DIRECTIVE AERIAL SYSTEMS

Practical Wireless 9D EVERY MONTH

Editor F. J. CAMM

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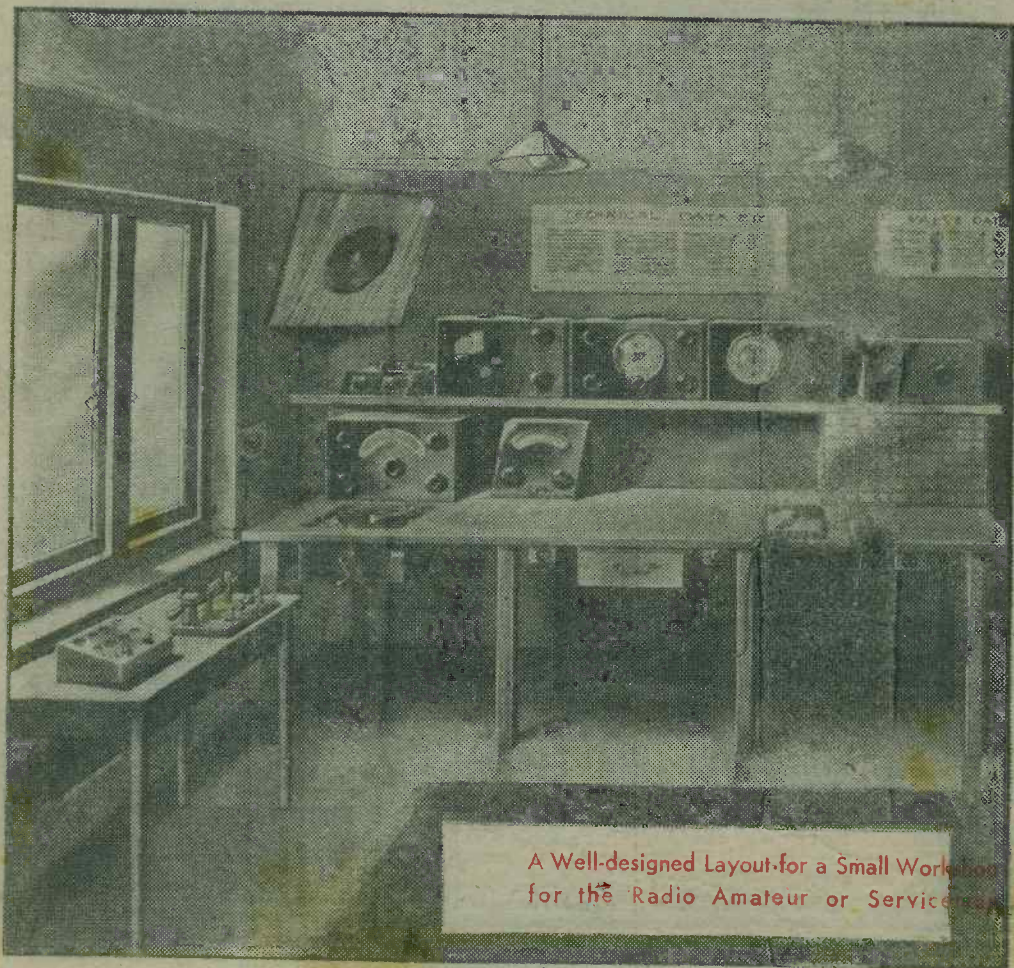

A Well-designed Layout for a Small Workshop for the Radio Amateur or Serviceman

Practical Wireless

and PRACTICAL TELEVISION

EVERY MONTH
Vol. XIX No. 442. APRIL, 1943.

Editor F. J. CAMM

Staff:
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COMMENTS OF THE MONTH BY THE EDITOR

The B.O.T. on the Battery Shortage

DURING February the Board of Trade held a press conference at which Mr. Hugh Dalton gave reasons why there has been a battery shortage. He also explained the steps he had taken to increase the supply. It will be remembered that magistrates had refused to fine cyclists charged with riding without a light. It seems a pity that holding these views magistrates did not advise the police to refrain from bringing cases and thus avoid wasting the time of the Court and, more important, the time of munition workers. The police could not have been unaware of the battery shortage, and many may think that they should have winked their eye at this minor technical offence.

Mr. Hugh Dalton explained that he had not been goaded into action by the protest of magistrates, for he was aware of the shortage long before magistrates had their attention drawn to it by large numbers of unnecessary prosecutions. He said that the troops had to be equipped at very short notice with large numbers of radio batteries which were to some extent built up of parts of the type used in cycle lamp batteries. Demands to-day have grown to a formidable degree for our fighting services, and our industrial army use large numbers of batteries of all kind, and the demands were unavoidable. There were two other types of demand which could be avoided. One was the hoarding of batteries, and the other was the excessive use of torches; they should only be flashed on occasionally.

No. 8 Batteries

REGARDING the famous No. 8, he said that this is the most uneconomical size to make and use. We would add that there are far too many types of flash lamps, and Mr. Dalton could quite usefully make an order limiting the number of types and specifying the minimum size. As with the design of certain battery radio receivers the "designers" of torches first produce some natty gewgaw masquerading as a torch, and then expect the battery manufacturers to provide some microscopical cell for it, which under continuous discharge would be completely exhausted in about a couple of minutes. A torch is an item of utility; it should not be designed as an ornament to fit the inner recess of some lady's handbag, or (most overworked of all terms) the waistcoat pocket. If the No. 8 size is uneconomical, it should be abolished, and especially during the war when materials are short. If Mr. Dalton can spend time specifying the requirements of utility lighters, he can also spend a little time specifying the minimum requirements of torches. He did express the hope that the public would gradually change over to a less extravagant size of torch. The steps taken to overcome the present shortage were initiated some time ago. A specialised industry could not increase its output overnight. Improvement had to be slow, but it had come. As a result the manufacture of batteries for civilian use in January this year exceeded December by a considerable amount. This was equal to the best production month of the war. In January 1943, the number of cycle batteries made was 1,900,500, an increase of 25 per cent. over November, 1942, and 24 per cent. over December. The next few weeks should see more batteries in the shops, although he stressed the necessity for the utmost economy in their use. Not every part of the country would quickly get increased supplies and no part would get more than its strict needs.

Regarding quality, he said that not all wartime materials were as good as they were before the war. As a result the average life of a battery was shorter than it used to be—a view with which operators of wireless sets will concur. It was even difficult for the manufacturer to avoid turning out an occasional dud, but reputable firms would replace defective batteries if the fault was one of manufacture.

While Mr. Dalton was considering the shortage of torch batteries, we think that he could have made some statement of the shortage of batteries for wireless receivers. While a wireless receiver cannot claim priority over torches and cycle lamps, it cannot be considered as a luxury. There is an acute shortage of certain types, and such as are available have a poor shelf-life and a poor active life.

Television in the War

REFERRING to the war-time developments of television mentioned recently, it could also be used to aid in the landing of aircraft at night or during fog. Television can also be used for the transmission of typewritten or printed matter, including maps and diagrams. But the snag has been the very limited range of the television signal—at most 30 miles under good conditions, due to the fact that, unlike radio signals, television signals travel in a straight line and do not follow the earth's curvature. The president of the Radio Corporation of America, David Sarnoff, announced to the Press that the problem of transmitting television over considerable distances has been solved by the construction of relay stations 30 miles apart. We have Mr. J. L. Baird's recent developments in colour, and stereoscopic television.

After the war television will be with us on the same scale as radio telephony is now. We can compare television with the talkies, and the ordinary broadcast to the silent pictures.

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Owing to the rapid progress in the design of wireless apparatus and to our efforts to keep our readers in touch with the latest developments, we give no warranty that apparatus described in our columns is not the subject of letters patent.

ROUND THE WORLD OF WIRELESS

Sewing by Radio

AFTER the war, wireless waves will be used to sew, gum things together, and for many other purposes, says Mr. David Sarnoff, President of the American Radio Corporation. In fact, thermal radio is likely to be used for heating, drying, annealing, welding and riveting.

Fined for Listening to the B.B.C.

IT is reported that two persons in Vichy France have been fined £50 for listening to the B.B.C. broadcasts.

C.B.C. Chief Resigns

MR. GLADSTONE MURRAY has resigned his position as Director-General of Broadcasting in the Canadian Broadcasting Corporation. He intends to enter the public relations field in connection with war industry and post-war reconstruction. Mr. Murray was general manager of the C.B.C. from 1936 to last August, when he was appointed Director-General of Broadcasting. He was with the B.B.C. from 1924 to 1935, first as Director of Public Relations, and later as Assistant Controller.

Wireless for the Blind Fund

WELL over £13,000 has been received in response to the Christmas broadcast appeal for the British "Wireless for the Blind" Fund. Most of the 23,000 gifts were accompanied by sympathetic messages. Over 100 civilians in this country are known by the National Institute for the Blind to have lost their sight through enemy action. These are in addition to the blinded members of the fighting forces and civil defence services.

Italy Bans Radio Sets

ACCORDING to Vichy radio Italy has banned the manufacture of new radio sets for the duration.

FM in Canada

THE first frequency-modulation transmitting system to be used by a transport concern in Canada will be used by the Toronto Transportation Commission. Traffic supervisors' cars will be equipped with two-way FM apparatus.

New Radiophoto Service

IT is reported from the United States that a new radiophoto service between Stockholm and New York was recently inaugurated by R.C.A. Communications in co-operation with the Swedish Telegraph Administration

Royal Signals O.C.T.U.

THE Royal Corps of Signals have their own O.C.T.U., where cadets who have passed the War Office Selection Course are training under war conditions to fit them as leaders. Basic training, technical training and battle training are carried out in courses lasting some 22 weeks.

In the basic training, man management, administration, infantry battle drill, weapon training, and convoy moves at night are some of the items.

In the technical training much time is devoted to wireless theory. Days and nights are spent in practice with vehicles equipped with most modern sets and maintaining communications.

Training Norwegian Radio Operators

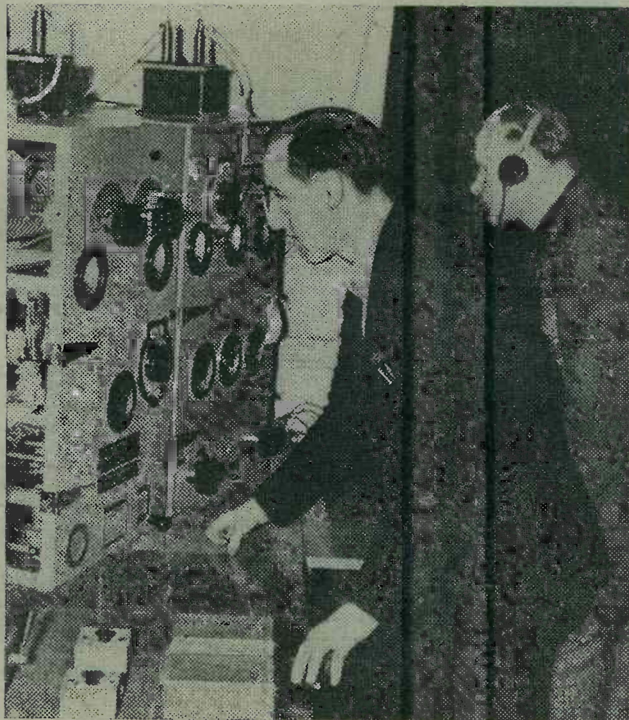
THE Norwegian Government have taken over several large houses, formerly the pre-evacuation hostels of London children, and transformed them into business-like workshops fitted with ships' engines and radio equipment. Here young Norwegian seamen who have arrived in this country are trained as radio-telegraphists and engineers. The training courses last from three to eight months. (See illustration on this page.)

R.A.F. Rebuilds Airmen

AIR crews grounded as the result of crashes or enemy action are helped by the R.A.F. to keep their hands in until such time as they are quite fit again for normal air duty. At an airmen's convalescent depot of Technical Training Command young pilots, wireless operators, navigators, bomb-aimers and air gunners go through routine courses of games, exercises, massage and dancing. They also have a Link trainer, a bomber cockpit and fuselage, and other devices designed to keep them in trim.

Grounded pilots take a short daily refresher course on the Link trainer for night-flying. Wireless operators, bomb-aimers and the other members of a bomber's crew pay constant visits to the "grounded" bomber cockpit and fuselage. These visits help, too, to keep their minds active.

This is a most important side of the work of this rehabilitation centre. It is vital to keep the mind as healthy as the body, and the centre's motto is "Mens Membra Medicat"—"The mind heals the body."



Norwegian trainees experimenting with a Marconi transmitter at one of the Training Schools in London.

Tail Piece

RECENTLY the popular Chessington Circus paid a visit to London and gave shows in the very heart of the West End. The nightly passage of the elephants to and from the circus has brought into existence a somewhat unexpected new London by-law, i.e., that elephants must be illuminated in built-up areas. Encounters with unilluminated elephants in the black-out were apparently beginning to leave their mark on the nerves of blitz-hardened citizens.

The B.B.C. paid a visit to the circus in order to include a broadcast from the performance in "Radio Newsreel" for the overseas service. At the first try-out all was going merrily until suddenly the recording apparatus went dead. Investigation showed that one of the elephants was chewing the cable that connected the "mike" with the recording car. It is suggested that he was trying to supply current for his tail lamp.

B.B.C. Engineers in the Forces

IT is not generally realised how serious a staff problem the B.B.C. Engineering Division has had to face in the past three years of war.

Of the 417 B.B.C. engineers now in the fighting services, 90 are in the Navy, 150 in the Army, 174 in the R.A.F., and three in the Royal Marines. Those in the Navy include a Commander. Of the 56 officers in the Army, 12 hold Field rank. A number of B.B.C. engineers helped to form the R.E.M.E. In the R.A.F., B.B.C. engineers include a Group Captain, and of 77 who are commissioned, 37 hold the rank of Flight-Lieutenant and above. In the Royal Marines they are represented, among others, by a Brigadier.

Of the total engineering staff released by the Corporation for His Majesty's Forces, four are known to have received awards, 10 have been killed on active service, and six are prisoners of war.

Let the People Speak

THIS new series is jointly presented by the B.B.C. and the Columbia Broadcasting System of America. It has been devised to give listeners on the one side of the Atlantic close-up glimpses of "the people at home" on the other side—the people on routine war work for whom few medals are struck, but who are as vital to the progress of the war as are those in the fighting forces.

In alternate weeks, Britons in all walks of life and from different parts of the country will come to the microphone to give America a picture of their daily life in wartime and of their hopes and aims. In the intermediate weeks corresponding programmes, originating in America, will project the U.S.A. for Britain.

Many of the problems which confront people to-day are common to both countries, and it is hoped that these programmes will prove helpful in the solution of those problems and will make for yet better understanding between the English-speaking nations.

D. G. Bridson will be the General Editor of the B.B.C. series and Norman Corwin—already known to listeners over here for his series "An American in England"—will direct the C.B.S. series.

B.B.C. Recording Department

THE Recorded Programmes Department of the B.B.C. has three main tasks. One is a question of time, one of place, one of history. The first job is to record things which happen when listeners are asleep or at work, and play them back when listeners are awake or at leisure. The second job is to go out in the recording cars, which are now as familiar a sight to the front-line troops in Africa as to the factories and villages of these islands, and bring back to the studio voices and sounds which lie beyond the reach of the studio microphone. The third job is to preserve for posterity some of the voices and sounds which characterise the times.

Requests

REQUESTS for recordings reach the central bookings room, by day and by night, at the rate of 2,000 and more a week. It may be that one is for a complete transcription of a speech by President Roosevelt. That will set many kinds of machines in motion. Post Office transatlantic circuits have to be booked. Operators all along the lines of communication from the White House to B.B.C. premises in London must be warned. Then the records are made, and a script prepared from them. A report is made to News Editors in the different services on quality and audibility. Extracts are marked for insertion in the bulletins. The "editing" of the records is an expert job, not unlike reading a book aloud and having to skip whole pages at a time without losing the meaning or the continuity. The records are laid out in a row on turn-tables all revolving at the same speed. The pick-up above each record is so suspended that the needle will drop on any previously selected point—even between two words following close on each other.

The illustration on the left shows Miss Doris Evans, 20 years ago, when she was one of the first women assistants in the original radio department of General Electric's research laboratory. The illustration on the right shows her to-day (now Mrs. Ausmus) with the ultra-modern scientific equipment with which she works at the G.E. lab. Mrs. Ausmus retired to become a housewife shortly after the photo at left was made. Her husband, Col. Delbert Ausmus, was reported missing at Corregidor and Mrs. Ausmus came back to put her experience to work for the war effort.

Two-wave-band Receivers

The Long-waves Offer Little Interest These Days, so Here are Some Suggestions for Receivers Covering the Medium- and Short-wave Bands

By W. NIMMONS

THE conventional two wave-band receiver, embodying the medium and long wavelengths, has reached a high point of perfection, at least, so far as the simple three-valve battery set is concerned. Many constructors would like to add a short-wave range, but when the attempt is made the construction of the set becomes much more complicated. Not only are special switches required for wave changing, but it is difficult to secure short wiring on the short wave side. At present, the commercial rotary switches for such purposes are unobtainable, and if the attempt is made to use ordinary push-pull switches the panel becomes bristling with knobs.

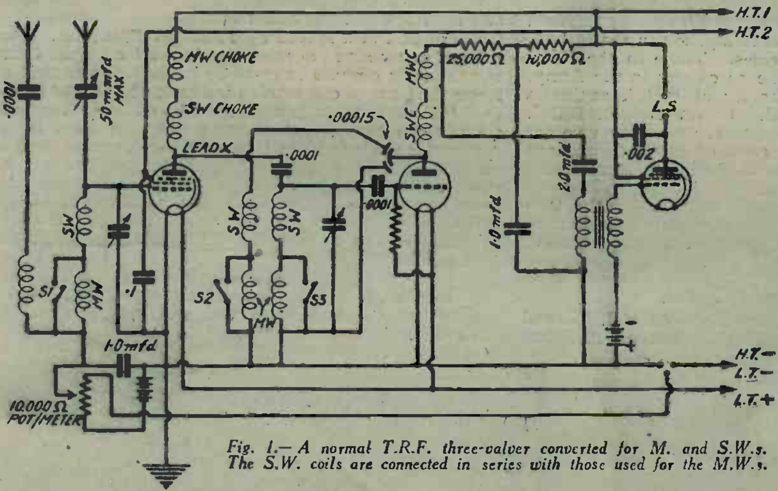


Fig. 1.—A normal T.R.F. three-valver converted for M. and S.W.s. The S.W. coils are connected in series with those used for the M.W.s.

A way out of the difficulty is to employ two wavebands only, namely, medium and short. The long-waves are of little interest at the present time, but the medium, and particularly the short wavelengths, are of great interest. By this means the construction of a (nearly) all-wave receiver becomes greatly simplified, and the scheme has the added advantage that ordinary push-pull switches may be used which can doubtless be obtained from the spares box.

To build a receiver of this description we need two medium-wave coils and two short-wave coils; the medium-wave coils can be the medium-wave portion of a dual range tuner.

The easiest way to build such a set is to connect the medium- and short-wave coils in series, as shown in Fig. 1. When receiving the medium waves this means that the wavelength of the medium-wave coils are raised by an amount proportional to the short-wave coils. That is, if the minimum coverage of the short-wave coil is 20 metres, all the medium-wave stations will be displaced by this amount on the tuning condenser. This is not so serious as it sounds; it simply means that one or two stations will be lost at the extreme bottom end of the medium range, and that stations like Athlone at the upper end will appear at a lower setting.

The wave-change switch S1 is an ordinary 2-point push-pull switch, while switches S2 and S3 can be a 3-point switch of the same pattern. It will be seen that there are two aerial connections, one being the primary of the H.F. transformer (aerial coil) on the medium waves, and the other going via a small variable condenser to the top of the short-wave coil. The value of this condenser should not be more than 50 mmfds. maximum. It will also be noticed that there is a short-wave H.F. choke in series with the medium-wave choke in the anode leads of the H.F. and detector valves, the short-wave choke being nearer the anode. The short-wave chokes are not necessary if the other chokes have an all-wave coverage, say 10-2,000 metres. It would, however, be as well to incorporate a short-wave choke in the H.F. stage, as few chokes are efficient at their extreme wavelength ranges.

Screening

It will, probably, be necessary to fix up some sort of screen around the H.F. coils to prevent the H.F. valve from "spilling over" at minimum settings of the stage gain potentiometer, because it must be remembered that although the medium-wave coils will, no doubt, be screened if they are commercial

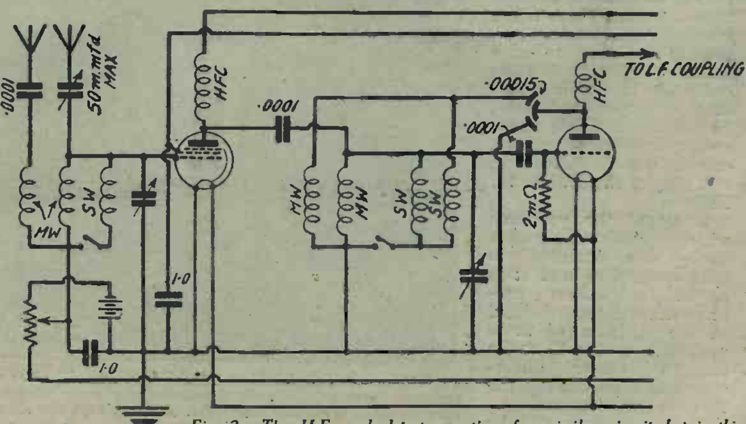


Fig. 2.—The H.F. and detector portion of a similar circuit, but in this arrangement the S.W. coils are connected in parallel with the M.W. sections.

products, the short-wave coils will not. For this reason they should be placed as far apart as possible, and a screen interposed between them.

Every endeavour should be made to secure short wiring in the H.F. stage. This should not prove too difficult if the H.F. tuning condenser is placed at one end of the panel and the other tuning condenser at the opposite end. The lead marked with an X in Fig. 1 can be screened if it is unduly long. Two separate tuning condensers are used, each of .0005 mfd. capacity, because it is doubtful if ganging would hold in a simple circuit of this type on both wavebands.

Coils in Parallel

Instead of arranging the medium- and short-wave coils in series they can be made to operate in parallel. By this method, when the switches are open the medium-wave coils function normally, and when the switches are closed the inductances of the coils are reduced to the short-wave range, the medium having little if any effect. This scheme is shown in Fig. 2.

Of course, the ideal arrangement for a wave-change switch is to provide for a complete change-over, as shown in Fig. 3. If such switches can be had then they should, of course, be used; but very often the constructor has to make use of the material on hand, and the ordinary 2- and 3-point wavechange switches indicated can be found in most spares boxes.

One advantage of the parallel method of connecting the coils is that switches can be dispensed with altogether; by simply withdrawing the short-wave coils from their holders the set is immediately converted to work on the medium waves, short waves being obtained by replacing them. This is useful for the constructor who doesn't mind coil changing.

Without H.F. Stage

If no H.F. stage is required on the short waves (and it must be realised that very little amplification is obtainable) then the method of getting down to the short waves becomes even simpler. We can have the ordinary H.F. stage on the medium wave, and incorporate a short-wave coil before the detector in the manner described in Fig. 1. If this has a separate aerial winding, the connection to which goes to a top terminal, then all we have to do to "get under" is (after shorting the medium-wave coil by means of a switch) to transfer the aerial to the top terminal of the short-wave coil. This will convert the set for reception on the short waves, and in order to save the current of the H.F. valve it may be withdrawn from its holder or else a switch inserted in the filament lead to this valve so that it may be cut out. Another method, if the short-wave coil has not a separate aerial winding, is to connect the aerial to the anode lead of the H.F. valve. You may or may not get oscillation from the detector valve when this is done; it depends upon the capacity of the coupling condenser from the H.F. valve anode to the succeeding tuned circuit, and unless this is very small the aerial will damp the coil. One way out of the difficulty is to make the coupling condenser a semi-variable one, so that its capacity may be reduced when changing over to the short-wave band.

For those who have the necessary switches, the circuit shown in Fig. 4 should be of interest. This is a two-waveband receiver of rather unusual design, the wave-bands covered being medium and short.

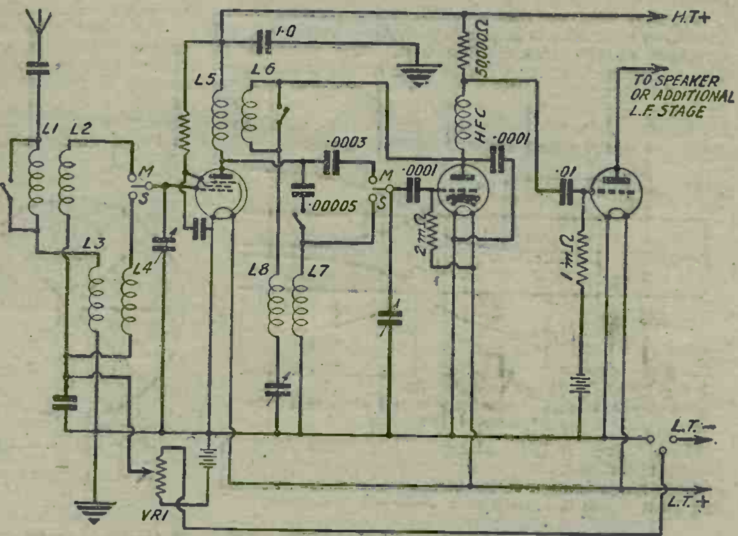


Fig. 4.—If suitable switches are available, this circuit has certain advantages which make it worthy of trial.

L_1 and L_2 are the aerial and grid coils of the H.F. stage on the medium-wave range, while L_3 and L_4 are the coils on the short-wave range. The H.F. coupling is tuned anode on the medium waves, as will be obvious from L_5 and L_6 when the switch is in the medium-wave position. On short waves, however, the coil L_7 is parallel-fed, the medium-wave coil acting as an H.F. choke; coil L_8 is the reaction winding coupled to L_7. This circuit gives good results on both medium-wave and short-wave ranges. The rest of the circuit is quite straightforward, and the detector valve can be coupled to the output by either "straight" or parallel-fed transformer coupling; or what is perhaps better in view of the weakness of some of the short-wave signals, a resistance-capacity coupled stage of amplification followed by a transformer coupled stage to the output valve. Volume on all signals can be cut down by means of the potentiometer VR1.

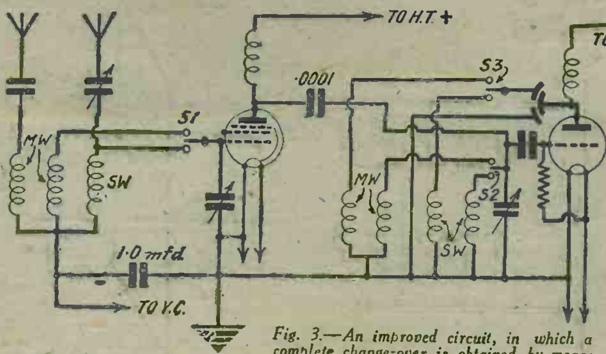


Fig. 3.—An improved circuit, in which a complete change-over is obtained by means of double-throw switches.

Directive Aerial Systems

Polar Diagrams. Simple Arrays. Parasitic Reflection and the Effect of the Earth's Surface

By S. A. KNIGHT

REFERRING to the article on Transmission Lines, in last month's issue, consider an open-circuited line where the distribution of current and voltage standing waves are as shown in Fig. 1. Due to the fact that the current at any point along the line is anti-phase in the two wires, the magnetic field at a point a short distance outside the region occupied by the line will be extremely feeble. This means that very little energy is radiated from the line in the form of electro-magnetic waves.

But now suppose that a length of $\lambda/4$ (quarter wave-length) of each wire is bent at right-angles to the normal direction of the transmission line. The diagram of Fig. 1 then becomes as shown in Fig. 2. It is now clear that the currents in the $\lambda/4$ vertical portions will be in phase, and therefore the field at external points will be large. This results in the production of electro-magnetic waves which are radiated into space.

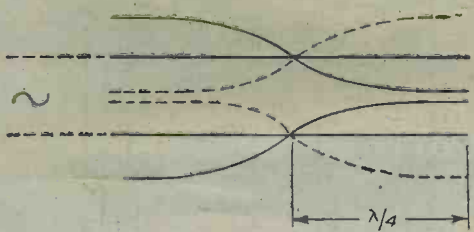


Fig. 1.—Distribution of voltage and current waves on an open circuited line.

These waves radiate energy which comes from the transmission line, and the arrangement for radiating such waves is known as an aerial. The case which has just been taken is known as a Half Wave Dipole.

Radiation Resistance

The aerial takes energy from the line and radiates it as we have seen, therefore the aerial produces a termination to the line which is a pure resistance. It can be shown that this Radiation Resistance, as it is called, is independent of the wavelength, and for a half wave dipole is approximately 80 ohms.

Polar Diagrams

Before proceeding with actual aerial arrays it is desirable that something be said on the subject of polar diagrams as concerned with aerial systems. This is a graphical representation of the manner in which the radiating or receiving properties of any aerial varies with direction, and may be regarded as a field strength contour, although it is not essential that any actual measurements of field strength be taken. It is sufficient to plot against direction anything proportional to field strength. Thus such a diagram is purely an indication of the relative strength of radiation in the various directions.

The vertical dipole, example 1, considered to be far removed from earth, and having perfect symmetry for its radiative properties in a horizontal plane, has a horizontal polar diagram which is circular, the centre of the circle being at the aerial itself (Fig. 3).

This circle may be drawn to any radius, since all it tells us is that the radiation is equal in all directions.

Now take example 2, a horizontal dipole, and consider moving in a circle at a fairly large distance from the aerial. If we have some device for comparing field strengths, then, as an example, suppose that at a point A in Fig. 4 we obtained a reading of 20 units. A distance

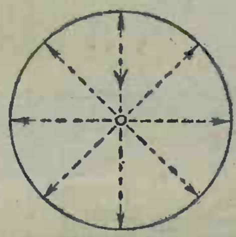


Fig. 3.—Circular polar diagram of a vertical dipole far removed from earth.

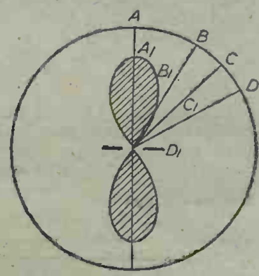


Fig. 4.—Production of the polar diagram of the horizontal dipole, showing the "figure of eight."

OA_1 can then be marked off on the diagram equal in length to 20 units, depending on the particular scale chosen. Now consider moving to point B and again taking a reading; this time it may have fallen from 20 to 16 units, therefore a length OB_1 equal to this new strength may be marked off along the appropriate line. Similarly, by moving around the circle further points may be plotted, C_1, D_1, etc., until finally the polar diagram is completed as shown in the figure.

In this case the resultant polar diagram is known as a "figure of eight."

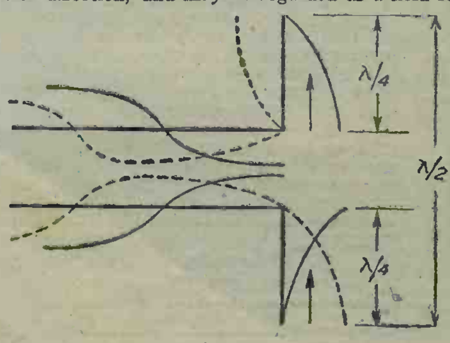
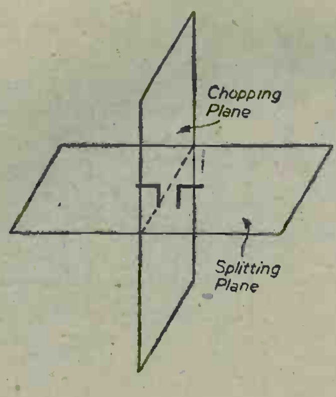


Fig. 2 (left).—Formation of the half wave dipole.

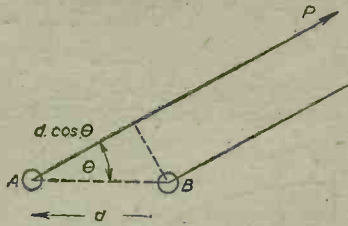
Fig. 5 (right).—Depicting the difference between chopping and splitting planes.



Three-dimensional Considerations

The three-dimensional polar diagram for the vertical $\lambda/2$ dipole is composed of a circular horizontal diagram and a vertical figure of eight. This combination might prove difficult to imagine in a three-dimensional sense, but can be roughly likened in some ways to an inflated car tube where the wheel and hub "space" is closed in to a point.

In the case of the horizontal $\lambda/2$ dipole, the vertical polar diagram is a circle while the horizontal is a figure of eight. Thus it is a replica of the diagram for the vertical dipole, but rotated through 90 deg.



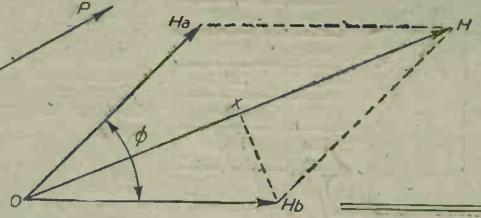


Fig. 6 (left).—Excitation of a two-member broadside array, used to calculate the resultant polar diagram.

Fig. 7.—Vector representation of the array of Fig. 6.

These three-dimensional polar diagrams have been built up of the circle and the figure of eight. It will be convenient at this stage to differentiate between circular polar diagrams and those giving figure of eight polar diagrams.

(i) The Chopping Plane. This is a plane perpendicular to any plane in which the dipole lies.

(ii) The Splitting Plane. This is a plane in which the dipole lies (Fig. 5).

It should be particularly noticed that the results so far described are obtained for an aerial well removed from other conductors and from the earth. The effect of the latter will be dealt with later on.

Simple Arrays

An aerial array consists of two or more radiators so spaced and phased that their resultant polar diagrams give some desired directive effect. They are generally of two main types, the End Fire and the Broadside array.

The End Fire array gives directivity in the line of array, the members not being excited in phase. In the Broadside array directivity is obtained perpendicular to the line of array, the members in this case being excited in phase.

Two Member Broadside Array

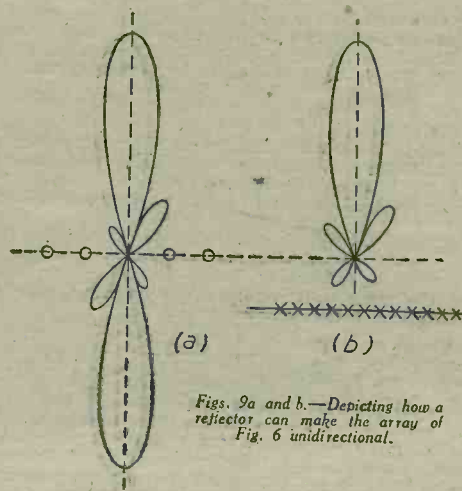
This consists of two $\lambda/2$ vertical dipoles spaced distance d apart and excited in phase. Consider Fig. 6, letting point P be so far away from the aerial system that the directions of radiation from A to P and from B to P are parallel. The radiation from A will be seen to have travelled a distance $d \cos \theta$ farther than that from B, so that at any instant the wave at P due to A started off at an earlier instant than the wave at P due to B.

This time difference is given by $d \cos \theta/v$, where v is the velocity of propagation. But $v=\theta/\lambda f$.

Therefore, the time difference $=d \cos \theta/\lambda f$.

It is more convenient to express the time difference as a phase difference Φ by using the relation that:

$$\Phi=2\pi f.t.$$



Figs. 9a and b.—Depicting how a reflector can make the array of Fig. 6 unidirectional.

Therefore, the phase difference in radians

$$=2\pi f\ (d \cos \theta/\lambda f)$$
$$=2\pi\ d \cos \theta/\lambda \text{ in radians.}$$

The resultant field at P will have two components, one due to A and one due to B. The field due to A leads the field due to B by an angle Φ. (Fig. 7.)

Since the distances PA and PB are almost equal, the magnitudes of Ha and Hb will be the same.

The length Ox equals $Hb \cos \Phi/2$.

$$\text{But } H=2\ Ox=2\ Hb \cos \Phi/2.$$
$$H=2\ Hb \cos (\pi d \cos \theta/\lambda).$$

Since we do not actually require to know the measure of H, it is sufficient to know how H varies as the quantities d, θ and λ vary. Thus, we can write that:

H varies as $\cos (\pi d \cos \theta/\lambda)$ radians.

If now we require θ to be measured in degrees we must have π in degrees as well,

i.e., H varies as $\cos (180 d \cos \theta/\lambda)$ with θ in degrees.

As an example, let the spacing between two such dipoles be $\lambda/2$, then:

H varies as $\cos (90 \cos \theta)$

Then plotting a table, as in Fig. 8, for values of between 0 and 180 deg. a polar diagram can be drawn, as shown. If we compare this horizontal polar diagram with that for a single vertical dipole (a circle) we see that directivity in the horizontal plane has been achieved. The directivity is perpendicular to the line of array, and can be considerably improved by increasing

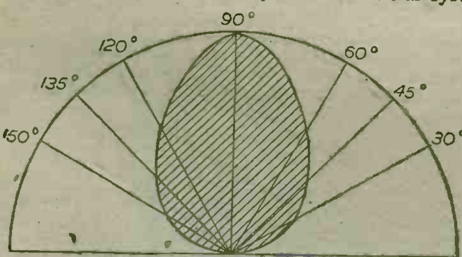


Fig. 8.—Horizontal polar diagram of the broadside array, showing that directivity has been achieved.

θ	cos (90 cos θ)	θ	cos (90 cos 0)
0	0	120	0.707
30	0.225	135	0.433
45	0.433	150	0.225
60	0.707	180	0
90	1.00	—1	—

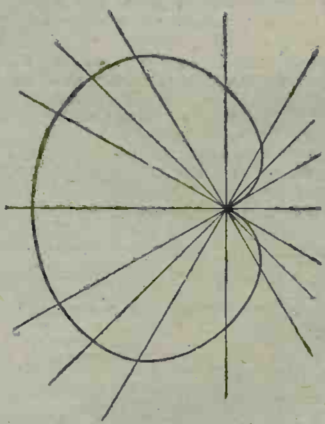


Fig. 10.—Polar diagram (spacing λ/4) of the end fire aerial array.

θ	cos (45 cos θ +45)
0	0
30	0.105
45	0.233
60	0.375
90	0.707
120	0.925
135	0.974
150	0.998
180	1.000

the number of the members. This arrangement is bi-directional, as drawn in Fig. 9a. but it can be made unidirectional by the addition of reflectors behind the dipole, which have the effect of producing one lobe only. (Fig. 9b.)

End Fire Arrays

Consider the two vertical dipoles of the last paragraph, spaced distance *d* apart, but energised so that the phase of *A* lags that of *B* by an angle ψ.

This time *Ha* leads *Hb* by an angle $\Phi+\psi$, so in this case :

$$H \text{ varies as } \cos(\Phi+\psi)\div 2$$
$$=\cos(180d\cos\theta/\lambda+\psi/2).$$

Taking an example as before, let the spacing be $\lambda/4$ and the angle ψ be 90 deg., the resulting table and the diagram being depicted in Fig. 10.

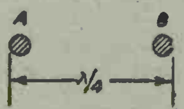


Fig. 11.—Two half wave dipoles spaced λ/4 apart.

Thus, directivity is obtained in the direction of the line of the array and of lagging phase.

This type of polar diagram is obtained with end fire arrays, when *d* is made the same fraction of λ as ψ is made of 360 deg. The directivity can be increased as before by increasing the number of members, each one lagging on its neighbour by 90 deg. The necessity for exciting the individual dipoles with phase differences introduces practical difficulties as regards feeding devices, e.g., the lengths of the feeders are critical.

Parasitic Reflection

If two half wave dipoles spaced λ/4 apart are excited in quadrature the cardoidal polar diagram of Fig. 10 results. It is possible to obtain the same directive effects without exciting one of the members. In Fig. 11 let *A* be directly energised, and *B* not so. Then the field at *B*, due to *A*, will lag by 90 deg. the field at *A*. The aerial *B* will be energised by this field, and by Lenz's Law will radiate so as to oppose the inducing field, that is, the field at *A* due to *B* will lead the field at *B* due to *A* by 180 deg. Thus, we have, in effect, excited aerial *B* so as to lead aerial *A* by 90 deg.

Hence we have a condition similar to the previous case, and the polar diagram might be expected to be cardoidal.

Consequently, *B* has the effect of causing radiation directed from *A* towards *B* to be re-radiated in the direction *B* towards *A* and reinforce the original radiation. Aerial *B* is called a *Reflector.*

The spacing is not in general exactly λ/4. Considerably better results can be obtained if the reflector is cut longer than the excited aerial, i.e., is made inductive. The optimum length is related to the spacing.

It is found that if a conductor of length less than λ/2 is placed in front of the original aerial at a distance of approximately λ/4 from it, directivity is further increased. This is called a *Director*, the exact length of the spacing being adjusted by trial and error.

The object of these arrays is to obtain a large front-to-back ratio.

Very narrow beams can be produced by using both directors and reflectors in a system known as a Yagi array.

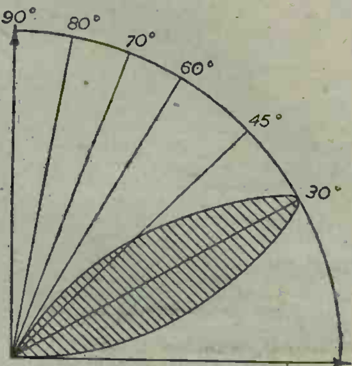


Fig. 12.—Vertical P.D. of a horizontal λ/2 dipole in the region of the earth.

θ	sin θ	180 sin θ	sin 180 sin θ
0	0	0	0
30	.0.5	90	1.0
45	0.7	130	0.76
60	0.87	156	0.41
70	0.94	163	0.19
80	0.98	177	0.05
90	1.00	180	0

The Effect of the Earth's Surface

Ideally the ground acts as a perfect conductor and behaves as a perfect electrical mirror. The radiation from an aerial to a distant point will consist of (i) a

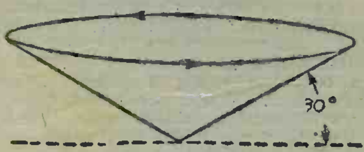


Fig. 13.—A basic figure for the construction of conical polar diagrams.

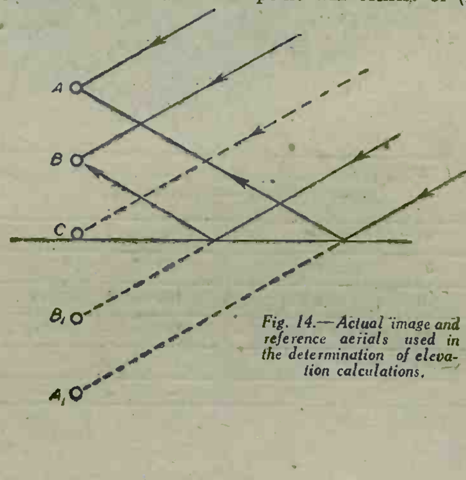


Fig. 14.—Actual image and reference aerials used in the determination of elevation calculations.

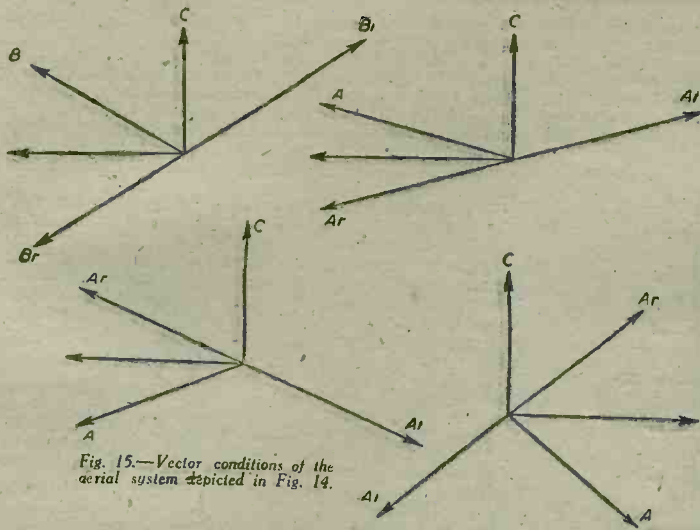


Fig. 15.—Vector conditions of the aerial system depicted in Fig. 14.

direct, and (ii) a reflected component. The reflected ray may be considered as emanating from a point as far below the surface of the ground as the aerial is above the surface of the ground. The resultant radiation reaching a distant point can be calculated by assuming the presence of an image dipole as far below the earth's surface as the aerial is above.

With a vertical aerial the image aerial must be excited in phase. For a horizontal aerial the image aerial must be considered as being in antiphase.

Horizontal $\lambda/2$ Dipoles in the Region of the Earth

Consider first the vertical polar diagram chopping the dipole. If the dipole is at a height h above ground, the image dipole can be assumed to be excited in antiphase at a distance h below the ground. The required polar diagram can be obtained by using the formula for the End Fire array using two vertical dipoles, taking it that $2h = d$ and angle $\psi = 180$ deg.

We have: $H \quad \cos(180. \; 2h \; \cos \; \theta/\lambda + 90°)$.

Normally angle of elevation is measured from the horizontal, but in this equation θ is measured from the line of array. Therefore, if the angle of elevation is θ_1 we have the relation:

$$\theta = \theta_1 + 90°.$$

Therefore substituting this value we have:

$$H \propto \cos\frac{(180. \; 2h. \; \cos(\theta_1 + 90°)}{\lambda} + 90°).$$

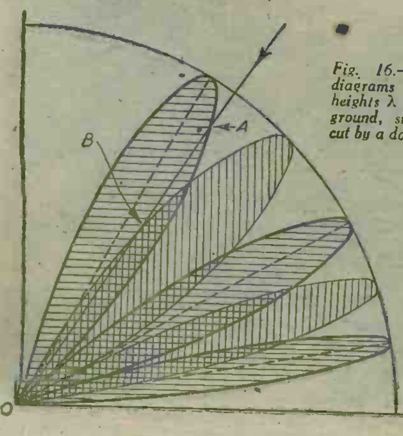


Fig. 16.—Vertical polar diagrams for aerials of heights λ and 3λ/2 above ground, superimposed and cut by a downcoming signal.

The expression $(\theta_1 + 90°) \cos = \sin \theta_1$.

$$\therefore \quad H \propto \cos\frac{(360h. \; \sin \; \theta_1 + 90°)}{\lambda}$$

Returning to specific values for d assume that the dipole is at a distance $\lambda/2$ above the ground, when $h = \lambda/2$.

$$H \propto \cos\,(180 \; \sin \; \theta + 90°).$$

$$\text{or } H \propto \sin \; 180 \; \sin \; \theta.$$

where θ is written for the angle of elevation (Fig. 12).

Conical Polar Diagrams

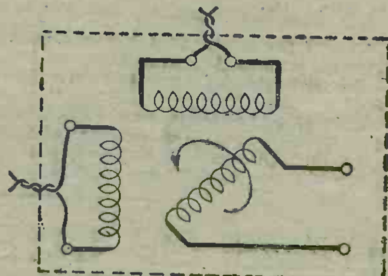
Imagine a receiver able to move in a horizontal circle above the ground, i.e., at a fixed angle from the originating point at which is situated a transmitter having a $\lambda/2$ aerial above the ground.

The receiver moves along the rim of a vertical cone of which the aerial is the apex (Fig. 13).

Consider the case when θ is 30 deg., then when broadside on a maximum signal will be received, for this is the best angle for reception. But in the end-on position not only will the signal be much weaker, but its maximum does not occur at 30 deg.

If signal strengths are compared and their results set down, a polar diagram of a special kind (called a conical polar diagram) can be constructed.

Fig. 17.—Theoretical diagram of the goniometer, showing the two stator and the search (rotor) coils.



Determination of Elevation

The basic facts determining the measure of the angle of elevation of a downcoming signal are as follow:

(i) The directional properties of an aerial system remain the same whether the system is used for transmission or reception.

(ii) If a system is made up of a number of horizontal $\lambda/2$ dipoles placed vertically above one another, a single downcoming signal will energise them so that they are in phase or antiphase.

(iii) Considering two such aerials arranged as in the second case, placed at different heights, a downcoming signal will energise them differently in accordance with their respective polar diagrams, and the ratio of the amplitudes of the standing waves set up on them by the signal will be characteristic of the angle of the downcoming signal.

Consider the second case (Fig. 14) where A and B are two horizontal $\lambda/2$ dipoles placed one above the other. Both will be energised by a direct ray and partly by an indirect one. In order best to study the conditions present at A and B respectively and vectorally, a reference dipole C will be employed which is on the surface of the earth. In this condition C can only be energised by the direct ray.

Refer to the diagrams of Fig. 15. Let the voltage induced in the reference dipole C be represented by a vector C. Then a direct ray energises B ahead of $C \longrightarrow B$. The indirect ray, first neglecting the reversal of phase on reflection, energises B, lagging on C by the same amount $\longrightarrow B1$. Since there is a reversal of phase of 180 deg. vector $B1$ must be reversed to give Br. The resultant excitation of B is thus the vector sum of B and Br, this leading vector C by 90 deg.

A similar vector diagram can be drawn for dipole A, but increasing the angle between vectors A and C and $A1$ and C. Again the resultant excitation leads the vector C by 90 deg., so that dipoles A and B are excited in phase.

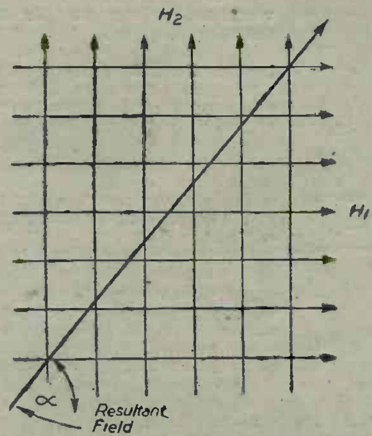


Fig. 18.—Fields produced in the goniometer stator coils and the resultant picked up by the rotor.

Now, if the height of A is raised until the vector A leads C by an angle greater than 270 deg, the resultant excitation of A lags C by 90 deg. and is therefore antiphase to B.

If, now, the heights of A and B were further increased, they would always be energised in phase or anti-phase.

In Fig. 16, vertical chopping polar diagrams for horizontal $\lambda/2$ dipoles are superimposed one on the other, one at a height of λ above ground, and one of height $3\lambda/2$ above ground.

Now consider any downcoming signal: the upper aerial will be energised to an extent indicated by OA while the lower aerial will be energised by an amount indicated by OB. The ratio of OA to OB will be characteristic to the angle of the downcoming signal. Some ambiguity is possible, and must, of course, be taken into consideration when choosing the height of the members above ground.

A method must be employed for comparing the ratio $OA : OB$, and the device used to achieve this end is an instrument known as the goniometer.

This device consists essentially of two coils, the one connected to the upper dipole and the other to the lower. These coils are arranged to be perpendicular to each other, and therefore when a current flows in them they will produce magnetic fields which are at right-angles. (Fig. 17.)

Let it be supposed that the upper aerial produces a field H_1 and the lower aerial a field H_2, horizontal and vertical respectively.

These two fields will be proportional to OA and OB respectively, and hence there will be a resultant field of a magnitude depending on H_1 and H_2 at an angle α to H_1 where α is given by:

$$\tan \alpha = H_2/H_1$$

But since H_2/H_1 is equal to OB to OA, we have:

$$\tan \alpha = OB/OA.$$

If, now, a third coil, called a search coil, is introduced, it will have a maximum pick-up when its turns are perpendicular to the direction of the resultant field. Such a device enables the determination of the angle α to be made by a rotation of the search coil until maximum pick-up is obtained. Thus it is possible to calculate the ratio of OA to OB and consequently the angle of elevation of the downcoming signal. (Fig. 18.)

$$\tan \alpha = \frac{\sin 360^\circ \sin \theta}{\sin 540^\circ \sin \theta}$$

Hence α, the goniometer reading, is simply related to θ, the angle of elevation.

ITEMS OF INTEREST

Fixed Capacitors

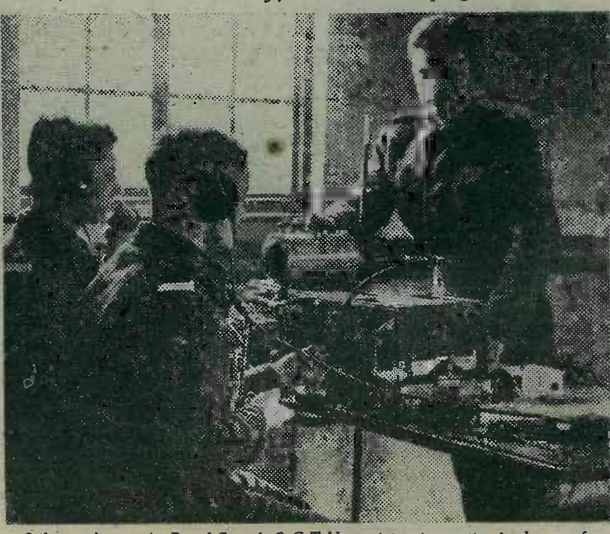
A NEW British Standard Specification has recently been published for Fixed Capacitors (B.S. 1082). This specification is based on technical information supplied by the British Electrical and Allied Research Association, which organisation has carried out considerable experimental work with a view of revising and extending the scope of the 1926 edition of B.S. 271.

The latter specification was limited in scope to the small capacitors used at that time in radio receivers, but the considerable extension of radio broadcasting in recent years, and the parallel developments of other activities involving the use of fixed (i.e., non-variable) capacitors, clearly necessitated the drafting of a more comprehensive specification. As will be seen in clause 2 of the present specification it covers all fixed capacitors for general purposes whatever the nature of the electrodes and insulant. It is not, however, intended to apply to capacitors for specialised application.

Copies of this new British Standard may be obtained from the British Standards Institution, 28, Victoria Street, Westminster, S.W.1, price 2s. (2s. 3d., post free).

Electrolytic Condensers

REPLYING to a question in the House of Commons recently, Mr. Hugh Dalton, President of the Board of Trade, stated that the shortage of electrolytic condensers was due to the ever increasing demands of the fighting services for radio equipment of all kinds, but steps had been taken to increase production of these components. He also stated that if arrangements already made were duly carried out, by the end of March gaps should be filled in the 1942 maintenance programme.



Officer cadets at the Royal Signals O.C.T.U. receiving instruction in the use of receiver-transmitters.

The Valve as a Voltage Amplifier

Showing the Derivation of the Voltage Amplification Factor *m* from First Principles

By C. HEYS

WHEN a small alternating voltage Vg is applied to the grid of a three electrode valve, the grid voltage of which is adjusted so that it operates on the straight part of its characteristic curve, the effect on the anode current is the same as would be produced by an alternating emf μVg in the anode circuit, μ being the amplification factor of the valve.

We can, therefore, look upon the anode circuit as being equivalent to a simple A.C. circuit, the D.C. components only serving to put the valve in its correct operating condition.

Fig. 1 (a) which shows how the anode circuit of a valve with no external load resistance can be represented by the equivalent circuit of Fig. 1 (b), which is a closed

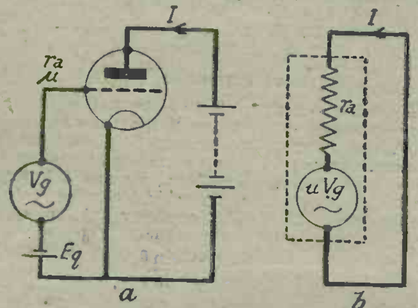


Fig. 1 (a).—A triode without load resistance, (b) its equivalent electrical circuit.

A.C. circuit, consisting of a source of alternating voltage μV_g with internal resistance ra, which is the A.C. impedance of the valve. The alternating current I round the equivalent circuit, is given by $\mu Vg/ra$ amperes (Ohms law). This expression ignores the D.C. components.

The triode valve is normally employed to act as an amplifier, detector, or to operate a speaker. To effect any one of these it is necessary that the alternating voltage applied across the grid must cause a corresponding change of voltage across some part of the anode circuit.

In Fig. 1 (a) or (b), although there is an alternating current present in the external circuit, there is no alternating potential. It is, therefore, necessary to connect resistance R in series with the anode circuit as in Fig. 2 (a).

The alternating current Ia now flowing will be:

$$\frac{\mu Vg}{ra+R}$$

The voltage thus developed across R will be:

$$V_R = IaR = \frac{\mu VgR}{ra+R}$$

Thus, a change of grid voltage will cause the anode current to change, thereby causing the voltage drop across R to alter, with consequent change in anode potential. A change in grid voltage to a more positive value will cause the anode current to increase, and, at the same time, increasing the voltage drop across R, which in turn will reduce the anode potential of the valve.

Voltage Amplification

As the amplification factor of a valve is given by

$$\frac{\text{Change in anode potential}}{\text{Change in grid potential}}$$

the voltage amplification obtained by a given valve and anode resistance can be calculated. Referring to the equivalent circuit, Fig. 2 (b). Where Vg is the alternating voltage applied to the grid of the valve an equivalent voltage μVg is brought into being in the anode circuit. This, in turn, produces an alternating current component which sets up an alternating voltage component across the load resistance R given previously.

as $V_R = \dfrac{\mu Vg\,R}{ra+R} = \mu Vg \times \dfrac{R}{ra+R}$

therefore $\dfrac{V}{Vg} = \mu \times \dfrac{R}{ra+R}$

The ratio $\dfrac{V}{Vg}$ being the actual voltage amplification m obtainable with given valve constants and anode resistance—

therefore, $m = \dfrac{\mu R}{ra+R}$ = Voltage Amplification Factor (V.A.F.)

Example

An amplifying valve has an A.C. resistance ra of 50,000 ohms, and an amplification factor μ of 50. Find the amplification obtainable, if the anode circuit has a resistance of (a) 20,000 ohms, (b) 100,000 ohms.

(a) $m = \dfrac{\mu R}{ra+R} = \dfrac{50 \times 20{,}000}{70{,}000} = 14.3$

(b) $m = \dfrac{\mu R}{ra+R} = \dfrac{50 \times 100{,}000}{150{,}000} = 33.3$

From these two results it is seen that the greater the anode resistance R the higher will be the voltage amplification factor. Continuing along this trend of thought, if R is made infinitely high, i.e., 10,000,000 ohms,

$$\text{V.A.F.} = \frac{50 \times 10{,}000{,}000}{10{,}050{,}000} = \frac{500{,}000{,}000}{10{,}050{,}000} = 49.75$$

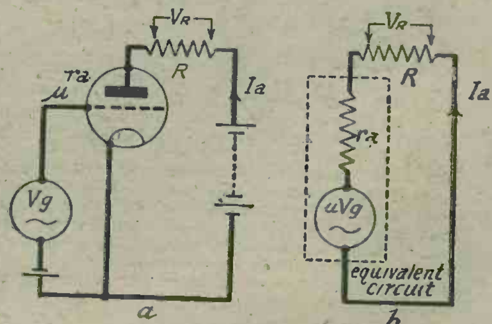


Fig. 2 (a).—The valve circuit with external anode load, and (b) its electrical representation.

which for all practical purposes is equal to the amplification factor of the valve. This is only a theoretical maximum, for under those conditions there would be no D.C. component voltage at the anode of the valve, and the valve would cease to function; for this reason it is not practicable to make R more than two or three times the resistance of the valve.

Elementary Electricity and Radio—3

Accumulators and Charging Boards. Charge and Discharge Rates. Faults and Remedies

By J. J. WILLIAMSON

(Continued from page 145, March issue)

The Lead-acid Accumulator

THE lead-acid accumulator, as its name implies, depends upon lead compounds and dilute sulphuric acid for its action. The composition of the plates depends upon the state of charge, and, quoted briefly, is:

When fully charged.
Positive plate.—Lead peroxide (PbO_2).
Negative plate.—Spongy lead (Pb).

When discharged.
Both positive and negative plates undergo reactions,

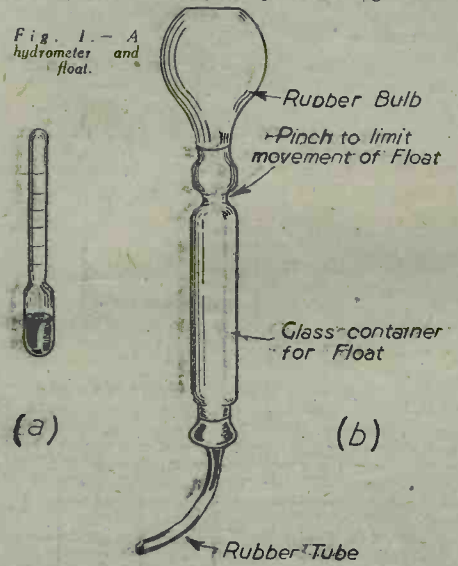


Fig. 1.—A hydrometer and float.

which first create lead oxide (PbO) and then convert it to lead sulphate ($PbSO_4$).

The formation of lead sulphate in the cell can be highly injurious if the crystalline form occurs, causing a serious fault known as sulphation. This factor sets a practical limit to the discharge voltage of the cell, which must never be allowed to fall below 1.8 volts. The E.M.F. of the cell is 2.2 volts.

The Signs of the Charged State

Certain signs indicate when the cell becomes fully charged.

(1) The electrolyte should be gassing strongly.

(2) The voltage of the cell should be at least 2.1 volts when removed from the charging board and placed on normal load (a definite current flowing from the cell).

(3) The specific gravity of the electrolyte should be at the value stated by the manufacturers, at 60 deg. F., measured with the hydrometer.

(4) The colour of the plates: positive, healthy chocolate brown; negative, a metallic slate grey.

These signs of charge should remain constant for at least one hour before the cell is removed from the charging board.

Capacity

The capacity of a cell, or the current it will give for a definite time, is measured in ampere-hours (A.H.) and is a very variable factor, depending upon the value of the current taken, efficiency of the cell, surface area of the plates, temperature, acid strength, etc. Thus the manufacturers state the ideal conditions for their cells and quote a cell's capacity with relation to a definite discharge current or rate, i.e., 80 A.H. at the 10-hour rate.

Discharge and Charge Rates

The discharge or discharge rate refers to the rate at which current is passing through the accumulator; thus "an 80 A.H. accumulator at the 10-hour rate" implies that if the cell was 100 per cent. efficient it would maintain a current of 8 amperes for 10 hours.

$$\text{Rated current} = \frac{\text{Capacity}}{\text{Rate}}$$

A word of warning here! Note that, owing to the fact that capacity depends to a certain extent upon the discharge current, we cannot say that an 80 A.H. accumulator would give 10 amperes for eight hours, or 80 amperes for one hour, etc., because the accumulator would no longer have its rated capacity of 80 A.H. *at the 10-hour rate*. The capacity of an accumulator decreases as the rate of discharge increases.

The normal charging current or "on load" current is always obtained in the manner shown.

The Efficiency in Terms of the Manufacturer's Rating

The percentage efficiency of an accumulator can be stated as:

$$\frac{\text{True capacity}}{\text{Rated capacity}} \times \frac{100}{1} = \%\ \text{efficiency}$$

The true capacity of a cell can be found by discharging a fully charged cell at the normal rate until its voltage reaches 1.8 volts, the time for this to occur being noted. The current must be kept constant during the test.

Example: An 80 A.H. (rated at the 10-hour rate) accumulator took six hours to discharge at the normal rate. What is its percentage efficiency?

$$\text{The normal discharge current} = \frac{80}{10} = 8 \text{ amperes.}$$

$$\text{True capacity} = \text{A.H.} = 8 \times 6 = 48 \text{ ampere-hours.}$$

$$\text{Percentage efficiency} = \frac{48}{80} \times \frac{100}{1} = 60\%$$

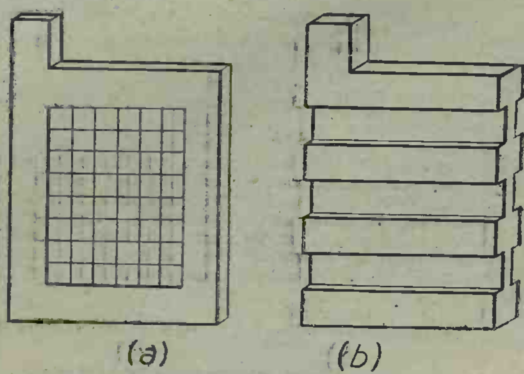


Fig. 2.—Two types of plate formation: (a) Faure or "pasted," and (b) Planté or "formed."

or: the cell should have fully discharged in 10 hours, but took six hours. Thus:

$$\text{Percentage efficiency} = \frac{6}{10} \times \frac{100}{1} = 60\%$$

Specific Gravity and the Hydrometer

The specific gravity of a liquid is a measure of its density with respect to distilled water, and is measured by the depth that a float sinks in it; the float and its glass container being called a hydrometer.

A typical float is shown in Fig. 1, together with its glass container fitted with a rubber bulb and nozzle.

Certain precautions are necessary when using a hydrometer. (1) The temperature should be 60 deg. F.; (2) the float must have free movement; (3) care must be taken to ensure that gas bubbles do not support the float; (4) never take a reading immediately after "topping up."

Temperature Correction for Specific Gravity

For every $2\frac{1}{2}$ deg. F. rise of temperature, a fall of 0.001 S.G. should be allowed.

Example.—The temperature of some acid was 80 deg. F.; the hydrometer gave its specific gravity as 1.240. What would be the specific gravity at 60 deg. F.?

Change in temperature $= 80 - 60$ deg. F. $= 20$ deg. F.

$\frac{20}{2.5} = 8$ thus 0.008 S.G. must be *added* to 1.240 (density *increases* upon cooling).

Therefore, Specific Gravity at 60 deg. F. $= 1.248$.

General Constructional Details

The Planté or "Formed" Plates.—The Planté type plate (Fig. 2) consists of solid blocks of lead which have been formed or converted to lead peroxide or spongy lead by means of many cycles of charge and discharge. Because of these cycles the plates are expensive to manufacture, and due to their solid nature they are very heavy.

Planté plates can withstand heavy currents and rough usage without undue damage, and are used where weight is of no concern, or as positive plates for car batteries, etc.

The Fauré or "Pasted" Plates.—To achieve a fairly light and cheap plate, grids of lead-antimony alloy are made; the grids being so arranged that they tend to retain the active material which is pressed into them in paste form.

Although Fauré plates, Fig. 2 (a), are much lighter and cheaper than the Planté type, they are not so capable of withstanding heavy currents and harsh treatment, due to the "shedding" or falling out of the active material from the grids. The positive plate is usually the most affected by "shedding," because of the changes in volume that occur in the active material, during charge and discharge.

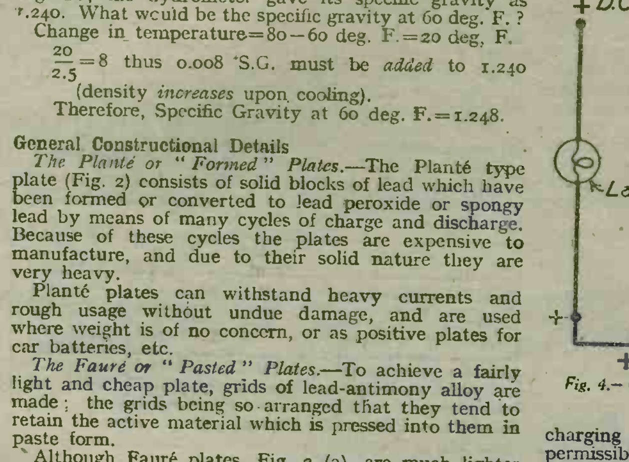


Fig. 3.—The fundamental assembly features of a lead-acid type accumulator.

Method of Arranging Plates in the Cell.—All negatives are connected to one bus-bar, and all positives to another; a terminal post attached to each bar carries the external connection. The two sets of plates are interleaved and separated from each other by porous insulating separators (Fig. 3). The whole assembly of the plates rests upon two ridges on the bottom of the container, thereby preventing the short-circuiting of the bottom of the plates against the conducting sludge that accumulates.

The vents are fitted with stoppers that allow the free passage of gases, and, in the case of a portable cell, they are of similar construction to the unspillable inkwell, permitting the cell to be placed in any position without acid loss.

Faults—Their Causes, Symptoms and Remedies

Sulphation—Causes.—Due to persistent undercharging; too high a specific gravity; too high a

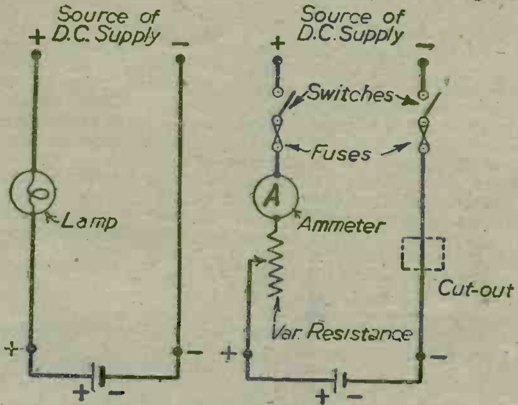


Fig. 4.—(a) The simplest type of charging board circuit, and (b) a standard arrangement.

charging temperature, i.e., 100 deg. F. maximum permissible; impurities in the distilled water or plates, allowing the cell's voltage to fall to 1.8 v. or less., etc.

Symptoms.—Overheating and buckling of the plates can occur; the P.D. of the cell is low on load; the P.D. of the cell is higher than usual on the charging board; the specific gravity does not rise on charge.

Remedy.—There is no remedy for bad sulphation, but if the cell is not badly affected it can be improved by the following procedure:

(1) Replace the electrolyte with fresh at the specific gravity of the old, and place the cell on a slow charge (reduced rate).

(2) If the specific gravity begins to rise the sulphation is clearing. Continue to charge until the specific gravity rises no further and the cell gasses freely.

(3) Replace the acid with fresh at the same specific gravity. Continue the charge until the cell once again gasses freely and the specific gravity ceases to rise.

(4) Continue this process until the cell shows the normal conditions of charge.

Hydration—Cause.—Permitting damp air to get to the plates. *Symptoms* and *Remedy*—the same as for sulphation.

Shedding of Active Material.—Causes.—Bad treatment, excessive vibration; too high a charge or discharge rate causing heavy gassing, etc.; sulphation or hydration. Slight shedding of active material is quite normal.

Symptoms.—The cell requires more charging, and discharges in less time owing to loss of active material and the consequently lower capacity. Short-circuiting of plates.

Remedy.—Very little can be done, beyond treating the cell gently, giving it reduced charges and washing out the sediment with distilled water to prevent short-circuiting of the plates.

Internal Open or Short-circuiting—Causes.—Sludge touching the bottom of the plates, pieces of active material between the plates, buckling of the plates, etc., will cause short circuits to occur; while open or partial open-circuiting can arise through breakage or cracking of connecting bars or terminal posts.

Symptoms.—An open-circuit will cause no E.M.F. to appear across the cell's terminals.

A partial open-circuit will give a very low P.D. on load and a high P.D. on charge.

A short circuit will cause a low P.D. on load and charge, and the cell will discharge rapidly whether in use or not.

Remedy.—Little can be done without extracting the plates, etc., except in the case of a short-circuit being caused by sludge or pieces of active material; then the cell can be thoroughly cleansed with distilled water.

Charging Boards

Fig. 4 (a) represents the simplest possible type of charging board, the essential factors being (1) a source of direct current (free electron movement must be in one general direction); (2) a limiting resistance, which, in this case, is a lamp, and (3) the positive of the supply must be connected to the positive of the accumulator; similarly, negative to negative.

Obviously, for different capacity accumulators different sizes of lamps are required, making such a changing board awkward to use and limited in its application. Thus, a heavy duty variable resistance or rheostat usually replaces the lamps.

To avoid calculation to find the current flowing, direct readings are obtainable by the insertion of an ammeter into the circuit.

Fuses and switches in each lead (positive and negative), together with a cut-out, completes the "better-class" type of charging board; all instruments being connected in series. See Fig 4 (b).

The Use of a Cut-out

A cut-out is a reverse current switch, i.e., it makes or breaks the circuit in accordance with the direction of the current. It is necessary, in the event of the failure of the dynamos supplying the charging board. If the supply voltage failed, the voltage of the accumulators would be able to force a heavy discharge current around the circuit, if complete, thus discharging them.

The Nickel-iron (NiFe) or Edison Accumulator

The components are: (1) Positive plates, consisting of alternate layers of nickel hydroxide and nickel flakes in a number of perforated nickel-steel tubes; (2) negative plates, comprising powdered iron oxide in perforated steel containers; (3) the electrolyte of a 21 per cent. solution of potassium hydroxide (caustic potash) to which a little lithium hydrate is added; and, (4) a case of stainless steel, thus forming a very strong assembly.

The NiFe cell is charged in the same way as the lead-acid cell, but much higher charge and discharge rates are permissible.

The E.M.F. of the cell is 1.33-1.35 volts, and the minimum permissible voltage, 1.1 volts.

Although the efficiency is lower than the lead-acid accumulator, the NiFe cell has the advantage of being capable of withstanding very hard usage, both mechanical and electrical.

General Examples

(1) A 2 volt 40 ampere hour accumulator of the lead-acid type, rated at the 10 hour rate, takes 4½ hours to discharge to 1.8 volts at its normal discharge rate.

What is its percentage efficiency?

(2) While mixing acid, the hydrometer gave a reading of 1.140, and the thermometer 85 deg. F.

What would be the specific gravity at 60 deg. F.?

(3) Four cells gave the following voltage readings at the times indicated. State the apparent condition of each cell.

Cell	1	2	3	4
Off the charging board	0	1.9	1.1	0.5
On the charging board, at beginning of charge	5	2.0	2.1	0.6
On the charging board at the end of charging time	5	2.7	2.3	0.7

Answers to General Examples. Article Two

(1) 1.5 ohms. (2) .0651 watts (approximately).

(To be continued.)

Books Received

FIRST COURSE IN WIRELESS. By "Decibel." Published by Sir Isaac Pitman and Sons, Ltd. 220 pages. Price 5s. net.

THIS book, which is a reprint of a series of articles which originally appeared in *World-Radio* forms an excellent introduction to more advanced textbooks on wireless. There are numerous illustrations.

TEACH YOURSELF RADIO COMMUNICATION. By Eric Reid. Published by English Universities Press, Ltd. 174 pages. Price 2s. 6d. net.

SPECIALLY written for beginners, this handy book covers the more elementary principles of the subject, from the theory of a current of electricity to the transmission and reception of high-frequency currents used in broadcasting. A slight knowledge of mathematics is necessary in order to understand the subject fully, but complicated formulæ have been avoided. The book is well illustrated with diagrams.

AIRCRAFT RADIO. By D. Hay Surgeoner, A.F.R.Ae.S. Published by Sir Isaac Pitman and Sons, Ltd. 154 pages. Price 15s. net.

DURING recent years the development of radio for communications, and as an aid to navigation, has proceeded hand in hand with the expansion of the air lines, and radio at the present time is looked upon as a means of achieving regular and smooth services, irrespective of weather conditions. In this second edition of the book, which has been completely revised, the author deals with the practical side of the subject as applied to the service of aviation, and of the various methods of application. The latest types of D.F., Communications, and Beam Approach Equipment are included, and in addition there is a chapter on Airport and Airway Lighting.

HIGH FREQUENCY THERMIONIC TUBES. By A. F. Harvey, B.Sc., D.Phil., A.M.I.E.E. Published by Chapman and Hall. 235 pages. Price 18s. net.

DEVELOPMENTS in the extensive and increasing use of very high frequency energy has brought about amazing changes in valves, component and circuit technique, and a realisation that the performance of such items and apparatus at the higher frequencies must be known with accuracy. In this direction, Dr. Harvey has already performed most valuable work, and the major portion of his book is due to the results of his experimental work carried out in the Engineering Laboratory of Oxford University, and later in the Cavendish Laboratory of Cambridge University.

The six chapters cover General Properties of Thermionic Tubes; Influence of Frequency Operation; Retarding Field Generators; The Magnetron—Part 1; The Magnetron—Part 2, and finally, Miscellaneous Tubes and Circuits at Very High Frequencies.

Radio Examination Papers—17

More "Test-yourself" Questions, with Suitable Answers by THE EXPERIMENTERS

1. Limitations of H.F. Amplification

THEORETICALLY, it would be possible to obtain an unlimited amount of H.F. amplification, but in practice there are many difficulties. Perhaps the most obvious is that if the gain were extended above a certain limit the amplification given to all forms of background noise, mush and very weak signals would be so great that this "interference" would tend to ruin the required signal. Another form of noise which becomes increasingly troublesome as the degree of amplification is increased is that due to electronic emission by the valve's cathode. This may pass quite unnoticed until the amplification reaches several thousands of times, but there is, nevertheless, this limiting factor.

Another limitation is one which varies to a certain extent with the frequency at which amplification takes place. This is due to the inherent capacity between different parts of the circuit. If there is any appreciable capacity between input and output circuits, or between grid and anode circuits of individual valves, instability is bound to occur unless the ratio of output to input voltage is low. And since capacitive reactance increases with increase in frequency, it will be seen that this limitation is more marked on short waves.

This demonstrates one advantage of the superhet, in which amplification takes place at a frequency lower than that of the signal being received. It also explains why H.F. amplification on short waves is normally very small; if attempts were made to increase the amplification the H.F. valves would probably fall into a state of self-oscillation.

From what has been stated above, it will be seen that the limitation of H.F. gain applies in one form or another whether the H.F. amplifier consists of a small number of valves operating at high efficiency, or a greater number where each is operated at a lower pitch of efficiency. In practice, a compromise has to be made so that each valve operates fairly efficiently without any danger of its falling into oscillation.

QUESTIONS

1. *What factors tend to impose a limit on the amount of gain that can be obtained with any H.F. amplifier?*
2. *Draw a diagram of a reflex circuit: briefly outline its action.*
3. *What are the essential differences between a "Marconi" and a "Hertz" aerial?*
4. *Following are set out the principal characteristics of two triode valves. From the data given, for what purposes would you expect the valves to be most suitable?*

Valve	Max. Anode Volts	Bias (Volts)	Amplification Factor	Mutual Conductance	Optimum Load
A	250	– 4	40	3.5 *mA/volt*	50,000 *ohms*
B	300	– 40	5	6.0 *mA/volt*	4,000 *ohms*

5. *Explain the principle and point out the advantages of dust-iron-core coils.*
6. *If a rotary converter gave an output of 250 volts, 100 mA, what would be the approximate input current if the machine were designed for operation from a 6-volt accumulator?*

2. Reflex Circuits

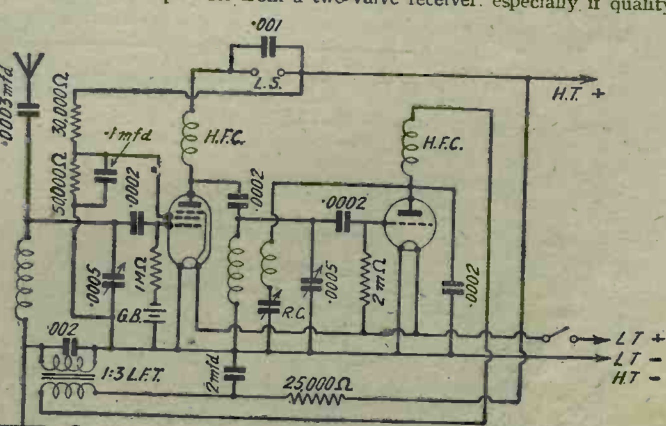
On the right is a circuit diagram for a two-valve reflex receiver. The object in using a reflex arrangement is that one valve shall do the work of two. In the circuit in question, the H.F. pentode acts as both an H.F. and an L.F. amplifier, while the triode is a normal leaky-grid detector.

It may be seen that the primary winding of an ordinary step-up L.F. transformer is connected in the anode circuit of the detector, and that the secondary of this transformer feeds into the grid circuit of the pentode. There is a small fixed condenser across the secondary winding to by-pass H.F. which circulates in the grid circuit of the double-purpose amplifier.

A loudspeaker is connected in the anode circuit of the pentode, and this also has a by-pass condenser.

If we trace the path of a signal through the receiver, we see that it is first applied to the grid-tuning circuit of the first valve and then passed to the valve, where it is amplified at high-frequency. The signal is then fed to the detector in the usual manner and is demodulated; that is, the L.F. is separated from the H.F., the latter being by-passed to earth. If a pair of telephones was connected in place of the transformer primary the two-valve receiver would be of conventional type.

But by passing the L.F. or audio-frequency back to the first valve, we get further amplification—this time at low-frequency. With a circuit of this kind it is very important that a good H.F. choke be used in the detector anode circuit, and that all H.F. should be prevented from passing back into the amplifier. Even then we do not obtain quite the same results as from a three-valve receiver, because we have to employ a valve which will operate reasonably well at both high and low frequency. In other words, a slight sacrifice in efficiency has to be made. In spite of this, however, the arrangement can normally be expected to give better reception than is possible from a two-valve receiver, especially if quality



Circuit of a two-valve reflex receiver in which the H.F. pentode serves as both H.F. and L.F. amplifier.

of reproduction is not regarded as being of great importance.

3. " Marconi " and " Hertz " Aerials

A Marconi aerial is not made to any particular length, and is tuned by means of a coil-condenser circuit connected in series with it. The Hertz aerial, on the other hand, is cut to a définite length, generally equal to one-half the wavelength at which it is to be used.

Most aerials used for reception are of the Marconi type, but a Hertz aerial is often used for short-wave reception on a particular frequency band. The precise length is not usually very critical, but for most satisfactory results it should be within about 5 per cent. of one-half wavelength. The so-called dipole or doublet is a form of Hertz aerial that is most commonly employed for reception.

The Hertz aerial can be shown to have a higher efficiency than the Marconi, but only when used on frequencies very near to that for which it is cut. It is impracticable on all except short waves, because it would be much too long on, say, the broadcast band. For example, a half-wave Hertz aerial for 400 metres would be 200 metres, or more than 600ft. in length!

4. Valve Characteristics

It is at once evident from the data given that the first valve (A) is of the H.F. or general-purpose type. This is indicated by the low negative grid-bias voltage and the high amplification factor. The comparatively low mutual conductance provides further evidence that the valve could not provide any appreciable amount of power in its anode circuit.

It is equally clear from the operating grid voltage that the valve could not handle other than a small input voltage; if serious distortion is to be avoided the A.C. voltage applied to the grid must not have a peak value higher than the negative bias voltage. In practice, it is wise to keep fairly well below this figure.

Valve B has entirely different characteristics, and the low amplification factor combined with the moderately high mutual conductance point to its suitability as a power output valve. The high standing bias voltage also indicates that it should be capable of dealing with a big grid input. The optimum load is low, and power—as opposed to voltage—can the better be developed in its anode circuit.

If full details of the valves were available it would undoubtedly be seen that the one we have decided to describe as a power valve would have a very much higher anode current than the general-purpose valve, which is ideal as a voltage amplifier. This is shown by the high amplification factor. The general-purpose valve would probably also prove very suitable as a detector.

Both valves would be expected to have been designed for use in mains-operated receivers. One obvious clue to this is the rated maximum anode voltages. Another, as applied to the power valve, is the high bias voltage and low optimum load, which normally point to high anode current. In the case of the G.P. valve, the mutual conductance is higher than would be expected for a battery valve of any type requiring only 4 volts negative bias with an anode voltage of 250.

5. Iron-core Coils

Dust-iron-core coils are fitted with a core consisting of very fine particles of ferrous metal moulded into solid form with a plastic type of insulating material. Due to the form of construction, each iron particle is insulated from every other particle. Because of this, there are no appreciable hystereses or " iron " losses.

The use of the special iron core gives a very much higher inductance for any given number of turns. In consequence, a coil of this kind can be much smaller than an ordinary air-core tuning coil. And due to the fewer turns of wire, copper losses are reduced. It is true that, to some extent, the reduced copper losses are offset by the losses in the core.

A smaller coil has an advantage quite apart from its use in midget receivers; its field is more confined and there is thus less danger of inter-action with other components.

Another advantage of the iron-core coil is that it can be " matched " with other coils very easily by moving the core slightly further into or out of the winding. In other words, the feature of variable permeability is employed as a means of trimming. This is a convenience in multi-valve receivers, and for pre-set tuners, such as I.F. coils.

6. Rotary Converter Consumption

Before we can estimate the input current consumption of the converter we must determine its output wattage. This is found by multiplying together the output voltage and output current in amps. Since 100 mA is one-tenth of an amp., it can be seen that the output wattage is 25.

If the machine were 100 per cent. efficient, the input wattage would be the same at the output. But there is, of necessity, some loss. This is partly electrical, due to the resistance of the windings, and partly mechanical, due to the inertia of the armature and the friction of the bearings. It is generally reasonable to assume the overall efficiency to be in the region of 66 per cent.

From this we can see that the input wattage will be about one and a half times the output wattage; the figure is therefore 37.5 watts. Since we know that power in watts is the product of voltage and current, the latter can be found by dividing 37.5 by 6. The answer is 6.25 amps. It would therefore be reasonable to expect an L.T. consumption of about this figure. A current very much heavier than this would be passed when the machine was first switched on, since it is then necessary to overcome the inertia of the stationary armature. After a second or two the current would settle down to its steady value.

When a Compass Misbehaves

THE compass in a bomber pilot's cockpit sometimes leads to a detailed investigation. When adjustments are made—" swinging the compass " it is called—mysterious deviations may be noticed, and the cause must be tracked down. The aircraft is turned slowly round to the magnetic north, and the compass checked. If the needle, or pointer, refuses to stay where it should an inquiry of experts is opened.

The story is told on one bomber station of a navigation officer, who, having cross-examined every witness about possibly hidden pieces of metal, and crawled about the aircraft on hands and knees remarked: " Well, all I can think of is that it's caused by the magnetic personality of the pilot."

The explanation is usually much simpler than that. A knife may be found tucked down the flying boot of one of the men standing near. A metal stud which had become lodged in the heel of a pilot's boot has been known to affect the compass. Hours of investigation into the strange behaviour of a compass in a Halifax ended when the pilot discovered that a circle of wire, used as stiffening in the inside of his hat, was the cause of the trouble. When he went near the compass he got a bad reading, until in desperation he flung off his hat, and then found that the compass's sensitiveness was no longer offended.

Lightning encountered during flight, a danger to any compass, may magnetise the aircraft. The compass must be " swung " every month as an aircraft, at its dispersal point, gradually becomes magnetised.

LONDON CENTRAL RADIO POSTAL BARGAINS

AMERICAN Octal base valve-holders, Mazda type, brand new, 6d. each.
FLEXIBLE DRIVES for remote control. Approx. 2ft. long. 4/- each.
ELECTRO-MAGNETIC COUNTERS. Resistance 500 ohms. 1-1999, size 4½in. x 1¾in. x 1¼in., 5/6.
VARIABLE CONDENSERS. 2 and 3-gang. Die cast frames in first-class condition, 6/9 and 7/3 each.
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TELEVISION diode valves. Unused Mullard EA50, 69 mm. x 12 mm. overall, 6.3 v. heater at .15 amp., 10/6 each.
COIL FORMERS. Cardboard and Paxolin. Assorted sizes, 2/9 doz.
PUSH-BACK Wire Flex, ideal for wiring receivers, etc., 1/6 8-yard coil.
VOLUME CONTROLS. Wire wound. 1 ohm, 3/6 each. Carbon type, 100,000 ohms, 250,000 ohms, 500,000 ohms, 1 megohm, 4/6 each.
VALVEHOLDERS. Chassis mounting, 7-pin. 6d. each; 5/6 doz.
PHILIPS Mica-dielectric .0003 mfd. Reaction condensers, 2/- each.
SISTOFLEX. 3 mm., 4 mm., 5 mm., 3d. each per yd. length, 2/6 doz. yards. 8 mm., 5d. yd. length, 4/6 doz. yds. 16 mm., 7d. yd. length, 6/6 doz. yds.
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EX-TELEVISION manufacturer. Heavy duty mains transformer. Input 240 v. A.C. tappings at 5,000 v. 5-8 milliamps., and for supplying filament of Mullard HVR 2 (6.3 v. at .65 amps.). Shrouded in metal box, 10/6 each, carriage forward.
VARIABLE RESISTANCES. Well-made resistances with wiping contact. Will carry about 10 watts. Brand new, first quality. Price 6/6 each.
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SPEECH COIL RIBBON WIRE. Enamelled copper. Gauge approx. 20 thou. by 5½ thou. Per 1 lb. reel, 3/-.
SINGLE R.A.F. EARPHONES, resistance 750 ohms. D.C. approx., 4/- each; ex-Govt. low-resistance single earphones, 2/6 each; microphone buttons, well-known make, 2/- each.
DECORATIVE CABINET GRILLES, 4-bar, 14½in. x 1½in. wide. Solid brass chrome-plated, 2/6 each. Heavier quality, 3/6. Also Rectangular Speaker Grilles, 7½in. x 5¼in., 1/6.
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CONDENSERS, with bakelite insulated terminals, 2.5+2.5+1 mfd., 250 v. working, 6/6. 2 mfd., 400 v. working, 7/6. 4 mfd. 250 v. working, 9/6.
PHILCO Bleeder Resistances, in metal cans, 100, 150, 250 ohms, all 10 watts, 2/6 each.
CHASSIS, drilled for 9 valves, etc., 16¾ x 9½ x 2in., 3/6. 11¼ x 9½ x 2¼in., 3/6. 11¼ x 7 x 2¼in., 3/6.
PUSH-BUTTON mechanism only unit, with 6 buttons, 4/6 each.

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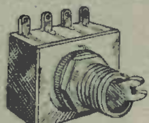

As illustrated. Carries 1.5 amp. at 250v. Well and strongly made, with excellent snap action. Price **4/6**
Post, etc., 3d. extra.

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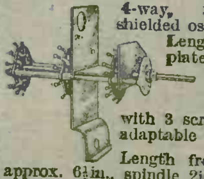

4-way, 3-bank, with shielded oscillator section. Length from stop plate approx. 5in., spindle 2in. ... **5/6**
5-way, 6-bank with 3 screened sections, adaptable to many uses. Length from stop plate approx. 6½in., spindle 2in. ... **6/6**
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Oak Switches, 2½in. spindle, comp. with knob. 4-way, 2-bank with connecting block. 4/6

4-way, 2-bank 3/9
Post, etc., 6d. extra.

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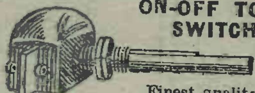

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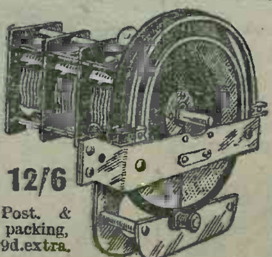

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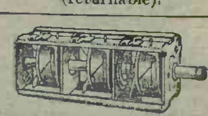

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.0005 mfd. without trimmers. As used in Philips well-known Push Button receivers. Plus postage and packing, 9d. Price **4/6**

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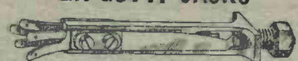

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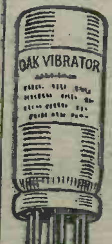

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LONDON CENTRAL RADIO STORES

23, LISLE STREET, *GER. 2969* LONDON, W.C.2

ON YOUR WAVELENGTH

By THERMION

"A Rag, a Bone and a Hank of Hair"

I TILTED at the B.B.C. last month for broadcasting utter nonsense concerning someone in the Forces whom, they claimed, had built a wireless transmitter out of some old tins, pieces of string and some bamboo. Surely the B.B.C., the very centre of wireless technique, should know better than to broadcast such piffle. Had it been broadcast in a humorous vein we need not have taken it too seriously. One of my readers, F. M. S., of Watford (although he does not say so), evidently wishes to support the statement, for he sends me a quotation from a house journal, in which the following appears:

"By arrangement with the *Wellington Journal and Shrewsbury News*, we are able to publish a photograph and details of an ingenious wireless set made by Mr. A. G. Meredith, A.M.I.R.E., manager of the Newport branch of Messrs. E. W. Jones & Co., constructed especially to demonstrate the efficiency of Exide and Drydex batteries.

"The three valves and the transformer are the only standard components used, otherwise the set is constructed as follows:

"Tuning condenser made of two fruit tins; aerial and reaction coils wound on whiskey bottle (empty, but complete with candle); grid condenser made with four razor blades and a clothes peg; anode resistance, cigarettes with graphite rubbed on one side; coupling condenser made from a cocoa tin with tinfoil wrapped on the outside; grid leak made from a small piece of wood, blackened on one side with a lead pencil; reaction condenser made from two lids of floor polish tins; one old margarine box.

"Tuning is controlled by lowering the one fruit tin inside the other, and the volume is increased by swinging the two lids closer together.

"The set works splendidly, and although it is only tuned to the National Programme, it can pick up other stations."

This is by no means a collateral case. Mr. Meredith uses three valves and a transformer, and the rest of the improvised components employ methods well known to our readers. However, I shall be glad to receive details of any quaint but practicable sets which have been built by readers.

An Announcer Joins Up

I AM sorry that Alvar Lidell's voice will not be heard from the B.B.C., reading the News Bulletins, until the war is over. I used to get a kick when I heard that "this is the 9 o'clock news, and this is Al *Var*leydale reading it." Had I not seen his name in print, that is how I should spell it. Personally, I am of the opinion that announcers should not state their names. This practice was introduced at the time when Chamberlain had put the whole country under the invasion anæsthetic, and he thought it would be wise to let the British public get accustomed to the announcers' voices. Does the statement of the name make it easier to remember a man's voice? Surely you get used to the voice, and if you are accustomed to a particular voice, of what value is the name? In any case the wily German would have been equal to picking a voice similar to the one to which we have grown accustomed. He could take recordings of British broadcasts for practice purposes. I have never thought, however, that invasion was ever contemplated; I have said so in print many times, and events to date have proved me right!

Now that the emergency has passed, can we not revert to the old practice? We must get used to the new announcer's voice. If so much importance was attached to our getting used to the voice of Al Varleydale, his was a most important task, especially if an invasion does take place. That being so, why has he been released for the Services?

And what about the new joke—Raif Lynn? I always thought his name was Ralph Lynn.

"Bush-magic"

[Recently the B.B.C. put over the air a story of some Servicemen who found themselves lost in the bush far from their unit, and one of them, who had been a radio operator, made a transmitting set out of some bits of bamboo, some cocoa tins and pieces of string by means of which a rescue party saved the lives of the lost detachment.

Interviewed on behalf of the British Technical Radio Press, the hero of this story made the following statement:]

"How did I win my V.C., sir,
This one, with the double bar of gold?
Only one of its kind, sir—
At least, so I've been told.

"Read all about it in *London Gazette*,
Anyone who desires,
How I saved the lives of my comrades
Of the good old 'Jungle Triers.'

"We were lost in the Burmese jungle,
And tigers had killed quite a few;
When we went to the river for water
The crocodiles bit us in two!

"And then I'd my inspiration
In a rush of brains to my head,
And I rigged up this here transmitting set
About what so much has been said.

"Only some cocoa tins I had,
Some string and some bits of bamboo;
But I puts them together the right way round,
And our message for help got through!

"I was asked by the B.B.C. next thing
To let the whole world hear,
And now, as I've given all details,
My invention should be quite clear!

"And the King, as he pins my V.C. on,
Says 'My lad, it's been splendidly won!
'Cos you've been and done something for radio
That Marconi could never have done!'"

"TORCH."

Our Roll of Merit

Readers on Active Service—Twenty-ninth List.

N. E. Hawly (Lieut., R.A.).
D. Korne (Gnr., R.A.).
E. L. Young (Sgn., Signals).
S. C. Negus (Pte., S.P.T.C.).
E. C. Lyndon (Spr., R.E.).
R. B. Harper (Pte., Dorsetshire Regt.).
A. G. Smallpiece (A.C.1, R.A.F.).
R. F. Pashley (L.A.C., R.A.F.).
E. W. Mitchell (L/Cpl., R.A.F.).
J. Marler (Cpl., R.A.F.).
J. Winstanley (Spr., R.E.).
J. Rigby (Dvr., R.A.S.C.).

Facts About Fixed Condensers

Why They "Block" D.C. and Do Not Interrupt the Flow of A.C. : Charging and Discharging : Use in Time-base and Neon-oscillator Circuits

IT is generally taken for granted that an electric current will not flow round a circuit in which is included a condenser. This is not strictly true, although it is a fact that a steady current will not flow, because of the insulation provided by the condenser dielectric. On the other hand, when the circuit is first "made" a current does flow for a short time—usually only for a small fraction of a second. This current is used in giving the condenser a charge.

The charging of a condenser consists essentially of

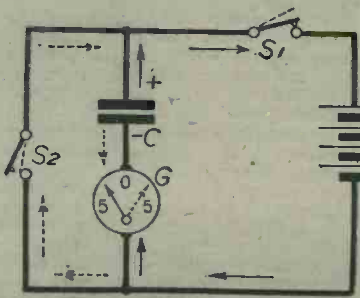


Fig. 1.—Circuit showing the charging and discharging of a fixed condenser.

setting up a strain in the dielectric; if the condenser terminals are later connected together the strain will be relieved, and a current will flow through the wire used to bridge the terminals. This can be shown by means of a circuit similar to that shown in Fig. 1, where it will be seen there is a battery, a fixed condenser, a centre-zero galvanometer or milliameter, and two switches, marked S1 and S2.

Condenser Charge and Discharge

Assuming that switch S2 is "open" when S1 is "closed" the meter will show a deflection, say, to the left. This indicates the flow of current "into" the condenser; the direction of flow is indicated by means of the full-line arrows. Unless the condenser were of very large capacity, the meter needle would do no more than give a "kick," since the condenser would be charged very rapidly. Once it has been charged the current flow ceases immediately.

Now, suppose S1 were "opened" and then S2 "closed," the meter needle would "kick" in the opposite direction—to the right—and there would be a sudden flow of current in the direction indicated by the broken-line arrows. After a very short interval of time the meter needle would return to zero, showing that current flow had ceased, and that the condenser had been discharged. This process could be repeated indefinitely, causing current to flow backward and forward through the condenser circuit.

Time Constant

In passing, it should be mentioned that the time taken for the condenser to charge and discharge is governed by the capacity of the condenser and the resistance of the circuit. Thus, if the capacity were increased, a greater time would elapse before the condenser were fully charged, and if the resistance of the circuit were increased the condenser would be charged more slowly. With a circuit such as that shown in Fig. 2, it can be shown that the time required to charge the condenser is equal to the product of the condenser capacity in farads and the resistance of the series resistor in ohms. In other words, $t = CR$.

Actually, this statement is not entirely complete, and the answer (in seconds) gives the time taken to charge the condenser to about two-thirds of its final voltage—which would be that of the supply. It is not difficult to understand that it would take an infinite time to raise the condenser voltage to the supply voltage if the matter is analysed in this way: When charging commences the voltage on the condenser is zero, and, therefore, there is no opposition to the flow of current "into" it. As charging continues the condenser acquires a voltage which tends to oppose the charging voltage. When this happens the charging current is automatically reduced and charging is slowed down. This continues until the condenser voltage approaches closer and closer to the charging or supply voltage.

Reactance to A.C.

So far we have considered only the effect on a condenser of direct current. The position is somewhat different when alternating current is used. During one half-cycle one condenser plate is charged positively and the other is given a negative potential. At the next half-cycle the polarity of the supply is reversed, and so the condenser discharges, and is then charged to opposite polarity. The consequence of this is that a current flows backward and forward round the circuit, just as it would if the condenser were replaced by a resistor (see Fig. 3).

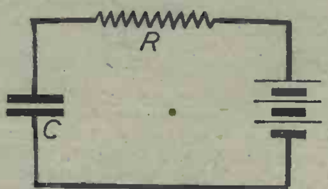


Fig. 2.—In a circuit such as this the time taken for the condenser C to charge is proportional to the product of the capacity and the series resistance.

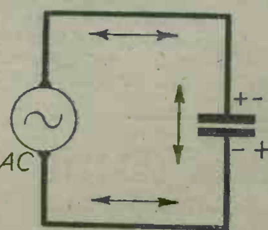


Fig. 3.—When A.C. is applied to a fixed condenser current flows backward and forward round the circuit, a indicated by arrows.

Additionally, the condenser has practically the same effect as a resistor, although the resistive effect is described as reactance. Reactance is measured in ohms, as is resistance, and varies inversely with frequency and with capacity.

For example, if a .01 mfd. condenser had a reactance of 16,000 ohms at 1,000 cycles per second, its reactance at 2,000 cycles would be 8,000 ohms. Similarly, if the capacity were doubled to .02 mfd. the reactance at 1,000 cycles would be 8,000 ohms. The reactance of a condenser can readily be found from the simple formula: Xc (capacitive reactance) = $\frac{1}{2\pi f C}$ where Xc is in ohms, π equals 3.14; f is in cycles per second and C is the capacity in farads.

By-pass Condensers

This explains to a large extent how a by-pass condenser behaves in a radio circuit. If, in a decoupling circuit, we use a 2 mfd. by-pass condenser along with a 25,000 ohm series resistor the condenser offers a reactance of only about 80 ohms at 1,000 cycles per second. This compares with the 25,000 ohms of the resistor, so it is obvious that any "stray" audio frequencies would flow through the condenser to earth rather than through the much higher resistance of the resistor.

A Neon Oscillator

A very interesting use of a condenser is in a form of oscillator circuit in which a valve is unnecessary. This is illustrated in Fig. 4, where it will be seen that there is a condenser in series with a variable resistor and a source of D.C. In parallel with the condenser there is a neon tube. It is common knowledge that a neon tube will not "strike" (that is commence to pass any current) until there is a certain critical voltage between its two plates.

Now let us see what happens in Fig. 4. First the condenser starts to charge through the resistor. After it has acquired a voltage equal to that at which the neon will strike, it suddenly discharges through the neon. The neon ceases to glow immediately the condenser is discharged, and the condenser once again starts to charge up. Again it will discharge when its voltage reaches the "striking" voltage of the neon tube. This process will continue indefinitely as long as the power supply is available. As mentioned before, the rate of charge of the condenser can be controlled by means of the variable resistor, and so the frequency of the oscillation can be regulated.

The oscillation produced is not a smooth sine wave of the kind usually associated with an oscillating valve, but is of "saw-tooth" form due to the fact that the condenser is charged comparatively slowly through the resistor, and then discharges almost instantly through the neon. The frequency can be determined from the formula previously given for the time required to charge a condenser through a resistor; that is, $t = CR$. To take an example, suppose the condenser had a capacity of .01 mfd. and the resistor a value of 250,000 ohms, the time taken for charging would be t (secs.) $= \frac{.01 \times 250{,}000}{10^6}$, which works out at 1/400 of a second. This means that the frequency of the saw-tooth oscillation would be 400 per second.

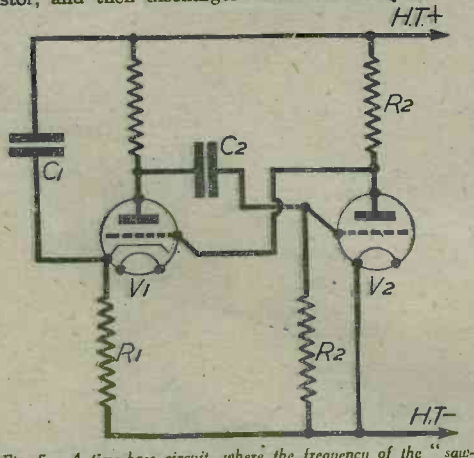


Fig. 5.—A time-base circuit, where the frequency of the "saw-tooth" wave is governed by the condenser C1 and the resistor R1.

For this circuit to operate satisfactorily it would be necessary for the voltage of the D.C. supply to be at least 50 per-cent. higher than the striking voltage of the neon lamp. In practice, it would be made as much higher as convenient, and the frequency would be regulated by means of the variable resistor.

Capacity Comparisons

It is possible to use a circuit of this kind for estimating the capacity of condensers. To do this, however, the charging must be slowed down so that the flashes of the neon are slow enough to be counted and timed, using a stop-watch. It will be seen that the capacity would then be indicated by the number of flashes per second compared with the number when using a condenser of known capacity. The circuit could also be used to modulate an H.F. oscillator, by connecting the two sides of the neon to the grid and cathode of the H.F. oscillator through low-capacity condensers. The latter would affect the previously estimated frequency, since they would be in series with each other, the series pair being in parallel with the main condenser. The effect of the condensers could easily be compensated for by adjustment of the charging resistance. It will be clear that an audio oscillator of this type would not give a very good note, because of the saw-tooth waveform; there would be various harmonics. This would not be a serious disadvantage in practice, since it is only the stability of the high-frequency oscillation which is of real importance.

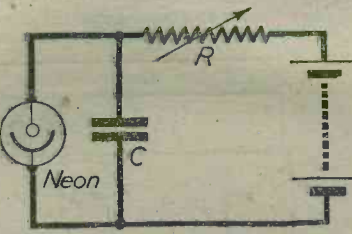


Fig. 4.—A neon oscillator. The neon "strikes" when the voltage on C reaches the "striking" voltage of the neon. The frequency of the "striking" may be governed by adjustment of the variable resistor marked R.

A Time-base Circuit

A more practical and efficient form of time base, for use with a cathode-ray oscilloscope may take the general form of the circuit given in Fig. 5. When this is first switched on the condenser marked C_1 is in a discharged state, and therefore commences to charge. This will be equivalent to connecting together the anode and cathode of the first valve, marked V_1, with the result that the valve will be inoperative, since the grid will be negative in respect of the cathode.

Once the condenser C_1 has become fully charged the anode voltage on V_1 starts to rise. The valve remains inoperative, however, until the anode voltage attains the same value as the grid voltage. It then suddenly starts to pass anode current, and condenser C_1 is discharged. At the same time, a voltage pulse is applied to the grid of V_2 through the grid condenser C_2. The cycle of operations is then repeated.

As with the circuit previously considered, the frequency of oscillation is governed primarily by the capacity of C_1 and the value of R_1.

Your Service

The First of a Series of Articles on the Lay

By S. BR

THE normal complement of service men is so depleted, owing to the requirements of the Forces, that it is opportune for radio amateurs to endeavour to fill their places. By so doing, they will be alleviating the acute servicing problem, as well as helping the community in general, and, incidentally, the war effort.

True, this is not the *best* time to start, but the difficulties are only superficial, and when faced squarely do not present real problems. The natural ability of the amateur to improvise stands him in good stead, for the job that might be turned down by the professional may be welcomed by the amateur, inasmuch as the former cannot spare the time (perhaps altering circuit arrangements, etc.), whereas the latter, since his time is usually less valuable, is in his glory adapting a certain component for the job.

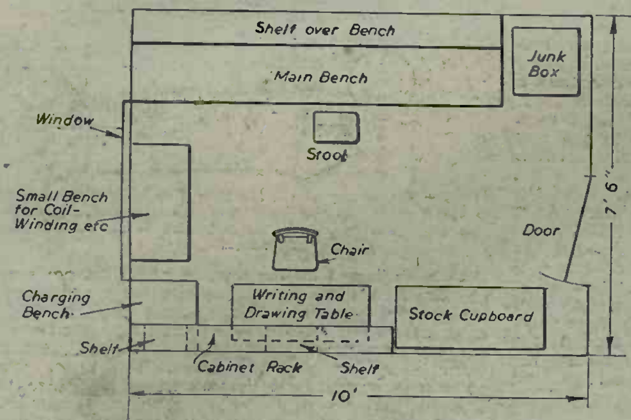


Fig. 1.—Plan of the layout of the room used and arranged by the writer. Full use is made of all available space without overcrowding.

One *must*, of course, *possess the necessary knowledge* for the work, but it is probable that the majority of regular PRACTICAL WIRELESS readers have reached the required standard. The constructor who has spent years in designing, building and experimenting with radio apparatus has served an extremely good apprenticeship to radio servicing, and, with the necessary instruments, he should be in a position to tackle any faulty receiver that confronts him. Moreover, he will increase his knowledge very considerably, as opportunity will be readily at hand to study varied commercial methods.

The way one sets about servicing is just as important as the ability to carry it out. A radio receiver *can* be serviced on the kitchen table with little more than a screwdriver and a pair of pliers, but one would obviously not get very far under those conditions. A small, suitably equipped workshop is essential, as it enables one to carry out work methodically, quickly and efficiently. Further advantages are that one is left in comparative quiet, and a job can remain on the bench at any stage with the assurance that it will not be tampered with.

Size of Room

The choice of a suitable room is a matter that only the would-be service man can decide, but if any choice is available it is preferable to have one in the house. An outside sectional building or garage might offer advantages in some ways, but these are usually offset by the difficulties encountered in heating, lighting, etc. Also the noise one might have to make—possibly at night—would no doubt give rise to some complaint from neighbours. A room in the house is much more satisfactory, if only from the point of keeping the temperature round about normal, as this is an important point, having regard to the instruments that will eventually be in it—and a room that is inclined to be damp should be avoided.

Since the amount of work carried out will not be comparable with that of a commercial workshop, the room may be comparatively small (with the amateur it usually has to be), and one measuring even 10ft. × 7ft. 6in. could accommodate all the gear necessary. The plan view and drawing of the writer's room, Figs. 1 and 2 (and cover), show what can be done with the space available. The bench should receive a good deal of thought, for upon this will depend one's comfort or discomfort during working hours. An obvious position for it is in front of a window (running along its length), but it is often convenient to fix a shelf above the bench—for the various test instruments—which would block out the light rather effectively. The arrangement shown in Fig. 2 is, however, very practical, as it makes the most of the light under such conditions. Since the amateur must carry out most of his work in the evening, this question of daylight is not so important as it may at first appear.

The Bench

What is *more* important is the *height* of the bench; an hour or so working at one that is too high or too low will soon show how uncomfortable it is. Due consideration should, therefore, be given to this point, even if it means trying it out for a day or so while temporarily supported. Its ultimate support must be sturdy, for there

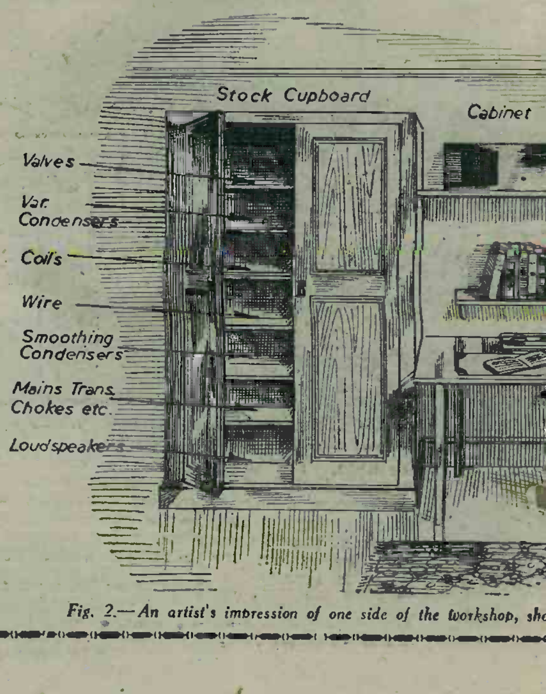


Fig. 2.—An artist's impression of one side of the workshop, sho

Workshop

out and Equipment of a Radio Workshop

ASIER

is nothing more annoying than to find the bench sagging or rocking under a weighty receiver. A framework of 3in. × 3in., or 3in. × 2in. wood should provide ample rigidity, and the top may consist of floor-boarding or any suitable lengths about ⅞in., but preferably ⅞in. to 1in., in thickness. In this respect, perhaps the local salvage dump may come in useful, although new wood is obtainable up to a certain quantity. The bench should be as long as possible, and not less than 2ft. wide.

It will be seen from Fig. 1 that a small bench is fitted in front of the window. This is useful for coil winding—mains transformers, etc.—which, these days is most important, and should not be beyond the scope of the service man. Nothing elaborate is necessary in the way of a coil winder, and much good work may be accomplished on a simple home-made winder similar to that shown in the illustration of Fig. 5. An ordinary geared hand-drill provides the driving power, and an adapted cyclometer makes an extremely good revolution counter, giving direct reading of number of turns. The machine must be screwed or clamped to the bench to ensure rigidity. Underneath is a shelf for storing wire, formers, transformer laminations, etc.

Battery Charger

Not all the receivers one has to service are of the mains variety, so that it is essential to maintain a small battery charging system in order that a fully charged accumulator is always at hand. It also puts one in the position of being able to loan out a battery occasionally—a service that is much appreciated. The charging bench may be quite small, but it is advisable to cover it with sheet zinc or even tin. This will prevent damage in the event of acid accidentally being spilt. The output of the charger may be quite modest, and an instrument giving from 2 to 12 volts at 1 amp. is shown in the illustration of Fig. 3. Regular readers will probably remember that this charger was described in PRACTICAL WIRELESS for September, 1942. It is necessary to point out that the usual precautions must be taken where acid fumes prevail, especially in a small room, and, for this reason, it may be convenient to arrange for charging during the period when the room is vacated.

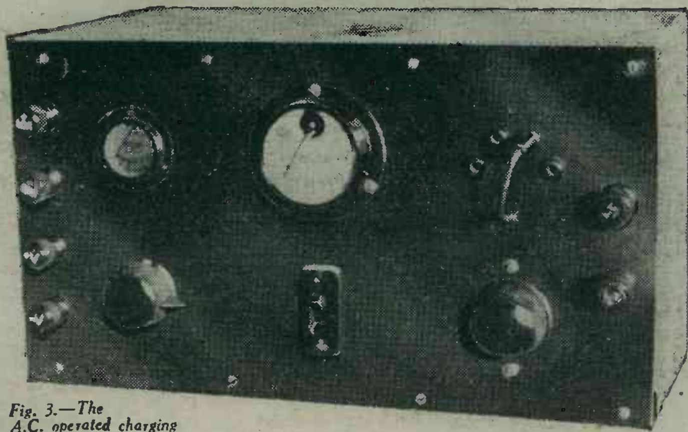
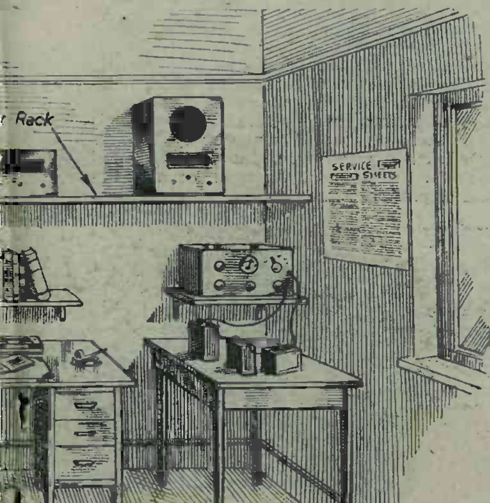


Fig. 3.—The A.C. operated charging plant having a variable output.

A small desk or table which one can use for drawing and writing is an essential item in the service workshop. The space underneath may be built into a cupboard to provide neat storage for literature, correspondence, books, etc.



showing stock cupboard, desk, cabinet rack and charging plant.

Component Storing

The problem of storing components, loudspeakers and valves is best solved by making use of a tall cupboard, if available. The cheap type of "wardrobe" sold in bare white wood is ideal when fitted with extra shelves as it can accommodate a lot of gear. The top can also be utilised to good advantage for chassis and cabinets, which are not wanted for immediate use. Dealing now with the question of electric supply points, it is advantageous to have several of these located at convenient places so that there is always a connecting point available for extra apparatus. Three or four just under the front edge of the bench is a good place for some of them, both 2-pin and bayonet sockets being used to accommodate either type of plug. A selection of electrical adapters of all types will also come in very handy. The circuit on which the permanent sockets are wired should be fused separately from the lighting circuit, if it is from the same source. Fig. 4 explains the system and will obviate the possibility of being left in the dark in the event of an accidental short on the "power" circuit. Where one has power mains proper in the house, it is obviously cheaper to use it for all apparatus except lighting, which is, of course, illegal.

Lighting

The lighting system in the workshop should also be arranged with due regard to its ultimate effect. Apart from the main light, a movable lamp arranged to travel the length of the bench, at a convenient height above it, is quite simple to arrange, and an adjustable standard lamp for the bench requires but little ingenuity to make. This latter is particularly useful for getting light just in the right place on an awkward job. To minimise the possibility of hum pickup, all wires, and particularly those running under, or near, the main bench, should be of the lead-covered variety, the outer casing being securely earthed at as many points as possible.

A good, reliable, permanent earth will also be required for normal working. This, if the room is upstairs, might present some difficulty and it may be more advantageous to rely on a nearby main water-pipe than to use a ground earth necessitating an extremely long lead. In deciding upon the type of aerial one will use, it is wise to remember the conditions under which the average domestic receiver is used. These conditions, sad to say, are not always very efficient, therefore it is

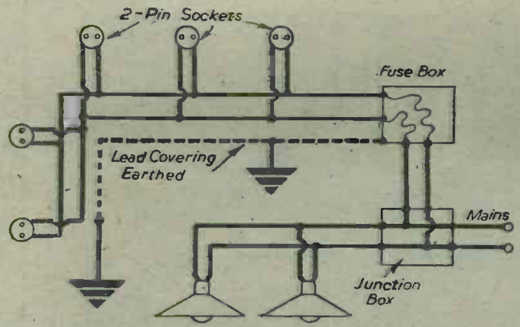


Fig. 4.—The circuits for the supply points and lighting. Note the position of the fuses.

unwise to test a service receiver on a super aerial, as one would receive a wrong impression of the set's capabilities under its own true working conditions. A good plan, therefore, and one that is adopted in the writer's workshop, is to have two aerials. One, a quite inefficient indoor affair, arranged round three sides of the room, and another, fairly efficient—but still not 100 per cent.—fixed in the loft. This is most convenient with an upstairs room as the lead-in can be brought through a small hole in the ceiling just where it is needed. Thus, with these two aerials a receiver can be tested under adverse as well as favourable conditions. The two wires, together with the earth wire, may be brought to a neat terminating connection in the form of a three-point wall socket, thereby doing away with dangling wires, which, at the best of times, are annoying. In this respect also it is advisable to keep the main bench—or at least the greater part of it—clear of apparatus. There is always a temptation to place a thing in a vacant space, and once there other things follow until there is just about a square foot of room in which to work. This does not make for orderly working, and one should avoid it if at all possible. For this reason the shelf—mentioned earlier—is most convenient for accommodating all the test gear. It looks neat, keeps the apparatus at a reasonable distance (a condition which is nearly always advisable) and *does* leave the bench clear for working. The shelf should be of ample thickness, well supported, and fixed at such a height that the various instruments are approximately at eye-level when the operator is standing. This will automatically give sufficient clearance so that it does not obstruct one when working on the back part of the bench.

A tool drawer is useful under the bench, just where one works, and a good idea also is to keep those that are invariably used in a shallow box. This may be kept handy on the bench, so that any particular tool can be selected quickly while working on an intricate job. All these little dodges may seem to be unimportant to some readers, but it is the culmination of attention to small points that counts in executing a job in an orderly and expedite manner. Take resistors, for example. If they are all jumbled up in one box it may take almost as long to find the required value and type as it does to put the receiver in working order again. All this sort of thing may be avoided by arranging these small components in boxes with the appropriate values plainly marked on the outside. A nest of drawers, built in the space between the bench and shelf—see cover—is a very convenient method of doing this. The drawers are about 3in. wide by 1in. deep, going back the width of the shelf, which is about 9in. They are sub-divided into six sections, so that one drawer will accommodate 36 resistances or small tubular condensers, i.e., six various values of six each. By this method, one knows when the stock of any particular value is getting low. Possibly some effort may be required to make these various fitments, but it is well worth it, if only for the sake of workshop tidiness. Even a nest of match-boxes glued together can be extremely useful for small nuts and bolts, screws, etc. But to return to tools.

Tools

The service man will naturally collect the usual assortment of pliers, screwdrivers, soldering-irons, etc., in various patterns and sizes, but other more or less unusual ones that make working easier must not be forgotten. A set of taps and dies, say, 2 B.A. to 8 B.A. are invaluable. These may be purchased separately and a set of them gradually built up. B.A. spanners in the above sizes are indispensable for tightening nuts in otherwise inaccessible places, and a good set of files of different cuts and shapes is really necessary. Drills, too, will be required in sizes from 1/64in. to ¼in. in the twist drill pattern and ¼in. to about 1¼in. in the wood drill type, these latter also being useful in metal work. In this connection a hacksaw, fretsaw, a pair of metal snips and an adjustable metal cutter are also desirable. A small brass-backed handsaw for cutting ebonite or wood and one or two chisels would not be out of place for small cabinet repairs, etc. This list of some of the tools required sounds pretty formidable, but all practical men will already possess a fair selection so that not all of them will have to be acquired. One tool, by the way, which has not been mentioned above, and which is indispensable to servicing, is the trimming tool. This can be merely a bakelite screwdriver, sometimes provided with a short metal tip for extra strength, or a home-made one could be produced quite easily.

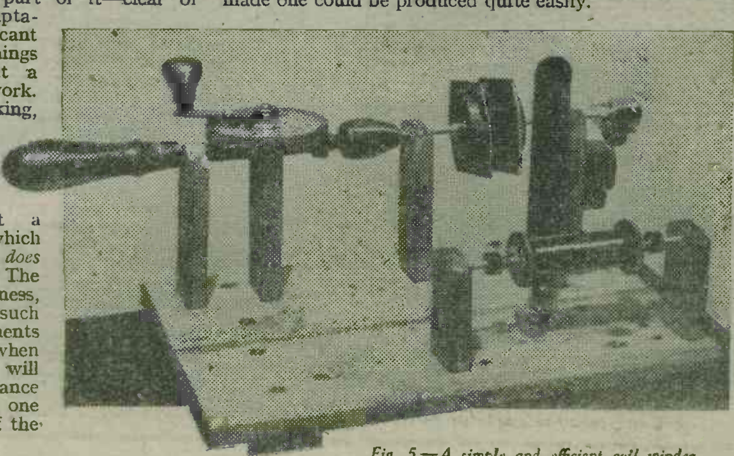


Fig. 5.—A simple and efficient coil winder.

It will be seen on the cover that it is convenient to have *some* apparatus on the bench, despite earlier comments. For instance, the gramophone turntable—so useful in testing—is situated at the extreme left-hand end. It is so arranged that it takes up little bench room; in fact, none while the gramophone is not in use, as to this end it is sunk below the bench, therefore, when not in use, a flush-fitting cover slides over it and the space becomes available if needed. An electric gramophone motor is not easy to obtain these days and for the purposes for which, in this case, a motor is required, one of the double spring type would serve. The main qualities of a good motor are ample power (to carry heavily recorded passages on records) and constancy of speed. Both these qualities should be available in a good spring motor, while the inconvenience of winding should not make itself felt to any large extent, since the pick-up is required only for short periods of testing. A further refinement in the method of construction shown is the space under the motor casing for a few special test records. On the bench at the rear of the gramophone assembly is the workshop receiver, of which more will be told in a later article. It is coupled via an output unit to the baffle speaker above. Towards the other end of the bench it is convenient to fix a small vice—one with 2½in. to 3in. jaws is suitable—for light metal work, etc. while nearer the middle a shallow metal tray, measuring about 10in. by 7in., to take the soldering iron, solder and flux, will be found handy for keeping the bench clean. The complete tray may also be transferred to any part of the bench, or in fact, the room, if a point is available.

Test Equipment

We come now to the servicing instruments, which, at this stage will be discussed only briefly, for it is hoped to describe all of them in detail during the course of this series. They occupy the major portion of the shelf over the bench, and from left to right consist, apart from the output unit, of the beat-frequency oscillator, the service oscillator, the valve voltmeter and output meter, while the valve tester is situated on the coil winding bench. The most convenient position for the universal test meter is at the back of the main bench where one works, but it is in connection with this instrument that a difficulty may exist since meters—particularly low reading milliammeters—are not a bit easy to obtain. However, it is doubtful whether anyone would contemplate setting up a service workshop without any gear at all, and since this is one of the first instruments that the amateur strives to possess, it may be that the difficulty is non-existent. Also, it is sometimes possible to obtain test meters, such as the "Avominor" or similar instrument, through the medium of private advertisements for second-hand radio goods, while the more ambitious constructor could, with the aid of information given in past issues of PRACTICAL WIRELESS or the "Practical Wireless Service Manual," contemplate making one himself. For the reasons given above, it is not proposed to describe the universal test meter—much information has been given in these pages already—but it would be perhaps just as well to run over some of its desirable features. The instrument should preferably be of the portable or semi-portable type, so that it can be taken out "on the job" if the necessity arises. That shown in the illustration of Fig. 6 exemplifies a home-constructed model that is completely portable, yet is handy for the bench. Useful ranges are 1, 5, 25, 100, 250, 500 and 1,000 in volts and milliamps, while for A.C. volts full-scale readings of 5, 25, 250 and 1,000 will prove to be necessary. A.C. current is not so important, but if incorporated, will find many useful applications, especially in universal receivers. Resistance measurements must be provided for, 0-50,000 ohms being typical, and multiples of this reading are invariably obtained by means of an additional battery. Low resistance measurements, say 0—100 ohms, are not as a rule accurate on the above reading, so that an external unit is sometimes employed for the purpose in conjunction with one of the meter ranges.

Date	Name	Address	Receiver	Symptoms	Fault	Cure
7/7/44	A. BROWN	London	"Empire 4" (A.C. Mains)	Loud hum	Grid resistor dis.	Replaced
8/7/44	B. BLACK	London	"Utility 4" (A.C. Mains)	Signals cease after about 3 mins from warm-up.	D.D. Pentode. Soft developed grid current.	Reduced H.T. to Pen. anode & Screen. Temporary cure whilst awaiting new valve.

Fig. 7.—A suggested layout for the pages in the record or reference book.

Fig. 6.—A portable multi-range test meter is essential.

The service man should, in his own interests, keep a record of all work done—not only for reference, for upon analysing the various entries much available information may be revealed. A suggestion for ruling up a suitable book is shown in Fig. 7.

It is appreciated that the reader will have to select his room and its fitments according to his assets in this direction, but the foregoing may help to arrange his (usually small) service workshop on methodical lines, which, after all, is the secret of success in any work.

(To be continued.)

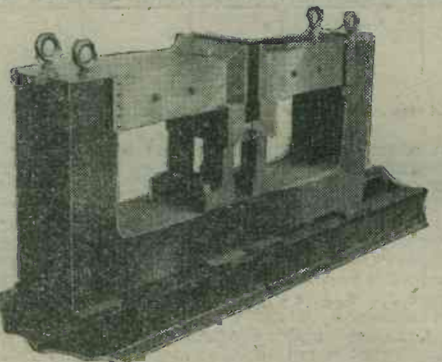
Permanent Magnets—II

Wheatstone's Work : Influence of Carbon : Magnetic Technique and Materials

By L. SANDERSON

(*Continued from page 162, March issue.*)

BETWEEN 1855 and 1860, considerable interest was taken in industrial tests of the magneto-electric machines derived from the Clarke machines, with the object of making use of a dynamic source of electricity to replace acid cells, then the sole ones used (notably in electrotyping workshops). This led, particularly in England, to a search for perfect artificial permanent magnets. At this period a machine could be seen installed in the Invalides Gas Works, designed by an English physicist named Sheppard, other models of which were already functioning in England. It was made up of 48 fixed magnets in horseshoe form, distributed in series of three round the circumference, and in front of these rotated five wheels, each provided with 16 induction bobbins.



Cobalt steel magnet for Cavendish Laboratory (magnet only), the largest permanent magnet in the world, made by Edgar Allen & Co., Ltd.

For a number of years, inventors endeavoured to reinforce the action by a sort of cascade effect, employing, as in the Wilde machine, for example, or in that of Siemens, the induction of the magnets, thus giving to the permanent magnets a force 50-100 times greater than they appeared to possess in their original state.

Wheatstone's Work

At the Universal Exhibition in 1867, the machine of the English physicist, Wheatstone, first revealed the special feature in which permanent magnets were eliminated in the production of current by induction, and only the permanent residual magnetism of the iron or steel employed. Permanent magnets were then investigated from the viewpoint of their constitution, properties, and most favourable arrangement. These researches were fairly widely spaced, and relatively little known until 1880-1890.

In 1847, Joule, working on bars as well as wire of soft iron and steel, stretched or not stretched, observed changes of length and volume produced at the time of magnetisation. Twenty years later, an officer of the French Navy, named Trève, was led to study the change of molecular conditions produced in a steel bar subjected to magnetic action. He noted the difference in the number of vibrations on two scales in unison, one of them afterwards being magnetised.

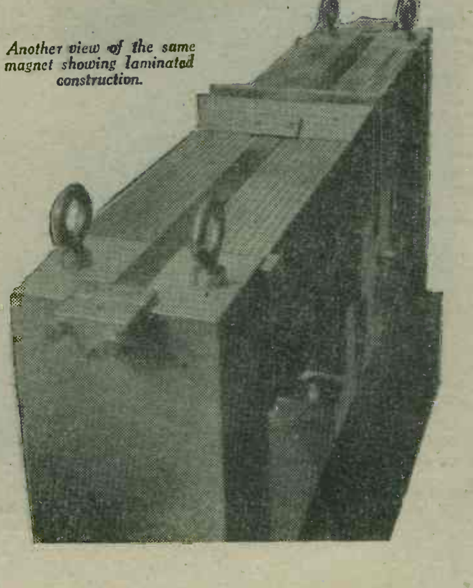
The first indication of heat treatment is found in a note communicated in 1860 to the Academy of Sciences by M. Cailletet, engineer of the metallurgical workshops of Chatillon-sur-Seine, indicating that he had found a means of preparing iron free from permanent magnetism (which was being much sought after then), either for the electric telegraph or for certain parts of magneto-electric machines and finally for all pieces subjected to successive magnetisations in the reverse direction. "It suffices," M. Cailletet remarked, "to expose sheets of commercial iron for some time to the high temperature of the welding furnaces in order to obtain this. The high temperature makes them take a crystalline structure."

In 1869, the industrial manufacture of permanent magnets was set up in the metallurgical works of Allevard in Dauphiny, where there are iron mines, blast furnaces, and forges whose exploitation dates from the thirteenth century.

Jamin Studies Magnets

About 1873 the work of the physicist, Jamin, at the Sorbonne, enabled marked progress to be made with permanent magnets. On the one hand he studied their carrying power and the relative distribution of the magnetism between the surface and the depth (penetration) of a bar, and on the other a modification of the magnetic power of the steel on hardening or annealing. Jamin studied the saturation of the magnets and, above all, the method of diminishing their weight while increasing their carrying power by the use of laminated plates superimposed on one another. He observed, in fact, that carrying power increases with the thickness, but less rapidly than the thickness, so that it reaches a point where it remains stationary, but the carrying power increases with the number of layers of which a bundle of given thickness is composed. Jamin showed also, in 1873, at the Academy of Sciences, who were greatly impressed, magnets built up of superimposed plates that carried 20 times their own weight.

These studies of Jamin enabled Gramme, from 1873 onwards a constructor of magneto-electric machines for producing continuous current, greatly to perfect the



Another view of the same magnet showing laminated construction.

output of his machines by using Jamin's laminated magnets. The progress thus realised was appreciable, but has now only a retrospective interest.

Influence of Carbon Content

Examining magnet steel, its hardening treatment, and its annealing, Jamin, in contradistinction to the first opinion he put forward, came to believe that steels of high carbon content should be chosen. He recognised that there is a maximum polarity after hardening that diminishes on heating, to disappear at red heat. For steels increasingly rich in carbon, the magnetic property diminishes increasingly on hardening. On the other hand, annealing under fixed conditions improves a defective magnet.

In 1875 permanent magnets began to be important enough to justify setting up in Paris a factory specialising in their production: Ets. Giffey, Pretre et Cie., which was still in operation in 1939 after more than 60 years of existence. In the same year, M. Trève made known the result of his work on the influence of the different hardening treatments on magnetic steels in collaboration with M. Durassier, Chief of the Creusot Chemical Works.

After hardening, carried out in cold water at 10 deg. C., in boiling water at 100 deg. C. and in oil at 10 deg. C., on bars heated between 767-800 deg. C., the conclusion was in favour of hardening in cold water, but with this indication, that: "the coercive force increases very little in steels above 0.5-0.55 per cent. carbon." In 1879 M. Trève, then a ship's captain observed the action of shock on magnets. "It suffices," he notes, "to strike some blows on the end of a magnetised bar, even with a non-magnetic substance, to demagnetise that bar." He insists, moreover, on the great disproportion between the force necessary to magnetise a bar, and that sufficing to demagnetise it.

Alloy Magnets

From 1880 onwards, Carre, showing how to obtain good magnets in cast iron, advocated introducing alloying elements, such as nickel, copper, and tin. Soft cast iron, slightly carburised, was cast in the crucible and run into dry moulds. The quality of the magnet improved if 10-15 per cent. of steel turnings was added to the cast iron, according to its carburisation. Equally good results were obtained by adding to cast iron, moderately carburised and cast in the crucible, 1.0-1.5 per cent. nickel, and 0.25-0.3 per cent. copper. The alloy of copper and tin with cast iron facilitates hardening at a higher temperature—cherry red.

In 1885 Barus and Strouhal published, in the United States, the result of their work on the causes of the demagnetisation of magnets, and in particular showed the necessity, for magnetic stability, of a prolonged annealing of the steels at a temperature by no means high.

Curie Enters the Field

In 1895, Pierre Curie, already known for remarkable work in his laboratory in the School of Physics and Chemistry of the City of Paris, published in the "Annals of Chemistry and Physics" a detailed study, "Magnetic Properties of Bodies," in which he examined successively the diamagnetic, the slightly magnetic, and the ferromagnetic bodies. On this occasion he specially studied the magnetic change points of iron and steels for which the name "Curie points" has, in France at all events, become classic.

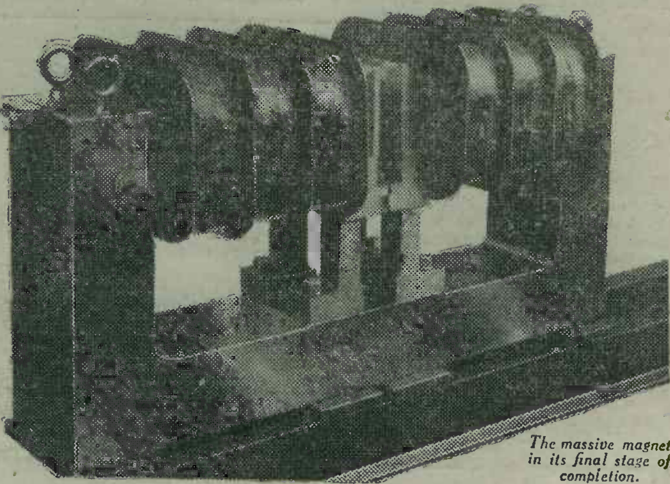
In 1896, Du Bois and E. Taylor-Jones showed in the "Electrotechnische Zeitschrift" the use of a partial demagnetisation after magnetisation.

Madame Curie's Researches

In 1897, Madame Curie, already known for original research into radio-activity, and later to become famous for her discovery of radium, was, before the insulation of this sensational new body, interested in magnetism in her husband's laboratory after their marriage in 1895. On December 12th, 1897, an interesting study on "The Magnetic Properties of Hardened Steels" was presented by Madame Sklodowska-Curie to the Alloys Commission of the Society for the Encouragement of National Industry.

"This work," she explained, "has been done with a view to studying the influence of the chemical composition of steels on their magnetic properties, and on the manner in which these properties are modified by hardening conditions. Steels suitable for good permanent magnets have been more completely studied. Finally, I have studied the effect of a slight annealing on the same steels, and the influence of shock and time on their magnetisation."

Madame Curie went on to add that this study had been carried out with the help and on the advice of M. Le Chatelier, and on samples of carbon steel, tungsten steel, and molybdenum steel, provided by different French steel works, among which were those of Allevard and of Unieux.



The massive magnet in its final stage of completion.

Magnetic Technique

After having described the intensity of permanent magnetism of a bar as compared with that of a ring, she accurately specified the essential facts of a magnetic technique in terms still applicable to the progress since realised. "The magnetic qualities of a magnet steel are characterised by the intensity of the remanent magnetism in the closed magnetic circuit and the coercive field. The coercive field is the uniform exterior demagnetised field in which the steel, magnetised to saturation, must be placed in order that the intensity of magnetisation should become nil. On the size of this field depend the stability of the magnetism and the possibility of magnetising short bars."

Examining finally the constancy of magnetism of the bars, Madame Curie observed: "Different causes may vary the state of magnetisation of a magnet, and in particular (a) shocks, shakes, jolts, and vibration; (b) variations of the surrounding temperature; (c) magnetic fields coming from neighbouring magnets or currents; (d) time, the magnet being spontaneously modified as a function of time."

She concluded that two operations contributed to render the magnet constant—annealing at a low temperature, and partial demagnetisation after saturation.

We may now turn to the modern materials used in the making of permanent magnets. Before we outline these, some notes on the principles and requirements of a good magnet are necessary.

It is well known that every molecule of iron is magnetic, but polarity, i.e., the direction of magnetic attraction, is not discernible in a bar of steel or iron, owing to the fact that the molecules themselves have no specific alignment. Consequently, small internal local magnetic circuits are formed, maintaining the magnetic effects within the bar. If, however, a magnetising force is applied by passing a magnet over the bar, or, to a more marked degree, by placing it in a magnetic field, the molecules are polarised, i.e., all their north poles are made to point in one direction, and polarity at once becomes evident at the ends of the bar.

Several theories have been advanced to explain this interesting and important phenomenon, and possibly it is necessary to go beyond the molecule to the electrons in the atom for a true solution.

Two Classes of Magnetic Materials

Magnetic materials can be divided into two classes: (1) those magnetically soft; (2) those magnetically hard. Magnetically soft materials are closely associated with high permeability magnetic materials, such as are employed in powerful electro-magnets, used for lifting purposes and in the pole pieces of dynamos. The high permeability material is extremely soft, and when placed in a magnetic field, conducts lines of force readily, or, in other words, is permeated by these lines to a much higher degree than magnetically hard material such as the alloy steels used for the manufacture of permanent magnets. (The harder the material, the lower becomes its permeability.)

However, immediately the magnetising force is removed, magnetically soft material has not the ability to retain the induced magnetism, and it is the fact that magnetically soft material has the ability to assume high permeability that makes it specially suitable for electro-magnets.

Relative Permeabilities

To show the relative permeability of steels with varying degrees of hardness, the following figures are given, and prove that soft materials are magnetised with greater facility than hard materials.

Carbon percentage.	μ max.
0.1	273
0.3	194
0.8	100
1.64	93

(To be continued.)

Uses for the Magic Eye

Two Interesting Circuits for Experimental Work

THE principal use for the magic eye hitherto has been as a tuning indicator for broadcast receivers. Its advantages as a null indicator in bridge measurements are well known, and it has been used as a valve voltmeter of the slide-back type. It can also be used as an indicator of resonance across a tuned circuit. The application of this latter use can be made to the substitution method of measurement, as in this case the actual voltage across the resonant circuit need not be known.

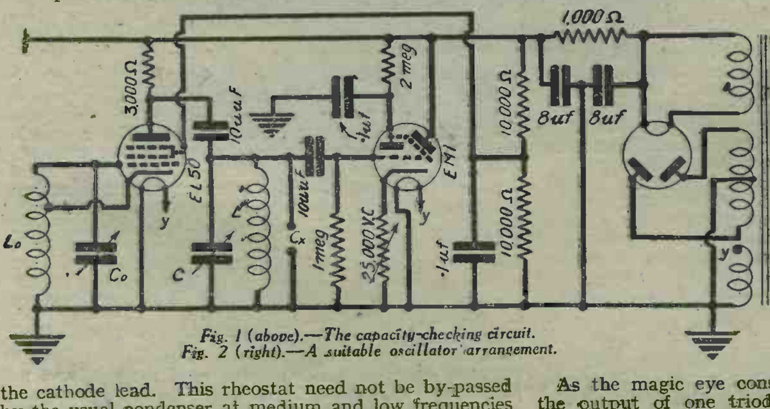
Capacity Check

Variable negative bias is applied to the grid of the triode portion of the valve by means of a rheostat in the cathode lead. This rheostat need not be by-passed by the usual condenser at medium and low frequencies as there is a certain amount of regeneration, thus contributing to the sensitivity of the indicator. The amplifier section is a triode employed as an anode bend detector. This makes the magic eye work backwards, i.e., you tune to maximum shadow or to the closing instead of the opening of the eye.

In Fig. 1 is shown the circuit for a simple condenser test by the substitution method. C, which is a standard variable calibrated capacity having a linear capacity law, is first tuned to maximum capacity, then tuning the oscillator by C_0 to the same frequency as the resonant circuit L and C. If an unknown condenser, having a value within the range of C, be connected with terminals C_x, it would disturb the resonant circuit L and C. By reducing C the resonant condition would be restored; and the change of capacity of C would be equal to the unknown condenser, the magic eye giving the indication of resonance. C_0 and L_0 must have the same tuning range as L and C_0 and C_0 can be an ordinary 500 mmfd. tuning condenser.

As an Oscillator

In Fig. 2 you will see a circuit for the magic eye used as an oscillator. This particular arrangement is the equivalent of the multi-vibrator or relaxation oscillator



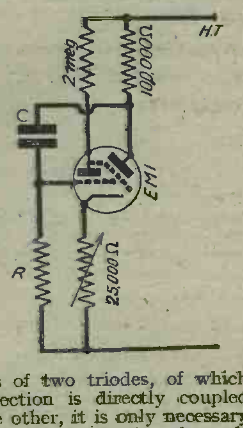


Fig. 1 (above).—The capacity-checking circuit.
Fig. 2 (right).—A suitable oscillator arrangement.

As the magic eye consists of two triodes, of which the output of one triode section is directly coupled internally to the input of the other, it is only necessary to insert a resistive load R in the target lead, and couple via condenser C to the control grid on the input circuit of the first triode section to produce the equivalent condition of the multi-vibrator. The frequency can be adjusted by the cathode bias variable resistance, and if the frequency of the oscillator be low enough it can be counted by the visual indication of the fluctuating opening and closing of the magic eye. A large range of frequencies can be covered by various values of R and C.

Practical Hints

Novel Coil Tester

I HAVE evolved a simple but effective device for testing coils in a receiver. It consists of a permanent mineral crystal detector and a pair of headphones. The crystal detector is wired in series with the phones (as shown in sketch), and the tags of the phones are connected to the grid and earth contacts of the coil.

The coil under test is used in a crystal set circuit, and any faults are soon discovered.

A handy coil tester utilising headphones and a crystal detector.

In this way a fault in the H.F. part of the receiver may be isolated. The crystal detector is easily attached to the headband by adhesive tape, care being taken to insulate it if the headband is bare metal. It is often convenient to replace telephone tags by crocodile clips, as indicated in the sketch.—A. EARLAND (Fulham).

THAT DODGE OF YOURS!

Every Reader of "PRACTICAL WIRELESS" must have originated some little dodge which would interest other readers. Why not pass it on to us? We pay £1-10-0 for the best hint submitted, and for every other item published on this page we will pay half-a-guinea. Turn that idea of yours to account by sending it in to us addressed to the Editor, "PRACTICAL WIRELESS," George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Put your name and address on every item. Please note that every notion sent in must be *original*. Mark envelopes "Practical Hints." DO NOT enclose Queries with your hints.

SPECIAL NOTICE

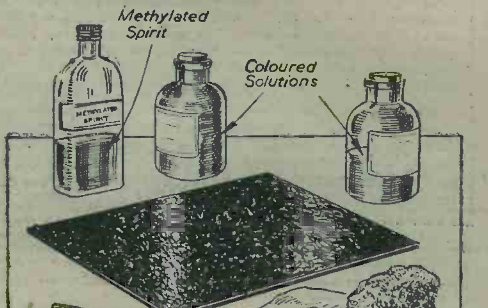
All hints must be accompanied by the coupon cut from page iii of cover.

Obtaining a Bakelite Finish

HERE is a hint for obtaining a bakelite finish on a plain wooden panel or cabinet. Two sticks of different shades of sealing wax are obtained, and each is broken up into small pieces and placed in a separate jar or bottle containing methylated spirit. The wax will be found to have dissolved in a few hours.

The darker of the two liquids should be painted on the cabinet lightly with a very soft brush, two or three coats being necessary, giving each a reasonable time to dry. A small sponge should then be very sparingly coated with the other colour. It is best to paint the substance on the sponge with a brush.

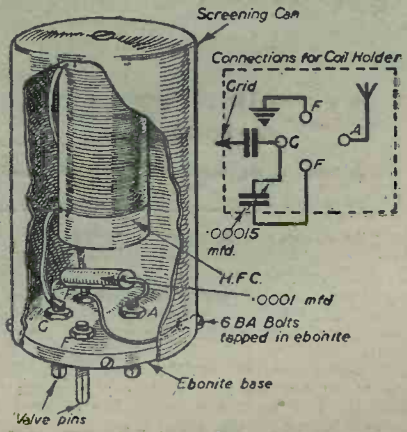
The sponge is then pressed on the cabinet. On removing it the surface beneath will be found to have a perfect mottled appearance. Continue this process over the whole surface of the cabinet. If a brilliant finish is desired, the cabinet should be given a thin coat of varnish. If the correct shades of sealing wax are used, very attractive results can be obtained.—JOHN R. ALLCOCK (Widnes).



Method of obtaining a bakelite finish on wooden panels by the use of sealing wax and methylated spirit.

An aperiodic Coupling Unit

WHILE experimenting recently with different aerial couplings in a short-wave T.R.F. receiver, I decided to make the following unit, to plug in the usual coil-holder when aperiodic coupling was required. The diagram of the unit is self-explanatory, but the theoretical circuit is not orthodox. It will be seen that the tuning condenser is connected directly across the grid coil, but the moving vanes are not earthed. Hence,



A compact plug-in aperiodic coupling unit.

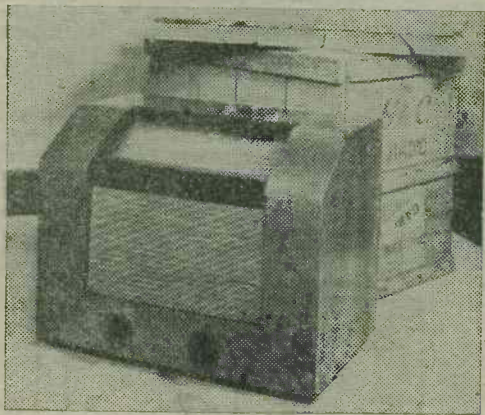
when the unit is plugged in, the condenser is out of circuit, but when a 4-pin coil (with its "filament" pins joined) is plugged in, the tuning is carried out in the usual way. If wanted, the choke can be replaced by a resistance, although if this is done, it is better to leave the screen on, as this forms a useful "handle." If the R.F. and detector condensers are not gauged, the R.F. condenser can be set at minimum capacity, and left in circuit for both couplings, thereby simplifying both coil and unit.—D. B. TAYLOR (Hale).

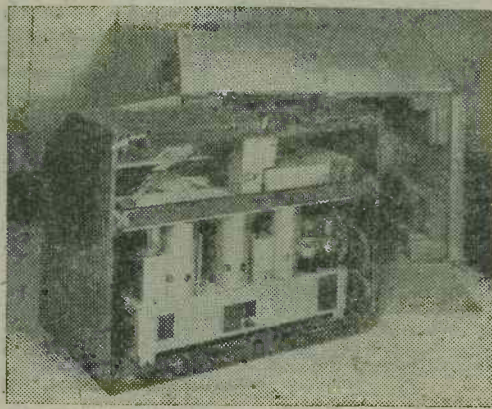
G.E.C. Set in Desert Battle Front

THE accompanying illustrations are of a G.E.C. "Overseas 6" receiver and its original packing. Looking at these pictures few would believe that the receiver, protected only by the light wooden case and carton, had spent many rigorous months on the battle fronts of the Middle East. Through all the hazards of modern warfare it accompanied its owner—a senior officer of a signals unit—providing news and other welcome (mostly short wave) programmes.

Apart from occasionally being cleared of fine sand which penetrated to almost every part of the cabinet and chassis, no "running repairs" were made or were even necessary. Perhaps the most amazing escape was when the officer's car, then being driven over the desert, struck a land-mine. By some stroke of good fortune both he and his companion were almost unscathed. The receiver in its packing case was thrown well clear of the debris. "That surely is the end of a faithful friend," ruminated the senior, but, to his astonishment, when later it was switched on the set worked perfectly.

This is only one of the "hair-raising" experiences through which both the officer and the set passed, but it was by no mere chance that that G.E.C. set has proved so reliable and robust, or that the carton in which it was packed afforded such excellent protection.





Two views of the G.E.C. "Overseas Six" which safely withstood the rigours of many months on the battle fronts of the Middle East.

"MEN BEHIND VICTORY"

INCIDENTS in the lives of inventors and scientists who are constantly experimenting to give Britain better means of waging and maintaining war are being described in this new Thursday evening series, which began on February 4th. Stories will range from the exciting adventures of Sir Robert Watson-Watt, who was attacked by bedouins while carrying out research work in the desert, to the experience of Dr. Franklin Kidd, who recently lived for a week entirely on dehydrated foods.

The first programme was about the late R. J. Mitchell, designer of the Spitfire. His widow and Sir Robert McLean—another "man behind victory"—were heard during the broadcast.

The dehydration experiment which was described in the second broadcast started with a conference held at Cambridge in 1939, when leading scientists met to find a means of simplifying the transport of food. From that meeting meat dehydration evolved, and the new means of drying foods while still preserving their calorific value. The way in which the perfecting of such processes has enabled men in British submarines and at isolated outposts to receive foods they could not otherwise have enjoyed was dramatised.

Other programmes will unfold the story behind one of Britain's lifelines of the air—the merchant air fleet—and some of the exploits of our test pilots.

Radiolocation will be one of the most interesting of the subjects dealt with. The pioneer of radiolocation, Sir Robert Watson-Watt, met Dr. Bruening and Dr. Goebbels in Germany in 1932 and 1933. As early as that he realised that war was all but inevitable. In consequence he came back to Britain and speeded up research which has since been of inestimable value in the locating of hostile aircraft as they approach these shores.

PRIZE PROBLEMS

Problem No. 442.

HAWKINS became interested in short-wave reception, and as he had sufficient spare parts to make a simple one-valve superhet converter, he decided to do so and use it in conjunction with his three-valve (1-v-1) medium- and long-wave set. The converter worked quite well as regards pulling in the stations, but Hawkins was puzzled to find that each transmission could be tuned-in at two settings of the dial. He tried everything he knew to eliminate this, but in the end had to give it up. Was there something wrong with the converter; and if so, what was the cure?

Three books will be awarded for the first three correct solutions opened. Entries must be addressed to The Editor, PRACTICAL WIRELESS, George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. Envelopes must be marked Problem No. 442 in the top left-hand corner, and must be posted to reach this office not later than the first post on Monday, March 15th, 1943.

Solution to Problem No. 441

Boyce's tests had proved that the I.F. transformer was satisfactory in a D.C. electrical sense, therefore, as it would not pass any signals, Boyce deduced that something must be wrong in an A.C. and/or mechanical sense. After removing the component, he stripped off its metal can, and found that the lower winding had become loose and had fallen away from the other section thus reducing the coupling between the two windings to a negligible quantity.

The three following readers successfully solved Problem No, 440, and books have accordingly been forwarded to them · 1790076 A. C. Buchan; D. Rackham, Bridge St. Farm, Long Melford, Sudbury; C. M. Jones, 28, Palace Road, Upper Norwood, S.E.19.

A Refresher Course in Mathematics

By F. J. CAMM

(*Continued from page 169, March issue.*)

The Infinitesimal Calculus : Differentiation

TECHNICAL students who, in the course of their mathematical studies, have made some acquaintance with the calculus and find it a little puzzling at first, are often disposed to ask, "What is the use of it?" This question is not easy to answer in a few words, but it may clear the ground to say at the outset that in very few calculations in engineering design is it necessary to use the "infinitesimal calculus"—to give it its full name. On the other hand, a working knowledge of the calculus may occasionally save time in calculation. The position is something the same as if a child were to ask what is the use of the multiplication tables. It might be said in reply that the multiplication tables are not *essential* (because what they do can also be done by somewhat laborious adding), but they are extremely useful in saving time.

Generally speaking, use of the calculus in mathematical work is advantageous, not because it gives a result that cannot be got in any other way, but because it gives the result with less labour (and often with higher accuracy) than is possible by more elementary methods. The designer need rarely be beaten because he knows no calculus, but he can sometimes do things more quickly if he can use it. Here again it may be interjected that a theoretical knowledge of the calculus is not quite the same thing as ability to use it advantageously in practical calculations.

The subject of the infinitesimal calculus is divisible into two main subjects, "differential calculus" and "integral calculus," which are related to each other in much the same way as are multiplication and division in arithmetic. It may be noted that the word "calculus" literally implies nothing more than a system of calculation, but its present-day use implies "calculus of infinitesimals," and the meaning of that is "mathematical relations between infinitely small quantities." It is here, right at the very beginning of the subject, that students' doubts may arise because they realise that infinitely small quantities have no essential place in practical engineering. The objection is not a serious one, however. It has a parallel in the subject of mechanics, where attention is often devoted to movements of "particles" connected by "weightless inextensible strings" and sliding over "perfectly smooth surfaces." In each case these unpractical subjects are selected for discussion so that the student may concentrate at first on fundamentals, leaving the entanglements of practical details to be overcome later.

Scope of the Differential Calculus

The calculus is used in dealing with quantities that change or that may be changed. In engineering practice there are many quantities that change continuously; for example, the pressure of the gas in the cylinder of an internal combustion engine. In engineering design everything is likely to change because the basic procedure is very often "cut and try." Certain dimensions are assumed (i.e., guessed), the main elements of the design are based on them, and the result reviewed. If it is not satisfactory in some respect changes are made in one or more of the assumed quantities and the results of such changes are investigated. It is necessary to answer the question, If we change A by so much, how much will B and C be altered? If there are known mathematical relations between A, B and C the differential calculus will answer this question more quickly than will the obvious way of going through all the original calculations again on the basis of the new value of A. In brief, the change produced in B by a certain change in A is equal to that change multiplied by the "differential coefficient of B with respect to A." This quantity with the long name, "differential coefficient of B with respect to A," is denoted in mathematical shorthand by $\frac{dB}{dA}$, and an essential part of the subject of the differential calculus is concerned with the rules for determining the differential coefficients of mathematical functions of a quantity.

Function

The word "function" used in the last sentence has a special and clearly definable meaning. If the value of a quantity B can be expressed mathematically in terms of a quantity A—that is to say, if we have a mathematical expression whose value is always equal to that of B when the appropriate value of A is inserted in it—then B is said to be a "function of A." It is equally true to say that A is a function of B.

Rate of Change

When the value of A is changed, the value of B will (nearly always) change, and the change in B divided by the change in A is the "rate of change of B with respect to A," and it is the differential coefficient of B with respect to A. By mathematical convention, dB means (not in this case d times B) "change in B," and dA is the corresponding change in A.

Now, strictly speaking, rate of change is the same thing as "ratio of changes" only when those changes are very small ones, and in fact, unless we specify that the change shall be infinitely small, the ratio of them has no definite value.

For example, let a quantity y be connected with a quantity x by the relation $y=5x^2$. Suppose that in the first instance $x=2$, then y is equal to 20.

Now consider what happens when x undergoes certain typical changes as worked out below in tabular form.

Original $x=2$. Original $y=20$.

Change in x	New x	New y	Change in y	Change in y / Change in x
1	3	45	25	25
0.5	2.5	31.25	11.25	22.5
0.25	2.25	25.313	5.313	21.25
0.1	2.1	22.05	2.05	20.5
0.01	2.01	20.2005	0.2005	20.05

Here are five changes in x ranging from 1 down to 0.01. It will be noticed that the value of the ratio (change in y) (change in x) is not constant, but varies with the amount of the change. As the change in x diminishes towards zero, the change in the ratio also diminishes, not towards zero but (apparently) towards the value 20. Actually it can be proved mathematically that the ratio does become 20 when the change in x is infinitely small. It is necessary to use some such expression as this last one and not to say "zero," because otherwise it could be objected that if the change is zero there is no change at all, and discussion of ratios of changes becomes meaningless.

So the differential coefficient properly so called is the ratio of the changes when they are infinitely small. A good deal of the usefulness of differential calculus in practical mathematics is, however, dependent on the fact that the ratio of the changes is nearly equal to the differential coefficient even when the changes are not infinitely small. For example, the table shows that when x changes by 0.1, y changes by as much as 2.05 which is certainly not infinitely small, but the ratio of the changes is 20.5, which is nearly equal to the differential coefficient, 20.

Determination of Differential Coefficient

The numerical example discussed above shows how the value of the differential coefficient can be determined (very nearly) in any particular instance by purely arithmetical work. Can it be determined for any given mathematical function by a straightforward mathematical process? The answer is "Yes," the process is called "differentiation," and it can always be carried out by following a few simple rules, no matter how complicated the mathematical function may be.

In the following, the variable quantities are x and y; the others are constant.

$$y=(ax+b)^n \qquad \frac{dy}{dn}=na(ax+b)^{n-1} \qquad (1)$$

$$y=a\sin(nx+b) \qquad \frac{dy}{dn}=na\cos(nx+b) \qquad (2)$$

$$y=a\cos(nx+b) \qquad \frac{dy}{an}=-na\sin(nx+b) \qquad (3)$$

$$y=a\tan(nx+b) \qquad \frac{dy}{dn}=na\sec^2(nx+b) \qquad (4)$$

$$y=ab^{(cx+d)} \qquad \frac{dy}{dn}=aeb^{(cx+d)}\log eb \qquad (5)$$

The quantity e in (5) is the "base of Napierian logarithms," 2.71828.

These formulæ cover many of the cases encountered in engineering mathematics. For example, if $y=4x^3$ the differential coefficient of y with respect to x is determined by the use of (1), the values of the constants in this special case being $a=4$, $b=0$, $n=3$, and so

$$\frac{dy}{ax}=3(4x+0)^2=12x^2.$$

Again, if $y=12\cos(-2x+7)$, the differential coefficient is determined by the use of (3), the values of the constants being $a=12$, $n=-2$, $b=7$, and so

$$\frac{dy}{an}=24\sin(-2x+7).$$

In addition to the formulæ given above, there are certain rules that make it possible to differentiate combinations of functions. In the following, u, v w, etc., are functions of x:

$$y=u+v+w\ \ldots\text{etc.} \qquad \frac{dy}{dx}=\frac{du}{dx}+\frac{dv}{dx}+\frac{dw}{dx}+\ldots\text{etc.} \qquad (6)$$

$$y=u,\ v,\ w\ldots\text{etc.} \qquad \frac{dy}{dx}=\frac{du}{dx}(v,w\ldots)+\frac{dv}{dx}(u,w\ldots)+\frac{dw}{dx}(u,v\ldots)+\ldots\text{etc.} \qquad (7)$$

$$y=u/v \qquad \frac{dy}{dx}=\left(v\frac{du}{dx}-u\frac{dv}{dx}\right)/v^2 \qquad (8)$$

For example, if $y=(x+1)\sin(2x-1)$, this is dealt with by means of (7), and

$$\frac{dy}{dx}=\frac{d(x+1)}{dx}\sin(2x-1)+\frac{d[\sin(2x-1)]}{dx}(x+1).$$

Using (1) and (2) this becomes—

$$\frac{dy}{dx}=\sin(2x-1)+[2\cos(2x-1)](x+1).$$

Variables

In accordance with established convention, the preceding examples have used x and y as the variable quantities. In engineering problems it very often happens that one of the variables is time measured from some selected instant. For example, the distance of a moving point from some fixed point may be denoted by s. The instant under consideration may be defined as t units of time later than some particular instant. Then the rate of change of s with t is the rate of change of the distance of the moving point from the fixed point, and this is what is known as the "velocity" of the moving point relative to the fixed point.

Hence the differential coefficient of distance with respect to time—or $\frac{ds}{dt}$—is the velocity of the point. Similarly the differential coefficient of velocity with respect to time—or $\frac{dv}{dt}$ where v represents velocity—is the acceleration of the point. Incidentally since $v=\frac{ds}{dt}$, the acceleration $\frac{dv}{dt}$ is $\frac{d}{dt}\left(\frac{ds}{dt}\right)$, which is written $\frac{d^2s}{dt^2}$ and is the *second* differential coefficient of s with respect to t.

If the relation between s and t can be expressed mathematically, velocity and acceleration at any instant can thus be determined by means of the differential coefficients.

Example in Kinematics

If in a reciprocating engine the crank-throw is r, and the length of the connecting rod is L, the distance of the cross-head pin from the centre-line of the crankshaft is (very nearly)

$$s=L-\frac{r^2}{4L}+r\cos(6.28nt)+\frac{r^2}{4L}\cos(12.56nt)\ldots \qquad (9)$$

where r is the speed of the crankshaft in revolutions per second and t is the time in seconds from an instant at which the crank is on inner dead centre.

On differentiating this expression with respect to t, the quantity $L=\frac{r^2}{2L}$ disappears because L and r being constant, their rate of change is zero. The other two terms are dealt with by use of (3) and

$$\frac{ds}{dt}=-6.28nr\sin(6.28nt)-12.56\frac{nr^2}{4L}\sin(12.56nt) \qquad (10)$$

This represents the velocity of the cross-head pin at any instant defined by the value of t.

Differentiating (9) with respect to t.

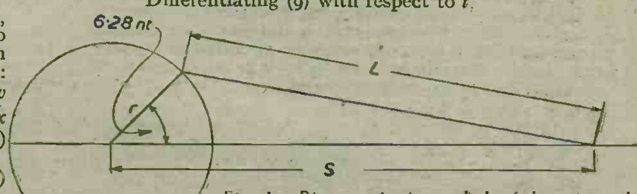


Fig. 1.—Diagram showing methods of determining the velocity and acceleration of a cross-head pin.

$$\frac{d^2s}{dt^2}=-(6.28n)^2r\cos(6.38nt)-(12.56n)\frac{2r^2}{4L}\cos(12.56nt) \qquad (11)$$

This represents the acceleration of the cross-head pin at any instant defined by the value of t.

The simplest alternative method of determining velocity and acceleration of the cross-head pin is a graphical one

(Fig. 1). The positions of the crank-pin, after suitable equal intervals of time, are marked on the circle representing its path. The corresponding positions of the cross-head pin are determined from these as centres by striking arcs (of radius representing the length of the connecting rod) intersecting the straight path of the cross-head pin. Consequently, the distance through which the cross-head pin moves during any one of the selected short intervals of time can be determined by direct measurement and thus the mean velocity over that interval of time is easily calculated. This may be taken as the velocity of the cross-head pin at the middle instant of the interval concerned.

The acceleration at the beginning of any interval is the difference between the distance covered in that interval and that covered in the preceding interval, divided by the square of the interval.

The graphical method is thus simple in principle, but it has to be carried out with great accuracy if the result (particularly the figure for acceleration) is to be reliable.

Use of the calculus makes it easier to attain a high standard of accuracy.

Maxima and Minima

When a quantity varies, it often does so in such a way as to attain one or more maximum or minimum values. For example, the velocity of a cross-head is zero at each end of its stroke and attains a maximum value somewhere near the middle of the stroke. If the changing values of any such quantity are expressed graphically (as, for example, variations of atmospheric pressure are traced by a recording barometer), the maximum and minimum values, and the positions they occupy, can be seen at a glance. If, however, the variations of the quantity can be expressed mathematically, the differential calculus may be used to ascertain maximum and minimum values and where they occur.

When a quantity is increasing, its value at any instant is greater than it was at a slightly earlier instant, so that the change in value between the earlier instant and the later one has been positive. The change in time from one instant to a later one is also positive. Consequently, the rate of change of the quantity with time is positive because it is equal to a positive quantity divided by a positive quantity.

Similarly, when one quantity is decreasing, whilst another one is increasing, the rate of change of the former with respect to the latter is negative.

If a quantity is increasing during one interval of time and decreasing during an immediately following interval, there will be some instant at which it is neither increasing nor decreasing, because it has just finished increasing and is just about to begin decreasing. At that instant the quantity has a maximum value.

Similarly an instant that lies at the end of a period of decrease and the beginning of a period of increase, marks a minimum value of the varying quantity.

At any such instant the rate of change (the differential coefficient) is neither positive nor negative, but is zero. It may be concluded, therefore, that when the differential coefficient of A with respect to B is zero, A has either a maximum or a minimum value. Conversely, to ascertain *when* A has a maximum or minimum value it is only necessary to determine when its differential coefficient is zero. To decide whether any one of these "stationary values" is a maximum or a minimum, a little more work has to be done.

In the neighbourhood of a maximum value the rate of a change is first positive, then zero at the maximum, and then negative. In other words the rate of change is decreasing in the neighbourhood of a maximum, or again, the rate of change *of* the rate of change is negative at a maximum value. Conversely the rate of change *of* the rate of change is positive at a minimum value.

In this way it is possible to decide whether any particular value that makes the rate of change zero is a maximum or a minimum.

Example of Determination of Maxima and Minima

These points may be illustrated by considering the previous "Example in kinematics." While the crankshaft rotates, the value of s, the distance from crankshaft to cross-head pin, is continually varying. Has it any maximum or minimum values? The geometry of the mechanism makes it clear that the answer is "Yes," but it is instructive to consider how the differential calculus answers the question.

The variation of s with time will have a maximum or minimum value if $\frac{ds}{dt}$ ever becomes zero. Now the value of $\frac{ds}{dt}$ at any instant is given by equation (10) and for the easier understanding of what follows, the quantity $\sin(12.56nt)$ is replaced, according to a standard trigonometrical transformation, by $2\sin(6.28nt)\cos(6.28nt)$. After further simplification (10) becomes

$$\frac{ds}{dt} = 6.28nr\sin(6.28nt)\left[1 + \frac{r}{L}\cos(6.28nt)\right] \quad . \; . \; (12)$$

Similarly (11) becomes

$$\frac{d^2s}{dt^2} = -(6.28n)^2 r\left[\cos(6.28nt) + \frac{r}{L}\cos(12.56nt)\right] (13)$$

Examination of (12) shows that $\frac{ds}{dt} = 0$, when $\sin(6.28nt) = 0$, that is, when $6.28nt = 0,\ 3.14,\ 2 \times 3.14$, etc., or when

$$t = 0,\ \frac{1}{2n},\ \frac{1}{n},\ \frac{3}{2n},\ \text{etc.}$$

and since n is the number of revolutions per second, $\frac{1}{n}$ is the number of seconds per revolution. Consequently the values of t correspond to 0, ½, 1, $^3/_2$, etc., revolutions of the crank from the inner dead centre. In other words, the maximum and minimum distances of the cross-head from the crankshaft occur when the crank is at the inner and outer dead-centres.

To determine the values of these maxima and minima and to use the calculus method of showing which is which, the various values of $6.28nt$ are inserted in (9) and (13), with the following results:

$6.28nt$	0	3.14	2×3.14	3×3.14
$\sin(6.28nt)$	0	0	0	0
$\cos(6.28nt)$	1	−1	1	−1
$\cos(12.56nt)$	1	1	1	1
s	$L+r$	$L-r$	$L+r$	$L-r$
$\frac{d^2s}{dt^2}$	$-(6.28n)^2r \times \left(1+\frac{r}{L}\right)$	$-(6.28n)^2r \times \left(-1+\frac{r}{L}\right)$	$-(6.28n)^2r \times \left(1+\frac{r}{L}\right)$	$-(6.28n)^2r \times \left(-1+\frac{r}{L}\right)$
Sign of $\frac{d^2s}{dt^2}$	−	+	−	+

As the nature of the mechanism is such that $\frac{r}{L}$ is less than 1, the sign of $(-1+\frac{r}{L})$ is negative.

It will be seen that the stationary values of s are alternately $L+r$ and $L-r$, and the signs of $\frac{d^2s}{dt^2}$ agree that these are maxima and minima. From the geometry of the mechanism it is obvious that these values are correct, but the calculus method of determining maxima and minima can often lead to results that could not be derived in any other way.

For example, suppose that it were required to know the maximum velocity of the crank-pin. This occurs (since velocity $= \frac{ds}{dt}$) when $\frac{d^2s}{dt^2} = 0$ and from (13), this is the case when

$$\cos(6.28nt) + \frac{r}{L}\cos(12.56nt) = 0 \quad . \; . \; . \; (14)$$

By use of the trigonometrical identity $\cos 2A = 2$

$\cos^2 A - 1$, equation (14) is converted, after some re-arrangement into

$$\cos^2(6.28nt)+\frac{L}{2r}\cos(6.28nt)-\tfrac{1}{2}=0$$

whence

$$\cos(6.28nt)=-\frac{L}{4r}\pm\sqrt{\left(\left(\frac{L}{4r}\right)^2+1\right)} \quad \ldots \quad (15)$$

Of the two values suggested by (15), the one involving two minus signs is inadmissible since it would make the cosine less than -1. The remaining value gives two values of $(6.28nt)$ less than 360 deg., or in other words two different angular positions of the crank corresponding to maximum or minimum velocities of the cross-head.

To take a numerical example, let $L=4r$,
when $\cos(6.28nt)=-1+\sqrt{2}=0.414$,
and from trigonometrical tables
$6.28nt=65°\ 32'$ or $-65°\ 32'$.

To decide whether these angles give maximum or minimum velocities, the sign of the differential of $\frac{d^2s}{dt^2}$, i.e. $\frac{d^3s}{dt^3}$ is considered.

Differentiating (13) with respect to t,

$$\frac{d^3s}{dt^3}=(6.28n)^3 r\left[\sin(6.28nt)+\frac{2r}{L}\sin(12.56nt)\right]$$

When $6.28nt=65°\ 32'$, both terms inside the square bracket are positive and therefore $\frac{d^3s}{dt^3}$ is positive, so that the velocity of the cross-head pin for that crank position is a minimum. As will be seen presently the velocity is then negative (i.e., towards the crankshaft), and so an algebraic minimum velocity from the crankshaft means a numerical *maximum* velocity *towards* the crankshaft

When $6.28nt=-65°\ 32'$, both terms inside the square bracket are positive and therefore $\frac{d^3s}{dt^3}$ is positive, so that the velocity of the cross-head pin for that crank position is a maximum from the crankshaft.

The actual velocities are obtained by use of (12), thus—

$$\frac{ds}{dt}=-6.28nr\sin 65°\ 32'\left[1+\frac{1}{4}\cos 65°\ 32'\right]$$
$$=-6.32nr$$

and

$$\frac{ds}{dt}=-6.28nr\sin(-65°\ 32')\left[1+\frac{1}{4}\cos(-65°\ 32')\right]$$
$$=6.32nr.$$

The two velocities are thus equal and opposite and are slightly greater than the crank-pin velocity which is $6.28nr$. The maximum (maximum outward) and minimum (minimum inward) velocities occur when the cross-head is at a distance from the crankshaft centre line determined by use of (9), thus —

$$s=L-\frac{r^2}{4L}+r\cos 65°\ 32'+\frac{r^2}{4L}\cos 131°\ 4'$$

and writing $L=4r$, this becomes

$$s=4r-\frac{r}{16}+0.414r+\frac{r}{16}(-0.657)$$
$$=4.311r.$$

The extreme distances of the cross-head pin from the crankshaft centre-line are $L-r=3r$, and $L+r=5r$, so that these maximum velocities occur not at mid-stroke (which is $s=4r$) but at a point further away from the crankshaft than mid-stroke.

Calculus of Small Differences

A knowledge of the differential coefficient of one quantity B with respect to another A makes it possible to calculate by how much B will change when A is changed by a small amount, or *vice versa*. The differential calculus is not essential for such calculations, but it is very often more accurate than the more elementary method.

For example, let a quantity y be connected with a quantity x by the relation—

$$y=6\sin x.$$

Now suppose that it were asked, "If y changes from the value 4 to the value 4.01, by how much does x change?" To answer this problem directly it would be necessary first to find the original value of x from

$$\sin x=\frac{4}{6}$$

then to determine the second value of x from

$$\sin x=\frac{4.01}{6}$$

and then to obtain the difference between the two values of x by subtraction. Trigonometrical tables would be needed and interpolation would be required. By use of the principles of the calculus, however, a formula can be derived for easy and more accurate solution of this problem without using trigonometrical tables.

Thus $$\frac{dy}{dx}=6\cos x=6\sqrt{(1-\sin^2 x)}$$
$$=6\sqrt{\left(1-\left(\frac{y}{6}\right)^2\right)}=\sqrt{(36-y^2)}$$

Now $\frac{dy}{dx}$ is (very nearly) the ratio between any small change Δy in y and the corresponding small change Δx in x, i.e.—

$$\Delta y=\left(\frac{dy}{dx}\right)\Delta x$$

or

$$\Delta x=\frac{\Delta y}{\left(\frac{dy}{dx}\right)}=\frac{\Delta y}{\sqrt{(36-y^2)}}$$

If the initial value of y is 4 and the new value 4.01 then

$$y=4.01-4=0.01, \text{ and so}$$
$$x=\frac{0.01}{\sqrt{(36-16)}}=0.00224.$$

In this formula the value given to the y in the denominator is the initial value 4. It is more accurate to use the value 4.005 half-way between the initial value 4 and the new value 4.01, but the gain in accuracy in this case is not worth the extra trouble involved in squaring 4.005 as compared with squaring 4.

This calculation is an example of the use of the "calculus of small differences," a branch of mathematics which makes use of the fact that although a differential coefficient is strictly the ratio between two *infinitely small* quantities, it is very nearly the same thing as the corresponding ratio between two quantities that are small but not infinitely small. Its advantage is that it shows how to calculate a difference directly instead of by the obvious, but less accurate, method of subtracting one quantity from another that is not much different.

(To be continued.)

BRITISH LONG DISTANCE LISTENERS' CLUB

The S.W. Station Register. Area Allocation. Correspondence

The S.W. Station Register

THE B.L.D.L.C. checking stations are now in operation. This brief announcement reveals an important step forward in the club's activities; it is the first time in its history that its members have taken part in a nation-wide co-operative operation, and in it we see the beginning of an ambitious programme of worthwhile contributions by the B.L.D.L.C. to the progress of the amateur movement. To the many who volunteered to undertake an active part in the preparation of the S.W. station register we extend our thanks, although this has already been done individually by letter to those members who have been selected to take part in the work.

It is unfortunate that many applications were received from certain areas, while from other districts response was poor. To achieve the greatest results from the idea it is necessary to avoid " grouping " of stations in certain parts of the country, and leaving other sections, so to speak, unattended. To obtain more even distribution we are still prepared to receive applications from enthusiastic members in the following counties:

Cornwall, Devon, Somerset, Wilts, Hampshire, Sussex, Suffolk, Norfolk, West, East and North Riding, Carmarthen, Cardigan, Merioneth, Cærnarvon and Scotland. Those interested in taking part in this interesting and most useful work should get in touch with us as early as possible, giving the details mentioned in the February issue of PRACTICAL WIRELESS.

Area Allocation

WILL all members note that for record and control purposes, we have divided England, Scotland and Wales into areas, each of which is approximately 40 miles by 30 miles. These areas have been given identification letters, and it would assist greatly the organisation if members would use the letters applying to the areas in which they reside, in conjunction with their membership numbers. For example, in place of the old method of simply giving their number, say, No. 1234, it will help considerably if it is now given as—using the same imaginary number —No. 1234, L.G., or whatever the area letters are.

How do you know your letters? Well, we cannot publish the names of towns and villages in each area, neither can we undertake to communicate with every member of the club—bearing in mind the number now serving in the Forces, etc. —therefore, for the present, we can only ask those members who would like their area letters to drop us a postcard saying so, and we will deal with it as quickly as possible. So far as members are concerned, it will enable them to see at a glance if any member quoted or mentioned on these pages is in their area, thus enabling them soon to determine their nearby fellow-members. The system has, of course, more important advantages than that, but more about that later. In the meantime send in your p.c., or mention the matter in your next letter.

Wakefield

R. HAIGH, No. 7201 G.E. (note area) has sent us a sketch of his den, which we have reproduced below. Here is his description:

" Since my last report I have been engaged in modernising my station. It now appears as shown in the illustration on this page.

" The RX is still on 0-v-2, and is putting up a fine show. The desk at the left houses ' spares ' and power supply. The ' mike ' is entirely home-built (from the article in PRACTICAL WIRELESS, June, 1942) and when used with the mixer panel on the desk, is capable of fine results. A 3-valve amplifier is incorporated in the Rx cabinet. The bookcase at the side of the desk holds several of your splendid books, including ' P.W. Encyclopædia.' The switch on the front of the desk controls the light over the map.

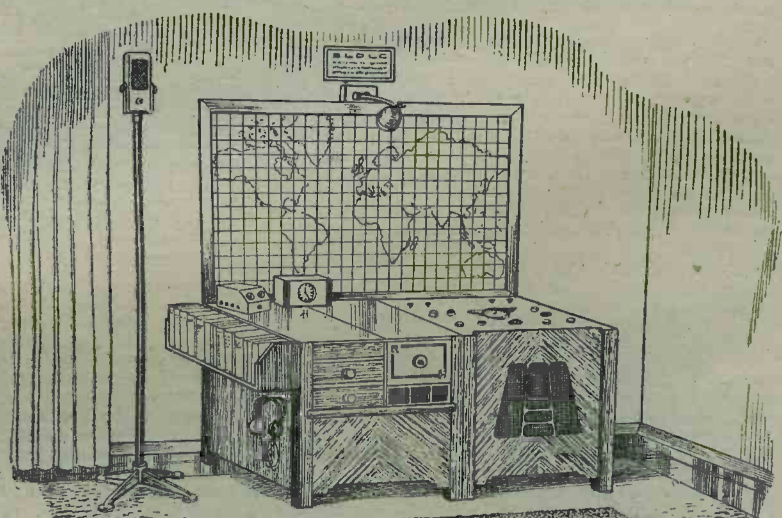
" Recently I experimented (*indoors*) with a 3ft. vertical aerial made with brass rod. To my surprise I received stations WNBI, WBOS, WRCA, India and Italy on full L.S. volume.

" I would be pleased to hear (via headquarters) from other members in my area.

" Well, here's wishing the club and PRACTICAL WIRELESS continued success."

Langold

R. W. IBALL, No. 7065 H.E., has a few more words to say again about the R.S.T. Code and its use.



The compact layout of the station operated by Mr. R. Haigh of Wakefield

We have noted his remarks about getting the matter cleared up, and, as soon as space permits, we will deal with it in detail, though there is little we can add to that which has already been said by E. H. Trowell, No. 5932 L.G. This is what No. 7065 H.E. has to say:

"I can add but little to E. H. Trowell's (5932) remarks on the R.S.T. code. My thanks to him for pulling me up and correcting me. Most SWL's, however, use that 'R' method of quoting the signal strength of a transmission. It appears to be an established custom and would take a lot of uprooting. I should add that during pre-war days this listening post used the R.S.T. code for CW transmissions, and for 'phone (speech) the "R" method in question, when reporting to 'amateurs' on all bands without being pulled up over it. Anyway, an editorial on the matter by you is needed to clarify the situation.

"Members 7217 and 7064 have come across the old mystery station gag again. It is my opinion that all bona fide transmissions give full identification, etc., and any station not doing so must be taken with the proverbial grain of salt. In these cases it is best to listen to the news bulletins and talks to determine their policy. Radiós Mexicali, Metropole are examples of non-bona fide stations. On the evening of President Roosevelt's speech many American stations carried full reports of it. These big events sometimes provide new stations for the SWL's log. This event provided me with four new ones. They are: WBA 30.78 m., WHL5 30.43 m., WCL 31.89 m. and WDJ 39.40 m. Later I logged WDL 30.89 m. The frequencies are approximate as the announcements only gave the frequency band, i.e., '30 m. band.'

"Any further details will be appreciated of those stations and the following:

"Delhi 49.85 m. (approx.), heard once on January 1st at 14.40 G.M.T. to 15.17 G.M.T. Relayed B.B.C. news at 15.00 and giving call as 'Delhi calling.' After announcing the next programme it suddenly closed down.

"HEO3 39.90 m. (approx.), calling COT Lisbon, at 09.40 G.M.T.

"That's all for now, so I'll sign off."

What Do You Say?

G. A. LOCKIE, No. 8040 C.D., of Kelso—a very active member—wants to know if any member can identify the transmission he describes in the following letter:

"I wonder if any reader heard on February 2nd or could help me with a station I received.

"After trying the short waves with hardly any success, I switched on to the medium waves. At 9.30 p.m. G.M.T. on 322 m. I received a station about R4-5; there was slight interference from other stations. The announcer said, 'This is the voice of America being heard over WDL in the 30-metre band. This is part of our English language programme, and now here is the Bob Hope programme.' The station grew to be fairly strong during this programme, but later the station faded out altogether."

In another letter the same member gives some very interesting details concerning an Australian transmission. He says:

"I have two items which may interest readers. First, in my letter in the August issue I said I received VLG7, which was often very strong, also Mr. Kahan said he had received it, in the September issue. I must say I got a bit of a surprise when I received an official verification from Australia stating that the transmission I had heard was an Australian domestic programme of the A.B.C., relayed on short wave to listeners in the North of Australia, and is one of those freakish things that can be heard in places and at times most unexpected.

"The other item is that Mr. W. Harris has been appointed Director, Radio Communications Anglo-American Caribbean Commission in Washington, D.C. Mr. Harris is best known as the 'Vagabond Traveller of W.R.U.L.' He said in his letter that, unfortunately, his programme is now only heard on a Latin-American beam, over station WRUL each Sunday at 12 midnight."

Crystal Set Improvement

J. H. WOODWARD, No. 7250 H.D., of Stoke-on-Trent, would like to see more experiments carried out with crystal set design. The desire is quite sound, but, unfortunately, the effectiveness of a crystal detector is limited by its sensitivity as a detector, and until this can be improved, the simple crystal set must remain a short range receiver so far as telephony is concerned. With the increase in power of many transmitters during the last few years, results and range of these sets have improved, but much depends on local conditions, absence of interference and efficiency of aerial.

Here are J. H. W.'s remarks:

"I was interested in the recent notes by F. G. Rayer and K. T. Hardman on the subject of crystal reception. I have been experimenting for a while on crystal sets, but, so far, have achieved no spectacular results. The main object of my letter is to ask whether any fellow-readers of PRACTICAL WIRELESS have had a crystal set working on portable lines, i.e., frame aerial, etc. I have received a few stations, including Continentals, using the wire mattress of my bed as an aerial. I consider there are distinct possibilities of achieving worth-while results from a modern version of the humble crystal set. The above notes refer mainly to headphone reception, and I am surprised that in times like these more experimental work is not carried out with crystal sets, especially in view of the need for the strictest economy.

"As regards B.L.D.L.C. activities, I have nothing to report at present. I have been lucky in obtaining a collection of pre-war components so I hope to make some progress in the near future as I am building a three-valver of my own design. I made the 'Rapid Two' and I must say its performance is very creditable. As for PRACTICAL WIRELESS, I say keep it going and the sooner we have it every week the better."

Your Last Letter

WHEN did you last write to give us details about your radio activities?

One of the chief objects of the club is to provide help and interest to all its members by the interchange of ideas, experiences, experiments and logs. This very important object depends on you, and all other members individually. If you do not write to headquarters, say, every month or six weeks, how can we tell if you are still taking an active part in radio, and, what is even more important, how can we pass along—through these pages—any information of general interest connected with your experiments, logging or constructional work?

You may have noticed that the names of certain members frequently appear on these pages: they write to us regularly, or, in other words, they are very keen supporters. We do, however, fully realise that most members have had their leisure hours seriously curtailed, and that letter writing is not always so easy, in spite of good intentions, but, even so, if you haven't been in touch with us lately, try to make a special effort to let us know how things are going.

The A.C.R. Certificate

WE have received several inquiries as to whether the A.C.R. Certificate is still being awarded. As most of you already know, this certificate is awarded to those members who have received verifications from stations on the five continents. The present is, of course, not the best time to expect or to try to obtain such verifications; in fact, we advise members to *refrain* from sending reports to stations overseas during the existing conditions. However, the award is still in force, but owing to paper restrictions, etc., we have substituted a letter in place of the certificate. When, once again, supplies become normal, we will exchange the A.C.R. Letter for the proper and more imposing A.C.R. Certificate.

If you wish to know which area you are in don't forget to send us a letter or postcard.

Impressions on the Wax

Review of the Latest Gramophone Records

H.M.V.

I DO not remember Yehudi Menuhin making any recordings with his sister as collaborator; therefore I think I am quite right in saying that the two *H.M.V.* records *DB*3552 and 3553 form a "first recording" of Yehudi and Hephzibah Menuhin as duettists. They have selected that delightful work by Mozart—"Sonata No. 34 in F for Violin and Piano (K.376)" which they render with perfect understanding and technique.

Another exceptionally fine record is *H.M.V. C*3328, on which is recorded Elgar's "Pomp and Circumstance March No. 1 in D Major" and "No. 2 in A Minor." The recordings have been made by the Toronto Symphony Orchestra, under the conductorship of Sir Ernest MacMillan, one of Canada's foremost musicians. The works are dignified, martial and exciting and, speaking for myself, I contemplate stately processions, pageantry and the rousing call of the trumpets. The presentation by the Toronto Symphony Orchestra is an outstanding piece of work.

Maggie Teyte—soprano—with Gerald Moore at the piano, has recorded, in French, "En Sourdine" and "Ici Bas" on *H.M.V. DA*1830. A delightful recording of a beautiful voice.

Two voices, which individually are delightful, do not always constitute the perfect medium for the rendering of a duet. Balance, blending and perfect understanding in a musical sense are vitally essential if two singers are to produce between them a vocal duet worthy of comment. Anne Ziegler and Webster Booth form an outstanding example of all that is required to produce the perfect duettists. Their voices—individually exceptionally fine—blend and balance to a perfect degree and their performances together reveal their complete harmony and sound technique.

On their latest record they give us two more fine performances. They render—with orchestra—"Tomorrow" and "Love Me To-night" from "The Vagabond King" with all their usual artistry and skill. It is, of course, an *H.M.V.* record, the number being *B*9311.

Joe Loss and his Orchestra make a good record this month with "Love Alone"—waltz—from "The Belle of New York" and "My Devotion"—a slow foxtrot, *H.M.V. BD*5788.

Another good investment is the latest recording by the R.A.O.C. Blue Rockets Dance Orchestra, as they put up a fine show with "We Mustn't Miss The Last Bus Home" linked with "Love Is A Song" on *H.M.V. BD*5785.

Leslie A. Hutchinson or, as he is more widely known, "Hutch," gives us "Nightingale" and "Serenade in Blue" with himself at the piano. The record is *H.M.V. BD*1030.

Columbia

THE highlight of the Columbia releases for this month is their first recording of the Liverpool Philharmonic Orchestra. This orchestra was founded in 1840, and is one of the oldest concert-giving organisations in existence; it has for its leader none other than the famous violinist, Henry Holst.

It is fitting that Constant Lambert—as guest conductor—should be conducting the orchestra for their first recordings, as he has made a life study of the Russian composers, and the work selected for the records is one of, if not the most, outstanding compositions by Alexander Glazounov, namely, his symphonic poem "Stenka Razine."

Constant Lambert and the Liverpool Philharmonic Orchestra give us a most magnificent performance of this striking work which has, as its main theme, a fragment of one of the most famous Russian folk melodies, the "Song of the Volga Boatmen." In "Stenka Razine" we have a legend of a brigand who sacrificed a beautiful princess to the river Volga, and it is this great waterway—which is now surrounded by the heroic deeds of the Red Army—which forms, so to speak, the main pillar of the work. There are two records, the numbers being *Columbia DX*1107 and 1108.

A delightful record by the ever popular Sandler Trio is *Columbia DB*2105 on which they have recorded "Ghosts of Old Vienna" and "The Night Has Eyes."

Two favourites of mine and, I am sure, of many other record enthusiasts, are Rawicz and Landauer, the two noted piano duettists. This month they offer us Gershwin's famous work—arranged by themselves—"Rhapsody In Blue" and I give it every recommendation. It is on both sides of *Columbia DB*2104.

Victor Silvester and his Ballroom Orchestra excel with "I'll Come to You"—founded on the famous melody "Chanson Bohemienne" and "All I Need Is You" these being in strict waltz and quickstep tempo respectively. The number ?—*Columbia FB*2891.

"Moonlight Becomes You"—from "The Road to Morocco" and two numbers from "Yankee Doodle Dandy"—(a) "Yankee Doodle Boy" and (b) "Mary's A Grand Old Name," form the contribution from Carroll Gibbons and the Savoy Hotel Orpheans, and a nice contribution it is. *Columbia FB*2889.

"St. Louis Blues" linked up with "Crazy Rhythm" are the names of the two pieces played by Felix Mendelssohn and his Hawaiian Serenaders on *Columbia FB*2882. Maybe it is that I don't appreciate Hawaiian music in modern style, or the work that has been done by Felix in introducing the innovation in this direction. Be that as it may, I still like to hear Hawaiian guitars, etc., playing the melodies which one links with the islands in the Southern seas.

Parlophone

THE record I place first in the *Parlophone* 12in. series this month, is *RO*20518. On it, we have two more examples of the artistry and technique of Richard Tauber. He has selected for these recordings "No More I'll Be Singing," Op. 6, No. 2 (Tysh-Tchaikovsky) and "None But The Weary Heart," Op. 6, No. 6 (Goeth-Tchaikovsky) which he sings in English with orchestra. A fine record of a fine singer.

"Every Night About This Time" and "I Met Her On Monday"—both foxtrots—are played by Geraldo and his Orchestra on *Parlophone F*1964. Two nice little numbers well presented. *Parlophone F*1962 is another good disc. Carter and Evens—two voices and a piano—offer us "Ol' Banjo" and "We'll Smile Again" in a snappy attractive manner.

The super rhythm fans will appreciate *Parlophone R*2862, which is No. 64 of the 1943 Super Rhythm-style Series. On it, Count Basie and his Orchestra put up a hot performance of "Twelfth Street Rag" and "Taxi War Dance."

Open to Discussion

The Editor does not necessarily agree with the opinions expressed by his correspondents. All letters must be accompanied by the name and address of the sender (not necessarily for publication).

Midget Universal Receiver

SIR,—With reference to your circuit of an A.C./D.C. receiver published in the January issue, I wish to inform you that I have constructed this receiver, and the set is giving 100 per cent. results, with perfect tone and volume equal to any commercial receiver I have tried, combined with perfect smoothing and no interference whatsoever. I only modified the circuit as regards the valves, using 6D6, 6C6, OM9 and 2525, and have screened the 2RF stages. At present I have two moving-coil speakers in parallel owing to the large output it gives without any distortion. I congratulate the designer on a most efficient and economical set.—C. BUCKLEY (Egham).

Identification Wanted: Station PMA

SIR,—I would be pleased if any reader can identify a station received in the middle of the 25 m. band, about 15 k/c below a German station. The interval signal was three notes on a piano, and the programme, which finished at 24.00 G.M.T., was entirely speech in a foreign language.

Readers may be interested to know that PMA is now called "Radio Nāchāfkā," as the Japanese have renamed Batavia. Radio Accra, 19.6 ? m., could be heard testing each morning between December 21st and 26th. PPQ, formerly a C.W. station, was heard on November 1st, 1942, calling WCW and WEE, and asking for a time-check and point-to-point transmission. All reception was on a modified Fleet S.W. Two. I would like to see more interest shown in commercial C.W. stations, as they are a great help to those learning Morse by themselves. My receiving speed is under 12 w.p.m. but I have been able to log 42 countries in the last six months on C.W. alone.

Finally, I would like to find out what ZHC, ZRK, ZOK (with or without a question-mark) mean, as they are used by most countries and thus cannot be secret.—D. B. TAYLOR (Hale).

Logged on a 1-v-2

SIR,—Here is a list of some short-wave stations picked up lately which might interest a few readers. My set is a 1-v-2 battery-operated receiver, working a loudspeaker.

Besides the usual Yanks I picked up WHL6 operating on the 22-metre band. This seems to work with WLWO on the "Voice of America" system. WHL5 on the 30-metre band, and WYW giving news at 23.00 from 970. WGEA seems to have replaced WGEO on the 25-and 31-metre bands. FXE, Radio Levant, Beirut, Syria, gives news at 18.20, 37.34 metres. Batavia has news at 12.00 on 16.6 metres. Radio National, Rio de Janeiro, Brazil, PRL8, operating on 25.6 metres, comes in extremely well about 21.30. Announcer John Adam. All times are B.S.T.—S. HUDSON (Cambridge).

An Appreciation

SIR,—I am somewhat of a beginner in radio, as I have taken an interest in it only since I joined the R.A.F. Although not engaged on the radio side, I am able to get plenty of information on points that puzzle me, from our wireless mechanics. My own job is that of a fitter, but at night *when* we finish there is a Radio Brains Trust held around my bed.

We are all very grateful for the series of articles you have started in the February issue entitled "Elementary Electricity and Radio," by J. J. Williamson.

I regret that I shall be unable to supply any regular listening information as it is impracticable to build anything except during my leave periods.—E. D. NELSON (Stoke Newington).

The Harkness Circuit

SIR,—I was very interested in the letter from Mr. N. A. Webb (York) appearing in the March issue of PRACTICAL WIRELESS *re* some of the old circuits, and especially the "Harkness circuit," of which you print a theoretical diagram.

I, too, made this set and, like Mr. Webb, I placed the two tuned circuits at each end of set with the two H.F. transformers directly connected to its variable condenser by one of the holding-down nuts of the bottom plate.

For purity and strength of signals I have never made or heard its equal in a 0.1.0. By a curious chance I picked up the circuit from the floor of a railway carriage, torn from the pages of a technical journal. I found later it was designed by an American radio engineer—a Mr. Harkness—and though many English amateurs had tried it, very few had succeeded in getting satisfactory results.

I should be grateful if Mr. Webb could give me the number of turns of wire on P. and S. of H.F. transformers, as I should like to make it again.—W. E. BODELL (Romford).

Replies to Queries

Home Recording

"I have been experimenting for some time on the problem of home recording with a 'mike' and an amplifier with an output of about 10 watts, on old records softened by steam from a kettle without as much as a solitary scratch being recorded.

"I should be very grateful for any information and help you may be able to give me on the following :

"How I could make a cutting head (I believe this is the name for the device used for holding the cutters) ? How could I make a cutting needle ? How I could make some sort of a feed across the disc when rotating ? The names of one or two firms dealing in the ready-made article ? Better disc softening method ?

"I realise that this is a lot to ask, but should be very much indebted for your co-operation."—R. F. R. (Southampton).

A GOOD make of pick-up can be used as a cutting-head provided it is connected to the amplifier through a choke-filter output, or a suitable output transformer. We would not advise you to attempt to make a cutting-needle. It is better to buy one of the specially hardened steel or sapphire types. The mechanical drive necessary to secure a correct tracking is rather difficult to make, unless you are experienced in thread-cutting; therefore we think it would be better if you decided to purchase the necessary equipment when such is again available.

Messrs. Electradix Radios, of 19, Broughton Street, Queenstown Road, London, S.W.8, might be able to offer you suitable parts at a reasonable price.

We do not recommend your methods of producing record blanks, as they cannot be satisfactory, and we would advise you to use some of the specially prepared "blanks" when supplies are better.

The £4 Superhet

"Will you please let me know what are the suitable Mullard valves for the £4 Superhet 4 ; also are the I.F. transformers still available ? If not, will the Varley BP122 and BP123 do ? Are coils to be had for 'Acme Allwave 4' ? Give address of suppliers, also address of Messrs. Wearite (Unigen coils)."—G. H. (Rhiw).

THE valves specified for the £4 Superhet are Cossor, 210 PG, 210 VPT, 210 Det., 220 PT. Suitable Mullard alternatives are FC2, VP2, PM2HL, PM22A.

The I.F. transformers are Eddystone, type No. 674, having a frequency of 465 kc/s. Messrs. Wright and Weare, of High Road, Tottenham, London, N., are also the makers of the coils for the "Acme" receiver, but we understand that they are now no longer obtainable. We would suggest that you modify the circuit to enable plug-in S.W. coils to be used.

General Purpose Valves

"I would be very much obliged if you could enlighten me on a subject about which I know very little. I am a newcomer to wireless, and though I may not know a great deal about the subject I am very interested in it, so much so that after looking through Mr. F. J. Camm's book, 'Sixty Practical Wireless Circuits,' I decided I would like to make a set of my own. The only thing of which I am short is valves. Now I have read about many circuits in which 'almost any general-purpose triode will do.' The trouble is when I enter a wireless shop they ask me the number of the valve and the maker. So could you please tell me a few makes and numbers of general-purpose valves, particularly for the valves in Circuits Nos. 7, 14 and 15 ? For instance, I see advertised in this month's 'Practical Wireless,' Tungsram H.R. 210 general-purpose valves. Would these valves be suitable for Circuit No. 7 ? Also I see advertised permanent detectors. Are these the kind as used in Circuit No. 3, comprising two crystals in contact ?"—D. D. W. (Yorkshire).

A GENERAL purpose valve has an impedance between 15,000 and 20,000 ohms, and these values will usually be found in the H.L., H.F., or Det. types of valves. For example, you could use a Cossor 210 H.L., 210 H.F., or 210 Det. The Tungsram H.R. would also be quite satisfactory.

A permanent crystal detector will be quite satisfactory for Circuit No. 3.

Ganging Circuits

"I seem to remember having read that it is possible to gang straight sets (say a 1.V.1. bandpass) by means of a milliammeter. If so, I should be glad of your advice or perhaps by another method *other* than the usual aural method.

"My difficulty seems to be with every set I have built or attempted to adjust for others these days that I can never get the middle trimmer of a 3-gang condenser down tight enough when bandpass coils are used."—N. C. (Surrey).

IF a low reading milliammeter is connected in the anode circuit of the detector it will serve as a tuning indicator to show when the preceding circuits are accurately adjusted. A better method is, of course, to use a calibrated external oscillator. If, during the adjustments, it appears that additional capacity is required across any one section of the gang condenser, then we would suggest that you try the effect of coupling a small trimmer condenser across the circuit. The component could have a value of, say, 50 mmfd.

Condensers and H.F. Currents

"Being an interested reader of 'Practical Wireless,' I have noticed from your circuits that a condenser from the anode of a detector valve to earth is known as an anode by-pass condenser, for by-passing the R.F. carrier to earth.

"Surely this statement is hardly true, as an R.F. carrier cannot go through a condenser. An R.F. carrier is certainly present at the anode of the detector valve, and has an R.F. choke present to prevent an easy path through the H.T. supply to earth. 'So where does the carrier go to ?'"—D. C. (Dorset).

AN H.F. component does reach the anode of the detector and as you state in your letter, it is usual to include an H.F. choke in the circuit to prevent the H.F. current from reaching the anode of other valves via the H.T. supply. If, therefore, an H.F. choke functions properly, some means must be provided to drain off the unwanted H.F. from the anode. The easiest and most satisfactory method of doing this, apart from the normal reaction circuit in a straight receiver, is to provide a small condenser between anode and earth. An H.F. signal—being A.C.—will most certainly pass through a condenser. A simple and outstanding example is the series condenser which is often incorporated in the aerial circuit of a receiver.

Crystal Set Selectivity

"Can you please let me know the data for making a wave-trap for a crystal set, as I wish to separate the Home and Forces programmes ?"—R. B. (Belfast).

A SIMPLE wave-trap can be made from a coil and variable condenser similar to those which are used in the crystal set, but only the medium wave section is required in your case. The condenser is connected across the coil, and the two components joined in series with the aerial lead-in.

A.C./D.C. Set Defect

"I built a 3-valve A.C./D.C. set a few months ago and it worked until a week ago, when after it had been on about 2 hours, I heard a click from the receiver which then started to smoke. I had a look at the set and I found that the loud-speaker (energised) smoothing coil had become very hot. Since then the set works well but it overheats, especially the loudspeaker and the main resistance. Do you think it is the loud-speaker smoothing coil, and if it is what is the best thing to do ? Is it all right to put a mains resistance in to the mains cord so as the set will be working below its voltage and therefore would not get so hot ?"—J. B. W. (Four Oaks).

THE trouble might be due to a breakdown in the insulation of the wire used for the field of the energised speaker, or a defect in one of the smoothing condensers. It would be advisable to get these components tested for short circuits and/or leakage. We would advise you to leave the mains resistor-cord alone.

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