RADIO SCIENCE

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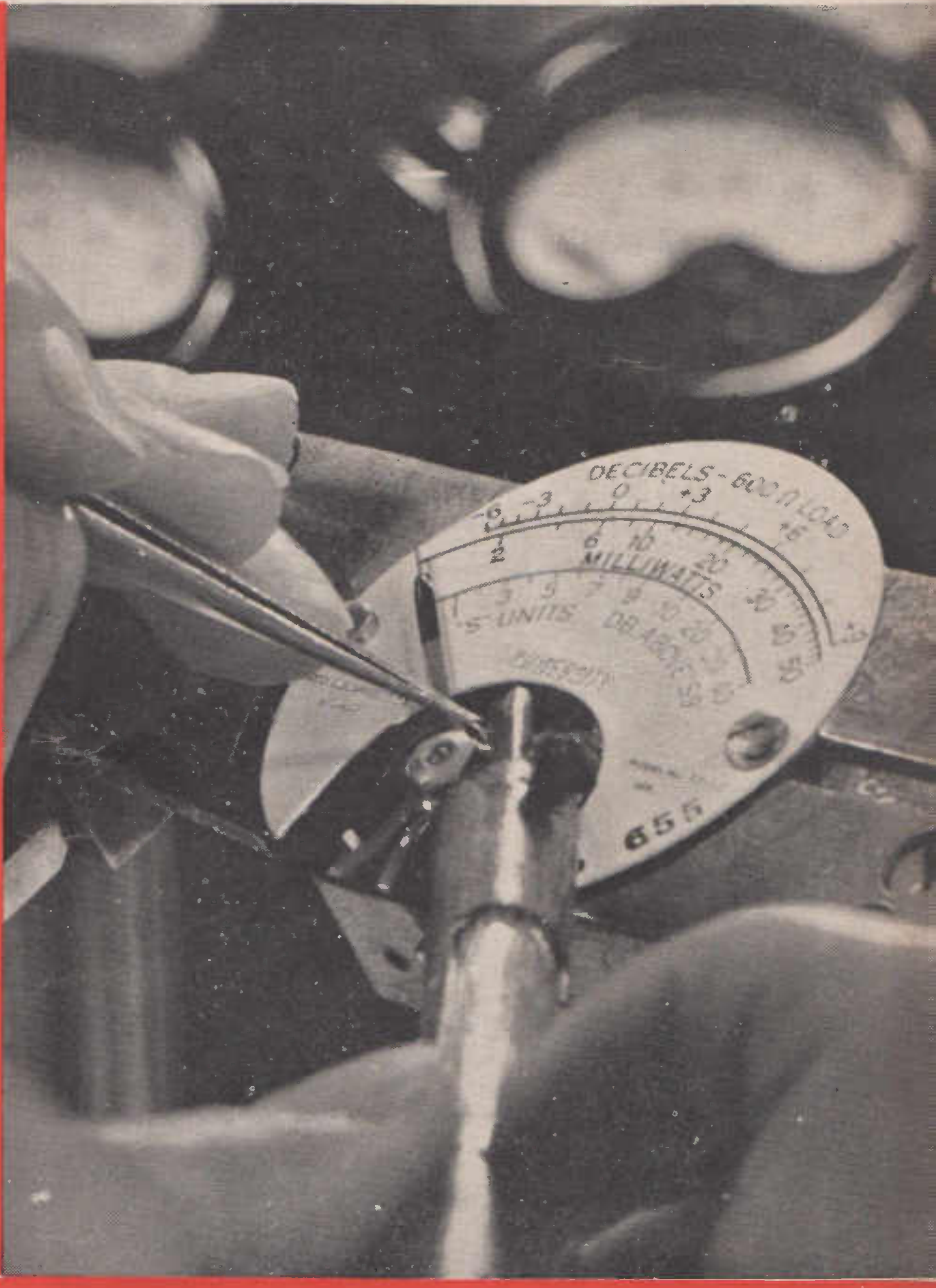

RADIO — ELECTRONICS — F.M. — TELEVISION

editorial.

Radar Aids For Aerial Navigation

The Commonwealth Government's decision to proceed with the immediate installation of various radar aids to aerial navigation is a most welcome one both from the point of view of the travelling public as well as the air-line operators.

Although the Australian airways have consistently maintained a high safety factor, the necessity for these modern aids has been clearly demonstrated during the recent inclement weather. Under conditions of low fog and poor visibility, air-line schedules have been seriously disrupted, causing needless inconvenience and financial loss. When all the proposed new aids are installed at the various major aerodromes, such non-flying conditions will be reduced to an absolute minimum, consistent with safety.

At present Australian airways are equipped with 33 Mc radio ranges, which enable the pilot to fly accurately an "aerial highway," but this equipment has certain limitations, and it is now intended to supplement the existing system with the more modern V.H.F. 112 Mc radio range. The present proposal is to instal 57 new V.H.F. ranges to ensure a complete coverage of all major air routes across Australia and the Mandated Territories.

These radio ranges will be augmented by an additional system known as Distance Measuring Equipment. This is a development of war-time radar and provides the pilot of an aircraft with a radio means of accurately determining his distance from a known ground radar beacon. The value of this system under conditions of poor visibility cannot be overestimated, as it enables the pilot to ascertain his ground position at all times.

Whilst the aids mentioned are sufficiently accurate to bring the aircraft within the circuit area of an airport, they cannot provide an instrument landing system for cases where the airport may be completely enshrouded in fog. This means that when the cloud base is below a certain minimum level, the affected airport becomes closed and inoperative.

To overcome this difficulty it is intended to instal an instrument landing system either along the pattern of current American I.L.S. installations, or similar to the war-time Ground Control Approach.

Either of these systems, in conjunction with a recently developed all-weather approach light system, will enable aircraft to be landed under conditions of the thickest fog. Preliminary tests overseas have indicated the feasibility of this light system piercing over 1000ft. of dense fog.

Australia has always been well to the fore in the installation of radio aids to aerial navigation, and, in fact, some of the schemes which have been developed in this country have been adopted by the United States of America, long recognised as the accepted leader in this field of aviation. Like the United States, Australia is most fortunate in having a unified control of the air, thus making it possible to formulate a single comprehensive navigational plan.

The completion of this system, which, it is understood, will extend over a period of four years and cost approximately £3,000,000, will provide Australia and the Mandated Territories with one of the most comprehensive air-safety systems in the world, and which will be more than comparable to the best overseas installations.

RADIO SCIENCE

For the Advancement of Radio and Electronic Knowledge

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EDITORIAL CONTENTS

OUR COVER: Adjusting the return spring on a meter. This excellent photograph shows one of the many intricate processes in modern meter construction.
(Photograph courtesy Radio Equipment Pty. Ltd.)

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ALL WEATHER APPROACH LIGHTING SYSTEM

Fog and other conditions of poor visibility are among the major factors which contribute to disrupted air-line schedules. The recently-developed "All Weather Approach Lighting," to be installed at major Australian airports under the new long-range air-safety plan, can pierce the thickest fog and provide the pilot with a positive visual indication of the runway location.

Fog and other conditions of poor visibility at airports which have always been severe handicaps to commercial flying, resulting in disrupted schedules and endangered lives and planes can be practically eliminated now by a radically new system of runway approach lighting known as *"All Weather Approach Lighting."* This equipment has successfully passed all preliminary trials in the United States, and it understood that similar equipment will be installed at certain Australian aerodromes under the new policy to introduce latest navigational and landing techniques.

Early Systems

Although in the past many lighting units have been devised to guide incoming pilots to a landing, they have, in the main, been adequate only for normal day and night conditions or for times when visibility is fair. But for zero-zero conditions these lighting systems have been impotent, the difficulty in most cases being that the light sources are far too puny for the severest conditions of fog, and not variable in intensity over a sufficient range to meet all conditions of weather.

As can be readily realised the spectrum of visibility conditions is of enormous scale, and to ensure positive identification of the runway approach and the runway itself under all conditions, without glare, requires a range of light intensities of many millions to one. Visibility conditions can vary from bright sunlight with heavy ground obscuring fog to clear moonlight with all the intervening amounts of light.

This new lighting system has been designed to overcome these earlier difficulties and is based on a fundamentally new concept of the problem of providing to the aircraft pilot visual indication of the runway location regardless of the visibility conditions. It comprises a system of lights with enough power to be of use in foggy daytime, and with special characteristics that cannot be mistaken for any airport lights used for navigation or other purposes.

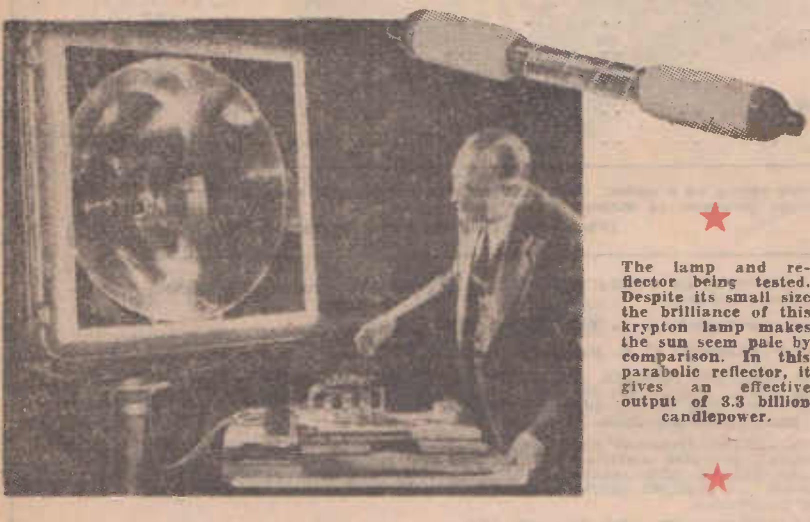
Penetrates Fog

The lights are visible through a thousand feet of the thickest weather, when objects fifty feet away cannot be seen in the daytime. In addition to employing the conventional units, the system includes special flash units, the brightest lighting units ever made, that will give up 3,300,000,000 peak beam candlepower for use in zero-zero daytime, and blaze units that are controllable so that they can be set to omit a soft red glow of about 100 candlepower for use on clear, moonless nights. Between these two extremes are steps of candlepower suitable for any intermediate weather conditions.

A technician checks one of the flashing krypton lamps used in the new light approach system.

One of the main advantages of this new system is that it requires no additional equipment in the aircraft—an important point to airline operators, and it works equally well with any type of instrument approach system: Instrument Landing System (ILS), Ground Controlled Approach (GCA) or Microwave. Consequently the adoption of this all-weather approach lighting system does not conflict with any radio or radar control, but merely supplements the existing and proposed electronic system.

An aircraft must be brought, at times of poor visibility, to the approach portal by radio or other instrument-control system. The new lighting system, in effect, takes over where this instrument control leaves off and guides the pilot through that difficult period of bringing his plane through those last few feet before making physical contact with the ground, and when his usual radio aids are inefficient.



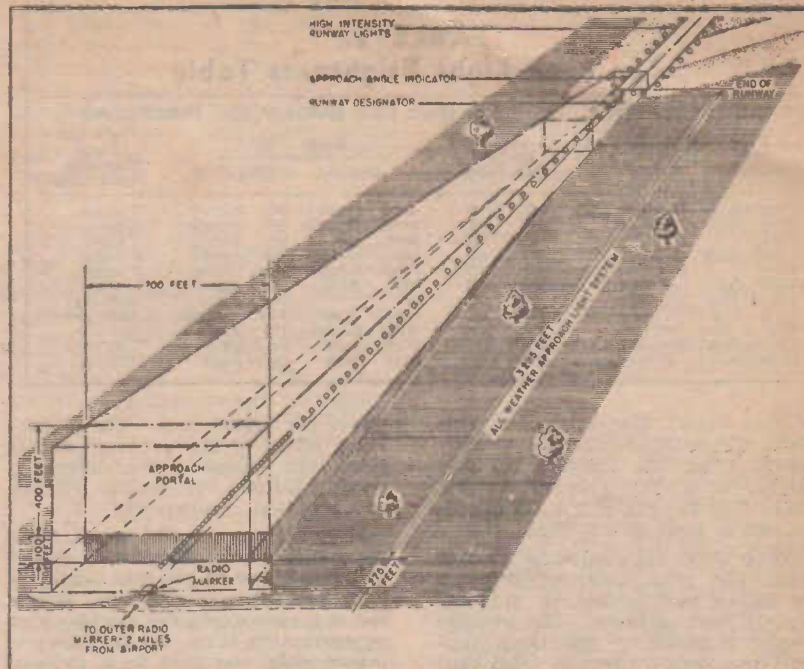
The lamp and reflector being tested. Despite its small size the brilliance of this krypton lamp makes the sun seem pale by comparison. In this parabolic reflector, it gives an effective output of 3.3 billion candlepower.

Development of the Lamp

Tests conducted during the war indicated that light can penetrate adequate distances in dense fog provided extremely high candlepower is used. However, in cases where a bright, continuous form of lighting is used, there is always the danger of background glare interfering with the pilot making the approach, and possibly being more of a hindrance than a help. Because of this, a flashing light was finally selected as the only means of obtaining the required intensity without blinding the pilot.

In actual practice the duration of the flash must be short enough (only a few millionths of a second) so that the eye will not even begin to respond to the great brightness and consequently will not lose its dark sensitivity at night. The krypton lamp, whose flash lasts but 17 micro-seconds, meets this requirement.

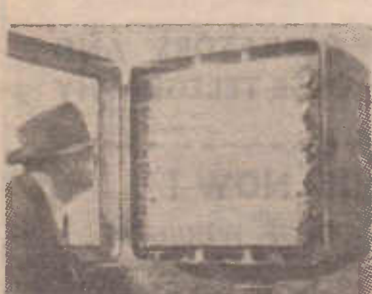
In determining the proper design, commercial photographic flash lamps having long, coiled discharge tubing were considered first. Rapidly repeated flashing was found to shorten lamp life excessively unless very low energy per flash was used. But low flash energy results in very low efficiency. It was apparent then, that a more compact and rugged flashing lamp, providing the maximum possible light intensity with repetitive flashing, was needed to fulfil the requirements.



The operation of the all weather approach light system is shown in this diagram. The pilot is directed by radio or other means to the approach portal which is an imaginary frame 400 feet high and 700 feet wide at the lower left of the diagram. Here a radio signal indicates the pilot must leave instruments and search for visual contact. Within this area, the pilot is guided, despite zero-zero visibility by the brilliant flashes from the approach line extending nearly two-thirds of a mile from the approach portal to the beginning of the runway. To assure safe completion of the landing, high intensity runway lights outline the runway brilliantly.

Krypton Lamp

A short, straight-tube lamp, using krypton gas, developed for experimental war projects was considered next. With its short arc length and relatively high gas pressure, the internal resistance during the flash is lower. Consequently, this krypton lamp gives a shorter duration of flash and for the same energy input a higher peak of light intensity is obtained than is possible with commercial photographic tubes.



This group of neon lights, known as the Blaze unit, assists the krypton units in piercing fog in bad flying weather or can be used alone when visibility is better. The brilliance can be varied from 10,000,000 flashing beam to a steady 100 candlepower glow.

The krypton lamp uses high-melting-point fused quartz around the discharge space to better the extreme heat generated. However, the heat is so great that even the quartz surface softens and gradually vaporises. Unless something is done about it, the quartz recondenses to form a white powder deposit that obscures the light output.

The krypton flashing lamp finally developed uses fused quartz but with special provisions to collect the vaporised powder where the light output will not be obscured. The central portion of the lamp is a thick-walled quartz tube two inches long with about one-fifth inch inside diameter and two-fifths inch outside diameter. At each end the low-thermal-expansion quartz is hermetically sealed to the high-thermal-expansion metal terminals by means of a graded seal.

The seals have a larger diameter than the quartz tube and form end cavities, which act as shock absorbers for the sudden expansion of gas during the flash. The vaporised quartz powder is blown into these cavities, leaving the quartz surfaces clean.

Lamp Operation

Although the lamp uses only 33 watts average power, the peak power in the flash is 3 million watts. It operates from energy accumulated in a 25-microfarad condenser charged to 2000 volts. Before ignition the lamp is non-conducting. Ignition is supplied by high voltage from an induction coil similar to that used in cars when this voltage—approximately 25,000 volts—is supplied to the external wire surrounding the tube, electrostatic action between the wire and main discharge electrodes ionises the krypton gas. This causes its resistance to drop suddenly from practically infinity to less than one ohm (virtually a dead short circuit) discharging the condenser almost instantly.

The lamp has a rating of 50 watt-seconds per flash at 40 flashes per minute. Operated in this manner, its rated life is 25 hours, but since the lamp is used only in the most severe fog conditions and then but briefly (only when an aircraft is landing), the life is spread out over many months of service.

Energy Consumpton

The average rate of energy consumption during the flash, obtained by dividing the energy per flash by flash duration (measured at 17 micro-seconds), is found to be 3

TABLE 1.
Approach Light Brightness Table

Weather Conditions		Approach Line Settings and Penetration				
Type of weather	Max. Daytime Visibility Condition	Flash Unit Setting Day	Flash Unit Setting Night	Blaze Unit Setting Day	Blaze Unit Setting Night	Approach Light Minimum Penetration
Clearest	30 miles plus	off	off	med. steady	low steady	2 miles
Very clear	30 miles	off	off	med. steady	low steady	2 miles
Clear	10 miles	off	off	med. steady	low steady	2 miles
Light Haze	5 miles	off	off	high steady	low steady	2 miles
Haze	2 miles	off	off	High steady	Med. steady	2 miles
Thin Fog	1 mile	off	off	low flash	med. steady	1 mile
Light Fog	½ mile	low	off	off	high steady	3500 feet
Med. Fog	¼ mile	low	off	low flash	low flash	2500 feet
Heavy Fog	500 feet	low	low	High flash	low flash	2000 feet
Dense Fog	200 feet	High	low	high flash	high flash	1500 feet
Zero Zero	50 feet	High	high	high flash	high flash	1000 feet.

million watts. The order of magnitude of the flash current is estimated using the formula for discharge of a condenser, $T = RC$. Since C is 25 mfd, and T, 17 microseconds R must be 0.68 ohm.

With 2000 volts applied to 0.68 ohm, the peak current estimated by Ohm's Law is 2940, or approximately 3000 amperes. The average power required by the lamp (energy per flash divided by total time per cycle) is only 33 watts.

The candlepower of the lamp itself is slightly less than four million. The area of the light source is 0.4 square inches. Dividing candle power by area, the brightness is just under 10 million candlepower per square inch. The magnifying effect of the reflector multiplies the light source almost a thousand times, projecting a beam of 3.3 billion candlepower.

Krypton gas in the lamp gives maximum light efficiency. Argon will give about 80 per cent. as much light and nitrogen still less. Krypton is a rare expensive gas obtained by extraction from the air where it occurs only one part to a million. It is inert, classed along with helium, neon, argon and zenon.

The complete all-weather approach lighting system consists of three parts; the *Approach Line*; the *Runway Designators* and the *High-Intensity Runway Lights*. Each of these parts does a specific job, and will be discussed now in some detail.

Approach Lighting

The *approach* line extending out from the runway for a distance of 3225 feet, is a single line of two entirely new types of lights called *flash* and *blaze* units. These are placed parallel to and twenty-five feet to the left of the extended centreline of the runway (see fig. 1) and are the pilot's first visual contact with the ground as he leaves instruments while passing through the approach portal. In all there are 72 lights—36 each of the flash and blaze units, and these point the way to the runway available for use. The units are spaced alternately, being close together at the outermost end (where they are most needed) and farther apart near the runway.

This approach line appears as a pale red line of 100 candlepower units on clear nights, a bright red line of 1000 candlepower units on clear days and hazy nights, or a brilliant red line of 10,000 candlepower units during hazy days and light fog at night. In increasingly worse weather, the intensity of this line can be increased as required to 100,000; 1,000,000; 10,000,000 or 3,300,000,000 candlepower.

The runway is unmistakably outlined by rows of units of this type. It consists of two powerful incandescent, sealed beam lamps, for use when visibility is poor, and on top, one incandescent lamp employed when low intensity only is required.

Heavy Weather Operation

In heavy weather when the lights are operated at the higher intensities, they are flashed successively, one after the other to give the effect of a streak of lightning travelling towards the end of the runway. A central control instrument controls the actions so that the outermost unit flashes first and each successive unit towards the runway flashes just before the light from the preceding unit appears to be extinguished. This vastly increases the visibility of the system, as the eye will perceive relatively lower apparent candlepower if positively guided to it. Table 1 gives the settings and penetration of the approach line for a complete range of visibility conditions.

As mentioned previously, this flash unit employs a krypton filled quartz tube approximately the diameter of a lead pencil and about two inches long. This is equipped with tungsten electrodes which have high heat resisting properties, fused into enlarged end chambers. When about 2000 volts are impressed on the tube and the gas is ionised, a discharge of capacitor-stored energy occurs through the quartz tube, producing a white light of astounding brightness.

Varying Brightness

By control of the stored energy discharge through the tube, the brightness can be varied from a relatively low value to as high as nine million candlepower per square inch. So intense is the heavy discharge at the peak of the flash, that any other material other than heavy-walled fused quartz tubing would melt or burst under the strain.

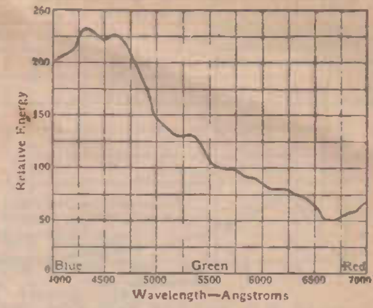
At the high value, the lamp is nine times brighter than the sun, which has at the earth's surface a brightness of one million candlepower per square inch. A polished-parabolic reflector concentrates the output of the krypton lamp, when burning at maximum brightness into a beam of 3.3 billion candlepower.

The second member of the pair of new lights is the so called *blaze unit*. This is made up of six tubular lamps, each about two feet long and a half inch in diameter, fitted with special electrodes and filled with neon to permit operation at different brightness levels. Neon lamps have not heretofore been considered susceptibe to intensity variation. However, by variable electronic control of the power supply these tubes can be operated at varying degrees of brightness.

Unlike the krypton units, which are operated only as flashing units, the blaze units are used almost continuously on the approach line day and night, operating as steady burning lights during weather ranging from clear to hazy daytime and from clear to light fog at night. In thicker weather they operate as as flashing lights, complementing the flash units. On steady burning service, they produce either 100, 1000 or 10,000 candlepower as selected, and on flashing service they operate at about 100,000 or 10,000,000 candlepower as needed.

Light Positions

In the make up of the approach line, the flash and blaze units are spaced alternately in the line, twenty-five feet apart for the outer 900 feet, fifty feet apart for the middle 1000 feet, and 75 feet apart for the inner 1200 feet, with the last units 150 feet from the threshhold. The line extends 3225 feet out from the threshhold to within 275 feet from the middle marker of the Instrument Landing System. All units are aimed at the centre of the approach zone at a point 6000 feet from the threshhold and at 1000 feet elevation. The beam spread of each unit encompasses the normal approach portal.



Richness in the blue part of the spectrum gives the krypton lamp a blue-white appearance.

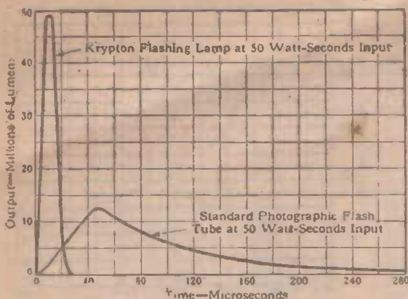
When the units are operated on flashing service, they are tripped successively, beginning at the outer end, each one firing before the one ahead appears to have been extinguished. This flashing is repeated 40 times per minute, so that to an incoming pilot the approach line appears as a streak of light of three-hundredths second apparent duration running for two-thirds of a mile towards the runway and recurring every 1½ seconds.

At the times of worst visibility, such as ground fog in the day time, the approach line is operated with the krypton and blaze units flashing at their maximum intensity and the krypton lamps emitting flashes of 3.3 billion beam candlepower of white light and the blaze units flashing with a reddish light of ten million beam candlepower. At the other end of the visibility scale, i.e., on clear nights when only a relatively faint approach line is desired so as not to produce glare, only the blaze units are turned on.

They are burned continuously at their minimum brightness level of 100 candlepower. Between two conditions the krypton and blaze units can be used in such combinations of intensities as to suit the occasion. At all times the object is to provide sufficient light to assure positive visual identification but not long enough to blind the pilot when landing. The degree of reflective density present, i.e., fog, controls the intensity used.

Characteristics of Krypton Lamp

Peak output (million lumens)	49
Peak output—lamp only (million candlepower)	3.9
Effective peak output—with reflector (billion candlepower)	3.3
Surface brightness (million candlepower per square inch)	10
Effective duration of light flash—above one-third of peak (microseconds)	17
Energy rating per flash at 40 flashes per min. (watt-seconds)	50
Rated life at 40 flashes per minute (hours)	25
Average rate of energy consumption during flash (kilovolts)	3000
Peak current during flash—estimated (amperes)	3000
Average power supplied to flashing lamp (watts)	33



Compared to a standard flash tube, the krypton lamp gives a higher output of shorter duration. The duration of the flash is commonly taken as that above one-third of peak.

Runway Designator

The second part of the system, the *runway designator*, consists of an assembly of neon (red) and zeon (green) luminous tube elements forming either a green arrow or a flashing red cross. The green arrow indicates that the runway is clear for landing while the flashing red cross shows that it is closed. At all other ends of runways, the designator is a large flashing red cross, showing it is closed for landings.

As an airplane passes over the green arrow, the control officer changes the arrow to a flashing cross, closing the runway until the airplane has landed and been cleared. It is then changed back to the green arrow, instructing the next airplane in the landing-sequence pattern to come in.

During instrument weather the designator is a last-moment safety signal to the approaching airplane. The green arrow is assurance to the pilot that the runway is clear and that he is at the proper position to make a landing. If an emergency arises that makes the runway unsafe for a landing, the flashing red cross is a warning to pull away and resume position in the traffic pattern until the emergency is cleared.

High-intensity Threshold and Runway Lights

The third part of the system consists of the *high-intensity threshold* and *runway lights* spaced at 200-foot intervals, 10 feet out from both sides of the runway borders and producing candlepowers up to 100,000. This is one hundred times the candlepower of the semi-flush runway lights in common use.

The new high-intensity runway lights use three lamps and can be operated as a high-intensity or a low-intensity unit, as visibility conditions require. For high-intensity service, two sealed-beam lamps are used, one for each operating direction on the runway. These lamps, only one of which is used at any time, are operated at five degrees of intensity: 100,000, 30,000, 10,000, 3000 or 1000 candlepower. For low-brightness service the high-intensity lamp is turned off and a single lamp mounted in a two-directional optical system at the top of the unit, is used. Like the larger lamp, it has five steps of intensity and can be operated to give 500, 150, 50, 15 or 5 candlepower. These ten steps match the ten steps of brightness available in the approach line.

During weather requiring only the top element, the emitted light is in two directions, along the runway, but with some scattered light. In the thick weather, when higher candlepowers are used, all emitted light is severely restricted to the direction of approach. This prohibits background lighting and prevents lighted haze or fog curtains behind each light that would reduce perception of the next light in the line.

RADAR AIDS TO NAVIGATION

To provide Australian airways with the most comprehensive air safety system in the world, the radar navigation aid—Distance Measuring Equipment—is to be installed on most major air routes. In the initial stages it is intended to instal 95 complete D.M.E. units throughout Australia and the Mandated Territories within the next three years.

The development and application of this equipment, together with details of the Australian Air Line Tests to prove the suitability of the system was given in the March and April, 1948, issues of RADIO SCIENCE.

Limited copies of these issues are still available and can be obtained by writing direct to our Subscription Department, Box 5047, G.P.O., Sydney. The price of each issue is 1s, and this can be remitted in either postal notes or stamps.

The color of the lens for the runway lights is chosen by the position of the unit along the runway. Clear light is used along the outermost section of the runway, and yellow indicates to the pilot the last 1500 feet. When used as range lights at the very end of the runway, the lenses are colored green.

Approach Angle Indicators

As a training means to aid pilots in becoming accustomed to making all approaches and landings as near to the correct instrument approach path as possible, a fourth type of light is used. Mounted in pairs, one on each side of the runway about 600 feet in from the threshold, *approach angle indicators* project tri-colored sandwiches of light toward the pilot, appearing as yellow caution lights if he is too high, red warning lights if he is too low or green lights if he is within safe limits.

To avoid confusion with other colored lights, the indicator signals are pulsed. ON for one second and OFF for one-half second. They are effective in weather down to one mile visibility.

Visual Contact with Ground Assured

The all-weather approach lighting system offers pilots positive visual contact with the ground at the critical moment when they must leave instruments and descend to a landing in all conditions of visibility from unlimited to zero-zero. The pilot is assured of positive identification of the runway location through even 1000 feet of the thickest fog from the time he passes through the approach portal until he taxies down the runway.

At the end of the runway, while he still has flying speed, the all-weather system runway designator gives the pilot a last minute traffic signal by telling him to set his plane down, or to circle and come in again when the runway is cleared. When the new system is used, the runway itself is outlined with the powerful lights built to guide him as he lands.

Preliminary Test

Preliminary tests have indicated the value of this new system, and proved that the transition from instruments approach to visual landings can be accomplished easily under any condition of fog. The tremendous range of candlepower permits all approaches to be made during any kind of weather, day or night, so that full instrument procedure becomes routine and bad weather introduces no new problems. It is anticipated that with the adoption of this all weather approach lighting system, air crashes due to poor landing visibility will be reduced by as much as 90 per cent. In addition, airline operators will now be able to maintain unbroken schedules all the year around, thus providing more efficient and economical operation.

Data and photographs made available through courtesy Westinghouse Electric Company.

ELECTROMAGNETIC UNITS and DEFINITIONS

An authorative article dealing with the question of units and definitions of the electrical quantities. Apart from the topical interest, a knowledge of the history of these electrical units is important in understanding electrical theory.

The decision of the National Physical Laboratory to implement on January 1st, 1948, the recommendation of the International Committee of Weights and Measures of 1946, by reverting from the so-called *"International"* electrical units to units based on the absolute system, brings to the foreground the question of the units and definitions of the electrical quantities. But apart from this topical interest, a knowledge of the history of the electrical units is important in understanding electrical theory.

The logical interdependence of the definitions form a kind of skeleton work upon which electrical theory can be supposed to depend. More than one of the issues which provide perennial difficulty and discussion among students are settled unequivocally by referring to the definitions of electrical quantities. An example of this is given at the end of this article.

The relation between the electrical units is complex, partly because they were originally framed by physicists whose needs in this respect were different from the needs of engineers, and partly because the modifications imposed by engineers have not always been happy ones. In fact, it is difficult, even for those who have the will to do so, to absolve the engineers completely from the charge of short sight or of haziness about fundamental theory in the establishment and use of the practical units.

Unit of Current

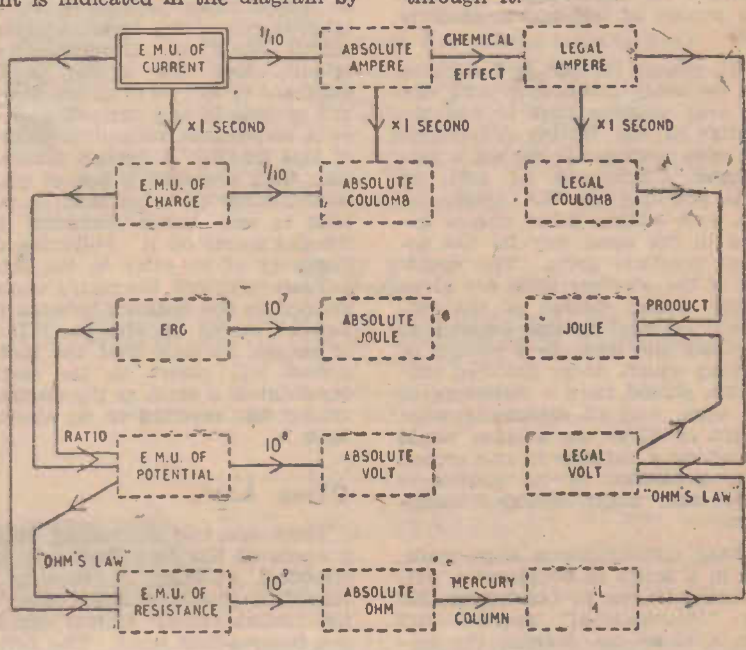
The relations between the units are displayed in the accompanying diagram. The starting point is the absolute electromagnetic unit of current, placed in a double border at the top left-hand corner of the diagram. This is defined as the current which, flowing in a circular coil of one turn and of one centimetre radius, exerts a force of two dynes on a unit magnetic pole placed at the centre, or as the current which, flowing in one centimetre of the arc of such a coil, exerts a force of one dyne on a unit pole placed at the centre.

There are other ways of framing this definition to avoid the objection to the above forms that they rely upon unrealisable circuits. One such form is that unit current is the current which, flowing in ANY circuit, produces the same magnetic field as a magnetic shell of unit strength and whose contour is the circuit. All these forms, and others to be met with in the text-books, can be shown to be mere mathematical variants of the same definition.

Having fixed in this way the size of the absolute unit of current, all the other absolute quantities are defined in terms of it and of familiar mechanical quantities. Thus there needs be, and in fact is in the absolute system of units, only one primary electrical quantity. The way in which the other absolute quantities are derived from the unit of current is indicated in the diagram by the notes on the links connecting them to the unit of current.

Absolute Units

Thus, as absolute unit of charge is conveyed by one absolute unit of current in one second, and one absolute unit of potential difference exists between two points, if one erg of work is done by or against the electrical forces when one absolute unit of charge is conveyed from one point to the other. The absolute unit of resistance is defined from the familiar relation: *"Resistance is the ratio of potential difference to current"* which is often referred to as *Ohm's Law*. The statement is not a law but a definition of resistance, and one absolute unit of resistance requires one absolute unit of potential difference to pass one absolute unit of current through it.



Derivation and relationships of the principal electrical units.

Ohm's Law specifies the conditions (nature of conductor, temperature, etc.) under which the resistance, defined in this manner, is independent of the current through it. All the other absolute units (of capacitance, inductance, etc.) are derived similarly from the absolute unit of current, but as the relations between the various systems of units can be displayed without considering these, the diagram has been extended no farther vertically.

It is important to notice that nearly all the precision measurements of electrical technology, with potentiometers and bridges, are methods of comparing currents or potential differences or resistance. To find the absolute value of any electrical quantity involves measuring it in terms of the absolute unit of current, or comparing its magnitude with a standard whose value has been so measured. It is by way of a reminder of the fundamental position of the absolute unit of current in this respect, that the tangent galvonometer and the Kelvin ampere balance figure so largely in a course of academic physics.

Measurements Difficult

In practice, the accurate measuremeant of a magnetic field presented formidable difficulties up to a few years ago. The British Association, therefore, sought to set up material standards of current and resistance which would be more convenient to realise, and also to measure these standards in terms of the absolute units. While they were doing so they decided to allocate special names, derived from the names of illustrious scientists, to multiples or submultiples by certain powers of ten, of the absolute units.

The reason for the last decision was certainly inadequate, and one can only suppose that it was the prestige of the British Association that was responsible for an International Conference in 1881, in Paris, adopting the B.A. nomenclature, and adding other names derived in the same way for the so-called practical units. The multiples of the absolute units are given in the second column of the diagram. It was further decided to construct and measure a column of mercury which, under specified conditions, should have a resistance of one ohm, and to determine what weight of silver one ampere would deposit on a cathode in one second from a solution of its nitrate in water, also under specified conditions.

These measurements were made, and in a series of conferences, culminating in one at London in 1908 the *"International"* ampere and ohm were set up, defining the ampere as the current which deposits silver at the rate of 0.00111800 grams per second, and the ohm as the resistance of 14.452 grams of mercury of uniform cross section and of length 106.300 cm. at 0 deg. C. These are known as the International or Legal units, having been made legal by enactments of the United Kingdom and of the other member nations of the conferences. They are placed in the third column of the diagram, and the nature of the observations which link them to the corresponding absolute units are indicated on the connecting links.

International Units

The "international" units were defined to be as near as possible identical in magnitude to the absolute ampere and the absolute ohm, and the name *"practical units"* dates from before any discrepancies had been observed between them. It is now, therefore doubtful whether the adjective "practical" refers to the replacement of the absolute units by the multiples by powers of ten of those units, or whether to their replacement by the chemically defined ampere and ohm. Since by modern measurements these units are perceptibly different, it would seem best to abandon the use of the term "practical" and to use the adjective "absolute" for the one system and the adjective "international" (or "legal") for the other, although in view of the almost certain loss of legality of the international units in the near future, the terms chemical ampere and mercury ohm may be appropriate.

The change from the absolute units to the international units has an almost exact parallel in the establishment of the metric standard length. The French Government originally took the length of the quadrant of the earth as the standard of length, and defined a metre as a convenient submultiple (10-7) of this length. A French Commission then prepared a bar of platinum-iridium to be as near as possible to one metre between the fiducial marks on it. Following the discovery of an error in the original measurement, the metre was redefined as the distance between the fiducial marks on the bar. It is, of course, unlikely that the metric system will revert to the earth's quadrant as a basis, as the electrical system has reverted to its absolute basis.

Ohms Law

There are two interesting consequences of the fact that only one electrical quantity is required to furnish a system of units, whereas the "international" system supplies two independent units. The first is that by the *"Ohm's Law"* relation a legal volt is obtained as the product of a legal ampere and a legal ohm. This legal volt is of very nearly the same magnitude as the absolute volt, but is quite distantly related to it, as is indicated by the diagram. On the other hand, the legal ampere and absolute ampere, like the legal ohm and the absolute ohm, are directly related, each by a single measurement.

The second consequence is that from the legal ampere and volt, a new unit of energy is obtained, called the *joule*, but which is only approximately 10_7 ergs. To define a joule as 10^7 ergs, as some writers have done, is wrong, for the Paris Convention of 1881 initiated the term joule, and defined it as the international unit of electrical energy. By analogy with the absolute ohm and the absolute ampere, 10^7 ergs should be called one absolute joule.

Commissions and Conference

We have stated that the reason for the introduction of the international units was to provide more easily realised standards of electrical quantities. At an International Conference of 1928 it was agreed that electrical quantities could now be measured in terms of the absolute units as accurately as in terms of the international units, so that the primary need for these latter units no longer existed. It was therefore resolved that the numerical relations between these units should be measured with all attainable accuracy, and that a later Commission should effect a formal reversion to the absolute system for technical purposes. Accordingly, the American Bureau of Standards published these results of comparisons:—

1934—One international ampere =0.999928±0.000020 absolute ampere.

1938—One international ohm= 1.000468±0.000020 absolute ohm.

Change in Units

A Commission in 1933 implemented the decision of the 1928 Conference by resolving that the change-over should take place on January 1st, 1940, and in the absence of the war, that would, presumably, have been decreed in this country. A conference of 1946 resolved that the change-over should take place on January 1st, 1948, and in accordance with this, the National Physical Laboratory has announced that it will implement the decision in its measurements from that date.

The most recent comparisons are:—

One international ampere= 0.99985 absolute ampere.

One international ohm=1,00049 absolute ohm.

These figures are of interest to compare with the American estimates of a few years ago to observe the order of accuracy of recent determinations.

In setting up the international units, two changes were made; first, the difficult absolute measurements were replaced by the then simpler ones of the chemical ampere and the mercury ohm and, second, more convenient multiples by ten of the fundamental units were adopted.

The M.K.S. system of units has been proposed to achieve identity of electromagnetic and practical systems. This system takes the metre, the kilogram and the second as the fundamental units of length, mass and time. If the system is adopted, it is to be hoped that a new name will be substituted for the "kilogram" and so the anomaly avoided of having a fundamental unit named in terms of another, a thousand times smaller. The new name should also, of course, be derived from the name of a scientist, following the avowed practice for the technical units.

"Practical" Units

It may be worth while clarifying here a common misapprehension among engineers in connection with the practical units. If an engineer is asked why powers of ten appear in so many of his formulae—e.g., the field of a solenoid is 4wni/10l, and the induced E.M.F. in a circuit is 10^{-8} d o/dt volts, the writer's experience is that he will generally be told that this is due to the use of practical instead of absolute, units. This, in fact, is not true. A consistent system of units must give the same formula as any other consistest system. These power of ten arise in all engineers' formulae which give the field of a current, and are due to the use of a mixed system of units—viz., practical units for the electrical quantities and absolute units for the magnetic quantities.

There is no reason whatever why practical units of field and flux should not be used by engineers, and they would then have formulae of the same form as those used by physicists, without the powers of ten. To call these formulae "practical formulae" is about as near the truth as to call the formula "circumference of a circle=79.8 x diameter" a practical formula, for this is the mensuration formula which must be used by one who measures circumferences in millimetres and diameters in inches.

Incorrect Titles

The matter was made more difficult by the allocation of the name *gauss* to the absolute unit of magnetic field, thereby violating the explicit international resolution to use proper names for the "practical" units. But perhaps the limit of culpability in this matter was achieved when a later International Conference, having noted that the name gauss was being used in different senses by different writers, decided to abandon the term, and the new name *oersted* was allocated to the absolute unit of field, thereby repeating the same error after having been provided with a remarkably lucky opportunity to right it.

Another interesting light on electrical theory is given by a consideration of units. In the absolute system, the first quantity defined is current, and all the others are derived from its through mechanical relationships. Thus potential difference is the work done per unit charge, or the power per unit current, and resistance is the potential difference per unit current. We can, therefore, express resistance directly in terms of current and power, and the result is that resistance is the power per unit current squared. Thus the relation, $R=W/I^2$ is the true definition of resistance. It is logically incorrect to regard this as a result which can be deduced Ohm's Law, however convenient that viewpoint may be for the purposes of elementary teaching.

The definition of resistance in terms of power and current at once answers the question of the reality of the radiation resistance of an aerial, or of iron-loss resistance in iron-cored coils. These are often thought of as in some way unreal resistances; in fact, some textbooks go so far as to distinguish between "*ohmic resistance*" and "*fictitious resistance*." The argu-

(Continued on page 46)

Ultrafax — High Speed Transmission System

This new facsimile method using cathode ray tubes as light sources at both transmitter and receiver is capable of handling motion pictures, slides and test patterns in television end the incoming signals are photographed on continuous film which can be developed within a few seconds.

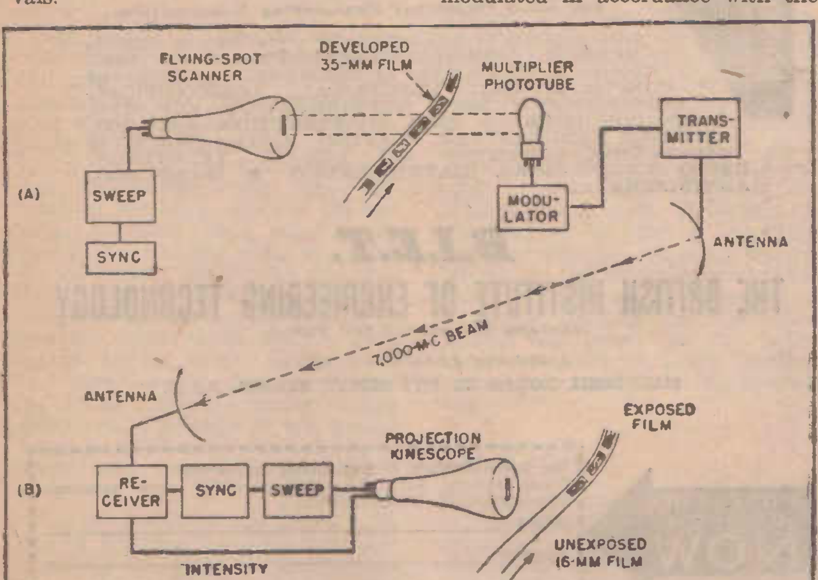
Ultrafax is the name coined to describe a technique that combines facsimile, television, and "hot" photography, for the extremely rapid transmission of intelligence in written or printed form by radio. Although the present laboratory setup transmits from a microfilm record at about 500,000 words per minute, it is estimated that later models will handle up to one million words per minute.

Elements of the system outlined in the simplified block diagram indicate the close relationship to conventional facsimile practice. The material to be transmitted is first reduced from page size to a dimension such that the page width corresponds to the useful width of a 35-mm film strip. The individual pages are spaced out along the length of film at convenient intervals.

As the film is moved between the lens system and the multiplier phototube at a rate of 15 "frames" or pages per second, the film width is scanned at a rate of 6300 cycles per second, using a special flying spot scanner tube as the source of illumination. Resolution corresponding to better than 1000 lines is obtained provided the circuits used have a band width of 10 Mc.

Receiver Unit

Output from the phototube goes to a modulator and transmitter. The receiver comprises the basic equipment shown in (B) of the block diagram. A single synchronising signal suffices to initiate the single line trace and blank out the return trace. The moving spot of the projection kinescope tube is modulated in accordance with the intensity of the signal picked up by the multiplier phototube and transmitted over the microwave circuit. This kinescope tube has a spectral response suitable for exposing the 16-mm film—as contrasted with the 35-mm film used at the transmitter, which is pulled past the kinescope at a rate of 15 frames per second.



Simplified block diagram of the Ultrafax System. Details of the photographic aspects are omitted.

A special high speed developing machine is used to handle the film at the speed of 8 feet per minute. Each frame of heat resistant film is moved in 15 seconds through developing solutions at temperatures about 125 degrees F. The finished film which can be recorded as either a positive or negative, is completely dried out in an additional 25 seconds, after which it may be freely handled.

Although this equipment is not as yet commercially available it does present new and interesting communication possibilities such as radio-mail system, the transmission of a full-length motion picture from a single negative in the production studio, to the screens of thousands of theatres throughout the country, or the exchange of international television programmes.

—Courtesy Electronics.

Man-Made Quartz Crystals

Clear, sparkling crystals of real quartz, identical in every way to those produced by the processes of nature, are now being grown in the Bell Telephone Laboratories. A finely powdered form of silica is placed in the bottom of a steel bomb "test tube" and an aqueous alkaline solution is added. A seed plate, a thin wafer of quartz, is suspended at the top of the bomb which is then sealed and placed in a furnace.

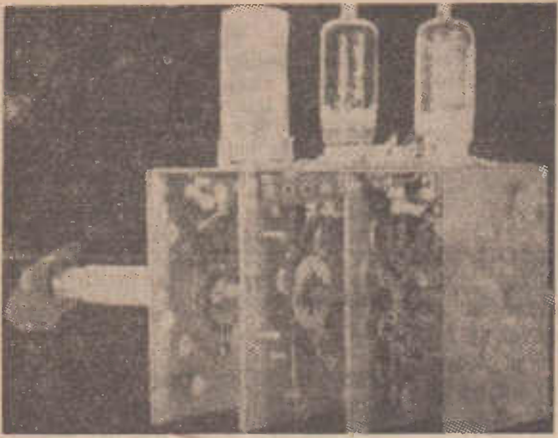
Under pressure exceeding 15,000 pounds per square inch and at temperatures of about 750 deg. F., the silica dissolves, rises to the cooler part of the bomb and is deposited on the seed plate, molecule upon molecule, in perfectly regular order until it is in the form of a single clear crystal.

Due to controlled uniformity of such production, the synthetically-produced crystals are superior to natural ones. Standard growth rate is an inch a month, and commercial manufacture is predicted for the near future.

STAMPED TELEVISION SWITCH ASSEMBLY

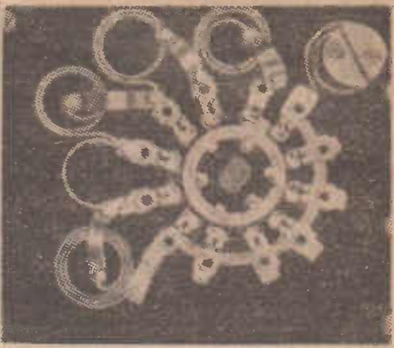
A new television channel selector switch assembly developed in the U.S.A. will probably be a major step towards reducing T-V receiver manufacturing costs. The tuning inductances for the 12 channels are die-stamped directly on to bakelite rotary tap switching wafers using specially designed die-cutting machines developed for this process.

The spiral coils are formed out of paper-thin sheet copper which has been coated on one side with thermoplastic cement for positive binding on the base insulating material. Complete switching and tuning assemblies incorporate r-f, oscillator and converter stages, and these are contained in a cadmium-plated steel housing measuring only 4 x 2½ x 3 inches.



Typical 12 channel television selector switch assembly without the steel housing.

Each unit employs three rotary tap switching wafers with the taps operating over a single coil of distributed length. Two brass tuning slugs one for channel six and the other for channel 12 are included on each wafer. These slugs are factory tuned for the set of tubes that accompany the switching assembly and enable readjustments to be made if a wide variation in the constants of replacement valves is encountered. The valves used in the unit are 6BH6, r-f amplifier 6AG5, converter and a 6C4 oscillator.



A view of the the bakelite switch wafer showing layout of the stamped coils and adjustable slugs.

Because of the simplicity of the assembly and the ease with which replacement wafers can be installed it is estimated that servicing and maintenance costs will be considerably reduced in receivers using the unit.—Courtesy Tele-tech.

Mapping Voltage Contours

A pantograph system is now being used at the Westinghouse Research Laboratories to determine the ideal shape of the external shield for an X-ray rectifier valve. The apparatus gives a graphic picture of the voltage gradient and equal-voltage contours surrounding the valve, and thus tells where protection against breakdown must be strongest and establishes the shape of the valve shield.

Equipment Details

The equipment consists of a pantograph, a drawing of the valve under investigation, metal electrodes (which follow the configuration of the valve), two conducting solutions (in which the electrodes are immersed), and an electrical circuit. Two solutions f different conductivities represent the different dielectric constants inside and outside the valve, which is oil immersed in actual service. The barrier conforming to the shape of the glass envelope separates the two solutions physically but permits proper electrical contact between them.

Voltages corresponding to the operating potentials of the valve are placed on the metal electrodes. To determine the contour of a particular voltage, the tracing point of the pantograph is moved about the area surrounding the drawing. The conducting needle follows these movements through the solution. This needle is connected to an electrical detector circuit, which measures the difference in potential between the needle probe and a calibrated potentiometer set to read zero for the voltage sought.

When the probe reaches a point in the solution at which the potentiometer reads zero, the potential at that point is equal to the voltage desired. This point is then marked on the drawing. The process is repeated until the complete contour for that voltage is traced. The potentiometer circuit is reset and the contour of another voltage is plotted on the drawing in like fashion.

The pantograph system used to trace the voltage contours of a valve, thus facilitating shield design.

LISTENER-INTEREST METER

The magazine published by the International Broadcasting Association reports the development in Denmark of an ingenious method of making direct measurements of listener response to broadcasts. The basic principle of the invention is this. when a receiving set is switched into an a.c. supply circuit there is a slight distortion of the supply wave form, owing to the action of the rectifier of the radio.

The distortion is small, but it is cumulative and the resulting harmonics introduced can be made to take the form of a voltage proportional to the number of radios in use at any time By using a calibrated cathode-ray oscillograph, the number of receiving sets in action can be measured directly.

The system is not just a matter of theory; it has been in use for some months in Denmark. Photographic records of the cathode-ray tube screen are made at regular intervals, and listener-response curves are easily prepared from these.

The idea has, of course, several limitations. A separate recorder is required for the circuits served by each supply transformer; that, though, is not altogether a disadvantage, for it enables the response of particular districts to be metered. The recorder cannot discriminate between the stations to which radios are tuned; all it can indicate is that so many sets are in use at a particular time.—Courtesy Radio Electronics.

FILM PICKUP UNIT

Details of the recently developed equipment used for handling motion picture, slides and test patterns in T-V stations.

Nowadays a considerable portion of the programmes presented by television stations is originated by means of both fixed slides and motion picture film. As a result, entertainment films, commercial films, sign-off and sign-on announcements, commercial slides, and test patterns, all make use of film pickup equipment. A typical system described herein performs the important function of converting the pictures obtained from slides and motion picture film into the video waveform required for the programme mixing facilities of standard television stations.

Arrangement

Associated with each film pickup tube is the film chain equipment, housed in three separate sections. One complete assembly, comprising a pickup unit, control desk, and the equipment cabinets, is represented by the block diagram in Fig. 1. In order to provide uninterrupted film programmes, it is usually found necessary to employ at least two pickup tubes in a so-called dual film chain. Each additional pickup duplicates the equipment shown in Fig. 1.

As far as practical, units have been located in the equipment cabinets, Fig. 2, where all their components are completely accessible for maintenance and service. Where circuit considerations such as lead lengths in high impedance circuits make necessary the location of units in the console, the units have been mounted on sliding tracks for accessibility. Stable circuits, and circuit components with large factors of safety have been chosen in an attempt to obtain long, continuous service with a minimum number of component failures. Electrolytic condensers, which are liable to deteriorate with time, are for the most part of the plug-in variety and can be replaced easily. Test points have been located at strategic places throughout the system to permit rapid trouble shooting.

Pickup Unit

The pickup unit contains the pickup tube, pre-amplifier, and pickup auxiliary as indicated in Fig. 1. The unit is designed for mounting on either a fixed pedestal or a platform which moves on tracks. With a fixed pedestal, the unit can operate with only one optical projector, unless mirrors or prisms are used. The moving platform permits one unit to be operated with several optical projectors.

Fig. 3 shows the pickup unit with the shield cover removed. The Iconoscope tube is mounted in a cradle which can be positioned by means of various mechanical adjustments. The tube can thus be moved readily so that the photosensitive mosaic is centred on the projected image, and lies in a plane normal to the centre line of projection. The back light, situated directly behind the Iconoscope, is contained in a small housing at the rear of the unit. Illumination of the back and side walls of the tube envelope reduces the spurious signal, and increases the sensitivity of the Iconoscope.

Pre-amplifier Unit

The pre-amplifier unit mounts in a separate compartment directly above the signal plate of the pickup tube, allowing a short connecting lead to the input grid. This can be seen in Fig. 3. The amplifier employs 3 gain stages, a compensating stage, and an output stage, using miniature tubes. The gain stages use simple shunt-peaking, with fixed peaking inductances. Compensation for the attenuation of the high frequency components

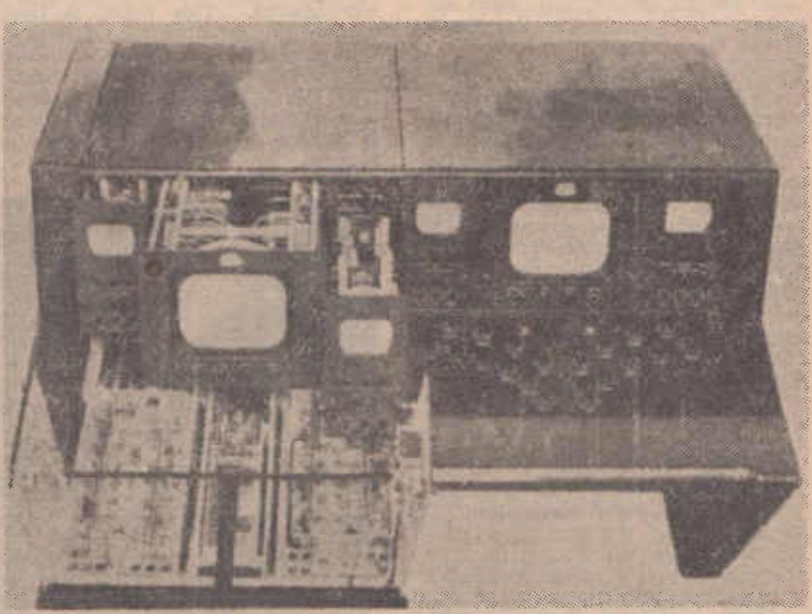


Fig. 2. To provide continuous operation, two identical film pickup control units are combined in this unit.

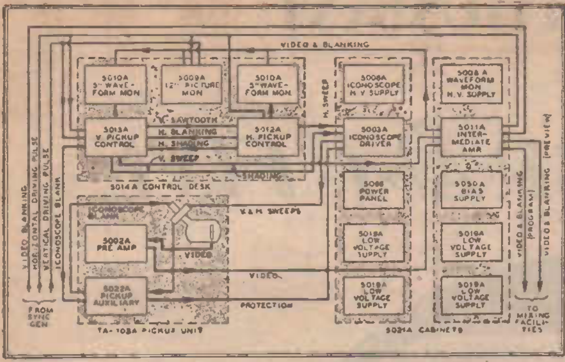


Fig. 1. A block diagram of the iconoscope film pickup system. Only one section of the control desk is shown.

of the picture signal, resulting from the inherent capacity shunting the input load resistor, is accomplished by a variable series combination of inductance and resistance in the compensating stage.

When this stage is properly adjusted, the over all frequency response of the pre-amplifier is flat within 5 per cent. up to 6mc. The output stage feeds the coaxial cable which carries the video signal to the intermediate amplifier in the equipment cabinet. A video phase-reversing switch in the pre-amplifier output stage makes possible the projection of negative film. This feature avoids the need for making a positive film when it is desired to project a recently-filmed event in the shortest possible time.

Pickup Auxiliary

The pickup auxiliary mounts in the bottom of the pickup unit, Fig. 3, where both tubes and components are readily accessible when the cover is removed. This unit contains the filament supply for the Iconoscope and pre-amplifier, a regulator for the pre-amplifier B supply, and an amplifier for the Iconoscope blanking signal.

Included also are two protection diodes which peak-rectify the flyback pulses appearing across the vertical and horizontal windings of the deflection yoke. Their DC outputs are fed to the Iconoscope driver unit in the equipment cabinet, where they control relays which remove the high voltage from the Iconoscope in the event of sweep failure, and prevent accidental damage to the Iconoscope mosaic.

Control Desk

The control desk as indicated in the block diagram, Fig. 1, contains two 5-in. waveform monitors, one 12-in. picture monitor, a vertical pickup control unit, and a horizontal pickup control unit. Each unit is mounted on sliding tracks and can be withdrawn while the system is in operation. As can be seen in Fig. 2, when a unit is withdrawn all components are readily accessible for testing and maintenance. The control panel on each desk contains all the controls necessary for operating the associated pickup unit.

The two waveform monitors normally present the vertical and horizontal video waveforms at the output of the intermediate amplifier. Two additional inputs are provided, one of which permits the monitor to be used as a test scope for checking waveforms in the nearby units, and the other permits the monitoring of an additional signal such as an off-the-air signal.

Picture Monitor

The picture monitor, using a 12in. magnetic deflection cathode ray tube, is capable of fully showing the four corners of the raster without reducing the picture size beyond a point where the operator can view the picture critically at a comfortable operating distance. The sweeps in this unit can be driven either from external driving impulses or from a self-contained sync separator. In this application, the former method is used since the synchronising pulses are not added to the video signal in the control section.

The vertical pickup control unit mounts at the left-hand side of the console, directly beneath the control panel. As its name implies, this unit contains the control circuits which operate at the 60 cycle vertical-sweep rate. The vertical driving pulses from the synchronising signal generator trigger or blocking oscillator whose output drives a capacitance-discharge type of sawtooth generator. Since the sawtooth voltage is required primary for the vertical sweep of the Iconoscope, an exactly linear sawtooth is not generated, but rather one whose rate of rise decreases as its amplitude increases.

This requirement is brought about because the mosaic in the Iconoscope is inclined with respect to the centre line of the electron beam. If the sweep were exactly linear, the horizontal scanning lines would be too widely spaced near the end of the sweep since, at this time, the beam is sweeping an area which is farther away from the yoke than it is at the beginning of the sweep. A close approximation of the required curvature of the sawtooth wave is obtained if the condenser which develops the sweep voltage is allowed to charge more than it would be for a linear sweep.

The output of one multivibrator is filtered and used as the 60 cycle sine-wave shading signal. The output of the other is used for vertical Iconoscope blanking. It is mixed with a similar signal from the horizontal pickup control unit and sent to the pickup auxiliary unit over a coaxial cable.

The horizontal pickup control unit mounts directly beneath the control panel at the right-hand side of the control desk, as shown in Fig. 2. This unit generates the required signals for the system which reoccur at the 15,750-cycle horizontal sweep frequency. Horizontal driving pulses from the synchronising signal generator trigger a blocking oscillator whose output

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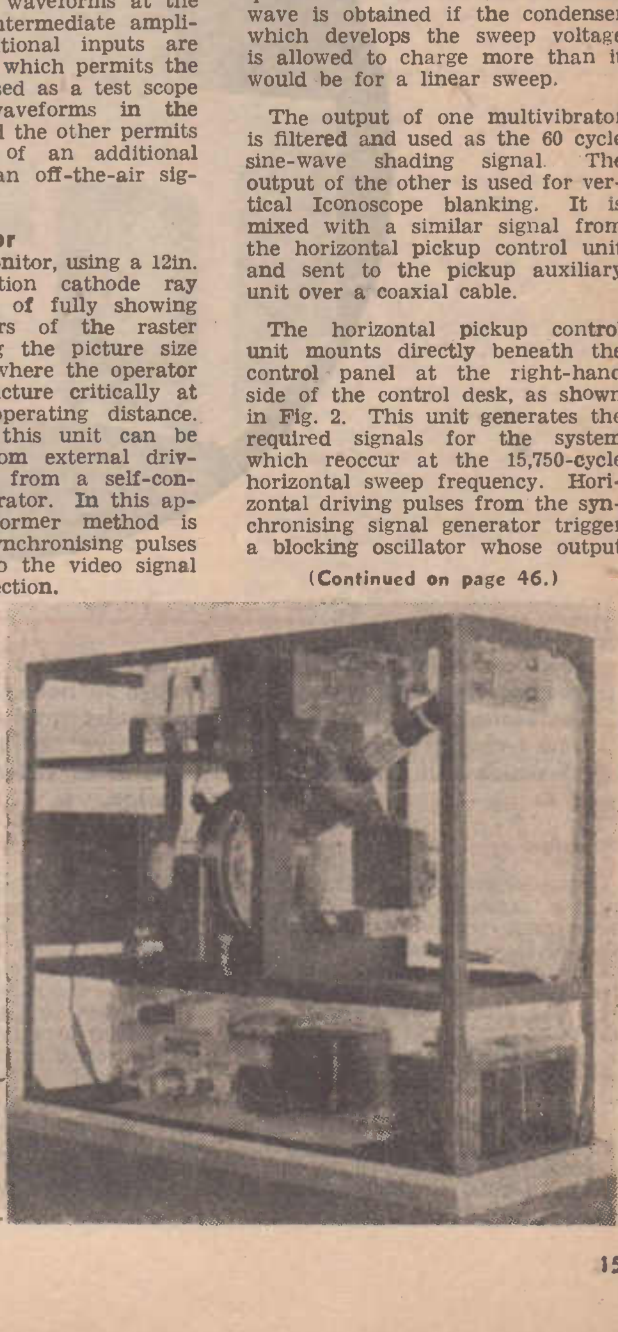
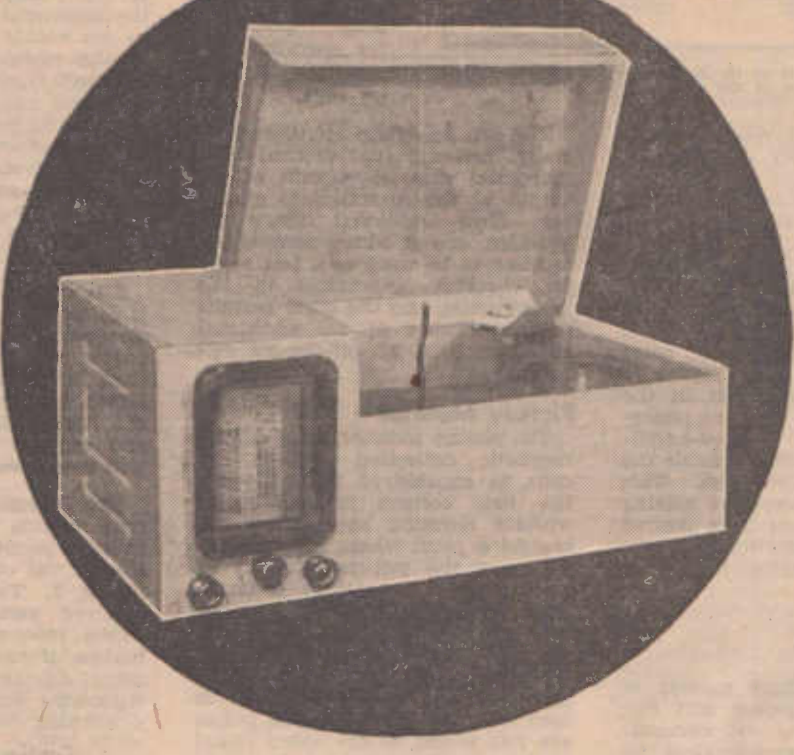


Fig. 3. A view of the iconoscope pickup unit with shield cover removed.

FOR THE RECORD ENTHUSIAST

THE RADIOGRAM FIVE



Here are full constructional details for building a receiver that will set a new standard in home construction. Combining a five-valve dual-wave receiver and an automatic record-changer, housed in an attractive cabinet, this is a set which will interest the music lover or those requiring a "different" design.

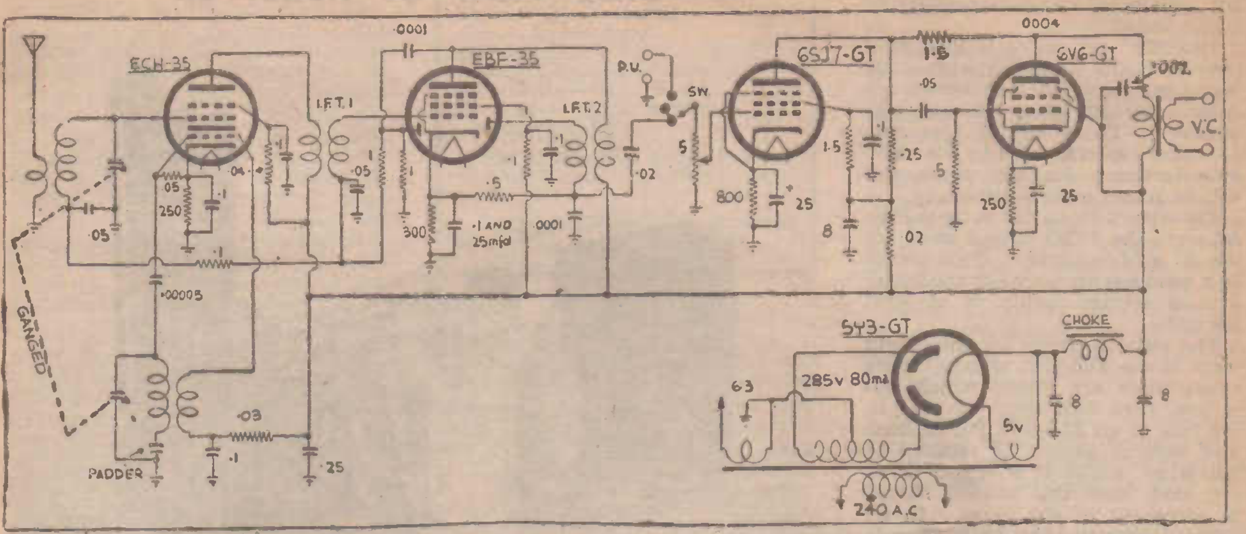
Since describing the Portagram in the January issue, there have been many requests for the description of an AC version of this type of receiver. This was to be expected, since this earlier battery design did provide the country, and for that matter, the city enthusiast with constructional details of a receiver not commercially available at the time.

When designing this new receiver, it was considered that, being AC operated it was not likely to be carried around to any extent, and in view of this it will be seen that the layout has been changed. The receiver for instance has been mounted at one end of the cabinet, with the speaker fret being on the side. The record changer, is installed in the right-hand section of the cabinet, and to keep the overall height to a minimum, this has been recessed as far as possible into the cabinet.

The receiver section employs a standard five valve circuit, and this will be found to provide ample gain on both radio and pick-up. Since in most cases the average receiver is operated at fairly low volume, the inclusion of a push-pull audio stage and other refinements did not seem warranted, if this additional gain was not going to be used. Certainly, some may consider that the distortion factor would be lower than that obtained with a single output valve but our own listening tests soon convinced us that the really acceptable and pleasing quality was to be obtained from the single 6V6GT.

Circuit Details

The circuit used is very similar to the Dual Wave Five described in the September 1948 issue, with several slight amendments. As in this earlier circuit, the valves used are: Converter, ECH-35, I-F Amplifier, diode detector and AVC, EBF-35, Audio Amplifier, 6SJ7-GT, Power Amplifier, 6V6-GT and Rectifier, 5Y3-GT. These valves are all modern types and will ensure that maximum gain is obtained from both the r-f and audio sections of the receiver. However, alternative types,



The circuit is a well-proven design, which is capable of excellent results on both radio and gramophone pickup.

if on hand, can be used with perhaps slight decrease in efficiency, providing the necessary circuit changes are made.

The ECH-35 is probably one of the most widely used converter valves in use nowadays, and it will be found to work quite satisfactorily with the dual wave unit. Circuit constants shown are standard for this stage and call for little comment. The separate screen and cathode resistors have been retained mainly in the interests of stability since circuit coupling could take place if a common cathode resistor and screen resistor were used for the converter and i-f stages.

Alternative Types

Other suitable converters include 6J8-G, 6A8-G and the 6K8-G. In using the first two valves, it will be necessary to change the screen resistor to meg, and at the same time reduce the oscillator plate resistor to .02 meg. The 6K8-G would require a screen resistor of meg, and a osc. plate resistor of .04 meg.

For the position of i-f amplifier, the EBF-35 is the logical choice as it enables maximum circuit gain to be obtained. Even when used with high gain intermediates, there was no trace of instability. Compared to the 6G8G, which also may be used in this position, it has a transconductance value of some 1800 microhms, whereas the Gm of the 6G8G is only 1100 microhms.

Apart from this difference in gain, the operating conditions of these two valves are very similar and if using the 6G8G the only change necessary would be to increase the bias resistor to 350 ohms. However, one point to bear in mind is that these two valves are not interchangeable for, although both are fitted with octal sockets, the sockets connections are entirely different.

Diode Connections

As this valve is fitted with two diodes, it conveniently allows the detection to be carried in the r-f section of the receiver. The usual form of diode detection is used, with the output being obtained across the .5 meg resistor connected in the cathode circuit. To simplify the connections for the gramophone pick-up it will be noticed that the diode load is a fixed .5 meg resistor, with the volume control being connected in the grid circuit of the 6SJ7-GT.

The second diode is used for the AVC control, and to provide maximum gain on weak signals this is provided with a small delay voltage. The control voltage is obtained from the plate to the I-F amplifier by means of the .0001 mfd condenser, and the resulting rectifier voltage is applied to the first I-F-T and converter through a simple series network circuit.

The audio voltage obtained from the diode load is applied to the grid of the 6SJ7-GT audio amplifier through the .02 mfd tubular condenser. Although a 6J7 could also be used in this position, the former type was preferred since it obviated the necessity for a long grid lead above the chassis to the grid cap, and ensured all leads under the chassis were a minimum length.

It should be remembered that the leads to the volume control must be

PARTS LIST

- 1 Chassis, 7½ x 10½ x 2.
- 1 Cabinet 24x 12x 10 inches.
- 1 2-gang /MSP tuning condenser.
- 1 Tuning dial to suit gang.
- 1 Dual Wave coil unit (Slade).
- 2 455kc. I.F.T's.
- 1 Power transformer, 80 ma., 285v H.T. 6.3v at 3 amps, 5v at 2 amps.
- 1 Filter choke.

CONDENSERS

- 2 25 mfd electrolytic.
- 3 8mfd electrolytic.
- 1 .25 mfd tubular.
- 5 .1 mfd tubular.
- 3 .05 mfd tubular.
- 1 .02 mfd tubular.
- 1 .002 mfd mica.
- 2 .0001 mfd mica.
- 1 .00005 mfd mica.

RESISTORS

- 2 1.5 meg. ½ watt.
- 2 1 meg ½ watt.
- 1 .5 meg ½ watt.
- 1 .25 meg ½ watt.
- 2. .1 meg ½ watt.
- 1 .05 meg ½ watt.
- 1 .04 meg 1 watt.
- 1 .03 meg 1 watt.
- 1 800 ohm 1 watt.
- 1 300 ohm 3 watt wire wound.
- 2 250 ohm 3 watt wire wound.
- 1 .5 meg potentiometer.

VALVES: ECH-35, EBF-35, 6SJ7-GT, 6V6-GT, 5Y3-GT.

SPEAKER: 7in. Permag matched to 6V6-GT.

SUNDRIES: 5 Octal sockets, 1 miniature; 4-pin socket, 4 terminals, and plug; 3 knobs, hook-up wire, braided wire, nuts and bolts.

made with shielded wire, to prevent any possibility of hum pick-up or audio instability.

This 6SJ7-GT valve is used as a pentode audio amplifier with a .25 meg plate load, 1.5 meg screen resistor, and 800 ohm cathode bias resistor. These circuit constants are those recommended by the valve manufacturers for this stage and will be found quite satisfactory.

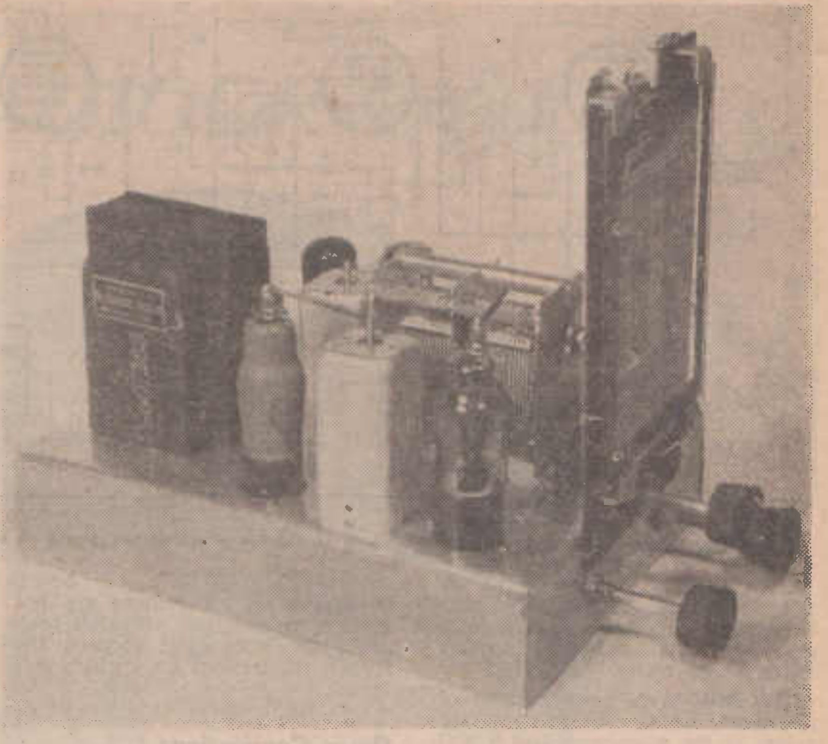
The output from this valve is then taken to the 6V6G output valve via the .05 mfd condenser. This should be a good quality coupling condenser with a voltage rating of at least 600 volts.

The obvious choice for the output stage is the 6V6-GT, although once again there are others which can be used here with equal success. In the case of an EL3-NG, the cathode bias resistor should be reduced to 150 ohms, whilst if a 6F6-G or 42 are used, then this resistor should be increased to 400 ohms. In all cases the speaker transformer should be increased to 7000 ohms, for correct matching.

No Tone Control

To provide the receiver with a balanced appearance, it will be noticed that the only controls provided are volume, tuning and wave change. In place of the tone control, a .002 mfd condenser has been wired across the speaker output terminals, and this in conjunction with

SIDE VIEW OF RECEIVER



Another view of the completed receiver.

the negative feedback provided by the 1.5 meg resistor will be found to provide a satisfactory tonal balance. However, if desired the value of this condenser can be experimented with using values from .001 to .006 mfd to obtain the required tonal response. In addition the 1.5 meg resistor can be changed to enable varying amounts of feedback to be obtained. Without this resistor it will be found that there is a marked increase in gain but at the same time the distortion factor will rise. Here again it is just a matter of experimenting to suit one's own tastes.

The power supply is conventional and consists of a 285v 80 ma power transformer, a filter choke and a 5Y3GT rectifier. The single filter in conjunction with the 2 8mfd electrolytics was found quite satisfactory in reducing the hum to a low level. In cases where this may not be sufficient, then another filter choke and condenser can be added, although in our case we did not consider this refinement essential.

Components Used

In this particular receiver, the recently released Slade Dual wave unit has been used, and consequently it should be noted that to ensure correct tracking, an AWA gang and suitable dial glass must be used. In the case of other dual wave units, a Stromberg Carlson gang is satisfactory. However, when purchasing the coil unit make sure of this point, as the tracking of either gang is not identical. Unless this is done, it will be found that the station locations will not be received exactly as marked on the dial glass, when the receiver is being aligned.

In addition to providing positions for the broadcast and short wave bands, this wavechange switch has an extra position to enable the gramo unit to be switched in without the necessity for another separate switch. This will be found very convenient as it now allows all controls to be mounted on the front of the chassis.

Gramophone Unit

As regards the type of gramophone motor to be used, this is left to the individual constructor. In our particular case one of the newer automatic record changers was used, but many readers may not wish to go to this extra expense. Consequently it will be found there are many makes and varieties of units at present available, and that the cabinet will accommodate most of these. The main point to watch is that the motor board is correctly cut out in cases where a motor template may not be provided.

COIL UNIT CONNECTIONS

Yellow Lead—Aerial.
Green Lead—Grid.
Black Lead—AVC.
Brown Lead—Osc. Grid.
Blue Lead—Osc. Plate.
Red Lead—Osc. B Plus.
White Spot—AVC.

Short shielded lead connects to "hot" side of Volume Control.

Long shielded lead connects to pickup terminals.

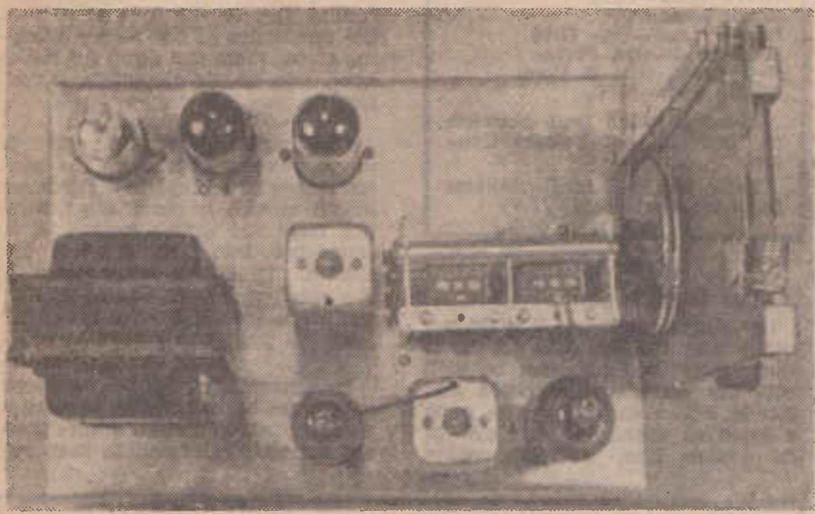
Layout Details

The chassis measures 7 x 10½ x 2 inches and the location of most components on this can be seen from the various photographs and chassis layout diagram. The gang is mounted slightly to one side of the centre line, with the wave change switch fitting on the right-hand side. The converter valve is mounted alongside and to the left of the tuning gang. Immediately behind this is the first IFT, with the remainder of the stages following across them and down the right-hand side of the chassis in a normal manner.

This arrangement, it will be found, enables all leads in the various stages to be kept to a minimum length as well as permiting the input from the gramo-section to be connected into the side of the chassis. To enable easy access to the receiver chassis this connection was made by means of a miniature four pin plug and socket.

In mounting the components commence by bolting the sockets in position, taking care to ensure these are correctly orienated to keep any

TOP CHASSIS DETAILS



This top view of the receiver clearly shows the receiver layout.

plate and grid leads as short as possible. Place the i-f transformers in their correct positions, once again checking that the lugs are in the position to ensure short leads. Failure to do this will result in long untidy leads, and possible instability troubles.

Bolt the tuning condenser in the position indicated, making sure the leads from the stator lugs are soldered in position and passed through the chassis holes. At this stage the dia˜ should be slipped into position and the tuning condenser adjusted in height as required. Mount the power transformer at the rear of the chassis, with the filter choke fitting into position underneath the chassis.

The dual wave unit is mounted on the right hand of the chassis, and it will be found that the leads can be made direct to the gang condenser and converter valve socket without any difficulty. The volume control is mounted in the left-hand hole.

Wiring Up

The wiring up should not cause any undue difficulty. First of all, fully wire up the power supply section, following the supplied colour code f.: the connections. Then taking each stage in turn, wire in the necessary resistors and condenser, cutting the pigtails short as they are mounted as close as possible to their respective circuit. Any necessary earths can be provided by placing solder lugs under a few of the valve sockets bolts and connecting these up with a length of tinned copper wire.

D/W Unit Connections

The dual wave unit is usually supplied with the colour code indicating the correct connections, but for the sake of completeness, they are included in the text. As the gramo switch is also provided on this unit, the two shielded leads should be wired in as indicated. The long lead is taken to the pickup input, making sure the outer braid is earthed whilst the short lead is taken to the "hot" side of the volume control.

The speaker, in our case a 7-inch Amplion, was screwed directly on to the cabinet with the necessary connections being made via a plug mounted on the side of the chassis.

★

Alignment Procedure

The final step in the construction, after all connections have been checked is to accurately align all the tuned circuits. Although these have been given previously, the following brief instructions are included as a guide.

Unless an oscillator is being used, the i-f stages should not be touched during the initial alignment procedure, since it will be found that these are adjusted to practically the correct frequency.

Commence by tuning in a station at the high frequency end of the band, and adjust the aerial trimmer for maximum output. Next tune in a station at the low frequency end of the band, and adjust the aerial coil slug for maximum volume. Loosen off the dial drum and adjust the pointer to register correctly on the known station. 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 aerial trimmer, and repeat low frequency adjustment.

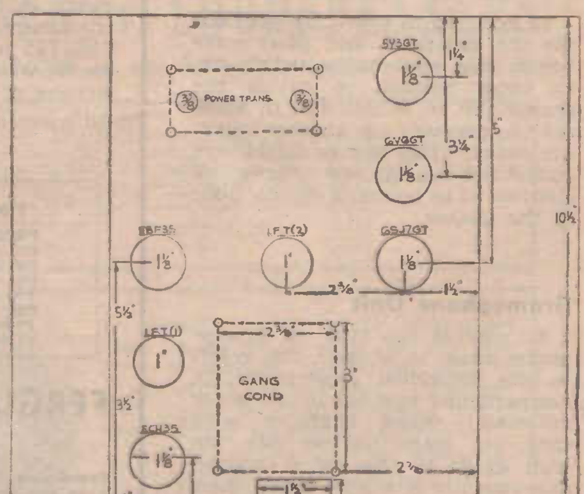
Then if the correct coils, gang and tuning scale are being used the various stations should be received at the positions indicated on the dial glass.

S/W. Bands

The alignment of the short wave band is carried out in a similar mann:-. Since there is no low frequency adjustment necessary on

(Continued on page 46.)

CHASSIS LAYOUT



This diagram shows the main dimensions for those who may wish to cut their own chassis.

Basic Electricity and Magnetism

This article points out the difference between lines of force and lines of induction and deals with the meaning of potential.

LINES of electric force and lines of electric induction differ in *both electrical* and *mathematical* significance. In the electrical sense a line of force indicates a state of stress, while a line of induction indicates a state of strain.

In the mathematical sense, a line of force indicates direction only and has *no quantitative meaning*. We have already noted that an infinite number of lines of force can be traced out in an electric field and this characteristic deprives lines of force of any useful significance that quantitative meaning could give them. Further, the direction of a line of force is closely associated with *length* because it seems logical to think of the point charge which traces it as moving *along* the field.

On the other hand, a line of induction has *both* directional and quantitative meaning. We have seen how the amount of induction at any point in an electric field depends on the *quantity* of charge induced per sq. cm. or unit area, and that there is unit induction at a point unit distance from unit charge. It is logical to represent unit induction with one line of induction per unit area, and this notion, in turn, gives rise to the idea that lines of induction are closely associated with *area* in contradistinction to lines of force which are associated with length.

Since space has three dimensions and can support electric fields it follows that electric fields must be three dimensional in character. They must have length, and they must have area.

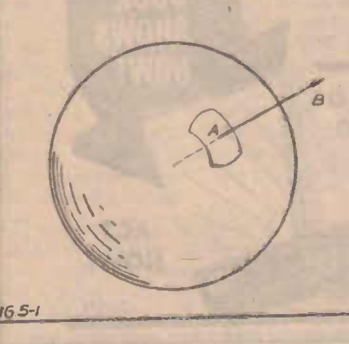


FIG 5-1

If we multiply length by area we get volume, and if we assign appropriate electrical qualities to length and area, we can calculate the "volume" of an electric field. We will see shortly that this "volume" actually represents the *amount of energy* stored in the field.

The Induction Concept

Lines of electric induction, commonly called lines of *electric flux*, have quantitative meaning so that a definite number of them must be associated with unit quantity of charge. We have seen that the charge or flux density at a distance of d cms. from a charge of Q e.s.u. is

$$\frac{Q}{d^2}$$

Now, an isolated charge in space must establish a uniform field in *all directions*. We can only think of a field in space as being unrestrained, and, the only possible form an unrestrained field in space can have is a spherical one. Hence, we can imagine an isolated charge Q being at the centre at an infinite number of spheres. Let us consider one particular sphere having a radius of cms. as shown in Figure 5-1.

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

The flux density, or the flux per sq. cm. at the surface of this sphere is Q/d^2 lines per sq. cm., and since flux must penetrate the surface of the sphere in all directions, the total flux produced by Q is evidently the flux per sq. cm. multiplied by the surface area of the sphere. The surface area of the sphere is:

Surface area

$$= 4_\pi d^2 \text{ sq. cms.} \qquad \ldots.5.1$$

Flux per sq. cm.

$$= Q/d^2 \text{ lines per sq. cm.} \qquad \ldots.5.2$$

So that total flux

$$= 4_\pi d^2 \times \frac{Q}{d^2}$$

$$= 4_\pi Q \text{ lines of flux.} \qquad \ldots.5.3$$

FIG 5-2

And, for the particular case when Q is of unit value, the total flux is:

Total flux $= 4_\pi \times 1$

$$= 4_\pi \text{ lines of flux} \qquad \ldots.5.4$$

Hence, according to Equation 5.4, 4_π lines of flux are produced by unit electric charge, and this result confirms the abstract nature of this idea. The numerical value of 4_π is a little more than 12.56 and it is clearly impossible to endow 0.56 of a line of flux with any physical qualities.

The Relationship Between Lines of Force and Lines of Flux

Lines of force and lines of flux are related mathematically. Equation 4.3. established the fact that

$$E = \frac{Q}{K.d^2} \qquad \ldots.4.3$$

and, according to Equation 4.6, the induction D, at any point, is

$$D = \frac{Q}{d^2} \qquad \ldots.4.6$$

and if we divide Equation 4.6 by 4.3 we get

$$\frac{D}{E} = K \qquad \ldots.5.5$$

so that $D = K.E \qquad \ldots.5.6$

Thus the amount of electric strain or deformation D, caused by an electric field stress, E, depends on the dielectric constant K of the material supporting the field. Equation 5.6 is mathematical confirmation of the idea we developed when we used the analogue of rubber and steel columns between two light rules. The higher the dielectric constant so more readily is the material strained.

Reference to Figure 5-1 indicates another important relationship. If we mentally explore the field *along* the line AB we are exploring it in the same direction as that traversed by a free positive charge. On the other hand, we can look *across* the field. From this viewpoint we see lines penetrating the area of the sphere. The line AB, being a line of force, represents field *intensity;* looking across AB and the area it penetrates we get the idea of field *density;* so many lines per sq. cm.

From this viewpoint, field intensity is associated with length, and field density is associated with area. Lines of force differ intrinsically from lines of flux insofar as length differs intrinsically from area.

The Perverse Positive Charge

We are going to imagine a point charge with an obstinate streak which impels it to force its way contrary to the direction wherein the field entices it. Such a charge moving against the field is clearly working, and the amount of work it does is equal to the product of the force against which it moves and the distance that it travels.

Thus, work done by charge
= Force x distance.
The force = Field intensity at point where charge is.
The field intensity due to Q e.s.u. of charge at a distance d cms. from charge is:

Field Intensity—

$$E = \frac{Q}{K.d^2} \quad \ldots.5.7$$

So that Force in dynes

$$= \frac{Q}{K.d^2} \quad \ldots.5.8$$

The distance through which the charge must force its way to reach Q is d cms.
Hence, work done by charge

$$= \frac{Q}{K.d^2} \times d$$

$$= \frac{Q}{K.d} \text{ ergs.} \quad \ldots.5.9$$

(You will recall that when a force of one dyne moves through a distance of one centimetre, the work done is one *erg* of energy.)

Since energy is never created nor destroyed *the work done by the perverse positive charge must be equal to the energy stored in the electric field.*

The Potential Concept

If two bodies at different temperatures are in contact, heat will flow from the body at the higher temperature to the one at the lower temperature. Similarly, if water in two tanks is at different levels and the tanks are connected at their bases by a pipe, water flows from the tank having the higher level of water to the tank at the lower level.

In electricity, the word *potential* has the same meaning as temperature and level in the simple examples just considered. It is important to note that neither the quantity of heat nor the quantity of water is involved; merely the intensity of heat in one case and the level of the water in the other.

In a similar fashion, the potential of an electrified body depends on the intensity of the field established by the body and *not* on the quantity of charge carried by the body. The field intensity, for a given quantity of charge, depends on the *size* and *shape* of the body. Thus, if an inflated balloon is electrified with Q e.s.u. of charge, we can imagine the charge distributing itself uniformly over the balloon's surface. If the balloon is slowly deflated, the charge must redistribute itself over a smaller area so that the density of charge per unit area must obviously increase, so that we will have more lines per unit area with a corresponding increase of field intensity.

The *field intensity increases* as the *area of the balloon decreases.* If the same quantity of charge was given two balloons inflated to the same degree, and then one balloon was slightly deflated, the smaller balloon would establish a more intense field than the larger one, and if the balloons were connected with a conductor, electricity would flow from the smaller balloon to the larger one. The smaller balloon, because of its ability to promote a flow of charge towards the larger one, is said to be at a higher *potential* than the other one.

Absolute Potential

In the same way as the temperature of melting ice is arbitrarily accepted as zero temperature, and sea level is taken as zero water level, so the earth is arbitrarily regarded as being at zero potential. When we speak simply of the potential of a body we imply that its potential is so many units above or below that of earth potential.

A body positively charged promotes a flow of charge to the earth when connected to it by a conductor and is said to be *above* earth potential. A negatively charged body is *below* earth potential and charges flow from the earth to it if it is connected to the earth.

The *absolute potential* of a body is thus its electrical condition which decides the direction in which electricity will flow when the body is electrically connected to the earth.

The Concept of Potential Difference

Since the potential of all electrified bodies is measured with respect to the earth's potential, it follows that the potentials of two electrified bodies can only be compared with reference to the potential of the earth, so that we must express the potential between two bodies as a *potential difference.* This idea will clarify when we consider the measurement of potential. You are doubtless familiar with the term, potential difference, but perhaps you have not realised before the full significance of it.

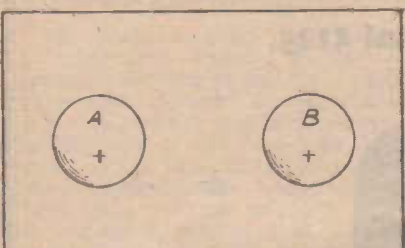


FIG 5-3

The Measurement of Potential and Potential Difference

If two electrified bodies at different absolute potentials are electrically connected electricity will flow from the body at the higher potential to the one at the lower potential. Thus if A in Figure 5-2 is at a higher potential than B, charge will flow along the conductor C between A and B. The body A loses charge while the body B gains it, so that the density of charge on A decreases while the charge density on B increases.

It is clear that in order to promote a flow of charge to B, the body A must compel charges to move *against* the repulsive forces of the charges accumulating on B, and hence in *moving against* a force through a distance the charges from A must be *doing work,* and the amount of work they do will depend on the difference of potential between A and B.

The idea of the charges doing work gives us a means whereby we can measure the potential difference between two bodies because to do this we merely have to define potential difference in terms of the work done by the charges. To simplify our definition we use the idea shown in Figure 5-3, wherein the bodies A and B are assumed to each carry unit quantity of positive charge. Now, to move the charge B to A will require energy and for our definition we assume the energy to be supplied by some *external source.* We can now define unit potential difference.

If the energy required to move unit charge from one point to another is one erg, then the potential difference between the points is one e.s.u. of potential.

It is important to note that although the potential difference between two bodies is measured in terms of the work done in moving unit positive charge between the bodies potential difference is NOT a unit of work; *neither* is it a force, *nor* a quantity. It is merely the electrical condition of a body, which can be thought of in terms of work.

Practical Units of Potential Difference and Quantity

We have so far used only electrostatic units of quantity and potential, and neither of these units are used in practice because the e.s.u. of quantity is too small, and the e.s.u. of potential is too large. Later it may be possible to establish the relationships between e.s.u. and practical units. Meantime we can accept the fact that the practical unit of quantity is the *coulomb* and is equal to 3×10^9 e.s.u. of quantity. The practical unit of potential difference is the *volt* and this is equal to $\frac{1}{300}$ of an e.s.u. of potential.

The definition of potential difference must be modified when practical units of potential difference, quantity, and work are involved. (You will recall that in Part 2 of this series it was mentioned that the *joule* was the practical unit of work in the electrical system and is a little less than the amount of work done in lifting a lb. weight through nine inches.) The modified definition of potential difference is:

If one joule of work is done in transferring one coulomb of electricity between one point and another the difference of potential between the points is one volt.

To express this definition mathematically we have only to realise if we do two joules of work the p.d. (potential difference) is two volts, or

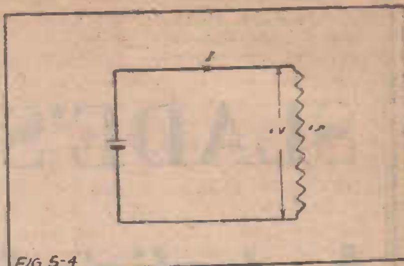


FIG. 5-4

if we move, say, 10 coulombs against a potential of 10 volts we will evidently do 10 x 10 or 100 joules of work. Hence, the work, W, is

$$W = EQ \qquad \ldots .5.10$$

where E is the potential difference in volts, and Q is the quantity of electricity transferred in coulombs.

The Importance of the Potential Difference Concept

In Part 1 of this series it was emphasised that electricity must be regarded as a form of energy if we intended to establish any kind of relationship between electricity and other forms of energy. It was further argued that to establish these relationships it was necessary to assign to electrical terms meanings which implied the energetic character of electricity.

Although we have not as yet considered electric current nor resistance, it is pretty safe to assume that you are familiar with both these terms and know that the unit of current is the ampere and the unit of resistance is the ohm. Further, you will doubtless understand the simple circuit shown in Figure 5-4, where a one-volt battery is connected across a resistance of one ohm.

Under these conditions a current of one ampere will be maintained in the resistor, and since an ampere is equivalent to one coulomb per second it is clear that the battery forces one coulomb of electricity through the resistor every second. The battery is doing work and we can use Equation 5.10 to find the amount of work that the battery does.

In this case the p-d. is one volt, and the quantity is one coulomb every second, so that every second the work, W, done by the battery is:

$$\begin{aligned} W &= 1 \times 1 \text{ Joules.} \\ &= 1 \text{ joule of work every second.} \\ &= 0.7375 \text{ ft. lbs. of work every second.} \end{aligned}$$

This direct relationship between ft. lbs. of energy and volts not only clarifies our ideas regarding electricity, but it is also extremely useful in establishing relationships between electricity and other forms of energy.

In the next article we will deal with capacitors and show how the energy concept enables us to not only calculate their capacitance but also get a very clear picture of why and how a capacitor works in practical applications.

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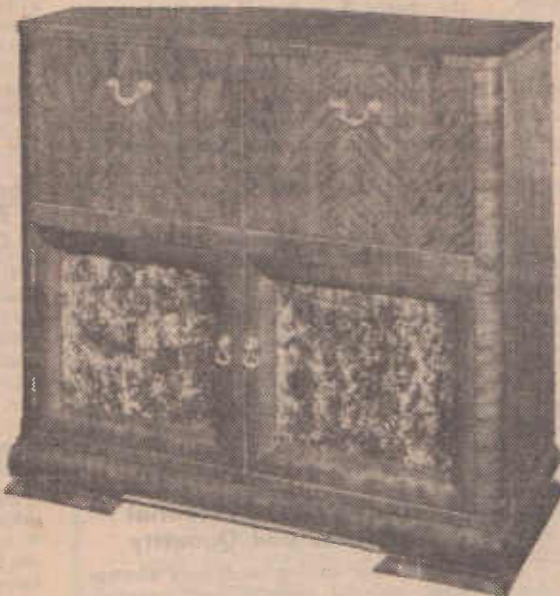

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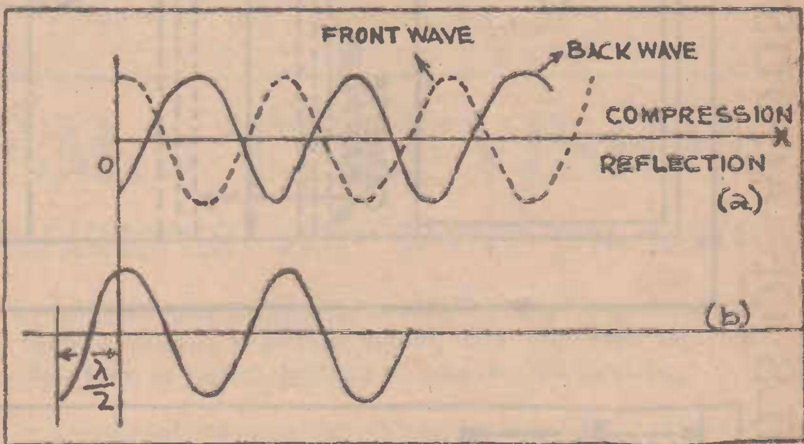
SPEAKER LABYRINTH FOR 3 WATT AMPLIFIER

In this second article the author details the construction of a practical acoustical labyrinth for use with the small amplifier described in our last issue.

The speaker used with this amplifier is a G 12 permagnetic type and is mounted in an acoustic labyrinth of which a centre-sectional side elevation is shown in Fig. 1. The function of the labyrinth is to apply mechanical loading to the cone so as to help provide a limited amount of matching between the cone impedance and that of the outside air. A more important function, however, is the fact that it acts as an acoustic phase inverter at some frequency determined in the design.



This diagram illustrates the effect or phase relationship between the front and back waves.

Movement of Cone

We shall consider this latter function first. Suppose we have a speaker operating in free air. As the cone moves forward a compression is set up in front, and a rarefaction at the back of the cone and vice-versa as the cone moves backward. These compressions and rarefactions leave the cone with the velocity of sound (approx. 1100 ft/sec.), and it is clear that if a compression and rarefaction of the same intensity arrive at a point at the same time, there will be complete cancellation of sound at that point.

On the other hand, if a compression (or rarefaction) from one side of the cone arrives at a point at the same time as the preceding or succeeding compression (or rarefaction) from the other side of the cone there will be complete reinforcement of the two waves. Between these limits there will be partial cancellation or reinforcement depending on the phase relationship of the back and front waves. This phase relationship is determined by the difference in path length travelled by each.

Referring to fig 2, suppose the speaker at O is emitting its front wave in the direction OX. Let the dotted curve represent the instantaneous air pressure at the various distances from O along OX due to a sound wave of some particular frequency emitted from the front of the cone. The distance between points having the same instantaneous air pressure will be equal to the wavelength of the sound emitted.

$$\lambda = \frac{\text{velocity}}{\text{frequency}}$$

Now the back wave is 180 deg. out of phase with the front wave, so that if the path length from the back of the cone to the front is small compared with the wavelength we get a considerable amount of cancellation as illustrated in Fig. 2a. for the air pressure at any point along OX will be the resultant of that due to each of the two sound waves nearly 180 deg. out of phase. However, if we delay the back wave by passing it through a labyrinth equal in length to half a wavelength before it gets to the plane of O, it is now in phase with the succeeding half-cycle of the front wave at O as shown by the curve of Fig. 2b.

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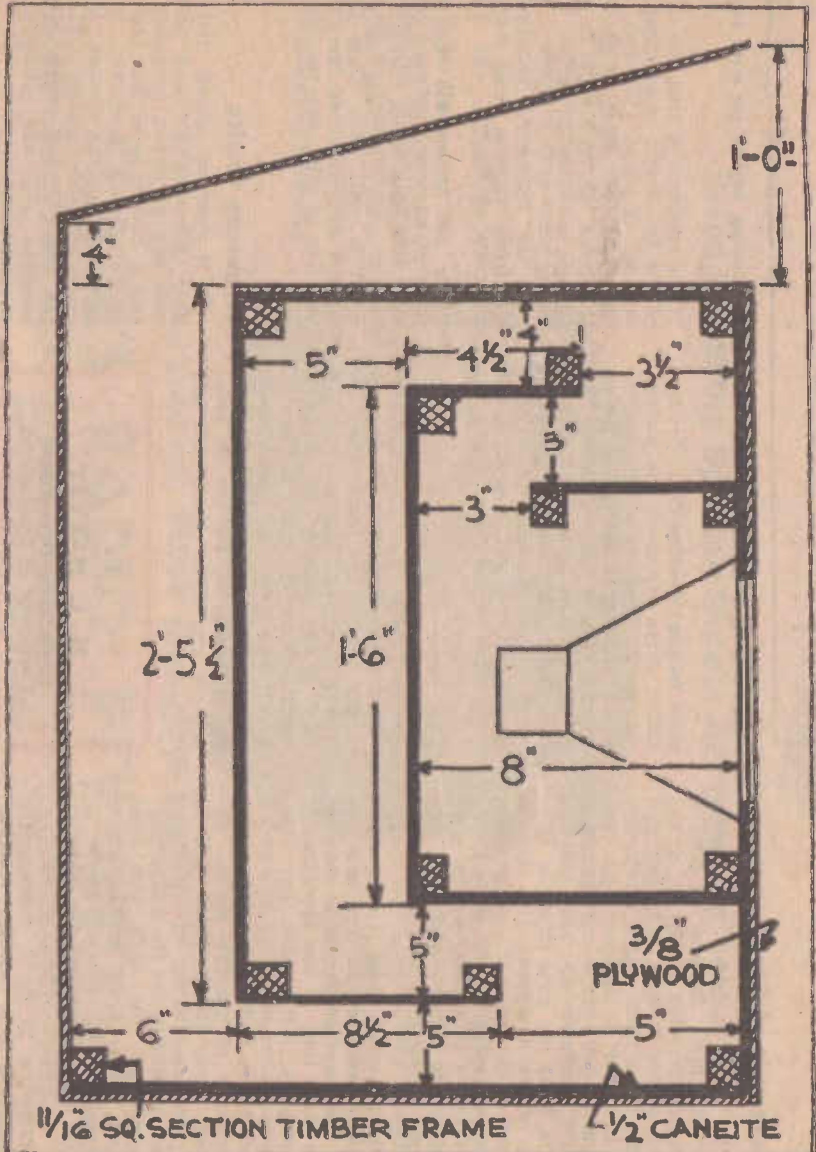
The two waves will then reinforce at all points outward from O since they both travel with the same velocity. The opening of the labyrinth is sufficiently close to the speaker to regard the waves as being able to mix near the plane of O.

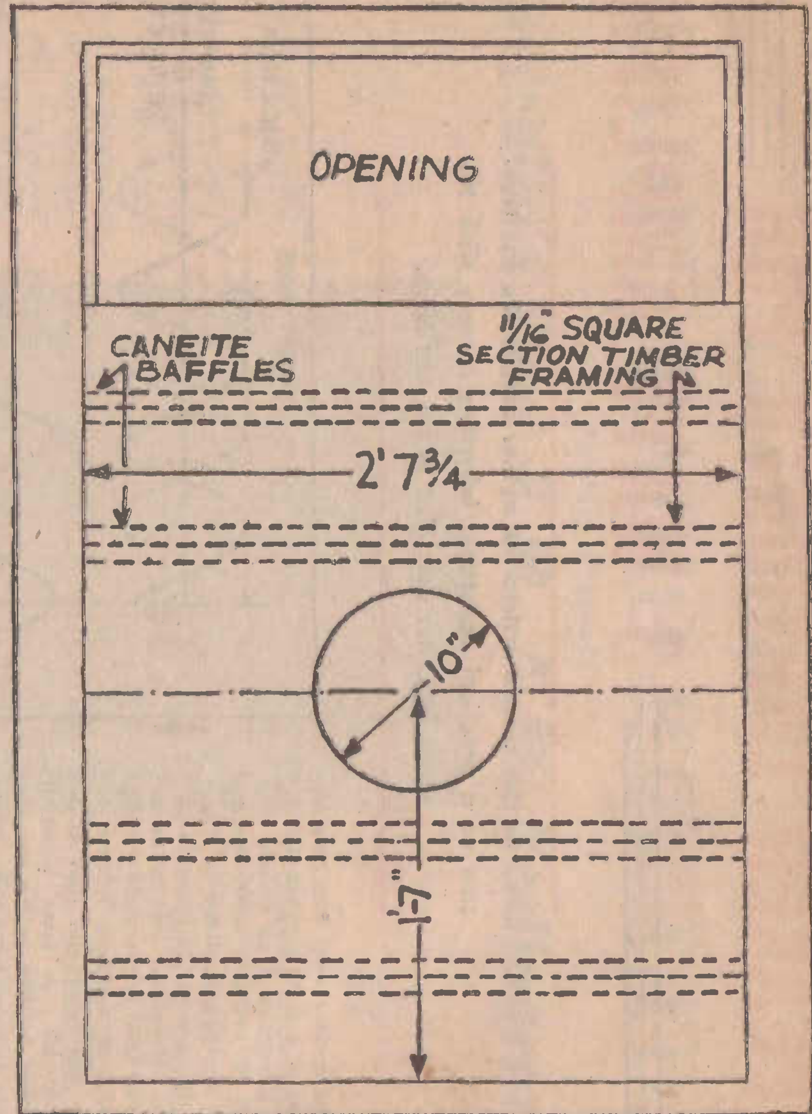
Frequency Choice

It is clear, of course, that complete reinforcement can occur at only one particular frequency, and this is chosen to be just below the bass resonant frequency of the speaker where the speaker response drops off fairly sharply. This has the effect of broadening the bass resonant peak and giving a more natural bass.

CONSTRUCTIONAL DETAILS OF ACOUSTIC LABYRINTH



The main dimensions necessary for constructing the labyrinth are detailed in this sectional side elevation.



Front elevation of the acoustic labyrinth.

In the labyrinth under discussion, 50 cycles was chosen as the full-reinforcement frequency, and the total length of air column from the back of the cone to the opening at the front was made 11 feet, which corresponds to half a wavelength for 50 cycles. (This need only be approximate, hence it is quite in order to take 1100 ft/sec as the velocity of sound).

It will be observed that partial reinforcement occurs in gradually decreasing amount down to 25 cycles, for which frequency 11ft. is a quarter wavelength, which means that the back wave is 90 deg. out of phase with the front wave at the plane of O (Fig. 2). The same thing occurs from 50 to 75 cycles, at which latter frequency 11ft. corresponds to ¾ wave length.

Effect on Low Frequencies

Now a labyrinth is intended to make use of the back wave at low frequencies only and to offer increasing absorption to the back wave as the frequency increases. This is accomplished by lining the interior of the air column with sound absorbent material and by folding the air column to provide as many changes of direction as is practically possible throughout its length.

It is well known that the lower the frequency the less is the reflection and absorption suffered by a sound wave in following a tortuous path. Hence if we make the path of the back wave very tortuous and highly absorbent we shall prevent all but the desired low frequencies from reaching the opening of the labyrinth in any appreciable strength. The higher frequencies are radiated from the front of the cone only, since this works directly into the open air.

Impedance Matching

On the matter of matching the cone impedance to that of the outside air, this can only be done completely by means of a properly designed exponential horn with its throat correctly matched through an air chamber to the cone impedance. This can be done quite easily in the case of an 8-inch speaker, but where a 12-inch speaker is used, it is much more difficult to match the cone impedance to a sufficiently small throat area to keep the exponential horn of reasonable size.

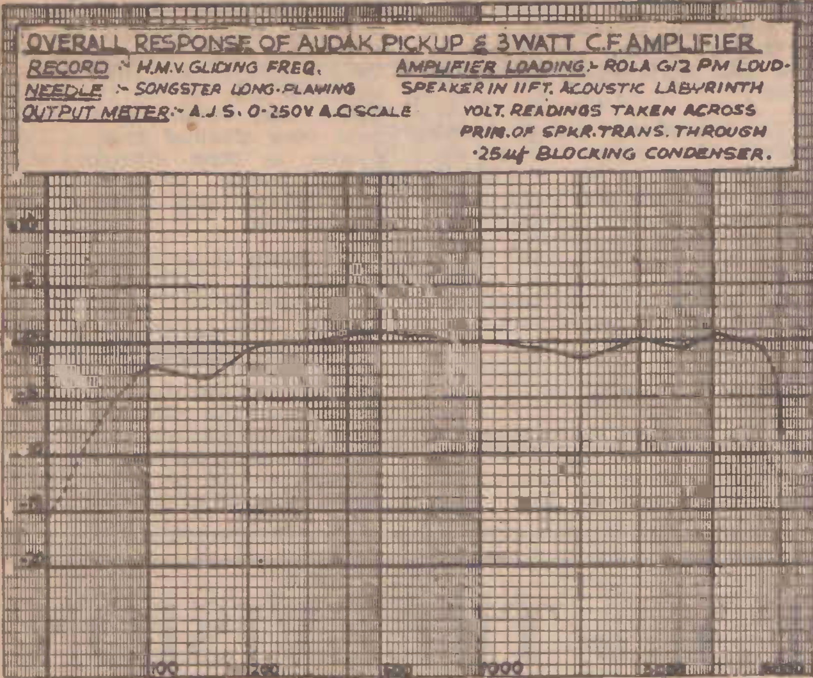
In the case of the ordinary acoustic labyrinth no attempt is made to provide accurate impedance matching, and the dimensions of the air column are therefore much less critical than for the exponential horn. There is one important point, however—the cross-sectional area of the air column should not be less than the projected area of the cone.

The rate of expansion of the air column cross section does not appear to be very critical, and can be varied over fairly wide limits to suit particular practical requirements. The opening of the labyrinth should be made as large as possible, but of course, there are practical limitations to this, especially where the labyrinth is to be an article of furniture in the house.

Labyrinth Details

In the labyrinth shown in section in Fig. 1, the air column occupies the full width of the cabinet (2ft 6in.) throughout its length and varies from 3in to 12in. in width. Thus the cross sectional area at the speaker end is 90 sq. inches, and the rate of expansion is not to any particular law. It might be mentioned that equally good results have been obtained from a 12in. speaker in three different labyrinths having widely different rates of expansion of air column cross section.

As regards constructional details, the labyrinth under discussion is made of ⅜in. plywood lined with ½in. caneite. The baffles are of ½in. caneite stiffened with 11/16in. square section timber, and the whole structure is made rigid. The front of the cabinet is removable to give access to the speaker. All air column discussions shown in Fig. 3 are internal, and do not take into account thickness of material.



This graph shows the overall response of the amplifier.

Performance

As a check on the performance of the whole system, a frequency response test was taken with the amplifier on loudspeaker loading. Usual practice is to put the amplifier on resistive loading and take voltage readings at the secondary of the output transformer. In this particular case, however, the secondary of the output transformer was not accessible without opening up the labyrinth. Readings were th refore taken across the primary of the speaker transformer and so do not take into account losses in the speaker transformer, or speaker characteristics other than those reflected into the primary.

The response curve, together with details of test conditions is shown in Fig. 4. Below 100 c/s it was difficult to take measurements, owing to the rapid change of frequency on the gliding frequency record. However, the reading of —15.5 .lb at 50 cycles is probably correct, showing that more equalisation is necessary for the pick-up. The fact that better bass response is obtained on radio programmes suggests that the fault lies in the pick-up rather than in the amplifier.

Uniform Response

Over the rest of the range the response is reasonably uniform, particularly in view of the fact that the curve of Fig. 4 includes not only the amplifier, but also the pick-up and to a minor extent the speaker. Owing to the good output voltage regulation of the Cathode follower, the voltage across the primary of the speaker transformer will not be greatly affected by variations in speaker impedance with frequency.

While not wishing to enter into the merits or demerits of cathode followers as opposed to plate-loaded amplifiers, the amplifier under discussion appears to be well up to the standard of the pick-up and speaker employed, and the combination gives very pleasing reproduction of good commercial recordings. However, it is felt that a considerable improvement in clarity of production of records having a high surface noise can be effected by incorporating a filter to cut off at 5500 cycles. Provided this cut-off is sufficiently sharp, it is surprising how little the apparent brilliance is affected by it.

As regards the acoustic labyrinth, it would be almost impossible to carry out an exact mathematical analysis of the conditions pertaining to the air column. Hence the dimensions given here were arrived at by practical experiment, and from experiments, the air-column dimensions do not appear to be at all critical. Somewhat better low frequency response has been achieved with a layer labyrinth using a Jensen M20 auditorium speaker, but in both cases the results were judged qualitatively by ear, as it has not been possible to make any direct acoustical measurements.

Checking Noisy Valves

Frequently valves that have been checked and found noisy can be made serviceable again by the simple expedient of resoldering the various pins. The noise in many valves is simply due to a high resistance or loose contact at one of the valve prongs, and can be cured by resoldering the tip. If the valve is also fitted with a grid cap, make sure this is also included in the check up, with the soldering iron.

MICROGROOVE RECORDINGS

by ALBERT PREISMAN

Considerable interest has been aroused among record enthusiasts since the announcement by Columbia of the new long-playing records. This article details some of the major recording requirements and difficulties, and how they have been overcome in the production of these recordings.

The announcement by Columbia of a new long-laying microgroove record has aroused considerable interest not only among record enthusiasts, but among radio engineers as well. Several technical questions arise covering the ability of this record to compare with the ordinary records on the basis of fidelity as well as playing time, and so a general review of recording will be in order. Once this is done, the advantages of the microgroove recording can be more readily appraised.

Recording Requirements

There are a number of requirements that have to be met by a recording system, and these requirements in general compete with each other. They are as follows:

1. **Frequency response.**
2. **Volume range.**
3. **Playing time.**
4. **Signal-to-noise ratio.**
5. **Nonlinear distortion.**
6. **Record life.**

The dominating factor is surface noise. If we assume that this is determined mainly by the record material (perhaps also by the recording matrix), then we can see how this affects the various requirements given above.

Suppose the record material is coarse in texture and therefore noisy. If we wish to keep the signal-to-noise ratio above a certain value, then we are limited as to the lowest level which can be recorded; that is, as to how small an excursion the stylus can make.

Suppose next we wish to have a certain volume range. Then the excursion corresponding to the loudest signal will have to be so

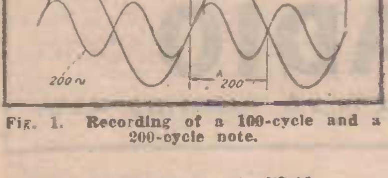


Fig. 1. Recording of a 100-cycle and a 200-cycle note.

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This record changer is a typical example of those developed for use with the long-playing records. Equipped with a special tone arm, this unit will handle either 10 or 12 inch records, at 33-1/3 r.p.m. turntable speed, thus giving up to four hours on continuous playing with a single loading.

★

many times as great as the smallest excursion. For example, if the volume range is to be 40 db, then the largest excursion must be 100 times the smallest excursion, and this in turn means that the grooves must be spaced sufficiently far apart so that two adjacent grooves will not cut into each other.

The groove spacing, for a given speed, and record size, determines the playing time; the greater the spacing, the less the playing time. So we see that the greater the surface noise, the less is volume range and/or the playing time.

Effect of Frequency

Actually, however, the situation is not quite as simple as just outlined. The frequency response or band width enters very definitely into the discussion. The reason is that the higher the frequency response, the greater is the surface noise that is picked up; indeed, the surface noise rises very rapidly with increase in band-width at the high end. Tests indicate that surface noise begins to be prominent at about 3000 c.p.s. and rises rapidly with frequency at least up to 20,000 c.p.s.

Consequently, the higher the frequencies to be recorded, the greater must be the minimum recording level, and hence the less must be either the volume range or the playing time. Once again, reduction in surface noise permits either an increase in frequency range, volume range, or playing time, or the advantage may be prorated over all three.

Record Speed

The next question that may arise is, **"How does record speed affect the factors mentioned?"** To answer this question, we must consider the difficulties encountered in recording the higher frequencies. In Fig. 1 is shown the recording of a 100-cycle and a 200-cycle note. They are assumed to be of equal loudness; in this case the amplitude of the 200-cycle note must be half of the 100-cycle note. This is because if the pickup generates a voltage proportional to the velocity of its stylus, then the amplitude of excursion must decrease as the frequency increases in order that the total distance covered by the stylus in one second, or velocity, be independent of the frequency.

The wavelength, or length of one cycle along the record groove, of course, also varies inversely as the frequency, and directly as the speed. As a result, the curvature of the groove increases with frequency; or in the language of the calculus, the radius of curvature becomes smaller as the frequency and/or the loudness of the tone is increased, and also as the record speed is reduced.

As a consequence, a loud high frequency tone will be recorded as such a sharply curved wave that the ordinary reproducing stylus may be too thick to track in the groove. Fortunately, however, the sounds encountered in nature have such weak high-frequency components that in itself the amplitude of the component would not produce sufficient curvature to cause any trouble in tracking.

Pre-emphasis

However, it is customary to peak the high-frequency response of the recording system by as much as 20 db or more over the low-frequency response, in order to improve the high-frequency signal-to-noise ratio, particularly in view of the increase in surface noise power with frequency. This is similar to the use of pre-emphasis in FM broadcasting, and the reproduction amplifier is given a drooping high-frequency response similar to the de-emphasis circuit in an FM receiver.

It is the pre-emphasis in the recording process that produces the danger of excessive curvature of the groove and consequent poor tracking of the reproducing stylus. This danger is greater for a slow-

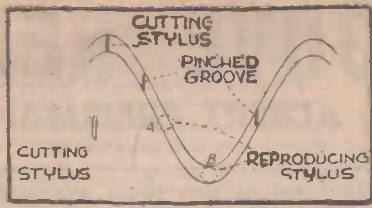


Fig. 2. Difference in shape between cutting and reproducing stylus makes pinch effect noticeable.

speed record than for a high-speed record; i.e., for a 33.1/3 r.p.m. record than for a 78 r.p.m. record.

To reduce the curvature, the recording level must be reduced. But this in turn lowers the signal-to noise ratio. To avoid this, increase the speed. But this reduces the playing time. If neither is to be altered, then the loudest sound to be reproduced must be reduced. But this reduces the volume or so-called dynamic range. So we see that the various requirements tend to be contradictory in their demands; and further, that a reduction in surface noise permits an increase in the various factors mentioned.

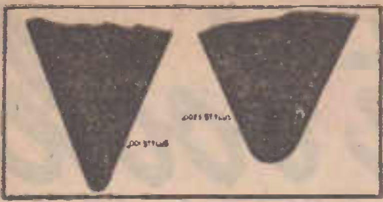
Distortion

Nonlinear distortion is not directly affected by the other factors. However, the greater the curvature of the groove, the greater is the "pinch" effect and hence the possibility of distortion. The pinch effect is illustrated in Fig. 2. Owing to the chisel shape of the cutting stylus used in recording the record, the sides of a sine wave recorded in the groove, or in general the steepest parts of any wave shape, are constricted or pinched. If the reproducing stylus were of the same shape, it could track perfectly in such a groove, but since for reasons of record wear, etc., it is of circular cross section, and is pinched and forced up out of the groove so that only the very tip rests in it at such points (position A in Fig. 2).

At the points of maximum amplitude (position B in Fig. 2) it can sink down further into the groove. As a result, the stylus not only vibrates sideways in a lateral-cut record, but also up and down **at double the frequency.** Modern reproducers are designed to permit such vertical motion in order to promote tracking.

Pinch Effect

The pinch effect can be reduced by reducing the maximum amplitude of recording; this will reduce the volume range unless the minimum amplitude can also be reduced, and this can only be done if the surface noise can be reduced. So we come back to the same limitations once more. Other types of nonlinear distortion also usually depend upon the amplitude of re-



A comparison of the stylus sizes used with the regular and new Microgroove long-playing records.

cording, and hence depend upon the same considerations as the pinch effect. Note also that if the record speed is increased, the pinch and other effects are reduced since the wave in the groove is stretched out longitudinally and does not hit the stylus so obliquely. But this expedient, of course, decreases the playing time!

Record Life

The record life depends upon several factors, including the steepness of the wave front; i.e., **the record speed** and the **maximum amplitude of recording.** It has been found that for a stylus whose spherical tip has a 2.5 to 3 mil radius, a weight of one ounce downward (counterbalanced weight of the pickup) does not stress either the stylus or the ordinary record material beyond their elastic limits, so that permanent deformation and accelerated wear are avoided.

The downward force on the stylus can be kept low if it vibrates freely in a lateral direction and can therefore track in the groove with little weight to hold it in place. This means a very light and freely moving vibratory mechanism, yet one of reasonably high electrical output. Modern pickups meet this requirement surprisingly well.

Microgroove Recording

In microgroove recording two factors have been whittled down to as small a value as possible. In the first place, a very quiet record material, Vinylite, is employed, although other manufacturers are also using this material. Incidentally there is a report that polyethelene, which is used at u.h.f. for transmission line insulation, is even superior in this respect, and picks up less static charge with accompanying attraction for abrasive dust.

From what has been stated previously, it is clear that once the surface noise is reduced, less amplitide is required to override it. Hence, even though the speed is reduced to 33 1-3 r.p.m., the radius of curvature is not reduced to too small a value, and the pre-emphasis of the "highs" can be safely accomplished. This in turn improves the signal-to-noise ratio, or the band width, or playing time, or volume range.

The second factor is that of stylus size; the microgroove reproducer uses a stylus of but 1 mil tip radius. This reduces the contact area on the groove, so that the tracking pressure has been reduced to but 1-5 ounce to avoid undue record wear. In the past such fine styli and low tracking pressure have been looked askance because of record-changer requirements, but these do not appear to be insuperable obstacles, as have been demonstrated by several radio firms.

The reduction in stylus radius permits tracking even for a very small radius of curvature of the wave recorded in the groove. Since the wave radius of curvature is smallest near the centre of the record, where the groove speed is least, the reduction in stylus radius permits recording and reproducing of high frequencies for grooves within 5¾ inches of the centre of the record, even though the speed is but 33 1-3 r.p.m.

Long Playing Time

In addition, the lower level of recording possible on the quieter Vinylite material, permits the grooves to be spaced as close as 224 to 300 to the inch, instead of 90 to the inch as in ordinary 78 r.p.m. records. This coupled with the low speed and small innermost groove radius permits as high as 50 minutes of recording, or so it is claimed. Perhaps half of this value will ordinarily be used.

Although a record changer is being considered for its use, even an ordinary 33 1-3 r.p.m. turntable will afford a fairly long programme from one record alone—probably sufficient for the needs of many people. Indeed, a 3 to 4-hour programme, as furnished by a microgroove record changer, appears 2 to 3 hours longer than necessary, except in special cases.

Most pickup and turntable manufacturers are turning out reproducing equipment to handle both the old and the new microgroove records. The turntable is a combination two-speed affair designed to operate at either 33 1-3 or 78 r.p.m. As regards the pickup, either two separate units and tone-arms are employed, or else one pickup with two styli is used.

There are probably many problems yet to be solved, and the engineer may possibly be justified in being somewhat sceptical as to all the features claimed for it: long playing time, wide frequency range, wide dynamic range, etc. But there is no question that it is an exciting and greatly desired development and that Columbia is to be highly commended for having had the courage to tackle this job and the ability to bring it to a successful conclusion.

For your note book

A page of radio servicing hints and notes of practical value to the radio serviceman and technician.

REPLACING FAULTY CONDENSERS

Capacitors, like resistors, will be found to change their operating characteristics as they age. While perhaps, individual units by themselves may not cause apparent change in any circuit, their aggregate effect in a receiver often shows up as low gain and low output.

When replacing any faulty condensers, the following points should be kept in mind. The voltage rating of a paper condenser should at least be as high as the original unit, and where possible of a higher value. In the case of an electrolytic condenser, the voltage rating should be the same, although a slight change—on the high side, is permissible. The use of a high voltage electrolytic in a low voltage circuit leads to the loss of capacity due to deforming of the condenser plates.

Bleed Resistor Necessary

Electrolytics should not be placed in series unless a bleed resistor drawing some 5 per cent. of the total rectified current, is connected in series across each of the condensers. This is necessary to prevent any inequality in condensers of the same capacity and size which could cause one to take most of the load and result in premature failure of the unit.

With paper type condensers there are also some problems to consider. The smaller sizes cannot be measured very accurately for power factor, and their use determines their discard point as much as their leakage. Intermittents can be checked by moving the wire pigtails, whilst a light tug on the condenser, and a careful visual inspection of the sealing wax should help in determining if the condenser is at fault. The operation of the set itself should be the determining factor in replacing a condenser.

For example, leakage through a grid to plate coupling condenser is best measured by disconnecting the condenser and measuring the grid voltage, replacing the condenser and noting the change, if any. Open circuits can be checked by using a signal tracer on the grid and watching or listening for any change.

Replacing Condensers

The size of paper replacement condensers is not very critical. Audio-coupling condensers need not run over .05 mfd, while .01 mfd is usually sufficient. Screen grid by-pass, plate filters, grid return filters rarely go over .5 mfd and .25 mfd is sufficient in most cases. Cathode by-passes sometimes go up to 50 mfd. But in most cases, the service man will not be far wrong with 10 mfd of the proper voltage.

Vibrator circuit buffers must be exact replacements. Not only does the high voltage winding condenser serve to keep the vibrator and transformer from acting as a spark coil, but it serves to tune the transformer to the vibrator frequency.

Such units are rated at 1600 volts and a set should never be operated without buffers, as the voltage will go up that high, and ruin the power transformer without them. Ordinary micas will usually not stand up to this voltage.

The condensers across the primary side of the vibrator transformer are rated at 150 volts, working, although the applied d-c voltage is only six.

When installing condensers care should be taken to keep the weight off the pig-tails, although they may seem sufficiently strong. Push the condensers against the chassis and under wires, for although the leads may be strong enough, speaker vibrations may eventually break them. Heat, of course, should be kept away from all condensers, and sets that suffer from repeated condenser failures may often be cured by moving any dropping resistors and or by increasing the ventilation of the set.

Curing Oscillation

Frequently in circuit where persistent oscillation occurs and which cannot be traced to any circut fault, it is possible that the various coil shields, etc., are not as effective as they should be.

Where this fault is suspected, it is well worth the time and effort to remove these shields and tighten the rivets holding the spade lugs, which are used to hold the can on the chassis.

Eliminating "Wow" Effect

The *"wow"* sound frequently encountered with gramophone units may be caused by any one of several conditions. For example, a warped turntable, a bent centre pin, records with worn centre holes, warped records, periodic variations in the speed of the turntable will all cause this *"wow"* effect.

Any of the first three mentioned causes can usually be detected by watching the pickup while the record is playing and the *"wow"* is present. If the pickup oscillates slightly back and forth, due to one of the off-centre conditions, the *"wow"* will be timed with the oscillations when they are causing the trouble. In such cases the remedy is obvious.

Checking For Fault

"Wow" caused by periodic variations in the speed of the turntable is evidenced by distortion on long, sustained notes — especially on long-playing records. The first step in eliminating this trouble is to check the speed of the turntable, with a stroboscope disc placed on the record while it is being played, and illuminated by a light connected to the a-c mains.

If the lines appear to be travelling forward, the turntable speed is too fast; if the lines appear to travel backward, the turntable is operating at too slow a speed. The speed adjustment provided should be regulated in either case.

Fluctuations in turntable speed, which may give rise to this *"wow"* effect, are sometimes due to the hardening of the leather rubber or soft felt washer on which the turntable rests. Usually in such cases, replacement of the washer corrects the condition. If it does not cure the condition, overhaul of the entire motor may be necessary. Oil and grease all moving parts, and recheck the soldering on all connections to the motor, and check moving parts for any undue wear or movement.

RADIO FREQUENCY MEASURING EQUIPMENT

By ALAN WALLACE

The basic operation of the Cathode Ray Tube was detailed in the previous issue. Now, in this article, the author discusses some important applications and in particular the use of the C.R.O. as a means of visually observing portions of the frequency spectrum.

graphy, it is now desirable to examine the means whereby this instrument may be put to effective use, and one application which the oscillograph makes possible is the provision of means of visual observation of portions of the frequency spectrum. This feature makes possible the construction of such instruments as the *Panoramic Adapter*, in which a portion of the Communications Spectrum, for example a complete ham band, is displayed upon the screen; or such as the "*Wobbulator*," which, used in conjunction with a Cathode Ray Oscillograph, enables portrayal of the selectivity curve of a tuned circuit or a series of tuned circuits.

Frequency Variation

Both of these units operate on the same principle, and hence may be considered together. They each contain a built-in oscillator, the frequency of which is varied by some known amount at a periodic rate. This is usually the recurrence rate, or sweep frequency, of the oscillograph in use, and arranged such that any particular frequency produced corresponds to a particular point of the trace on the screen.

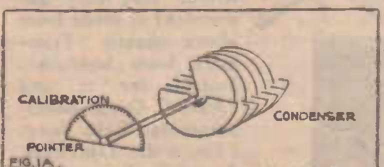


Fig. 1 (a). A simple method of frequency calibration.

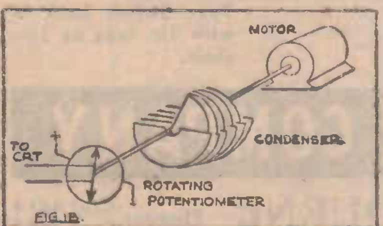


Fig. 1 (b). A motor-driven condenser will produce a certain sweep frequency.

This may perhaps be more easily seen if we consider first a mechanical analogy, as in Figure 1a. Here we have a condenser, determining the frequency of an oscillatory circuit, and since the position of the condenser is indicated by the position of the pointer on the dial, we may construct a direct relationship between the points indicated on the dial and their relative frequencies.

Now consider Figure 1b. Here we have a condenser being rotated continuously by a motor, and as a result the frequency of the oscillator is being swept continuously through the range of the condenser, say, from 500 to 600 Kcs, i.e., a swing of 100 Kcs, or a deviation

Part 5.
SPECTRUM SCANNING EQUIPMENT

of plus or minus 50 Kcs about the mean carrier frequency corresponding to the central position of the condenser, in this case 550 Kcs. Connected to the same shaft as this condenser and motor is a potentiometer, the object of which is to produce a voltage which when applied to the deflection plates of the CRT, will cause the spot to be deflected away from its central position to an extent determined by the displacement of the tuning condenser from its mean position. This may perhaps be seen better in Figure 2, where it will be seen that each position of the tuning condenser has a corresponding spot position on the screen.

Resonance Curve

Assume the output of an oscillator tuned by such a mechanism is now fed into a selective circuit,

Having considered the simpler problems of Cathode Ray Oscillo-

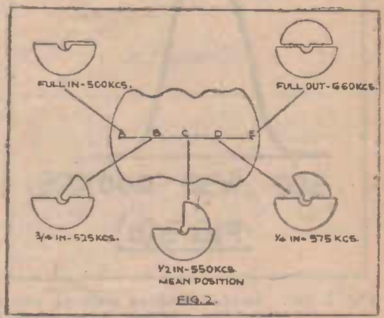


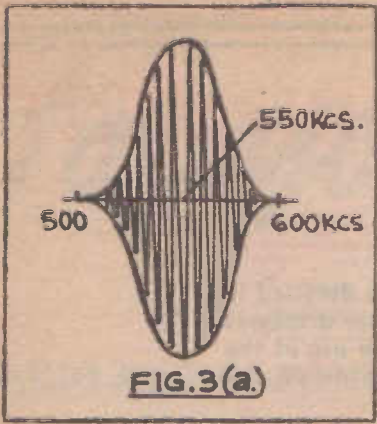
Fig. 2. Each position of the condenser has a corresponding spot position on the screen.

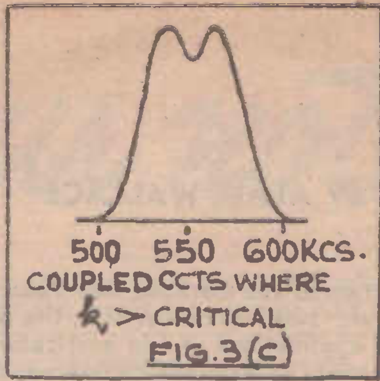
resonant at, say, 550 Kcs. If the resultant signal is amplified and fed to the Y plates of the CRT, it can be seen that, since the output of the tuned circuit is governed by the frequency of the input, being a maximum at resonance, and the input frequency varies with the position of the spot on the horizontal axis of the screen, constant amplitude being maintained, then the resonance curve of the particular tuned circuit will be reproduced, as in Figure 3.

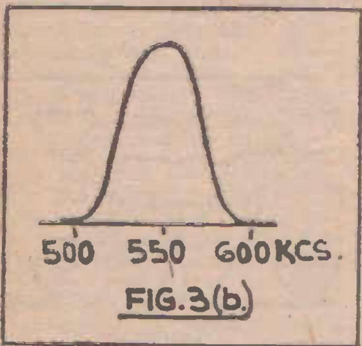
Panoramic Adapter

Figure 3a illustrates the type of curve which is obtained when the RF output is fed directly to the CRT plates without rectification, whilst Figures 3b, c, d illustrate the types of trace obtained when the voltage is first rectified and filtered from RF components before being applied to the CRT. It will be seen from this description that such a presentation possesses many advantages for receiver alignment, although normally a completely electronic system of frequency modulation is employed, as will be described later in this article.

To consider the case of the panoramic adapter, which is somewhat parallel, suppose that the oscillator, which is sweeping from 500 to







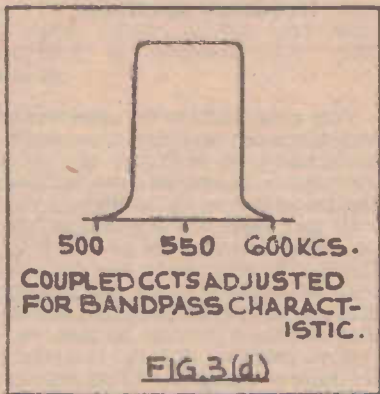


Fig. 3 (a). Curve obtained without any rectification, (b), (c) and (d), types of trace when the voltage is rectified and filtered of any r-f component.

600 Kcs at a rate of, say, 30 times per second, is used as the local oscillator in a "receiver" which has an IF frequency of 100 Kcs. The effect will be to tune that "receiver" through a range of frequencies from 400 to 500 Kcs, at a rate of 30 times per second, and if the output of this receiver is fed to the CRT, then all signals in this range will be produced on the CRT screen, in their respective positions on the trace, and with patterns representative of the type of emission. This may be seen in Figure 4.

Beat Frequencies

If, instead of being connected to an aerial, this "receiver" is connected to the IF channel of a conventional receiver, with an Intermediate Frequency of 450 Kcs, then it will be seen that the Panoramic Adapter will reproduce, on the screen, all those signals which beat the local oscillator of the receiver to produce frequencies within the range of 400 to 500 Kcs. That is, all those signals within the range of plus or minus 50 Kcs of the frequency to which the receiver is tuned, irrespective of whether it may be 1Mcs or 28Mcs, and hence it may be used to portray those parts of the spectrum surrounding the tuned signal.

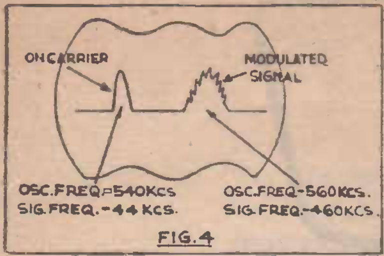


Fig. 4. Type of trace to be seen on the CR tube when being used as a panoramic adapter.

This allows the operator to maintain visual watch on adjacent transmissions and, as is often particularly desirable in ham operation, to note the appearance of a new transmission on some part of the band. The arrangement necessary, which has just been detailed, is shown in block form in Figure 5.

Although the system of producing the desired frequency modulation and sweep voltage described above is practicable, and has in fact been used, it is more usual, in current practice, to employ some electronic means to achieve the desired result. One device which makes this possible is the reactance tube circuit, commonly used in automatic tuning circuits, as well as in frequency modulated transmitters of various types.

Reactance Tube Circuit

This circuit employs a vacuum tube, usually of the pentode type on account of its higher transconductance, connected in such a manner that it "appears" to possess reactance, either capacitive or inductive, which may be varied by variation of the voltage applied to its grid. This may perhaps be more clearly understood if we consider Figure 6a where, for simplicity, a triode tube is shown connected in an equivalent reactance tube circuit, with the appropriate phase relationships shown on the vector diagram, Figure 6b.

In this case, where the voltage developed across the oscillatory circuit LC is applied to the plate and grid of the reactance tube, the voltage applied to the grid is applied through a phase shifting network in such a manner that, owing to the fact that the current through C leads on the applied voltage by almost 90 degrees, the voltage applied to the grid of the reactance tube leads 90 degrees on the voltage at the bottom of the coil, which, however, leads the voltage at the top of the coil by 180 degrees. Since the plate current of the tube is in phase with the applied grid voltage, and the plate voltage is determined by the voltage fed from the top of the coil through C^1, which is sufficiently large to produce negligible phase shift, the tube appears to the external circuit as a reactive device in which the current flowing lags upon the applied voltage. In other words, it appears as an inductive reactance, the magnitude of which may be varied by variation of the current component, as for example, by variation of the bias on the tube with an applied signal.

Synchronism

It will be seen from this brief description that this device has immediate application tot he problem of the Panoramic Adapter or Wobbulator. It is now only necessary to apply to the reactance tube a sawtooth voltage, as is applied to the CRT, and automatic synchronism will be achieved, and this is what in fact is usually done.

If portion of the voltage from the CRO timebase is fed to the reactance tube, usually through an attenuator, so as to allow control over the deviation produced, the desired effect will be achieved. The choice of this factor will be governed in the case of the Panoramic Adapter, by the bandwidth which it is desired to present on the screen, and in the case of the Wobbulator, by the selectivity of the circuits which are being tested.

Since a Panoramic Adapter is normally used only as an indication of the transmissions which are present on a band, and not for any highly detailed measurements, it is normally quite satisfactory to employ a smaller cathode ray tube, thus obviating the need for large high voltage supplies which are required with the 5in. tubes. Similarly a large tube is not really necessary for the observation of response curves, or for aligning of receivers, as it is only desired to check on the general symmetry and shape.

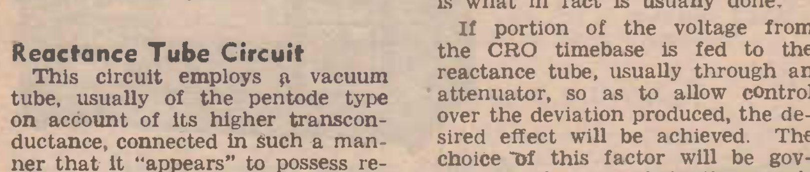


Fig. 5. Block diagram of equipment for spectrum scanning.

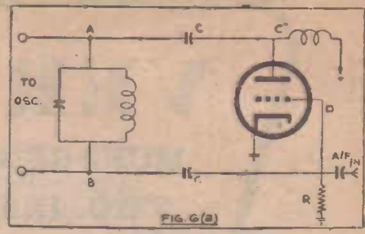


Fig. 6 (a). A Triode connected in an equivalent reactance tube circuit.

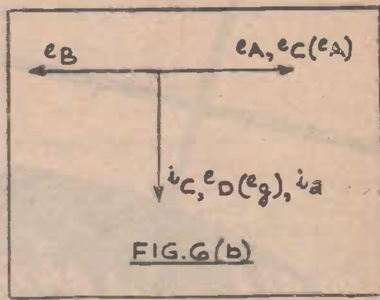


Fig. 6 (b). This vector diagram shows the phase relationship in circuit 6 (a).

Low I.F. Value

In order to produce a clear pattern, in the case of the Panoramic Adapter, it is desirable to use an IF which is much lower than normal, so as to obtain greater selectivity, although there is a definite relationship between the available selectivity and the maximum sweep rate of the time-base, if maximum sensitivity is to be obtained. This will be dealt with further in the constructional article next month, and it will suffice to say at present that, using 175 Kcs IF transformers, since 100 Kcs transformers are not at present commercially available in Australia, it is quite permissible to use sweep frequencies up to about 50 per second.

To return to the consideration of the Wobbulator, it will be apparent from the previous discussion that this swing in frequency of 100 Kcs for a given change in circuit reactance will only apply at that particular mean frequency. If, for example, the mean frequency had been shifted to 1000 Kcs, then the change in frequency produced would perhaps be of the order of 200 Kcs.

This change in deviation as the oscillator is tuned over its range would be most unsatisfactory, as it is necessary to have some indication of the band-width being swept in order to assess, even approximately, the selectivity of a particu-

(Continued on page 47.)

VERSATILE TONE CONTROL

In this interesting tone-control circuit, the treble and bass frequencies are independently boosted or attenuated in steps to provide 121 different response curve combinations for the reproduction of speech and music. Gain at 500-cycle crossover is automatically held constant by switching in cathode followers.

The Tone Control described here originated largely with a desire to compensate for the limitations of recording techniques. With it, treble frequencies can be boosted or suppressed, and bass frequencies can be similarly treated independently, all in small steps.

The bass and treble controls each provide sharp rise or fall, starting at 500 cycles or any other crossover frequency chosen. Bass control produces no substantial effect above crossover, and treble control produces no substantial effect below. The rising or falling slope is adjustable in steps of one db per octave up to a maximum of 5 to 7db per octave. The overall volume level at the crossover frequency is unchanged by applying any bass or treble compensation, or by applying both simultaneously. All frequency determining components are resistances or capacitances. All curves flatten off above 10 kc and below 25 cycles.

R-C Networks

Selective frequency boost is achieved by attenuating one group of frequencies and readjusting the overall level with flat amplifiers. The basic R-C networks used for this purpose are shown in Fig. 1, along with the networks used primarily for attenuation.

Treble boost (Fig 1A) is obtained with a bass attenuation network having a gradual drop near the crossover and a sharp flattening off at the lower frequencies. When this curve is slid up the frequency axis until the sharp bend reaches the crossover frequency, it becomes treble boost.

Treble attenuation (Fig. 1B) gives an abrupt drop near the crossover frequency and a smooth flattening off at higher frequencies.

Bass boost (Fig. 1C) is obtained with a treble attenuation network having a gradual drop near the crossover and a sharp flattening off at the higher frequencies. When this curve is in effect slid along the frequency axis until the sharp bend occurs at the crossover frequency, it becomes bass boost.

Bass attenuation (Fig. 1D) gives an abrupt drop near the crossover frequency and a smoother flattening off at lower frequencies.

Changing R-C Values

Any desired crossover frequency may be achieved by selection of resistance and capacitance values for the R-C networks. For example, doubling all indicated resistance values without changing the capacitances will shift the entire curve toward lower frequencies by a factor of two. Doubling all capacitances produces the same effect, while decreasing resistances or capacitances or both, shifts the curve bodily toward higher frequencies.

The impedance any network presents may be altered by a factor N, without altering the frequency response curve by multiplying all resistance values by N and at the same time dividing all capacitances by N.

Complete Circuit

The final tone control circuit is shown in Fig. 2, along with the response curve combinations obtainable and the control switch settings for each. Since all the required compensation cannot satisfactorily be provided in variable form in one network section, composite networks consisting of three such sections in tandem or cascade are used for bass and treble attenuation, with provisions for tapping the composite network at the desired points.

The succeeding sections in any one network increase in impedance by a factor of four or five each time, so that succeeding sections do not furnish loading which would alter the frequency response characteristics of preceding sections.

Because of the nature of the basic bass boost section, the building up of a network from several such sections would add many bulky components. Instead, therefore, a switching arrangement was developed wherein three sections of 1.4, 2.8, and 2.8-db boost per octave were combined successively to give in turn 1.4, 2.8, 4.2, 5.6 and 7db boost per octave. The same system is employed for treble boost, and the network sections again increase in impedance as they are added.

Two six-pole eleven-position switches are required. The five positions of boost and the five positions of attenuation are wired to one switch for each frequency range, along with a neutral posi-

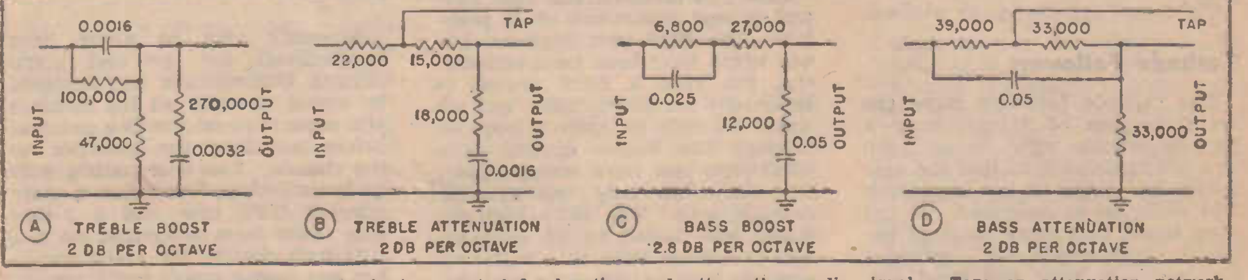


FIG. 1. Typical R-C networks used in tone control for boosting and attenuating audio signals. Taps on attenuation network provide half the indicated effect.

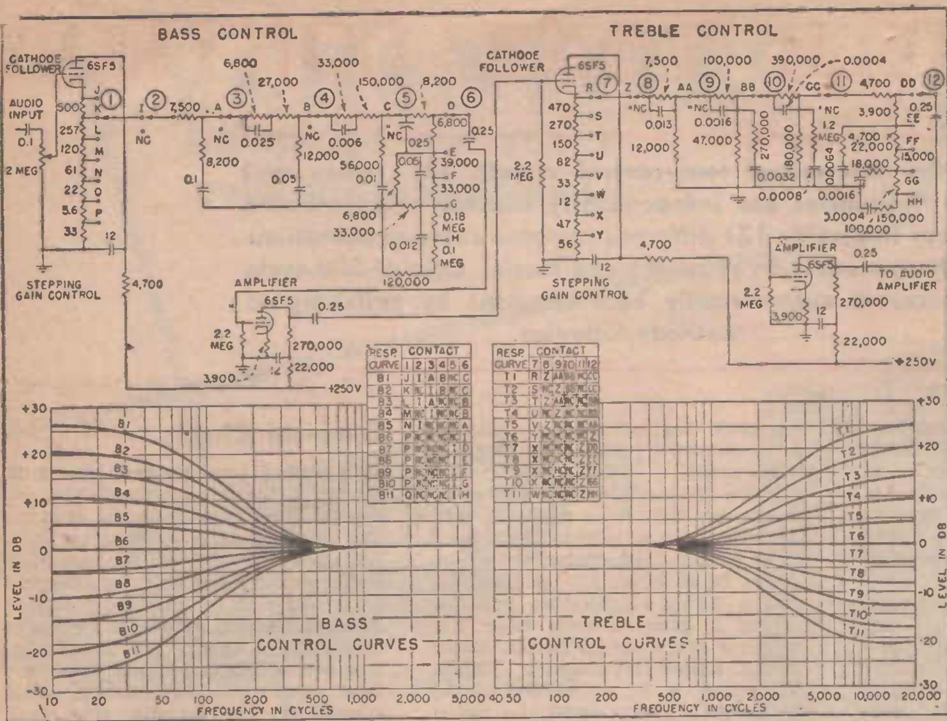


Fig. 2. Complete tone control system. When inserted in an amplifier, its overall gain is zero at the 500 cycle crossover frequency. The inset tables gives the positions of the contact arms of the two six-pole eleven position control switches to provide the indicated bass and treble control curves. Treble curves were taken with the bass control at B6 (neutral), and the bass curves with the treble control at T6.

tion in which no bass or treble alteration occurs. Continuous control is not provided, but small enough steps to make the action gradual as the switches are rotated.

The overall result, then, is to have one switch for bass, giving from 7 db of boost per octave of 5 db of suppression per octave in ten steps, and one switch for treble, giving from 5 db boost per octave to 6 db reduction per octave in ten steps, with no interaction between controls. The words per octave here refer to the number of octaves displacement from 500 cycles.

In order to achieve a constant volume level at the crossover frequency, a stepping gain control was added, ganged to the bass and treble switches, in the cathode circuits of two cathode followers. In this way, the proper amount of input signal is chosen for each position of the selector switch in order that the gain at 500 cycles may remain constant. In practice, this is easily achievable within one db if care is taken in selecting components.

Cathode Followers

The cathode followers serve the main purpose of transforming a high-impedance input signal down to a low impedance so that the networks may begin at low impedance and build up as described. It has been found that stray coupling between high-impedance networks can seriously alter the ideal frequency response curves.

With capacitance values all larger than 400 micro-microfarads a small, unintended coupling capacitance (on a switch wafer, for example) will not produce a noticeable effect on the tone.

Amplification must be provided (not necessarily within the tone control) in order to re-establish the original volume level. At the same time, it is advisable to amplify and then again transform down to low impedance between the bass and treble controls. This serves the added purposes of isolating the bass and treble components electrically and keeping either from operating at too low a voltage level.

All these networks are bound to have insertion loss at any frequency, and a total of 40 db of attenuation at 60 or 120 cycles (as provided by bass suppression and treble boost, before re-establishment of the 500-cycle level) could push the signal into the heater-to-cathode hum voltage level.

Amplifier Design

Choice of tubes for this tone control proved somewhat of a problem. The 6SL7 twin high-mu triode would have been most convenient, but even a 6SL7 proved to be usually too microphonic, and always too rich in hum introduced through the heater circuit. The 6SN7 does not have enough gain; the 6SC7 has only one external cathode lead. The 6SF5 high-mu triode was found to be available and free from hum in a sufficient number, and so this type was decided upon.

In the amplifier stages, cathode resistors were left unbypassed to make the neutral amplification curve as flat as possible, at the sacrifice of some gain. A total of 12 db more of gain may be obtained by suitable bypassing of these two resistors. All plate supply circuits must be decoupled as shown, and all blocking capacitors must be large enough so that low frequencies are not attenuated.

The input signal level must be low enough so that, after boosting, neither the bass nor the treble signal will overload either level-restoring amplifier. A gain control is therefore provided directly at the input to the tone control.

This is not intended as a main gain control for the entire control and amplifier combination, but as an auxiliary which may be set according to the maximum level of the incoming signal.

In commercial recording, compression takes place before the mechanical limitations of recording techniques produce their tone-modifying effects. Therefore, the tone control should be used before a volume expander. This also lessens the danger of overloading the amplifiers in the tone control.

Assembly may be along lines conventional for low-level audio circuits. Compactness was achieved by wiring virtually all the resistors and capacitors on the two switches before installing the switches on the chassis. The tone control with its two switches, four tubes, a spare selected 6SF5 tube and a 3-tube a-m tuner were assembled on a 9 x 11-inch chassis, the audio amplifier and power supply being remote.

—Reprinted courtesy Electronics.

IS YOUR TRANSMITTER SAFE?

by ROTH JONES, VK 3BG

"Switch to Safety" is an axiom which should find a place in every operator's station. In this article, the author stresses the lethal power of the average amateur transmitter —a point which is not always realised by many operators.

Few of the 4000-odd radio amateurs in Australia today realise how closely they are playing with death. Fewer still make their transmitters SHOCKPROOF. Fortunately the number of deaths in this country from amateur radio transmitters has been small over the years. This, however, is due to more good luck than adequate protective measures.

Some who have lived to tell the tale after passing some hundreds of volts through their bodies now have safe transmitters. These, however, are in a minority. Without a doubt highly lethal transmitters are in the majority.

Throughout the commercial radio world death through electrocution is impossible. For a technician to gain access to his transmitter it is necessary for him to open a small door which automatically switches off the power. When making adjustments, the transmitter is dead.

Could the same be said with the average amateur radio transmitter?

Few of us could deny having made adjustments when the power was switched on. Frequently these adjustments were made using both hands, thus giving the high voltage a direct path over the heart should the hands unwittingly be placed across the high tension.

Increased Power

The danger threat in Australia has increased to an all-time record during the last 12 months. This follows the P.M.G. order authorising a maximum power increase of 100 watts for all amateur radio transmitters in a contrast to the 25 watts permitted in pre-war years. Today most of the transmitters use the 100 watts with at least a 1000 volt power supply.

Despite this sudden power increase corresponding steps to increase the safety factor have not followed. Eager to use the maximum permissible power, most of Australia's radio amateurs have not made their transmitters any more shock proof than when they operated them at considerably reduced power input.

This type of unshielded transmitter is a potential source of danger should the user become careless when operating.

"Switch To Safety" Slogan

It was not until the late Ross Hull, QST Technical Editor, was electrocuted in 1936, that America became safety conscious and "Switch to Safety," was the cry that spread throughout the country. But still the death roll in America continued and frequently when perusing radio magazines from that country during the past decade many a well-known radio amateur has been listed in "Silent Keys"—his untimely death being caused by electrocution.

Frequently a first hand tale is told by the lucky man who, although severely shocked, has lived. It is a gruesome tale. It tells of third degree burns from the r-f voltage in the final tank coil, of burnt fingers with some lost or damaged forever —a grim reminder of a few seconds' carelessness.

Yes—these things could easily happen to YOU, when you become careless and do not observe simple safety rules with your equipment. The transmitter of which you are so proud could easily be the means of you losing a hand, a finger or even your life leaving your family to fend for themselves—simply because of your own carelessness.

No doubt to many, this will sound a scare story, but nevertheless it is quite factual and could happen. It has happened before and will happen again if commonsense preventive measures are not adopted.

Perhaps the simplest of all rules is that quoted previously and adopted by the American Radio Relay League: "Switch to Safety." Regularly it is seen in the pages of A.R.R.L. Publications alongside a transmitter's power transformer with the switch in the OFF position. It is a firm significant reminder to switch "off" before making adjustments. But even though this sounds so foolproof, some transmitters still have lethal powers with the switch OFF.

Safety Precautions Ignored

Keen to run the power transformer at maximum ratings, many operators purposely refrain from placing bleeder resistors across the filter condensers. This leaves the latter fully charged even though the power is OFF. Modern high voltage condensers will hold this charge for days.

The simple lesson is to always place a high voltage bleeder across

(Continued on page 47)

Around The Industry

New Dual Wave Unit

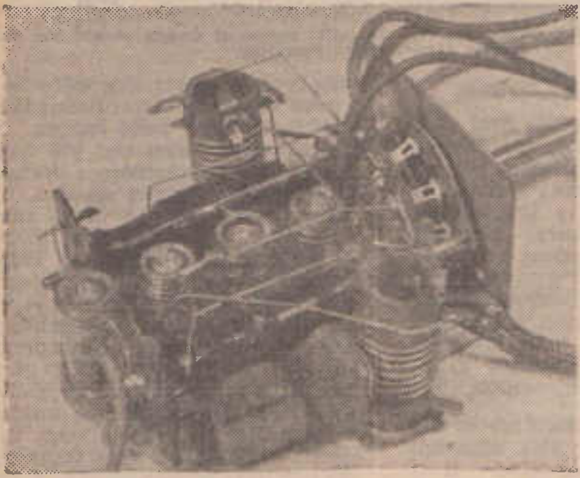
From Slade's Radio comes details of a new dual-wave bracket which is particularly suitable for use in receivers where an RF stage is not required.

This new unit is of a particularly neat construction, measuring approximately 4 inches long, 3¾ inches wide, and 1¾ inches deep. The broadcast and short wave coils, and wave change switch are all mounted on a dural "L" shaped plate which provides a rigid support for the unit.

The unit has a frequency coverage of: Broadcast 550-1600 k.c., and Short Wave: 13-42 metres, and has been designed to track correctly with an MSP gang and dial glass. The wave change switch is fitted with a third position, which enables the radio-gramo connections to be made through the coil unit, thus avoiding any necessity of wiring in another separate switch for this purpose.

Before delivery each unit is pre-aligned and air-tested in a receiver, and to ensure that the coil alignment remains stable, AWA type air dielectric trimmers are used in place of the more usual compression type. The various leads and coil lugs are clearly colour coded to simplify connections into the receiver.

The retail price of this bracket is £3 10s, complete, and is now available from Slade's Radio Pty. Ltd., Lang Street, Croydon.



The new dual wave unit which includes the radio - gramo switch on the wave change switch.

McGRATH'S NEW SERVICE

Of interest to all Melbourne radio enthusiasts is the news that J. H. McGrath and Co. have now fitted out a special room with test equipment where amateurs, experimenters and others who may wish to do so, can check over their equipment.

Further details of this service as well as permission to make use of this room can be obtained by writing or calling on the above firm at 208 Little Lonsdale Street, Melbourne.

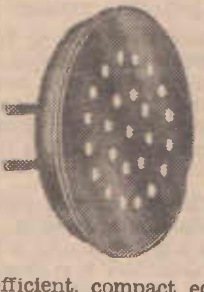
VALVE PRICE REDUCED

In a recent circular, the Amalgamated Wireless Valve Coy. announce that the price of the Radiotron type 6J7G/1620 has been reduced. The new price for this valve, which is now classified within the "Receiving" category, is 22/6 plus the usual 2/- war loading tax.

CRYSTAL MICROPHONES AVAILABLE

Advice has been received from Amplion (A/sia) Ltd. that further supplies of the Acos miniature crystal microphones are now available.

Of a particularly light construction, this diaphragm actuated crytal microphone has a rising frequency response from 1000 cycles, making it admirably suitable for all speech frequencies. Although originally designed for hearing aid equipment, these units are now being used in many other applications, such as public address equipment, home broadcasting systems, office and factory call systems, and "ham" stations, where efficient, compact equipment is required.



The output from the unit is quite high, and sufficient in many cases to enable it to be connected direct to the pickup terminals of a modern receiver without the necessity for any transformer or preamplifier stage. The price of this microphone is £1 8s 2d.

Another item of interest is the new GP9 crystal cartridge. This features a special construction which makes it virtually impossible to break or damage the crystal element.

The motion from the stylus is transferred to the crystal via a rubber transmission which permits only the transfer of lateral movements, such as received from record grooves. Any vertical motion as would occur when the pickup arm is dropped onto the record, etc., is absorbed by a special rubber block, thus preventing any damage to the crystal.

The main specifications of this cartridge are:—Needle pressure, 35 grammes, Impedance at 1000 cps, 265,000 ohms, output at 1000 cps, 1.7 volts, with a recommended load of .5 megohm. The frequency response is from 50-8000 cps, with the output being well maintained at lower frequencies.

Both of these units are obtainable from most radio stores, or direct from the agents, Amplion (A/sia) Pty. Ltd., 36-40 Parramatta Road, Camperdown.

INTERNATIONAL AMATEUR PREFIXES

AC3 Sikkim.
AC4 Tibet.
AR Syria.
AR1 Syrian Republic.

CE Chile.
C-XU China.
CM-CO Cuba.
CN1 Tangier Zone.
CN8 French Morocco.
CP Bolivia.
CR Portuguese Colonies.
CR4 Cape Verde Island.
CR5 Port Guinea.
CR6 Angola.
CR7 Mozambique.
CR8 Port India Goa.
CR9 (MX) Macao (Portr).
CR10 Timor.
CT Portugal.
CT1 Portugal (Proper).
CT2 Azore Islands.
CT3 Madeira Islands.
CX Uruguay.

D Germany.
D2 Germany (British Zone).
D4 Germany (U.S. Zone).

EA Spain and Colonies.
EA1 2, 3 4, 5, 7 Spain (Proper).
EA6 Balearic Islands.
EA8 Canary Islands.
EA9 Spanish Morocco and North Africa.
EI Eire (Ireland).
EK Tangier Zone.
EL Liberia.
EP-EQ Iran (Persia).
ES Estonia.
ET Ethiopia.

F France and Colonies
F3, F8 France (Proper).
FA Algeria.
FB8 Madagascar.
FC Corsica.
FD8 Togoland (Fr.).
FF8 French W. Africa.
FE8 Cameroons (Africa).
FG8 Guadelope.
FI8 Fr. Indo-China.
FK8 New Caledonia.
FL8 Fr. Somaliland.
FM8 Martinique.
FN8 Fr. India.
FO8 Fr. Oceania and Tahiti.
FP8 St. Pierre and Miquelon.
FQ8 Fr. Equatorial Africa.
FR8 Reunion Island.
FT4 Tunisia.
FU8 and YJ New Hebrides.
FY8 Fr. Guiana and Inini.

G Great Britain.
GC Jersey, Guernsey, Alderney, and Sark Island (Channel Is.).
GD Isle of Man.
GI Northern Ireland.
GM Scotland.
GW Wales.

HA Hungary.
HB Switzerland.
HC Ecuador.
HE1 Lichenstein.
HH Haiti.
HI Dominican Republic.
HJ-HK Columbian Republic.
HL Korea.
HP Republic of Panama.
HR Honduras.
HS Siam.
HZ Hedjaz (Arabia).

I Italy.

J Japan.
J4 Japan (British Forces).
J8 Korea (Chosen).
J9 Okinawa, Marshall Is.

K Continental, U.S.A.
K4 Puerto Rico.
K5 Canal Zone.
K6 Hawaii.
K7 Alaska.
KA-KZ Territories of U.S.A.
KA Philippine Islands.
KB4 Virgin Island.
KB6 Baker, Howard, Phoenix Islands.
KC4 Little America.
KC6 Wake Island.
KD6 Midway Island.
KE6 Johnston Island.
KG6 Guam.
KH6 American Samoa, Hawaiian Is.
KJ6 Johnstone Is.
KL7 Alaska.
KM6 Midway Is.
KP4 Puerto Rico.
KP6 Palmyra and Jarvis Is.
KS4 Swan Island.
KS6 Samoa (U.S.).
KV4 Virgin Is.
KW6 Wake Is.
KX6 Marshall Island.
KZ5 Canal Zone.

LA (LH) Norway.
LI Libya.
LU Argentina.
LX Luxembourg.
LY Lithuania.
LZ Bulgaria.

MC1, MD1, MD2 Libya.
MD1 Cyrenaica.
MD2 Tripolitania.
MD3 Eritrea (M13).
MD4 Somaliland (Ital).
MD5 Suez Canal.
MD7 Cyprus (C4).
MI6 Eritrea.
MX Manchuria (Manchukuo).

NY U.S. Navy Yards.
NY1, 2 Canal Zone.
NY4 Guantanamo, Cuba.

OA Peru.
OB Sarawak Area.
OD Lebanon.
OE (MB9) Austria.
OH Finland.
OK Czechoslovakia.
ON Belgium.
OQ5 Belgian Congo.
OX Greenland.
OY Faroes Is. Jan Mayen Is.
OZ Denmark.

PA (PI) Netherlands.
PJ Curacao.
PK Netherlands Indies.
PK1, 2, 3 Java.
PK4 Sumatra.
PK5 Dutch Borneo.
PK6 Celebes, Dutch New Guinea. Molucca Is.
PX Andorra, Angola.
PY Brazil.
PZ Surinamm (Neth. Guiana).

SM Sweden.
SP Poland.
ST2 Egyptian Sudan.
SU Egypt proper.
SV (SX) Greece, Crete.
SV5 Dodecanese Island.

TA Turkey.
TF Iceland.
TG Guatemala.
TI Costa Rica, also Cocos Is.

UA1, 3, 4, 6 European Russian Federated Soviet Republic.
UA9 Asiatic S.F.S.R.
UB5 Ukraine.
UC2 White Russian SSR.
UD6 Azerbaigan.
UF6 Georgia.
UG6 Armenia.
UH8 Turkoman.
UI8 Uzbek.
UJ8 Tadzhik.
UL7 Kazakh.
UM8 Karghiz.
UN1 Karelo-Finnish Republic.
UO5 Moldavia.
UP2 Lithuania.
UQ2 Latvia.
UR2 Estonia.

VE Canada.
VK Australia.
VK2, 3, 4, 5, 6, 8, Australian Mainland.
VK4 Papua, also Queensland.
VK7 Tasmania.
VK9 New Guinea Mandated Territory.
VO Newfoundland and Labrador.
VP1 British Honduras.
VP2 Leeward and Windward Is. and Antigua.
VP3 British Guiana.
VP4 Trinidad and Tobago.
VP5 Jamaica, Cayman, Caicos and Turks Is.
VP6 Barbados.
VP7 Bahamas.
VP8 Falkland, S. Georgie, S. Orkney, and S. Shetland Is.
VP9 Bermuda.
VQ1 Zanzibar.
VQ2 Northern Rhodesia.
VQ3 Tanganyika.
VQ4 Kenya.
VQ5 Uganda.
VQ6 British Somaliland.
VQ8 Mauritius and Chagos.
VQ9 Seychelles.
VR1 Gilbert, Ellice and Ocean Is.
VR2 Fiji Is.
VR3 Fanning Is. (Christmas Is.).
VR4 Solomon Is.
VR5 Tonga (Friendly) Is.
VR6 Pitcairn Is.
VS1 Straits Settlements.
VS2 Federated Malay States.
VS3 Non-Federated Malay States.
VS4 British North Borneo.
VS5 Sarawak and Brunei.
VS Labuan (Borneo).
VS6 Hongkong.
VS7 Ceylon.
VS8 (VU7) Bahrein, Khuria, and Muria Is.
VS9 Maldive Is.
VS9A and another letter, Aden.
VS9K and another letter, Kamara.
VS9P and another letter, Perim Is.
VS9S and another letter, Socotra.
VU British India.

AP Pakistan.

VU4 Laccadive Island.
VU7 Bahrein Island.

W Continental, U.S.A.

XE Mexico.
XU China.
XU4 Mongolia.
XZ Burma.

YA Afghanistan.
YI (MD6) Iraq.
YJ New Hebrides.
YL Latvia.
YM Free City of Danzig.
YN Nicaragua.
YR Roumania.
YS El Salvador.
YT (YU) Yugoslavia.
YV Venezuela.

ZA Albania.
ZB1 Malta.
ZB2 Gibraltar.
ZC1 Transjordania.
ZC2 Cocos Is.
ZC3 Christmas Is.
ZC4 Cyprus.
ZC6 Palestine.
ZD1 Sierra Leone.
ZD2 British Cameroons, Nigeria.
ZD3 Gambia.
ZD4 Gold Coast (Brit. Togoland).
ZD6 Nyasaland.
ZD7 St. Helena.
ZD8 Ascension Is.
ZD9 Tristan da Cunha.
ZE1 Southern Rhodesia.
ZK1 Cook Is. Zanzibar.
ZK2 Nieu.
ZL New Zealand.
ZM6 British Samoa (West).
ZP Paraguay.
ZS1, 2, 5, 6, Union of South Africa proper.
ZS3 South West Africa.
ZS4 Basutoland.

TRANS-TASMAN DIARY

By J. F. FOX

(Special N.Z. Correspondent)

USE OF RADIO IN CLUTHA FLOODS

During the widespread Clutha floods, which inundated the surrounding country for over two weeks, amateur radio operators in conjunction with the R.N.Z. Corps of Signals provided the authorities with a highly efficient communication system.

When the largest river in New Zealand, the Molyneux, burst its banks in the Clutha district last November hundreds of acres of farm land were flooded for nearly two weeks. In low-lying areas of Balclutha water lay in the streets, while Inchclutha, an island of about 10 miles in length and nearly three miles in breadth, was submerged by flood waters for over a week. Residents of Balclutha and the surrounding districts were supported by volunteers from Dunedin in fighting the swirling flood waters.

With telephone lines washed away, and increased river patrols, amateur radio operators assisted by the Army built up an excellent and smooth-running communications system. Hundreds of messages were handled, directing material and men to vital points, helping with the evacuation of Inchclutha, reporting the river heights, the condition of the retaining banks, and arranging meals and transportation.

Early Warnings

The initial flood warning was transmitted to the four radio amateurs of Balclutha about 2 o'clock on the afternoon of November 2, with the request that they assist with communications, and to be in action by 6 p.m. that night. Three stations were set up by the required time, one at the River Trust Engineer's Office in Balclutha, one at the main Ministry of Works Depot in Stirling, four miles away, and at Finegand, six miles distant, which was the site of the worst break in the previous floods.

It was soon realised that the whole operation would require more assistance, and as a result of a request to Dunedin, amateurs and equipment were able to be sent down the following day. A further request was sent to the Southern Military District headquarters at Christchurch for assistance. Equipped with seven No. 48 radio sets (walkie-talkie), six signallers of the Royal New Zealand Corps of Signals were flown by two R.N.Z.A.F. Oxford aircraft to Dunedin where they were joined by another four Army personnel.

All Night Watch

On Tuesday, November 3, the river commenced to rise more rapidly, and the depots at Stirling and Finegand were cut off, requiring a detour in each case of about 12 miles. That night the main channel of communication from Stirling to the headquarters at the River Trust in Balclutha was in operation continuously. The District Telegraph Engineer had very generously granted exclusive use of 50 kilocycles of the 80 metre band. Meanwhile the headquarters of the New Zealand Amateur Radio Transmitters requested amateurs not to transmit from 3500 to 3550 kilocycles so to enable the emergency stations in South Otago to work on 3525 kilocycles.

On the third day of the flood the river reached its danger mark, and it was necessary to retain the services of the Dunedin and other visiting radio amateurs. An exten-

(Continued on Page 46)

TELEVISION—WHEN?

The chances of having television in this country within the next few years seem fairly remote. It is no surprise to New Zealanders to learn that a television service is still a long way off. The main difficulty is the high cost of T-V equipment, and at present the New Zealand Broadcasting Service is faced with a large expansion plan for their medium wave stations.

The Government would have to stand the heavy cost of establishing T-V stations throughout the country as it is highly improbable that private companies would be granted a permit other than for experimental purposes. Again, the N.Z.B.S. would have to produce shows of a high-class entertainment value. To add to the cost of a T-V service the topography of New Zealand would restrict the range of coverage of a station.

However, though no steps have been taken in establishing a T-V service in New Zealand, the engineers of the N.Z.B.S. are keeping a close watch on overseas developments.

2YA's NEW TRANSMITTER

According to a Press message from Sydney which was published in New Zealand newspapers recently, the Amalgamated Wireless (Australasia) Ltd. are completing the final tests at Ashfield of the new 60 kilowatt transmitter for the New Zealand Broadcasting Service.

It was reported that this was the largest medium wave broadcasting transmitter ever made in Australia. However, this is hardly correct, as the A.W.A. built the present 60 kilowatt transmitter of station 2YA 13 years ago.

When the new transmitter is installed at Titahi Bay, the location of the Wellington transmitters and Radio New Zealand, 2YC will take over the present 60 kilowatt transmitter.

Recently work was carried out on the 700ft. mast at Titahi Bay in converting the aerial to a vertical mast radiator for the two 60 kilowatt transmitters. Another radio mast will shortly be making its appearance at the "Bay," when construction is started on the 400ft. tower for the new 10 kilowatt transmitter of 2ZB.

ON THE BROADCAST BAND

CHINESE STATION CHANGES

The following changes in callsigns of Chinese and other Near East broadcasting stations should be of interest to all DX enthusiasts.

To the many difficulties surrounding attempts to maintain a clear picture of the broadcasting scene in China, and this is particularly the case during the present unsettled conditions, we must now add the confusing problem of altered call signs. Since the recent international radio conference held at Atlantic City, many of the Chinese stations have changed their call signs in conformance with the regulations agreed to at this meeting.

In his column in "Radio Call," Rex Gillett has quoted information recently received from the director of the Taiwan station, formerly XURA, detailing the callsigns for stations operating in the Taiwan area. From January 15, this report states, the powerful outlet on 750 kc will use the call sign BED2, 1020 kc will be BED3, 670 kc—BED22 and 1340 kc—BED29.

In addition, it is mentioned that the prefix C as used in Chinese call signs has now been replaced by the letter B. We have doubt that further changes along the lines mentioned will take place in other sections of China, and these should make listening even more interesting when the Chinese as well as other Asiatics, improve in signal strength during the winter months.

P.I. Station Changes

From the Philippine Islands, stations have also been heard operating with new call signs. Initially these caused some confusion, but we now consider the following notes are fairly accurate. The major changes appear to be:—the prefix KZ has been replaced with the letter D, while the location of the station within the islands appears to govern the use of the second letter in the call sign. The 3rd and 4th letters of callsigns of existing stations as far as has been checked, remain unchanged.

As a result we find stations operating from Manila with such calls as DZRH, 650 kc (and formerly KZRH), although in some instances the prefix DU is also being used by some of these stations. From Cebu City, KZRC, 600 kc, announces as DYRC, and KZBU (1250 kc), announces as DYBU, indicating that the prefix DU has apparently been allotted to stations in the Cebu area. One of the first leads to these changes came from Bill Belford and Dave Harding, who pointed out that "hams" were using the prefix D, in place of KA, at the beginning of the year.

Up to the present time of writing, it has not been possible to check on all stations in this area, and consequently we would appreciate receiving reports from readers who may hear these stations between now and the next issue. As the information to date from several sources regarding these callsigns appears to vary, we have purposely refrained from publishing any amended station lists until we are certain of all changes.

Stations Being Heard

In listening to these stations, it is well to bear in mind that the American pronunciation of the letter Z, is Zee and not Zed as most of us are accustomed to using and hearing. Most easily heard stations include: 1000 kc (formerly KZOK), 950 kc (formerly KZMB), 800 kc (formerly KZPI), 710 kc (formerly KZFM). The powerful "Voice of America" relay unit on 920 kc does not usually announce it callsign.

It will be noticed that each frequency employed by any one station in this group is now given an individual callsign, whilst the SW outlets use different calls to the medium-wave station, which of course was not formerly the case.

Saigon and Bangkok Stations

Both Saigon and Bangkok provide interesting signals on most nights from South-east Asia, each transmitting, generally, Asiatic native-type programmes. Saigon, French Indo-China, operating on 1050 kc, is now being heard in several locations, and verifications have been received by readers from this station during recent weeks. Bangkok, Thailand, is perhaps, the stronger station of these two, and should be listened for on its frequency of 825 kc.

The usual good strength signals should be received during the coming weeks from India and Pakistan. VUT, Trichinopoly, 758 kc, should provide one of the best signals, while VUD, Delhi, 886 kc, is heard till after 3 a.m. at fair level. Numerous other stations from this area can often be heard at fair level.

From Pakistan, Dacca, 1186 kc, and Peshawar, 629 kc, come through at good strength.

by
ROY HALLETT

According to Ian Johnston, Manly, two of the strongest signals from Asia at present undoubtedly come from the Japanese JOAK, Tokyo, 690 kc, and "Radio Malaya," Singapore, 618 kc. This corresponds with our own experiences during the past weeks.

JOAK is heard late at night, and generally in the mornings from re-opening at 5 o'clock till it fades out shortly after. This station should be a good signal with the approach of the winter months.

This reader is in doubt about the actual identity of a Japanese signal being heard relaying the same programme as JOAK just after 200 closes its night transmission. He thinks it may be JOBK, Osaka, actually on 690 kc, with 10 kw, as it seems unlikely that either of the two Japanese stations operating on 2CO's channel (670 kc), JOUG, Hofu, and JOJG, Yamagata, with only 500 watts in the aerial, would give such volume at his location.

Also being heard by this correspondent, are JOHK, Sendai, 10 kw, on 770 kc, till it closes at midnight; with a Japanese home programme relayed from JOAK, and WLKH, Saga, Japan on 850 kc, 10 kw, carrying the Armed Forces Radio Service programmes. He mentions that a signal is being heard from the Orient on 750 kc, but to date has not identified it. From the information given this sounds very much like XURA (or as it is now called BED2), Taiwan.

Are you interested in Broadcast DXing? If so, you are invited to send in reports of your latest logging, equipment being used, as well as any suggestions regarding the information you would like included in this page. All letters should be posted direct to Mr. Roy Hallett, 36 Baker Street, Enfield, N.S.W.

New Zealand Stations

Of particular interest during the coming winter mornings should be the improved reception expected from New Zealand stations due to the numerous increases in power carried out in that Dominion since September last. The many changes in frequency and call signs will make the logging of these stations even more interesting, as the entire set-up is now quite different to what we have experienced in the past.

A complete list of the stations operating from New Zealand appeared in the August, 1948, issue "Trans Tasman Diary" notes," and should be used as a guide by all would-be listeners.

The reliable Wellington is still on 670 kc, and others to listen for include:—4ZB, operating from Dunedin, 1040 kc, with its increased power, should provide quite a good signal from opening at 4 o'clock. Like other ZB's and 2ZA, this one carries sponsored programmes. Stations in this group run programmes along much the same style as our own commercial stations.

3YZ, Greymouth, 920 kc, is certainly one to listen for, as station authorities are anxious to receive reports just now.

2YZ, Napier, 860 kc, presenting non-advertising programmes.

4YZ, Invercargill, 720 kc, should also provide a good signal, and like many other NZers heard around 5 a.m., may be heard in relay with 2YA.

Verifications

The receipt of a card or letter verifying reception of a long-distance broadcasting station seldom fails to provide the DX enthusiast with an added feeling of pleasure, as well as, of course, providing a permanent record of the logging. With regard to these verifications, or QSL cards and letters, it should always be remembered that radio stations are under no obligation whatsoever to verify a listener's report. They only do so as an act of goodwill, or perhaps because there happens to be someone on the station staff particularly interested in the hobby.

A verification is normally obtained after the listener has proved by forwarding a list of programme items heard at stated times, that the station in question has actually been received.

Station Addresses

Frequently requests are received from readers for addresses of particular overseas broadcast stations, and consequently the following details should prove of interest. Usually when forwarding the envelope containing the reception report, it is sufficient to merely address it to the director of the particular station, care of the town or city in which it is located—e.g., The Director, Radio Station KOPA, Honolulu, Hawaii. However, when a complete address is known, this should always be used.

New Zealand stations may be addressed to c/o the National Broadcasting Service, in their respective cities, excepting stations, 1ZB, 2ZB, 3ZB, 4ZB and 2ZA, which should be addressed, c/o the Commercial Broadcasting Service.

Indian stations, excepting Hyderabad, may be addressed c/o All India Radio, in their respective cities.

Station in Japan: C/o The Broadcasting Corporation of Japan (Nippon Hoso Kaioki), in their respective cities.

Malaya: C/o "Radio Malaya," in respective cities. In the case of Singapore, make sure whether this station is in this network or the British Far Eastern Broadcasting Service. This latter address should be used in the second case. It should be noted that the former network provides the Home service, and the latter the overseas programmes.

SHORT WAVE LISTENER

Hawaiian Station Transmits Standard Frequency

According to K. Boord, the National Bureau of Standards has begun broadcasting of standard frequency, standard tone and time signals from Hawaii. The new station has been allocated the call sign WWVH and is located at Puuene, Maui.

The operating power of this station is approximately 400 watts and it transmits on frequencies of 5, 10 and 15 megacycles. The transmission is continuous except for a short period each day when the transmitters got off the air to enable the oscillators to be checked with the American station WWV.

Transmissions will consist of 4000 cycles and 440 cycles tone signals, interrupted for one minute every five minutes during which the call WWVH and the time in GMT will be sent in telegraphic code. A *tick* is broadcast every second, except the fifty-ninth. The first *tick* after the skip marks the beginning of a new minute. Tone comes on exactly on the hour and every five minutes thereafter.

The accuracy of WWVH will not be quite as precise as WWV which is one in fifty millions, but it is expected to maintain an accuracy of one in ten millions.

This is the beginning of a new service which will eventually increase power to 2500 watts. WWVH will confirm reports from Engineer-in-charge, Field Station, National Bureau of Standards Box 901, Puuene, Maui, Hawaii.

STATION ADDRESSES:

TGLA, 6290 kc., Radio Periodico y Difusora, La Voz de Centro America, 10a Calle Oriente No. 22 Guatemala, Guatemala.

RIAS, Berlin, Schoeneberg, Kuffsteiner Street, RIAS-Haus, Germany.

CR6RF—Radio Club, Benguela, Caiza Postal NR19, Benguela ANGOLA.

V3USE—Mauritius. Mauritius Broadcasting Service, Forest Side, MAURITIUS.

Paris, France—U.N. Services, Palais de Chailet, Pais 16, FRANCE.

YV5RY—Radio Continente, Caracas. Apartado 866, Caracas, VENEZUELA.

Polskie Radio—Noakowskiego 20, Warsaw, POLAND.

KZBU—Cebu City, P.I. Philippines Broadcasting Corporation, Gotiaoco Building, Comercio St., Cebu City, PHILIPPINES.

KZFM—Philippines. Managing Director, Government Broadcasting Station, KZFM, City Hall, Manila, PHILIPPINES.

Short Wave Station, Macassar.—This is now Radio Indonesia, Macassar Studio, Strandweg Zuid, 2, Macassar, Celebes, State of East Indonesia.

Iceland (Commercial Phone Stations) Minister des Communications direction Generale des Postes et des Telegraphes, Rayjkavik, Iceland.

Readers' Reports

Until further notice would all S.W. listeners forward their list of station loggings direct to the Short Wave Editor, Box 5047, G.P.O., Sydney. Copy for inclusion in May notes should reach us not later than the 1st April, 1949.

Irish Station Abandoned

The Department of Posts and Telegraphs of Ireland reports that the new high-powered short-wave station under construction has now been abandoned as an economy measure. At the present time the only SW outlets are on 17,840 kc. and 9595 kc., which transmit for limited periods only.

Radio Moscow

Radio Moscow requests reception reports of their transmissions and they will forward verification card and other data to all who write. The address is Radio Moscow, Overseas Service, Moscow USSR.

Changes in Spanish Stations

From Miss Sanderson, Victoria, comes a list of alterations to times of transmissions from Spanish Stations. These were recently received from K. M. Dobeson, England.

9368 kc. Transmission in Roumanian, 1715, Polish, 1730, 2130 Hungarian, and closing at 2145 GMT. American Service, 2145-0300 GMT on Saturdays, News at 2300, 2350, and 0200 in Spanish, rest of week as above.

7380 kc. Transmissions in French, 1830-1900, Spanish, 1900-2030 and 2200-2330 GMT.

Radio Seu, EDV10, 7191 kc., 4174 metres usually on the air from 1900-0000 GMT.

Radio Falange de ovideo, FET22, 7130 kc. as back on the air with 250 watts, closing at 2330 GMT.

Radio Med. de Valencia, 7037 kc., 42.63 metres Power of this station is to be shortly increased from 0.1 kw.

Radio Nac. de Espana, Malaga, Operating times now 1700-0000 GHT.

FETI. Closes 2300 Fridays and 2330 Sundays, other days 2230 GMT.

Reports from Australia on various frequencies are welcomed and verifications for correct reports are guaranteed from Teneriffe Valencia, and Madrid, for frequencies of 7191, 7368, and 7380 Kc.

Technical BOOK REVIEW

INDUSTRIAL ELECTRONICS REFERENCE BOOK

by Electronics Engineers of Westinghouse Electric Corporation. Published by John Wiley and Sons, Inc. 680 pages, stiff cover, price 58/- plus postage.

This is a most comprehensive reference book covering the theory, design and application of industrial electronic equipment. As stated in the preface: "This book has been prepared with the hope that the technical data and application information set forth will enable those concerned with the application and utilisation of electronic equipment to have a better understanding of the possibilities and limitations of such equipment." And this it does in an admirable manner.

The book has been written by a group of 37 engineers, each one a specialist in his particular field. Although most of the techniques and applications data are based on specific American equipment, the treatment in each case is from the basic electronic viewpoint, which ensures that the book does not become out of date as equipment changes are made.

The first three chapters cover the fundamental basic laws of electronics, including the various methods of electronic emission Chapters 4 to 10 embrace the design, operation and construction features of the different types of electrons tubes. The various forms of resistance, capacitance and inductance as well as tuned circuits, filters and transformers are covered in chapters 11 to 14. Chapters 15 to 18 detail the circuits for rectifiers, amplifiers, oscillators as well as various control circuits, and the design and application of transmission lines and antennas are presented in chapters 19 and 20.

Of the remaining sixteen chapters, 14 are devoted to reviewing many different types of current industrial equipment, whilst the remaining two discuss the care and maintenance of such electronic equipment.

The text is illustrated with 1259 tone and line illustrations and the extensive reference lists at the end of each chapter will enable the reader to locate additional information on any of the subjects involved.

In summing up this is an excellent book for the price, and one which will provide a valuable addition to any technicians' reference library.

MICROWAVES AND RADAR ELECTRONICS

by Ernest C. Pollard and Julian M. Sturtevant. Published by John Wiley and Sons, Inc. 426 pages, stiff cover, price 38/9, plus postage.

During the past few years there has been a vast amount of technical literature published concerning techniques in the microwave and radar fields. However, this present text, unlike many of its predecessors, is essentially a post-war effort, that deals mainly with the problems that have arisen in this relatively undeveloped field since the end of the war.

This text, which has been compiled and written by two University professors, who worked at the M.I.T. Radiation Laboratory during the war years, is essentially for the student who has not an extensive background in communications and electronics. It is written in an easy to follow style, with many line drawings and photographs to illustrate the relevant portions of the text. Although mathematics are used freely where necessary, the major portion of this book is descriptive and of a practical and interesting nature.

The book contains some thirteen chapters covering topics as: Electromagnetic Fields, and Microwaves, Coaxial Lines, Waveguides, Microwave Technique, Pulse Circuits, Cathode Ray Tube Indicators Tuned Amplifiers, Amplification of Very Weak Signals, Radar and its accessories, etc. In addition, there are three appendices giving additional notes on the Fourier Integral, Curl and Stokes' Theorem, and Units. Most of the chapters list additional problems as well as giving suggested references for further reading.

This book will be of particular value to the reader just becoming interested in this field, as the scope of the topics covered is broad enough to give a general view of the overall field, and yet provide sufficient background for further studies in any particular section of this wide field.

All books made available through Angus and Robertson Ltd., 89 Castlereagh Street, Sydney.

Use of Radio in Clutha Floods

(Continued from page 42)

sive radio network was brought into action with a ZC1 at Balclutha working to another ZC1 transmitter at Stirling. This Stirling outlet was used as a control station for the six No. 48 sets located at various parts of Inchclutha. A third channel was in operation to Kaitangata located near the mouth of the river.

The ZC1's were operated by the amateurs while the Army transmitted from the portable sets which were assigned to a foreman of each working party. The No. 48 sets were netted to the ZC1 transmitter and all operated on 6900 kilocycles.

Difficulties Encountered

Great difficulties were experienced by those on the island; one Army operator stationed at the Stirling bridge was waist high in water, while another party took 65 minutes to cover a quarter of a mile.

The radio communication network was spread over a period of eight days. In the latter part the amateurs maintained three stations for the River Trust, a ZC1 at Balclutha and Stirling with a portable transmitter and receiver in the engineer's car.

The complete amateur coverage entailed a total of 30 amateurs from Balclutha, Dunedin, Gore and Mataura, while Invercargill amateurs offered their services. However, these were not required.

Authorities Impressed

During the whole operation only one technical breakdown occurred, when a 6U7 tube failed in a receiver of a mobile station which was returning to its base. This reflects a remarkable credit to the design of the ZC1's and No. 48 sets, and to the keenness of the operators.

Once again the amateurs of New Zealand have proved that when an emergency arises they are to the fore in setting up a communications system to handle the urgent traffic. The amateurs who took part in the Clutha flood earned high praise from both the local authorities and the press.

An official of the River Trust was impressed with the radio network which had saved the Trust 10 hours' work as the telephone lines were either washed away or congested at the exchanges.

Film Pickup Unit

(Continued from page 15)

is coupled to a sawtooth generator. The sawtooth wave is used for horizontal Iconoscope sweep voltage, shading signal, and waveform monitor sweep.

Equipment Cabinets

Units mounted in the equipment cabinets are the DC power supplies for the system as well as the Iconoscope driver, intermediate amplifier and power switching panel, as indicated in Fig. 1. The power supplies include 4 low-voltage supplies which provide well-regulated plus 350 and plus 250 volt DC power for the various units; a regulated high-voltage supply of —1000 volts for the Iconoscope; and a high voltage supply of plus 1800 and —1000 volts for the type 5CP1 cathode-ray tubes in the waveform monitors. A —150 volt bias supply is also included. The power panel provides a central switching and fusing point for filament and plate power to all units.

In the Iconoscope driver unit there are both horizontal and vertical deflection amplifiers for the Iconoscope sweeps, and two DC control-amplifiers which operate the protection relays. The vertical sweep section employs current feedback to ensure good vertical sweep linearity. The horizontal sweep current is coupled to the low-impedance yoke circuit by means of a shunt-fed deflection transformer with a diode damping tube connected in its primary.

Performance

Operating tests on this system, conducted over a considerable period of time, have indicated consistent, trouble-free operation. Excellent picture quality is obtained with a 16-mm movie projector of the type generally used for television service. With a high-definition test pattern projected on the Iconoscope mosaic by a standard slide projector, the picture monitor shows the limiting horizontal resolution of the system to be in excess of 550 lines. Such resolution is considerably better than that which can be transmitted over the air according to the present day standards for video transmitters.

FM, T-V.

RADIOGRAM FIVE

(Continued from page 20)

this coil unit, simply tune in a station of the high frequency end of the dial, and adjust the aerial trimmer for best results. Correct tracking and positioning of the stations can be effected by adjusting the oscillator trimmer.

After this the I-F slugs can be peaked for maximum output, using a weak station at the high frequency end of the band as a guide.

Metal Television Tube

Latest development in the television field is a 16-inch television picture tube made with spun-steel cones joining the plate-glass image fronts and glass necks.

The major portion of the "envelope" of this new tube consists of a cone of spun chrome steel alloy. Only the image screen and the neck or stem which houses the cathode ray gun assembly are made of glass. These are fused by a special process to the steel cone, which has the same coefficient of expansion as the glass.

Main Advantages

The main advantages claimed for the metal tube include light weight—about one-sixth that of an equivalent all-glass tube, better shielding for the removal of ambient light, increased safety factor (the tube will not shatter if broken) and a larger and better scanning surface. Curvature of the glass screen in the metal tube is so slight that it can be scanned without distortion practically to the edge where it is joined to the metal cone, giving nearly 150 sq. in. of clear image area. For greater clarity, the image screen utilises drawn glass, polished on both sides, instead of the usual pressed glass.

R.-F. MEASURING EQUIPMENT

(Continued from page 35.)

lar circuit or unit. It is necessary, therefore, to arrange the circuit so that, irrespective of the frequency to which the oscillator is tuned, the deviation about that mean frequency will be constant, for a given change in circuit reactance, i.e., for a given deviating voltage.

Constant Frequency Circuit

One means of achieving this result is shown in Figure 7. Here the output of a variable frequency oscillator is mixed with the output from a frequency modulated reference oscillator of fixed mean frequency, to produce a beat note or frequency. The mean frequency of this is determined by the variable frequency oscillator, whilst the deviations about that mean frequency are determined by the modulation applied to the reference oscillator, and hence remain constant in amplitude irrespective of the frequency range being covered. After filtering to remove the undesired original components, this signal may then be used in exactly the same fashion as if it had been directly frequency modulated.

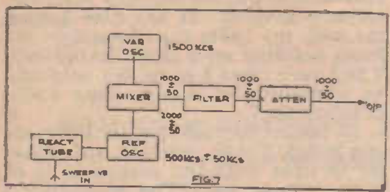


Fig. 7. Block schematic circuit used to obtain a constant deviation frequency.

It should be noted that, because the complete instrument is, in effect, a beat frequency oscillator, it is not possible normally to extend the frequency range by the use of harmonics, as is often the practice with simpler modulated oscillators. If this were to be done, it would be found that on harmonic frequencies the deviation would increase with the harmonic employed, causing an uncertainty of calibration.

Since it is required that the reference oscillator should maintain a high degree of stability, both with respect to its mean frequency, and the deviation produced by a given input voltage, it is usually operated at a relatively low frequency, of the order of 400 Kcs. It is then caused to vary about that figure to an extent determined by the amplitude of the input voltage. In practice it is a common expedient to use separate tubes as the reference oscillator and its associate reactance modulator, whilst the mixer, and variable frequency oscillator may be combined in the one envelope, using a conventional triode heptode mixer tube.

It is hoped to describe shortly full constructional details of a frequency modulated test oscillator of this description, which may be used in conjunction with any standard oscillograph, and which will cover all the ranges normally required in such an instrument as well as having provision for internal or external amplitude modulation.

ELECTROMAGNETIC UNITS AND DEFINITIONS

(Continued from page 11.)

ment appears to run in some such way as this: In the case of an aerial, power is radiated when current flows in it; now, in a direct current circuit, power is developed when current flows, the amount being I^2R. Let us, therefore, pretend that the aerial has a resistance greater than its real resistance, just so great, in fact, as to make the relation $W=I^2R$ true. This value of R is called the *radiation resistance* of the aerial, and is a fictitious resistance introduced to make our equations "come out right."

It is, perhaps, unnecessary to say that an equation which needs such pretences to make it come out right is not worth having, and, in fact, the reality of radiation resistance is seen at once from the fact that whenever current supplies power, the circuit has a resistance of $R=W/I^2$ *by definition.* Any other meaning which the term resistance may acquire by habit is to be regarded with suspicion.

It appears that engineers generally acquire another view of resistance which associates it with the frictional forces between molecules and electrons. This point of view was not inconvenient until technical apparatus appeared in which the chief forces on elections in a wire were not the frictional molecular forces, but the fields in the wire. The work done against the molecular forces is turned into heat in the wire, while the work done against the field forces is radiated away in the case of the aerial, and transferred to the core in the case of the iron-cored coil. The distinction between ohmic and fictitious resistance would be justified if the definition of potential difference were the heat produced (instead of the work done) when unit charge passes from the one place to the other.

Reprinted by arrangement from "Wireless World."

Is Your Transmitter Safe?

(Continued from page 39)

filter condensers. It may consume some power but it will always remove charges from condensers when the switch is off. Better to have the resistor discharge the condenser than yourself.

Remember These Rules

Here are a few simple safety rules learnt from experience. They apply to the newcomer equally as well to the veteran whose years of accident-free operation have frequently made him careless:

(1) Always keep one hand in the pocket when making adjustments; this does not allow a path via the heart should you get across the high voltage.

(2) Only use well insulated screwdrivers. Discard all metal drivers. They are not wanted near any transmitter.

(3) Use insulated plate connectors to all valves with external plate connections, especially mercury vapor rectifiers.

(4) Use parallel feed to all variable condensers placing the rotor at earth potential.

(5) If series feed is essential isolate all rotors with an insulated extension rod.

(6) Fuse all HT circuits.

(7) Get out of the haywire habit. Safety and neatness go hand in hand.

(8) Do not place test loops near RF circuits when the power is on. Anchor them, such as, to a wooden peg.

(9) Be wary of drawing RF sparks with pencils. Carbon is quite a good conductor and you might stop a 1000 volts.

(10) When making adjustments always keep your balance. If you are off balance, it's quite easy to topple to your death.

(11) When wiring transmitters insulate well. Many radio amateurs have lost their lives due to broken insulation.

(12) Don't start meddling around if you have had a few drinks. You need all your wits even with the "safest" transmitter.

(13) Last but not least. If at all possible switch OFF before making any adjustment.

If one can become safety conscious there is no need to worry. Most accidents through electrocution are caused by carelessness, or forgetfulness. The world's greatest hobby has an always present lethal power. Keep it at a distance.

The Mail Bag

I.C.S. (Paradise, S.A.) forwards a circuit of a SW receiver for publication in RADIO SCIENCE.

A.: Thanks for the letter and description of the receiver. We will check this through and advise you of any changes necessary, by mail. It may be possible to include this circuit in a later issue as no doubt it would be of interest to many of our readers. We agree with you on the idea of running the 6V6G with only 100 volts on the screen where low output is required. It certainly does reduce both the current drain and heat problem. We appreciate your remarks about the magazine.

B.R.C. (Toorak, Vic.) asks some general radio questions.

A.: Unfortunately in the limited space it is not possible to fully answer all your questions. Plate dissipation is the power dissipated in the form of heat from the heat as a result of electron bombardment. It is in effect the difference between the power supplied to the plate of the valve and the power delivered to the load. There are three forms of operating conditions—Class A, B and C, and each has its special function in a circuit. Class C is normally only used in transmitter circuits. The term cathode refers to the emitting surface of an indirectly heated valve, whilst the term filament is usually reserved for battery-operated valves. The color code for resistors and condensers can be obtained from most radio text books. We are pleased to hear you enjoy reading RADIO SCIENCE, and thanks for the appreciative remarks.

D.K.C. (Seaforth, N.S.W.) writes: "I have been reading RADIO SCIENCE for some months now and I think it is the best radio publication in Australia. There is only one drawback—it is published monthly instead of weekly. I am an experimenter and part-time serviceman, so my main interest lies in good test equipment. I built the Signal Tracer described in April, 1948, issue, and also the audio oscillator in the October issue. Both of these instruments have been incorporated in my test panel and are operating very well."

A.: Thanks for the interesting letter, DKC, and we are pleased to hear of your success with the two circuits. To date we have not described a VTVM circuit, and consequently at the moment cannot supply you with the information you require. The Public Library or one of the booksellers probably have texts dealing with this topic, which should be of assistance to you. It may be possible to include such a circuit in a future issue of the magazine.

F.K.P. (Crookwell, N.S.W.) compliments us on the high standard of technical articles published in RADIO SCIENCE, and asks if we intend publishing any articles dealing with magnetic wire recorders.

A.: During recent weeks there have been several inquiries regarding a description of this class of equipment, but to date we have not been able to do anything about the matter. One of the main drawbacks is the non-availability of suitable parts, such as motors, and recording wire, and until these are reasonably easy to obtain there seems little likelihood of running a constructional article. However, in a future issue it may be possible to publish some theoretical aspects of the design of such a unit, and leave it to the reader to obtain the necessary parts. From memory we think some of the overseas journals such as Radio News and Radio Craft have published articles on these recorders, but cannot state the particular issue. We appreciate your remarks about the magazine.

TECHNICAL QUERY SERVICE

Readers are invited to send in any technical problems, either dealing with our circuits or of a general nature, and an earnest endeavor will be made to assist you through the medium of these columns. For convenience keep all letters to the point, with questions set out in a logical order, as space is rather limited.

All technical enquiries will be dealt with in strict rotation and the replies will be published in the first available issue of the magazine. Address all letters to RADIO SCIENCE, Box 5047, G.P.O., SYDNEY, and mark the envelope "Mailbag."

D.R.M. (Dubbo, N.S.W.) mentions a newspaper report concerning the installation of radio and other navigation equipment to certain airports, and asks if we can give any details of the high intensity light system mentioned.

A.: Apparently we must have anticipated your letter, D.R.M., as this month's feature article deals with this type of equipment. It was originally developed in America, and is said to provide a ready means of airport identification and runway location up to distances of approximately 1000 feet through the heaviest fog. Special types of lamps are used, and these are detailed in the article mentioned. Thanks for your interest in the magazine and we appreciate your good wishes.

J.M.Y. (North Sydney, N.S.W.) recently built up the Dual Wave Five receiver, and asks why we don't include tuning indicators in our circuits.

A.: We are pleased to hear of your success with this receiver, and that it has come up to your expectations. We have received many other similar reports concerning this set. The main reason that tuning indicators are not shown is that during the past few years these have been in very short supply, and consequently have more or less gone out of vogue. However, if you have one on hand there is no reason why you shouldn't add it to this set. The plate and target of the 6G5 should be connected together through a 1.0 meg resistor, with the target being connected direct to B plus. The grid connection can be connected through a 1.0 meg resistor to the F terminal of the 2nd IFT. Also a .1 mfd condenser should be connected from the grid terminal to earth.

T.A.R. (Ryde, N.S.W.) in forwarding his subscription renewal writes: "I have much pleasure in renewing my subscription for another year, for in my opinion this publication of RADIO SCIENCE is something the radio minded Australian has been waiting for, for a long time. In my profession of designing, I find that the square and compasses are of little use without the necessary literature, and for that reason this publication has been extremely helpful. It has also helped me with my radio experimenting for I am building up a radio laboratory, I feel sure what I have just said will be endorsed by many other radio enthusiasts."

A: Many thanks for the interesting letter, T.A.R., and we are pleased to hear that the magazine is of such help to you. The subscription has been passed on to the department concerned, and no doubt have written direct to you.

B.R.C. (Mittagong, N.S.W.) has a 25B8-GT valve and asks for the socket connections and circuit uses.

A: The 25B8–GT combines a high mu triode and an r-f pentode in the one envelope. This enables the valve to be used as detector or a-f amplifier (triode section) and an r-f or i-f amplifier (pentode section). A standard octal base is used and the connections are: **Pin 1,** Cathode (pentode), **Pin 2,** Heater, **Pin 3,** Plate (pentode), **Pin 4,** Screen grid, **Pin 5,** Plate (triode), **Pin 6** Cathode (triode), **Pin 7,** Heater, **Pin 8,** Grid (Triode). **Grid cap,** Grid (Pentode). **It** is suitable for 100 volt operation only. We trust these remarks will be of assistance to you.

RED LINE

TRANSFORMERS OF DISTINCTION

HIGH TENSION PLATE SUPPLY TRANSFORMERS

The units listed in this Section are high-tension transformers for ful-wave rectifier circuits. Valve heater windings are not incorporated, as they are designed for use in amateurs' transmitters, large public address and paging installations, and many other applications where it is necessary to break the B positive D.C. supply line for "stand-by" operation.

Item 20. — **TYPE No. 27/600.**
Primary: 200-230-240v. .... 150vA 50 cups.
HT.: 600-500-500-600v. 250 mA Choke Input
Base: 5 x 5 x 4-5/8in. H. .... Weight 13lb.
Mntg.: V15 .... "S" is 2in.

D.C. VOLTS	CHOKE INPUT
866	(A) 515v. (B) 415v.
5Z3	(A) 415v. (B) 310v.

Item 21. — **TYPE No. 27/880.**
Primary: 200-230-240v. .... 250vA 50 cps.
H.T.:880-710-710-880v. 275 mA Choke Input
Base: 5 x 6 x 4-5/8in H. .... Weight 18lb.
Mntg.: V15 .... "S" is 3in.

D.C. VOLTS	CHOKE INPUT
866A	(A) 765v. (B) 615v.

Item 22. — **TYPE No. 4/1250.**
Primary: 200-230-240v. .... 500vA50 cps.
H.T.:1250-1250v. 400 mA. Choke Input
Base: 6½ x 6 x 6½in. H (app.) .... Weight 27lb.
Mntg .... Not shown
D.C. Volts .... 1000v. 866 Rectifier

Item 23. — **TYPE No. 4/1400.**
Primary: 200-230-240v. 575vA .... 50 cps.
H.T.: 1400-1400v. 400 mA .... Choke Input
Base: 6½ x 6½ x 6in. H. (app.) .... Weight 30lb.
Mntg. .... Not Shown
D.C. Volts .... 1250v. 866 Rectifier

CHOKES

The Chokes covered in this Section are tested under measured inductance values with rated D.C. flowing, as the meaningless "30 Henry" values are misleading to the uninitiated, and ignored by the engineer. They are smoothing inductances for use as the first choke in condenser input systems, or, of course, as the second choke for choke input circuits.

All inductances are sufficiently high for effective filtering, while D.C. resistance values are made low to maintain good regulation.

Item 24. — **TYPE No. 3068**
Maximum Direct Current .... 60 mA
D.C. Resistance .... 400 ohms
Voltage Drop .... 24 volts
Maximum Inductance .... 25 hys.
Minimum Inductance .... 15 hys.
Base: 3½ x 2 x 2¼in. H. .... Weight 1lb. 8ozs.
Mtng: MHI .... "S" is 1in.
Insulation .... 500v.

Item 25. — **TYPE 50825.**
Maximum Direct Current .... 80 mA
D.C. Resistance .... 500 ohms
Voltage Drop .... 40 volts
Maximum Inductance .... 30 hys.
Minimum Inductance .... 18 hys.
Base: 3 x 3 x 2¾in. H. .... Weight 2lb. 10ozs.
Mntg.: V2 .... "S" is 1¼in.
Insulation 750v

Item 26. — **TYPE No. 301214.**
Maximum Direct Current .... 125 mA
D.C. Resistance .... 300 ohms
Voltage Drop .... 38 vols
Maximum Inductance .... 30 hys.
Minimum Inductance .... 12 hys.
Base: 3¼ x 3 x 2¾in. H. .... Weight 3lb. 2ozs.
Mtng: V2 .... "S" is 1½in.
Insulation .... 750v.

Item 27. — **TYPE No. 201515.**
Maximum Direct Current .... 175 mA
D.C. Resistance .... 200 ohms
Voltage Drop .... 35 volts
Maximum Inductance .... 25 hys.
Minimum Inductance .... 12 hys.
Base: 3¼ x 3 x 2¾in. H. .... Weight 4lb. 4ozs.
Mtng: V14 .... "S" is 1½in.
Insulation .... 1000v.

Item 28. — **TYPE 102512.**
Maximum Direct Current .... 250 mA
D.C. Resistance .... 100 ohms
Voltage Drop .... 25 volts
Maximum Inductance at 10v. A.C. .... 15 hys.
Maximum Inductance at 80 v. A.C. .... 20 hys.
Full Load Inductance at 10 v. A.C. .... 7 hys.
Full Load Inductance at 80v. A.C. .... 10 hys.
Base: 3¾ x 2-7/8in. x 3½in. H. .... Weight 5lb. 4ozs.
Mntg.: V14 .... "S" is 2in.
Insulation .... 1000v.

Item 29. — **TYPE No. 5735.**
Maximum Direct Current .... 300 mA
D.C. Resistance .... 60 ohms
Voltage Drop .... 18 volts
Maximum Inductance at 10v. A.C .... 10 hys.
Maximum Inductance at 80v. A.C. .... 14 hys.
Full Load Inductance at 10v. A.C. .... 5 hys.
Full Load Inductance at 80v. A.C .... 7 hys.
Base: 4 x 3 7-8in x 4in. H. .... Weight 7lb. 12ozs.
Mntg.: Not Shown .... "S" is 2in.
Insulation .... 1000v.

Item 30. — **TYPE No. 35215.**
Maximum Direct Current .... 15 mA
D.C. Resistance .... 350 ohms
Maximum Inductance .... 30 hys.
Minimum Inductance .... 15 hys.
Base: 2 x 1 3/8in. H. .... Weight 8ozs.
Mntg.: MHO .... "S" is 11/16in.

Item 31. — **TYPE No. 294.**
Maximum Direct Current .... 1 amp.
Filament Choke .... 4 m/Hy
Base: 2 x 1 1-8in. H. .... Weight 8 ozs.
Mntg.: MHO .... "S" is 11/16in.

SWINGING CHOKES

The swinging chokes in this section have the same general design and constructional features as the smoothing chokes above. Gap ratios, however, are modified on an incremental inductance bridge to develop large initial inductances, and at the same time, to maintain sufficient inductance under full load conditions to comply with the circuit requirements of high efficiency rectifier systems where the maximum possible regulations is required.

Item 32. — **TYPE No. 10255.**
Maximum Direct Current .... 250 mA
D.C. Resistance .... 100 ohms
Voltage Drop .... 25 volts
Swinging L is from 20 hys to 5 hys
Base: 3¾ x 2 7-8 x 3½in. H .... Weight 5lb 4 ozs.
Mntg: V14 .... "S" is 2in.
Insulation .... 1000 vols

Item 33. — **TYPE No. 5734.**
Maximum Direct Current .... 300 mA
D.C. Resistance .... 60 ohms
Voltage Drop .... 18 volts
Swinging L is from 15 Hys to 4 Hys
Base: 4 x 3 7-8 x 4in. H. .... Weight 7lb. 12ozs.
Mntg.: Not Shown .... "S" is 2in.
Insulation .... 1000 volts

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