. The actual inductance at — 3 db from rated output would be many times that given.

ITEM 55. TYPE No. AW1

Primary Z: 5000 ohms pp. .. .. Plus 33 db
Secondary Z: .. .. 8 ohms or 2 ohms
Insertion Loss .. .. 0.44 db
Primary L: 80 Hys. .. .. Leakage L: 85 mHY
Freq. Resp: +/- 1 db 30 cps to 12 Kc/s.
Base: 4 x 4 x 4¼" H .. .. Wgt 6 lbs.
Mntg: VII .. .. "S" is 1½"

ITEM 56. TYPE No. AW2

Primary Z: 5000 ohms pp. .. .. Plus 33 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. 0.38 db
Primary L: 85 Hys. .. .. Leakage L: 70 mHY
Freq. Resp: +/- 1 db 30 cps to 12 Kc/s.
Base: 4 x 4 x 4¼" H .. .. Wgt 6 lbs.
Mntg: VII .. .. "S" is 1½"

ITEM 57. TYPE No. AW3

Primary Z: 3000 ohms pp. .. .. Plus 34 db
Secondary Z: .. .. 8 ohms or 2 ohms
Insertion Loss .. .. 0.5 db
Primary L: 40 Hys. .. .. Leakage L: 55 mHY
Freq. Resp: +/- 1 db 30 cps to 12 Kc/s.
Base: 4 x 4 x 4¼" H .. .. Wgt 6 lbs.
Mntg: VII .. .. "S" is 1½"

ITEM 58. TYPE No. AW4

Primary Z: 3000 ohms pp .. .. Plus 34 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. 0.5 db
Primary L: 40 Hys. .. .. Leakage L: 50 mHY
Freq. Resp: +/- 1 db 30 cps to 12 Kc/s.
Base: 4 x 4 x 4¼" H .. .. Wgt 6 lbs.
Mntg: VII .. .. "S" is 1½"

ITEM 59. TYPE No. AW5

Primary Z: 12,500 ohms pp. .. .. Plus 39 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. Leakage L: 150 mHY
Freq. Resp: +/- 1 db 30 cps to 15 Kc/s.
Base: 4 x 4½ x 4" H .. .. Wgt 9 lbs.
Mntg: VII .. .. "S" is 2¼"

ITEM 60. TYPE No. AW6

Primary Z: 12,000 ohms pp. .. .. Plus 38 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. 0.6 db
Primary L: 100 Hys. .. .. Leakage L: 140 mHY
Freq. Resp: +/- 1 db 30 cps to 12 Kc/s.
Base: 4 x 4 x 4¼" H .. .. Wgt. 6 lbs
Mntg: VII .. .. "S" is 1½"

ITEM 61. TYPE No. AW7

Primary Z: 12,000 ohms pp. .. .. Plus 33 db
Secondary Z: .. .. 8 ohms or 2 ohms
Insertion Loss .. .. 0.6 db
Primary L: 100 Hys. .. .. Leakage L: 140 mHY
Freq. Resp: +/- 1 db 30 cps to 10 Kc/s.
Base: 4 x 4 x 4¼" H .. .. Wgt 6 lbs.
Mntg: VII .. .. "S" is 1½"

ITEM 62. TYPE No. AW8

Primary Z: 1500 ohms pp. .. .. Plus 37 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. 0.6 db
Primary L: 35 Hys. .. .. Leakage L: 28 mHY
Freq. Resp: +/- 1 db 30 cps to 12 Kc/s.
Base: 4 x 4½ x 4¼" H .. .. Wgt. 9 lbs.
Mntg: VII .. .. "S" is 2¼"

ITEM 63. TYPE No. AW9

Primary Z: 6600 ohms pp. .. .. Plus 37 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. 0.6 db
Primary L: 75 Hys. .. .. Leakage L: 85 mHY
Freq. Resp: +/- 1 db 30 cps to 10 Kc/s.
Base: 4 x 4½ x 4¼" H .. .. Wgt 7 lbs.
Mntg: VII .. .. "S" is 1¾"

ITEM 64. TYPE No. AW10

Primary Z: 10,000 ohms pp. .. .. Plus 39 db
Secondary Z: .. .. 500 ohms and 125 ohms
Insertion Loss .. .. 0.5 db
Primary L: 80 Hys .. .. Leakage L: 100 mHY
Freq. Resp: +/- 1 db 30 cps to 10 Kc/s.
Base: 4 x 4½ x 4¼" H .. .. Wgt 9 lbs.
Mntg: VII .. .. "S" is 2¼"

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