RADIO SCIENCE

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RADAR AIDS TO NAVIGATION—G.C.A.

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RADIO — ELECTRONICS — F.M. — TELEVISION

editorial.

RADIO—And World Peace

In the midst of this Festive Season, the time honored adage *Peace on Earth, Goodwill to all Men*—so manifested among the peoples of democratic countries—strikes a hollow note in this third year of our somewhat shaky "peace."

Recent events clearly indicate that most, if not all, nations are striving to bring their defences up to war-time strength, as their international diplomacy appears to fail in providing a satisfactory and equitable solution to world-wide problems. In this latter regard, however, it is not generally realised how important is the spoken word in building up either trust or mistrust between the peoples of the earth, and how Radio should be utilised to engender world-wide friendliness and co-operation.

To many, the vast field of radio and electronics merely symbolises an undreamt of march of intellect, but there is still a unique aspect of its potentialities which to date has not received sufficient emphasis. When radio transmission became a commercial reality some 25 years ago, high hopes were entertained that this could become a major force in achieving world-wide understanding and concord between all nations.

A recent attempt to promote international goodwill was initiated by the United Nations Organisation in opening Station K2UN for the dissemination of peaceful propaganda. Whilst its force in clearing away the doubts, suspicions, hatred and ill-will that seem surreptitiously to creep into the minds of the best of men must not be under-estimated, it still has not gone far enough in this direction.

The physical nature of radio phenomena does not and cannot discriminate between continents. Consequently, this necessitates the radio scientists and engineers considering their problems on a world scale instead of merely local value, and accepting the technical offerings of other countries. An example of this collaboration is evidenced in long distance radio communications.

Broadcasting as we know it today could not operate without world conformity in the control of interference. The preparation and revision of these world agreements to enable each country to achieve maximum results from the allotted frequencies, provide an exceptionally fine demonstration of the possibilities of whole-hearted international co-operation. At the present time in Geneva, Switzerland, an international body of engineers is working on new improved assignments for world-wide communications, and this conference will enable all radio men to display those principles of fair dealing and mutual respect which are an essential ingredient in promoting permanent peace amongst mankind.

The international understanding already achieved, through goodwill, intelligent co-operation and reasonable mutual adjustments in the difficult field of radio communications, might well provide an important contribution to future international relations in other spheres.

This Issue

As readers will have noticed, this publication has been dated Vol. 2, No. 1, as it represents the first of our new improved issues.

A change in printing methods has necessitated a slight reduction in the over-all width of the magazine, but this has been more than offset by the use of a uniform grade of paper throughout the magazine. In addition, the introduction of new type faces and improved layout has resulted in no curtailment in the amount of reading matter presented.

Most of the changes indicated have been based on letters which have been received from readers. Consequently, we still invite readers to continue to offer their constructive criticism as by such co-operative effort RADIO SCIENCE will undoubtedly become the leading all-technical radio journal in this country.

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RADIO SCIENCE

FOR THE ADVANCEMENT OF RADIO AND ELECTRONIC KNOWLEDGE

Vol. 2.—No. 1. JANUARY, 1949

EDITORIAL CONTENTS

OUR COVER. Central station F-M ground plane antenna operating on 70.25 Mc. located on the heights at New Lambton. This radiates energy delivered from a 250 watt transmitter working in conjunction with 12 radio-equipped vehicles of the Newcastle Electricity Supply Department.
(Photograph through courtesy Amalgamated Wireless (A/sia) Ltd.)

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G.C.A.—GROUND CONTROLLED APPROACH

Details of a wartime navigational aid which can be modified for use at civil airports. In addition to providing a ready means of controlling aircraft in the approach area of the airport, it also enables landings to be made under conditions of poor visibility.

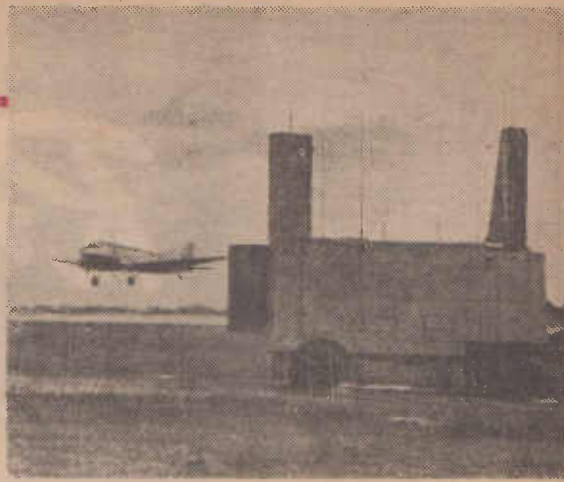


Fig. 1 Photograph of the G.C.A. trailer, with aircraft in background making an approach to the runway.

In this article it is proposed to describe a navigational aid for aircraft evolved during the last war. which has the unusual property that no part whatever of the navigational equipment is carried in the aircraft. This is the system known as Ground - Controlled Approach, or, more commonly, G.C.A. The system, therefore, differs from practically all other radio aids to navigation such as radio compasses, radio ranges, hyperbolic navigational aids, distance measuring equipment, and so on, all of which involve the installation of special radio equipment in the aircraft.

The application of the GCA system has been confined entirely to the navigation of aircraft in the approach area surrounding airports (that is, within a radius of some 20 miles of the airport), and more particularly to the operations of final approach and landing.

In the GCA system all the navigational apparatus, which consists of a group of high-accuracy radars, is on the ground, and the only equipment needed in the aircraft are the ordinary transmitter and receiver used for radio-communication. The position of an aircraft making an approach is continuously and accurately determined by the ground equipment, and the movement of the aircraft along a safe path is controlled by passing verbal instructions from the ground to the pilot; in other words, the aircraft is *talked down* to a safe landing.

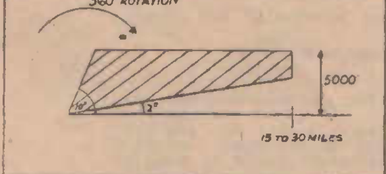


Fig. 2. This diagram shows the coverage of the search radar.

The GCA system was evolved during the latter stages of the recent war, following on the development of microwave radar sets for accurate range and bearing determination. It went into operational use in various theatres of war and was immediately successful, a very large number of blind approaches and emergency landings being made with the aid of the equipment. So valuable and adaptable did the system prove that it was clearly of interest after the end of the war to test the system as an aid to civil flying. The development and application of GCA for such purposes is now being carried on, both in Great Britain and in the United States.

by
JOHN G. DOWNES,
B.Sc., A.M.I.E.E.

Form of the Equipment

As developed for military applications the Ground Controlled Approach equipment was housed in a truck and trailer combination and was completely self-contained in form. An external view of the trailer is seen in Fig. 1.

The equipment comprises basically the following units:—

(1) A search radar, operating at a wavelength of 10 centimetres, which can scan through 360 deg. and which detects and guides aircraft on first entering the approach area.

(2) A precision radar operating at a wavelength of 3 centimetres which scans through a limited volume of space surrounding the path followed by the aircraft during the final approach to the runway.

(3) Radio equipment for communication with approaching aircraft and also with the airport control tower.

(4) A display and control centre where the information from the radars is interpreted and co-ordinated, and where directions to the approaching aircraft are formulated.

(5) Power supplies and other auxiliary equipment.

The Search Radar

As already mentioned, the search radar operates at a wavelength of 10 centimetres. This value of wavelength is a compromise. being sufficiently low to allow the use of an aerial which will give adequate definition for the purposes of searching, and at the same time high enough to allow sufficient r.f. energy to be conveniently generated. The power radiated by the search radar during pulses is approximately 100 kilowatts.

One of the most important features of the search radar is the aerial, which must be so designed that its pattern adequately covers the approach area. The lower limit of elevation at which aircraft can be detected has been set at two degrees. Any attempt to reduce the minimum angle of detection below this figure leads to considerable pick-up of echoes from ground objects, and consequent objectionable "*clutter*" on the screen. The upper limit of elevation at which aircraft can be detected is made as high as possible without sacrificing performance in the directions in

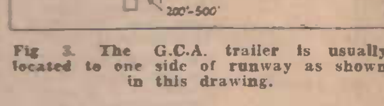


Fig 3. The G.C.A. trailer is usually located to one side of runway as shown in this drawing.

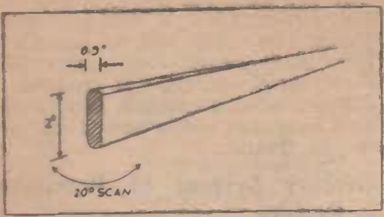


Fig. 4. The beam of the Azimuth antenna.

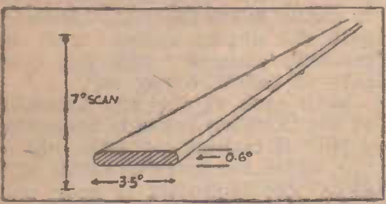


Fig. 4b. The beam of the Elevation Antenna.

which most aircraft will appear; a suitable figure for this upper limit of elevation has been found to be 10 degrees.

Within these limits of elevation the polar diagram of the aerial takes a special form. It is desirable that within these limits the performance of the aerial—that is to say, the strength of the signal transmitted or that received — should be independent of the distance to the aircraft up to some given maximum range. If this result can be achieved all aircraft within the range of the aerial will be equally well served.

Maximum Height

The maximum height which the search antenna is designed to serve is 5000 feet, as it is considered that no aircraft intending to land will enter the approach area at a height greater than this. It is an advantage that aircraft passing through at greater heights are not detected, since confusion is thus reduced. It will be noticed from the diagram of Fig. 2 that aircraft within an area immediately over the station are not detected, but the area concerned is small and the disadvantage not serious.

The antenna assembly is mounted vertically on the roof of the trailer and is drawn at an angular speed of 30 revolutions per minute. The width of the beam in the horizontal plane is 5 degrees approximately. The antenna can be seen on top of the trailer in Fig. 1.

The maximum range at which the search radar can detect aircraft lies between 15 and 30 miles.

Echoes detected by the search radar are presented on two identical displays in the form of 7in. diameter Plan Position Indicators. Each indicator provides a pictorial presentation of the area around the radar, the GCA set being at the centre of the picture. The scale of each Plan Position Indicator (PPI) can be adjusted so that the maximum radius represented on the PPI is 7.5, 15 or 30 miles, as desired.

Independent Operators

Two independent operators interpret the information on the two search radar PPI's. These operators are known as the *traffic controller* and the *aircraft selector* respectively. It is the job of the traffic controller to *"pick up"* aircraft as they enter the approach area and to identify them, since on the PPI screen all aircraft appear the same, namely, as small spots of light.

The identification may actually be carried out by the approaching aircraft itself, which calls up the GCA station and advises that it is entering the approach area at a given distance and bearing. Alternatively, the aircraft may be identified by use of ordinary direction-finding equipment to determine the bearing of the aircraft, which is asked to radiate an identifiable signal for D.F. purposes; or, again, identification may be carried out by asking the approaching aircraft to make some readily-discerned manoeuvre which can be observed on the P.P.I. screen.

Identification having been effected, the traffic controller directs the aircraft along some definite path in the approach area until it is nearing the point at which the turn into the final approach must be made.

At this point it is the job of the aircraft selector to take over control of the aircraft and provide the pilot with verbal instructions to enable him to bring the aircraft into the opening of the narrow sector along which the final descent is made. When this has been done, the operators of the precision radar set will be in a position to assume control of the aircraft for the final approach, the details of which we shall describe shortly.

The required number of radio communication channels from the GCA set to aircraft varies with the number of aircraft within the approach area at any given time. If a single aircraft only is being handled, one communication frequency is sufficient, this being handed on from one controller to the next as the aircraft goes through successive phases of the approach. When, however, several aircraft are in the approach area simultaneously, two communication channels at least are required to avoid confusion; one channel would be used by the search radar or PPI operator, the other by the precision radar or final approach operators.

Location of the GCA Equipment

The normal position for the GCA trailer is on the right-hand side of the landing strip if one looks along the strip in the direction of the approaching aircraft. For safety reasons the trailer is located a distance of 200 to 500 feet from the centre of the runway and 2000 to 4000 feet from the approach end of the runway. With this arrangement aircraft will normally touch down before passing the GCA set, and can be *seen* by it up to the time of actual landing. Figure 3 shows the location of the GCA set.

It is noteworthy that the GCA trailer can be quite rapidly moved to another runway on the airport if required; hence the system is very flexible in this regard.

The Precision Radar

As already mentioned, the purpose of the precision radar of the GCA set is to check accurately the progress of the aircraft down the final approach path.

The wavelength used in the precision radar is 3 centimetres. This is low enough to allow aerials to be designed with the necessary narrowness of beam width, without being at the time unduly large. Since the precision radar is used only to detect aircraft on the final approach, a maximum range of about 10 miles is all that is normally required of it, so that its transmitter power and receiver sensitivity need not be excessively high.

One of the most important features of the precision radar are the antennas, two in number and known as the *azimuth* and *elevation* antennas. The azimuth antenna has an extremely narrow

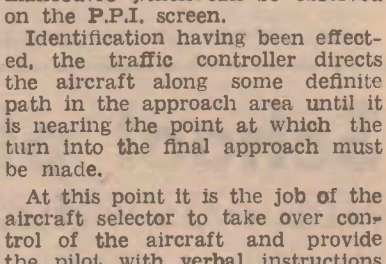


Fig. 5a. Azimuth indicator set on the 10 mile range.

Fig. 5b. Elevation indicator set on the 10 mile range.

beam, only 0.9 degrees in width, in the horizontal plane; in the vertical plane the beam is 2 degrees wide. The beam is made to swing back and forth through a sector of 20 degrees in azimuth, namely, from 5 degrees right to 15 degrees left of a line through the GCA set parallel with the runway centre line. The characteristics of the azimuth beam are illustrated in Figure 4a.

Azimuth Aerial

The construction of the azimuth antenna and the method of swinging the beam are of interest. The antenna consists of an array of dipoles which are located at the focal line of a long semi-cylindrical reflector of parabolic cross-section. The dipoles are fed directly out of a waveguide of rectangular section, to which they are attached and which runs along the array. One side of this wave guide is free to move, and is driven mechanically in such a way that the cross-section of the wave guide is being continuously varied between a maximum and minimum value; in other words, the wave guide is *"squeezed."*

Now the wavelength in a waveguide differs from that for a wave of the same frequency in freespace, and the amount of difference depends upon the dimensions of the guide. Consequently, in our azimuth antenna the wavelength inside the guide which feeds the dipoles will be undergoing a continuous variation. Since the dipoles are spaced along the waveguide at certain definite intervals, the relative phases at which the dipoles are excited will vary, and this causes a swinging of the beam.

A rapid and effective method of producing a scanning beam is thus provided which obviates the necessity for moving the antenna as a whole with its attendant mechanical problems. All that is required is a small motor, which actuates a section of the feed waveguide via a gear box.

Elevation Aerial

The elevation antenna has the very narrow beam width of 0.6 degrees in the vertical plane, while its horizontal beam width is 3.5 degrees. The elevation beam is caused to scan vertically through a range from −1 degree to +6 degrees above the horizontal; the method of achieving the scanning is the same as that described for the azimuth antenna. The characteristics of the elevation beam are shown in Fig. 4b.

Each of the azimuth and elevation antennas goes through a complete scanning cycle (e.g., up and down again in the case of the elevation antenna) in two seconds. The two antennas are alternatively fed power from a single radar transmitter. The rate of scanning may be increased four times for short-range operation if required.

The precision azimuth and elevation antennas are mounted on top of the Trailer.

Display System of Precision Radar

If rapid and accurate tracking of the aircraft is to be achieved as it moves down the final approach path the display system must be carefully planned. This has been done in the GCA system.

With each of the two antennas of the precision radar is associated a pair of cathode-ray tube indicators which are modified forms of a PPI. The indicators of each pair cover ranges of 10 miles and two miles respectively, so that we have:

(i) 10-mile and 2-mile azimuth indicators;

(ii) 10-mile and 2-mile elevation indicators.

An operator is allocated to each pair of indicators; these operators are known respectively as *azimuth* and *elevation trackers.*

The type of presentation provided by the azimuth indicator is shown in Figures 5a and 6a. It is a partial PPI presentation, in which a sector of scan is displayed on the C.R. tube screen. The actual angle of scan is amplified two or three

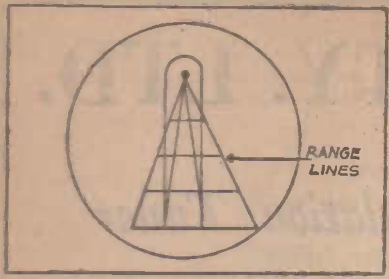


Fig. 6a. The Azimuth indicator set on the two mile range.

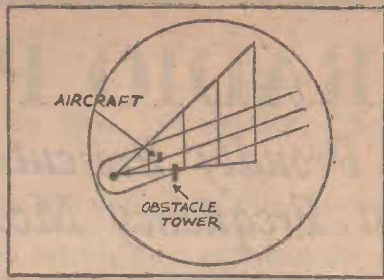


Fig. 6b. The Elevation indicator on the two mile range. The aircraft signal is shown above a permanent echo due to an obstacle (tower) on the airport boundary.

times in the C.R. tube presentation, for purposes of clarity. The sweep is specially designed so that lateral deviations of the aircraft left or right from the centre line of the runway can be measured directly as straight lines on the face of the C.R. tube.

Information regarding elevation is provided by a type of presentation known as a range-height display. Figures 5b and 6b show the general appearance of the 10-mile and 2-mile elevation indicators. Here again the actual angle of scan is much amplified in the display to allow a clearer presentation. Range is measured horizontally and height vertically, and the sweep is specially designed so that deviations of an aircraft from the correct angle of descent (glide angle) can be read directly from the tube face as straight lines.

Associated with each of the precision indicators is a cursor in the form of a narrow, transparent scale pivoted at a point representing the origin of co-ordinates. These cursors are shown in Figures 5 and 6. They carry engraved lines representing the correct path of the aircraft in azimuth and elevation, and also lines indicating deviations of a definite amount. The purpose of the cursors will be explained shortly.

The actual display arrangement is such that the patterns on the C.R. tube screens are reflected to the operator via half-silvered mirrors which allow map outlines to be superimposed on the radar pattern.

Final Approach Control

It is the job of the azimuth and elevation trackers, when an aircraft is making an approach, continuously to adjust the corresponding cursors so that the scale lines bisect the signal which represents the aircraft. The adjustment of the cursors is carried out by means of handwheels. Associated with each cursor and handwheel is a potentiometer, the output voltage of which is fed to a special display unit which is used by a member of the GCA crew known as the *final approach controller*.

This display unit is so arranged as to indicate directly and precisely on two meters the displacement of the aircraft in azimuth and elevation from its correct approach path. In outline the principle is as follows: The adjustment of each cursor causes a corresponding voltage to be produced at its potentiometer. This voltage is compared in the final-approach controllers' display unit with a voltage the value of which corresponds to the correct approach path. The difference between the two voltages, known as the error voltage, is fed to the appropriate meter, the reading of which is therefore proportional to the deviation (with appropriate sign) of the aircraft from the correct path.

In addition to following the signal on his display, each tracker has a second duty to perform. It will be noticed from Fig. 4a that the azimuth antenna beam is only two degrees wide in the vertical plane. Since the precision radar has a vertical coverage from −1 to +6 degrees (see earlier), it is clearly necessary that the azimuth antenna beam be adjusted in elevation so that it can pick up the approaching aircraft. It is the duty of the elevation tracker to carry out this adjustment; on his display is a secondary cursor which shows the elevation of the azimuth beam. By means of foot pedals he adjusts the azimuth antenna (which can be rotated about a horizontal axis) until the azimuth beam, as indicated by the secondary cursor, is roughly coincident with the aircraft signal.

Similarly, the azimuth tracker has the duty of adjusting the elevation antenna (which can be rotated about a vertical axis) so that its beam, which is only 3.5 degrees wide in the horizontal plane, coincides in azimuth with the approaching aircraft.

Error Meters

By interpreting the *error meters* on his display unit the final approach controller is able to assess whether an approach is proceeding satisfactorily. The controller is responsible for the all-important task of instructing the pilot during the final approach. He must also keep the pilot informed of possible hazards during the approach, as for example, the proximity of other aircraft or of dangerous obstacles.

Since the controller is functioning to some extent as the pilots' "brain" he must be quite conversant with the landing procedure from the pilots' viewpoint, and must be quick to foresee any possible danger during the final descent. It is the controllers' responsibility to order the aircraft to "pull out" of the approach if it is apparent that for any reason the approach is unsatisfactory.

High Accuracy Essential

Clearly, the overall performance of the precision radar must be of a high degree of accuracy if safe approaches are to be achieved. To this end special monitoring facilities are provided. At certain known points on the airfield are located corner reflectors, which are metallic screens designed to reflect a large percentage of the energy falling on them. Echoes from these targets are readily seen on the C.R. screens of the precision radar, and their known actual range, elevation and azimuth can be immediately compared with the radar indications of these quantities, thus providing a very good check of the overall accuracy of the radar.

To ensure stability of the azimuth and elevation indications on the final approach controllers' display unit, thorough regulation of all voltage supplies is provided.

Application of the GCA System

The principal object of the GCA set is to navigate aircraft, under conditions of bad visibility, down the final approach path to a point at which the runway is visible. At this point the pilot takes over and lands the aircraft. Many thousands of approaches have been made in this way. GCA is not ordinarily used to guide the aircraft up to the instant when actual touchdown is effected, but under emergency conditions it can be so used. Clearly, however, it is better for the pilot to have control at the final stage if the runway is visible to him.

Future of GCA In Civil Aviation

The GCA system that has been described was evolved for military purposes. Certain modifications are desirable for purposes of civil aviation. The present tendency is

(Continued on Page 46)

Television—Choice of Frequency

By Don. W. George, B.Sc.

Since the recent announcement that television services are to be introduced into this country, there has been intense interest aroused in this form of broadcast engineering and much speculation regarding its future in Australia. In this authoritative article, the author reviews some of the many factors which must be considered when determining the most suitable frequency for such television services.

With the recent news that television services are soon to be inaugurated in this country, there has been intense interest aroused in this form of broadcast engineering, and much speculation regarding its future in Australia. In England and the U.S.A. regular television services have been in operation since 1935, and much research has taken place both in these countries and pre-war on the continent of Europe, mainly in Germany and France. In England, television transmission was suspended during the war, but is now well under way again, with large expansion programmes and regional development.

One of the very first choices that has to be made before construction of transmitters and receivers can commence, is that of carrier frequency for the proposed service. Under present television services overseas, the method of transmission of the picture is by basically the same methods as those employed in telephonic broadcasting, viz., by modulation of a carrier frequency by the picture or video frequencies, radiation of this carrier wave into space, and subsequent demodulation of the picture information at the receiver.

It is usual to employ a separate transmitter on a different frequency for transmission of the sound programme, and thus we are faced with two decisions regarding frequency allocation. In this article we will outline the factors which govern these decisions, and indicate existing literature on this subject.

Scanning Process

With existing television systems an optical image of the scene to be transmitted is translated into an equivalent electrical signal by means of a scanning process. The scene is focused through a lens in the television camera on to a mosaic plate, consisting of an optically active metal, such as silver globules with surface layers of cesium oxide, so that each globule releases a negative charge in proportion to the light falling on it.

An electron beam is caused to pass over the mosiac with a regular scanning motion. Thus the potential of the image plate continuously changes in such a way that the change in its potential at any instant is proportional to the change in brightness between adjacent picture elements being scanned by the electron beam at that instant. An analogous process in reverse is used at the receiver picture tube to translate the electric signal back into its optional equivalent.

Thus the picture or video signal consists of a succession of electrical impulses corresponding to the brightness level of the scanned picture elements, together with blanking signal impulses for the retrace motion of the scanning agent and horizontal and vertical synchronising pulses. It is evident that the quality of the received picture will depend on the rate at which the scanning process takes place, and the number of scanning lines per picture, the finest picture detail corresponding to the maximum frequency in the video range.

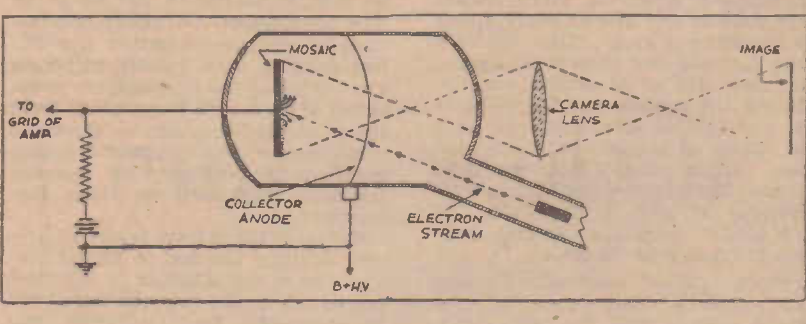
An expression for the maximum frequency in the video range can be derived (1), in which it is seen that the maximum frequency varies directly as the frame repetition rates, and as the square of the number of scanning lines. Thus, under existing standards of transmission in the U.S.A. (525 scanning lines and 30 complete pictures per sec.) the video frequencies range from as low as 30 c/s up to 4 or 5 Mc/s. In England the present standards are 405 scanning lines and 25 complete pictures per sec., and the maximum expected video frequency is 2 to 3 Mc/s.

A-M Picture Transmission

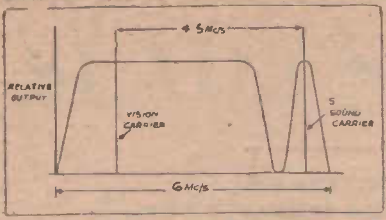
It is usual to adopt amplitude modulation of the carrier wave for picture transmission, in which case the amplitude of the carrier signal is caused to vary at a rate corresponding to the frequency of the modulating signal. This is known to be equivalent to generating *"sideband"* frequencies, the frequency separation between the carrier and a sideband component being equal to the frequency of the modulating signal producing that component.

As a guide to the selection of a carrier frequency, we note first that the carrier frequency must be higher, preferably much higher than the modulating frequency. In fact, for ease in securing linear amplitude and phase responses in the transmission, it is desirable that the highest modulating frequency should not exceed 5 to 10 per cent. of the carrier frequency. This corresponds to a frequency of approximately 40 Mc/s in the above cases, and thus the large bandwidth required does not permit any but ultra-high frequencies to be used for television transmitters.

It is apparent then, that we can-



This diagram illustrates the basic operation of the iconoscope tube.



The standard American television channel.

not adopt a long distance television service, using the ionosphere as a transmission medium in the same way as existing telephonic broadcasting services, as, at frequencies of the order mentioned, above, the ionosphere no longer reflects radio waves back to the earth. However, this would not be a desirable method of picture transmission in any case.

Effect of Reflections

Due to the relative instability of the ionosphere as a transmission medium, the resulting selective fading would cause contrast of the received picture to vary markedly, while existence of multiple ionospheric paths would give repetition of the subject matter of the picture, or *"ghosts."* Whereas in sound broadcasting these effects can be reduced to a tolerable level, the effects of such interference on a television picture would not be tolerable.

Also, due to the bandwidth required per station (shown later to be about 6 Mc/s wide), the number of stations that could be allotted channels below 40 Mc/s would be very limited and it would be necessary to have different stations operating in the same channel, preferably which were widely separated geographically. By adopting frequencies greater than 40 Mc/s, we avoid long distance interference between such stations operating in the same frequency channel.

Minimum Frequency

We thus adopt as the minimum desirable frequency some frequency greater than the maximum usable frequency (M.U.F.). Of the regular ionospheric layers at every season and time of day and at every epoch of the sunspot cycle. This will vary with latitude and thus must be determined for a particular locality. During the winters of 1936-37, 1937-38, and 1938-39 (corresponding to a maximum of sunspot activity), signals from the B.B.C. television transmitter were received fairly consistently at several places in the U.S.A. (2) (operation was on a carrier frequency of 45 Mc/s).

From these observations and many others made since then, it would appear that the m.u.f. in a middle latitude of the northern hemisphere is approximately 45 Mc/s (3). Allowing for 15 per cent. variation from this average from day to day, 50 Mc/s would be a fairly safe low limit for the frequency desirable for a television transmitter.

For a transmitter located at Sydney, there would be only a small difference in the above figures, and 50 Mc/s could again be taken as the lower limit. Reflection of waves of frequencies up to 75 Mc/s can occur from an irregular ionospheric layer within the E-region, known as *"sporadic E."* However, the occurrence of this is not common, and for practical purposes is negligible.

It is important to note that the minimum desirable frequency is dependent primarily on the standards of transmission that are adopted. Under existing overseas standards, it has been shown above to be 50 Mc/s. However, with proposed improved television services (4) using greatly increased numbers of scanning lines per picture, the video frequency would be of the order of 20 Mc/s or greater (the maximum video frequency increases with the square of the number of scanning lines) and the transmitter must be modulated over a correspondingly increased band width.

Similarly, the advent of color television would greatly increase the modulating frequencies. In such cases the minimum carrier frequency would be required to be of the order of 200 Mc/s or greater.

Multipath Interference Problems

Having arrived at a minimum desirable frequency for the picture transmitter, we now investigate the possibility of determining a maximum desirable frequency for such a transmission. However, whereas it was possible to arrive at a definite minimum desirable frequency, the question of an upper limit is very open and is likely to remain so until experience with actual television services in these higher frequencies has been obtained.

The large part of experience in television transmission has been had in the 50 Mc/s region, although at present experimental television stations are operating in the U.S.A. on frequencies up to 350 Mc/s (5). The development of radar and associated equipment during the war has resulted in a greatly increased knowledge of the propagation properties of waves at frequencies from 100 to 30,000 Mc/s, and at the same time lessened the equipment design problems associated with possible television operation in these frequencies.

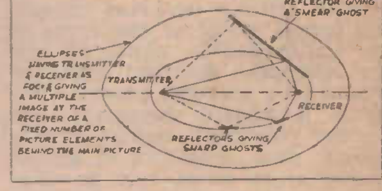
Probably the largest factor at present limiting the use of higher frequencies is the presence of interfering signals in the received signal due to reflections from buildings and similar large objects. These result in multiple patterns in the received picture, which may appear as definite patterns displaced slightly to the right of the main pattern, or as a general loss of definition *"smear"* ghost), or even as a loss of synchronism, giving a *"tear-out"* of the picture.

The effects have been observed at all frequencies used for television services; but it is certain that the interference becomes worse with increase of frequency. As the frequency of propagation is increased, the smaller become surfaces which will act as efficient reflectors, and thus the amplitudes of interfering signals are increased. Similarly increased video frequencies would mean delays of larger numbers of picture elements for a given path difference. Thus interference resulting from paths not very different in length, and not visible with present video frequencies (different observers place harmful interference effects as those giving separations of one or two picture elements or more) would become visible.

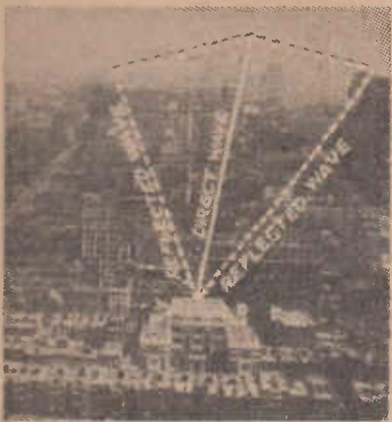
Images Increase with Frequency

Several recent papers describe investigations that have been made into this problem. An extensive field survey was carried out by Du Mont and Goldsmith (6) on the three New York television transmitters (the frequencies being approx. 51.5 Mc/s, 61.5 Mc/s, and 79.5 Mc/s), after which it was concluded "the prime requisite is a method to eliminate secondary images (ghosts) which become worse with higher frequencies."

D. I. Lawson (7) has made a mathematical investigation of the location of buildings which will give interfering signals of any known number of picture elements behind the main presentation and in this way derives ellipses (with transmitter and receiver as foci) such that buildings lying inside them will not give harmful interference images. His calculations are based on the present standards of transmission from Alexandra Palace (the London transmitter) and were for wavelenths of 7, 1, 0.25, and 0.1 metres. He concludes, "The interference will become worse as wavelength decreases, but even in the worse case considered on a 405-line transmission it could be overcome by using a small parabolic reflector about 1 foot in diameter, while a simple dipole reflector would remove most



The method of determining location of buildings or objects likely to give rise to objectionable multi-path interference.



The reception of multi-path signals as shown results in the form of interference known as "ghosts."

of the interference on longer wavelength transmissions."

D. A. Bell (8) has followed up Lawson's paper with a closer study of the relative strengths of the direct and reflected signals, in which he includes the effect of coefficients of reflection of various surfaces, and shows how, with known experimental data regarding reflecting obstacles, the behavior of a particular carrier frequency can be calculated. "For a wavelength of 0.1 metres and an obstacle of the order of 10 metres in size, to obtain a 100:1 signal/reflection ratio would require a receiving aerial having a total beam width of about 6 degrees. Thus the difficulties in the way of the use of such high frequencies are clearly visible."

Due to wind pressure and economic factors, the use of parabolic reflectors greater than two feet in diameter (corresponding to carrier frequencies of several thousands of megacycles) is not very feasible (9), and thus satisfactory removal of multipath interference problems does not appear possible until frequencies of 1000 or 2000 Mc/s are reached.

Other Limiting Factors On Maximum Frequency

We now consider the effects of other factors such as propagation properties and "noise" interference on the choice of the most desirable frequency.

When the first television services were established on V.H.F. it was expected that the useful service range would be limited to the optical horizon of the transmitter aerial. However, it was soon found that this was not so, and in fact, the useful range was increased by up to 50 per cent. (10) more than the optical horizon due to diffraction of the waves around the surface of the earth. Within the optical horizon, the field strength at the receiver can be considered to be due principally to direct *"line-of-sight"* transmission between aerials and to reflection of the wave from the surface of the earth and other obstacles. Beyond the optical horizon, the field strength is due to diffraction of the waves by the earth and refraction in the lower layers of the atmosphere.

Two recent papers (11, 12) have summarised present knowledge of the propagation properties of very short waves and allow calculation of field strengths from empirical relations, making assumptions regarding hills, buildings, etc. However, in general, the complicated nature of the surface of the earth makes exact prediction very difficult. The general transmission characteristics of V.H.F. have also been recently discussed in an article in Radio Science on mobile radiotelephone communications (13).

From these papers we find that the diffraction of energy around buildings and hills decreases with increase of frequency. Similarly the absorption properties of walls and foliage of trees (14) increase with frequency. The actual effect of some of these factors depends on the nature of the polarisation of the transmitted wave. For transmission over water, vertical polarisation has been found preferable, but horizontal polarisation is preferable from the viewpoint of multipath interference (5). In the U.S.A. the standard direction of polarisation adopted is horizontal, whereas in England vertical polarisation has been chosen.

Effect of Frequency

Due to the difficulty in locating the transmitter aerial at such a height that all listeners can have line-of-sight working between the two aerials, a large proportion of the service area normally depends on the diffraction of the waves around hills and buildings, etc.; for the reception of a signal. At frequencies greater than 1000 Mc/s, the shadows from such obstructions become quite sharp and seriously limit the usefulness of such frequencies. Similarly, beyond the horizon, the attenuation increases rapidly with increase of frequency, and thus at frequencies greater than 1000 Mc/s the limit of the service area virtually becomes the optical horizon.

Actually, for unobstructed paths from aerial to aerial, simple theory (15) shows that the transmitted power required to give a certain field strength at the receiving aerial decreases with increase of frequency. However, it has been verified by experiment that, due to the diffraction and absorption mentioned above, the power required to give a minimum satisfactory field strength at *average* receiver locations does increase with increase of frequency and thus places an economic limit on the maximum frequency desirable for adoption.

Airborne Transmitter

In locations where it is possible without difficulty to elevate the transmitter aerial to a thousand feet or more, the above objections to the use of such frequencies are greatly minimised. A proposed system of making the transmitter air- (16) that has been tried out in the the U.S.A., virtually places no limit on the maximum frequence that can be used, as difficulties due to multipath interference and *"shadows"* are automatically eliminated, at the same time enormously increasing the service area (an aircraft at 20,000 ft. has an optical horizon of approx. 175 miles). However, such a system may not be economically feasible, and would certainly not be desirable for an inaugural service, such as at present contemplated in Australia.

Interference to television services of a pulse nature, such as car ignition radiation, and of a continuous wave nature, such as radiation from medical diathermy apparatus, is found to vary with frequency, and thus has a bearing on choice of frequency. Fortunately atmospheric disturbances which provide severe interference to sound broadcasting services are practically absent from all frequencies above 50 Mc/s. A

A proposed system of using an airborne transmitter enables the service area to be increased as well as the elimination of many interference effects.

recent investigation (17) shows that ignition interference has a continuous frequency spectrum from normal broadcast frequencies up to at least 650 Mc/s.

Originally it was thought that above 100 Mc/s the intensity of ignition interference decreased with increase of frequency, but although the strength does vary with frequency, it has now been shown that there is no general decrease in intensity up to 650 Mc/s. Continuous wave interference has been observed, due to harmonics from powerful broadcast and amateur transmitters and also due to medical diathermy apparatus (18).

These forms of interference operate on definite single frequencies and are found to decrease in frequency and occurrence with increase in frequency. Thus the minimum field strength at a given point to overcome interference due to these effects, and hence radiated power required, becomes less as the frequency is increased, but the advantage so gained is only very slight in comparison to the increase in power required due to changing propagation properties.

The difficulty of determining from existing data the most desirable frequency for television transmission is clearly seen from the above discussion. E. W. Engstrom, director of research, R.C.A. laboratories, in testimony before the Federal Communications Commission of America (19), stated that, "All factors considered, television broadcasting channels should start as near to 145 Mc/s as possible." For average city locations and present American standards, this would probably be the most satisfactory compromise.

However, it is evident that a large factor in the making of a final choice is the actual nature of the area to be serviced. Where the country is particularly broken or wooded, or where there is a predominance of large prominent buildings, frequencies closer to 50 Mc/s would probably give improved service.

Sound Transmitter

The sound intelligence accompanying the picture transmission could of course, from a technical point of view, be transmitted on any wavelength in the existing broadcasting bands, but owing to the congestion which exists, few channels are available in this region. Moreover, in the interests of simplicity, it is desirable that the television receiver should be capable of picking up both the sound and vision in the one aerial.

Hence the frequency for the sound transmitter for a given television service should be made as close as possible to that chosen for its vision transmitter. It is desirable also to have the service areas of the vision and the sound transmitters approximately equal. This is simply achieved by using similar frequencies, rather than frequencies widely apart, and thus having different propagation properties.

The minimum separation of the two carrier frequencies will be determined in a given case from a knowledge of the bandwidths of the separate transmissions. The picture transmitter bandwidth can be determined as explained in section 2, while the sound transmitter bandwidth will depend upon the nature of the modulation adopted, i.e., either amplitude modulation as in England, or frequency modulation, as in the U.S.A. The separation should be sufficient to prevent side-band interference between the two signals, without at the same time encroaching more than is essential on the total wave band available.

U.S.A. Standard

In the U.S.A. the present standard adopted by the R.M.A. (20) is the allocation to a television service of a channel 6 Mc/s wide, in which both transmitters are located (see fig. 1). The separation between carriers is 4.5 Mc/s and is achieved by *"quasi-single sideband"* or *"vestigal sideband"* operation, in which a large proportion of the lower sideband is suppressed from transmission, resulting in a reduction of the total bandwidth requirements.

In England, the Alexandra Palace television station adopted a picture transmitter frequency of 45 Mc/s and a sound transmitter frequency of 41.5 Mc/s, giving a separation of 3.5 Mc/s. By placing the sound transmitter below the vision transmitter in frequency (as in the latter case above) a slight advantage is gained with respect to frequency band requirements of the vision carrier, but this advantage is insignificant at frequencies over 50 Mc/s.

A recent proposal suggests the use of a single frequency for both vision and sound transmitters (21), the sound being allotted a certain proportion of the transmitter's time when no video signal is being transmitted. In this way the total band-width required could be reduced still further.

The choice of frequency for the sound transmitter is thus not a separate problem on its own, but is dictated primarily by the frequency of the picture transmitter. The propagation properties of the sound transmitter will be very nearly those of the picture transmitter, while sound distortion effects due to multipath interference can be reduced by the adoption of amplitude modulation instead of frequency modulation. (6) Once a decision has been reached on the relative disposition of the picture and sound carrier signals and their respective sideband components, it is important that this be standardised, so that all transmitters will emit signals which can be received by any receiver.

By way of summary, the following conclusions can be drawn from the foregoing discussion.

1. The choice of frequency is primarily dependent on the standards of picture detail adopted.
2. The frequency of a television transmitter should not be less than 50 Mc/s.
3. It is not yet possible to state an upper limit to the desirable frequency. Such a limit will probably be dictated by loss of coverage due to shadows from buildings and hills, together with the ease with which multipath interference effects can be overcome.
4. The power required to provide a given field strength at a receiving aerial increases as the frequency increases.
5. With increase of frequency above 50 Mc/s the choice of transmitter location and heights of aerials becomes increasingly critical.
6. Increase of frequency means better picture detail, and less interference due to man-made disturbances.
7. All factors considered, for present standards of transmission the frequency should be as close to 150 Mc/s as possible.
8. In localities where there is a predominance of large buildings or the ground is hilly or heavily wooded, frequencies closer to 50 Mc/s would be preferable. In small cities with a few large buildings and where the distances to be covered are only short, frequencies greater than 150 Mc/s could be used to advantage.
9. The frequency of the sound transmitter can conveniently be made as close to that of the picture transmitter as side band considerations permit.

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TUBULAR-BELL CARILLON

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A survey of basic design considerations for electronic carillons with particular emphasis on amplified tubular-bell techniques.

Though the ancient art of bell ringing might have been expected to remain relatively immune from the influence of modern electronic science, it is not surprising that the large bulk, high initial cost, and relatively inefficient sound distribution, to say nothing of difficulty in playing technique, of conventional bell installations has, in recent years, provided a particularly inviting field of application for electroacoustic developments. Amplification systems of high power and fidelity have now made it possible to reduce greatly the bulk of the initial source of musical tone from an assemblage of great bells occupying many thousands of cubic feet of space to a compact console little bigger than a normal piano.

As a consequence, while very few church towers are big enough to accommodate a large peal of conventional bells, no tower is too small for the installation of the electronic equivalent of a peal of 20 or more bells with a listening range, if desired, of several miles, and costing something in the order of one-tenth of that of the conventional bell equivalent. Correspondingly the playing technique of such an installation has been so simplified that the arduous work of a dozen bell ringers may now be accomplished by a single player with the fingers of one hand.

For all these obvious advantages of an electronic bell peal or carillon, there need be very little practical sacrifice in tonal quality. In fact, the resemblance of a well-played electronic carillon to a bell installation of similar note range is very close except perhaps in the immediate vicinity of the tower.

Atmospheric Transmission of Bell Tones

Owing to the more rapid attenuation of the higher audible frequencies with increasing distance, bell tones undergo a mellowing effect as the listener moves away from the immediate vicinity of the tower. With this mellowing effect and for the same reason, the characteristic tonal quality, which at close range may distinguish sharply between bells of various kinds, becomes less marked as the higher harmonic tones, in which much of the initial difference resides, become attenuated. In practice, for propagation, over the surface of the earth, the characteristics both of the intervening terrain and atmospheric conditions appreciably affect not only the intensity but also the tonal quality of any complex sound received (Fig. 1).

Perhaps the most disturbing atmospheric influence on the transmission of sound in out-of-doors spaces is that due to wind; for not only does wind raise the general noise level at the listening site but results in appreciable attenuation and often distortion of the programme received.

Effect of Wind

A steady head or tail wind in the line of propagation results in a vertical deflection of the sound as indicated in Fig. 2. Owing to the increase in wind velocity with altitude, when the direction of propagation is against the wind the wavefront is slowed down with increasing height resulting in the line of propagation being directed upwards, the converse being the case when the sound is travelling with the wind. In either case the consequent dispersion of sound, either on to the ground or up into the air, results in higher attenuation at great distance than would occur in still air.

A rapidly varying wind has a far worse effect on the reception of outdoor music than has a steady one. For not only does the intensity of the sound undergo large fluctuations, resulting in amplitude

Fig. 5. Photograph of an 18-note tubular bell console.

distortion of sustained notes and perhaps complete loss of single notes and short phrases, but the actual pitch may vary from note to note giving the impression that the bells are out of tune. This is due to a variation of the "Doppler effect" whereby a change in the velocity of the medium of propagation has the same effect on the pitch of the received sound as though the actual source itself were moving relative to the observer.

As disturbances of intensity or pitch are particularly serious when single-note tunes are being played, it is preferable in windy weather to restrict carillon performances to change music, reserving tunes for more favorable conditions. It has been determined that the most favorable weather conditions are those in which the air is still, moist and cool. Hence the most suitable times for carillon recitals are in the early morning and in the evening.

Tonal Content of Bell Sounds

The most significant feature about the tone of a bell is that it consists not of a single complex note comprising a fundamental and series of harmonics, but a number of distinct tones called *partials* not necessarily in harmonic relation. These arise from relatively independent radial and circumferential vibrations, whose frequency relations are governed by the shape

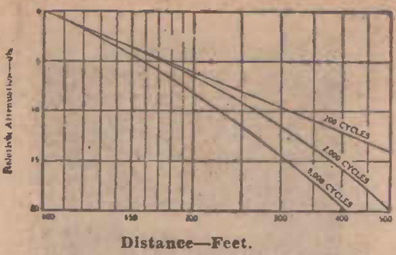


Fig. 1. Curves showing the relative attenuation with distance from the source for the frequency range 200 to 8000 cycles.

of the bell and the distribution of mass in its cross section. It is the object of bell founders so to control these that the partials coincide with specific notes of the musical scale forming a self-consistent harmonious chord.

Pitch and Strike Note

When the frequencies of a number of partial tones of a musical instrument are successive integral multiples of a fundamental frequency, the pitch is determined by the difference between any two successive harmonics which is, of course, equal to the fundamental of the harmonic series. Even if the fundamental itself is absent the ear will judge the pitch of the tone to be that of the absent fundamental; this has usually been attributed to the synthesis by the non-linearity of the ear of the fundamental from the incidence of several successive harmonics.

The pitch of a bell is determined by the most prominent tone heard when the bell is struck along with other bells in succession. This characteristic note is termed the *strike note*, and its precise relation to the other tones of the bell is of paramount concern to bell tuners. The exact nature and origin of the strike note is still somewhat obscure, but, whatever its origin, there appears to be good reason for belief that it is essentially subjective in character.

Tubular Bells

A tubular bell or chime is constructed of thin drawn tubing, usually of bronze or special brass, one end of which is closed by a metal cap or short cylindrical plug. The tube is suspended from a flexible cord passing through two diametrically opposite holes spaced about one tube diameter from the closed end. When struck obliquely with a suitable mallet on the closed end the tone emitted resembles somewhat that of a conventional bell. In point of detail, however, the tonal quality differs appreciably from the latter owing to the different distribution of its partials.

The mode of vibration of a tubular bell is a transverse or flexural mode about an axis perpendicular to the principal axis of the tube. The displacement configuration for the first five partials is shown in Fig. 3.

Sources of Sound in Electronic Carillons

In considering the application of electronic principles to musical production, the most fundamental choice to be made is whether the musical tone itself shall be generated electrically or merely amplified after generation, at low level, with a suitable acoustical instrument. The direct electronic generation of musical sound, though presenting the greatest versatility of tone quality and range, necessarily results in considerable complications of equipment with high initial and maintenance costs.

If the restriction is permitted that only one bell note at a time shall be required, a relatively inexpensive electronic generator can be employed. In this system, a number of valve oscillators are tuned respectively to the various partials of the bell tone to be simulated. The oscillator outputs are then applied to the grids of the separate amplifiers, each initially biased beyond cut off. To *strike the bell* the bias on each valve is suddenly reduced by closing a relay contact, and then allowed to rise slowly to the cut-off value through a circuit of suitable time constant.

By adjusting the time constants for each valve, the varying partials of the bell tone may be simulated. Different notes of a bell peal are produced by pre-selecting the tuning capacitors for the oscillators before the note is struck. This is achieved by a relay system. Independence of the notes in the peal would incur multiplication of the complete generator system by the number of notes in the peal.

Although the initial cost of such a system is still but a fraction of that of a large bell installation, the complexity of the equipment, with consequent possible service difficulties, would appear to make it less favorable for general commercial application than some form of miniature acoustic carillon with electronic amplification. The salient advantages of direct acoustic generation, at least at the present stage of the art, are simplicity of manufacture and permanence of tonal quality and pitch.

Acoustical vibrators suitable for percussive excitation for the simulation of bell tones include miniature bells, hemispheres, spirals, rods and tubes. Of these, the tubular bell offers perhaps the most convenient source of sound for amplified carillons.

Fig. 2. Diagram showing the effect of a head or tail wind on the direction of propagation of a sound wave.

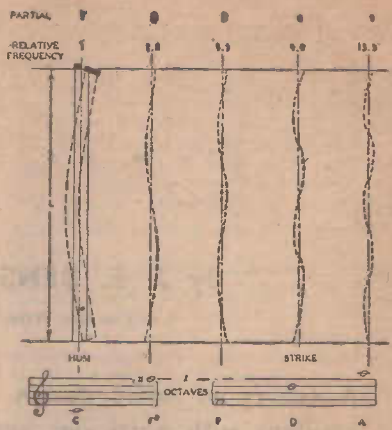


Fig. 3. Diagram showing the modes of vibration of the first five partials of a tubular bell.

Keyboard Operated Tubular-Bell Carillon Console

The first consideration affecting the detailed design of a key-board operated carillon is the method of actuating the hammers from the playing keys. If it is not desired to achieve a touch-responsive action, a simple electromagnetic system may be employed.

If it is desired to achieve a touch-responsive action, as is universally employed in percussive instruments of the pianoforte class, some form of direct mechanical action would appear to present the simplest solution. A very convenient and effective way of achieving this is by means of a simple bell-crank lever in which the planes containing the two arms are separated by the distance apart of the key and the hammer.

The composition and mass of the striker hammer have an important bearing on the tone quality obtained from a tubular bell. The hammer usually employed for manually struck orchestral chimes consists of a small mallet whose head is composed of laminated rawhide empregnated with glue. The size of the head is approximately 1½in. square by 3¼in. long, with a weight of about 4oz. The significant feature of this mallet is that it produces a pleasing bell-like sound, neither metallic nor woolly, at the instant of impact with the tube.

An essential feature of the hammer mechanism is that the mallet head shall rebound clear of the tube immediately after impact so as to avoid the occurrence of any chattering effect. This is readily achieved by providing a mechanical

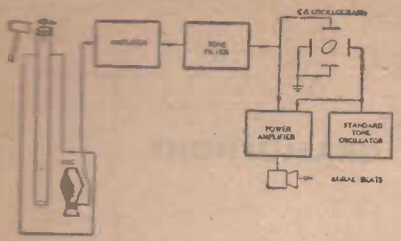


Fig. 4. Block-schematic diagram of the equipment employed to measure the frequency of the individual partial tones in a bell.

stop for the mechanism at a point on the hammer handle a short distance from the fulcrum and ensuring some flexibility between this point and the mallet head.

Typical Tubular Bell Console

Fig. 5 shows on early 18-note tubular-bell carillon console complete with special elevated stool. It is to be noted that the height of the console is fixed by the longest tube employed, viz., approximately 5ft. 3in. This feature is offset with the aid of a special stool enabling the instrument to be played in comfort as an ordinary piano.

Fig. 6 is a close-up view of the console with key cover removed showing the hammer mechanism. The hammer handles are of 5/8in. hardwood dowel. The roller-rod bearings are of cast metal and are bushed with special wear-resisting bushing cloth to provide shock-absorbing and self-aligning bearings. The buffer beams are visible at the top of the console. Behind these can be seen the adjustable buffer pads and hammer heads with tube suspension rods at the rear.

Fig. 7 is a rear view of the console showing the mounting of the tubular bells. The pedal-operated damper bar is visible in the centre just below the microphone platform. This consists of a flat metal bar covered with felt. It is located between the two rows of tubes and normally lies parallel to them.

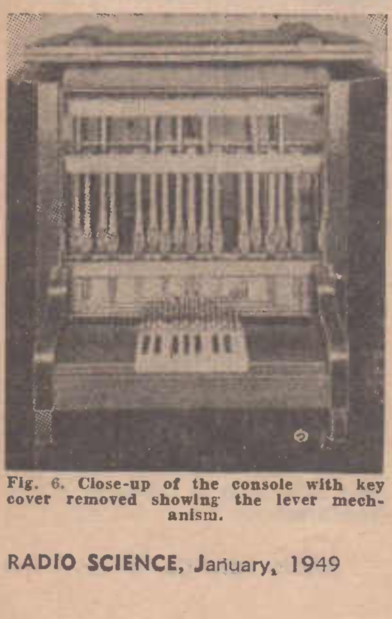


Fig. 6. Close-up of the console with key cover removed showing the lever mechanism.

Just above the bar is a tube guide platform with a felt-lined hole for each tube slightly larger than the tube diameter. The damper pedal causes the felt-covered bar to rotate and press the two rows of tubes outwards against the felt-lined periphery of their guide holes.

The microphone is located near the top of the tubes so as to accentuate the strike note at the expense of the sustained hum notes which follow the strike and are emitted most strongly by the centre region of the tubes. The microphone platform acts also as a baffle to reduce the level of this sustained sound at the microphone. The console is lined with absorbent underfelt to assist in the attenuation of sound by the console walls and so to reduce internal reverberation.

Electroacoustical Amplification

The design of the electroacoustical equipment for an amplified carillon installation plays a vital part in determining the success or failure of the project in the popular estimation. Adequate power-handling capacity, good frequency and transient response and freedom from distortion are basic essentials in any electronic amplification system which aims at successful competition with conventional bell carillons.

The pronounced accentuation of any narrow band of frequencies is particularly deleterious for bell reproduction. Such an accentuation, which is usually due to an inadequately damped resonance in some part of the system gives rise to an oscillatory transient in the acoustic output, whose natural frequency coincides approximately with the mid-frequency of the accentuated band.

The effect of this is that every note struck is accompanied by the same predominant tone which tends to mask the natural tonal composition of the note. It is therefore necessary to ensure that, not only has the electrical amplifier system a flat frequency response, but that the electroacoustic transducers, i.e., microphone and loudspeakers, are free from underdamped resonance effects.

Power Rating

The effects of location, distance coverage, extraneous noise level and weather conditons must be taken into account when determining power output requirements. So great is the change in atmospheric attenuation with changes in weather conditions that a sound level that could be produced by an output of 10 watts on a cool day with still air, would require as many kilowatts on a warm day with adverse wind.

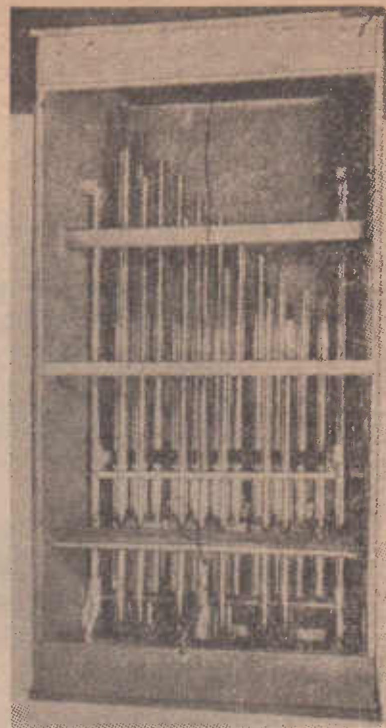


Fig. 7. Rear view of the console showing the suspended tubular bells, the damper bar (centre) and the microphone (top).

Whatever the power-output capacity of the installation the most vital consideration is that under no circumstances should it be possible to overload the amplifier under normal playing conditions. Peak overloading of an amplifier used for bell reproduction produces a particularly objectionable form of distortion which can best be described as similar to the sound produced by striking a *tin can.*

Amplifier Overloading

The seriousness of slight momentary overloading of the output stage of the amplifier is greatly reduced if the output impedance of the driver stage is reasonably low. A high-impedance pentode driver is the worst possible arrangement since the slightest amount of grid current in the output stage results in a sharply clipped output waveform.

The driver stage should be either a low-impedance triode or pentode with negative voltage feedback or preferably a cathode-follower stage directly coupled to the output. Obviously, even with such low-impedance drivers, the undistorted peak output power is still finally limited by the regulation of the power supply. In an optimum design the peak limiting of a steady-state wave due to output-stage grid-current loading should be of the same order as that due to drop of supply voltage consequent upon the extra plate current drawn.

(Continued on Page 46)

THE "PORTA-GRAM"

COMBINATION BATTERY RECEIVER AND GRAMOPHONE

The complete unit is housed in an attractive carrying case.

MAIN FEATURES

- Excellent results on both radio and pickup.
- Low current drain ensures maximum battery life.
- R-F stage for maximum performance.
- Uses loop aerial, with provision for outdoor aerial.

Housed in an attractively covered carrying case, this design is our idea of a receiver suitable for the week-ender, caravan or even the country home. Combining a high performance five-valve battery receiver with a spring gramophone unit, it is capable of excellent radio and record reproduction.

With the advent of summer, most home constructors usually think about building up some form of portable receiver to use on their weekend outings. The popularity of such receivers has been evidenced in our recent mail, where many requests have been made for a portable receiver based on the Countryman's Five circuit. This high performance circuit appeared to be ideal for such a purpose, and consideration was given to describing a receiver based along the lines suggested by our readers.

However, with increased interest now being shown in record players and such equipment, it was considered that instead of describing an ordinary portable, many readers would be interested in a design having provision for record playing. Such a set would be far more versatile than a straight receiver and would be ideal for the weekender, in the caravan or even taken along to the beach in the car. Then depending on the mood, the listener would have the choice of either a radio or record programme.

Naturally in an all-battery design this meant that only a spring type gramophone motor, with its inherent disadvantages, could be used. It was considered, however, that the slight disadvantage of having to wind the motor after each recording was more than outweighed by the extra utility of the idea. To date all who have used the original receiver have not worried about this minor point.

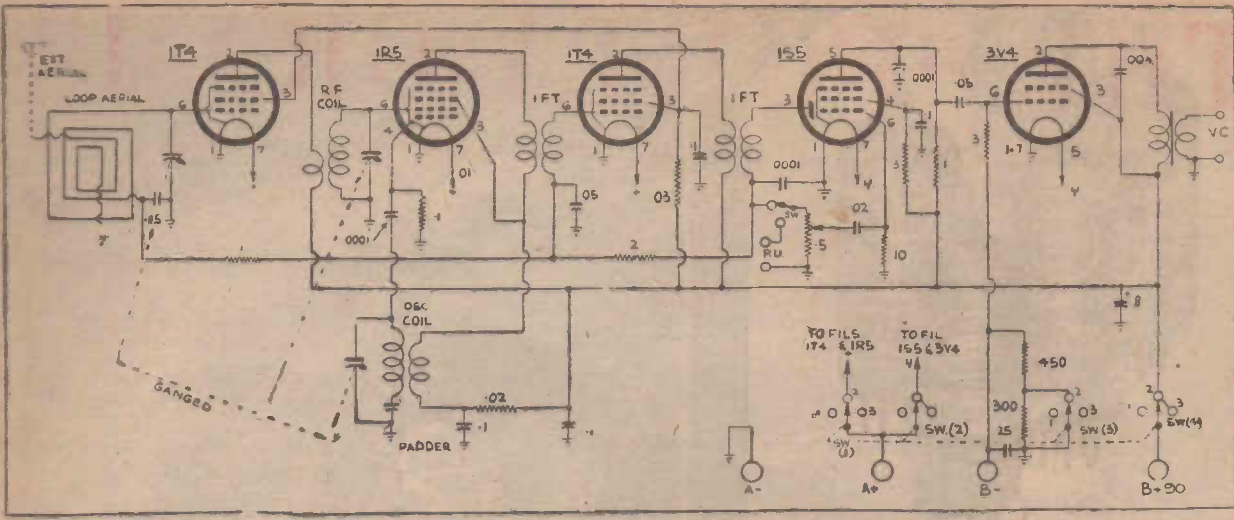
Although the weight of the completed set is not excessive and it can be carried around quite comfortably, it is not in the strictest sense a portable design. Because of this no provision has been made for the inclusion of records in the cabinet. If the constructor desires to carry the records in this manner, then it should be a simple matter to add a wing nut and bolt in the lid of the cabinet and slip the records over these. For extra support two removable wooden cleats could also be added. This once again depending on the constructor's own ideas on the matter.

The compact five valve receiver, gramophone and crystal pickup are housed in an attractive leatherette-covered carrying case. This cabinet is a standard design now readily available at most radio stores and measures only 15 x 14 x 10 inches overall. One aspect of this design which should not be overlooked is that it would make the ideal receiver for the country home which may not have access to AC mains. If desired the unit could be mounted in a suitable polished wood cabinet, thus providing an excellent table model radio-gramophone combination.

Circuit Details

The circuit used is basically the same as that described for the Countryman's Five in the October, 1948 issue, except for slight changes. As before, IT4's are used in the r-f and i-f amplifier stages, a 1R5 as converter, a 1S5 combined diode detector, AVC control and first audio amplifier and a 3V4 as power output valve.

The r-f coil has been replaced with a loop aerial, although there is provision to add an external aerial if required to increase the signal pickup. However, it will be found that on the loop alone, there should be no difficulty in tuning in all the local stations at ample volume from most of the outer suburban areas.



The circuit is generally similar to the Countryman's Five described in the October issue. Note the filament switching which enables the tuner section to be switched off when using the pickup.

With a receiver of this type, one of the major considerations is to keep the total H.T. current within a reasonable figure. If the valves are operated at the normal ratings listed in the valve data handbooks, it will be found that the total current works out in excess of some 20 m.a.—hardly an economical proposition for a battery receiver.

Reduced Ratings

To overcome this difficulty it is usual practice to operate the valves at reduced ratings, as this can result in a considerable reduction in current, and yet the overall performance is not greatly impaired. In this instance the IT4 screen and 1R5 screen and plate voltages are lower than usual, whilst the 3V4 has been slightly overbiassed.

The IT4 screens are connected together and fed from the B plus line through a .03 meg resistor, bypassed in the usual manner with a .1 mfd condenser. The 1R5 circuit is a standard arrangement with the screen and B plus lead of the first I.F.T. being connected to H.T. through the oscillator coil and a .02 meg resistor. Both these resistor values are higher than normally recommended, but enable upwards of a 40 per cent. saving in total receiver current.

The 3V4 obtains its bias voltage through the 450 ohm resistor (or the combination of the 450 and 300 resistors in series when operating on the pickup) and again these values result in a slightly higher than normal bias—just sufficient to effect a saving without impairing the output. The result of these changes gives a no signal current drain of 11 m.a., which drops to slightly under 10 m.a. with a strong signal.

These are quite reasonable figures for a receiver of this type and although the valves are operating under reduced ratings, it will be found that the performance of the receiver leaves nothing to be desired. on the many suburban beaches where this unit has been tested there has been no trouble in hearing the local stations at excellent volume on the loop aerial only. In the gramophone position, using a crystal type pickup, the volume was more than ample, due to the high gain obtained from the audio amplifier section.

The 1S5 is used as the combination diode detector, first audio and A.V.C. control. Since the valve contains only one diode a simple form of AVC is used. This is the usual series arrangement and is applied to only the i-f and r-f stages, leaving the 1R5 to operate at full sensitivity at all times.

The diode load consists of a .5 meg potentiometer and this is used as the volume control for both the radio and gramophone sections. To enable the volume control to be switched from RADIO to GRAMO. a two-way switch is wired into the circuit. This is mounted on the main motor board just adjacent to the pickup. Shielded leads are necessary to make these connections.

Main Switch Operation

To effect a further saving in current drain, it will be noticed that the first three valves are switched out of the circuit, when the pickup is being used. This is accomplished by using a 4x4 rotary switch wired up as shown in the schematic or if it is easier to follow in the separate wiring diagram. The operation of this switch is quite simple.

Two switch banks are used to control the filament circuits, whilst the other two are the bias control and

PARTS LIST

1 Chassis
1 Cabinet
1 3 gang tuning condenser (midget)
1 Tuning dial SLV21
1 Loop aerial
1 R-F, 1-osc. coil
2 I.F.T.'s 455 kc.
1 Spring gramophone motor
1 Crystal pickup

CONDENSERS

1 25mfd electrolytic
1 8mfd electrolytic
4 .1 mfd tubular
3 .05 mfd tubular
1 .02 mfd tubular
1 .004 mfd tubular
3 .0001 mfd mica
1 .0004 mfd mica (padder)

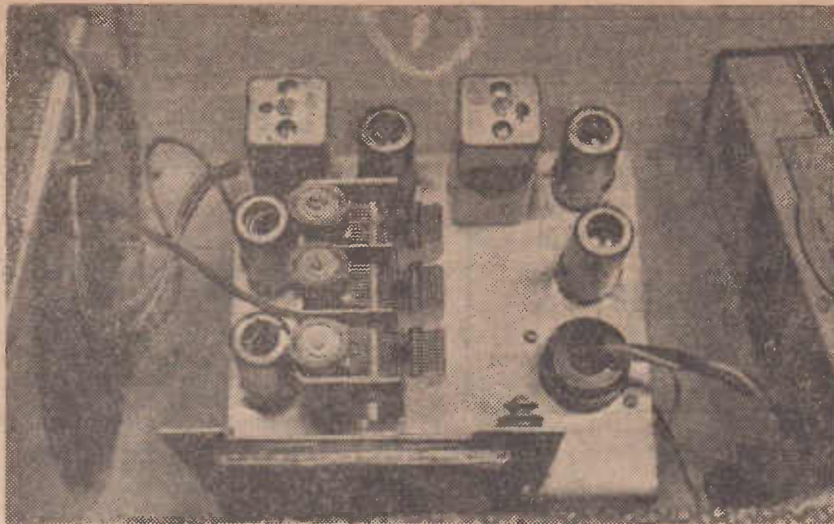
RESISTORS

1 10 meg ½ watt
2 3 meg ½ watt
1 2 meg ½ watt
1 1 meg ½ watt
2 .1 meg ½ watt
1 .03 meg ½ watt
1 .02 meg ½ watt
1 450 ohm ½ watt
1 300 ohm ½ watt
1 .5 meg potentiometer

VALVES: 2-1T4, 1-1R5, 1-1S5, 1-3V4.
BATTERIES: 1-1.4 volt "A," 2-45v "B"
SPEAKER: 5 or 6 inch permag matched to output valve.
SUNDRIES: 5 valve shields, complete with sockets, 1-4x4 miniature rotary switch, 3 knobs, 1 pointer knob, 1 4-pin plug and socket, hookup wire, nuts and bolts, braided wire, etc.

HT-On-Off switch respectively. It will be noted that Pin No. 1 on all switch banks has been left blank, as this provides a convenient On-Off control. When the switch is turned into position 2, both filament switches (SW1 and SW2) are in the circuit, thus ensuring all valves are operating. At the same time SW3 switches in the 450 ohm bias resistor providing the necessary bias for the 3V4 whilst SW4 connects up the HT voltage. Under these conditions the set is operating as a normal receiver.

On turning the switch to position 3, the filaments of the 1T4's and 1R5 are open circuited, thus leaving only the amplifier section in operation. As SW3 is now open, the 300 ohm resistor is placed in series with the original 450 ohm bias resistor. Since the tuner section is inoperative, this additional resistance in the bias circuit is necessary in order to maintain the same negative bias on the output valve, with the reduced HT current.



The top chassis layout is clearly shown in this photograph. The loop aerial is screwed on the left-hand side of the cabinet and the batteries fit on the right-hand side as shown. The two shielded leads connect to the change-over switch on the motor board.

Receiver Layout

The layout of the completed receiver, which can be seen from the various photographs has been based on the use of a standard type of amplifier carrying case, now available around the trade. If you intend using another cabinet, or even making up your own cabinet, then this layout can be amended to suit your own particular requirements.

The receiver chassis measures 6 x 5½ x 2 inches and fits into the left-hand corner of the cabinet. The three gang condenser is mounted slightly to the left of the chassis centre line, with the dial plate flush with the side of the chassis. The 1T4 r-f amplifier and 1R5 converter are placed immediately alongside the gang, whilst the r-f and oscillator coils are placed under the chassis. For this purpose a small aluminium bracket is riveted to the main chassis, in the position shown in the underneath chassis photograph.

The two IFT's and 1T4 and 1S5 valves are mounted along the back edge of the chassis, with the 3V4 immediately in front of the 1S5. It will be noticed that all valves have been fitted with the special valve shields designed for miniature valves. Whilst these are not essential from the stability point of view, they are particularly advantageous in holding the valves securely in position and prevent any likelihood of them becoming loose or falling out of their sockets as the set is carried around. For the slight cost involved you will find this "extra" quite worthwhile.

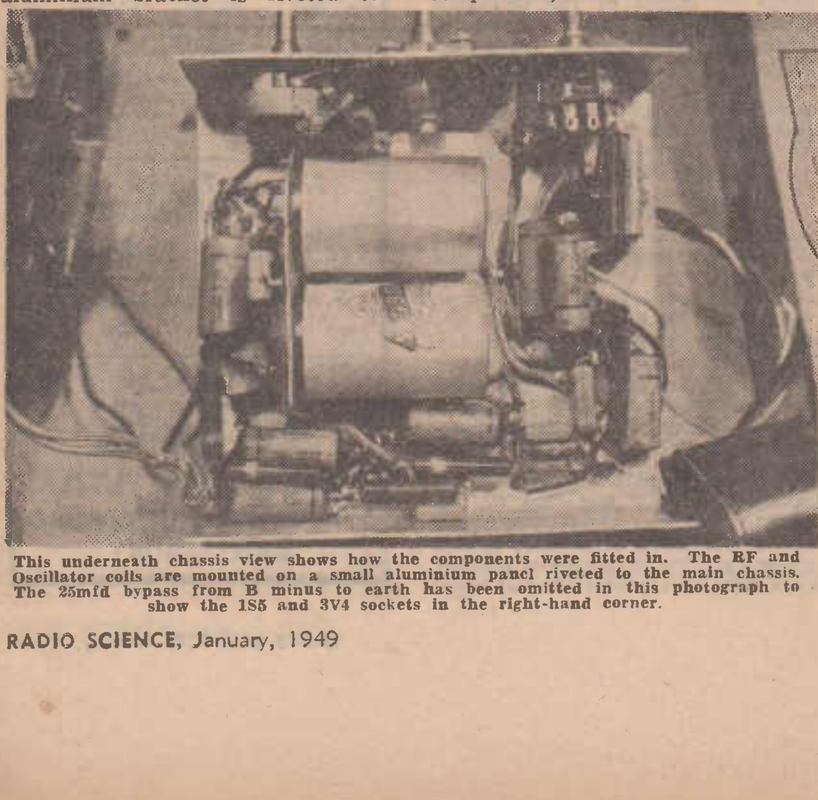
Wiring Up

The wiring up of the set is quite straightforward, and providing care is taken with the positioning of the components, this should cause little difficulty to the average constructor. In most cases it will be found that all components in any stage can be mounted adjacent to the respective valve socket, and this ensures all leads being kept short, obviating possibilities of instability and feedback.

The leads to the volume control as well as those to the gramophone change over switch should be made with shielded wire ensuring the outer metal braid is earthed.

The leads to the switch are taken from the *hot* side of the volume control as well from "F" of the second I.F.T. and these can be seen near the bottom left hand corner of the underchassis photograph. Care should be taken to ensure these leads are left long enough to enable the main motor board to be lifted out without any difficulty.

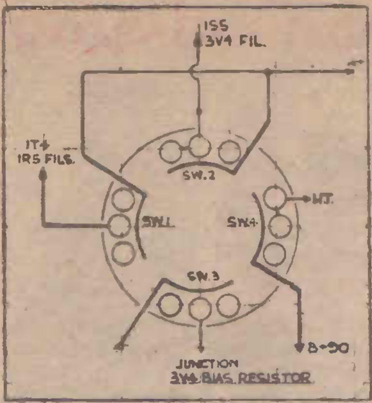
The battery plug and socket is the standard 4 pin variety and this is mounted near the output valve and rotary switch thus ensuring short leads. The two back bias resistors are wired direct from the B minus lead on the socket to the respective pin on the switch.



This underneath chassis view shows how the components were fitted in. The RF and Oscillator coils are mounted on a small aluminium panel riveted to the main chassis. The 25mfd bypass from B minus to earth has been omitted in this photograph to show the 1S5 and 3V4 sockets in the right-hand corner.

Gramophone Mounting

The actual mounting of the gramophone motor will depend on the type used. In our case, the motor was salvaged from a small portable gramophone, and no doubt many other readers will be in the position. To obtain their motor from a similar source, the main point to watch is that adequate clearance is provided for the motor cutout, and it is positioned so the winding handle can be conveniently brought out to one side of the cabinet. Make sure that the motor is mounted on rubber pads, and if these are not already fitted, then suitable rubber grommets can be used. Unless this is done, a certain amount of motor vibration may be heard when in operation.



This diagram shows the switch connections.

Type of Pickup

As regards the pickup, either a crystal or magnetic type can be used, although the former type is to be preferred in view of its somewhat higher output. To date, satisfactory results have been obtained from one of the cheaper crystal units now readily available around the trade.

Irrespective of the pickup used, it is necessary to ensure that it tracks correctly and for this purpose a mounting template is usually supplied. By placing one end over the motor spindle, it should be moved around to find the most convenient mounting position for the pickup.

Although a five-inch speaker was used in the initial tests with this receiver, it will be found that by using one of the modern six-inch types, a worthwhile increase in output and performance will result. However in making this change it will be necessary to cut out a small section of the motor board to provide adequate clearance, or alternatively the motor board can be raised up slightly. In this latter case, make sure that the lid will still close without pressing down on the pickup arm.

Installing Chassis

The main receiver chassis is mounted in the left-hand corner of the cabinet fitting flush with the front and side of the cabinet. It is held securely in position by bolting a metal bracket to the top edge of the dial plate and screwing this into the cabinet side. Also a screw through the bottom edge of the chassis will prevent any undue movement. The loop aerial, is mounted directly on to the side of the cabinet adjacent to the chassis as shown in one of the photographs. The only connections to this are the lead from the aerial gang section and the AVC lead. Incidentally, make sure the gang is fitted with a small trimmer across each section to enable the circuits to be lined up.

The batteries are mounted on the opposite side of the cabinet being held in position by means of an aluminium clip. This can be easily bent up from scrap aluminium and is simply screwed in to the bottom and side of the cabinet around the batteries.

Switching On

When the wiring up is completed, check over the receiver for any possible wiring errors. Connect the A battery and check that the respective filaments light up with the main switch turned in both the radio and gramophone position. Then with a small torch globe wired in the B minus lead, plug in the B batteries, and if everything is in order then you should be able to pick up some station as the condenser is rotated. If no sound is heard, then re-check the wiring—by switching over to the gramo. position and touching the pickup head the audio section can be readily checked enabling any fault to be quickly localised.

Alignment Procedure

Assuming all is in order, loosen the trimmers off slightly and then proceed with the following alignment procedure. Tune in a station at the high frequency end of the band, and adjust the aerial and r-f trimmers for maximum output. Next tune in a station at the low frequency end of the band and adjust the aerial slug for maximum output. Also loosen off the dial drum and adjust the station pointer to register correctly on the known station.

Re-tune the receiver to a known station at the high frequency end of the band and position it correctly by means of the oscillator trimmer. Check the aerial and r-f trimmers for maximum gain, and if the coils, gang and tuning dial are correctly matched, all stations should be received at their correct positions on the dial.

B.B.C. TELEVISION

The frequencies to be employed by the Sutton Coldfield television station operated by the B.B.C. are: vision 61.75 Mc and sound 58.25 Mc. Asymmetric sideband transmission in which the upper sideband of the vision will be partially suppressed is to be used to reduce the band width required. The sound channel will be A.M.

The output of the vision transmitter is 35 kW and that of the sound transmitter 12 kW. The aerial system consisting of a short square tower carrying 8 dipoles is erected on a steel lattice mast 750 feet high.

Long Distance V.H.F. Transmission

By A. G. BROWN

Engineering Sales Dept., Amalgamated Wireless (A/sia.) Ltd.

Details of the results obtained from some recent tests carried out with F-M Mobile Radiotelephone equipment.

Recent tests of long-distance transmission in one of the V.H.F. bands will be of interest to readers who are observing the introduction of F.M. mobile radiotelephone services in the 70-85 mc/s and 156-170 mc/s frequency bands.

Newcastle-Sydney Communication

On the 14th of October signals from the main station of the Newcastle City Council Electricity Department were heard throughout the day on an F.M. receiver whose aerial was installed on a high building in the city area of Sydney. The point-to-point distance is 74 miles, and although the 250 watt Newcastle transmitter on the frequency of 70.25 mc/s gave a signal of good merit at Sydney, a 20 watt transmitter at Sydney could not be heard by the Newcastle Council technicians. At the same time, a radio-equipped car heard the Newcastle signals at a number of spots in the Manly and Mosman areas.

A direct line from Newcastle to Sydney passes partly over the coastal terrain and partly over the lakes of Macquarie and Tuggerah; the weather on the day of observation was fine, warm, and clear with moderate wind.

On the 25th of October, engineers at the A.W.A. works, Ashfield, were again testing and were surprised at the strong signals received from Newcastle. On this occasion two-way conversation was maintained, using a 20 watt transmitter at the Sydney end. The latter aerial was located at a height of about 75 feet above sea level, whilst the Council's station has an aerial 560 feet above sea level, at New Lambton (see cover photo). The weather on this day was fine, warm, and clear, with light wind.

So as to show clearly the relation between optical range and the actual range obtained in this instance, an approximate profile of the terrain involved is drawn in the illustration. The earth's curvature is exaggerated in this drawing and the heights are exaggerated in correct scale proportion, so that a straight line drawn between two points represents the actual path which would exist between the two objects on the earth. It will be seen that the path in this case is fairly clear, a large proportion of its length being over water.

Mobile Tests

A car fitted with an F.M. receiver and a 20 watt F.M. transmitter, both tuned to the Newcastle Council frequency of 70.25 mc/s, left Sydney early in November to proceed to Brisbane; it returned to Sydney about ten days later, and tests were made on both occasions.

It was found that two-way operation could be maintained from about the Hornsby area (as the southern limit), to within about 6 miles of Scone, as the north-western limit. The radial distances are 65 miles and 70 miles respectively. In some areas which are shaded or low-lying, such as the township of Gosford, communication could not be established. The two tests were made at different times of day while travelling in opposite directions, and were very similar in their results.

On the 15th of November the car worked to Newcastle while on the Hume Highway south of Sydney, at the top of the ridge known as the Razorback at Picton. The time was about 8.30 in the morning and the point-to-point distance is about 100 miles.

Newcastle-Moss Vale Communication

As a further example of point-to-point V.H.F. telephony, the test now to be described is also of interest. A station was set up on a hill on the eastern outskirts of Moss Vale on a terrain height of 2400 feet. The ground plane aerial was erected about 40 feet above the ground and the transmitter power was again 20 watts.

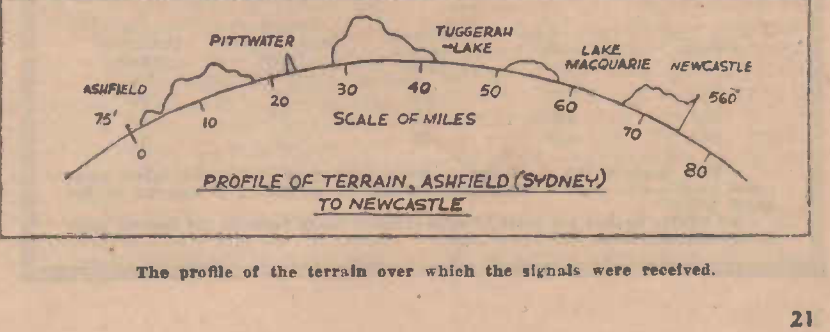
Between 3 and 5 p.m. on the 15th of November signals were heard from the Newcastle transmitter, their strength as indicated by the receiver limiter grid current being about 1 microvolt. Transmission from Moss Vale was not heard at Newcastle. The weather over the whole area at the time was warm and sultry with light winds. The point-to-point distance in this case is 137 miles.

The following morning at 9.15 a.m. the strength of the Newcastle signals was sufficient to cause full limiting action in the receiver, indicating an amplitude of more than 5 microvolts. Two-way conversation was carried on, with excellent signals both ways. The radio-equipped car was standing at the foot of the aerial mast, and although Newcastle signals were well received in it, the car transmitter did not produce a signal strong enough to operate the muting circuit on the receiver at Newcastle, and consequently could not be heard.

Throughout the morning Newcastle was heard carrying on normal routine business, observations ceasing at 1.30 p.m. It was noted that after 10 a.m. the signals fell to about 1 microvolt in average strength, wide fluctuations being present.

The weather over the path on this day was unsettled, being overcast and cooler, with high humidity and light winds. While local tests were being made with the car some 25 miles south-west of Moss Vale its signals were at times compar-

(Continued on page 46)



The profile of the terrain over which the signals were received.

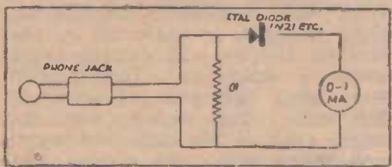
FOR THE EXPERIMENTER

By A. H. NICHOLLS, VK2NI

Null Indicator for Heterodyne Wave Meters

Where exact zero beat is required, such as when setting a harmonic type wavemeter, a visual means is always better than aural.

With the device shown in the accompanying drawing exact zero, or plus or minus zero, may be determined by the swing of the needle of the 0-1 m.a. meter.



Eliminating Drift in BC 348 Receivers

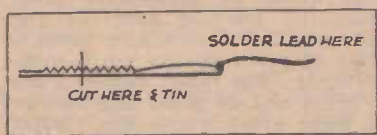
The high frequency bands on a B.C. 348 often will drift slightly. To eliminate this, a small negative or positive temperature coefficient ceramicon should be wired across the oscillator section.

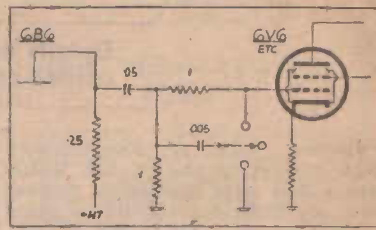
If the drift is to a lower frequency (as is usually the case), use 5 mfd. negative temperature coefficient across that particular range. The trimmer, of course, on the oscillator section must be reduced by that amount.

Simple Antenna Clip

Often it is necessary to have a movable tap on an antenna or P.A. coil so as to permit easy adjustment of these circuits. Usually an ordinary "alligator" clip is too large across the jaws and shorts out adjacent turns.

To overcome this difficulty obtain a "bobby" pin from the XYL. Cut off at the middle and tin the tips and solder a lead to the tops. It will be found this makes a handy little miniature clip that will hang on to 16 or 18 gauge without taking up much room.





H.F. Boost Circuit

The usual wide bandpass audio system in a communication receiver can be readily altered to provide treble boost. One method of carrying out this change is shown in the accompanying circuit.

The grid circuit of the output valve is amended to include a three-position switch which enables any of three ranges of H.F. boost to be selected. It will be found that this arrangement will often improve the readability of QRM'd signals.

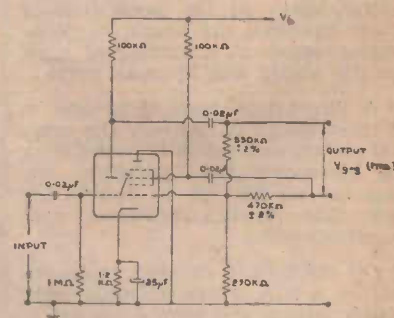
NEW PHASE SPLITTER CIRCUIT

Although a fairly comprehensive range of double triodes for AC operation is now readily available, there is a number of applications for which no suitable type exists. In particular, designers of push-pull circuits for use with AC-DC power supplies or other series-operated systems such as car radio and mobile amplifiers, have found no suitable double triode phase-splitter to meet their needs.

These difficulties have now been overcome as a result of investigations into the operation of triode-hexodes as double triode phase splitters. The recommended circuit arrangement and component values for a self-balancing phase divider using the triode-hexodes ECH35, CCH35 (octal types for AC and AC-DC operation) and ECH42 and UCH42 (all glass B8A types for AC and AC-DC 100 ma operation), together with the performance figures for such an arrangement was recently given in a Mullard Technical Report No. 5/1948. The performance of the circuit detailed is practically identical irrespective of which type of the above valves is employed.

CIRCUIT ARRANGEMENT

From the diagram it will be seen that the oscillator section of the triode-hexode is used as input triode, and the amplified signal is taken from its plate circuit and passed to the grid of one of the output valves. The plate of the hexode section is earthed, and the screen grid (numbers 2 and 4), together with the signal input grid (number 1), act as the second triode. The signal from this "triode" is fed to the grid of the other output valve.



A resistance network across the grids of the two output valves taps off an approximate proportion of their signal voltage, which is used to drive this second triode. Since the driving voltage for this triode is a function of the grid-to-grid output voltage, a self-balancing action is secured. For accurate balancing, it is necessary to ensure that the 330K and 470K meg resistors are of not more than ± 2 per cent. tolerance, although the 0.27 meg earth-return resistor may be of the usual ∓ 10% tolerance.

★ Data courtesy of Mullard-Australia Pty. Ltd.

Performance

H.T. Line Voltage (V)	H.T. Line Current (mA)	x Output Voltage (g-g) (V rms)	Gain Output (g-g) / Input (Times)	Total Distortion (g-g) (%)
200	2.6	33	25	2.6
300	4.0	57	26	2.8
400	5.3	79	26	3.0

x This figure is the maximum available voltage at the output valves measured grid-to-grid, up to the commencement of positive grid current in the phase splitter.

All figures headed g-g refer to measurement made between the control grids of the output valves.

Noise Neutralising Detector

For many years engineers have been trying to find a method for the elimination of static from AM broadcast reception without impairing audio reproduction. This article describes a static free system of detection in which a second carrier is introduced to fill up spaces caused by noise impulses in the original carrier thus ensuring continuity of signals.

The recently developed noise neutralising detector circuit (NND) eliminates crash static of any amplitude by taking part of the the noise energy and making it work to cancel its own damage. Advantage is taken of the fact that the amount of noise on the received carrier is much less than the noise on its sideband.

This suggested a sideband acceptance circuit which was connected in the detector circuit in such a way as to modulate a second carrier (locally generated). The resultant circuit combines the incoming carrier, damaged by noise, and the local carrier, modulated by noise, in such a way as to reconstruct the incoming carrier to its original form, but without the noise.

Interference caused by man-made static (ignition, constant impulse, switching) as well as atmospheric discharge, are eliminated. This action is in contrast to squelch circuits which desensitize a receiver during the time when impulse interference is at its worst, thus losing intelligence continuity.

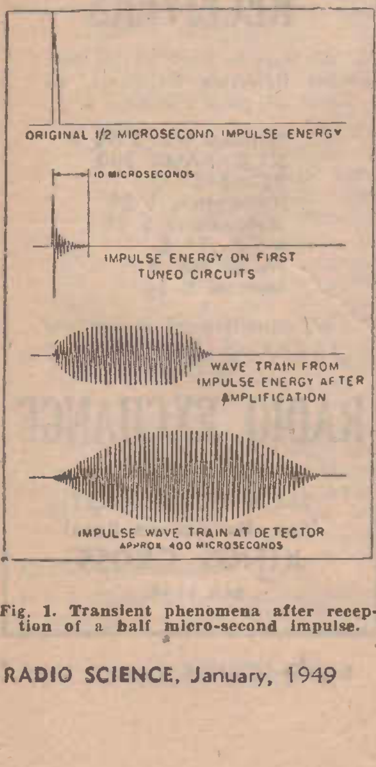


Fig. 1. Transient phenomena after reception of a half micro-second impulse.

In the development of the NND circuit, one of the first problems attacked was the analysis of avc. Most avc systems are actuated by interference energy, and consequently receivers using these systems retard the signal amplitude and decrease the receiver sensitivity when noise is present on the carrier.

However, this noise varies greatly in amplitude, and a circuit to eliminate these wide variations without harming the signal modulation, was difficult to design. For this reason initial development started on the basic requirement that all magnitudes of interference must be handled successfully. Present systems of audio limiting and squelching do not measure up to this strict specification.

Second Detector Experiments

The second detector is the logical point for the elimination of noise. One of the first essentials was to present a linear response of radio frequency and intermediate frequency at the second detector, regardless of whether the energy is generated by noise or signal. If distortion occurs in the amplifier prior to detection, then there is practically no way of neutralising the shock due to noise impulses. This suggests the obvious; that long-time constants must be eliminated in the RF and the IF sections of the receiver.

One way of doing this is to apply avc control voltage to the screen grid of the amplifier valve instead of to the control grid. This permitted the grounding of the control grid return circuit and effectively eliminated RC components.

The next step was to eliminate all cathode bias resistors, which allowed the screen grid to control the impedence or the amplification factor of the valve. To accomplish this it was necessary to use twin-triode tubes with positive avc control voltage on the grids. This was found successful in reproducing a wave with very high peaks and without

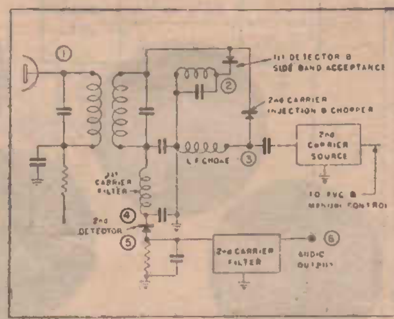


Fig. 3. Basic schematic of noise neutralising detector circuit.

distortion or poor time-constant effects at the second detector.

The Q of the various circuits produced a time constant such that a half-microsecond. high amplitude impulse at the antenna, reproduced at a much lower amplitude in the second detector and a ringing time of only 400 microseconds. During this 400 microsecond period, the carrier is completely swamped by the impulse noise on the second detector.

In conventional detector circuits, this same impulse produces a dead period of the order of 1250 microseconds. (Fig. 1). In this latter case, the intelligence on the carrier would be obliterated between three to four times as long as in the case of the NND circuit. A 1250 microsecond obliteration would be heard as a strong pop in the receiver output.

Conventional Limiting

Conventional limiting circuits designed to reduce noise would, indeed reduce the amplitude of the pop, but the intelligence is nevertheless gone for that length of time. Further, if the noise impulse is occurring at frequent intervals, it is quite possible that the end of one pop may coincide with the beginning of the next and the whole system simply operates on noise.

This indicates that the percentage of modulation is very critical with respect to the amount of noise that

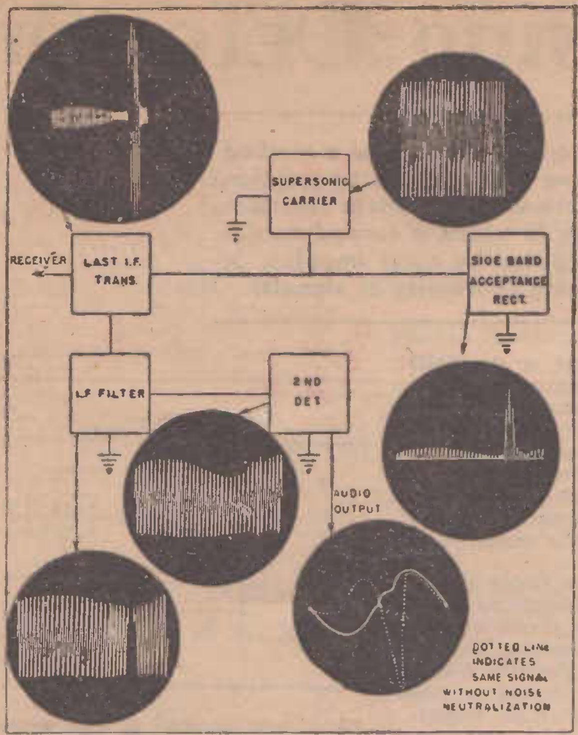


Fig. 2. Effect of 400 micro - second impulse on a 50% modulated carrier.

can be permitted to be reproduced with the audio. Full 100 per cent. modulation will, of course, give a greater audio component and thus withstand more noise. But high levels of modulation cannot always be depended upon, and the next design step proceeded on the basis that noise had to be suppressed regardless of the percentage of modulation

Since the amount of noise on the received carrier is much less than the noise on the sideband, this knowledge was used to evolve a system of noise elimination regardless of fading and signal-to-noise ratio. With this in mind, a circuit was set up whereby the incoming carrier from the last IF fed into a detector network.

Sideband Circuit

Unlike the conventional detector, this network permits diode detection to take place through a sideband acceptance circuit. The result is a sideband reaction in the same circuit which detects the carrier. The impedance of the sideband selector circuit is much higher at the frequency of the carrier or IF. This allows the detector to rectify into its load at the carrier or IF. This allows the detector to rectify into its load at the carrier or IF frequency.

Two problems remained: (1) **Large variations in noise required some form of limiting; (2) The random phase relation between the noise and the carrier had to be corrected before detection.**

This is where the effectiveness of the second carrier comes in.

A locally-generated carrier just above the audible frequencies is injected at the output of the last IF transformer. It is important to remember that the random amplitude of the noise taken from the sideband must be held within certain limits so that the proper reconstruction of the original carrier is possible. This is necessary because the carrier is of a certain amplitude and requires a specific amount of energy to be replaced in the hole caused by the noise impulse. Since the noise energy derived from the sidebands may exceed this value considerably, a form of limiting of the noise amplitude is necessary such that it will be proportional to the required energy to reconstruct the carrier.

This supersonic carrier is passed through a crystal detector and takes the form of a polarised impulse which continuously controls the limiting of the entire circuit from zero amplitude to a point of great enough amplitude to include the positive peaks of modulation of the signal carrier. This dictates that the signal and supersonic carriers must be controlled from an avc source which does not depend on noise energy. In other words, a peak of noise extending the first carrier will cause negative modulation in the second carrier.

When these two carrier modulations are recombined in the second detector load circuit, the supersonic carrier has just the right modulation and the right duration to exactly fill the hole in the signal carrier. Thus the signal carrier has been freed of the impulse shock component. The noise impulse has been neutralised and the modulation that still exists on the carrier is that of intelligence only. This is graphically shown in Fig. 2. Fig 3 is a schematic of the heart of the NND circuit.

Main Uses

This carrier control detection unit has been developed primarily for commercial reception of radio and telephone signals. It is ideal where standby periods are required without a carrier, and yet where the receiver is set for high sensitivity, as in the case of airport control towers. Due to the reconstruction of the carrier wave in the detector circuit, little distortion occurs on modulation even when very severe impulse noise exists.

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F-M AND T-V STATIONS

It is reported that a total of 593 F-M stations and 22 non-commercial educational F-M outlets are now in operation in the U.S.A. Conditional grants now number 109, and 788 construction permits were issued.

Regular television stations now on the air have increased to 30, with 104 construction permits outstanding and 299 applications still pending.

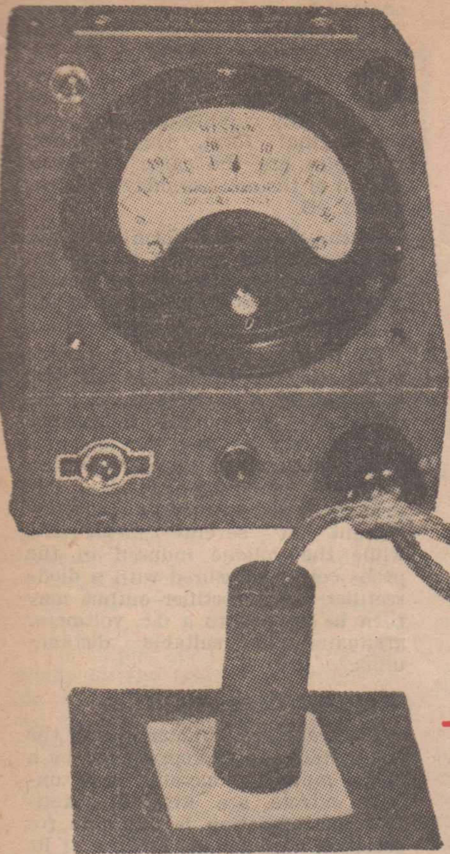


Fig. 1. An instrument for measuring insulator thickness using variable mutual inductance.

ELECTRONIC MICROMETER

by M. L. GREENOUGH

NATIONAL BUREAU OF STANDARDS

The principle of variable mutual inductance is utilised in the construction of this very accurate electronic micrometer. It is suitable for determining the thickness of paint coating, oil film, sheet metal, etc., to a high degree of accuracy.

The variation of mutual inductance between two coils in the vicinity of a metal surface can be used as an indication of the distance between the coils and the metal. This principle may be incorporated in devices for high level, linear, electrical distance measurement. Such devices are suitable for determining the thickness of paint coatings, oil films, insulators, or air gaps.

Fluctuations of distance at any frequency mechanically possible are indicated as a corresponding electrical variation. Therefore this principle may be used for vibration measurements. In this field lie microphones, phonograph pickups, pressure recorders, seismographic instruments, etc., as well as direct vibration analysers.

Still another class of service is in the measurement of the thickness of sheet metal. An example would be to furnish a continuous indication of sheet thickness in a rolling mill. For applications of this type a double pickup style of construction would be employed.

Typical Instrument

Fig. 1 shows an instrument which has been built around the principle of variable mutual inductance for the measurement of insulator thickness. It has two full scale ranges, .005 and .05 inches. Accuracy is better than one per cent., that is the error is no greater than .00005 inch on the low range, and .0005 on the high scale. With suitable meter multiplier resistances, displacements of 100 millionths of an inch have been read, although this is by no means the limit of sensitivity of this method of measurement.

Numerous systems have been used for the electrical measurement of distance. Most of these are based upon the variation of a capacitance 1, 2 of an inductance, 3, 4 or of an optical light path.

The capacitive systems are subject to errors arising from variation in the dielectric constants of the material being tested. In order to measure large distances, the capacitances necessarily become very small, or else the physical size of the plates has to be increased. Ordinarily, the output is a non-linear function of distance. For measuring very small gaps on curved surfaces, the two electrodes must be precisely matched. An electrical connection to the base plate is required, and the length and position of this lead is sometimes critical.

Inductive Systems

Some inductive systems have been developed for measuring insulating materials or non-magnetic metals on iron or steel backings. The reluctance of a gap of the non-magnetic material under test controls the flux in an iron core. The base plate completes the magnetic path.

In general, the output is not a linear function of distance. Excitation of the core is limited to a low frequency because of core losses, so that rapid variations of distance cannot be indicated. Specially shaped pole pieces are again required for small gaps about curved surfaces. Usually no electrical connection to the base is necessary for inductive systems.

An air core coil excited at radio frequency has been used for this time of measurement. The inductance variation can be made fairly large, but linearity of response over any appreciable range is difficult to secure.

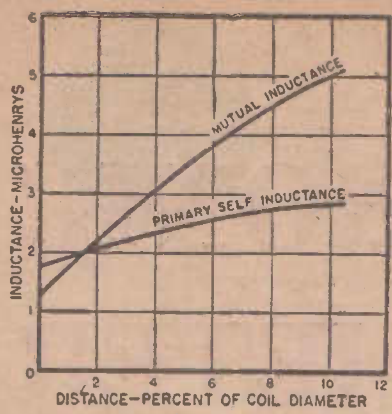


Fig. 2. Self and mutual inductance of the two coils as a function of distance from end of coil form to metal plate.

Optical position indicating devices arranged for electrical output have been used to some extent. The disadvantages of these are that the base plate must either be highly polished, or have mirror attached. The gap being measured must be transparent. A great degree of dependence is also placed on the somewhat variable characteristics of photoelectric cells.

Most of the drawbacks of these methods mentioned may be overcome with the system utilising the variation of mutual inductance of two air core coils. In the description that follows the steps in its evolution are traced.

Operation of System

Suppose that a primary coil is excited by radio frequency current, and that the plane of the coil is parallel to a nearby metal surface. Fig. 3A shows such an arrangement. Let it be assumed that the metal plate is of a perfectly conducting, nonmagnetic material. Under such conditions, the electromagnetic field is exactly cancelled by the field of the eddy currents induced in the plate. A secondary or probe coil placed just at the surface has no voltage induce in it. If the probe coil is moved away from the plate toward the exciting coil, it will be found that an increasing voltage is picked up as the probe coil is placed closer to the primary coil. The voltage output of the probe coil can then be used as an indication of the gap between it and the metal surface.

Such a system has mechanical disadvantages, because of the necessity of flexible leads, etc. An improvement is to mount both the exciting and probe coils on one form, and to move this coil assembly with respect to the metal. The same basic principles still apply.

Now the strength of the exciting field is no longer constant, as in the previous example, since the spacing between the primary coil and the plate is varied. The resulting correction to the effect of variable distance from probe coil to plate is small, so that there is not much loss in scale factor. At the same times the device becomes readily adaptable for many applications.

Inductance vs. Distance

A typical relation between distance from probe coils to plate and mutual inductance between the two coils, is shown in Fig. 2. This relation is apparently linear up to about 5 per cent. of the coil diameter. Linearity to within one per cent. is not difficult to secure over this 5 per cent. range. One commonly useful size of probe coil is one inch in diameter, permitting linear measurement up to .05 inch.

This graph shows the difference between the relative variations of mutual and self-inductance, although the plot of self-inductance may not represent optimum design for a single coil.

The mutual inductance is not zero at zero spacing, for several reasons. The probe coil cannot be located at the surface of the metal, because the coil must have finite size and enough wall thickness for mechanical rigidity.

Another factor, although much smaller, is the skin depth of the metal itself.

The resulting initial mutual coupling may in some instances be cancelled by employing a third coil on the same form mounted close to the exciting coil, so that coupling between it and the exciting coil is relatively unaffected by the proximity of the metal. It is connected in series opposition with the probe coil, and is adjusted for zero total mutual coupling to the primary coil when the metal surface is at the end of the coil form.

Considerable experimental investigation has been made of the effects of geometry of the various coils. The characteristic shown in Fig. 2 can be made concave upward, linear, or concave downward. The optimum form has been found to be two concentric, co-planar coils, one coil having an average diameter 70 per cent. of the other. Maximum change of mutual coupling for the greatest linear range has been secured from this design. Although it apparently is quite different from the original form, the operating principles are the same. A cross section of the coil assembly is shown in Fig. 3B.

Inasmuch as this form does not lend itself very readily to the installation of a buckout coil, some other method of cancellation of initial coupling must be employed.

Electrically, the electronic micrometer may be treated as any two coils having a variable mutual inductance. A mutual inductance bridge could be used for distance determination, but direct excitation is more generally useful. The primary is fed with radio frequency current at several megacycles, while the voltage induced in the probe coil is measured with a diode rectifier. The rectifier output may then be applied to a d.c. voltmeter graduated in suitable distance units.

Transfer Characteristics

The transfer characteristics of the coil system can be represented by a single mutual inductance if resonance effects are avoided. Nonresonant operation is desirable for precision applications because of its independence of operating frequency and coil losses. Operation at lower than resonant frequency is not alone the solution as harmonics of the exciting frequency may be accentuated, sometimes causing distortion of the linear relation of the voltage output with distance.

In order to keep the resonant frequency as high as possible, the rectifier is usually mounted directly on the coil form. A simple low-pass filter, consisting of a series resistance operating in conjunction with the shunt capacitance of the diode rectifier has been found to reduce the resonance rise to negligible proportions. A typical output circuit for the micrometer is shown in Fig 4.

For some applications, the enhanced output due to resonance, at

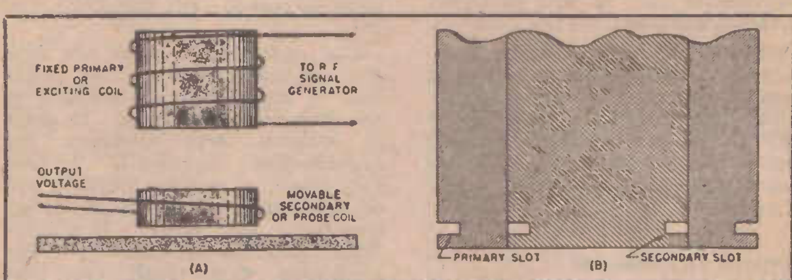


Fig. 3. (a) Functional form of the Micrometer; (b) Cross-section of the probe coil form.

the expense of stability is of benefit. The scale factor may be increased by a factor of ten or twenty if it is practical to take advantage of resonance. The range of linearity is likely to be reduced in this case.

As long as the inductances of the input and output coils are not changed, it makes no difference which slot is used for which winding, and the mutual inductance remains the same. In general, the large coil is used as the high current exciting winding in order to increase the heat-dissipating area.

Micrometer Output

The micrometer output may be in the form of a radio frequency signal, a d.c. voltage or a low-frequency a.c. voltage. For the first, the probe coil output is used directly. For the last two, a diode rectifier is employed. The low frequency a.c. output can be produced by amplitude modulation of the exciting r.f. current at the frequency desired.

The output obtainable is limited chiefly by the power dissipation in the primary winding. With a voltage doubler rectifier, it is easily possible to secure an output of 150 volts d.c. for movements of .05 inch. This is 3 volts per thousandths of an inch. These are some representative values for reasonable excitations, such as can be supplied by one-tube, low power oscillators in continuous wave operation. If a pulsed r.f. carrier is applied, with a peak rectifier on the secondary, the output may be raised considerably for the same average primary power.

Associated Circuits

For most uses the coil assemply is driven by a radio frequency oscillator, a typical diagram of which is shown in Fig. 5. The power generation circuit consists of an oscillator at 3 megacycles, whose output current is held constant in amplitude. Since current rather than voltage is monitored, changes in lead length and in copper resistance of the primary winding will have no effect upon the scale factor of the output of the probe coil.

To supply as much power as possible to the exciting coil, and to reduce the number of tuned elements, the exciting winding is made part of the oscillator plate tank coil itself. In series with it is a current transformer for getting an indication of output current. The feedback winding for the oscillator grid voltage is also on this current transformer. The combination of exciting coil and primary winding of the current transformer is parallel resonated by the tank condenser, so that the tube itself has to supply only a small fraction of the current in the load.

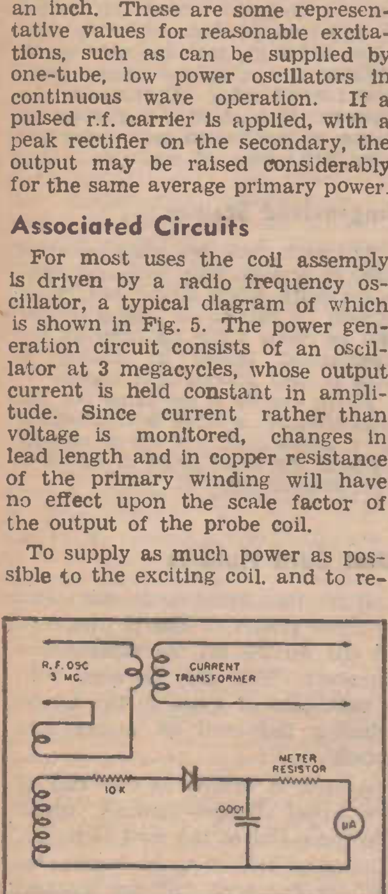


Fig. 4. Typical Output circuit.

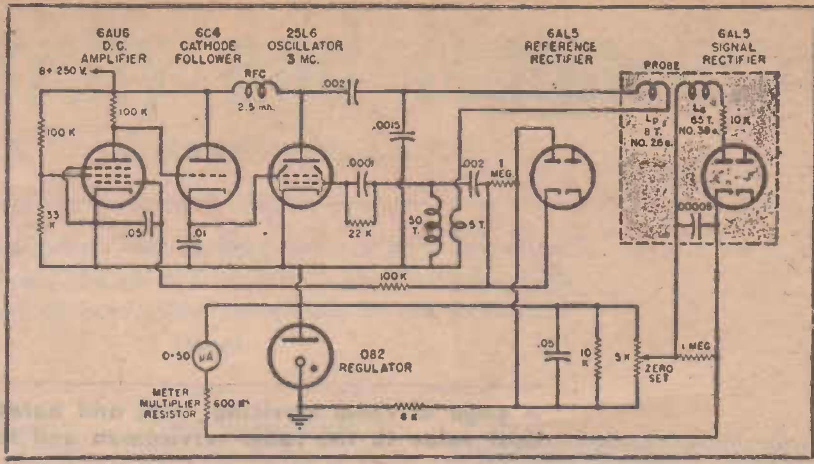


Fig. 5. Complete circuit diagram of the electronic micrometer.

Coil Details

The secondary of the current transformer consists of 50 turns of No. 30 e.s.c wire on a form half-inch in diameter. Directly over this is the 5-turn primary of No. 24e wire. The probe itself has 8 turns of No. 26e on the primary and 55 turns of No. 38e on the secondary coil.

The voltage from the secondary of the current transformer is rectified, compared to a d.c. voltage from the voltage regulator, and fed to the d.c. amplifier. Through a cathode follower, this amplifier controls the screen voltage of the oscillator tube. This regulator circuit has a loop gain of the order of 100, holding the oscillator output quite constant for tube, line voltage, etc, variations.

The secondary circuit for the output consists of a diode peak rectifier and a d.c. voltmeter. Cancellation of initial coupling is provided by inserting a bucking d.c. voltage in series with the rectified probe output. This makes for easy range switching, since it is only necessary to change the multiplier resistance in series with the meter.

Any pentode or beam power tube is suitable as an oscillator. A 25L6 at 110 volts plate supply is adequate for driving one micrometer at 50 volt amperes. A single 807 is capable of supplying 1000 volt-amperes, more than enough for four micrometers.

Effect of Metal

The metal itself has some influence upon the performance of the micrometer. While there is still a significant change in mutual inductance with magnetic material, a relatively large initial coupling, and a loss in scale factor, are manifested.

Ferromagnetic materials have appreciable permeability effects at radio frequencies so that there is an opposing effect superimposed upon the reduction in coupling caused by eddy currents. As the frequency is increased, the performance with ferromagnetic materials tends to improve, but non-magnetic metals are still preferable.

Very little difference in performance can be observed for metal surfaces of non-magnetic materials normally considered as conductors of electricity. Brass works equally well as silver, for example. At a frequency of 3 mc. it has been found that the metal need only be about .001 inch thick. What lies underneath this layer does not matter, so that a convenient way to make measurements with magnetic materials is to plate on a layer of copper or silver, for instance, to a thickness of .001 inch.

If the metal plate is greater than one and a half times the diameter of the larger coil, there appears to be little further effect due to the size of the plate. For most applications, it is suggested that the plate be not smaller than the coil. A hole in the centre of the plate is not particularly detrimental to performance in those cases where lightness of the metal plate or vane is important.

(Continuet on Page 45)

For your note book

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

Checking Filter Condensers

A handy tool consisting of an electrolytic condenser with a lead and test prod soldered to each terminal will enable filter condensers in a receiver to be readily checked. To use the tool, simply turn on the set and apply positive and negative leads to the corresponding terminals of the questionable filter condenser.

The output quality of the set will improve if the filter capacitor is defective.

Leaky Coupling Condensers

Frequently servicemen, after having traced bad hum or distortion to a plate coupling condenser, have checked the grid side of the suspect condenser only to find no positive voltage reading. As a result they have passed the plate coupling condenser up as a source of trouble and wasted a lot of time looking elsewhere.

When in doubt, disconnect this condenser and check it on a reputable checker, as in many cases the small leakage may only wholly or partially offset the negative bias. Consequently there is no positive voltage at the grid as the leakage voltage is insufficient to swing the grid positive. However, the decrease in negative grid bias is sometimes sufficient to cause as much trouble as though the grid were positive.

Checking Converter Operation

As most readers are aware, a common method of checking the operation of the oscillator section of a superheterodyne receiver is to unsolder the oscillator grid leak and check on the grid current by means of a suitable milliammeter. However, there is another simpler and more convenient way of carrying out this test, and without the necessity of unsoldering any leads.

Connect a voltmeter of suitable range between the B plus connection of the oscillator coil and chassis, i.e., across the bypass condenser, and short circuit the oscillator section of the gang condenser to chassis. A reduced reading on the voltmeter indicates that the oscillator section is functioning.

The reason for the reduced reading is that the bias across the oscillator grid leak is removed by shorting the gang. This is turn causes the triode section to draw more current, thus resulting in a greater voltage drop across the oscillator plate dropping resistor.

Finishing Aluminium Panels

Aluminium radio panels can be given a very attractive machine surface to provide a smart looking background for meters or the dials of radio receiving and transmitting apparatus. The only special equipment required consists of a round piece of wood (a section of a broomstick is quite satisfactory), about 3 inches long and ½ to 1 inch in diameter.

A short thick nail is driven on to the centre of one end, and a piece of emery paper is placed over the other end with the rough side outwards. This is held in position by means of a strong rubber band snapped around the wood.

The aluminium panel is placed on a flat surface and clamped down. The nail in the end of the wood is inserted in the chuck of a hand or electric drill, then with the emery covered end of the wood pressed firmly against the surface of the panel, replace the shiny aluminium surface with overlapping circles. If the row of circles are lined up carefully, the result is a flat panel of fine appearance.

Handy Combination Tool

A combination tool having many uses can be fashioned from a discarded toothbrush. The section holding the bristles is cut off and the handle filed into a small screwdriver. This is suitable for lining up purposes, as there is no metal to affect the tuned circuit.

The other end is sawn off slightly on the diagonal across the centre of the hanging hole and this provides a handy tool for guiding or holding a wire in its proper position for soldering. Cutting on the diagonal instead of straight across makes it possible to manoeuvre the wire into awkward positions.

Improvised Scriber

Although very few experimenters have a scriber, this tool is almost a necessity when laying out metal chassis or panels. A useful scriber can be easily made up from an old mechanical pencil by fitting it with a steel phonograph needle.

If the needle is too large for the lead channel, a large sewing needle or a small nail will serve equally as well, the main point to watch is that it is a tight fit.

Dial Cord Holders

It is often desirable to carry two or more grades or size of dial cord in the service kit for replacement purposes. This may be done with a minimum of space in the kit by winding the cord on empty film spools.

A hole is drilled in one end of the spool flange—through which the loose end of the cord is pulled. The spool ends may be marked as "F" for fine cord, "M" for medium cord, etc., with white enamel paint.

Basic Electricity and Magnetism

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

In this second article, the author, after a brief historical resume, explains the shift from words to numbers—that is, the method of expressing definitions in mathematical terms.

Authors of technical literature have the problem of guessing how much their prospective readers already know about the matters of which they write. Authors who write on abstract subjects like electricity find this problem intensified. One way of dodging this dilemma is simply to ignore it and let the reader decide whether or not he can comprehend what he reads.

Believing that problems are never solved by avoiding them, it is proposed now to detail the educational high-lights you will need, to follow these articles intelligently.

You should be able to follow simple transposition of algebraical formulae. You should be familiar with the elements of geometry, trigonometry and physics. Your knowledge of physics should include Newton's Laws of Motion, the parallelogram law of forces, the definitions and mathematical relationships of such quantities as force, mass, velocity, acceleration, energy and power. It will help if you know the difference between scalar and vector quantities and the graphical method of representing vector quantities with vector diagrams.

Electrical Units

Electrical units are derived from the Metric system so that if you are not familiar with the c.g.s. units of measurement you will have trouble in visualising the magnitude of the various quantities involved in definitions and fundamental formulae. The more important entities are those of force, mass, distance and energy.

The unit of force, or the *dyne*, is roughly equivalent to the weight of a piece of 5 amp. fuse wire, one quarter inch long. The unit of *mass* or the *gram*, is approximately one twenty-eighth the mass of a half penny. The *centimetre* or unit of distance, is a little more than one-third of an inch; penny rulers usually have one edge calibrated in centimetres. The practical unit of energy which is the one that concerns us, is the *joule*. The joule is equal to 0.7375 foot pounds, or, roughly, the amount of energy you will use in lifting a pound of anything through a vertical distance of nine inches.

Suitable books which should be of assistance to you in revising your knowledge of these phases of physics and mathematics include, "Elementary Physics," by Edgar Booth, "Arithmetic for Engineers," by Clapman, and, "Mathematics for Engineers," by Rose. The latter volumes are in the D.U. series.

If these suggestions sound formidable remember that scientific terms often sound far more awe inspiring than they are. Once you become familiar with them you will be glad you understand them.

Historical Interlude

In the first article, we mentioned that authors of electrical literature tend to ignore those socio-psychological factors which influenced early electrical theories. You have probably inferred that we intend to do what they have left undone. You will be relieved to know that we intend no such thing, or, rather, no more than was done in the first article. Electrical history is informative but hardly important tion. We will cull from the cavalcade of electrical events only those historical highlights which will aid our comprehension of present theories.

These articles differ from conventional literature in that they aim to develop a viewpoint which will enable you to read contemporary electrical technology and understand better the ideas you find there. You will also, we hope, find them more entertaining.

As early as 300 B.C. people knew that if a piece of amber was rubbed briskly it acquired the property of attracting small particles like paper. There is no record of anyone giving the phenomenon any serious thought. Early in the fifteenth century Sir William Gilbert developed enough interest in the phenomenon to classify the various kinds of substances which exhibited the property of enticing small bodies across space, and distinguish it with the name of *electricity* from the Greek word, *elektron*, meaning, amber.

The Elizabethan physicist, Dr. William Gilbert, performed many experiments in classifying substances exhibiting electrical properties. He is credited with giving electricity its name — derived from the Greek word "elektron," meaning amber.

In the interval between the work of Sir William Gilbert and the kite flying and other experiments by Benjamin Franklin, electrical machines were designed which produced inexplicable but highly satisfactory streams of blue and green sparks.

In his efforts to elevate electrical phenomena to the status of a science, Benjamin Franklin developed the *two fluid* theory. He arbitrarily called one fluid *positive* and the other one, *negative*.

The two fluid theory postulated that two fluids mingled uniformly throughout any substance in its normal, uncharged state, and so mutually neutralised the electrical effects that were noted when the substance was *charged*. The dual fluid theory explained why there were two kinds of electricty but it did not explain why bodies charged with positive fluid repelled each other while attracting other bodies charged with negative fluid.

The first statement about electrical phenomena which could be regarded as a law, recognised the existence of two kinds of electricity. This first law stated: *Like charges repel; unlike charges attract.*"

The Mystery Of Space

Before men began to think seriously about electricity they were able to conjure up more or less adequate explanations about forces putting bodies in motion or pushing them out of shape. It was just common sense to understand that if you pushed or pulled on something you would either start it moving or deform it in some way. Until the advent of electricity, the agent producing these effects always had something tangible to work on.

Electricity introduced two problems. One was concerned with the true nature of electricity; the other was *why* and *how* two electrified bodies could exert mechanical forces on each other with nothing between them excepting their distance apart.

The apparent transmission of force across space endowed it with properties which shattered every notion men had about space.

Rather than modify their ideas the early investigators invented a tenuous, invisible substance which they called *ether* and which they endowed with the incredible property of existing in both space and matter throughout the cosmos like an all-pervading blanc-mange. This ether concept, which Einstein rejects and Steinmetz denied on his death bed, retarded research because scientists, who should have known better, pursued a pot of proof at the foot of an ethereal rainbow, instead of devoting their time to more sensible activities.

Ether vs. Mathematics

We have rejected the idea of ether because it is cumbersome and unnecessary; we can explain electrical effects easier with mathematics than we can with ether.

Since electrical effects are manifested in and through space as well as in and through matter we must discard all notions about space being simply a void. When a body is electrified the region around it is no longer like it was before the body was charged. The space around the body is modified. Nobody knows what the alteration is but everyone who has experimented with static electricity has seen the attraction which exists between an electrified glass rod and tiny bits of paper.

We are at liberty to explain this electrified region in any way we please but if we intend to use mathematics to explain electrical effects, and, at the same time, develop theories that will dovetail in with theories developed by other branches of science, we must obviously be careful in our selection of ideas.

The concept which is generally accepted as being most amenable to mathematical treatment and most consistent with other physical theories is the idea that an *electric field* surrounds a charged body.

We learned in the first article that all terms we use must be defined and the purpose of the definitions was to make the terms amenable to mathematical manipulation. Any descriptive qualities a definition may have are purely incidental—I very nearly said, accidental.

An electric field is defined as *any region wherein an electric charge experiences a force.*

Abstract Definitions

It will help you if we digress at this point to emphasise the fact that all definitions are *abstractions*; you must put all intuitive notions based on electric charges poured like syrup over tiny marbles, sternly out of your mind. The concepts that we will develop are not about material objects at all but about creations of the mind abstracted from material objects. This is not as difficult as it may appear. Authors of advanced text books assume that you do this and never bother to warn you.

The definition of an electric field *must not* be interpreted to mean that an electric field is a field of force; an electric field is not a field of force. An electric field is a region wherein some charge A at some point P near another charge B experiences an actual mechanical force. It is the *electric* force acting on charge A which produces a *mechanical* force. An electric force is not force as we think of force; it is something which gives rise to the manifestation of a force in the normal sense of the word.

Merely thinking about an electric field as a region wherein an electric charge experiences a force does not provide sufficient information about conditions existing there. Neither have we any idea as to its size and shape. The matter of its form is important but the method we use to deduce its form is more important. None of our physical senses can detect the presence of an electric field. Any enquiry into its contents, its size, and its shape is an adventure of abstraction.

The only way we can deduce its characteristics is by using mathematics and the only way we can use mathematics is to discover some statement about electricity which lends itself to mathematical treatment. So far no suitable statement has been made.

Coulomb's Law

In 1785 Coulomb completed a series of incredibly delicate experiments. Using a sensitive torsion balance, he measured the variation of the forces exerted between electrically charged bodies as the distance between them was altered. His observations, expressed in modern terms, were, "The force between two charges is directly proportional to the product of the charges and inversely proportional to the square of the distance between them."

Coulomb's announcement, quickly raised to the status of law, bridged the gap between electricity and mathematics; it was a stepping stone in the quagmire of qualitative data wherein electrical phenomena were bogged.

Coulomb's law seldom gets the recognition it deserves. It seldom gets this recognition because the mathematical expression of it—the first mathematical statement about electricity — has little application in practical problems.

The Shift From Words To Numbers

Coulomb's statement is the kind of statement that can be expressed mathematically once you know the trick of doing it. Once you know it you can use it on all similar statements.

First, we substitute symbols—usually letters—for every noun in the statement on which we are operating. For Coulomb's law we write, F for force, q^A and $q^{n/2}$ for the two charges, and d, for the distance. Then, using the sign of proportionality, we write,

$$F \propto \frac{q^1 \; q^2}{d^2} \qquad (1)$$

This expression is a statement of proportionality. Before numbers can be used for symbols, a sign of equality (equal) must replace the sign of variation ($\propto$) when the sign of quality can be used the expression becomes dignified by the name of *equation*.

The change is effected by either prefacing the symbols on the right hand side with another symbol—usually k—and which is called a *constant*, or by the use of cleverly you may prefer, cunningly—phrased definitions. Remember that a definition is a device for switching from words to numbers.

Using a constant on the right hand side is the simpler and more general method. We will deal with this later. The only method we can use with Coulomb's law is the "definition" method.

If we want to use an equal sign instead of a variation sign in Expression (1) we must assign to all quantities appearing in it such numerical values as will ensure that the left-hand side is numerically equal to the right-hand side. The only possible way in which we can introduce numbers is by developing a suitable definition.

We already have definitions of force and distance, these being the dyne and centimetre, respectively. We gave you an idea of the magnitude of these quantities earlier in this article. What we need is some idea about electric charges. Whatever electric charges are; whether we think of them as a quantity of invisible fluid, or as a collection of electrons, we can think of a charge as a quantity of something. We can also imagine a definite amount of this mysterious quantity as having unit value. We can now define unit charge.

"Unit charge is that charge which, when placed at a distance of one centimetre from an equal and similar charge in a vacuum, repels it with a force of one dyne."

This definition is a very clever definition. Not only does it define unit charge in terms of force and distance—which also appear in Expression 1 — it also defines unit charge in terms of *unit* force and *unit* distance.

Value of Unity

Now, the integer, *one*, has important mathematical qualities. It has the unique and valuable property of being able to endure multiplication and division, of and by itself, an infinite number of times without any change in value. Authors of definitions designed for subsequent mathematical treatment always contrive to introduce the value of unity. Now you know why!

Justified by our definition of unit charge, we can re-write Expression (1), for the special case when unit charges are involved. In this case,

$$1 \text{ equals } \frac{1 \times 1}{1^2} \qquad \ldots (2)$$

We are too clever to admit, of course, that this mathematical result was in our minds at the time we coined our definition.

Isaac Newton (1642-1727), discoverer of the law of gravitation, was also a great mathematician. The "binomial theorem" and "differential calculus" are due to him.

Again, based on our belief in Coulomb's law, we can express (2) in what is known as the *general* form;

$$F \text{ equals } \frac{q1 \; q2}{d^2} \qquad \ldots (3)$$

Expression (3) is an *equation*. It is the first equation ever derived about electrical phenomena. It is true for the specific case when the charges are immersed in a *vacuum*, and when they are concentrated at *points*; that is, when they are *point charges*.

Equation (3) is *not* true when the charges are separated by a medium other than a vacuum. We will consider the effect of other mediums very shortly.

This explanation of how a shift is made from words to numbers should impress on you the *mathematical* significance of electrical terms and concepts. It also confirms what has already been said about the true purpose of definitions. Now you know the motives underlying all statements defining electrical and magnetic effects you will be able to understand more easily the ideas developed in advanced electrical literature and which will subsequently be discussed in these articles.

R.S.G.B.- and Empire Amateur Radio

By ROTH JONES, VK3BG.

Founded some thirty-five years ago, the Radio Society of Great Britain is now gaining support as the voice of Empire amateur radio.

With its headquarters in London, the Radio Society of Great Britain ranks a close second to the American Radio Relay League as the voice of amateur radio. Founded 35 years ago, when radio was in its infancy, the society has established records and proud achievements which are indicative of the English-speaking race.

Many of its foundation members are still active, both in the administration of the society and on the air. Its pre-war patron, the Duke of Windsor (then Prince of Wales), has and still is maintaining a constant interest in the R.S.G.B.—as the society is known to all its members at home, in the Dominions and the Colonies of the British Empire.

In its early days it was called the London Wireless Club, and did not assume its present title until after the 1914-18 World War.

Started in 1913

Mr. Rene Klein started the club off in the summer of 1913 when, in a statement to the Press, he deplored the fact there was no association in London where amateurs interested in radio problems could meet and discuss their hobby.

In his own home at West Hampstead, on July 5, 1913, he and a group of enthusiastic amateurs interested in the then new science of radio communication answered his pathetic plea in the Press and founded the club. Hardly had it commenced to function than its operations were suspended due to the war. The club was revived in 1919 under a new title—The Wireless Society of London.

During this vital period many names famous in radio, such as Marconi, Lodge and Fleming, laid the society's foundation stone upon which later generations have been privileged to build up an Empire-wide organisation.

From its earliest days the society has acted as spokesman for British radio amateurs and has undertaken the task of negotiating with the G.P.O. on all matters appertaining to the issue of amateur licences.

Early Experiments

The period 1921-26 witnessed epoch-making discoveries by amateurs, who demonstrated that wavelengths below 100 metres were capable of being used for world-wide communication. The society played a prominent part in these pioneer achievements and did much to encourage development by organising, in collaboration with the American Radio Relay League, the first trans-Atlantic tests.

During 1925 a group of enthusiastic amateurs who had earlier formed the Transmitter and Relay section of the society published the first issue of the T. and R. Bulletin. For 23 years the Bulletin has appeared monthly. Although present issues are much smaller than previous (due to the newsprint restrictions), the Bulletin is still a fine technical publication.

Three years later, when Mr. A. E. Watts (G6UN) was president, the British Empire Radio Union was formed, linking amateurs in the Dominions and Colonies with the home country. This body is still very active today and a vital link.

Co-operated with Services

Prior to the 1939-45 war the society co-operated with the Admiralty and the Air Ministry in the formation and organisation of the Royal Naval (Wireless) Volunteer Reserve and the Royal Air Force Civilian Wireless Reserve. At the outbreak of hostilities many hundreds of members joined the services and, by reason of their expert radio knowledge, were able, with little special training, to undertake duties of great importance.

The R.S.G.B. council decided in September, 1939, that the work of the society should be continued during the war years. It was recognised that an active and fully representative organisation would be required during and after the war to negotiate with the Licencing Authorities for the early resumption of amateur transmitting facilities.

A group of early British amateur radio operators getting set before the annual Cambridge-Oxford boat race. Battery-driven portable transmitters are on the floor of the boat.

The wisdom of that decision became evident in 1946. Not only were licences restored within a few months of hostilities ceasing, but the terms and conditions under which such licences were granted were found to be considerably more favorable than was the case before the war.

Although the principal aim of the society is to assist those who are interested in amateur radio, many members are specially interested in such subjects as frequency measurement, propagation and receiver design. All interests are catered for and all new developments encouraged.

Increasing Membership

At the outbreak of war in 1939 the society had a membership of 3500; today the figure is approximately 15,000, of which number some 6000 hold an amateur transmitting licence. The rapid increase both in membership and the num-

(Continued on page 45)

RADIO FREQUENCY MEASURING EQUIPMENT

By ALAN WALLACE

The basic requirement of a heterodyne frequency meter is that it should provide an accurately calibrated, stable oscillator against which the incoming signal may be compared, together with some means of calibratian checking. This article deals with the problems associated with the design of such an instrument, its associated mixer circuit and power supply.

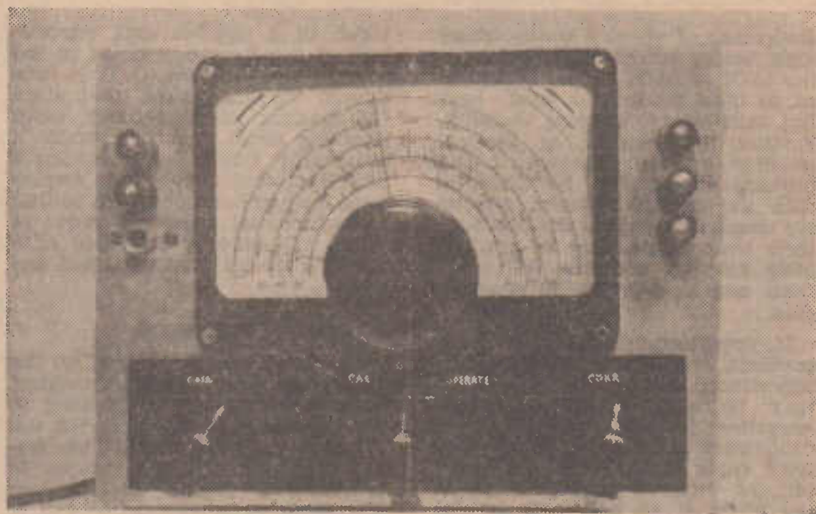
It cannot be too highly stressed that it is of vital importance that a prime consideration must be the attainment of mechanical rigidity, since, even with a high C oscillator circuit, any variation in circuit constants, as will be caused by mechanical distortion of the chassis or case may shift the frequency by a considerable amount. To this end, the chassis should be constructed in such a manner that the relative movement of its various parts should be a minimum.

For example, in the instrument described in conjunction with this article, the chassis is attached to the front panel in such a manner that its whole weight is supported by that panel, rather than allowing the weight of the chassis to be supported by the case which may be subject to distortion. Furthermore, the weight distribution on the chassis should be such that stresses are minimised, and last but by no means least, the actual tuning coil must be mounted in such a way that its distance from any surrounding metal work is such that any relative movement which takes place will have a negligible effect on the frequency.

It is, of course, requisite that all materials and components used in the instrument must be of the highest quality. In addition, the final accuracy of the instrument will be governed by the care taken with the calibration as well as the accuracy of the calibrating instrument, which should preferably be of a sub-standard nature.

Oscillator Circuit

There are many types of oscillator circuits which possess the required inherent stability, but for all round simplicity, reliability and ease of operation, it is considered that the electron coupled oscillator is most suitable. In this oscillator, which is sometimes known as an *"Inverted Hartley,"* the screen of the tube acts as a virtual oscillator anode, with the output being taken from the plate. The only coupling between the load and the oscillator section of the tube is via the electron stream of the tube, thus greatly reducing the effect of any variation in load up oscillator frequency.



A front view of the completed instrument. Note the hand calibrated dial.

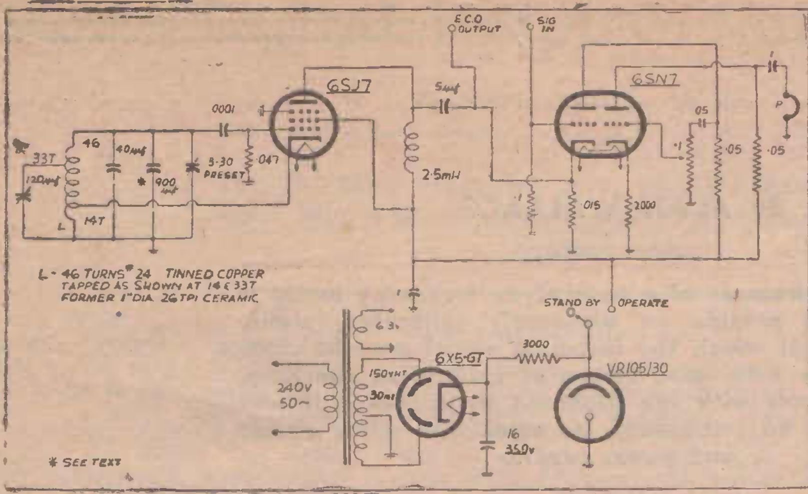
Additionally, with the electron coupled oscillator, by proper arrangement of the plate and screen potentials, it is possible to ensure that the output frequency is substantially independent of the plate potential. Whilst this consideration may be of vital importance in the design of a V.F.O., however, it is felt that, in view of the greater stability and accuracy required of a frequency meter that more definite stabilisation is necessary. Therefore, it will be noticed in this instrument that provision is made for regulation of the plate supply by a gaseous voltage regulator tube.

Part 2—HETERODYNE FREQUENCY METER

It is essential with an instrument of this type to ensure that any variation in frequency due to the heating of components, for example the valve socket, coil former, etc., is prevented or at least kept to a minimum. To this end, ceramic, or some equivalent, insulation material should be used throughout the oscillator circuit. The use of thermoplastic materials (for example, bakelite or polystyrene) must be particularly avoided, and in order to minimise drift due to the fixed capacitors in the oscillator circuit, these should be of the *"Zero drift"* variety, such as silvered mica.

Heat Dissipation

To reduce the heat dissipation about the oscillator circuit, an oscillator valve must be selected which has a minimum heater dissipation consistent with adequate cathode emission to ensure stability under load. A satisfactory tube in this regard is the 6SJ7 having a heater

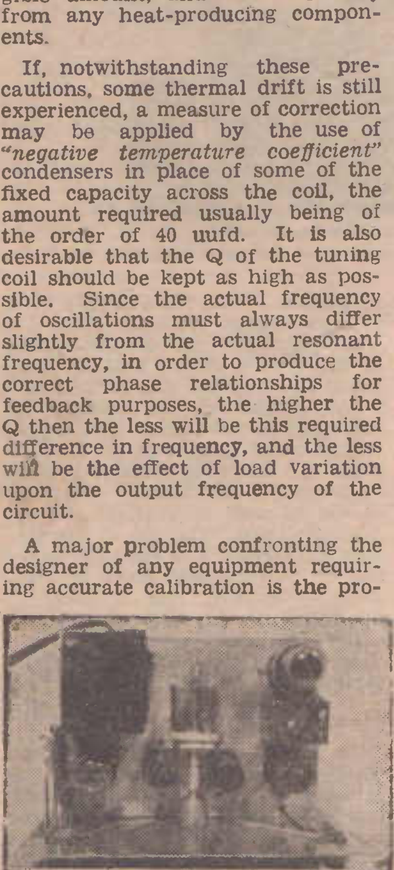


The circuit is not complicated and should offer little difficulty to the constructor.

dissipation of about 2 watts, whilst high heater current tubes such as the 6AC7 or 6AG7 should be avoided, as these produce too much heat for satisfactory thermal stability. Further improvement in thermal stability will be obtained if the physical layout can be arranged that the oscillator tuned circuits are situated in such a position that their temperature rises by a negligible amount, and are well away from any heat-producing components.

If, notwithstanding these precautions, some thermal drift is still experienced, a measure of correction may be applied by the use of *"negative temperature coefficient"* condensers in place of some of the fixed capacity across the coil, the amount required usually being of the order of 40 uufd. It is also desirable that the Q of the tuning coil should be kept as high as possible. Since the actual frequency of oscillations must always differ slightly from the actual resonant frequency, in order to produce the correct phase relationships for feedback purposes, the higher the Q then the less will be this required difference in frequency, and the less will be the effect of load variation upon the output frequency of the circuit.

A major problem confronting the designer of any equipment requiring accurate calibration is the provision of a suitable dial, particularly if the frequency range to the covered is at all great. It is considered in this regard, that since the existing amateur bands cover relatively small frequency ranges, a convenient means of obtaining a sufficiently open scale is to employ some form of bandspreading, so that a fundamental frequency range of either 1750-1800 or 1750-1900 kilocycles is spread across the full dial scale.



This top view shows the chassis layout.

Bandspreading Used

This procedure is adopted on the instrument described, bandspreading being achieved by the tapping of the tuning condenser on to the coil at an appropriate point. This system has the dual advantages of providing a flexible control over the degree of bandspread as well as improving the mechanical stability of the arrangement by providing a relatively high C in the variable portion of the circuit.

It is usually desirable to include some form of compensating trimmer to enable initial calibration of the instrument, as well as permit correction for any variations which may occur due to ageing of components, changing of tubes, etc. This trimmer must be of the highest quality, and preferably one of the newer concentric air or ceramic varieties.

The ordinary compression trimmer will be found to be quite useless for the purpose, as also will be the midget *"air"* variety of trimmer at present so plentifully available through disposals channels. These latter condensers it has been found are somewhat unstable mechanically, probably on account of their extremely close spacing, and give rise to mechanical instability and microphonism.

The actual dial to be used on the instrument will depend on the individual constructor, but its design must be such as, in addition to permitting a high order of reset accuracy, provides a smooth vernier movement with no backlash. Several dials are at present commercially available which will fulfil these requirements, although many readers may have a suitable unit on hand.

Regulated Power Supply

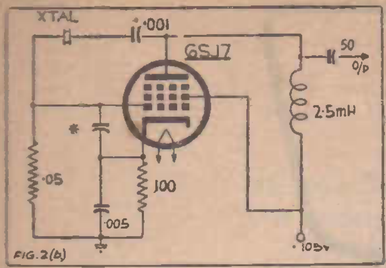
It is desirable as stated above, to provide some form of regulated power source for this instrument which, however, need only supply a comparatively low voltage at low current. In view of these considerations the circuit as shown has proved very satisfactory, providing as it does a well regulated supply which is at the same time quite adequately filtered. Due to the very low current drain it was found that neither a filter choke nor a second electrolytic condenser were necessary, the function of the latter being assumed by the voltage regulator tube VR105/30.

In the event of this tube not being available it is possible to use either a type VR75/30 or type VR150/30, the dropping resistor in each case being increased to 5000 ohms, whilst additionally in the case of the VR150/30, the transformer voltage must be increased to about 250V per side. With the circuit arrangement shown, the VR105/30, in the stand-by position with no HT drawn from the supply, draws its full 30 m/a. Under normal operating conditions, the drain of the oscillator and mixer tubes are such that the VR105/30 current falls to about 10 m/a, but this is still well within the operating range of this tube.

Mixer Circuit

Provision is made for the inclusion of a mixer circuit in the instrument as described, although this is a refinement which may well be omitted if the frequency meter is always to be used in conjunction with a receiver, as is usually the case. The mixer circuit employed is of somewhat unconventional design, but it has been found that, in order to achieve a satisfactory audio level when the equipment is used for direct comparison with a transmitter frequency, some form of

A simple crystal oscillator circuit.



At higher frequencies the Pierce oscillator circuit will be found more stable and reliable.

amplification of the beat note must be provided. Hence the mixer circuit employs cathode injection, the signal voltage being impressed on the control grid of one section of the 6SN7GT, whilst the other section of the tube is used as a convential audio amplifier.

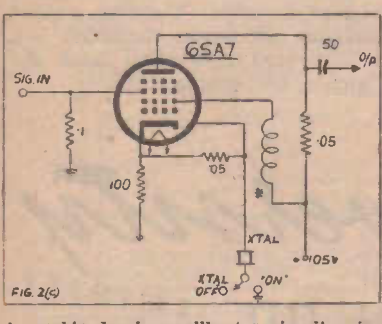
It has been found that sufficient gain may be realised if the cathode resistor is left unbypassed, thus providing a certain degree of degeneration. If it should be desired to feed a low impedance load, such as 130 ohm headphones, increased output will usually be obtained if the load is fed from this cathode resistor through a large capacity condenser (e.g. 0.5 ufd.) but normally the output obtained from the plate circuit will be quite adequate for all ordinary purposes.

Alternative tube types may be used throughout the instrument with little change in component valves or performance, suggested alternatives being 6SK7 or 6SS7 for the E.C.O., 6SL7GT or ECC35 for the mixer-amplifier, and 6SK7 or 6SS7 for the crystal oscillator which will now be described.

Crystal Oscillator

The crystal oscillator circuit may be qute conventional, the exact arrangement being determined by the frequency of the crystal employed. For this reason no crystal calibrator has been included in the main circuit diagram, three alternative circuits being shown in Figs. 2 (a), (b) and (c).

Where it is desired to employ a crystal of either 100 or 1000 Kcs. the most suitable circuit is that shown in Fig. 2 (a) where the crystal is connected into a simple electron coupled crystal oscillator circuit, the "anode" inductance being provided by the screen R.F.C. which has an inductance (7mH for a 100 Kcs. crystal) such as to present an inductive reactance at the operating frequency thus sustaining oscillations. This circuit has the advantage also, since the output is taken from the plate of the tube, of producing a certain degree of harmonic amplification which is of great assistance when working at the upper limits of the frequency range.



A combined mixer-calibrator circuit using a 6SA7.

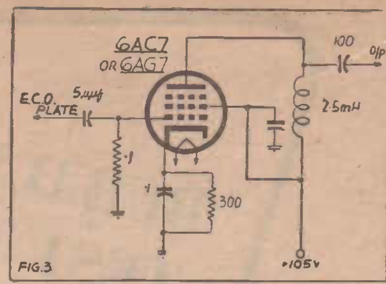
However, at frequencies above 1 Mcs., this circuit becomes too critical in adjustment to be of any great use, as a preset calibrator. Alternatively, the crystal may be connected in a Pearce crystal oscillator circuit as in Fig. 2 (b). Once again the output of this oscillator is quite rich in harmonics, whilst the oscillations are now quite reliable using 3.5 or 7 Mcs. crystals. The actual crystal calibrating frequency, therefore, may be any frequency, a harmonic of which lies in one of the amateur bands covered by the instrument, although, preferably, for convenience, it should be one which will accurately indicate the band edges. Ideally, a 100 Kcs. band provides 3 check points on the 7 Mcs. band, marking each band edge accurately, but 1000 Kcs., 3.5, or 7 Mcs., are also suitable for calibration purposes.

Constructional Points

The construction of the instrument should present no difficulties to the average amateur, providing due care is taken with the points previously mentioned. In the particular instrument shown no crystal calibrator is included as this particular job has been modified by the addition of a buffer stage, to enable its use as a V.F.O. crystal substitute. However, as explained earlier, the particular circuit arrangement employed will depend upon the frequency of the crystal on hand, but nevertheless, constitutes a relatively simple addition to the circuit as shown on Fig. 1.

Suitable *"zero drift"* condensers are at present available and have a stated temperature coefficient of only 80 parts per million per degree C, and will, therefore, contribute a negligible amount of thermal drift. The availablity of negative temperature coefficient condensers is rather uncertain at present, although small quantities have been available through the disposal stores. Probably the most plentifully available type are the Erie "Ceramicons" which have quite a high negative temperature coefficient, one particular condenser tested exhibiting a 5 per cent. change in capacitance for a change in ambient temperature of approximately 50 degrees C.

It will be noticed that specific values are not stated for certain components, particularly in the oscillator circuits. In these cases

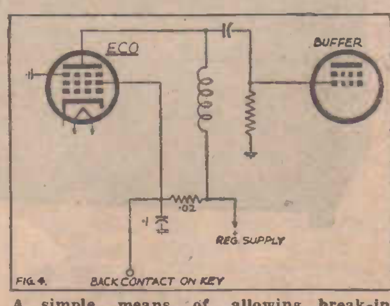


A buffer stage is necessary when using the instrument as a VFO.

it will be found that the best value may be obtained by experiment, the criterion, in the case of the E.C.O. being the attainment of the desired frequency range with the present trimmer at approximately the centre of its range, and in the case of the calibrating oscillators, the achievement of satisfactory output and stability with a minimum of crystal current, in order to minimise crystal heating.

A suitable buffer stage to enable this instrument to be used as a V.F.O. is shown in Fig. 3. Although not particularly recommended unless some form of crystal calibration is included, since a frequency meter should be entirely independent of the actual transmitter circuits to enable maintenance of calibration, this device may be convenient where the outlay upon separate items of equipment must be kept to a minimum. The buffer (or isolator) stage simply employs a 6AC7 or 6AG7 as a class A buffer, the output being taken from the aperiodic plate circuit at the fundamental frequency (1750 Kcs.). In practice it has been found that this arrangement, with 105 volts on the plate, will give sufficient output to drive a normal crystal oscillator stage, this stage then being used as a doubler.

Although it is possible to calibrate the frequency meter by beating its output, or harmonics of its output, against signals of known frequency, or by some other such means, the only satisfactory method is to calibrate it directly against some frequency source of known accuracy, for example, the familiar Bendix BC221AK, or a crystal controlled heterodyne secondary standard frequency meter such as will be described next month.



A simple means of allowing break-in whilst not directly keying the oscillator circuit.

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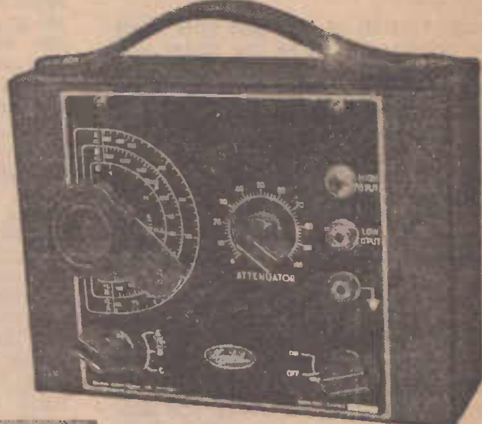

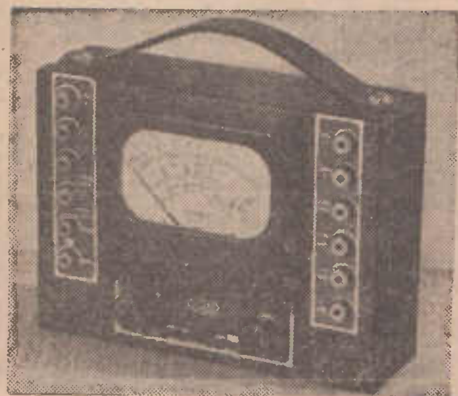

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The Reactance Modulator

An analysis of a circuit employing a capacitive change which is widely used in F-M receiving and test equipment.

The reactance modulator is one of the most common and least understood methods of accomplishing frequency modulation. This method has found universal acceptance in sweep generator design and, of course, is the means of providing a.f.c. in receiving equipment.

The circuit to be described in this article employs a capacitive change, although other types (inductive/push-pull inductive - capacitive) have found application in special circuits.

Two-element Oscillator

Illustrated in Fig. 1 is a simple two-element oscillator. If we change the setting of the capacitor, C1, the frequency of the oscillator must also change. If we connected the shaft of the variable capacitor C1 to a motor, the capacitor would be rotated and the oscillator frequency changed, or frequency modulated, at the rate of the driving mechanism. Although this method serves only as a basic illustration, it was actually used in earlier equipment. The reactance modulator simply substitutes for the variable capacitor, and causes the frequency of the oscillator to vary when a modulating voltage is applied.

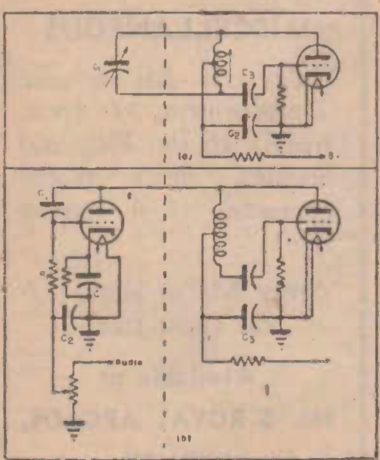


Fig. 1. In (a) we have a circuit of a simple triode oscillator with C1 representing the tuning capacitor across the inductance. C2 places the tap at r-f ground potential, and C3 is used to isolate the control grid from B plus. In (b) the tuning capacitor of the (a) circuit has been replaced by its electronic equivalent, a reactance modulator.

The first requirement in replacing the capacitor by an electronic system is that it LOOKS the same electrically when shunted across the oscillator tank circuit. This, of course, means that it must cause the current to lead the voltage by 90 deg., the same as a pure capacitor.

Typical Circuit

Fig. 1a represents the reactance modulator circuit, where we note that the total oscillator voltage is applied across the series circuit C1.R1. The reactance of C2 is made small at the oscillator frequency, so the low end of R1 may be considered at r-f ground. The reactance of C2 is also small, so that the reactance modulator is actually across that portion of the tank coil between centre tap and plate. The reactance of C1 is made about 10 times as large as the value of R1 at the operating frequency, so that R1 has no effect on the phase change across the series combination.

When the oscillator is operating, the voltage generated between the plate and the r-f ground point (C3) is, in turn, applied across the series combination C1.R1. Since C1 has an impedance 10 times that of R1 at the oscillator frequency, it will cause the current to lead the voltage by 90 deg. This current causes a voltage drop across R1. This voltage being created by the leading current, must, of course, be in phase with it.

Phase Relations

Since the plate current of the reactance modulator must be in phase with the grid voltage, it follows that this must also be 90 deg. ahead of the oscillator voltage. As we have satisfied the requirements of a 90 deg. phase shift, we have simulated electrically the shunt of a fixed capacitor across the oscillator circuit. It is now only necessary to vary the magnitude of the effect to vary the frequency of the oscillator. The relations of voltage to current are shown in the simple vector of Fig. 2.

The amount of apparent capacity change, or the amount of frequency shift of the oscillator, may be described as a change in the capacitive reactance across the circuit. Since we know that capacitive reactance is determined by the ratio of voltage to current, we can vary the magnitude or the effect of our simulated capacitor by changing either of the values in the simple formula XC = EAC/IAC.

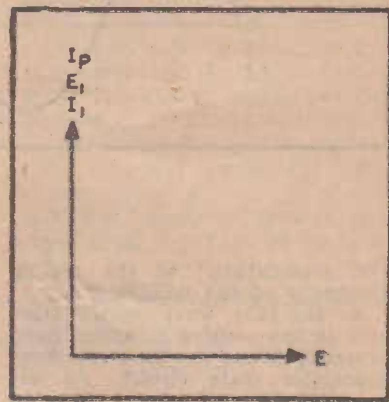


Fig. 2. A simple vector illustrating the relationship of voltage and current.

Since the voltage in our case is fixed, we may vary the current to derive the frequency change required. If, for instance, it is possible to vary the bias on the reactance modulator grid, it becomes possible to change the value of total plate current and thus the apparent value of capacity across the oscillator tank circuit.

The universal method of accomplishing this apparent capacity change is to apply a sine wave modulating voltage to the reactance modulator grid. In the resting, or "no modulation" condition, the bias on the reactance modulator is determined by that supplied by the voltage drop across R1, supplemented by the steady cathode bias. This is carefully adjusted to bias the tube to the centre of the straight portion of the plate current characteristic.

Effect of Sine Wave

When a sine wave modulating voltage is applied to the grid the amount of plate current is varied and the oscillator frequency changes accordingly. If we consider Fig. 3 this is apparent. The zero line represents the state of

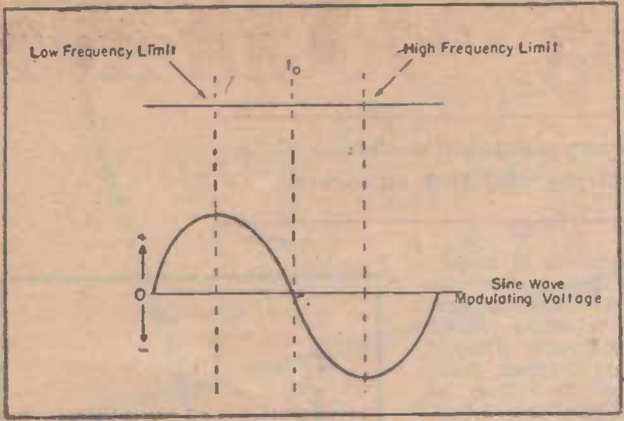


Fig. 3. A plot illustrating how a sine wave modulating voltage applied to the grid causes a variation in plate current and changes in oscillator frequency. Here we note that the highest frequency is determined by the peak of the negative portion of the modulation sine wave.

"no modulation," or the resting frequency of the oscillator.

As the sine wave varies from zero to the positive direction, more current flows in the reactance modulator plate circuit. As determined by the simple formula, the capacitive reactance has decreased because the voltage is fixed, and the current has decreased. If the capacitive reactance has decreased, it is the same as if the capacity has been increased. The effect on the oscillator is therefore to lower its frequency. The oscillator reaches its lowest frequency at the crest of the positive excursion of the modulating sine wave.

As the sine wave varies from positive to negative, less plate current flows in the reactance modulator plate circuit, and the opposite effect is true. The capacitive reactance in this case is increasing, and the effect on the oscillator is as though the capacity were decreasing. The oscillator frequency therefore varies from its lowest to highest frequency. The highest frequency is, of course, determined by the peak of the negative portion of the modulation sine wave. This is shown graphically in Fig. 3.

Frequency Change

The amount of frequency change that can be obtained by the reactance modulator method is determined by a number of conditions. The ratio of the amount of apparent capacity change to the value of fixed capacity in the oscillator circuit must be taken into consideration. It is desirable to use only the distributed capacity of the circuit to determine oscillator frequency when the capacitive system is used. For this reason most commercial circuits slug tune the oscillator coil with no fixed capacitance where maximum frequency SWING is desired. The reactance modulator tube itself must be of a high transconductance type, so that a large plate current change may be realised.

Sweep Rate

It is interesting to note that the rate of frequency change of the oscillator or the *sweep rate* is twice the rate of the modulating voltage. The *sweep rate* may be described as the number of times per second that the oscillator carrier is varied through any given point in its excursion. The oscillator frequency may be varied from the lowest to highest frequency points as the modulating voltage changes from the positive to negative crest. If we consider the centre or resting frequency point as the reference, the carrier has been swept through this point once. The time involved so far as the modulating voltage is concerned is one-half cycle. The same thing happens in the opposite direction as the modulating voltage varies from negative to positive. The total time consumed is one cycle of modulating voltage for both sweeps. The *sweep rate*, therefore, is always twice the modulating rate when a sine wave is used.

System Advantages

The reactance modulator system of producing a frequency modulated wave has some disadvantages, such as non-linearity of frequency change versus modulating voltage change. It is also difficult to get much frequency change at lower oscillator frequencies. The advantage of obtaining a f-m wave by a reliable, non-mechanical method more than outweighs these objections, however, and this system is thus finding wide utilisation in present-day sweep generator equipment, and a host of other applications.

—Reprinted courtesy "Service."

Amateur NEWS *and* VIEWS

SP ● T NEWS . . .

• VK2UK: Greg Denny's active on 20 metre phone, using a folded dipole, fed with 300 ohm telcon, using 20 watts.

• VK2VH: Allan Ward active on 40 metre CW, chasing DX.

• VK2WP: Bill Potter using type A Mark 3 to drive 6V6/807. Heard working ZL's, and G's on CW in early morning.

• VK2WV: Reg Waters using English triodes running 60 watts, CW on 20 metres. Receiver 11 valve home built.

• VK2BC: Bill Bullivant, originally 2WB in Albury, call changed to A2WB, then OA2WB, VK2WB — now present call is VK2BC. Operating on 20 metres VFO, running 100 watts, to pair 807's. Receiver is eight valve home built.

• VK2AEO: Ol Polmear, who has not been active for a few years, will be on the air after Christmas. New rig will be VFO controlled with an 809 running 100 watts. Receiver is an eight valve super.

• VK2AHQ: Ted Quilty will be VK2AHY by the time this issue reaches all readers. This is another VFO controlled 100 watt station. Active on 40 type 2 transmitter and 20 metres CW with 100 watts to an 809. Receiver is a 10 valve home built super.

• VK2SV: Bill Peters active on 20 metres with two element rotary beam. Will shortly have an 813 in final and new modulator with AMC. Bill keeps regular "skeds" with G40V at 5 p.m. every evening on 20 metres. Receiver is a 12 valve home built super.

• VK2ASK: Ced Harte active on 144 Mc, using a converted SCR522, and has had good reports from all around the city area. Active on 20 metre CW with 809 crystal controlled. Receiver is Hallicrafters.

SOUTH COAST ACTIVITY

Wollongong DX enthusiasts are making some excellent contacts; some calls worked lately include ZBI, ZC1, MP4, MD4, UB5, EI, GM. G, C, J and many others. Their club is an active concern, kept moving by Eric Fisher.

144 Mc activity has commenced at Wollongong, with VK2MT on the air of an evening at 8 p.m. and during the weekend. Several others are preparing rigs for 144 Mc, so this should mean more DX contacts on 144 Mc.

VK2DO: Don Douglas, ex Tamworth, has entered the South Coast with Dapto as his QTH.

VK2AOX: Harry Cox, also another new call on the South Coast, his QTH being Rixons Pass. Heard often on 40 metre phone with 10 watts of VFO. Receiver 6 valve home built.

Calling All Amateurs

This section is conducted for the amateur by Ken Kinney, VK2AIL. All amateurs and radio clubs are asked to cooperate by forwarding any news items, amateur or club notes for inclusion in these pages. Such items should be addressed to Box 5047, G.P.O., Sydney, marking the envelope "Amateur Notes," and reach us not later than the first of the month.

Reading the R.S.G.B. Bulletin recently it was noticed that a very popular brand of receiver now on sale in this country is being sold for £27 10s. The tax, excise and customs duty almost treble that price in Australia.

CAN YOU HELP?

G2BJY, Geoff Johnson, 22 Lynton Ave., Hateley Heath, West Bromwich, Staffs., recently had the misfortune of losing by fire most of his treasured QSL cards, including 92 cards towards DX C.C., 42 towards W.A.S., and 49 towards E.DX.C. G2BJY would be most grateful if those who have worked his station would send a duplicate card. He was particularly proud — and rightly so — of his original collection, since all contacts were made using less than 30 watts input.

CLUB NOTES

WOLLONGONG AMATEUR RADIO CLUB (VK2AMW)

This club meets every Friday at 21 Bourke Street, Wollongong. Club transmitter has been active lately working W's and Europeans. At present a modulator is being built for use of younger members. Also in progress is new receiver which is being made in three sections to enable its use in lectures. Technical discussions and lectures are conducted every Friday, whilst the club roomy is open to members every night and at weekends.

HURSTVILLE DISTRICT AMATEUR RADIO CLUB

C.W.A. Rooms, 378 Forest Road, Hurstville

On Sunday, 31st October, the above club held its Field Day at Carrs Park, and an excellent day was had by all members and visitors. About 30 people attended the gathering, and contacts were made on 40 and 6 metres and on 144 Mc.

It has been decided that the Club will hold another Field Day about February or March, and the date and location of this will be advised in these columns.

The club meets on the 1st, 3rd and 4th Tuesday of each month at the above address, and any visitors and new members will be welcomed.

ST. GEORGE RADIO CLUB

1a Market Street, Rockdale, N.S.W.

The meetings of this Club are held on each Tuesday and Friday at the above address. Interested readers can obtain further information by ringing the secretary, LX3403 or LX2012.

GLADESVILLE AND DISTRICT EXPERIMENTAL RADIO CLUB

Rear, 117 Victoria Road, Gladesville

This club meets in its own clubroom at the above address each Thursday at 8 p.m. Three meetings each month are devoted to lectures, technical discussions, with the fourth being given to club business.

Any intending members are invited to contact the secretary, Mr. Sullivan, 11 Shipley Avenue, Concord. Telephone UM6226 after 6 p.m.

KINGSFORD DISTRICT AMATEUR RADIO CLUB

48 Rainbow Street, Kingsford

Meetings are held every Tuesday night at Griffith Hall, 48 Rainbow Street, Kingsford. Technical and Morse classes are a regular feature, and new members are cordially welcomed.

SHORT WAVE LEAGUE OF W.A.

Secretary, Mr. F. R. Mathews, 24 Midgley St., Riverdale, W.A.

This league is always interested to bear from enthusiasts, and regular monthly meetings are held at the offices of Hales Reporters, 2nd Floor, South British Chambers, Barrack Street, Perth.

Intending members may apply direct to the secretary, or by writing to Box P1179, G.P.O., Perth, W.A.

N.S.W. RADIO DX LEAGUE

Meetings are held every Thursday at 8 p.m. at 520 Woodville Road, Guildford. All interested are asked to contact Mr. B. Penhall, 2 Brady Street, Merrylands, either personally, by letter or at the meetings.

Around The Industry

MINIATURE PIN STRAIGHTENER AND WIRING JIG

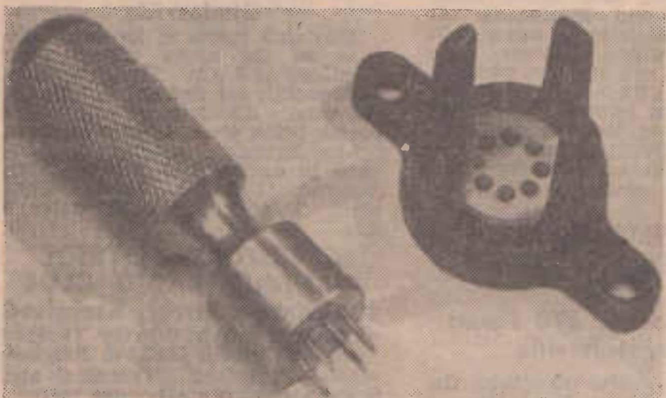
Of particular interest to the radio trade and all users of the recently-introduced range of miniature valves are details of the handy miniature pin straightener and wiring jig recently announced by the Amalgamated Wireless Valve Co.

The pin straightener has been designed to provide a ready means of straightening the small pins of the new miniature valves. To use the valve it is pushed into position until the button base is sitting squarely on the metal, and this automatically forces the pins back into correct alignment. This obviates the possibility of broken pins or a cracked base if other methods such as long nose pliers are used to straighten the pin.

The die is constructed of a special alloy and attractively finished in crackle black. Special mounting lugs are provided, and these in conjunction with the four side supports enable the unit to be either held firmly in the hand, or, if desired, to be screwed direct on to the work bench.

The wiring jig is finished in a steel blue color and has a knurled handle to provide an easy grip. In use this jib is simply pressed into the socket, being soldered to prevent the lugs from being pulled out of alignment by the wiring, and possibly preventing insertion of the valve.

Although only samples are to hand at present, it is considered ample supplies will be available towards the end of January. The price of the pin straightener will be 9/- and that of the jig as 12/-. Further inquiries and advance orders can be made by writing direct to the Amalgamated Wireless Valve Coy., York Street, Sydney.



The new wiring jig (left) and miniature pin straightener soon to be released by the A.W.V. Coy.

NEW MULLARD FLASH TUBE

Details of the recently-released LSD-7 photo-flashtube have been received from Mullard - Australia Pty. Ltd. This photo-tube is similar in appearance to the already well - known LSD-3, and provides a light flash of 350 microsecond duration, making it suitable for all high-speed photography, stroboscopic work and other similar applications where a brilliant light source of short duration is required.

The recommended operating voltage is 2700 volts, with a trigger voltage of 2000 volts. Under these conditions, and using a 54 mfd condenser, the maximum energy discharge is 200 joules, with a light flash approximating normal daylight.

Supplies of these tubes are now readily available and circuit details and other technical data can be obtained from Mullard-Australia Pty. Ltd., 35 Clarence St., Sydney.

"UNIVERSITY" MODULATED OSCILLATORS

From Radio Equipment Pty. Ltd., manufacturers of the well-known "University" test equipment, comes details of a modulated oscillator which should be of interest to all radio servicemen.

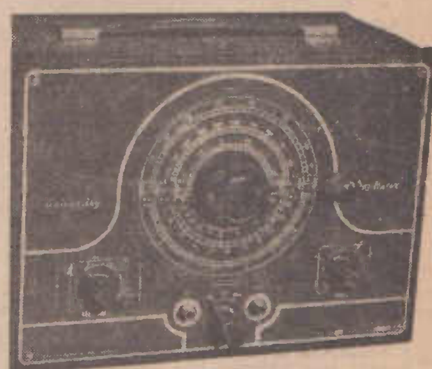
This instrument is available either as an AC operated (Model XOA) or battery operated (Model XOB) with built-in batteries, and is suitable for radio alignment and general testing purposes.

The circuit consists of a 6V6-GT used as a Colpitts RF oscillator with all tuning coils being well shielded in an internal metal case. Each tuning coil is fitted with an adjustable iron core and an adjustable trimmer condenser to ensure accurate tracking with the tuning scale, which is directly calibrated in kilocycles and megacycles.

The RF output is taken through a capacity piston attenuator to the shielded RF output cable. The attenuator voltage is from 5 microvolts to .1 volts, and the scale is calibrated directly in microvolts and millivolts.

A Hartley type 400 cycle AF oscillator with harmonic filter provides internal modulation. The 400 cycle voltage at a strength of approximately 20 volts is available at the AF output connection.

The unit has an attractive appearance, being fitted into a black brocaded steel case measuring 11½ x 8½ x 7½, and has front panel finished in dark red enamel with raised nickel-plating markings.



Full particulars of this instrument can be obtained from any University distributor, or by writing direct to the manufacturers, Radio Equipment Pty. Ltd., York St. North, Sydney.

TRANS-TASMAN DIARY

By J. F. FOX
(Special N.Z. Correspondent)

MOBILE RADIO TELEPHONE SERVICE

A radio telephone service for use in motor vehicles has been installed at Auckland and Wellington. This new service inaugurated by the Post and Telegraph Department, will enable persons travelling in and around the cities to speak by radio telephone to their office or headquarters.

Primarily intended for public utilities such as fire brigades, ambulances, harbour services and power boards, the service will later be made available to private companies. It will be many years before the ordinary motorist will benefit from this service owing to the heavy cost of installation.

The Post Offices radio telephone station at Auckland is situated 640 feet above sea level on Mount Eden, and is connected by land line to each of the subscriber's premises. Central office equipment which is located on the premises of each subscriber is installed and maintained by the department's technical staff.

Speech from the Central office equipment is conveyed by land line to the Mount Eden station, whence it is transmitted to the mobile units. Conversely, speech from mobile units is received at the fixed station and relayed by land line to the central office. In the initial stages, the service will at least be on a non-secret party line basis.

The service is an amplitude-modulated very high frequency system operating in the frequency band of 100 to 108 megacycles. The transmission frequency of both fixed and mobile stations in the Auckland system is 107.5 megacycles.

Equipment at Mount Eden

The transmitter-receiver is part of the surplus war aircraft equipment (SCR522a) and has been modified for commercial mobile operation. The set, from which all unnecessary facilities have been removed, has been modified for single channel operation from a 230-volt a.c. source.

The power supplies for the transmitter and receiver are two integral units separate from the main transmitter-receiver unit. The "transmitter" power supply incorporated also a bias supply (-150 volts), and a relay rectifier unit. The "receiver" power supply (which also incorporates a relay rectifier unit) is transferred over to provide power for the modulator and oscillator sections of the transmitter upon operation of the microphone press-to-talk switch.

Local Control Box

This enables local operation of the transmitter-receiver unit to be conducted from the fixed station. Essentially, it consists of a relay system which is operated by means of the press-to-talk switch in either the "local" microphone or in the microphones at the subscriber's premises. Operation of this relay system results in—

(a) **Transfer of the antenna from receiver to the transmitter.**
(b) **Transfer of high-tension voltage from the receiver tubes to the modulator and oscillator sections of the transmitter, and the application of high-tension voltage to the remaining transmitter tubes.**
(c) **The earthing of the receiver input circuit.**

Antenna

The antenna is an array consisting of four vertical collinear half-wave elements, and three quarter-wave phasing sections mounted horizontally on a 50-foot hardwood pole adjacent to the Mount Eden station. The array which is constructed of half-inch, 16 gauge, half-hard copper tubing is matched to a single conductor coaxial cable, terminating directly on the transmitter-receiver unit.

In the Subscriber's Premises

A desk mounting remote control unit is situated in each of the subscriber's premises. This unit, which is connected by land line to the local control box at the fixed station comprises essentially (1) A loudspeaker, together with the speaker amplifier for received speech. (2) A dynamic microphone and microphone amplifier for transmitted speech. (3) Associated power supplies and relay system.

Normally the remote control unit is in the "receive" position. Under this condition speech from any mobile unit is picked up by the fixed station receiver and fed by land line via the local control box to the speaker amplifiers in the remote control units at the subscribers' premises. It is thus possible for any subscriber to know by audible monitoring if the channel is being used by any other subscriber on the "party line."

Subscribers' remote control units are connected in parallel across a common cable control pair to the fixed station. It is obviously possible also in cases of emergency for a subscriber to break in on the conversation of another subscriber in the party group and request the use of the channel. When a subscriber wishes to use the channel he operates the press-to-talk switch in his microphone and speaks normally.

The operation of the press-to-talk switch operates the relay system in the local control box at the fixed station. This prepares a circuit to the modulator for the subscriber's speech and causes other operations to occur as already explained under the heading "Local Control Box." On release of the press-to-talk switch a circuit is prepared for the receiver audio output via the local control box to the remote control units at the subscribers' premises.

Satellite Station at Wellington

Although this description refers specifically to a single station installation as is in use at Auckland, a similar system utilising two stations is in use at Wellington. In this case topographical considerations dictated the use of two stations for adequate coverage. The main station operates on 107.5 megacycles and, the satellite station on a frequency of 107.48 megacycles. The band-pass of the mobile receives as specified will simultaneously admit signals from both stations where the mobile set is in a common area of coverage from the two stations. Both the main and satellite stations are connected by landline and both are used simultaneously for transmission and reception.

Tests in Southern Cities

Preliminary technical tests were recently completed in Christchurch and Dunedin by Post Office engineers for the installation of mobile radio telephone. Owing to the topography of Dunedin the department engineers are at present working on building two transmitting stations which will be similar to the Wellington scheme.

It is anticipated that in the case of public utility organisations each channel will cater for up to four subscribers and a total of 40 to 50 vehicles. Ultimately, it is envisaged that the mobile radio-telephone system will be connected to the main automatic exchanges and that selective calling devices will be instituted.

Radio New Zealand Shortwave Transmitter at Titahi Bay, Wellington.

ON THE BROADCAST BAND

FRENCH BROADCAST TRANSMITTERS

The following information recently received from the French capital concerning the activities of radio stations in that country should prove of interest to all DX enthusiasts.

At the present time in most locations it is possible to tune in signals from many of the medium-wave broadcasting stations operating from Europe, and in particular those in France can be received from about 4 to 6.30 each morning.

Under the present system only Government-controlled broadcasting is permitted in France, all stations being operated by "Radiodiffusion Francaise." The many stations now in operation are contained in the following lists. To give a clearer view of the whole scheme, these have been arranged according to their originating programme and not according to the frequency. For those who may prefer the list in frequency order, it can be easily compiled from the information given.

It will be noted that on some frequencies several synchronised transmitters may be on the air and, consequently, the identity of a station on, say, 1339 kc or 1393 kc, using the French language, should not be taken for granted. Frequently some word or phrase from the announcer will help in identification.

"NATIONAL" PROGRAMME.

The main "National" programme from Paris emanates from a 100 kw transmitter at Villebon on 695 kc. This station's programmes are frequently relayed over the following regional or provincial network:—

1077 kc Bordeaux—Neac, 100 kw.
1321 kc Clermont—Ennezat, 20 kw.
1158 kc Dijon 1, only 2300 watts.
832 kc Grenoble 2, only 50 watts.
1213 kc Lille. 1—Camphin, 20 kw.
648 kc Limoges 1—Nieul, 100 kw.
895 kc Lyon 1—Tramoyes, 100 kw.
749 kc Marseille 1—Realtort, 20 kw.
1068 kc Montbeliard, 10 kw.
1348 kc Montelimar, 1 kw.
1158 kc Montpellier 2, only 200 watts.
959 kc Nancy 1, 20 kw.
1185 kc Nice—La Brague, 60 kw.
1068 kc Nimes, 2 kw.
1348 kc Perpignan, 1 kw.
832 kc Quimper—Quimerch, 10 kw.
1040 kc Rennes 1—Alma, 20 kw.
859 kc Strasbourg 1—Brumath, 20 kw.
913 kc Toulouse 1—Muret, 100 kw.

SECOND PROGRAMME.

On 776 kc we may hear what is known as the second programme from Paris, over station "Parisian," running 10 kw from Romainville. This station's programmes are frequently relayed over the following regional (or "Provincial," as our French friends term it) network:—

1393 kc Bordeaux 2—Carrere, 40 kw.
1456 kc Clermont—Ennezat, 1 kw.
1393 kc Dijon 2, 20 kw.
1393 kc Grenoble 1, 15 kw.
1456 kc Lille 2—Camphin, 1 kw.
1339 kc Limoges 2—Nieul, 20 kw.
1339 kc Lyon 2—Dirdilly, 25 kw.
1339 kc Marseille 2—Realtort, 10 kw.
1393 kc Montpellier 1, 10 kw.
1339 kc Nancy 2, 10 kw.
1366 kc Nantes—Montbert, 10 kw.
1393 kc Nice 2—Antibes, 25 kw.
968 kc Pau, 20 kw.
1348 kc Poitiers, 1 kw.
1393 kc Rennes—Thourie, 24 kw.
1393 kc Rouen—Louvetot, 20 kw.
1456 kc Saint—Brieuc, only 50 watts.
1393 kc Strasbourg 2—Brumath, 10 kw.
1339 kc Toulouse, 20 kw.

Our thanks to Mr. Stuart Kerr, Maryborough, Victoria, for his able assistance in compiling this information regarding the French stations.

By
ROY HALLETT

LISTEN FOR THESE

If you are one of those readers who has not the time to spend long hours listening for stations in the early morning or late at night, we do suggest you should at least try for the following. These 10 stations are among the strongest likely to be heard during the coming month, and should be received in most locations with little difficulty.

XERF, Piedras Negras, Mexico, 1570 kc: This one uses studios in Del Rio, and heard around 9 p.m., with many English announcements.

XERB, Tijuana, Mexico, 1090 kc: Studios in San Diego, California. Try around midnight.

KZRH, Manila, 650 kc: One of the best signals from the Philippines around 1 a.m.

VUT, Trichinopoly, India, 758 kc: Often a good signal with news in English, 1.30 a.m. Mainly Indian native-type programmes.

KNBC (formerly KPO), San Francisco, California, 680 kc: One of the several fair signals from North America around midnight.

KIRO, Seattle, Washington, 710 kc: Another midnight American.

KMVI, Wailuku, Hawaii, 550 kc: Opens well 2 a.m.

KPOA, Honolulu, Hawaii, 630 kc: Another good one, 2 a.m. Several other Hawaiians at this time. Don't let KGMB, 590 kc, confuse you using Japanese.

BBC, England, 1149 kc: Try this channel when listening for Europeans around 5 a.m.

WVTR, Tokyo, Japan, 870 kc: American forces programmes in English. News at midnight.

NEW 2KY TRANSMITTER

The official opening of 2KY's new transmitter at Homebush, replacing the equipment at French's Forest, marks another step forward in the progress of broadcasting in this country.

This station first took the air from the small studios in the old Trades Hall, with the transmitter, built by Mr. G. Beard, operating from the same premises 23 years ago, in October, 1925. Several years later, studios moved to their present location, in Dymocks Building, George Street, Sydney. At the same time the transmitter was moved to French's Forest, where in 1935, what were then the tallest wooden masts in the Commonwealth were erected.

A further improvement took place when a new transmitter was installed in July, 1940, and up-to-date studio equipment some two years ago. The station's programme policy is designed to provide light musical programmes, primarily for listeners anxious to hear something a little different to those provided by most other local stations.

The new transmitter is capable of an output of just over 2kw. although the station at present is running only to 1kw. Distortion, 1.1 per cent. and frequency response is flat from 30 to 10,000 cycles. The galvanised steel aerial mast which is situated on the flats of Homebush Bay is some 13ft. higher than the 2UW mast. Our many thanks to Mr. John H. Brown, Chief Engineer of 2KY, for his assistance in compiling this information.

NEW NORTHERN REGIONAL

We have heard what we believe to be 2NU's carrier at our listening post. Mr. Cushen says he has heard the station testing in the mornings, and so we expect that it will not be long before the A.B.C. brings this additional regional, operating from Manilla, Northern N.S.W., on 660 kc, into operation.

During the recent parliamentary broadcast over the National programme we learned from an announcement made by the Minister for Information that, apart from the new Regional relay stations planned by the A.B.C. mentioned in earlier issues, new transmitters are to be installed shortly at 4RK Rockhampton, now sharing 940 kc with 7ZR and 6WN Perth, now on 800 kc.

SHORTWAVE LISTENER

by TED WHITING

READER'S INTERESTING VERIFICATIONS

As an example of what can be achieved by a listener in a comparatively short space of time, we recently received a well-arranged Album from Mr. J. Hargreaves, whose loggings are a feature of these pages from time to time.

Mr. Hargreaves' location is in the heart of the city of Sydney, in an area almost totally served by D.C. mains, and one in which man-made interference goes almost unchecked. But despite this handicap this listener has compiled some very creditable logs, and has forwarded for our perusal his records covering only the last year.

Within this neatly-arranged album are letters and verification cards from no fewer than seventeen countries. Reports have been sent to 25 countries, and no doubt more reports will be soon forthcoming.

Addresses culled from this album will be of interest to most readers, and will give an idea of the variety of verifications received by Mr. Hargreaves.

Radio Australia. Mr. G. Hutchins, Radio Australia, Shortwave, Div., Dept. of Information, 475 Collins Street, Melbourne.
ZL3-ZL4. Mr. J. Shelley, The Director. N.Z. Broadcasting Service, P.O. Box, 3045. Wellington, C.I., New Zealand.
KZRH. F. H. Stevens and Co., Iogar Filipino Building, Manila, Philippines.
Voice of America, Manila. Mr. J. H. Fletcher, Chief Engineer, International Broadcasting Division, C/o American Embassy, Manila, P.I.
Radio Batavia. Mr. P. R. Hill, Stichting Radio Omroep, i.o., Hfdkantoor Koningsplein Z17, Batavia.
All India Radio. Y. Venkata Ramiah, Station Engineer, All India Radio, Broadcasting House. Parliament Street, New Delhi, India.
KRHO, UNO transmissions. Mr. G. I. Smith, Chief, English Sections, Radio Division. United Nations, Lake Success. New York.
KNBA. KNBI. Walter E. Law, National Broadcasting Company, Inc., R.C.A. Building, Radio City, New York 20.
Canada. Neville Friedlander, Pacific Unit, Canadian Broadcasting Corporation. Box 7000, Montreal, Quebec.
XGOY. Fung Chien, Director XGOY, The Voice of China, Chungking, China.
XMPA. Cal. F. H. Hsu, 10, Snake Mountain, Nanking, China.
Paris, Mr. R. Lange, Director, Radiodiffusion Francaise, 118, Champs Elysees, Paris, France.
FK8AA. Pierre Bannau, Le Directeur du Cabinet du Gouverneur General, Directeur du service de L'Information, Noumea, New Caledonia.
Radio Saigon. Radio Saigon, Bureaux and Studios, 86 Rue Mac-Mahon, Saigon. French Indo-China.
HCJB. La Voz de Los Andes, Radiodifusoras HCJB, Quito, Ecuador, Casilla 691.
ZPA5. Compania Paraguaya de Radiodifusion, Casilla Correo 5522, Posadas, Paraguay.
WLWK, WLWO, WLWR. Crosley Broadcasting Corporation, Cincinnati Ohio, U.S.A.
Switzerland. The Swiss Shortwave Service, 28, Neuengasse, Berne, Switzerland.
XGOA. The Central Broadcasting Station, Nanking, China.
Singapore. British Far Eastern Broadcasting Service, P.O. Box 434, Singapore.
WCRC, WCBX, WOOC, WOOW. Columbia Broadcasting System Inc, 485, Madison Avenue, New York 22. New York.
WRUW, WRUS, WRUL, WRUA, WRUX. World Wide Broadcasting Corporation, Hatherly Beach, Scituate, Mass. U.S.A.
SEAC. Wing Commander Smith. Radio Seac., Colombo, Ceylon.

READERS' REPORTS

Readers desirous of submitting Short Wave reports for inclusion in these notes, should ensure they reach our Short Wave Correspondent not later than the 1st of each month. Address all letters to:—Mr. Ted Whiting, 16 Louden Street, Five Dock, N.S.W.

LATEST JAPANESE SCHEDULES

We are indebted to Miss Sanderson, in that she passed on to us the latest schedule for the Broadcasting Corporation of Japan.

1st Network

JKF Nazaki, 9655kc, 5Kw, 7.25 a.m.-7.15 p.m. JKF2, Nazaki, 4910kc, 5Kw, 4.55 a.m.-7.15 a.m., 7.25 p.m.-11.30 p.m. JKC Yamata, 7257.5 kc, 5 Kw 4.55 a.m.-11.30 p.m.

2nd Network

JKA Nazaki, 7285kc, 5Kw, 6.25 a.m.-8 a.m, 4.55 p.m.-10.5 p.m. JKG Kawachi, 9695kc, 5Kw, 4.55 p.m.-10.5 p.m. JKG2 Kawachi, 4930kc, 5Kw, 7.15 p.m.-10.5 p.m.

Repatriates

JVW Kawachi, 1522kc, 15Kw, 7.50 a.m.-7 p.m. JVW2 Kawachi, 9505kc, 15 Kw, 7.15 p.m.-10.30 p.m. JVW3 Kawachi, 15235kc, 5KW, 7.50 a.m.-7.15 p.m. JVW4 Kawachi, 9560kc, 5Kw 7.25 p.m.-10.30 p.m.

A.F.R.S.

JKD Nazaki, 6015kc, 5Kw, 6.15 a.m.-11.05 p.m. JKE Yamata, 9605kc, 5Kw, 6.15 a.m.-7 p.m. JKE2 Yamata, 4860kc, 5Kw, 7.15 p.m.-11.05 p.m.

A.F.R.S. Schedules

KCBA, 15150kc, 3.15 p.m.-8.30 p.m. Alaska, Aleutians, and China. KCBA, 15330kc, 7 p.m.-12.30 a.m. South West Pacific and Philippine.. KCBF, 11810kc, 1.15 p.m.-6.30 p.m. Alaska, Aleutians, and China. KCBF, 9700kc. 7 p.m.-12.30 a.m. China and Japan. KGEX, 9570kc, 1.15 p.m.-6.30 p.m. Alaska and Aleutians. KGEX, 11860kc, 7 p.m.-10.30 p.m. China and Japan. KGEI, 15210kc, 3.30 p.m.-8.30 p.m. South West Pacific and Philippines. KGEI, 9350kc, 8.45 p.m.-10.30 p.m. South West Pacific and Philippines. KGEX, 11730 kc, 3.30 p.m.-6.45 p.m. South West Pacific and Philippines. KNBX, 15250kc, 3.30 p.m.-6.45 p.m. South and Mid Pacific Area, KWID, 11900kc, 3.30 p.m.-9.30 p.m. South and Mid Pacific Area.

"Radio Falange" Reports

Miss D. Sanderson, Malvern, sends along her usual excellent report on her listening for the month. In the accompanying letter Miss Sanderson states that she has been requested by the station engineers of Radio Falange to observe their transmissions over a period, and she asks that any reader would send their reports to her so that she can forward them on to the station.

Radio Falange heard on 7380kc between 6 a.m. and 7 a.m. EST, is at present operating on low power, which it is hoped will be increased in the near future. In addition, the period of transmission will be extended to 8 a.m. EST. These reports should be addressed to Miss D. Sanderson, 499-501, Bourke Street, Melbourne, C.1. Vic.

Verifications received by Miss Sanderson during the past month include a copy of Malaya Radio News and letter from Kuala Lumpur; Letter of confirmation from JKG2, card and letter from XGAF for the transmissions on 11680kc and 7100 kc. This station requests reports, and particularly a comparative report on the two frequencies used. The address for those interested is Major Chen, XGAF, Station of the Chinese Air Force, Nanking, China.

Likely Frequency Changes

In an announcement by the P.M.G. is found the information that changes are projected in the limits of the bands of frequencies allotted to Short Wave Broadcasting. The matter is at present being discussed at Geneva, but it seems likely that the allocations finally decided upon will be as follows.

TROPICAL BROADCAST BANDS

Shared with other services, with priority to Broadcasting.

2300kc-2495kc, 4750kc-4995kc.

3200kc-3400kc, 5005kc-5060kc.

HIGH FREQUENCY BROADCAST BANDS

3900kc-3950kc. Shared with Aeromobile Services.

3950kc-4000kc. Shared with Fixed Services.

Exclusive Broadcasting Bands: 5950kc-6200kc, 7150kc-7300kc, 9500kc-9775kc, 11700kc-11975kc, 15100kc-15450kc, 17700kc-17900kc, 21450kc-21750kc, 25600kc-26100kc.

Notes from K. Boord

Flashes from Ken Boord, Radio News Short Wave Editor, U.S.A., state that the Chilean station CE1180 11980kc, located at Santiago, relays a Spanish service from FZI, Brazzaville from 1 p.m. possibly will not be heard here, especially at this time of the year.

XYHT is now on 6096kc, but appears to drift lower in frequency, signal is much better since the change.

A new Forces Broadcasting Station is operating in Libya, heard on 11850kc at 2.45 p.m.

HOLA, Panama, has English transmissions daily at 5 a.m.-6 a.m., 1 p.m.-4 p.m., 5 p.m.-6 p.m. Spanish is heard at other times. HOLA operates on 9505 kc.

HVJ, Vatican City, formerly on 9660kc to 9640kc, but has not been heard at this location on this new frequency.

Radio Sario, Celebes, is on 9840kc at 8 p.m.-12.30 a.m., quite a good signal.

A station is being heard on 4845kc, operating from Sumatra, possibly the Medan station which has disappeared from its former frequency of 7210kc. A relay is taken from PCJ at 11 p.m., and news in Dutch from Batavia at 1 a.m.

Listen For These Stations

China

XGOY 15170kc. Heard in English news and commentaries at 7.45 p.m.

XGOA 15100kc at 7.30 p.m. with news commentaries, etc., and at 9 p.m. on 5985 kc is heard with news in English and musical transmission.

XLRA 11500kc. Heard well at 8.15 p.m. with Chinese News and music.

XMTA 12210kc. Similar service, but with western type music at 9 p.m. Fine signal.

ZBW3 9520kc. Located in Hong Kong is heard well with B.B.C. relay of news at 9 p.m.

India

VUD5 15190kc. At 6 p.m., news and programme, fine reception.

VUD8 21510kc. Transmission in Chinese at 8.15 p.m. followed by English.

VUD10 17830kc. News in Hindustani at 8 p.m., good signal.

VUD4 9670kc. Good one in English at 10.30 p.m.

VUD2 9630kc. Programme for local consumption at 9.30 p.m.

VUM2 4920kc. Chimes at 10 p.m., news and usual programme. Good signal.

VUD9 15350kc. Another good signal in English at 12.30 p.m.

Burma

Rangoon 6035kc. News heard in one of the local dialects at 10 p.m., announcement is made in English also.

Siam

HS8PD 6000kc. Fair signal in English news transmission at 9.15 p.m., interference can be bad on this channel.

Ceylon

SEAC 17730kc Forces service with news and many B.B.C. transmissions, good one at 9 p.m.

SEAC 15120kc. Forces programme heard on this frequency from 8.30 p.m. Fine signal.

SEAC 9520kc. Another outlet of same service at 9.45 p.m.

SEAC 6070kc. Schedule of frequencies given at 10 p.m., good signal also.

Malaya

Singapore 15300kc. News. Market and Stock Exchange reports at 8 p.m.

Singapore 11850kc. Frequency schedule given at 7.30 p.m. News, etc.

Singapore 9690kc. B.B.C. relay of news of the world, followed by local news, good level.

Singapore 6025k.c. Fine at 9 p.m., music and transmission for the children.

Philippines

KZFM 11840kc. Purely local programme of news and music, heard well 7.15 p.m.

KZOK 9690kc. Another local effort with good signal, at 9.30 p.m.

KZFM 9620kc. Heard well at 8 p.m. and later with musical programme.

KZPI 9500kc. At 7.30 p.m., another good signal heard nightly.

KZFM 6170kc. Fine at 8 p.m., but heard till after midnight.

KZRC 6140kc. News for local listeners follows musical programme at 7.45 p.m.

KZBU 6100kc. Similar type programme at 8 p.m. and later.

KZMB 6005kc. American type shows and news, good entertainment at 8.30 p.m.

Canada

CKLO 9630kc. Music, news and "Ferry Schooner" series of programmes at 8.45 a.m.

CBLX 15090kc. News and weather information at 10 p.m., fine transmission.

CKCX 15190kc. News from the Canadian service, fine at 9.45 a.m.

CKRA 11760kc. Another outlet heard at 10 a.m., good signal here.

CHLS 9610kc. At 6.45 p.m. talks, etc., heard well most locations.

CHOL 11710kc. News in French at 7.15 a.m., music followed by news in English.

Italy

Rome 15120kc. Heard well at 8 p.m., Italian news also relayed on 11810kc.

Rome 9630kc. Another good outlet heard at 7.30 a.m. with news in Italian, also to be heard on 7270kc. at 7.15 a.m.

Rome 6085kc. Frequency details and news in English and Italian at 7 a.m.

Norway

LLM 15175kc. Fine musical transmission at 5 p.m., well worth hearing.

LLG 9610kc. Good musical programme at 4.30 p.m., followed by news in Norwegian.

Holland

PHI 17760kc. Heard at 11 p.m. with news and music for listeners in D.E.I.

PCJ 15220kc. News in English and Dutch at 7.45 p.m. on this frequency.

Monaco

Monte Carlo 6038kc. A very fine signal at 7 a.m. from this high power station located in one of the smallest countries in the world.

U.S.A.

KNBA 21460kc. Fine in Latin American service at 11.30 a.m. with news, etc.

WCBX 17830kc. Service to Europe with fine programmes at 7.45 p.m.

KNBA 17800kc. News broadcast to European listeners at 3:45 p.m. Fine signal.

KRHO 15250kc. Located in Hawaii, strong signals at all times but at 7.45 p.m. is on with U.N.O. transmissions.

KCBA 15150kc. News and Sporting Broadcasts at 3.15 p.m. with colossal signal.

KCBR 15130kc. In Far Eastern Service of Voice of America, news, etc., at 7 p.m.

KWID 11900kc. Report from U.N.O. and music at 7.45 p.m.

KCBF 11810kc. News and fine musical services at 3 p.m.

KNBX 1179kc. Voices of Spring session at 7.15 p.m., fine signal.

WRUS 11790kc. English World News at 8.45 a.m., news from U.N.O. followed by music.

WNRA 11770kc. News and music in English at 7.45 p.m.

KNBI 9650kc. Sports casts and news broadcasts from this one at 5.15 p.m.

KWIX 9570kc. At 3.45 p.m. "Meditation Time in Music," fine transmission.

KWID 9570kc. Opens at 10 p.m. in Far Eastern service, news, etc.

WGEO 9520kc. In Latin American service at 7.30 p.m., good one this.

KGEI 9530kc. Opening at 8.45 p.m., usual type of programme.

KCBR 6180kc. U.N.O. Review, Stamp Club review, well worth listening to, 8.30 p.m.

KNBA 6060kc. "University of the Air," heard here at 7.30 p.m.

Dominican Republic

HI2T, 9727kc. Good one now at 7 a.m., all in Spanish, easily identified, however.

HIG 6115kc. Music, news in Spanish and Chimes at 9.15 p.m.

HI4T 5970kc. Chimes, Anthem and News in Spanish at 9 p.m.

Trinidad

VP4RD 9625kc. Heard with "Church in the Wildwood" at 8 p.m., good one, news and music later.

Cuba

COBC 9370kc. At 9.15 p.m. with nice signal in news, opens at 9 p.m.

COKG 8960kc. Heard equally well in news and commencement of programme at 8.45 p.m., improves later to fine signal despite inroads of Morse.

COCQ 8830kc. Opens at 9 p.m. some nights, news and music. Occasionally uses English on opening.

Mexico

XEBT 9620kc. Very fine signal in musical programme at 3.30 p.m.

XEWW 9500kc. The best of all Mexican stations, heard in afternoon till 4 p.m. Good programme.

XEHH 11880kc. Noise bad, but heard fairly well at 2.30 p.m., news and chimes.

XERQ 9610kc. Heard with American programmes at 3.30 p.m.

Panama

HP5K 6005kc. Announces as Panama at 9 p.m., Chimes and news-music follows.

Haiti

HH3W 1013kc. Very fine signal these days at 10.15 p.m., carries C.B.S. service at this time. Opens about 9.30 p.m.

Argentine

LRY1 9545kc. Opens at 8.30 p.m., news in Spanish.

LRM 6180kc. Good signal in News and music. Spanish spoken throughout, try this one at 9 p.m.

Guatemala

TGLA 6295kc. Chimes, news and music at 10.12 p.m., opening.

STATION ADDRESSES

VY1RG, 6150kc, Venezuela. Radio Cabimas, Calle Democracia, Cabimas, Venezuela.

CE622, 6220kc, Santiago. P.O. Box 2626, Santiago, Chile.

XURA, Taiwan, China. Taiwan Broadcasting District, Chong Sun Park, Taipeh, Taipan, China.

YV3RN, 4990kc, Barquisimeto, Venezuela. Radio Barquisimeto Apartado 76, Barquisimeto, Venezuela.

EAJ-43, Canary Islands. Radio Club Tenerife, Estaciones, EAJ-43 y EA8AB, Apartado 225, Santa Cruz de Tenerife, Canary Islands.

ELECTRONIC MICROMETER

(Continued from Page 27)

If the surface of the metal is curved, the indicated reading is to an average distance. The initial mutual coupling is larger, so that more buckout is required, but incremental readings are very nearly the same as for a flat plate. There is no necessity to match the end of the probe form to the shape of the surface, as would be the case in capacitive micrometers. The useful linear range is reduced, however, because part of the effective surface of the metal is at a greater distance from the end of the coil form.

Some measurements have been made with the micrometer to examine the effect of placing materials of various dielectric constants between the probe coil form and the metal. This is the normal way of measuring the thickness of insulators. Any error present due to dielectric constant is so small as to be within the accuracy of the instrument. As far as has been determined, materials making very poor condensers at radio frequencies (tap water, for instance) give the same indication as an air gap of the same amount.

There are many places where this principle of measurement of air or insulating gaps may be used. Before going into some of them, it might be well to review the characteristics of the micrometer. Here is a device which gives a high level d.c. or a.c. voltage linearly proportional to the spacing between the end of a coil form and a non-magnetic metal plate, for distances up to 5 per cent. of the diameter of the form. The form diameter may be anything from ¼in. up. The metal surface needs to be at least equal to the coil diameter, .001 inch thick, and does not require any electrical connection to it. The metal surface may be tilted, or curved; the indication given is an average distance.

One obvious application is for measuring paint or varnish film thickness on airplane skin. The sheet aluminium skin would be the necessary metal backing. In practice, the end of the probe coil form would be held directly against the painted surface.

When mounted on a bearing, the probe could be made to give an indication of the lubricating film thickness. Here the backing metal would be the shaft itself. It should be possible to examine the shaft vibration by this system; the information could be presented directly on a cathode ray tube.

An application may be in phonograph pickups. In a superheterodyne receiver, the local oscillator could be used for the excitation of the primary coil, while the secondary r.f. voltage could be rectified by a 1N34 germanium diode and fed to the audio amplifier.

ACKNOWLEDGEMENT

The electronic micrometer was developed in connection with projects for the Navy Department, Bureau of Ships, in the Electronic Instrumentation Laboratory of the Bureau of Standards. A patent application has been taken out in the name of the United States Government and will be made available without charge.

The author wishes to acknowledge the very material assistance of W. E. Williams, of this laboratory, in the experimental investigation of the characteristics of this system of distance measurement.

REFERENCES

1. R. W. Dayton and G. M. Foley, "Capacitive Micrometer"—Electronics p. 106-111, September 1946.
2. Eric Bradshaw "A Change of Capacitance Method for the Measurement of Mechanical Displacements"—Journal of Scientific Instruments, Vol. 22, p. 112, 1945.
3. A. V. Mershon "Precision Measurements of Mechanical Dimensions by Electrical Measuring Devices."—General Electric Review 35, p. 139-44, 1932.
4. M. A. Busher "Enamel Thickness Gauge"—Bulletin American Ceramic Society 14, p. 365-7, 1935.
5. Allen L. Alexander, Peter King and J. E. Dinger, "Instrument for Measuring Thickness of Non-Conducting Films Applied over non-Magnetic Metals."—Industrial and Engineering Chemistry, Analytical Edition, Vol. 17, No. 6, June, 1945.
6. Abner Brenner, "Magnetic Method for Measuring the Thickness of Non-Magnetic Coatings on Iron and Steel"—Journal of Research, National Bureau of Standards 20, p. 357, 1938.
7. Henry P. Kalmus "Pickup with Low Mechanical Impedance"—Electronics p. 140-145, January 1946.

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What is claimed to be an amateur record for EHF two-way communication was set up when a frequency of 2350 Mc was successfully used over a distance of 13 miles. The stations were situated at Brighton Racehill and Salvington Hill, Worthing, England.

* * *

Air-ground communication channels for civilian aircraft are being moved progressively from the m-f band to the EHF band. The freed medium frequencies will then be used for essential radio-navigational services. The change over has been necessary because of the reduced numbers of medium frequencies available to aeronautical telecommunications at last year's Atlantic City Conference.

R.S.G.B. EMPIRE AMATEUR RADIO

(Continued from Page 32)

ber of licences issued provides a striking example of the universal interest in radio communication. When hostilities ended it was estimated some 10,000 of the 12,000 members had served in the colors.

Unfortunately, the R.S.G.B. has not had the support in Australia it warranted. Most of this country's early amateur radio enthusiasts have handed on their pro-American ideas to the next generation. Since the termination of hostilities, however, the Australians have leaned toward England, and the society, no doubt due to the praise it received from ex-servicemen radio amateurs who, when in England, received a royal welcome from a society previously comparatively unknown to them.

Greatest R.S.G.B. "unofficial ambassador" to Australia in post-war years is Lieut.-Commander Edward ("Ted") Ironmonger, R.N., now stationed at Navy Office, Melbourne. Previously G8PO, and now VK3WU, he created a controversy throughout the Empire with his "G8PO special"—a two-element antenna with a phenomenal front to back ratio. His presence in Melbourne and interest in Australia has induced many to join the society.

With its sound, democratic, progressive policy, the R.S.G.B. is destined for a life as long as amateur radio. Rich in tradition, it will progress as the years roll on and be another link binding together a great Empire.

Although older in years than the American Radio Relay League, it should be mentioned that the society is not the oldest amateur radio body in the world. Honors go to the Wireless Institute of Australia, which was founded in 1912.

TELEVISION—CHOICE OF FREQUENCY

(Continued from Page 12)

16. Nobles—"Tel. Programmes from the Stratosphere," Westinghouse Engineer, V 5, N 6, Nov., 1945.

17. W. Nethercot—"Ignition Interference," Wireless World, Oct., 1947.

18. Smyth — "Continuous Wave Inter. with Tel. Reception," Electrical Communication, V 19, N 4, 1941.

19. "Tel. Service Hinges on Frequency," Electronic Industries, V 3, N 12, Dec., 1944.

20. R.M.A. Standards, I.R.E.-Proc., July, 1948.

21. "Pye Television System," Engineering V 161, N 4177, Feb., 1946.

TUBULAR-BELL CARILLON

(Continued from page 15)

Electroacoustic Transducers

The object of the electroacoustic transducer system of an electronic carillon installation is to simulate as closely as possible the acoustic effects of actual bells mounted in a tower and, if possible, to effect some improvement in the attainable distance coverage without the occurrence of excessive sound level in the immediate precincts of the tower. The particular arrangement of the loudspeaker system will, in fact, be influenced somewhat by whether local or distant coverage is of primary importance.

When the emphasis is on local coverage, as would often be the case in closely populated city or suburban areas, the loudspeakers should be mounted inside the tower, set well back from the tower openings so that the sound emerges from the openings under conditions similar to those obtained in a conventional bell tower. For this type of installation a suitable arrangement may take the form of a bank of cone speakers mounted round the outer surface of a cylindrical enclosure, or an omnidirectional horn mounted in the centre of the tower.

Where relatively long-range coverage (1 to 2 miles) is an essential requirement of the installation, the directional characteristics of horn projectors make them virtually a necessity if an adequate sound intensity at great distances is to be achieved without an excessively high level of sound near the tower. It is possible, by orienting the projectors horizontally, to offset largely the normally high rate of attenuation with distance from the source, so providing a pleasant listening area of, say, half a mile in radius within which the sound level is substantially constant. Useful coverage up to 1 or 2 miles may thus be realised without producing a distressingly high level at the base of the tower.

Power and Fidelity

The combination, in a single horn, of high fidelity in the reproduction both of steady-state and transcient waveforms with high power-handling capacity is a requirement increasingly difficult to achieve. The high power efficiency of horn speakers resulting from the excellent acoustic loading provided is inseparably associated with a form of distortion which occurs in the throat of the horn and which is accentuated when high power combined with wide frequency range are required from a single horn.

Another form of distortion in loudspeakers handling a wide frequency range with a single vibrating system is the introduction of frequency modulation of high frequencies due to the simultaneous movement of the source at low frequencies. The vibrating diaphragm behaves, with respect to the high frequency as a moving source of sound, and so gives rise to a periodic change in pitch of the high-frequency note, the frequency and amplitude, or deviation, of the resulting frequency modulation being governed by those of the simultaneously occurring low-frequency signal.

Fig. 8. A high-power 4-entry exponential horn showing details of the throat casting.

From analysis and experimental measurements of this effect with cone speakers it is possible to reduce the amplitude of vibration of the actuating diaphragm by loading with a horn or else employ separate acoustic channels for low and high frequencies. It would thus appear that this form of distortion is relatively less serious in horns than in unloaded cone speakers.

From the above considerations it can be seen that for really high fidelity high power work single wide-range speakers are virtually an impossibility, so that recourse must be had to multiple speaker assemblies of two or more channels, each of restricted frequency range.

A Multiple-Throat Horn

A convenient and economical method of producing a high-power horn projector without the need to design a special driving unit is to employ a multiple-throat horn with medium-power driving units of standard type.

Fig. 8 shows a typical four-entry horn designed for use in amplified carillon installations. The throat is of cast aluminium, cored and cast in one piece. The four throat channels merge smoothly from circular to quadrant shape and the total area of all sections is a continuous exponential function of anxial length from throat to mouth.

The overall length of this horn is thus somewhat shorter than that of a single horn of the same single throat diameter and cut-off frequency. The horn is designed for a nominal cut-off frequency of 140 cycles. The mouth diameter is 26 inches, the overall length 48 inches, and the nominal maximum power input rating of the horn is 40 watts.

V.H.F. Transmission

(Continued from page 21)

able in strength with those from the Newcastle transmitter 137 miles away, and intermittent capture interference occurred.

Conclusions

These results are an indication that V.H.F. services should not be planned upon the basis that their range will only be a little more than the optical range, but that careful attention should be paid to the fact that considerably greater distances can be attained, for at least a proportion of the time. Such ranges cannot be achieved consistently as it has been shown by propagation studies overseas that conditions of the lower atmosphere are a determining factor, and that slow and high-speed fading, and complete failure of signals for long periods will be encountered.

It indicates to some degree the amount of geographical separation which will be needed between two services sharing the same V.H.F. channel, a situation which is certain to arise in the future.

In conclusion, the tests point to the great potential value of V.H.F. links as a means of providing high-quality telephony channels in an economical manner with the use of relatively simple apparatus.

(The author is indebted to Amalgamated Wireless (Australasia) Ltd. for permission to publish these notes.)

GROUND CONTROLLED APPROACH

(Continued from page 7)

to arrange for the displays to be located in the control tower, and for the control of approaching aircraft to be carried out from there also. The GCA trailer would then be unmanned and remotely controlled. A further change will be in regard to the nature of the displays; these will be grouped and simplified so as to be read by one or two operators. In particular, the final approach controller will view the precision displays direct. These changes are directed toward reducing the number of trained personnel required for GCA.

Present indications are that the GCA system will eventually be installed at most large international airports where the flow of traffic is sufficiently great to justify the cost.

The Mail Bag

W. M. (Condobolin, N.S.W.) is an interested reader and forwards a hint for use in the "For your Notebook" page.

A.: Thanks for the letter and hint. W.M. Many contributions have been received for this page, but yours will be used as soon as space permits.

A.V.D. (Wingham, N.S.W.): forwards a subscription and would like to see more articles on audio engineering, other than describing amplifiers.

A.: Your subscription is appreciated, and this has been attended to by the Subscription Department. The Nov.-December issue has been forwarded and no doubt reached you by this time. We realise the growing interest in the audio subjects mentioned, and hope to publish some articles of this nature in the near future. The material will be written by practical sound men and consequently quite authoritative.

J.L. (Dulwich, S.A.) forwards a change of address.

A: Your new address has been noted by the Subscription Department, and this will take effect from the January issue. Many thanks for the letter.

S.R.H. (Semaphore, S.A.) intends building up the small mantel receiver described in the last issue, and asks whether a 6SN7-GT could be used in this circuit.

A.: We appreciate your remarks about the magazine, S.R.H., and are pleased to hear you enjoy reading every issue. The valve you mention can be used in this circuit, and as the base connection are identical with those given for the ECC35, it should be possible to plug it into the socket without making any circuit changes. We would be pleased to hear from you when you have this set in operation.

A.K.B. (Adelaide, S.A.) writes in for a copy of the February issue containing details of the Speaker Divider Networks, and mentions he has built up the amplifier described in the April issue. The vibrator section has been omitted, but an additional stage using a 6SN7-GT has been included to provide a bass boost section. Now he intends to build up a dual speaker Frequency dividing Network.

A.: The issue requested has been forwarded along, and you should be able to work out all the necessary values from the information given in this article. We would be pleased to hear of your success with this speaker network when you have completed it.

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."

R.S.B. (Fairfield, N.S.W.) forwards a servicing hint for inclusion in the "For your Notebook" page.

A: Many thanks for the letter and servicing hint. This was quite interesting and has been included in the current issue. The payment for this will be made within a few days after the general distribution of the magazine is effected. We would be pleased to hear from you again and will always consider any further notes you may send in.

B.R.C. (Hunters Hill, N.S.W.) intends erecting a new aerial system and asks about using a transposed lead in and the method of fitting same.

A.: In the aerial system you mention, it is usual to break the main aerial wire in the centre by means of an insulator and then connect the two separate aerials to the receiver by means of twin lead-in wires. These leads should be kept apart by means of wooden or bakelite spacers transposed every two or three feet, depending on the length of the line, and they ultimately connect to the two ends of the aerial coil primarily. If one end of this winding is already earthed it will be necessary to unsolder this lead to provide the second connection for the aerial lead in. Although this type of aerial system offers little improvement over the ordinary inverted L type in the average locality, it may be found quite advantageous in areas where electrical interference is particularly severe. Thanks for the letter and appreciative remarks concerning the magazine.

P.K. (Potts Hill, via Regents Park) sends in a change of address.

A.: Thanks for the letter. P.K.: Your new address has been noted by the subscription department, and there should be no further troubles with future issues.

C.R. (Charters Towers, Qld.) writes in appreciative letter and includes a contribution for insertion in "For Your Notebook" page.

A.: Many thanks for the letter and appreciative remarks. We are pleased to hear you enjoy reading each issue of the magazine. The "hint" forwarded was quite suitable, and will be used in the page as soon as space becomes available. Payment will be made on publication for this.

A.R.D. (Leederville, W.A.) in forwarding his change of address writes: "I am pleased to see that your magazine is still the outstanding radio magazine in Australia and I think it compares favorably with the best of the overseas publications. . ."

A.: Your kind remarks about the magazine are most heartening, and it is our intention to produce an even better magazine for the radio enthusiast. We would appreciate having your opinion on this latest issue which as you will note embodies many changes. Your new address has been noted by the Subscription Department, and this will become effective from the current issue.

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