SHORT-WAVE TWO-VALVER

# Practical Wireless

9D EVERY MONTH

Editor F. J. CAMM

Vol. 19. No. 441. NEW SERIES. MARCH, 1943.

Colour Television: J. L. Baird viewing his latest development which incorporates a new electrical-optical system

Practical Wireless
and PRACTICAL TELEVISION
Editor F. J. CAMM
Vol. XIX No. 441. EVERY MONTH MARCH, 1943.
Staff: L. O. SPARKS. FRANK PRESTON.

COMMENTS OF THE MONTH BY THE EDITOR

# The Battery Shortage

ONE or two magistrates have protested against the battery shortage as it affects cyclists. Large numbers of cyclists have been prosecuted for riding cycles without lights when they have no option, where they live a considerable distance from their homes, but to break the law. Many of them are war workers who have to waste time going to Court to answer a charge of committing an offence which they cannot avoid committing. Some indeed have been stopped whilst on their way to work during blackout, and have thus arrived late, thereby committing another offence. These protests have a wider significance in that they draw attention to the general shortage of batteries, not only for cycle lamps, but for wireless sets. We are glad to know that the Board of Trade have promised to investigate and possibly remedy the matter.

It is almost impossible to obtain certain types of high tension battery, and large numbers of battery sets have, therefore, been out of action for months. It is observed that there are literally dozens of types of high tension batteries, and we think that this is the main cause of the trouble.

Set designers design their sets without reference to standard sizes, and then call upon the battery manufacturers to make a special battery to suit the space available.

With fewer types it is possible that there would be a greater supply, because more people and plant are required to make a large number of types than a smaller number. We are aware certain battery materials are in short supply, and that the demands of the Services must be met first.

After the war we hope that the various component manufacturers will get together and agree on certain standard sizes and capacities. There is no sound reason for such a large variety of types, some of which are too small to yield long life.

## Electrical Industries Red Cross Appeal

MANY of our great national industries have already responded to the appeal of H.R.H. the Duke of Gloucester for the Red Cross and St. John Fund by organising appeals within their industries with gratifying results.

It was felt that the electrical industries should take part in this scheme, and an appeal is now being launched with the widest support of the associations representing all branches of electrical activities, including electrical manufacturers, radio manufacturers, electricity supply undertakings, and wholesalers, contractors and retailers.

At the joint invitation of the associations, Lord Hirst of Witton has consented to act as chairman of the appeal, and a personal letter from Lord Hirst is now being sent out to all units of the industries.

The initial working committee was formed under the chairmanship of Mr. V. Watlington, M.I.E.E. (director of B.E.A.M.A.), with Mr. V. W. Dale (business manager of E.D.A.) and Mr. H. S. Pocock, M.I.E.E. (who initiated the appeal), acting as joint secretaries.

Lord Hirst's appeal letter is accompanied by a statement of the purpose and aims of the appeal, and particular attention is drawn to the advantages of entering into a covenant to subscribe annually for seven years, *or the duration of the war*. By this means whatever sum is contributed is doubled (at the present rate of income tax), because the Red Cross are able to recover the tax. The gross amount is credited to the subscriber as his contribution. Single or occasional donations are, of course, welcome, but they have not this special advantage and do not give the Red Cross the same assurance of a regular annual revenue. The official form of covenant is being sent with each appeal letter.

## Mathematical Tables and Formulæ

A NEW Vest Pocket Book, entitled "Mathematical Tables and Formulæ for Engineers and Technical Students," has just been published from this office at 3s. 6d., or by post at 3s. 9d. The book contains 137 pages, including a 16-page index. Contents include Standard Mathematical Symbols; Mathematical and General Constants; Approximation; Trigonometry; Calculus; Progression; Permutations and Combinations; Interest, Discount and Annuities; Binomial Theorem; Algebraic Identities; Mensuration, Velocity; Acceleration, Force, Energy and Power; Horse Power; Electrical Units; Electrical Equations; Ohm's Law; Heat, Time and Velocity; Pressure; Equivalent Pressures; Water; Force, Energy and Power; Units and Equivalents; English Weights and Measures; Metric System; Metric Conversion Factors; Metric Equivalents; Metric Conversion of Fractions; Standard Density; Slide Rule Gauge Points; Specific Gravity and Weights; Density of Solids and Liquids; Weights of Various Substances; Weights of Woods; Table of Elements; Properties of Elements; Comparison of Thermometers; Temperature Conversion Table; Values of Single Degrees; Chords and Radians; Table for Converting Minutes into Decimals of a Degree; Natural Sines; Logarithmic Sines; Natural Cosines; Logarithmic Cosines; Natural Tangents; Logarithmic Tangents; Chords of Circles; Powers and Roots; Prime Numbers and Factors; Powers and Roots of $\pi$ and $g$; and Decimal Equivalents.

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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

## Wireless Licences

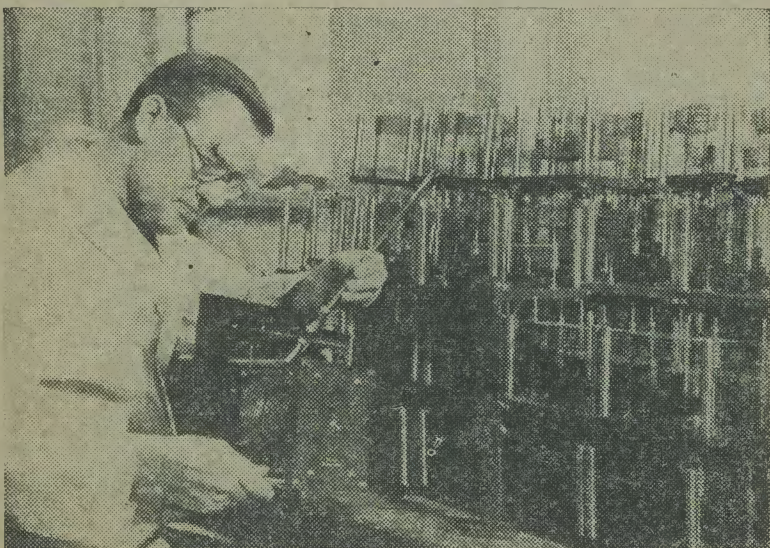
IT is interesting to note that the number of wireless licences, which commenced to decrease soon after the outbreak of war, now shows an upward trend. It was stated in the House of Commons last December that on August 31st, 1942, there were 8,836,724 licences in force, and since that date the number has increased to over nine millions.

The comparative figures are:

| | |
|---|---|
| 1939 .. .. .. .. | 8,947,570 |
| 1940 .. .. .. .. | 8,904,177 |
| 1941 .. .. .. .. | 8,625,579 |

## Edison's Collaborator

DR. NICOLA TESLA, who once worked with Thomas A. Edison, has just died in New York, aged 86. He championed alternating current against Edison's theory of direct current—and won, living to see his principle embodied in the great Niagara Falls power plants. Austrian born, he had hundreds of electrical inventions to his name, and was a pioneer of radio-telegraphy. One of his ideas was to use cosmic energy in working machinery to eliminate the need of fuel.



*Mr. Andrew Walker, who was recently awarded the B.E.M. He has worked on lathes and drilling machines, and general efficiency marked him out, and he was promoted to supervisor. He is also Cpl. Walker in the Home Guard attached to the works, and is Chief Fire Guard at the works. In the illustration he is seen at work gauging large condensers.*

## Bogus Radio

BRAZZAVILLE Radio, the Fighting French station in French Equatorial Africa, warns its listeners regarding a secret radio station, operating on 49 metres, and claiming to be Brazzaville. It is stated that the bogus station is situated in Bourges, France.

## Rail Radio-'phone

A RECENT report from Stockholm states that radio-telephone communications between traffic controllers and engine drivers are to be tried out by the Swedish Saltsjoe Railway Company. An ultra-short wavelength will be used.

## Women Make Sets

WIRELESS equipment for the South African Army is now being mass produced in South African factories, and most of the workers are women.

## Back to the B.B.C.

AFTER an absence of 13 years, the Hon. David Tennant has just rejoined the B.B.C. staff as a home announcer. From 1924 to 1929 he took part in a number of radio plays, and frequently read the epilogue.

## B.I.R.E. Paper

AT a members' meeting of the British Institution of Radio Engineers, held at 11, Upper Belgrave Street on Saturday, January 23rd, a paper on Modern Condenser Technique was read by J. H. Cozens, B.Sc., A.M.I.E.E.

## More B.B.C. Dance Music

WE understand that the B.B.C. is to broadcast more dance music, in accordance with the new policy of substituting a contract band for the "Band of the Week." This assurance was given to a deputation of dance band directors who met the B.B.C. recently to discuss the matter. The B.B.C. agreed to arrange for broadcasts to take place from provincial studios by bands on theatrical tours.

## Polish Listeners

A REPORT from a German source reveals that in that part of Poland occupied by Germany only 20,000 people are licenced to use receiving sets. This gives a good idea of the situation in this country with its population of over ten millions. Before the war Poland had more than a million listeners.

## Station WGEO

THE recent inauguration of the new 100 kW. transmitter, WGEO has resulted in a considerable improvement in the power and quality of transmissions from the Schenectady short-wave station of the General Electric Company. The new transmitter has been built to replace the one transferred to KWID, San Francisco, to counteract Japanese broadcasts in the Pacific.

## Empire Radio Communication

THE Australian Premier, Mr. Curtin, has recommended the Commonwealth Communications Council to consider the freedom of the partner Governments to establish direct wireless communication with other countries in the Empire, and also with foreign countries.

## First to be Televised

DR. ALEXANDER RUSSELL, former principal of Faraday House, whose death at the age of 81 was recently announced, believed that he was the first man to be televised. His image was flashed on a screen at Baird's old studios in St. Martin's Lane.

## Radiolocation in New Zealand

IT was revealed by the Dominion Defence Minister, in Wellington, recently, that New Zealand now uses radiolocation, with women forming most of the operating staff.

## Music Aids War Production

MR. WYNFORD REYNOLDS, who has been in charge of "Music While You Work" since May, 1941, relates how, in one most important shop in a large engineering works, an increase in production of over 22 per cent. was obtained within a week of introducing these programmes—and this increase was maintained over a period of 12 months. Many other such stories could be told indicating the value of music in industry.

## "Music While You Work"

MR. REYNOLDS has just written a booklet about "Music While You Work," published by the B.B.C. at 2d., which summarises the research he has made and is the most comprehensive publication that has been issued on the subject. The various advantages of different types of musical combinations are dealt with, and the kind of music best suited to these programmes.

"Hot" music, Mr. Reynolds points out, must be avoided, likewise vocal and organ music. A steady rhythm or tempo must be aimed at, with a constant tone-level or volume. The music chosen must be bright, cheerful and melodious; dance-music, though it helps to provide a gay background to work, and is a valuable stimulant, is not the only kind of music suitable for this purpose.

## B.B.C. Women Operators

THE next 12 months will undoubtedly see an increased number of women filling the gaps on the operation and maintenance side of the B.B.C. engineering department made by the withdrawal of men for the Services. Only one quarter of the original established staff remains. Replacement has been effected partially by taking on youths under 19 (who go to the Forces at 19) and in part by women operators, of whom 600 are now employed by the Corporation.

## Training School

THE majority of these came to the B.B.C. with more enthusiasm to do a job of war work than the technical knowledge of how to do it. Therefore a training school had to be set up to provide them with this knowledge and a training manual had to be written.

The women operators are doing well, and are showing themselves to be very painstaking in their work. They are employed particularly in control rooms at studio centres and at transmitting stations; and a large number of them have already become expert operators of sound-recording equipment. Some of them have a natural flair for these operations which need a sense of programme presentation, and have thus become successful "programme engineers."

## Signal City

SIGNAL CITY, where Wrens handle the Navy's messages, is the busiest naval station outside the Admiralty. Situated in the grounds of an old house in the North, 200 Wrens work there under the supervision of the signal commander, with a few naval signalmen. The Wrens—wireless telephonists, cypher officers, teleprinter operators, despatch riders, etc.—handle hundreds of vital messages daily, to and from ships at sea, naval bases, and posts all over the United Kingdom. Most of the messages are in code—coding and decoding is handled exclusively by 35 Wren officers, who deal with over 3,000 confidential signals a week. Signal City was specially designed by the signal commander.

## Progress of Short-wave Broadcasting

THE B.B.C. is now using 44 wavelengths in its short-wave services, and the number of transmitter hours put out per day is 356. These figures contrast with the eight wavelengths used 10 years ago at the first station to be built for broadcasting to Empire countries, and with the 23 transmitter hours a day which its two transmitters sent out. The actual number of transmitters being operated may not be given in wartime, but some idea of the comparison can be got from this fact: the cost of the first station was about one-fortieth of the cost of the plant by which our programmes are now being transmitted.

The bare principles on which this first station was designed 10 years ago are still much the same to-day for the much vaster stations which several countries are operating. Wavelengths in several groups within the limits 13 to 50 metres are still used, except for the 100-metre transmissions to Canada. The principle of transmitting on directional beams, taking various parts of the world separately in turn following the clock, still more or less applies to-day.

## Aerial Design

TECHNIQUE and methods improve as experience is gained. Much has been learned, for example, about the design of aerials, and how to construct them, so that they shine, or radiate, a beam of the right width and depth, and as nearly as possible at the right angle to the earth, so that they will be reflected back to earth by the ionosphere, and arrive in that part of the world for which they are intended.

Discussing the future of shortwave broadcasting, Sir Noel Ashbridge, the B.B.C.'s controller of engineering, says that if progress in the next 10 years is anything like that in the last 10 years, we may look forward to the day when reception from far-off countries is almost as good as from the local station.

*A Wren wireless telegraphist and a naval w/o receiving messages from ships on the Atlantic.*

# Chassis Construction

## Some Hints on the Easiest Methods of Cutting, Drilling and Bending

By S. BRASIER

AN all-metal chassis is not an easy thing for the constructor to make unless a proper bending press is available, therefore this article shows how suitable chassis may be constructed with the tools that are in the possession of the average constructor.

Aluminium is by far the easiest metal to work, but since it is scarce and its use not conducive to the war effort, one resorts to sheet iron or steel. Unless of thin gauge, this is extremely difficult to bend and not easy to cut, so that any construction which will obviate work in these directions is to be recommended.

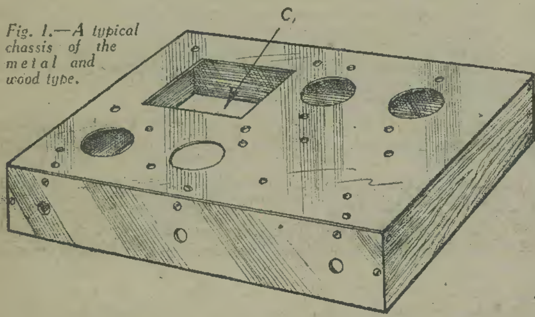



*Fig. 1.—A typical chassis of the metal and wood type.*

### Wood Framework

Let us suppose that an ordinary box type chassis is required of, say, 16 by 8 by 2in. In order to retain most of the advantages of a metal chassis, it is sufficient to make only the top and the front of metal, and a suitable method of construction is shown in Fig. 1. The first procedure would be to make a framework of wood for the sides, front and back (Fig. 2), the outside measurements being to the required size of the chassis. In this case ample strength would be secured by using material of ¼in. thickness—the front strip being of ½in. square section—as anything thicker would greatly restrict the space under the chassis and limit component mounting, etc. This may seem a small point, but consider for a moment a chassis made completely of ½in. plywood. The available space underneath would be decreased by nearly 1in. on the length, 1in. on the width and ½in. on the depth. A simple calculation will show that 20 square inches of space is lost—disregarding the loss in depth. In Fig. 1 the top consists only of iron or steel sheet of about 3/64in. thickness, no wood being necessary. The front is made from a piece of the same metal. The wood strip A in Fig. 2 is for the purpose of laying a piece of copper foil 1in. wide along its length in such a manner that perfect electrical connection exists between the top and front plates. The foil is bent to the shape shown at B and laid along the wood strip. The metal top and front are then placed in position covering the foil, and screws may be passed through the metal and foil into the wood. A rather better method would be to replace the wood strip by a piece of angle brass—if this is obtainable—and secure by means of nuts and bolts.

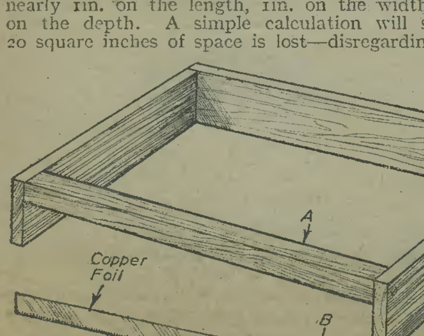



*Fig. 2.—The wooden framework of the chassis shown in Fig. 1.*

### Cutting the Metal

To cut the metal sheet to size, it is best to use a hacksaw with a fairly fine blade, finishing with a smooth file. Many constructors make the mistake of using a coarse saw blade in the belief that they will get through the work quicker. This is a fallacy, because much pressure has to be used, the work (unless securely clamped) slides about and the result is a rough edge that needs a lot of smoothing. A fine blade, however, is not so liable to jam, is easy to guide and produces a smooth finish which only needs a touch with the file. A little oil run along the line of cut will also materially assist the process. With the chassis top and front cut to size and marked out, it will be necessary to attend to the drilling and cutting of the larger holes. The quickest method is to drill a small hole, say, 1/16in., through every point where a hole is required, the drill for this purpose being quite short in order that plenty of pressure may be exerted without fear of the drill breaking. It is a good idea to keep a special one for this purpose. Any hole may then be enlarged to the necessary size by gradual steps. An ordinary twist drill would, in all probability, wander to some extent so that the hole would not be where it is wanted and far from circular. Consequently it is wise to adopt the method outlined above by starting with a 1/16in. drill, next a ⅛in. or 3/16in., followed by a ¼in. or 5/16in., and finally the required ⅜in. It is all a matter of how hard the metal is; if you are working on soft iron sheet or aluminium, then a ⅛in. pilot followed immediately by a ⅜in. drill would probably suffice, but, better still, use a fluted drill.

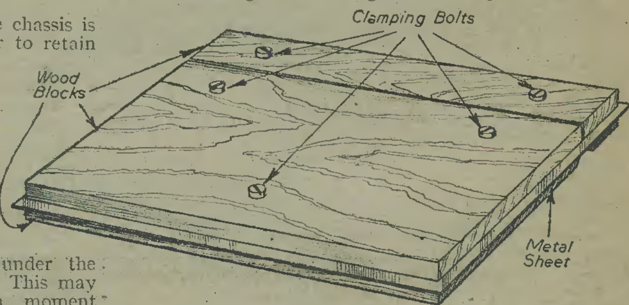



*Fig. 3.—Showing how the metal is clamped between pieces of hard wood prior to bending.*

In dealing with the square hole marked C in Fig. 1, which might be required for mounting a mains transformer, there are three methods which may be adopted. One is to use an adjustable drill or cutter. This tool is

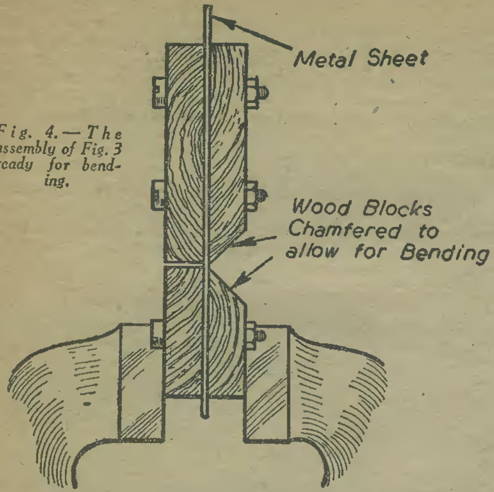



*Fig. 4.—The assembly of Fig. 3 ready for bending.*

provided with a centre drill of about 3/16in. or ¼in. diameter, and a cutting arm is so arranged that it may be adjusted to any desired radius within its range. What is known as a "tank cutter" is designed on much the same principle, is usually cheaper to buy and should be suitable.

**Cutting Square Holes**

If the hole C were, say, 4in. square, a drill of the same diameter as the centre drill of the cutter would be passed through the exact centre of the square. The cutter is then adjusted to a radius of a little under 2in.

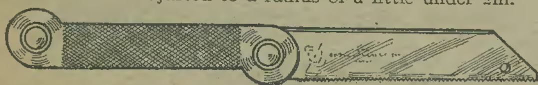


*Fig. 5.—A useful type of small hacksaw.*

and the cutting commenced. After a reasonably deep cut has been made in the metal, the plate should be turned over and the cutting continued on that side. Before going right through, the metal is turned once again and the operation completed. One disadvantage of the adjustable cutter is that owing to the pull or drag imposed on the centre drill by the cutting arm, the central hole enlarges, thus the cutting circle is thrown out of true. The trouble can be obviated, however, by replacing the drill with a short length of steel rod of the same diameter, as the drill is usually secured in the cutter by a set screw. The work must be securely clamped and the tool used in an ordinary brace.

Having thus removed the greater portion of the hole C, it will be necessary to cut away the remaining corner pieces. This is best accomplished by means of a hacksaw of a type similar to that shown in Fig. 5, finally smoothing up the edges with a file. While on the subject of hacksaws, a very useful tool for general metal work is the "Eclipse" 4S tool, so named because provision is made for sawing, slotting, slitting and scraping, according to the type of blade used. These are all interchangeable with a well-designed handle, and the whole outfit is quite inexpensive.

The second method of dealing with a square hole is one that is often advocated for a round one, namely, drilling small holes all round the edge, so placed that they practically join one another. The piece to be removed is then knocked out, and the edges filed to shape. It is, to say the least of it, a most laborious business and is not advocated, except when no other tools are available.

The third method, and one that is, in the writer's opinion, the best of all, makes use of the ordinary fret-saw in a frame of about 14in. as used for fret-sawing in wood. It is not generally appreciated how adaptable these little blades are to metal work; the manner in which they cut their way through quite tough steel is amazing; furthermore, any shape may be cut out exactly to the pattern and the result is a fine smooth edge which needs little finishing.

When buying fret-saws for this type of work, one should ask for "metal" blades, and select brittle ones where possible. These can generally be distinguished by their colour, which is black or which sometimes has a blue steel appearance. Other types which can be bent in two without breaking, and which have, as a rule, a brownish colour, do not possess the cutting qualities, but are not so liable to break in use. The brittle saws, however, are much more satisfactory and, with care and a little practice, it will be found possible to do quite a lot of work with one blade.

Any round holes for valve holders, condensers, etc., are best dealt with by the above method. In this case a further tip which might be useful is to first use the adjustable cutter so that a line is scored round the circumference of the circle. When the fret-saw is used it will then practically guide itself and the cutting will be much easier, especially if the metal is thick. In all metal work of this nature a trace of oil run along the line of cut will help matters considerably, and when using aluminium it is really essential since it helps to prevent the clogging of the saw or file.

**Chassis Design**

An interesting chassis design and one that is very suitable for short-wave work is shown in Fig. 6. All the controls, including tuning condensers, etc., are mounted under the chassis, under a cover of perforated zinc, which protects the components on the top, and affords quite an effective screen for any coils, etc.

Since there is not a great deal of bending to be done, the metal portion might well be made in one piece.

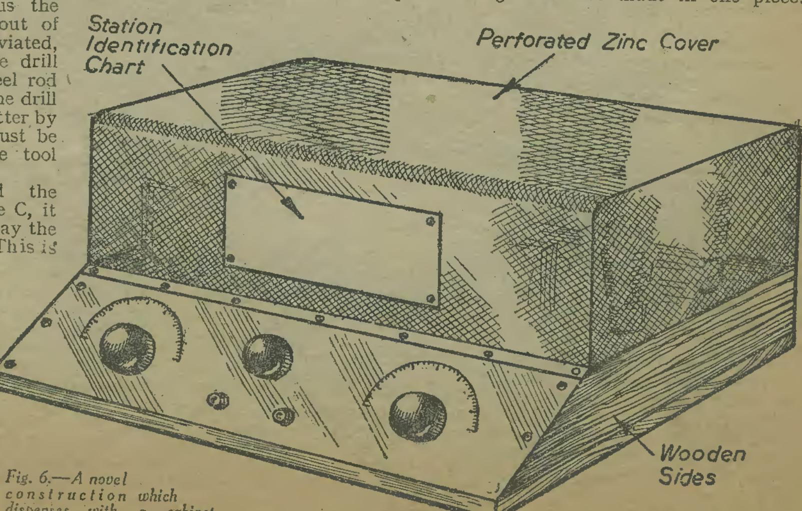



*Fig. 6.—A novel construction which dispenses with a cabinet.*

The front of the chassis needs to be at an angle of about 140 deg. for ease of operation of the controls and the best way to tackle the bending is as follows:

Having marked off the portion to be bent, the line should be scored on each side of the metal, and for this it will be necessary to use a sharp, hard, steel instrument in conjunction with a steel rule. The scoring on the top s de should not be too deep. Just a well-defined line is a ll that is required in order to get through the "skin" of the metal. The underside demands a rather more severe treatment, so that the scoring can be considerably heavier but consistent with the gauge of the metal. The scoring should not be carried so far that it weakens the metal unduly. For the actual bending process four pieces of wood will be required. Plywood, ½in. or ¾in. thick is very suitable owing to its strength, and the fact that it is usually dead flat. The four pieces should be as long or longer than the length of the chassis and two of them may be about 2in. wide, while the remaining two will need to be 9in. or 10in. wide. Chamfer those edges of the underside pieces which will be level with the scored line in order to allow for the bending.

The metal sheet, together with the four pieces of wood, are assembled as in Fig. 3, using two bolts for the small part and three for the large and positioned roughly as indicated. The whole assembly may be placed in a vice—Fig. 4—or two in line if available, and the bending to the desired angle will then be a simple matter.

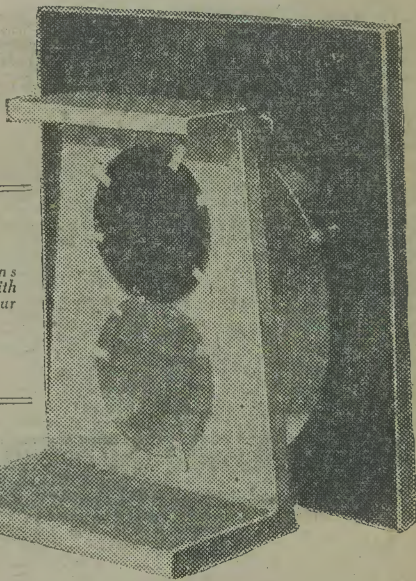
# Colour Television

## J. L. Baird's Latest Developments

COLOUR television is no new achievement. As far back as 1928, J. L. Baird demonstrated to the British Association a television receiver which produced a coloured image. Since then, however, much has happened in the world of television, a fact which was brought home to those who attended the recent demonstration by J. L. Baird and who remember his early efforts.

Hitherto, coloured television has been accomplished by the use of rotating discs used in conjunction with cathode-ray tubes. In Mr. Baird's latest apparatus the rotating discs have been eliminated and the coloured television images are produced entirely by electro-optical means.

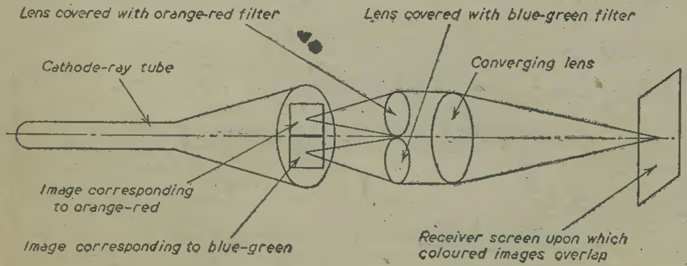
Images corresponding to the primary colours, blue, red and green (or blue-green and orange-red where a two-filter process is employed), are reproduced side by side in sequence on the fluorescent screen of the cathode-ray tube at the receiver. Lenses with their optical centres on perpendiculars through the centres of each of the three images, and at a distance from the images equal to the focal length of the lenses, project parallel beams on to a large lens separated from the receiving screen by a distance equal to its focal length. The pictures are thus caused to overlap on the screen, the arrangement is shown in the diagram as applied to a two-filter process.



*The lens assembly with two-colour filter*

### Two Filter 600 Line

The apparatus demonstrated were receivers adapted to receive a 600-line two-filter transmission (blue-green and orange-red). The two images corresponding to the blue-green and orange-red components appear in sequence one above the other on the flat face of a 10in. projection type cathode-ray tube operating at 26,000 volts. In the lens system, which is shown in the photograph, single lenses have been employed (owing to the difficulty of obtaining special lenses in war-time), and this entails a certain loss of optical efficiency; the actual aperture has nevertheless the large value of approximately 3.5. Proper registering of the two pictures presented several initial difficulties, as great accuracy is necessary, but these experimental problems have been solved and very accurate registration is now obtainable. The system is, of course, equally applicable to the transmitter, but at present a revolving disc is still employed, the same transmitter being used both for the old type colour disc and the new discless type.




*The electro-optical system for a two-filter process.*

### Demonstration

Three different types of colour and stereoscopic receiver produced by Mr. Baird during the war were demonstrated, arranging from a small popular model with a screen 5in. by 4in., to a De Luxe model with a picture 2ft. 6in. by 2ft., the pictures being in natural colours, and by putting on special glasses the pictures became stereoscopic, acquiring depth and relief to a surprising degree, so that instead of looking at a flat surface, one appeared to be looking at a scene through a window.

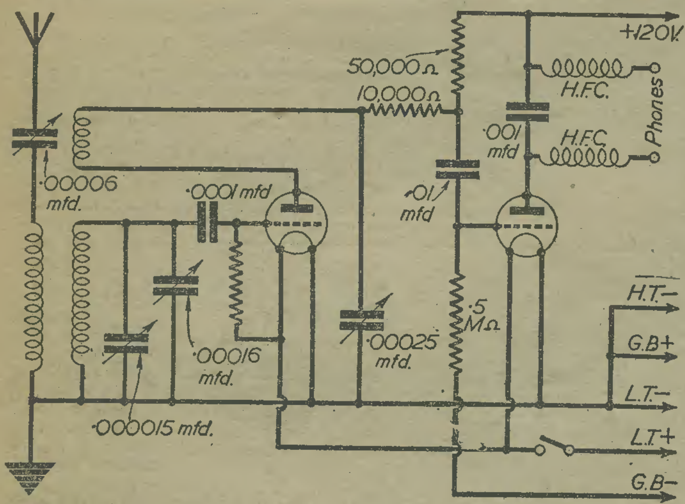
It is most encouraging to note that neither of these important developments has ever been shown, except in England, and, in spite of the many difficulties imposed by war, Mr. Baird is continuing—in his own private laboratories—extensive research work which will help to keep Britain well ahead in the development of this comparatively new science, whose importance in post-war planning can hardly be overestimated.

# A Two-valve Short-wave Receiver

## A Fine Headphone Set of Tested Efficiency, Ideal for the Battery-operated Station

By F. G. RAYER

THIS receiver is the outcome of a number of practical experiments. It is entirely free from hand-capacity effects under all normal conditions; it is sensitive and most easy to handle. The layout follows sound lines, the connection from coil-holder to bandset and bandspread condensers is only 1½ins. long. All the components can be obtained from firms whose advertisements regularly appear in the pages of PRACTICAL WIRELESS.




*Here is the circuit of the receiver. Quite simple and very efficient.*

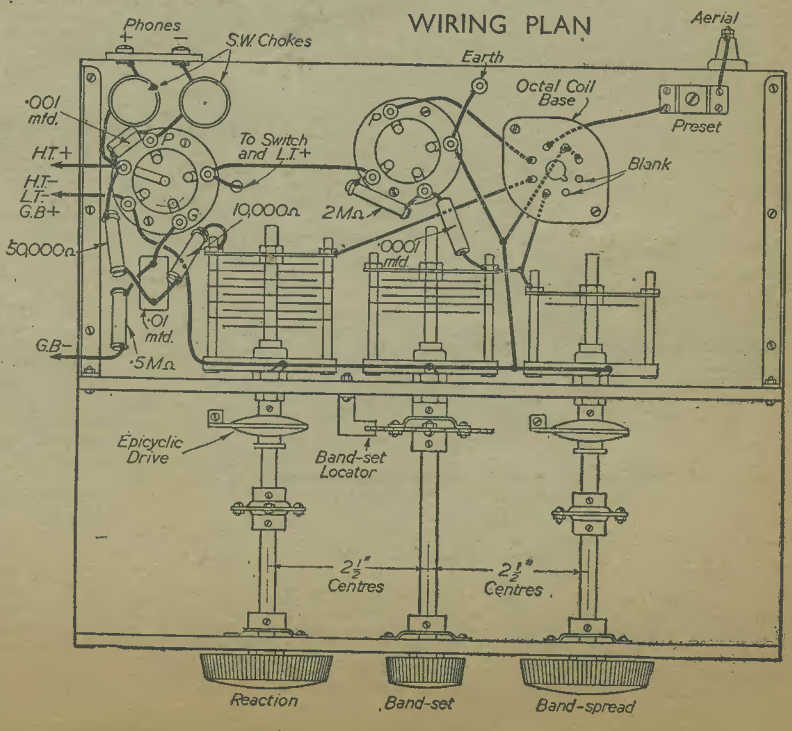
### Construction

The chassis—9ins. by 11ins.—is made from 4-ply and has runners 1in. deep. The small sub-panel is mounted 5ins. from the rear edge of the chassis and is supported by stout brackets, and the layout shown (right) should be followed as closely as possible. The coil-holder is mounted 1½ins. above the chassis by means of long bolts and insulated sleeves of appropriate length. The variable condensers should be fixed to the sub-panel so that the soldering-tags which are connected to the fixed vanes are at the same height as the tags of the coil-holder. It should be noted that the soldering-tags of the reaction and band-set condensers are located adjacent to each other to simplify and shorten wiring.

If an L.F. transformer of reliable make is to hand, it can be used in place of the R.C. coupling, and it will provide slightly louder signals; a separate H.T. connection should be taken from its primary so that a suitable voltage can be applied to the detector.

The band-set condenser has the great advantage of being set in definite steps—thus assuring accuracy of calibration. The locating mechanism is easily contrived; the flexible couplers will be found to consist of two cranks with centre boss bolted to two thin discs of flexible material. One should be dismantled and reassembled with a metal or ebonite disc of, say 2ins. diameter, replacing the flexible disc. Around one-half of the circumference of the disc, 14 notches are filed, and a catch made from springy brass is arranged to locate with them. The slight labour involved will amply be repaid by convenience of operating.

The spindles of the controls are extended with lengths of ¼in. diameter ebonite rod, secured with shaft-couplers; wooden dowel could be used, but



it can only be regarded as a substitute. The method of arranging the bandspread condenser's pointer and dial is not shown, as this is a matter for individual preference. The band-set condenser should be equipped with one of the small knobs supplied with the epicyclic drives and a scale marked from 1-14. These details will become apparent when the actual components are to hand.

### Operation

A valve of the H.L. type can be used as detector; the L.F. valve is of the detector or L.F. type—the former for preference. The aerial-series condenser must be adjusted until entire freedom from dead-spots is obtained with all coils, and then securely locked. The 'phone leads should not be run near the receiver or batteries as this will tend to partly remove the advantages obtained from the two H.F. chokes connected in series with the leads. There will be no hand-capacity troubles, even if the receiver is used without an earth—this being a valuable point when listening to low-power DX.

The receiver should be housed in a cabinet; if an existing cabinet is to be used, it is well worth while to make it dustproof—thus assuring that the receiver will not become noisy in operation. It is also a sound plan to make a coil-box having individual compartments lined with felt. Near the top of the coils will be found a groove into which a cardboard disc can be fitted—if the coils are thus identified and placed in the coil-box they will be saved from possible damage and will always be to hand.

It should be noted that a pentode may be placed in the L.F. stage without altering the wiring, but the grid-bias must be adjusted to suit.

### LIST OF COMPONENTS

**One each S.W. variable condensers: .000015, .00016 and .00025.**
**One each ½ watt resistances: 2 meg., 10,000, 50,000 and 500,000 ohms.**
**One each mica fixed condensers: .001, .0001 and .01 mfd.**
**Two 2in. diameter control knobs.**
**Two epicyclic reduction drives.**
**Two S.W. high-frequency chokes.**
**Six flexible couplers.**
**One 60 mmfd. pre-set condenser, Steatite insulation.**
**One octal coil base, coils type O6, O6A, O6B, O6C (or as required).**
**One small stand-off insulator. All above items from "Premier Radio."**
**One 4-pin ceramic valve-holder, "Webb's Radio."**
**One 5-pin ceramic valve-holder, "Webb's Radio."**
**On-off switch, connecting wire, etc.**

*In Answer to Querists*

# Resistors—Resistance

RESISTANCE, when used in connection with electrical circuits, denotes the property of a material to oppose the flow of an electric current. A *resistor* is the name given to a component which is specifically designed to possess resistance. The two terms are often misused; resistance is not a component any more than a resistor is a property of a circuit.

We speak of an electrical circuit having a certain resistance—see "Elementary Electricity and Radio (1)," page 101; and there is a law connecting resistance with voltage and current, known as Ohm's Law.

The unit of resistance is the ohm, but when dealing with radio circuits this is too small or too clumsy to express resistance when hundreds of thousands of ohms are concerned. A grid-leak might have a value of 1,000,000 ohms, which, if written in full, would not only look terrifying to the beginner, but it would also take up space and time. To remedy this a larger unit is used, namely, the *megohm*, which is simply another way of writing 1,000,000 ohms.

Supposing a resistor has a value of 500,000 ohms, well, this can be expressed far more neatly and quicker as a decimal part of a megohm. (If your decimals are rusty see "Refresher Course in Mathematics," page 106, February, 1942.) Now, 500,000 ohms is exactly half of 1,000,000 ohms, or 1 megohm, therefore, we simply write it as 0.5 megohm. Carrying this example further, 250,000 ohms is 0.25 megohm; 100,000 ohms is 0.1 megohm; 50,000 ohms is 0.05 megohm; and so on. Now for a simple conversion tip. If the value in ohms consists of *six* figures simply put a decimal point in front of it to convert it to a decimal part of a megohm. If *five* figures form the value in ohms then put 0.0 in front of it.

### Voltage Drop

Ohm's law will show that the resistance in a circuit will produce a voltage drop, the value of which will depend on the current flowing and the value of the resistance. This is important in radio, where high values of resistance are often encountered. In the majority of calculations one usually has to measure the current flowing in milliamps (mA.s), one milliamp representing the 1,000th part of an ampere—the unit of current. To calculate the voltage dropped by the resistance of the circuit, or by any resistor introduced into the circuit, when the current is expressed in milliamps and the resistance as so many thousand ohms simply multiply the thousands figure or figures of the resistance value by the current figure. Example, a resistor of 50,000 ohms is in a circuit in which is flowing 5 mA.s; what voltage will be dropped? Answer: $50 \times 5 = 250$ volts. This simple form of calculation will be found useful when dealing with decoupling resistors, voltage dropping resistors in eliminators, and so on.

### Wattage

Resistors are many in various types, each of which is intended to satisfy some particular requirement. In addition to their various forms, each resistor has a certain wattage rating—this is specified by the manufacturer, and should not be ignored. If a circuit calls for a 1 watt resistor, which, incidentally, could be of any value as regards its resistance, then it would be asking for trouble to use a resistor having a ½ watt rating, as it would be, so to speak, overloaded, and would soon be destroyed.

The wattage required can be calculated quite easily if the resistance and current are known. This is the formula: $\text{Watts} = I^2 \times R$ when I represents the current in amperes and R the resistance in ohms. If the current is in milliamps then decimals must come into use again, remembering that 1mA. is equal to 0.001 ampere, i.e., one thousandth

An alternative method is:

$$\text{Watts} = \frac{\text{Milliamps}^2}{1{,}000{,}000} \times R.$$

So you can take your choice.

It does happen that one gets hold of a resistor of known resistance and wattage rating, and wants to find out the maximum current which can be passed through it. In this case the following calculation can be applied:

$$\text{Milliamps} = 1{,}000 \times \sqrt{\frac{\text{Watts}}{\text{Ohms.}}}$$

# Frequency Meters

## Heterodyne Meters. A Simple Triode Arrangement. The Electron-coupled Circuit

*(Concluded from page 113 February issue)*

By L. O. SPARKS

THE absorption wavemeter—discussed last month—cannot act as a signal generator; its uses, therefore, are restricted, and in spite of its recognised utility value, it cannot claim to be so universal as those instruments capable of producing a signal. This does not mean that the absorption type is obsolete; in fact, there are many tests which demand the use of a meter of this kind, and it is usual to find an absorption wavemeter and a signal generator among the equipment of a well-fitted amateur transmitting and/or receiving station.

### Heterodyne Wavemeter

If the buzzer type of meter is ignored, the single-valve heterodyne wavemeter ranks next in simplicity. The fundamental circuit of one type is shown in Fig. 1,

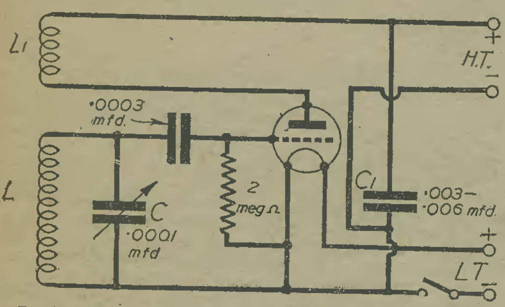



*Fig. 1.—A simple heterodyne circuit utilising a triode valve and fixed " throttle " control.*

where it will be seen that it bears a marked similarity to a single-valve receiver.

A triode valve, having characteristics of the H.L. type, has a tuned circuit across its grid and filament, the values of the inductance L and the variable condenser C governing the frequency band covered by the circuit. The anode is coupled to L by means of the fixed reaction winding L1, thus providing—in conjunction with the fixed condenser C2—the requisite amount of feed-back to keep the wholecirc uit in a smooth state of oscillation.

As every reader knows, it is an easy matter (too easy in many instances) to make a single-valver oscillate round the dial by adjusting the tuning and reaction controls. Such a set could, therefore, be used as a heterodyne wavemeter, were it not for the fact that it would be very unreliable and most annoying to nearby listeners. The circuit under discussion (Fig. 1) is essentially an oscillator, so it is necessary to take certain precautions so that it performs only the functions for which it is intended.

The first precaution is to ensure that the oscillations produced do not radiate over distances greater than the immediate vicinity of the meter. The second is, to secure stable or constant oscillation over the whole frequency-band covered by the meter. This is very essential, otherwise the calibration will not hold, and unless frequent checks are made against some standard frequency, the results will be very misleading. To secure consistent oscillation, particular attention must be given to (1) the " goodness " of the coil; (2) the quality of the components; (3) the characteristics of the valve; (4) the constancy of the sources of H.T. and L.T., and finally, (5) the construction of the unit.

### Constructional Notes

Because the circuit is so simple, it does not follow that its assembly and wiring can be " hooked-up." For the most reliable results, the constructor should arrange the components so their associated wiring is short and rigid. The coil and valve holders should be located close to the tuning condenser, if necessary, using distance pieces to raise the holders to reduce length of wiring. Before fixing, rotate the holders until their terminals are close to or in direct line with other points of connection; don't have " wandering wiring."

The inductances L and L1 can take the form of a standard type of four-pin S.W. coil—assuming the meter is to be used on the S.W. bands—L being the grid winding and L1 the normal reaction section. It is essential, however, for the coil to be of *good make*, otherwise appreciable H.F. losses will be introduced by a poor quality coil former.

Speaking of plug-in coils raises a point about which there are various opinions. When it is desired to use the meter on another frequency-band, it would appear to be quite feasible to remove the existing coil and plug in another one to cover the new band, in the same manner as one would do with a set. In practice, this does not always prove too satisfactory, as there is the grave risk of upsetting the calibration, although if a reputable make of coils is used the risk is reduced, provided the coils are handled with care so that their windings are not damaged, i.e., turn spacing affected, etc.

An alternative arrangement uses one coil, which is wound to cover the lowest frequency band of the normal S.W. range, and when higher frequency bands have to be checked, harmonics of the fundamental frequencies are used. This method is not liked by every amateur, as some think there is a risk in identifying the harmonics, but whatever is said against the single coil idea, it does possess one very important feature—provided the coil is well made—it scalibration, assuming other factors are constant, will retain its accuracy. The coil must be robust in construction; securely fixed in the assembly and its connections rigid and soldered. It is

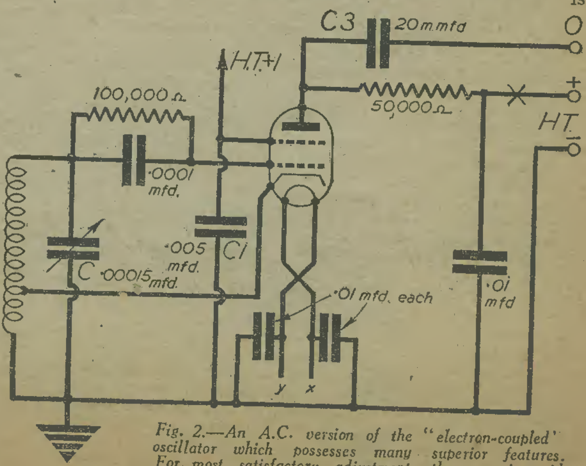



*Fig. 2.—An A.C. version of the " electron-coupled " oscillator which possesses many superior features. For most satisfactory adjustment, the screening-grid voltage should be obtained via a potentiometer.*

preferable to use a slotted or threaded former so that the turns forming the windings cannot move; if one is forced to use a smooth tubular former, it is advisable to anchor each turn with *a spot* or two of shellac varnish or other suitable adhesive.

The objection to working to the harmonics of the fundamental frequency is not always without foundation, as some valves are not so good as others as regards harmonic generation and, of course, there is always the reduction in output from the oscillator as value of the harmonic is increased. This, however, is usually turned to good account by using it as a check on the tuning of the meter. For example, the oscillations produced when the meter is tuned to the second harmonic will not be as powerful as those generated on the fundamental frequency. Similarly, the output on the fourth harmonic will be less than that of the second, and so on, therefore it should not be a difficult matter to determine on which harmonic the meter is working.

With a meter of this type it is really essential to use a dial capable of giving split division readings, and having a smooth and efficient and slow-motion control. It is useless going to a lot of trouble during the construction of the meter to secure stable calibration if means are not provided to enable the *exact* setting of the tuning condenser to be observed and if due care is not exercised when making such observations. To protect the meter—*and rough handling must be avoided*—and to reduce its field of radiation, a metal case should be constructed to house it, the case being connected to the common negative side of the circuit. Battery leads should be kept short.

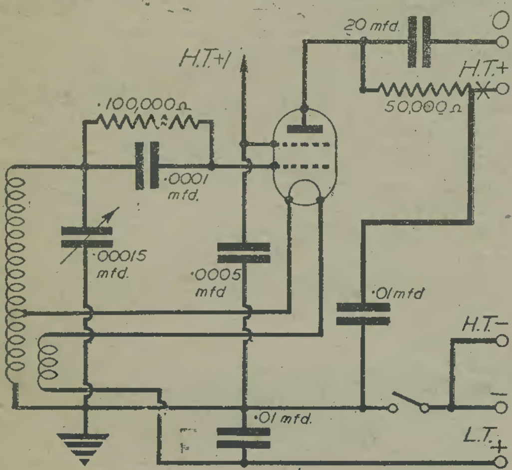



*Fig. 3.—The battery operated counterpart of Fig. 2. Note the filament circuit.*

### The Electron-coupled Oscillator

Mention has been made about the necessity of securing stable oscillations in a heterodyne frequency meter; in fact, the point cannot be stressed too strongly. One oscillator which is particularly good in this respect, provided it is adjusted correctly, is the "electron-coupled oscillator." A suitable circuit is shown in Fig. 2 (for A.C. operation), and its battery valve counterpart in Fig. 3. It will be recognised as a Hartley or Colpitts oscillator using a screen-grid valve. The output is taken from the anode proper, but the screen-grid acts as the anode of the oscillator, and, as regards H.F., it is anchored to earth by means of the condenser C1. The cathode of the valve is at an H.F. potential above earth but lower than that of the control grid, and it is the H.F. potential of the latter, which swings over a very wide range of values, which controls the amplitude of the anode (proper) current. Due to the characteristics of the circuit and the screen-grid acting as an electrostatic screen between the anode and the actual oscillator section it is possible to take output from the anode with practically negligible effect on the oscillator frequency. The output terminal is marked O in Figs. 2 and 3, the connection being made to the anode via the small fixed condenser, C3.

One of the worst offenders as regards causing frequency instability in self-controlled oscillators is a varying source of H.T. supply. When considering the S.G. valve it is possible to *increase* its impedance by *increasing* its anode *H.T.*, but, by *increasing* the *H.T.* applied to the *screen-grid*, the impedance will be *lowered*. This characteristic is turned to good account in the circuit in question, as it is possible to find a ratio between anode and screen-grid H.T. potentials which will cancel out any variations in the impedance of the valve created by fluctuating source of H.T. This, combined with the qualities of the circuit, ensures a very high degree of frequency stability being obtained. If the screen voltage is provided via a potentiometer across the H.T. supply, its value can readily be varied until the correct ratio is reached. The potentiometer can have a resistance in the region of 50,000 ohms provided its wattage rating is in keeping.

The electron-coupled oscillator is capable of producing strong harmonics in its output, thus overcoming, or, at least, considerably reducing, the objection to harmonics mentioned in connection with the simple triode arrangement.

### Construction

Little can be said about construction, as all the points stressed for the previous circuit apply equally to Figs. 2 and 3, and, in fact, to any frequency meter. The construction must be sound electrically and mechanically; good rigid connections, high-grade components, a first-class dial and a metal cabinet or case which is not flimsy.

Quite a number of amateurs have the idea that frequency meters and like apparatus can be knocked-up from odd parts out of the junk-box; such ideas are likely to prove most unsatisfactory, or, at least, involve a far greater amount of work than if reasonable thought and selection had been given in the first instance.

The coil is best wound on a 1½in. diameter former, and all connections brought out to soldering tags anchored to the coil former by means of short 6 B.A. bolts. The completed coil should then be mounted securely to the baseboard in the most convenient spot for short wiring to the grid and tuning condenser.

The cathode tapping point is best determined by experiment, the correct one being that which produces a reasonably constant reading on a milliammeter when one is connected in series with the negative H.T. line to indicate the anode current. Usually a ¼ or ⅕ of the total number of turns is satisfactory, when counted from the earthy end of the coil.

With the battery-operated circuit it should be noted that both sides of the filament are returned through windings. One—the negative side—is tapped into the tuning coil similar to the cathode in Fig. 2; but for the other side—the L.T. positive—another winding must be added, and it can be wound over the negative section, and have the same number of turns.

An alternative method is to wind the top portion of the coil (from the grid end to the tapping point) with single wire in the normal manner, and then use two strands of the same wire for the bottom section. One of the top ends of this double winding would then be connected to the adjacent end of the grid winding and to the negative side of the filament, while the remaining top end of the double section would be taken direct to the positive side of the filament. Care must be taken to see that the two bottom ends are connected correctly, i.e., the first one to the earth-L.T. negative line and the second to the positive supply of the L.T. battery. In some circuits, interference with the tuning coil is eliminated by using special low-resistance H.F. chokes in the filament circuit. Suitable components can be obtained from the makers of the "Eddystone" products. The point X in Figs. 2 and 3 denotes where headphones can be inserted if it is required to use the meters as monitors.

# Elementary Electricity and Radio—2

## The Effects of Electric Current: Sources of E.M.F.: Primary and Secondary Cells

By J. J. WILLIAMSON

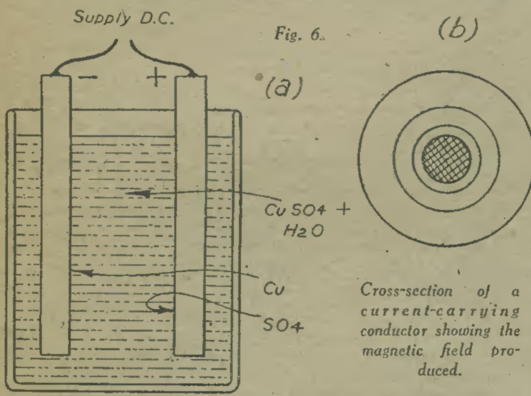
(Continued from page 102, February issue)

### Power

THE statement that a car would do 50 m.p.h. would mean little, if no consideration of what weight the car could carry at this speed was given.

Similarly, consideration of the voltage acting or current flowing taken separately would give us no true indication of what work could be done.

In the case of the car, if we had said that it would carry 1 ton at 50 m.p.h., then we have a clear idea of the work it could do. Again, if we say that a certain circuit has a current of so many amperes at such-and-such a voltage then we have a good idea of the rate at which




A voltameter.

Cross-section of a current-carrying conductor showing the magnetic field produced.

work can be done, i.e., the power. Power is, therefore, the rate of doing work. The unit of power is the watt.

Power $=IV$ watts.

Replacing $I$ with the Ohm's Law equivalent $V/R$ we get $P=V/R\ V$ watts $=V^2/R$ watts.

Similarly, $P=I\times I\times R=I^2R$ watts.

As can be seen from the last two formulæ, the power expended in a circuit is not proportional to the current or voltage, but to the *square* of $I$ or $V$—an important fact.

In the case of Fig. 4 (a) $R_3$ has

$$P=\frac{V^2}{R}=\frac{12^2}{6}=24 \text{ watts}$$

or

$$P=I^2R=2^2 6=24 \text{ watts}$$

or

$$P=IV=2\times 12=24 \text{ watts}$$

$R$ (Fig. 4 (a)) has:

$$P=IV=2\times 18=36 \text{ watts}$$

etc.

### General Examples

1. In Fig. 5 (a) calculate the total resistance and current flowing.
2. What power is being dissipated in $R_4$ Fig. 5 (a)?
3. A 10,000Ω ½watt resistor is available. What is the maximum permissible current this resistance can take?
4. In Fig. 5 (b) what power will the lamps consume, (a) in series; (b) in parallel?

There are four main effects of an electric current, namely, heating, chemical, magnetic and electro-magnetic.

### The Heating Effect

As mentioned under the heading of fuses, when a current of electricity encounters resistance, heat is produced.

By a careful choice of materials and conditions under which these materials are used, the heating effect makes possible electric lamps, fires, toasters, etc.

### The Chemical Effect

If a current of electricity is passed through certain solutions chemical action takes place. In the case of a solution of copper-sulphate and water ($CuSO_4+H_2O$) we find that copper is deposited at the negative pole, the $SO_4$ moving and usually combining with the metal of the positive pole; oxygen is evolved, and sulphuric acid forms. This chemical effect of an electric current is termed "*electrolysis*," the solution is an "*electrolyte*," while the complete apparatus wherein electrolysis takes place is a "*voltameter*."

Electro-plating, electrolytic condensers, etc., utilise this effect. See Fig. 6 (*a*).

### The Magnetic Effect

An electric current is always accompanied by a magnetic field, which extends as a region of force around the conductor, and acts at right angles to the direction of the current. See Fig. 6 (*b*).

The magnetic effect makes possible such things as electric clocks, trains, motors, radio, and many other important items.

### The Electro-magnetic Effect

Whenever electrons change their speed, i.e., the magnitude of the current alters, electro-magnetic waves are produced.

Electro-magnetic waves are capable of existing independently of connecting wires, and hence make radio communication possible.

### Sources of E.M.F.

Once again, four sources are available: heating, chemical, magnetic and electro-magnetic.

### The Heating Source of E.M.F.

If two unlike wires have one pair of their ends twisted together, and the junction heated, then an E.M.F. will appear across the free ends.

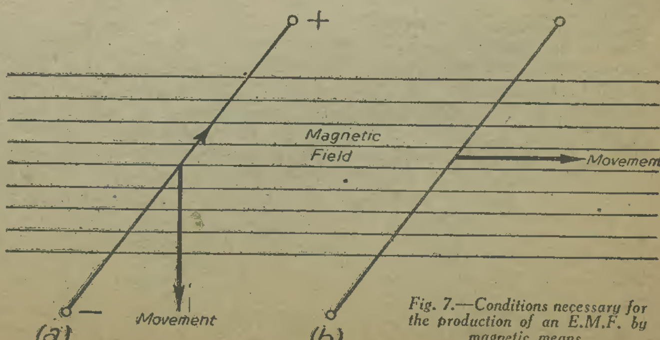



Fig. 7.—Conditions necessary for the production of an E.M.F. by magnetic means.

(a) A wire, cutting lines of magnetic force at right angles, has an E.M.F. produced across its ends.

(b) A wire travelling parallel to the lines of force has no E.M.F. produced across its ends.

The two dissimilar conductors form a "*thermocouple*," such as antimony and bismuth.

The principle is used in high-frequency meters, pyrometers, etc.

### The Chemical Source of E.M.F.

If two unlike conductors are placed in an active liquid, i.e., an acid or an alkali, an E.M.F. is produced across these conductors.

Accumulators, flash-lamp cells, etc., depend upon this principle for their action.

### The Magnetic Source of E.M.F.

Whenever magnetic lines of force cut or are cut by a conductor an E.M.F. appears across the ends of that conductor.

The meaning attached to the word "cut" is important; first, either the lines of force or the conductor must be in movement; and, secondly, the conductor or lines of force must not be moving parallel to one another; maximum E.M.F. being produced when they are moving at right angles to one another. See Fig. 7.

Dynamos operate upon this principle.

### The Electro-magnetic Source of E.M.F.

Whenever an electro-magnetic wave strikes a conductor in the correct plane an E.M.F. is induced in that conductor, due to the electric and magnetic fields of the wave.

We shall deal more thoroughly with this in a future article.

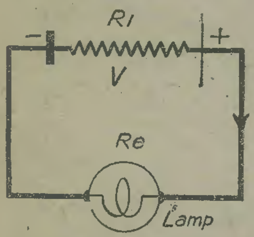



*Fig. 8.—The effect of the internal resistance of a cell.*

### E.M.F., IR drop and P.D.

E.M.F. refers to the total energy of a supply, expressed in volts.

IR drop refers to the voltage produced across a resistance through which current is flowing.

P.D., or potential difference, refers to the voltage produced by the product of resistance and current, or is another way of speaking of IR drop.

### The Internal Resistance of a Source of Supply

In using any source of supply its internal resistance must be taken into consideration.

Suppose that in Fig. 8 the cell had an internal resistance of $\frac{1}{2}\Omega$, and that it has an E.M.F. of 2v. and is supplying 1 ampere to the lamp.

Now, 1 ampere through $\frac{1}{2}\Omega$ produces an IR drop of $\frac{1}{2}$ volt, which represents energy wasted as heat in the resistance of the cell, therefore,

$$P.D. = E.M.F. - IR$$
$$1\tfrac{1}{2} = 2 - \tfrac{1}{2}$$

thus only $1\frac{1}{2}$ volts are available across the lamp.

*P.D. of a supply* $= E.M.F. - IR$
*E.M.F.* „ „ $= P.D. + IR$
*IR drop in a supply* $= E.M.F. - P.D.$

### The Conditions for Maximum Power from a Supply

Maximum power is obtained from a supply when the external resistance of the circuit is equal to the internal resistance of the supply.

Let us investigate the truth of the statement by means of Fig. 8.

Case 1.—$Re = R_1$, and $R_T =$ Total resistance.

Let $Re = R_1 = 2\Omega$. E.M.F. of supply 8v.

$I = V/R_T = 8/4 = 2$ *amps.*

Power dissipated in $Re = I^2 Re =$ 8 *watts.*

Case 2.—*Re smaller* than $R_I$

Let $Re = 1\Omega$. $R_I = 2\Omega$. $E.M.F. = 8v.$

$I = V/R_T = 8/3 = 2\frac{2}{3}$ *amps.*

$P$ *in* $Re = I^2\ Re = 7^1/_9$ watts. (approx.)

Case 3.—*Re larger* than $R_1$.

Let $Re = 4\Omega$. $R_I = 2\Omega$. $E.M.F. = 8v.$

$I = V/R_T = 8/6 = 1\frac{1}{3}$ *amps.*

$P$ *in* $Re = I^2\ Re = 7^1/_{10}$ watts. (approx.)

Thus, only when $Re = R_I$ does the power in the external circuit reach a maximum.

### Primary and Secondary Cells

A primary cell is chemical source of E.M.F., which cannot be recharged by means of a reverse current, while a secondary cell is rechargeable by a reverse current.

What is meant by recharging with a reverse current?

When a cell discharges or "runs down," chemical changes occur within it which either make its internal resistance so high that its P.D. for a useful current becomes negligible, or alters the chemicals so that the dissimilarity between its poles diminishes, and hence its E.M.F. falls.

If it is possible to return the chemicals to their original state by electrolysis, i.e., passing a current through the cell, in the opposite direction to that which the "discharge" current flows, then the cell would "recharge" and thus be a secondary cell.

A primary cell can only be recharged fully by renewing its exhausted chemicals.

The only primary cell of practical importance to us is the Leclanché cell, while our study of secondary cells will deal with Lead-Acid and Nickel-Iron or NiFe accumulators.

### Leclanché Cells

The Leclanché cell (see Figs. 9 *a*, *b* and *c*), is composed of: (1) Positive pole—carbon; (2) Negative pole—zinc; (3) Electrolyte—ammonium chloride or sal ammoniac; (4) Depolariser—manganese dioxide. The E.M.F. of a Leclanché cell is approximately 1.5 volts.

The chemical action of the cell is as follows:

$$Zn + 2NH_4Cl = ZnCl_2 + 2NH_3 + H_2$$

(Zinc) + (Ammonium Chloride) = (Zinc Chloride) + (Ammonia) + (Hydrogen).

The hydrogen which is set free is the cause of a great deal of trouble, as it is a good insulator and is attracted to the carbon rod, forming a high resistance film around it. Obviously, the internal resistance of the cell increases enormously, and the P.D. of the cell for a useful current falls to a very low value. This effect is called *polarisation*, and any method of overcoming it, *depolarisation*.

The formula for the process of depolarisation, using manganese dioxide as the depolariser, is:

$$H_2 + 2MnO_2 = Mn_2O_3 + H_2O$$

(Hydrogen) + (Manganese dioxide) = Manganese sesquioxide) + (Water).

From this equation, it is clear that the manganese

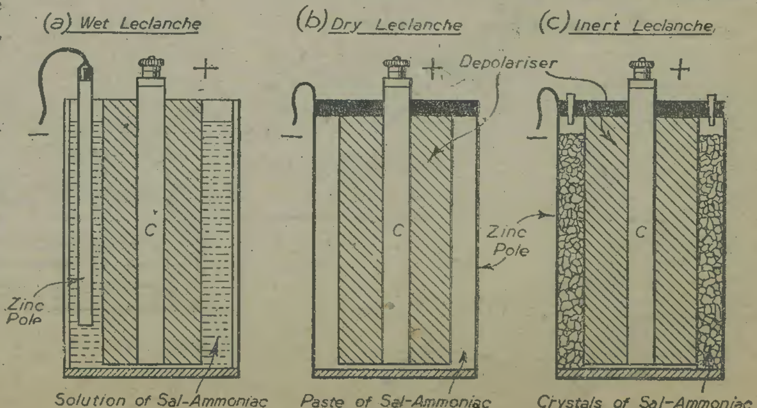



*Fig. 9.—Sectional diagrams of Leclanché cells.*

dioxide is constantly being converted, and hence the life of the cell is mainly governed by the amount of depolariser available. The internal resistance of the cell is still high, because of the poor conductivity of the manganese dioxide; therefore, powdered carbon is mixed with it to reduce its resistance. As the depolariser is only able to get rid of the hydrogen at a definite rate, the cell is only suitable for small currents and intermittent operation if polarisation is to be avoided.

### Types of Leclanché Cell in General Use

There are three types: (1) Wet, (2) Dry, and (3) Inert.

### The Wet Leclanché

The Wet Leclanché is generally used in cases where long life and short periods of operation are required, i.e., door bells, etc. (Fig. 9*a*).

The cell will keep running for many months provided that the electrolyte level is maintained with water to allow for evaporation. The cell is unfit for many purposes because of its spillable and cumbersome nature.

### Local Action

In the case of the wet Leclanché the zinc rod can become badly pitted due to the presence of impurities in the zinc. These impurities; iron, lead, arsenic, etc., together with the zinc and the electrolyte, will act as miniature cells, and in the running down process of these cells, the rod becomes badly eaten away. Fig. 10 (*a*) and (*b*). Local action can be prevented by coating the rod with mercury, when only pure zinc will be able to reach the electrolyte, thus the rod wears evenly, except, perhaps, for a slight taper due to the greater density of the electrolyte at the bottom of the cell. Fig. 10 (*c*).

### The Dry Leclanché Cell

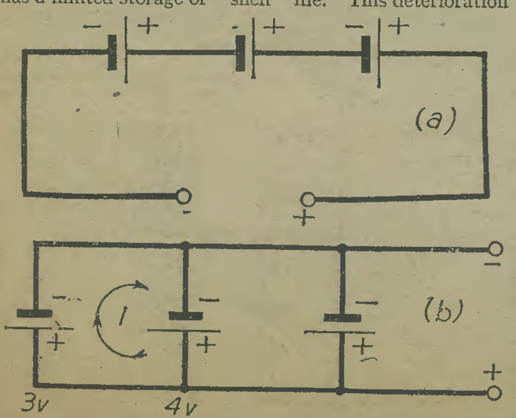
This provides a compact and portable means of providing a source of E.M.F.

It is used for H.T. batteries, flash-lamp cells, gas-lighters, etc. Fig. 9 (*b*).

Note that the zinc rod has been replaced with a zinc pot or container and that the cell is sealed with pitch; that most of the space in the cell is occupied by the depolariser sack; that a cardboard disc is placed between the bottom of the sack and the zinc pot, and finally, but most important, the electrolyte is in paste form—sal ammoniac and gelatine, etc.

Local action is of little consequence in this case, because the cell is usually exhausted before the zinc is seriously affected.

The advantages of the dry cell are: Portability, compactness, and readiness for instant use, but, unfortunately, one serious disadvantage exists, namely, the cell starts to deteriorate as soon as it is made and thus has a limited storage or "shelf" life. This deterioration is due to the necessary presence of moisture in the so-called "dry" cell. Cells and batteries of the "dry" Leclanché type and of good manufacture are usually date-stamped.




(*a*) *Cells in series.* (*b*) *Cells in parallel.*
*Fig. 11.—If the E.M.F.s of the cells are unequal, wastage occurs continuously.*

### The Inert Leclanché Cell

This cell can withstand long storage or use in hot climates. As the cell's name implies, it is "inert" until "activated" by the addition of water. Fig. 9 (*c*).

Points to note are: (1) That crystals of sal-ammoniac now replace the paste of the dry cell or the solution of the wet cell; (2) that two vents fitted with "stoppers" for the access of water have been fitted. The cell becomes ready for use within a day, after activating.

### Cells in Series and Parallel

In order to obtain higher E.M.F.s than one cell could give, a number of cells may be connected in series, when

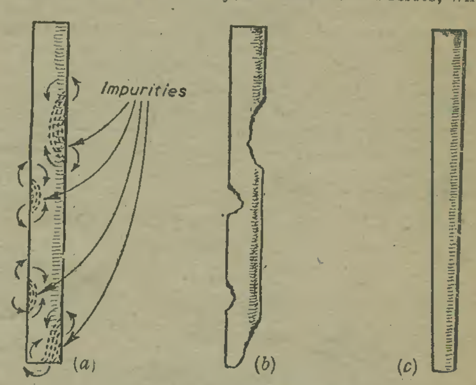



*Fig. 10.—Diagrams showing effects of local action.*

(*a*) *Arrows indicate the local currents due to impurities.*
(*b*) *Impurities eaten away causing badly pitted rod.*
(*c*) *Tapered wearing of an amalgated rod.*

their total E.M.F. is equal to the sum of the individual cell's E.M.F. Fig. 11 (*a*).

Cells should never be placed in parallel unless their E.M.F.s are equal, and they are similar, because, as shown in Fig. 11 (*b*), wastage continually occurs.

When cells of the same E.M.F. are connected in parallel, the current which can be taken for a given time is increased, but the E.M.F. of the combination remains the same as that of a single cell.

### General Examples

(1) In Fig. 8. Calculate the internal resistance of the supply, if one ampere passes when the P.D. of the supply is 10 volts. $R_e = 8.5\Omega$.

(2) By how much does the power dissipated in $R_e$ fall when the internal resistance of the cell is doubled as a result of polarisation taking place as the depolariser becomes exhausted? Fig. 8. ($R_e = 10\Omega$, J. $= 1/5$ amp.; *E.M.F. of cell, 2.2 volts.*)

Answers to general examples (Page 143):

1. Total Resistance, $6.2^{1}1^{1}$ ohms.
   Total Current, 8.048 amperes.
2. 11.9072 watts.
3. 7.07 milliamperes (approx.).
4. 161.3 watts in series, 726 watts in parallel.

(*To be continued.*)

# Potentiometer Problems

## Correct Use of "Graded" Volume-control Potentiometers: Calculating the Values of Resistors Required for Fixed Potentiometers and Potential Dividers

THE ordinary potentiometer is such a simple component that the constructor is apt to overlook some of the points concerning its correct use. In the case of variable potentiometers, such as are often used for variable-mu bias control in battery sets, input volume control to an L.F. amplifier, and sometimes for controlling the screening-grid voltage, there are very few pitfalls; provided that the correct overall value is chosen and that the potentiometer is well designed, it is not easy to make a mistake.

Even here, though, it is well to remember that a "graded" type of component is generally to be preferred. The chief feature of this kind of potentiometer is that the variation of resistance over any given angle of rotation of the knob is smaller toward one end of the resistance element than it is toward the other. This feature of design is incorporated so that a smoother

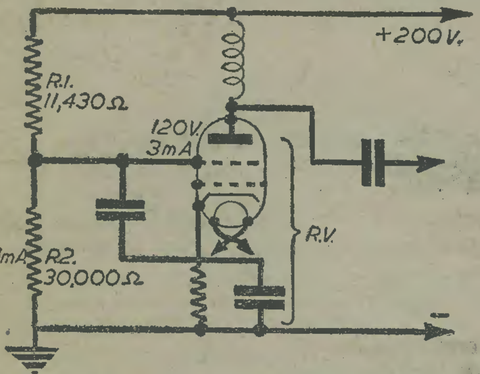



*Fig. 1.—A fixed potentiometer, comprising R.1 and R.2, used to supply the screening-grid voltage to an H.F. tetrode.*

control of volume is permissible. But this improvement will be obtained only if the potentiometer is correctly wired; if the connections to the two outer terminals should be reversed, control will be far more awkward than when using an ungraded component.

### Volume-control Connections

It is easy to remember the rule for correct connection. The terminal connected to the end having the lower resistance per unit length should go to the "maximum volume" point in the circuit. For example, in the case of the variable-mu control, the terminal in question should be wired to the earth line, or to G.B.+; with a variable S.G.-voltage potentiometer, it should be connected to H.T. positive (either directly or through a fixed limiting resistor), and in the case of the L.F. control, it should be connected to the "grid" terminal of the L.F. transformer or to the grid condenser, according to whether transformer or R.C. coupling is employed.

It is not always easy to tell which is which of the two outer terminals, but in the case of a wire-wound component, the fibre strip or similar material on which the wire is wound will be found to taper towards one end. The terminal connected to the narrower end is that which should go to the "maximum-volume" point.

The reason for control being smoother when the potentiometer is correctly wired is not difficult to understand. Consider a variable-mu control in conjunction with the anode current-grid volts curve of the controlled valve. The curve is reasonably straight around the point of zero grid volts, but flattens out toward the maximum G.B. negative voltage. Thus, there is a marked drop in anode current between, say, zero and one volt negative, but only a small variation between, say, four and five volts negative. Our need is to reduce the variation at the upper end and increase it correspondingly at the lower end. This same general principle will be found to apply to potentiometers used in other parts of the circuit.

If there is any difficulty in tracing the connections by visual inspection it is an easy matter to find the correct wiring by trial, reversing the leads to the two outer terminals and checking the smoothness of control.

### Fixed S.G. Potentiometers

It is customary in all reasonably modern receivers to provide a fixed voltage for the screening grid. For reasons which need not be discussed here, this avoids distortion and gives better results than are obtained when using a variable S.G. voltage. Additionally, of course, better volume control is obtained by making use of variable-mu valves. We can readily find the most suitable S.G. voltage from the valve-makers' instruction sheet, and if the S.G. current at that voltage, and with a given anode voltage, is known, the values of resistors required to make up the necessary fixed potentiometer can be calculated.

At this point it should be mentioned that it is usually better to use a potentiometer for S.G. supply than merely to feed the screening grid through a fixed voltage-dropping resistor. The reason is that a potentiometer maintains a more-nearly constant S.G. potential than

(*Continued on page 149*)

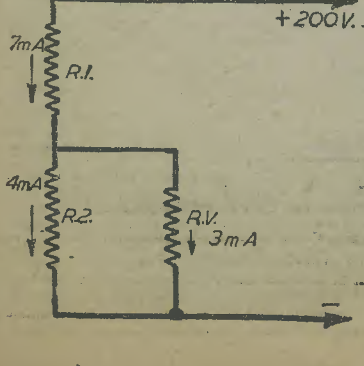



*Fig. 2.—(Left) An equivalent circuit to that in Fig. 1. It shows how the current is distributed.*

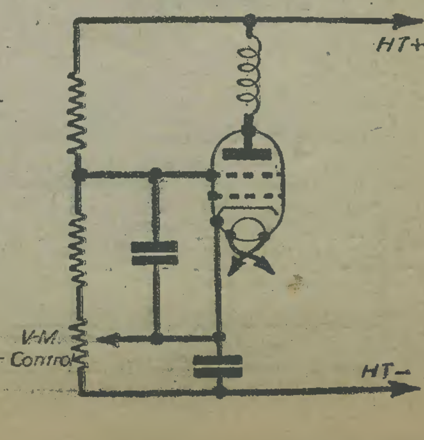



*Fig. 3.—(Right) An alternative method of connecting the S.G. potentiometer when using an indirectly-heated variable-mu valve.*

(*Continued from page 146.*)

can be obtained by other means. We know that if two resistors are wired in series the potential between one end of the pair and the junction is proportional to the value of the resistors and applied voltage.

For example, if two 50,000-ohm resistors were wired in series across a 100-volt supply, the potential between the negative terminal of the supply and the centre point of the two resistors would be 50. Similarly, if the resistors had values of 25,000 ohms and 75,000 ohms, the corresponding voltage would be three-quarters of the total, or 75.

**Effect of S.G. Current**

It is in this connection that a fallacy often creeps in. The facts just set out assume that no current is being drawn from the centre-tapping, and that the voltage is being measured with a meter of infinite resistance. If current were being drawn—as it is in the case of a screening grid—our calculations would be entirely upset. This can be understood by making reference to Fig. 1. Here we have an H.T. supply of 200 volts, and we

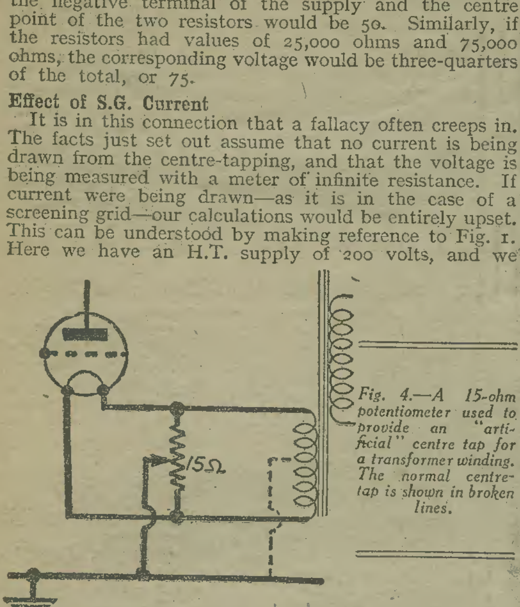



*Fig. 4.—A 15-ohm potentiometer used to provide an "artificial" centre tap for a transformer winding. The normal centre-tap is shown in broken lines.*

require a voltage of 120, at 3 mA, for the screening grid. If we overlooked the fact that current was being drawn we should deduce that since R.1 had to drop 80 volts, and R.2 120 volts, that R.1 should have two-thirds the resistance of R.2. For example, values of 20,000 and 30,000 ohms would give the desired result. This assumes that we can afford to have a standing current of 4 mA passing through the potentiometer.

These values are, in fact, entirely incorrect. This is because of the screening grid taking current; this has to be drawn through R.1 in addition to the standing current, with the result that the voltage dropped across R.1 would be in excess of 80. Let us work out suitable values for these two resistors. We must start with R.2, basing our calculations on the amount of standing current which is to be taken. With a battery set we should not normally wish to pass more than about one milliamp, but with a mains set we could generally "spare" about four milliamps. And within limits, the higher this standing current, the more accurately is the S.G. voltage maintained at a constant figure.

**Calculating the Values**

Assume, then, that 4 mA is taken as the steady current. We can find the value required for R.2 by straightforward application of Ohm's Law, knowing that the voltage to be dropped is 120. The resistance would be E/I multiplied by 1,000, where E is 120 volts and I is 4 mA; the answer is, therefore, 30,000 ohms. The screening grid takes 3 mA, which means that R.1 has to pass 7 mA in all. Its value will thus be 80 (volts) divided by 7 (mA) and multiplied by 1,000, which is approximately 11,430 ohms. In practice, we should choose the nearest standard value available—probably 12,000 ohms.

It may appear that there is a "catch" in this. If so, look at Fig. 2, which is what is known as an equivalent circuit for that shown in Fig. 1. It will be seen here that a resistance marked R.V is shown in parallel with R.2. This is the equivalent resistance of the valve. This shows why 7 mA can pass through R.1 when on[ly] 4 mA is passing through R.2, which is in series with [it]. The difference of 3 mA passes through the valve between the cathode and the screening grid.

When using a variable-mu valve of the indirectl[y] heated type it is often better to wire the potentiomet[er] as shown in Fig. 3. Here it will be seen that the fix[ed] potentiometer is in series with the V.M. potentiomet[er] or variable resistor (either will serve). The reason f[or] connecting the potentiometer in this manner is that th[e] resistance between the screening grid and earth remai[ns] constant. From this it would appear that the S.G. voltage would also remain constant. In practice it do[es] not of necessity do so, due to the fact that the S.G. current is reduced to a certain extent as the bias voltag[e] is increased. Nevertheless, this is probably the be[st] that can be done without adopting an unnecessaril[y] complicated arrangement.

**Artificial Centre-tap**

Another use for a potentiometer, this time a variab[le] or pre-set component, is in conjunction with the filamen[t] supply to a directly-heated output valve in an A.C. operated receiver. If the L.T. winding is withou[t] a centre tap, or, if the tapping point is not at th[e] "electrical centre" of the winding, we use a[n] "artificial" centre tap, as shown in Fig. 4. A 15-ohm potentiometer is connected in parallel with the filamen[t] terminals of the transformer, and the slider is earth connected. When the receiver is being set up initiall[y] this potentiometer is adjusted until mains hum can n[o] longer be heard, or until it reaches its lowest level. It [is] not without interest that the optimum setting is no[t] always at the precise centre of the resistance, but [is] often offset from it. It is the electrical centre of th[e] winding which is required.

**The Potential Divider**

Fig. 5 shows a potential divider, which is simply [a] modified form of potentiometer. A device of this kin[d] may be used with a mains unit to enhance the voltag[e] stability of the various tappings. The necessary value[s] of three resistors forming the potential divider can b[e] calculated by adopting a procedure similar to tha[t] followed when determining the values for our S.G. potentiometer. First we must know how much standin[g] current is to be allowed. It is best to allow as much a[s] possible, and it would normally be the difference betwee[n] the maximum output from the rectifier and the tota[l] H.T. current required. Very often the potential divide[r] is used as a "bleeder" or as a load resistor to prevent th[e] D.C. voltage rising above the rated voltage of the rectifier.

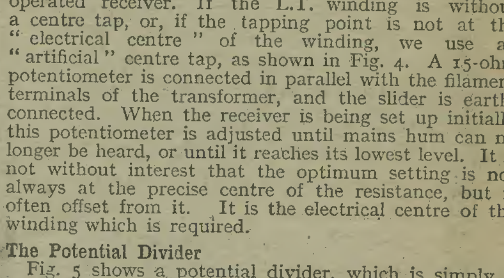



*Fig. 5.—A po[tential] divide[r] made up fro[m] three separat[e] fixed resistor[s] and used fo[r] regulating a[n] H.T. supply fro[m] a rectifier.*

For present purposes we may assume that th[e] rectified voltage is 250 and the output current 50 mA whereas the total consumption by the receiver is only 40 mA. The potential divider must therefore pass 10 mA. The current load on the various tappings is shown in Fig. 5, along with the required voltages. Starting with R.1, we see that this must drop 60 volts, and we know that it has to pass 10 mA; its value will thus be 6,000 ohms. R.2 has to drop 40 volts (V.2 minus V.1) and is required to pass 12 mA. Its value will be 3,333 ohms (3,500 would probably be near enough). R.3 is to drop 150 volts and must pass 10 mA, plus 2 mA, plus 5 mA—17 mA in all. Its value will therefore be 150/17 times 1,000, or approximately 9,000 ohms.

# Transmission Lines

## Standing Waves, Imput Impedance, Matching

By S. A. KNIGHT

(*Continued from page* 108, *February issue*)

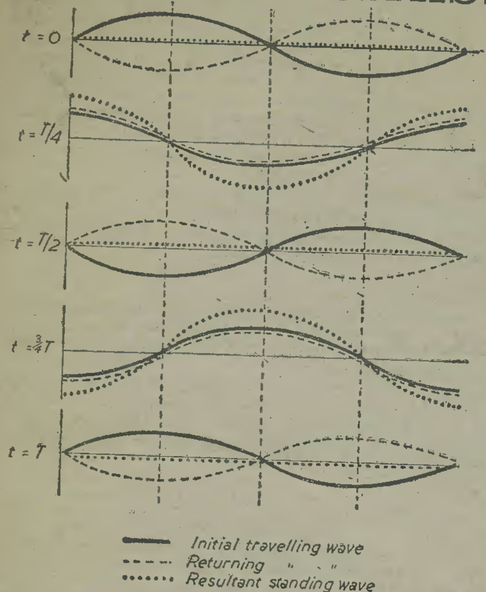



*Fig. 8.—Voltage standing waves set up by the travelling and reflected components.*

THIS energy is given to the electric field, and so the voltage at the termination is greater than the voltage due to the original travelling wave.

Since the reflected wave of current must have the same amplitude as the forward wave, the voltage at the termination is *doubled.*

Thus no-phase reversal of voltage occurs at an open circuit termination and, as before, the resultant voltage is obtained by adding point by point of the forward and returning travelling waves. (Fig. 8.)

It should be noted that voltage nodes occur at distances $\lambda/4$, $3\lambda/4$, etc., from the termination, and voltage antinodes occur at distances $\lambda/2$, $\lambda$, etc., from the termination. Again, any two points on the line are either in phase or antiphase.

The above types of waves, which are due to a combination of two or more travelling waves, are known as *Standing Waves.*

### R.M.S. Considerations

Fig. 9 gives the R.M.S. values for current and voltage that would be obtained in R.M.S. instruments placed at any points on the line. R.M.S. voltages are always positive, so the reversal of phase of current or voltage which occurs at every half cycle is not indicated.

### A Line Short-circuited and $\lambda$ in Length

Consider first the voltage variations. The termination in this case is a short-circuit and has zero impedance, consequently there can never be a voltage developed across it, the termination being, in fact, a voltage node. In order to obtain this the reflected voltage wave will have to suffer a phase reversal at the termination. This is comparable with the case of the current wave for the open circuit case, and Fig. 7 can be used in this instance to indicate the voltage variations for the short-circuited line. Thus voltage nodes for the open circuit coincide with current nodes for the short circuit, and voltage antinodes for the open circuit coincide with current antinodes for the short circuit.

### Current Considerations

At the termination the electric field must collapse and its energy will be given to the magnetic field. This results in an increased current at the termination and for a perfect short circuit will be twice the value of the travelling wave current. Therefore the reflected current wave does not have a phase reversal and corresponds to that of the voltage in the open circuit line.

A new diagram is unnecessary, and Fig. 8 can be referred to again, in this case for current variations on the short circuited line.

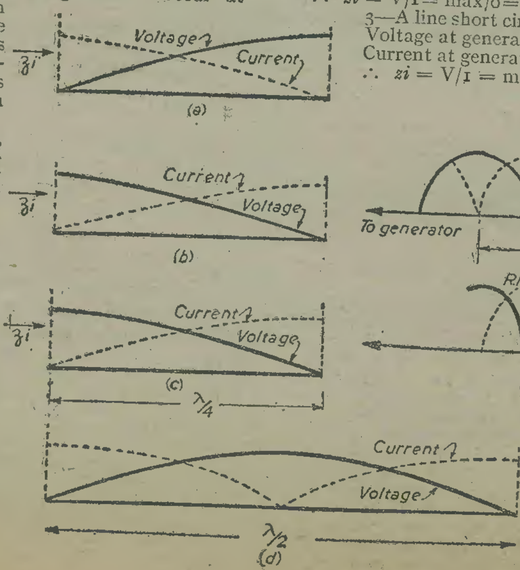
### Input Impedance of a Length of Line

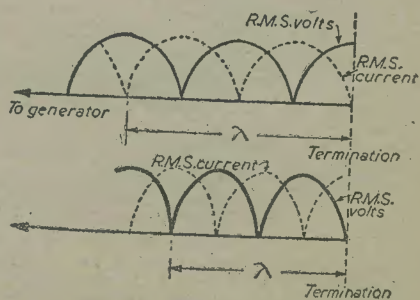
In the case of the open-circuited line and the short-circuited line, R.M.S. voltage and current varies as we move along the line. Thus, if the length of line is varied the generator will look into an impedance which depends upon, as far as magnitude is concerned, the ratio between the amplitude of the voltage and the amplitude of the current variations.

1—A line open circuited and of length $\lambda/4$ (Fig. 11a)
Voltage of the generator = 0
Current of the generator = a maximum
∴ Input impedance $zi$ = V/I = 0

2—A line open circuited and of length $\lambda/2$ (Fig. 11b)
Voltage at generator = a maximum
Current at generator = 0
∴ $zi$ = V/I = max/0 = infinity.

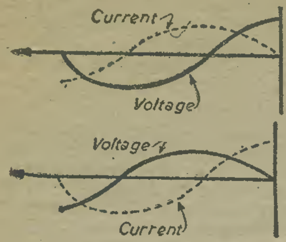
3—A line short circuited of length $\lambda/4$ (Fig. 11c)
Voltage at generator = a maximum
Current at generator = 0
∴ $zi$ = V/I = max/0 = infinity.



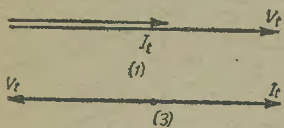

*Figs. 9 and 10 (Above).—The R.M.S. values of the open-circuited and short-circuited lines respectively.*

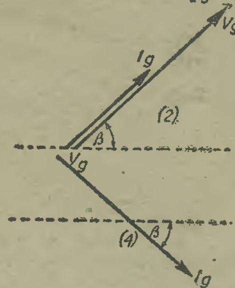
*Fig. 11 (Left).—Showing the effect of line length on input impedance.*

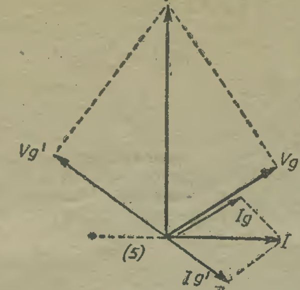



*Figs. 12 and 13.—Voltage and current curves for open-circuited and short-circuited lines.*

*Fig. 14 (Below and Right).—Vector representations of the nature of the input impedance for a s/c line less than λ4.*




4—A line short circuited and of length $\lambda/2$ (Fig. 11d)
Voltage at generator $= 0$
Current at generator $=$ a maximum
$\therefore\ zi = V/I = 0/\text{max}$
$= 0.$

Consider the cases 1 and 4. These can be compared with a series-tuned circuit, while cases 2 and 3 can be compared with a parallel-tuned circuit.

**General Case for an Open-circuited Line**

Fig. 12 gives the voltage and current waves for any length of line $l$. The current can be represented by a cosine expression, $l$ being measured from the termination.

If now we look into the line at any distance $l$ from the termination, the input impedance $zi$ will be a ratio of a cosine to a sine expression, i.e., a cotangent expression.

**General Case for a Short-circuited Line**

This time (Fig. 13) the voltage is represented by a sine and the current by a cosine expression. *Zi* will therefore be a tangent expression. Thus, in general, for a length of line other than multiples [of $\lambda/4$, the input impedance can have a magnitude which varies between zero and infinity.

**Nature of the Input Impedance**

*Case 1.—Short-circuited line less than λ/4.*

Consider the vector diagrams of Fig. 14 which are for the initial travelling wave at the termination and the generator respectively.

The first pair represent the wave reaching the termination a short time after it has left the generator. This is represented by $\beta$ which has a value between 0 degrees and 90 degrees for a line less than $\lambda/4$.

The reflected wave is obtained by reversing the voltage vector $V_r$ at the termination (second pair), and this wave now reaches the generator again with a phase lag of $\beta$.

The resultant voltage and current at the generator by the combination of (2) and (4) is shown in the fifth diagram. We see from this that the resultant voltage leads the resultant current by 90 degrees; thus the input impedance of a loss-less short-circuited line less in length than $\lambda/4$ is a *pure inductance.*

*Case 2.—Short-circuited line less than λ/ greater than λ/4.*

This case is represented as the previous one vectorally, in Fig. 15, the input impedanc being a *pure capacitance.*

*Case 3.—Open-circuited line less than λ/4.*

It would be possible to construct simila vector diagrams remembering that in this cas the current vector has a phase reversal at th termination instead of the voltage. We shoul find that the input impedance this time woul be a *pure capacitance.*

*Case 4.—Open-circuited line less than λ/ greater than λ/4.*

The input capacitance would be a *pur inductance.*

**General Cases**

It can be shown that for the general case of loss-less line of characteristic impedance zk terminated in an impedance $zr$ and of any length is given by:

$$zi = zk\frac{(zr + jzk.\tan 2\pi l/\lambda)}{zk + jzr.\tan 2\pi l/\lambda}$$

Take as examples: a short-circuited line, z being zero. Substituting this value for $zr$ in the abov equation:

$$zi = zk.\frac{jzk.\ 2\pi l/\lambda}{zk}$$
$$= jzk.\ 2\pi l/\lambda$$

Now: an open-circuited line, $zr$ being infinity. Thi time we can re-arrange the equation by dividing num erator and denominator by $zr$.

$$zi = zk\frac{1 + j.zk/zr\ \tan 2\pi l/\lambda}{zk/zr + j.\ \tan 2\pi l/\lambda}$$

Now, if $zr$ equals infinity:

$$zi = zk.1 + 0/j.\ \tan.\ 2\pi l/\lambda$$
$$= -j.\ zk\ \text{cotan}.\ 2\pi l/\lambda$$

Fig. 16 shows curves which give variations of $zi$ a the length of the line is varied, both open and short circuited cases. They are plotted from the formulæ:

(i) $zi = j.\ zk\ \tan 2\pi l/\lambda$ for the S.C. case.

(ii) $zi = -j\ zk.\ \text{cotan}.\ 2\pi l/\lambda$ for the O.C. case.

These formulæ assume loss-less lines and perfec open and short circuits. In practice these ideal condi tions cannot be obtained and the curves fall short of th true representation of $zi$, for $zi$ will, in general, contai resistive components.

Take a specific length of line, $l$ being $\lambda/2$.

Then $zi = zk\dfrac{zr + j.\ zk\ \tan 2\pi l/\lambda}{zk + j.\ zr\ \tan 2\pi l/\lambda}$

$= zk.\ zr/zk$

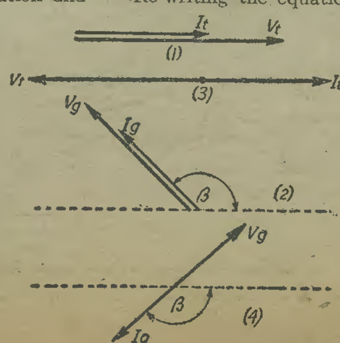
$= zr$

i.e., $zi = zr$

Thus this length of line can be used as a 1 : 1 transformer.

Take a specific length of line, $l$ being $\lambda/4$.

Re-writing the equation, by dividing by $2\pi l/\lambda$



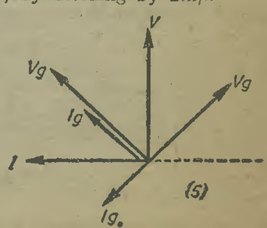




*Fig. 15.—Vectors of the short-circuited line, the input impedance being a pure capacitance.*

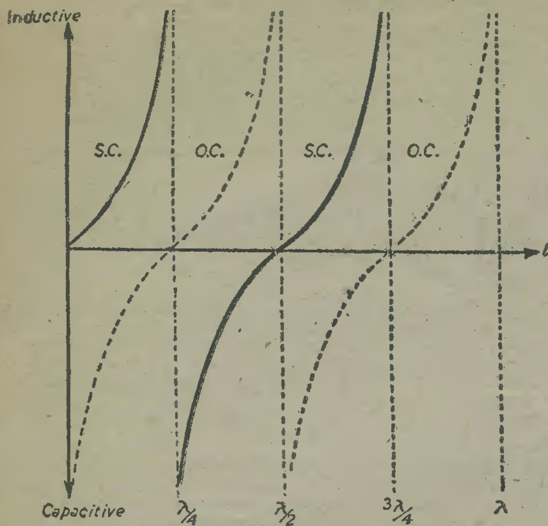



*Fig. 16.—Curves showing variations of zi as length of line is varied, for open- and short-circuited cases.*

$$zi = zk.\frac{(zr/\tan 2\pi l/\lambda) + j.zk}{(zk/\tan 2\pi l/\lambda) + j.zr}$$

When $1 = \lambda/4$, $\tan 2\pi l/\lambda$ is infinity.

$$zi = zk.\ j.zk/j.\ zr.$$
$$zi.\ zr = zk^2$$
$$zk = \sqrt{zi.zr}.$$

**Matching**

Consider the case of an aerial whose resistance is 80 ohms fed from a 600-ohm transmission line. The required $zk$ for the $\lambda/4$ of the matching device is given by:

$$zk = \sqrt{zi.\ zr}$$
$$= \sqrt{600 \times 80}$$
$$= 220 \text{ ohms}.$$

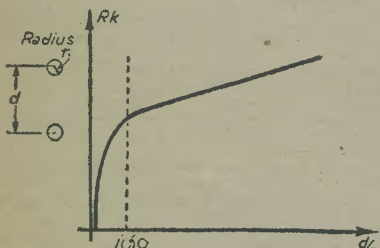



*Fig. 17.—Rk increases very rapidly with d/r up to d/r approximately equal to 100.*

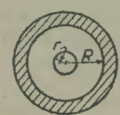



*Fig. 18.—The coaxial line, where Rk=138 log10 R/r.*

Thus we see that by suitably choosing the value of $zk$ by the $\lambda/4$ length of line, we can obtain the required matching for the 600-ohm line. We have, in effect, an impedance transformer, and is in fact called a Quarter Wave Impedance Transformer.

We have:

$$zi = zk^2/zr$$

therefore, the impedance is changed from $zr$ to $zk^2/zr$.

**Practical Types of Lines**

(1) The Twin Balanced Pair.—Consists essentially of a pair of parallel wires. It can be shown that the characteristic impedance (resistive) is given by:

$$Rk = 276 \log_{10} d/r \text{ (air-spaced)}.$$

Thus the $Rk$ increases very rapidly with $d/r$ up to $d/r$ approximately equal to 100. For larger values of $d/r$, the $Rk$ remains fairly constant (Fig. 17).

The lines are referred to as balanced because at any point along them the current in the two wires is in antiphase, this tending to reduce radiation from the transmission line.

The effect of a dielectric is thus: the $Rk$ of a transmission line is given by $Rk = \sqrt{L/C}$, but if a dielectric is introduced, $L$ is unaffected since $\mu$ (permeability) for most substances is very nearly unity. If the dielectric has a $\mu$ $K$, the effective capacitance per unit length is increased $K$ times.

Thus $$Rk = \sqrt{L/KC}$$
$$= 1/\sqrt{K} \times \sqrt{L/C}$$
$$Rk = 1/\sqrt{K} \times Rk \text{ for air}.$$

(2) The Coaxial Line.—This has two conductors, the second forming a tube around the first (Fig. 18). It can be shown that for an air-spaced cable:

$$Rk = 138 \log_{10}.\ R/r.$$

$Rk$ is normally of the value of 80 ohms and is not so constant for variations in $R/r$ as is the balanced line feeder. Also the cable is self shielding, i.e., currents flow on the inner surface of the outer conductor and no external radiation occurs.

(3) Twisted Pair.—This consists of a two-wire line composed of twisted rubber-covered wire. Since $d/r$ can be made quite small the $Rk$ is fairly small, generally from 100 to 200 ohms.

The application of transmission line theory to aerial systems must come under a later heading.

## *PRIZE PROBLEMS*

### Problem No. 441.

**BOYCE built a four-valve superhet using all the correct parts, but when first switched on he could obtain no signals. He therefore borrowed a signal generator and commenced to line-up the receiver. He adjusted the second I.F. transformer and then connected the generator to the grid of the frequency-changing valve but could not obtain a signal in the output stage. He tested the secondary of the I.F. transformer and this was in order, and then he found also that the primary was in order. A D.C. test showed that the frequency-changer was passing anode current correctly, but no adjustment of the trimmers could enable him to obtain the note from the generator in the oscillator stage. What was wrong?**

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. 441 in the top left-hand corner and must be posted to reach this office not later than the first post on Monday, February 15th, 1943.

### Solution to Problem No. 440.

On testing his receiver, Nash found that the oscillator section of the frequency-changer did not function on the long-wave band owing to a defect in the grid winding of the oscillator coil.

The three following readers successfully solved Problem No. 439, and books have accordingly been forwarded to them. Miss Lilian Knox, 40, Howick Street, Alnwick, Northumberland; L/Bdr. S. A. Longhurst, R.A.; L. F. Halliday, c/o G.P.O.

# ON YOUR WAVELENGTH

## By THERMION

I LISTENED-IN the other morning to the 7 o'clock news, and I wish to complain to the B.B.C. that, as the result of a particular news item I thought I was dreaming, and I therefore missed my physical jerks. The item to which I refer drew attention to the experiences of some Servicemen who found themselves wandering through the Bush far from their unit. One of them happened to be a radio operator, and the B.B.C., in all seriousness, told us that this man had made a transmitter from some pieces of string, some cocoa tins, and pieces of bamboo!!!! Now this, I am certain you will agree, is careless talk. It is giving valuable information to the enemy. The secret has been so well kept that even I had not heard of it, and here is the B.B.C. broadcasting this valuable item to all and sundry. The Germans now know that we have invented a means of making radio transmitters out of cocoa tins, string and bamboo, and I have no doubt that their Teutonic cunning will enable them too to produce superior transmitters made from these rawest of raw materials. I had for a long time wondered why the Government had issued an order making it an offence to waste string, but I can now see that every inch of it was required to build this new secret weapon. Perhaps this is the reason why it is almost impossible to purchase a bamboo pole for drawing-room curtains, and why cocoa is becoming scarce. They want the tins for these transmitters. Why the B.B.C. should give this information away to the Germans I do not know, and I can only hope that the Mystery of Inflammation have severely reprimanded the B.B.C. news editor who had been so culpably negligent. Here have we all these years been building expensive transmitters from equally expensive apparatus when we could have achieved superior results from materials rescued from the dustbin. For all I know, the B.B.C. may be radiating its programmes by means of these transmitters. The string may provide the necessary degree of distortion to convert a normal singer's voice into that of a cryner. Here I want to register a protest on behalf of the technical press of this country. I demand to know why we have not received details of this wonderful transmitter to pass along to our various publics. It is true that readers of technical papers may not be so credulous as numbers of B.B.C. listeners. I rang the B.B.C. on the matter, and after being shunted about from department to department I eventually got through to the chief office boy, who informed me that the only thing he knew about string was that it was useful to have people on!

I also want to enter a vigorous protest on behalf of the publishers of Technical Books whose stocks of books dealing with transmitters and transmitting will be rendered obsolete. I met Mr. F. J. Camm the other day walking along the corridors of Tower House in a thoughtful mood, and when the Editor is in a thoughtful mood he is either going to write a book, or trouble is brewing. When trouble is brewing I make myself as scarce as during an air raid. Tactful inquiries from his retinue of private secretaries elicited the information that the publishers wished to know why his various wireless books did not include the string-tin-bamboo transmitters. The Publishing department had been answering urgent telephone calls all day from disgruntled purchasers of books who presumed that F. J. C. was holding out on them. The usual excuse that the Censor had refused to pass the information would not wash.

On behalf of the wireless industry who manufacture transmitting valves and components I protest that the disclosure by the B.B.C. of this new invention is rendering valuable stocks obsolete. I implore the B.B.C. to suppress this information, and save an industry, and a technical press from disaster.

### Slush

ALTHOUGH the B.B.C. has set its face against debilitated music, otherwise known as cryning or slush, I have not noticed any great diminution in the surge of this silt from the sewers of music. In fact there seems to be more of it. The B.B.C. also announces that it opposed the pirating of classical music. I notice, however, that Handel has been jazzed. They are giving Mozart a rest.

### The British Sound Recording Association

THE British Sound Recording Association was formed in 1936 by a number of engineers and amateur enthusiasts with the primary purpose of uniting in one body all those engaged or interested in the art and science of sound recording. The membership was steadily rising until the outbreak of war, and there were members in many parts of the world. A quarterly journal and a bi-monthly bulletin were issued, but since 1940 the activities have been curtailed because the officers and members have been scattered by war service. All officers acted in an honorary capacity. For the past two years or so it has been decided not to enrol or accept any subscriptions from new members in fairness to them, but full details are listed, and as soon as conditions permit they will receive application blanks and the latest information. Earlier members maintain contact through correspondence, and technical questions are still dealt with. I mention these points because D. W. Alduce tells me that a rumour has been going round that the club has suspended activities. Although it may be in a state of animation it is still in existence, and is not dying.

### "Sound the Loud Pibroch"

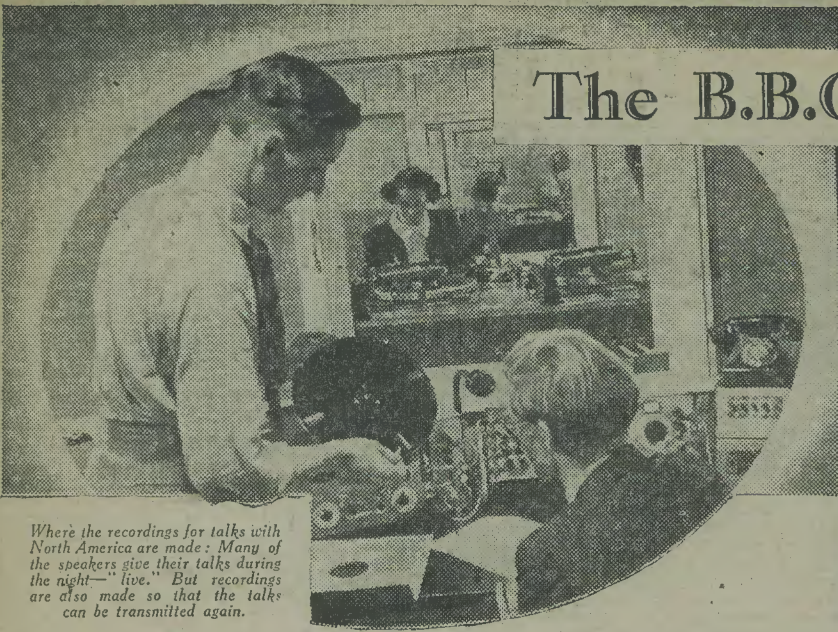
*[Press item.—Referring to musical compositions, it is curious that in some of the less civilised parts of Europe even semi-tones were until recently hardly used.]*

Send roond the Fiery Cross ainee mair,
  Tae summon up each clan;
And march wi' kilts and pipers braw,
  Until they find the man
Wha this fresh insult tae the Scot
  Has jealously devised.
Och aye! And daurs tae tell the wurruld
  Scotland's no ceevilised!
Whit kens he o' the bagpipe's charrrms,
  Contemptuous o' half-tones;
Whit ither eenstrument sae weel
  For Scotsmen shrieks and groans,
Expressing thus their attitude
  Tae ither lesserr races,
Wha should, in common modesty,
  Frae Scotsmen hide their faces?

Was Bobby Burrrns nae ceevilised,
  Wha Shakespeare pits tae shame?
Is haggis not a royal dish
  Tae silence hunger's pain?
And whusky—there's a drink for ye
  Nae savage could invent;
And wha like Scots so weel inforrrmed
  Hoo bawbees should be spent?
Forbye, let's waste nae furrtherr time
  Aboot this feckless loon,
But leave him tae his blathering
  Awa in London toon!
He doesna need tae fash himself—
  Oor parritch still is prized;
And all the wurruld may see from this
  Hoo farr we'rrr ceevilised!

"TORCH."

# The B.B.C. Talks



*Where the recordings for talks with North America are made: Many of the speakers give their talks during the night—"live." But recordings are also made so that the talks can be transmitted again.*

*Radio News Reel goes on the air: A day's news. This nightly programme is feature.*

IN a building that was once a well-known West End store, the North American Service of the British Broadcasting Corporation now functions. The main hall of the shop is now partitioned off into nests of offices like an egg box. The bare walls are roughly painted, and the marble staircase—which used to lead to the basement—now looks as ludicrous as if it were furnishing a hay loft.

The North American Service is one of the B.B.C.'s most ambitious programmes. Starting at 11.15 p.m. each night, $7\frac{1}{2}$ hours' non-stop service of news, talks, features, and variety goes out to America.

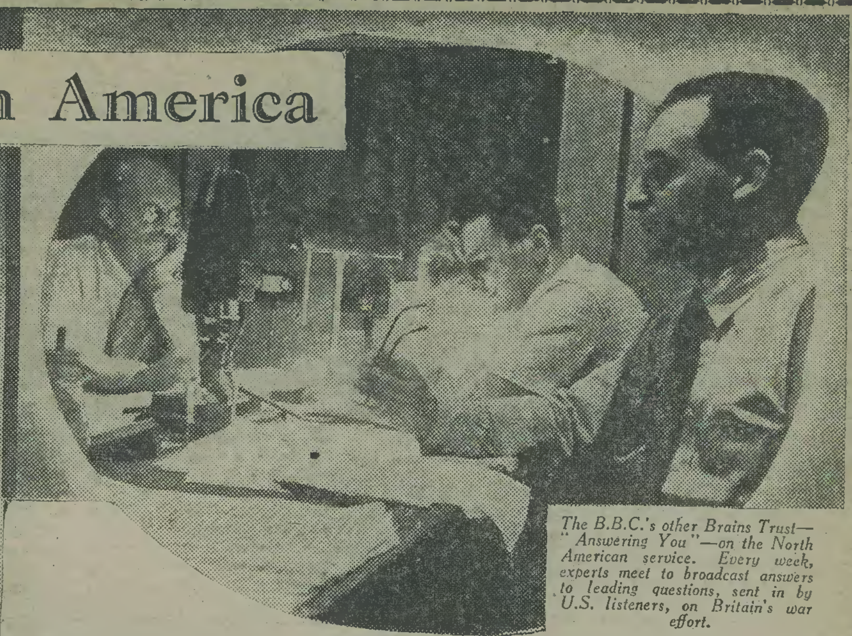
**Underground Studios**

The studios are underground. On your way to them, you are guided through narrow passages lined with compartments like a railway coach. Through half-open doors, you occasionally catch a glimpse of a shirt-sleeved

*The night's programme begins: Broadcasting a London letter.*

*An outdoor broadcast: America n Every week, an outdoor recordin London streets to collect unreh ordinary Londo*

# ... to North America



*The B.B.C.'s other Brains Trust—" Answering You "—on the North American service. Every week, experts meet to broadcast answers to leading questions, sent in by U.S. listeners, on Britain's war effort.*

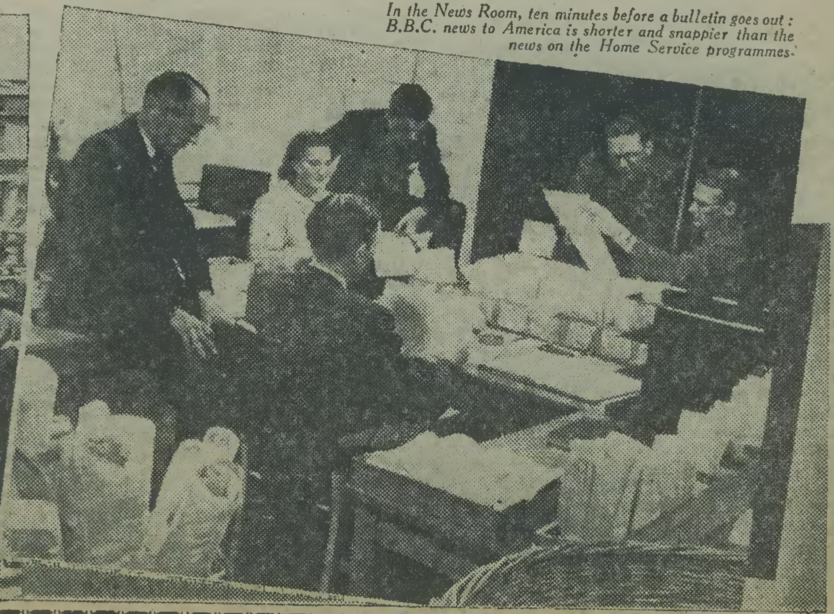
*: A sound picture of the ...ne is an important overseas*

figure behind a battery of telephones; a tousled-haired body—probably belonging to a producer with an early morning programme to see to—resting on a camp bed; a trousered secretary dividing her attention between a typewriter and beef tea. It is the night staff on duty.

Down below, on the studio floor, you see engineers—men and girls—bending over turntables cutting discs. You go into a room labelled Red Network, where two more girls are in charge of a formidable control board. Finally, you're shown into a little cell heavily lined with some sound absorbent material, from where you make your broadcast. A few minutes before your zero hour, you are joined by an announcer. As the second hand climbs the last quarter-minute before you make your talk, the announcer says " Quiet, please," in a mechanical voice. Then he announces : " This is the North American Service of the British Broadcasting Corporation," and you are left with the microphone.

*...ca meets " John Londoner." ...rding van goes out into the ...nrehearsed interviews with ...ndoners.*

*In the News Room, ten minutes before a bulletin goes out : B.B.C. news to America is shorter and snappier than the news on the Home Service programmes.*



# Radio Examination Papers—16

## Another Series of Questions, Taken at Random, with Suitable Replies by THE EXPERIMENTERS

**QUESTIONS**

1. *What would be the effect of using long leads between the secondary of a high-ratio step-down transformer and the speech coil of a low-impedance moving-coil speaker?*
2. *In what principal ways can a slice of quartz crystal be used for frequency stabilisation?*
3. *Why is it very important to switch off the H.T. before moving a grid-bias plug, especially when the plug to be moved is that for the bias supply to an output pentode or tetrode?*
4. *If the signal strength obtained from a good receiver provided with A.V.C. were just the same whether using a 10ft. or a 60ft. aerial, it would still be advantageous to employ the longer aerial. Why?*
5. *When using an A.C. power pack, what faults would you suspect if the following symptoms were observed:*
   (a) *Output D.C. voltage too high?*
   (b) *Voltage normal under no-load conditions, but falls rapidly to less than half the rated figure as the load is raised to the rated output current?*
6. *For how many hours should a 2 volt., 40 a.h. accumulator, fully-charged and in perfect condition, operate a five-valve receiver the filaments of which take .15 A., .15 A., .1 A., .1 A., and .2 A, respectively?*
   *What should be the no-load voltage of the accumulator when fully charged, and to what figure will the voltage fall after the set has been in use for approximately 55 hours?*

### 1. Audio-frequency Loss

THE effect of long leads in the secondary circuit of the step-down transformer would be to cause an appreciable reduction in signal strength. This is because the transformer secondary, the leads and the speech coil are all in series, as shown in Fig. 1. Thus, instead of the whole output from the transformer being developed across the speech coil, a proportion of it would be lost in the leads. For example, if the speech-coil impedance was, say, 20 ohms and the impedance of the leads also 20 ohms, only half the available output voltage would be applied across the ends of the speech coil.

Should the impedance of the leads be, say, 100 ohms, only one-sixth of the available output would be applied to the speaker. The current with which we are dealing is audio-frequency, but the principle is just the same as that which applies when a D.C. is passed through a number of resistances in series. This is shown in Fig. 2, where a 20 volt battery is shown connected to three resistors of 10, 20 and 10 ohms each respectively; the battery represents the output from the transformer and the resistors represent the two leads and the speaker.

The voltage across the 20-ohm resistor will be only 10, and the voltage across each of the 10-ohm resistors will be five. These give a total of 20 volts. If the two 10-ohm resistors were short-circuited the voltage across the 20-ohm resistor would be 20 volts—assuming that the battery was a source of constant voltage.

In terms of power, the wattage developed across the 20-ohm resistor in the first instance would be 20 watts; in the second instance it would be only 5 watts

### 2. Crystal Frequency Control

The most frequent use of a quartz crystal is in the oscillator stage of a transmitter. It may be connected in the grid circuit of a valve having a tuned anode circuit, or it may be connected between the grid and anode. In either case, the valve is caused to oscillate at the resonant frequency of the crystal (and harmonics of that frequency, of course). It is not proposed to explain the reason for that here, since that has been done fully in previous issues of this journal.

A crystal can also be used in a receiver. It might be connected in the grid circuit of the oscillator valve of a superhet, if fixed tuning is provided for the input circuit. In that case, the crystal would require to have a resonant frequency higher or lower than the frequency of the signal to be received by the I.F. In practice, a number of crystals would probably be used, a selector switch being provided to bring each into circuit as required. At the same time, a corresponding number of pre-set condensers would be fitted in the input circuit to the first detector, these also being controlled by means of a multi-position switch.

Another use of crystals in a superhet receiver is in the I.F. circuit. In this case a crystal, or a pair of crystals, would be chosen that resonated at the required intermediate frequency. The crystal would act as a "gate" and so allow the passage only of signals at crystal frequency. When using this arrangement the oscillator and input tuning circuits would be of conventional design, and the tuning of the receiver would not be limited by the number of crystals available.

### 3—Current Surge

When the bias supply is removed from a valve, the anode current rises to many times its normal value, and there is a danger of the valve being damaged. If the breaking of the G.B. circuit is repeated a number of times damage is inevitable, with any type of valve designed to operate with a negative grid bias.

In the case of a pentode or tetrode the rise in anode current is accentuated because of the high amplification factor of the valve. At the moment the bias is removed, there is a sudden surge of anode current, and, in certain circumstances, the valve may be ruined immediately. This is most likely if the valve is receiving its maximum rated anode and screen voltage.

It is because of the facts given above that the valves should be made inoperative—either by switching off the

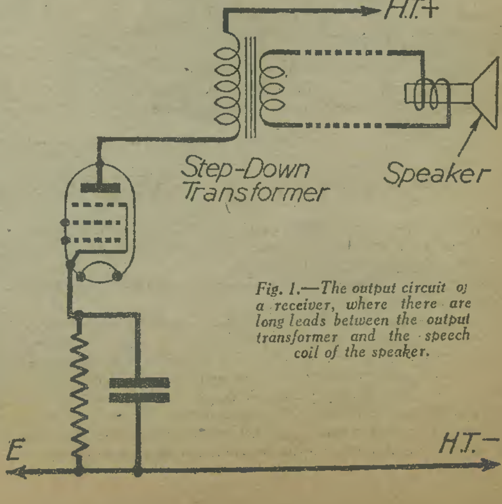



*Fig. 1.—The output circuit of a receiver, where there are long leads between the output transformer and the speech coil of the speaker.*

set or removing the H.T. supply—before the grid-bias wander plugs are removed from and connected to the bias battery.

**4—The Aerial and A.V.C.**

Signal strength, considered alone, is not a criterion. More important for comfortable reception is the ratio of signal strength to "background" noises. A signal of moderate strength free from background noise, "mush" and "hiss" is far more easily understood than a very loud signal accompanied by extraneous noises.

Now in the case of a sensitive receiver with efficient automatic volume control a number of high-frequency and/or intermediate-frequency amplifying valves is essential. And every valve introduces a certain amount of noise in consequence of the electronic emission from the cathode and slight vibration of the electrodes. Moreover, this noise increases rapidly as the maximum sensitivity of the valves is approached.

It is clear, therefore, that background noises will be least in evidence if the valves are "running light," or not providing their maximum amplification. And it is known that the effect of A.V.C. is to reduce the amplification, or gain, of the controlled valves as the signal strength at the second detector is increased. The increase may be due to the greater amplification provided by the valves preceding it, or by the greater pick-up by the aerial system.

The advantage of using a good aerial will now be apparent, as will the reason for using the 60ft. as against the 10ft. aerial wire. It is being assumed, of course, that the aerial in both cases is being placed in the most suitable position, and that the receiver is so designed that it has adequate selectivity when the longer aerial is connected; any properly-designed sensitive receiver with efficient A.V.C. would certainly meet this requirement.

Another incidental advantage of the longer aerial, in most modern houses, is that it would, for a good deal of its length, be well away from electric cables and equipment, which may produce a certain amount of interference.

**5—Power-pack Faults**

The excessive D.C. output would generally be attributable to using the incorrect primary tapping for connection of the A.C. mains supply. In that case the output voltage could easily be reduced by connecting the A.C. to a *higher*-voltage tapping on the primary of the mains transformer. Another reason for excessive D.C. voltage might be that the current load was less than that for which the power pack was designed. As an example of this, a power unit designed to give 250 volts, 60 mA would probably produce a voltage of about 340 if the current load was only 30 mA. In such a case, it is unlikely that sufficient "correction" would be obtained by stepping up the primary tapping.

The second fault could be due to a rectifier which had become faulty; for example, a valve which was losing its emission. It could also be caused by the use of a smoothing choke of much too high a resistance, or to a bad contact in the wiring which produced a high resistance in some part of the circuit. It could also result from the omission or open-circuiting of a smoothing condenser in certain circumstances.

**6—Accumulator Problems**

A 40 a.h accumulator will give a current of 4 amps. for 10 hours if fully charged and in perfect condition. In general, the "life" will be increased *pro rata* as the current load is reduced. That is, the accumulator would give over 40 hours' service if the current drawn from it were 1 amp. In passing, it should be noted that, as a general rule, the "life" is reduced disproportionately if the load exceeds one-tenth the a.h. capacity. For example, if the accumulator in question were discharged at 10 amps. it would not last for four hours—and possibly not for two!

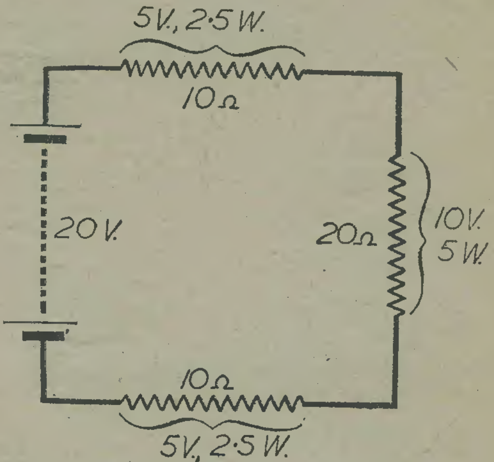



*Fig. 2.—An "equivalent" circuit to that in Fig. 1, showing the distribution of voltage and power dissipation.*

The five-valve set referred to in the question takes a total of .7 a., therefore, the accumulator should last for, at least, 40/.7 hours, or approximately 57 hours. In practice, a really good accumulator may run for longer than this when used intermittently and when delivering only about one-sixth of its maximum current based on the ten-hour rate. But allowing for an average accumulator the figure calculated above should be sufficiently accurate for all practical purposes.

A fully-charged 2-volt accumulator, off load, should read about 2.2 v. immediately after being removed from the charging board. This voltage will fall to 1.8 on load, by the time the accumulator is fully discharged. Dealing with the question as set, it may be stated that the voltage of the 2-volt cell would be approximately 1.8 after it had been in use with the set for 55 hours.

# A Letter To You From The Prime Minister

FOR the men and women of the Forces at home and abroad I make an appeal to which every family in the Kingdom can respond.

I do not ask for money. I ask only for books, magazines and periodicals.

If you had seen, as I have seen on my many visits to the Forces, and particularly in the Middle East, the need for something to read during the long hours off duty and the pleasure and relief when that need is met, you would gladly look, and look again, through your bookshelves, and give what you can. If you hesitate to part with a book which has become an old friend you can be sure that it will be a new friend to men on active service.

The procedure is quite simple. Almost any post office will take your books and magazines if handed in unwrapped, unstamped and unaddressed.

They will then be distributed to all the Services where most required. Malta, the Middle East, Iceland, and a dozen other places abroad will welcome your gifts, and there are lonely stations at home to be supplied.

Will you contribute from your shelves, and remember when you buy a book or magazine that there are many waiting to read it after you?

(*Signed*)

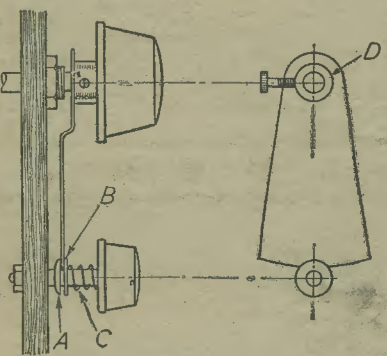
WINSTON S. CHURCHILL.

# Practical Hints



## Bandspread Slow-motion Dial

FACED with the problem of obtaining an effective slow-motion dial for a miniature set (built in an Army mess tin) the following gadget was devised. A bushing taken from an old knob was soldered to a segment of tin (as shown) and into the grub screw hole a long screw was fitted, with an ½in. milled-edged washer soldered to the end. This was slipped on to condenser spindle and then the knob was replaced. A drive was devised from a piece of ⅛in. brass tube, a washer A being soldered to spindle while the other, B, was left floating and held against the segment by the spring C. A 6 B.A. screw was slipped through the tube and bolted to the panel. The method of tuning is to slacken off the screw in bush D and rotate the dial until the desired waveband is found. Tighten up screw D, and select stations with the slow-motion drive knob. It will be seen that a ratio of something like 12 to 1 can be obtained without using much panel space. The segment can be cut to spread over 10 or 20 degrees according to requirements.—J. A. ROBINSON (Salford).

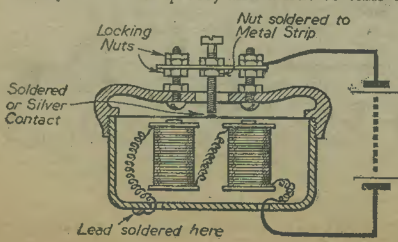



*A simple slow-motion dial arrangement.*

## An Improvised Buzzer

HERE is a small buzzer I devised from the junk box. It is a high-note buzzer with a pleasant musical tone which I find ideal for morse practice.

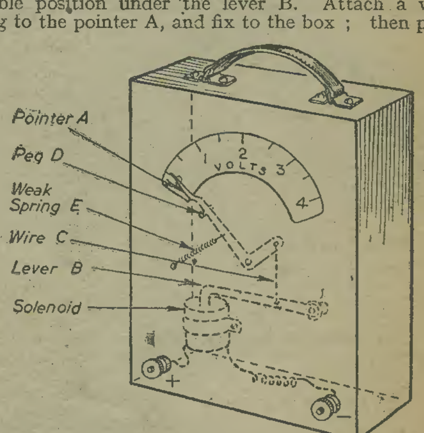
The sketch is self-explanatory, but here are a few words on construction. An earphone is taken to pieces, and in the earpiece two small holes are drilled each side of the centre hole for taking two bolts which are fitted with lock-nuts, as shown. A fairly thick strip of metal is then drilled with three holes corresponding with the holes in the earpiece, and a nut to take a small bolt is soldered over the middle hole in the strip of metal, the strip being then bolted to the earpiece and locked with nuts. The diaphragm is scraped and sandpapered all round the edge so that it beds down and makes a good electrical contact with the base. On the other side the paint is scraped away in the middle and then a blob of solder is dropped on to make the contact. The whole is then reassembled, one wire of the earphone is soldered to the earphone itself, the other wire being taken to a battery. Another wire is connected to the bolt on the top from the battery, and the buzzer is then ready for use. Slowly screw the middle bolt down until the buzzer starts to work, then gradually tighten the screw for the required pitch. If the buzzer just gives a "click" and nothing more, reverse the connections to the battery. In the original I fitted silver contacts and a condenser to eliminate sparking, but these, of course, are optional.—A. B. WEST (Winchmore Hill).




*A high-note buzzer contrived from an old earphone.*

## Simple Voltmeter

AN easily made voltmeter can be constructed as follows: Make a wooden box, of a suitable size, and cut a pointer A from thin aluminium, and pivot it to the back of the box. Next make the lever B from thin iron strip, and solder a piece of thin wire to A and B. Obtain a solenoid, and screw it to the back of the box in a suitable position under the lever B. Attach a weak spring to the pointer A, and fix to the box ; then put a small nail or peg on the back of the box, to prevent the pointer from being pulled right back. To complete, make a small scale and stick behind the pointer. If desired it can be calibrated with a standard voltmeter.—W. W. SMITH (Plymouth).




*A useful voltmeter made from odd parts.*

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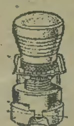

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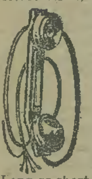

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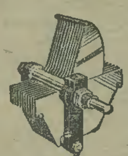

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# Permanent Magnets

**Magnets Play an Important Part in Radio, and this Article by L. SANDERSON Describes How Various Types are Made**

NOTHING is more astonishing in the history of metallurgical research and its application to industry than the progress in the design, use and composition of permanent magnets, as well as in the processes by which they are manufactured. The writer can remember, some 30 years or so ago, when the only available types of permanent magnets were made from a steel containing tungsten, and how numerous were the complaints of breakage in hardening! While it is untrue to say that tungsten steel magnets cannot be successfully hardened, it remains a fact that the old types of permanent magnet needed great skill in hardening, and even so, a percentage of fractures was then regarded as inevitable. Moreover, the uses of these magnets were limited.

To-day, not only are materials being used for permanent magnets that were never dreamed of in those days, but the properties obtainable from such magnets seem incredible by comparison with what was formerly thought possible. Moreover, the applications of these magnets have multiplied and spread, until to-day their manufacture constitutes one of the most vital and important new industries of the north and Midlands. Permanent magnets are used to-day in speedometers, magnetic compasses, miners' lamps, radio and gramophone sets, electric measuring apparatus, electric clocks, telephonic apparatus, and many other fields.

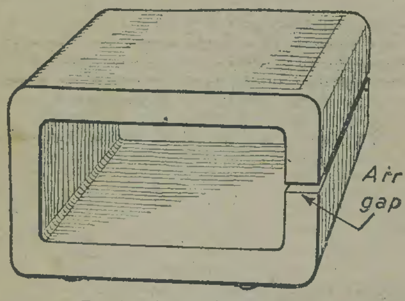


*Fig. 1.—A typical meter magnet.*

A permanent magnet is one that keeps its magnetism even after the magnetising force has been removed. There appears to be no definite rule governing the length of time a magnet retains its magnetism. Much depends, of course, upon the application and the treatment given to it. In general, however, it used to be considered that an ordinary loudspeaker magnet would retain sufficient magnetising force to fulfil its effective function for a period of nine to ten years, by which time it was assumed that design would have altered and improved so radically as to render the magnet obsolete, anyhow.

### How Permanent Magnets are Made

Before we embark upon the intricate details of magnet application and design, it is advisable to indicate as clearly as possible how permanent magnets are made. It must be borne in mind that magnets are of numerous types, weights and dimensions. Magnets may weigh as much as 22lbs. or more, and as little as the fraction of an ounce. Edgar Allen and Co., Ltd., of Sheffield, manufactured some time ago the largest permanent magnet in the world. This was made for the Cavendish Laboratory, Cambridge, and weighed approximately $2\frac{1}{2}$ tons complete.

We shall deal later with the materials now being used for magnets, but it is important to note that by far the majority of the magnet alloys being used to-day are cast to form owing to their inability to be forged.

### Electric Meter Magnets

Electric meter magnets constitute a typical example. These are first moulded in an oil-bonded sand, specially suitable for the casting of small objects. The moulds are mechanically produced by manually-operated moulding machines in which are incorporated stripper plates. By the adoption of an ingenious system, as many as 24 castings can be obtained from a single built-up mould. A typical meter magnet is shown in Fig. 1. The magnets, when cast, are grouped about a central stem, and are severed from this by means of a series of light hammer blows.

The method of building up the mould is interesting. The first item is the base (Fig. 2), on to which is placed a series of five intermediate moulds (Fig. 3), the whole being crowned by a cap or top piece having a funnel-shaped pouring hole. The base contains four impressions, and, consequently, produces four magnet castings. The same is true of the five intermediate moulds, which, however, have, in addition, a hole cored through the middle to allow the molten metal to flow (Fig. 4).

Sometimes magnets are cast, as more convenient, in sets of eight, employing the base, an upper mould and a top piece. A mould of this type is capable of being easily conveyed by means of a roller conveyer. Pairs of assembled moulds are placed on steel strips spanning approximately four rollers. The alloy is then poured into the moulds, which are allowed to cool. On completion of cooling they are conveyed by the roller conveyer through an opening into a knock-out shed. The three portions of each mould are secured by clamps and wooden wedges.

### Electric Crucible Furnace

The magnet alloys are usually melted in a high-frequency electric crucible furnace, the advantages of which in purity of metal and facility of operation are well enough known to need no special enumeration here. Each furnace holds approximately 5 cwts. of metal, tilts bodily, and teems the magnet alloy into ladles, which are then transported to the mould assemblies on the roller conveyer.

The casting cooled down, the moulds are broken open and the castings cleaned up ready for machining. There are five machining stages. In the first the rough casting is ground on sides and ends. The magnet is then subjected to a necessary heat treatment and a later

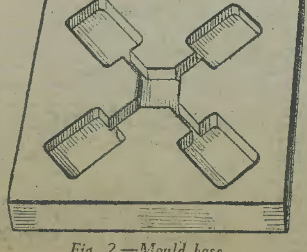


*Fig. 2.—Mould base.*

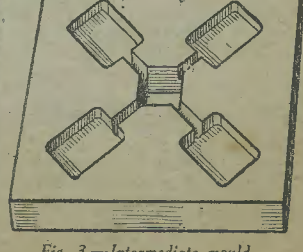


*Fig. 3.—Intermediate mould.*

secondary treatment, and ground again, after which it is drilled, finish-machined after hardening, and the gap cut.

The first grinding operation comprises grinding both faces on a surface-grinding machine, 36 magnets being ground simultaneously by means of a magnetic chuck, using a 12in. diameter segmental wheel running at a spindle speed of 1,450 r.p.m. The wheel segments last on average about eight hours.

The sides and ends are next ground on an end-grinding machine, the magnet being positioned by means of a right-angle plate and clamped in position. A three-segment wheel is employed for this work, running at the same speed as the surface-grinder, and measuring 12in. in diameter. This operation completed, the magnet is stamped with the manufacturer's name and other marks as required. After heat treatment the next stage is surface-grinding the work on a single face in a surface-grinding machine. The same number of magnets is ground simultaneously on a magnetic chuck. Drilling of the hole is carried out on a sensitive drilling machine with a 5mm. drill of super high-speed steel, and specially short and stubby design. The jig carries a screw which engages one side of the magnet and presses the other side up against a stop. The magnet is clamped from the back, the plate pulling it back against a ground plate which positions the face ground at the earlier operation.

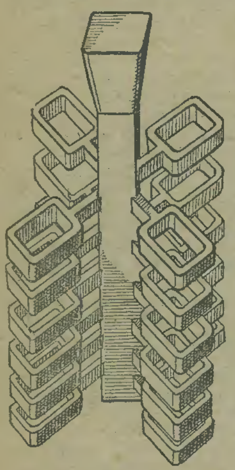


*Fig. 4.—Magnets grouped around a central metal core, produced with a single built-up mould.*

### Magnets Cooled in Air Blast

After being hardened the magnets are cooled in an air blast; magnets, such as those used for electric clocks, are clamped in place on trays of wire gauze. The method of cooling is to provide air ducts of cylindrical form in which are perforated an adequate number of holes. The necessary air blast is furnished by an electric motor-driven fan, and the flow is regulated by means of a damper. The ducts are placed over the cooling trays, and a horseshoe magnet is employed as a means of deciding when the magnets have cooled sufficiently to be magnetic.

The next stage is sand-blasting, followed by surface grinding of the bottom face, using a surface grinder and segmental wheel. Some accuracy is demanded of this operation, the effective tolerance on magnet thickness being plus or minus 0.002in. The gap in the magnet is then cut by means of an abrasive wheel, the gap width being 2.5mm., and this again is held to a tolerance of plus or minus 0.01mm. Accuracy is also essential in regard to the location of the gap, *vis-à-vis* an end of the magnet, and here the tolerance permissible is plus or minus 0.075mm.

The final stages cover magnetisation, testing, gauging, demagnetisation, and re-magnetisation for dispatch. The procedure for magnetising is of interest. A number of the magnets are strung over an assembly of three copper rods each insulated from its neighbour and bound together. When placed in the magnetiser, the extremities of these rods are clamped to insulated copper contacts. The magnetising current is furnished by an electric generator operating at a low voltage. In effect, the current is virtually short-circuited through the copper rods, passing at 4,000 amps. Thus, the three rods produce in combination an effect of 12,000 ampere turns, fully adequate to saturate the magnet.

### Small Magnets for Electric Clocks

Somewhat different methods have to be used when the magnets are of extremely small dimensions, such as those employed for electric clocks and other purposes, illustrated in Fig. 5. These are made from strip magnet steel by means of a punch and die. Where the magnets are of relatively large dimensions, the strip material is heated up to a suitable temperature, and the punching carried out hot, but the smaller pieces are punched out cold. Extreme accuracy is essential in the manufacture of these magnets, and as a rule it is seldom that a greater tolerance than plus or minus 0.001in. is allowed on the overall external diameter and the thickness. The central hole has a diametral allowance of plus or minus 0.0015in.

### Magnetisation and Test

A different type of apparatus is, however, required for their magnetisation and test. The apparatus includes a magnetising fixture, a testing fixture, and a fluxmeter, the latter providing a reading of the magnetic strength of the magnet in the testing fixture. These particular clock magnets are of what is termed the six-pole variety, alternate points forked and having opposite polarity. Thus, the piece possesses three north poles and three south poles, north and south being alternately spaced.

The magnetising fixture has six electro-magnets whose cores run radially from the centre where the magnet is located. By means of a lever, the brass table on which the magnet is laid is elevated to facilitate loading and unloading. When the magnet is correctly located on the table, the latter is lowered, and the current is passed through the coils for a brief period, thus strongly magnetising the magnet. The magnet is then removed to the testing fixture. Here, the magnetic circuit is completed from the magnet poles through a six-poled jig, the poles of which register with the poles of the piece under test. The jig poles are coil-wound, the coil wires being linked up in series with the fluxmeter terminals. By means of a second lever, the table carrying the magnet is elevated and indexed through 60 deg., then permitted to descend. This breaks down the magnetic field, and builds it up again in the contrary direction. As this field is cut by the coils, a current is necessarily generated through the wires, and is measured by the fluxmeter.

Before we come to discuss the modern materials used for permanent magnets, it will be of value to outline briefly the early history of magnets. Magnetism was studied in extremely ancient times. The Greeks knew about magnetic iron oxide, and a certain shepherd named Magnus is said to have discovered by chance the action of magnetic iron oxide on his iron-shod boots when he was tending sheep on the slopes of Mount Ida. The Romans also knew this same "loving stone," which was later described by a French troubadour, Guyot de Provins, in 1180, as "an ugly and brownish stone to which iron joins itself willingly." It was, however, only towards the twelfth century that the magnetised needle and the compass employing it were known to the navigators of Europe, at first in a most rudimentary form.

*Fig. 5.—Extreme accuracy is necessary in the production of these magnets for electric clocks.*

In 1675 lightning striking an English ship reversed, it is said, the poles of the magnetised needle of the compass, and made the ship involuntarily return towards its point of departure. At that time the phenomena of magnetisation and demagnetisation were almost unexplained, and remained so right up to the beginning of the 19th century, running parallel with electrical phenomena.

By degrees the work of Oersted, Arago, Ampère, Faraday and numerous other workers in this field, founded the science of magnetism and electro-magnetism. The electric telegraph was one of the first applications to derive benefit from this science, the others still constituting simple curiosities that employed only the carrying power of the magnets.

*(To be continued)*

# A Refresher Course in Mathematics

By F. J. CAMM

(*Continued from page 124, February issue.*)

## Annulus, Ellipse, Prisms, Pyramids, Cones, Spheres, Etc.

### Area of Annulus

THE area of an annulus is the difference of the areas of the two circles. Thus, in Fig. 1, the area of the outer circle is $\pi R^2$, and the area of the inner circle is $\pi r^2$. Hence:

Area of annulus $= \pi R^2 - \pi r^2$.

As $\pi$ is common to both, we may write:

Area of annulus $= \pi(R^2 - r^2)$

$= \pi(R+r)(R-r)$.

Here it will be seen that the bracketed quantity has been factorised, as explained in the chapters on algebra. It will be seen from this last formula that to find the area of an annulus we multiply together the sum and the difference of the two radii and then by $\pi$.

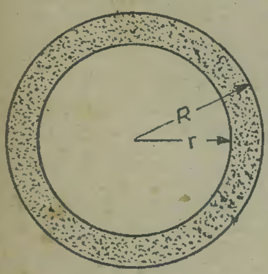



*Fig. 1.—Annulus.*

### Length of Coil of Belting

The rule to find the length of a rolled coil of belting is $L = \frac{\pi n}{24}(D+d)$, where $L$=length of belt in feet, $\pi = 3^1/_7$, $n$ = number of turns and fractions of a turn in the coil, $D$=outside diameter of roll in inches, $d$=inside diameter of roll in inches. As, however, $\frac{\pi}{24}$ is constant the formula may be rewritten thus: $L = .139n\,(D+d)$.

### Area of an Ellipse

The area of an ellipse is $\pi ab$ (Fig. 2). This can be proved in a manner similar to that already given for proving the area of a circle.

Another practical proof is to draw two ellipses of identical size, and to circumscribe one of them with a rectangle. Divide this into four equal rectangles. Now divide one rectangle into seven equal strips, and cut away the shaded part (Fig. 3). Now cut out the other ellipse, and place it in one pan of a pair of scales, and the other in the second pan of the scales. It will be found that the weights of each are equal. As the shaded portion has an area equal to $3^1/_7 \times$ the area of one rectangle, it is obvious that the area of an ellipse is $\pi ab$.

The circumference of an ellipse can only be calculated approximately. The formula yielding a fairly close result is:

$$\pi(a+b)$$

Where $a$ is half the major axis, and $b$ half the minor axis.

*In other words, the length of the circumference of an ellipse is found by multiplying half the sum of the major and minor axis by $\pi$.*

### Centre of Gravity

The centre of gravity of a body is that point through which the resultant of the gravity of its parts passes in every position a body can assume. It is well known that every particle of a given body is attracted by the earth, and the weight of the body represents the total force which gravity exerts on the particles. The forces acting on the body are directed towards the centre of the earth, and their resultant, in other words the weight of the body, will act through a definite point, known as the centre of gravity. It is obvious that with a symmetrical figure the centre of gravity will coincide with the geometrical centre. With a circular disc of metal, or any other substance, the centre of gravity will be the centre from which the circle is struck, provided the disc is of uniform thickness.

With a triangle, the centre of gravity will be in a line which joins the vertex to the middle point of the opposite side, as in Fig. 4. The centre of gravity of the triangle is the point of intersection of the two bisecting lines, Fig. 4.

With an irregular figure, suspend it from any two points, as in Fig. 5; the point of intersection of the two lines will be the centre of gravity.

### Area of Sector of Circle

A circle contains 360°. It therefore follows that the area of a sector will bear the same relation to the area of the circle as the *included angle* A bears to 360° (Fig. 6). From this (remembering that the area of a circle is $\pi r^2$) it is easy to arrive at the formula for a sector of a circle. The formula is (letting A denote the angle in degrees of the sector):

$$\frac{A}{360}\pi r^2$$

In circular measure it is more usual to denote the angle by $\theta$. We have seen that $360° = 2\pi$ radians, and therefore

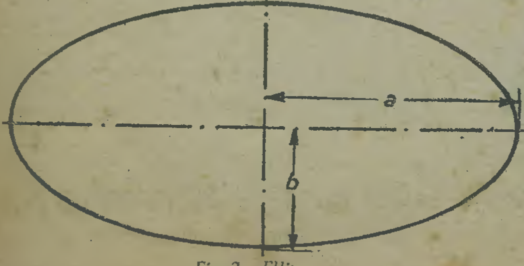



*Fig. 2.—Ellipse.*

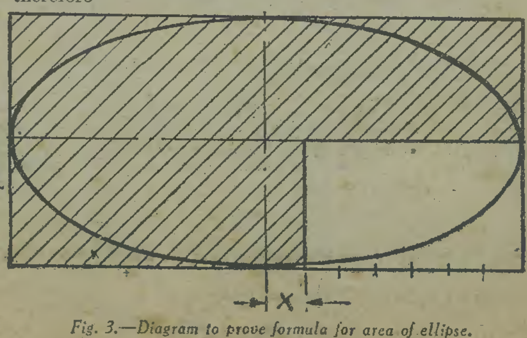



*Fig. 3.—Diagram to prove formula for area of ellipse.*

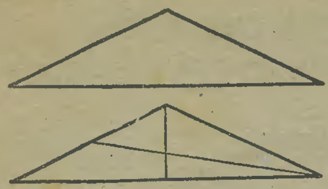


*Fig. 4.—The centre of gravity of a triangle.*

we can rewrite the formula:

$$\frac{A}{360}\pi r^2 = \frac{\theta}{2\pi}\pi r^2$$
$$= \frac{\theta r^2}{2}$$

*Example.* — The diameter of a circle is 6 feet. What is the area of a sector containing 45°?

$$\text{Area of circle} = \pi 3^2$$
$$\text{Area of sector} = \frac{45}{360}\pi 3^3$$
$$= \frac{1}{8}\pi 3^3$$
$$= \frac{1}{8}\times 3.1416\times 9$$
$$= 3.5343 \text{ sq. ft.}$$

We can also calculate the area of a sector if we are given the length of the arc (such as BC, Fig. 7), for the length of the arc bears the same relation to the circumference as the area of the sector does to the total area. Hence, if the length of the arc BC (Fig. 7) is 4.5 ft. the area of the sector will be

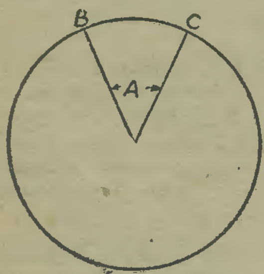


*Fig. 6.—Area of segment of circle.*

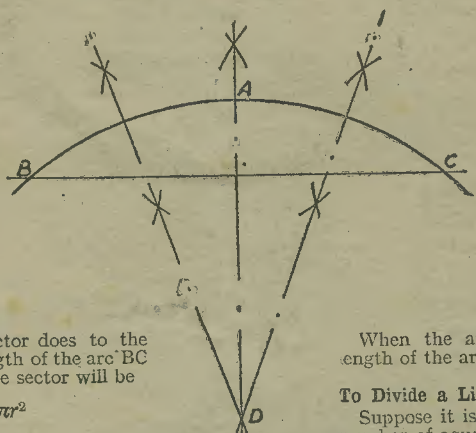



*Fig. 7.—Finding radius and length of circular arc.*

$$\frac{4.5}{\pi d}\times \pi r^2$$
$$= \frac{4.5}{d}r^2$$
$$= 6.75 \text{ sq. ft.}$$

**Length of Circular Arc**

It is often necessary to find the centre of a circle when only a circular arc is given. Let BAC be the arc. Draw the line BC to cut the arc at any two convenient points. Using B and C as centres and any convenient radius, bisect AC and AB. Produce the bisecting lines, and the point O at which they intersect is the centre of the circle.

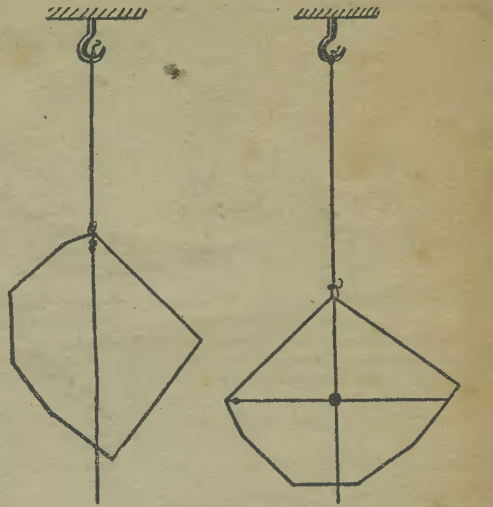


*Fig. 5.—Finding centre af gravit of irregular figure.*


*Fig. 8.—Dividing a line into a number of equal parts.*

When the angle and radius are found the length of the arc can be calculated.

**To Divide a Line into Equal Parts**

Suppose it is required to divide a line into a number of equal parts, say 11. Draw a line at any angle from A (Fig. 8) and step off with the dividers (opened to any convenient distance) 11 equal distances, and connect B to C. Lines drawn parallel to BC from the points marked on AC will cut AB into equal divisions.

**Volume, Weight and Density**

It is well known that *the volume of a rectangular solid is found by multiplying the length, breadth and height together*; the units of length, breadth and height must, of course, be similar. If one dimension is given in ft. and another in ins. the ft. must be reduced to ins., or the ins. to ft. Thus, in Fig. 9, which represents 1 cubic ft., the *volume or cubical content* is 12 × 12 × 12 = 1728 cubic ins.

The *gallon* is the British unit of *volume and capacity*; it is the volume occupied by 10lbs. of chemically pure water at a temperature of 62°F. Nearly all bodies expand when hot and contract when cold.

Thus, when hot, 10lb. of water would occupy a greater volume than 1 cubic ft. and when cooled to a temperature lower than 62°F. it would occupy less than 1 cubic ft. Hence, it is necessary to state the temperature of the water in defining its volume.

(*Continued on page 166*)

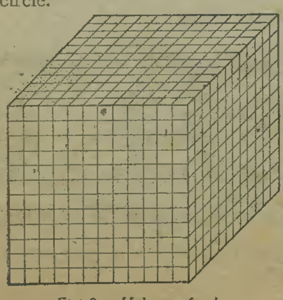


*Fig. 9.—Volume of cube.*

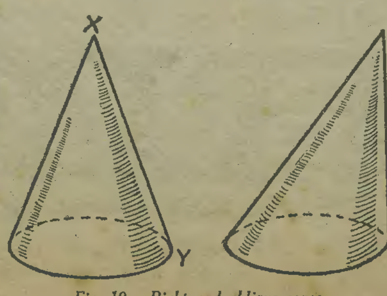
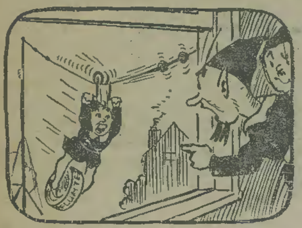



*Fig. 10.—Right and oblique cones.*



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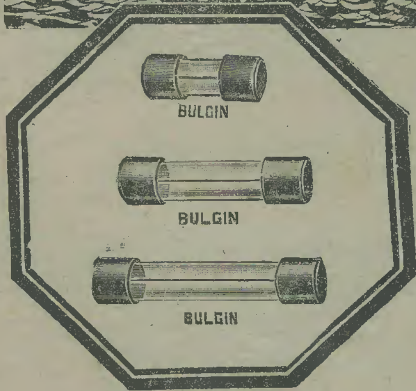


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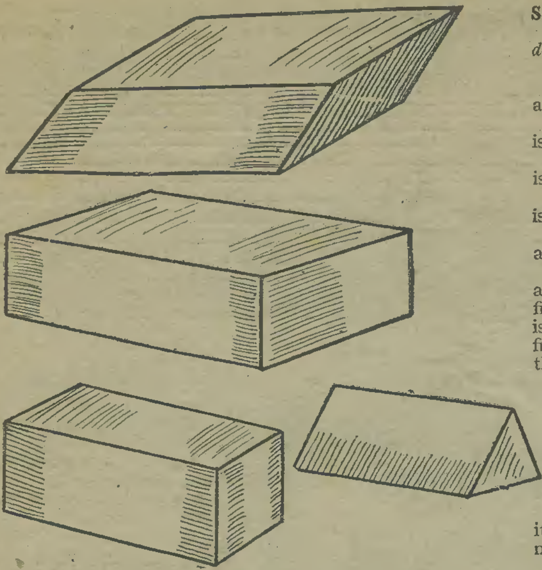


*Fig. 11.—Various prisms.*

At 32°F. the weight of a cubic ft. of water is 62.418lbs.
At 62°F. the weight of a cubic ft. of water is 62.355lbs.
At 212°F. the weight of a cubic ft. of water is 59.64lbs.
For ordinary calculations the weight may be taken as 62.3lbs. Often the weight of 1 cubic ft. of water is taken as 1,000 ounces (62.5lbs.), which equals $6\frac{1}{4}$ gallons.

A pint of water weighs $1\frac{1}{4}$lb.

The metric unit of volume is the *litre*, which is (very approximately) a cubic decimetre (see section on the metric system), or 1,000 cubic centimetres. This equals 1.76 English pints.

**Mass**

The quantity of matter a body contains is known as its *mass*. The *pound avoirdupois* is the British unit of mass.

The metric unit of mass is the *kilogram*. It is the mass of a platinum cylinder deposited in the French archives.

A litre of pure water weighs, at 4° C., 1 kilogram, or 1,000 grams.

The *weight* of a body is defined as the *attractive force* exerted (at the surface of the earth) upon it. The force is greatest at the poles and least at the equator. This force is known as *gravity*. The force of gravity varies with the distance from the centre of the earth. At this point the force of gravity is nil, and there the weight of the body would also be nil.

The acceleration due to *g*, of a free falling body, is 32.2 ft. per sec./per sec.

**Density**

The mass of the unit of volume of a body is known as its *density*. If the unit of mass is 1 lb., and the unit of volume 1 cu. ft., then the density is the number of pounds in a cubit foot of the substance; in the metric system the density is the number of grams in a cubic centimetre of the substance.

**Specific Gravity**

The *relative density* of a substance is *the ratio of its weight to that of an equal volume of another, and standard, substance*. Distilled water is the standard substance adopted. The relative density of a substance is known as its *specific gravity*. If the specific gravity of a substance is stated to be 9.7, then the weight of 1 cubic foot of that substance is 9.7 times the weight of a cubic foot of pure water. Hence the weight would be:

$$9.7 \times 62.3 = 604.31 \text{ lbs.}$$

**Solids**

The *regular solids* are the *cube, tetrahedron, octahedron dodecahedron* and *icosahedron.*

A cube has six equal and square faces.

A tetrahedron has four equal faces, each of which is an equilateral triangle.

The octahedron has eight equal faces, each of which is an equilateral triangle.

The dodecahedron has 12 equal faces, each of which is a pentagon.

The icosahedron has 20 equal faces, each of which is an equilateral triangle.

Other solids are the *cone, cylinder, pyramid, sphere,* and *prism* or *parallelopiped.*

When one end of a line, as XY (Fig. 10), passes through a fixed point, whilst the other describes a curve, the figure described is a pyramid; and if the curve described is a circle, the figure traced will be a *right cone* if the fixed point is exactly over the centre of the circle. If the fixed point is not so located, the figure traced will be an *oblique cone.*

Various prisms are shown in Fig. 11.

If a line, as XY (Fig. 12), traces the contour of any *rectilinear polygon*, the figure so described is a prism and the prism is designated according to the shape of its ends. Thus, there are hexagonal, pentagonal, triangular, etc., prisms.

A *right prism* (sometimes termed a *parallelopiped*) has its ends perpendicular to its side faces. If the ends are not perpendicular it is termed an *oblique prism.*

*The volume of a right prism is found by multiplying together the length, breadth and height; and the volume of an oblique prism is the area of the base multiplied by the altitude* (Fig. 13).

The volume of a cylinder is found by *multiplying the area of the base by the height*, or:

$$\pi r^2 h$$

The surface of a cylinder consists of the *area of the two ends, plus the area of the curved surface.*

Area of curved surface $= \pi dh$, or $2\pi rh$.
Area of two ends $= 2\pi r^2$.
Total area $= 2\pi rh + 2\pi r^2$.
$= 2\pi r(h+r)$.

The volume of an *oblique cylinder* (Fig. 14) is:
Area of base $\times$ height $= \pi r^2 h$.

A cylinder cut by a plane not parallel to the base is termed a *frustum of a cylinder*. The volume of a frustum of a cylinder (Fig. 15) is found by multiplying the area of the base by the mean height *h*.

Volume of frustum of cylinder $= \pi r^2 h$.

$$= \pi r^2 \left(\frac{a+b}{2}\right)$$

The end surface of a cylinder cut by a plane not parallel to the base is an ellipse.

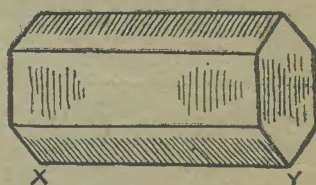



*Fig. 12.—Regular polygon.*

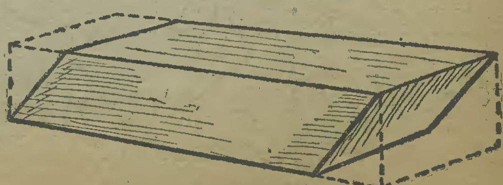


*Fig. 13.—Oblique prism.*

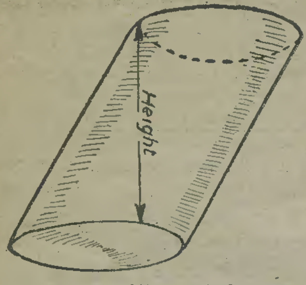



*Fig. 14.—Oblique cylinder.*

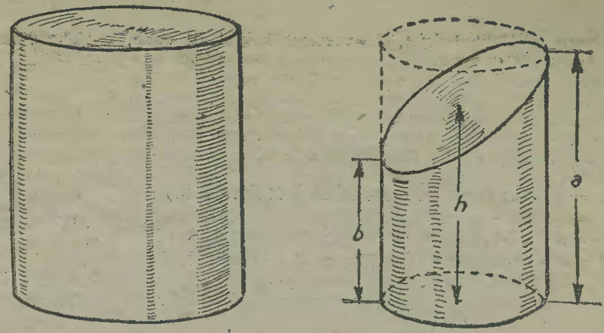



*Fig. 15.—Cylinder and frustum of cylinder.*

The volume of a hollow cylinder is obviously the volume of the outer cylinder, less the volume of the imaginary inner cylinder=

$$.7854\ (D^2-d^2)h.$$

**Pyramids**

Draw a cube as Fig. 16, and from a point representing the centre of the cube construct the square pyramid shown. From inspection of the diagram it is obvious that the cube contains six such pyramids, and therefore the volume of the pyramid is $\frac{1}{6}$ the volume of the cube.

If the length of one side of the cube be $x$, then the volume of the pyramid will be:

$$\frac{1}{6}x^3$$

Taking half the cube, the volume of the pyramid will be:

$$\frac{1}{3}x^2\times\frac{x}{2}=\frac{1}{3}x^2h$$

($h$ being the height of the pyramid).

Therefore,

Volume of pyramid $=\frac{1}{3}$ (area of base × height).

The total surface area of any pyramid is the sum of the areas of the triangles plus the area of the base, and if the latter is a regular polygon, the triangles will be isosceles triangles. Draw perpendiculars from the vertex $O$ (Fig. 17), from which the area of each triangle will be:

$$\frac{\text{Length of side}\times OP}{2}$$

The total surface of all the faces will be:

$$\left(\frac{\text{sum of all the sides}}{2}\right)OP$$

Letting $l$ equal $OP$, and $a$ the length of one side

Total area of all triangles $=\frac{l}{2}\Sigma a.$

Let $n$ represent the number of sides.

Then lateral surface of all the triangles $=\frac{nal}{2}$

In other words *the total surface of the triangles equals half the perimeter of the base × the slant height.*

The total area = area of base + area of triangles.

The *slant height* OP (Fig. 17) can be calculated from the trigonometrical formula previously given.

If a pyramid be cut across a plane parallel to its axis, each face will form a trapezium (Fig. 18). We have already seen that the area of a trapezium is found by multiplying half the sum of the parallel sides by the distance separating them. Let this distance be $l$, the length of the smaller side $ab$, and the longer AB. Then

$$\text{Area of each trapezium}=\frac{ab+AB}{2}\times l$$

And, letting $n$ represent the number of sides, the total surface of all the trapeziums will be:

$$\frac{n}{2}(ab+AB)l.$$

Expressed as a rule, *the total area of the trapeziums is found by multiplying the sum of the perimeters of the end polygons by half the distance between them.*

**Cone**

A pyramid on a circular base is a cone and the same rule for volume applies:

$$\text{Vol. of cone}=\frac{1}{3}\text{ (area of base and height)}$$

$$=\frac{1}{3}\pi r^2h$$

The volume of a cone is therefore one-third the volume of a cylinder of the same base and height.

*The lateral surface of a cone is found by multiplying the circumference of the base by the slant height.*

*The slant height of a cone* is found from the formula:

$$s=\sqrt{(h^2+r^2)}$$

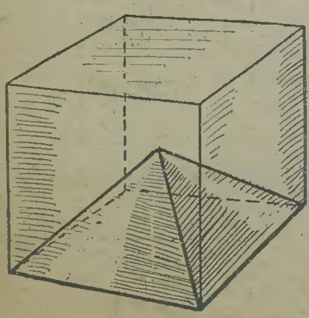


*Fig. 16.—Pyramid.*

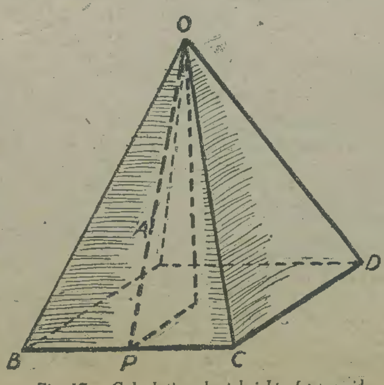



*Fig. 17.—Calculating slant height of pyramid.*

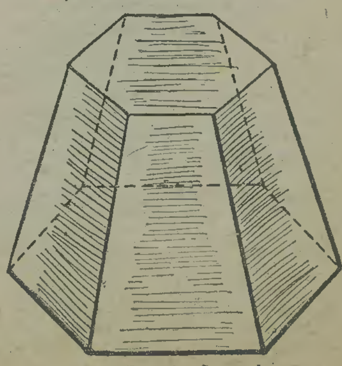


*Fig. 18.—Pyramid*

Where $s$=slant height, $h$=vertical height of cone, and $r$=radius of base.

As with a frustum of a pyramid, the curved surface of a cone may be considered as consisting of a number of trapeziums, the circular ends forming the parallel sides, and the slant side being the distance between them. Therefore, the curved surface of a frustum of a cone

$$=\frac{1}{2}\text{(sum of perimeters of ends} \times \text{slant side)}$$
$$=\frac{1}{2}(2\pi r+2\pi R)\, l$$
$$=\pi(R+r)\, l$$

$R$ and $r$ represent the radius of the base and of the small end respectively.

Total area (curved surface plus area of ends) is found from the formula:

$$\pi(R+r)\, l+\pi(R^2+r^2)$$

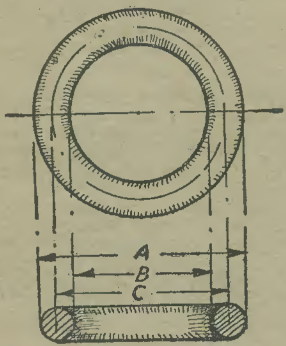



*Fig. 19.—Solid ring.*

**Solid Ring**

A solid ring may be considered as a cylinder bent into circular form, and it is apparent (Fig. 19) that the height of such a cylinder will be equal to the mean diameter of the ring. The mean diameter may be found by adding together the inner and outer diameters and dividing by two.

*The surface area is equal to the circumference of a cross section multiplied by the mean length.*

The mean length is $\pi C$.

Mean diameter is $\frac{A+B}{2}$

Therefore total area$=2\pi r\times 2\pi R$, where $r$= radius of cross section and $R$=mean radius.

$$2\pi r\times 2\pi R=4\pi^2 Rr.$$

*The volume of a solid ring is the area of a cross section multiplied by the mean length.*

Area of cross section$=\pi r^2$
Mean length$=2\pi R$
Volume$=\pi r^2\times 2\pi R$
$=2\pi^2 Rr^2$

Also, if the solid ring is rectangular the mean diameter is multiplied by the area of the cross section to obtain the volume.

**Sphere**

A sphere is a *semicircle* rotated about its axis (the diameter). Any plane section of a sphere is a circle, and if the plane passes through the centre of a sphere, the section will be a *great circle*. Now, the area of the great circle is, as we have seen, $\pi r^2$, and the area of a *hemisphere* is $2\pi r^2$. Therefore, the area of a sphere will be twice that, namely $4\pi r^2$, or $\pi d^2$.

*The area of a sphere is the same as the area* of a cylinder which exactly encloses the *sphere* (Fig. 20).

The volume of a sphere is $\frac{2}{3}$ the volume of the cylinder enclosing it.

The volume of a cylinder is $2\pi r^3$, and dividing this by $\frac{3}{2}r$, we obtain $^4/_3\pi r^3$, which equals $\frac{\pi}{6}d^3$.

**Circumscribing Circle**

The radius of a circle which may be inscribed in a triangle is found from the formula:—

$$R=\frac{abc}{4\times\text{area of triangle}}$$

Where $a$, $b$ and $c$ are the lengths of the sides of the triangle.

**Inscribed Circle**

This is found from the formula:

$$R=\frac{\text{Area of triangle}}{s}$$
$$=\sqrt{\frac{(s-a)(s-b)(s-c)}{s}}$$
$$=(s-a)\tan\frac{A}{2}=(s-b)\tan\frac{B}{2}=(s-c)\tan\frac{C}{2}$$

Where $s$ = sum of lengths of sides.

**Escribed Circle**

To find the radius of the circle touching side $a$ and sides $b$ and $c$ produced:

$$\frac{\text{area of triangle}}{s-a}=\sqrt{\frac{s(s-b)(s-c)}{(s-a)}}$$

Figs. 21 and 22 show two examples of the construction of triangles. It is very important to remember the point illustrated in Fig. 21, as it frequently occurs in examinations.

**Area of Irregular Figures**

A reliable method of calculating the area of irregular figures, such as the diagram ABDC (Fig. 23) is given here.

Divide the baseline AB into any convenient number of equal parts. The greater the number the more accurate the result. At the centre of each part erect ordinates, as shown dotted. Now measure the height of the ordinates *aa*, *bb*, *cc*, *dd*, *ee*, *ff*, *gg*, *hh*, and add them together. Divide their sum by the number of ordinates. This will give the mean height H, or mean ordinate AJ.

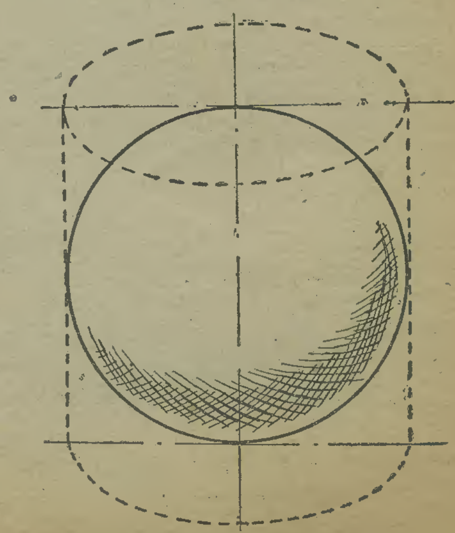


*Fig. 20.—The surface area of a sphere is equal to the surface area of its circumscribing cylinder.*

*Fig. 21.—The ambiguous case, when two sides of a triangle and one angle are given ; there can be two solutions, as shown here.*

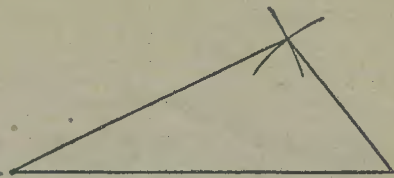


*Fig. 22.—To construct a triangle where the lengths of the three sides are known, draw one side, and from each end describe arcs of a radius equal to the length of each of the other sides.*

A simple method of obtaining the total length of the ordinates is to use the edge of a piece of paper, starting with *aa* and adding *bb*, *cc*, etc. The area is then found by multiplying AB by AJ.

*The Trapezoidal Method.*—Divide the base into a number of equal parts (say 8), spaced a distance *s* apart. Let the height of each ordinate be $h_1$, $h_2$, $h_3$, $h_4$, etc., and the mean height $h$. Then:

$$h=\frac{8}{s}\left\{\tfrac{1}{2}(h_1+h_9)+h_2+h_3+h_4+h_5+h_6+h_7+h_8\right\}$$

(The number of ordinates is always 1 more than the number of parts.) Expressed as a rule: *Divide the base into any number of equal parts, and add half the sum of the end ordinates to the sum of all the others. Multiply the result by the common interval* s *to obtain the area, and divide by the number of spaces to obtain the mean ordinate.*

*Simpson's Rule.*—Probably the most accurate method. Divide the base AB into an even number of equal parts (say, 6) to produce an odd number of ordinates (7), spaced a distance *s* apart. Then:

$$\text{Area } ABDJ=\frac{s}{3}\left\{h_1+h_7+4(h_2+h_4+h_6)+2(h_3+h^2{}_5)\right\}$$

This reduces to:

$$\frac{s}{3}(A+4B+2C),$$

Where $A$ = sum of first and last ordinates.
$B$ = sum of even ordinates.
$C$ = sum of odd ordinates.

Expressed as a rule:

*Add together the extreme ordinates, four times the sum of the even ordinates, and twice the sum of the odd ordinates (omitting the first and last) ; then multiply the result by one-third the space between the ordinates.*

In the case of an irregular figure in which the end ordinates are zero, then $A$ is zero, and the formula then becomes:

$$\frac{s}{3}(0+4B+2C)$$

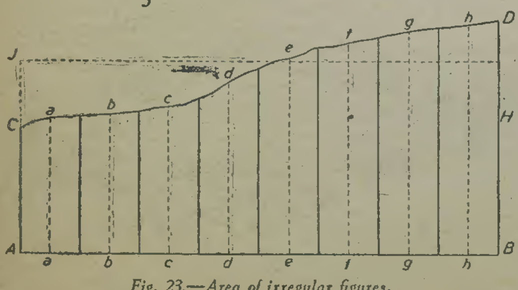



*Fig. 23.—Area of irregular figures.*

In some cases, where the irregular figure is bounded by two curved lines, it is convenient to divide the figure into two parts, and calculate the area of each independently.

When the area is completely bounded by an irregular curve, parallel lines are drawn, touching the top and bottom of the curve, and vertical lines touching the sides. The figure is thus enclosed in a rectangle, and by means of ordinates the area can be found as before.

(1) For any reasonably smooth curve the ordinate $y$ at a distance $x$ from the origin can be represented very nearly by an expression of the form $y=a+bx+cx$.

Now the area of any vertical strip of height $y$ and width $dx$ is $ydx$ and so the area under the curve between $x=0$ and $x=L$ is—

$$\int_0^L ydx=\int_0^L(a+bx+cx^2)dx=aL+\frac{bL^2}{2}+\frac{cL^3}{2}$$

$$=\frac{L}{6}(6a+3bL+2cL^2).$$

Now the ordinate at the left-hand end where $x=0$ is $a+b\times 0+c\times 0^2=a$.

The ordinate at the right-hand end is $a+bL+cL^2$.

The sum of these is $2a+bL^2+cL^2$, and subtracting this from the quantity in the square bracket above the remainder is—

$$4a+2bL+3cL^2=4\left(a+\frac{bL}{2}+\frac{cL^2}{4}\right).$$

The mid-ordinate is

$$a+b\left(\frac{L}{2}\right)+c\left(\frac{L}{2}\right)^2$$

which is just one-quarter of the remainder. Hence:

$$\text{Area}=\frac{L}{6}\left(\begin{array}{l}\text{left-hand ordinate }+\\ 4\times\text{ mid-ordinate }+\\ \text{right-hand ordinate}\end{array}\right)$$

If a figure is divided into four equal widths the formula is applied first to the left-hand half and then to the right-hand half, and the total area for an overall length $L$ is then:

$$\frac{1}{6}\frac{L}{2}(A+4B+C)+\frac{1}{2}\frac{L}{6}(C+4D+E)$$

$$=\frac{L}{12}(A+4B+2C+4D+E).$$

where A and E are the end ordinates, and B, C, and D the equidistant intermediate ones.

*(To be continued.)*

# BRITISH LONG DISTANCE LISTENERS' CLUB

## The S.W. Register. A Workshop Den. Correspondence

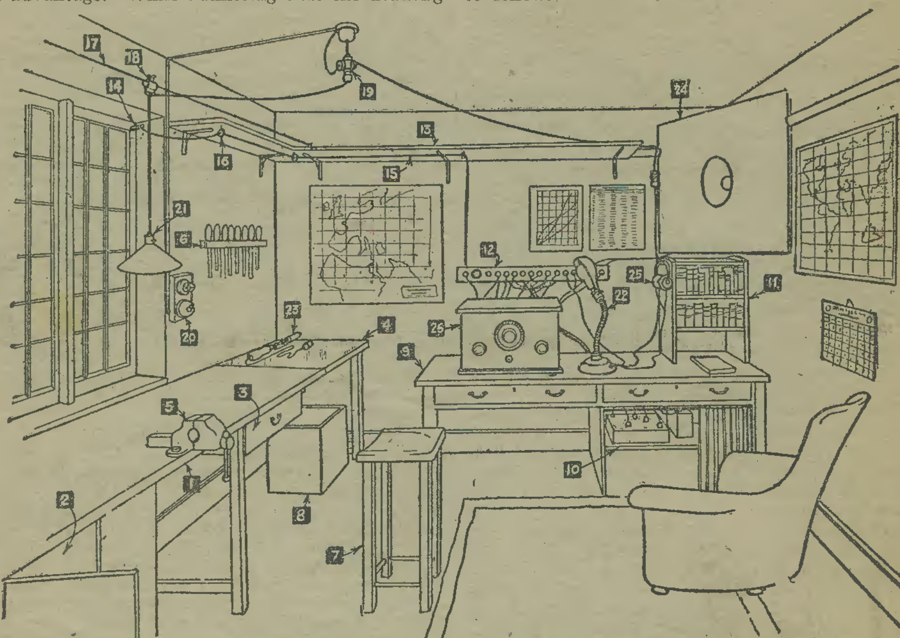
### The Short-wave Station Register

SEVERAL members have submitted details concerning their stations and activities in response to the suggestion we made last month, but we are deferring comment on the matter to afford other readers an opportunity of submitting suggestions and ideas.

### A Workshop Den

BELOW we illustrate a suggested layout for a workshop den which utilises the space available to the greatest advantage. While admitting that the drawing conveys the impression that the room is somewhat spacious, further study of the layout will soon reveal that this is not necessarily so, and that all the ideas and equipment shown are intended to save space.

The time taken to build up a station varies between months and years, in fact, with the majority the job is never finished. There is always something to add, improve or alter, and one's activities are usually limited by time, available supplies and, of course, finance. The building-up process offers great interest; it provides a wide field for the exercise of ingenuity and craftsmanship, but to avoid a lot of unnecessary work, and possibly the wastage of material, it is a good plan to map out the layout and equipment before too much work is expended. It is with this idea in mind that we publish the illustrations shown on these pages. They form a very useful basis for the planning of individual stations and, we hope, will bring to light some items which might have otherwise been overlooked. We would remind members that we are always pleased to receive details of their workshops/dens, especially when some novel features or labour-saving devices are included in the layout or equipment. Sketches to illustrate the description are really necessary, as they help to make the subject matter more interesting and easier for others to follow.



*AN EFFICIENT LAY-OUT FOR A WORKSHOP DEN.*

*No. 1.—Work bench.*
*„ 2.—A useful cupboard.*
*„ 3.—Tool drawer.*
*„ 4.—Sheet of zinc.*
*„ 5.—Vice.*
*„ 6.—Tool rack.*
*„ 7.—Bench stool.*
*No. 8.—Scrap box.*
*„ 9.—Testing bench.*
*„ 10.—Battery compartment.*
*„ 11.—Bookshelf.*
*„ 12.—Universal terminal strip.*
*„ 13.—Shelf.*
*„ 14.—Lead-in tube.*
*No. 15.—Aerial lead-in.*
*„ 16.—Insulated hook.*
*„ 17.—Stout galvanized wire.*
*„ 18.—Sliding Clip.*
*„ 19.—Three-way adaptor.*
*„ 20.—Wall-plug and switch.*
*No. 21.—Light plug and switch.*
*„ 22.—Adjustable lamp.*
*„ 23.—Electric soldering iron.*
*„ 24.—Loud-speaker.*
*„ 25.—Headphones.*
*„ 26.—A set under test.*

### Lindley

MEMBER No. 7,227, H. B. Alderson, has been doing some constructional work. Here are his remarks.

"My short-wave work so far has mainly been concerned with receiver construction rather than actual reception. The first set I made was a simple one-valver, using home-made four-pin coils. Later I added an L.F. stage transformer, coupling it to the detector. I then converted the set for six-pin coils to enable me to use a dipole aerial which I had erected for the 20-metre band. This increased signal strength slightly. My next step was to add an untuned H.F. stage, but this didn't seem to make much difference. I found later that, instead of

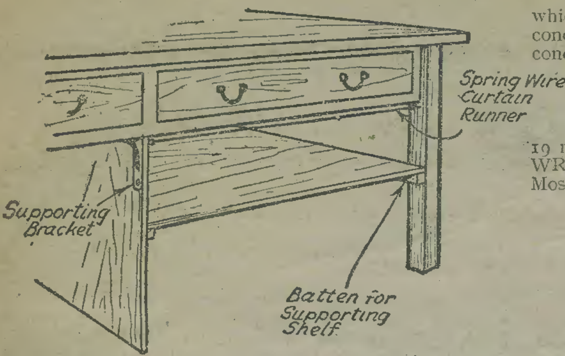



*Fig. 1.—A shelf enables the batteries and/or mains unit to be kept out of harm's way. A curtain covers the front to protect them from dust, etc.*

taking the output from the top cap I was taking it from the base and using the top cap as auxiliary grid. As my detector valve was getting poor, I decided to use a screen grid valve instead. This meant slight alteration of the wiring, taking the reaction coil to the auxiliary grid instead of to the plate. I was pleased to find the performance was better in all respects.

"I often read in club notes members describing sets

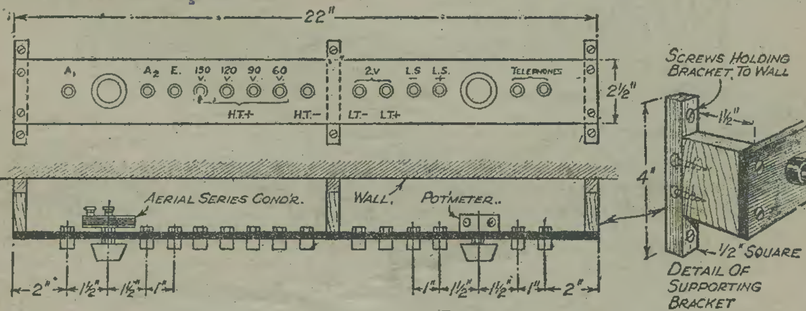



*Fig. 2.—A useful distribution board, the terminals of which are connected to their appropriate supplies, etc., thus allowing quick connections to be made without taking up bench space.*

as of the o-v-2 type, etc. I would be very grateful if you could give me some information on this subject."

*Regarding the meaning of o-v-2, we refer No. 7,227 to the Query page in the February issue, where the matter is dealt with.*—Hon. Sec.

**Newcastle**

G. FERGUS, No. 7,024, gives details of his outfit, and some of the stations he has logged, in his second report.

"I am basing my second report to you on the subject of short-wave DX. My receiver is a o-v-1, screen grid detector transformer-coupled to a pentode output. It uses 4-pin coils and operates satisfactorily with a 60ft. inverted 'L' aerial pointing east. Tuning condenser is .00015 mfd. with .000015 mfd. bandspread. The bandspread control is operated with a 12-1 slow-motion dial, which gives very accurate and well-spaced tuning. Slow motion is also used in conjunction with the reaction condenser, which enables me to get the set working at its most sensitive spot, which is just under oscillation point. The reaction condenser is an air-spaced .0005 mfd. with a fixed condenser .0005 mfd. capacity in series.

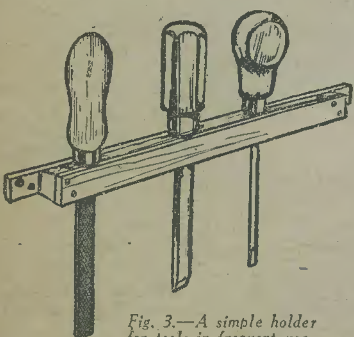


*Fig. 3.—A simple holder for tools in frequent use.*

"Here are some of my latest entries in my log-book: 16-metre band: PMA, Batavia; JLS4, Tokyo; WCRC, WNBI, WRUL, 'The Voice of France,' Vichy. 18.9 m.: WCW, New York. 19 m.: Radio Berne, Switzerland; OIE, Lahti; WGEA, WRUL, WLWO, WRCA, Radio Metropole, WCBX, Moscow, SM5XX. 20 m.: WLA, WCD, Kuibishev.

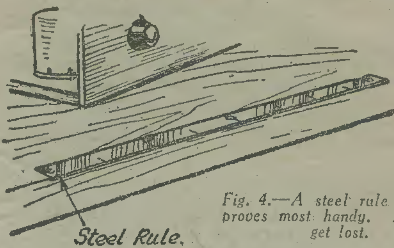



*Fig. 4.—A steel rule fixed thus proves most handy. It cannot get lost.*

23 m.; Kuibishev, Radio Maroc, Rabat, Morocco. 25 m: Radio Brazzaville, WCDA, OFD, JZJ, WLWO, WRUL, Radio Algiers, WGEO, WBOS, Radio Saigon, WNBI, Radio Congo-Belge, 'The Voice of France,' TAQ, Ankara. 28 m.: Lahti, Finland, Moscow, Radio De-bunk. 31 m.: Radio Algiers, JZI, 'The Voice of Spain for Europe,' Radio Mozambique, Lahti, Radio Budapest, Moscow, Radio Metropole, TAP, Ankara. 37 m: Radio Maroc. 38 m.: SUX, Cairo. 41 m.: Moscow. 43 m.: Moscow. 49 m.: Emissora Catholica de Portugal, OAX4Z, Lima, Peru; Radio Metropole, Moscow, Radio Andorra, HVJ. 59 m.: Moscow.

"I would like to draw your attention to WJP, on 34 m., as I have not seen it reported before. It is situated at New York and is owned and operated by Press Wireless, Inc. It broadcasts the News in English every hour on the hour and would appear to commence operating at midnight B.S.T."

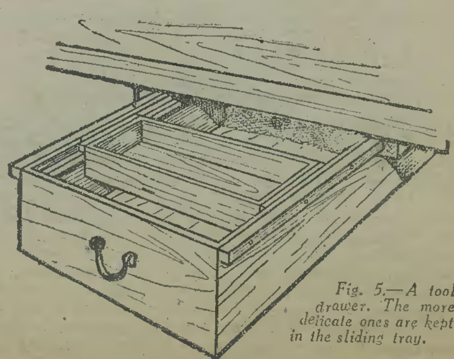


*Fig. 5.—A tool drawer. The more delicate ones are kept in the sliding tray.*

# Impressions on the Wax

## Review of the Latest Gramophone Records

### H.M.V.

E. J. MOERAN'S "Symphony in G Minor"—recorded under the auspices of the British Council, and performed by the Hallé Orchestra conducted by Leslie Heward—occupies 11 sides of six 12in. C series records. The numbers are *H.M.V. C7566–71.*

With a work of this magnitude I cannot attempt to review it in detail in the space at my disposal, therefore my remarks must be confined to the briefest details.

The symphony, which was completed in 1937, and first performed at a Royal Philharmonic Society's concert at Queen's Hall, London, in January of last year, consists of four movements: Allegro, lento, vivace and, finally, lento and allegro molto.

The work is scored for a moderate-sized orchestra (double woodwind), and does not—like "programme music"—possess a story; in fact, it could be said that its inspiration is due to the natural surroundings in which it was planned and written.

The twelfth side of the six records is "Four Bagatelles for Piano" (Alan Rawsthorne), rendered as a pianoforte solo by Denis Matthews.

In the 10in. series I have only three *H.M.V.s* this month. The first, *BD1029*, is of "Hutch" singing "Ev'ry Night About This Time" and "My Devotion."

"Praise the Lord and Pass the Ammunition" and "We'll Smile Again"—both fox-trots—are played by Joe Loss and his Orchestra on *H.M.V. BD5786*. Two very popular numbers well presented.

"Hot Lips" Page provides vocal and trumpet solos in "St. James Infirmary Blues," Parts 1 and 2, which is recorded in true swing style by Artie Shaw and his Orchestra.

### Columbia

MANY of the great composers have written variations on themes—perhaps their own work or that of an earlier master—but not all have produced something possessing outstanding musical merit. Speaking for myself, I find many variations far from entertaining; runs, flourishes and such like are all very well in their place, but one can have too much, and that, I think, is why some of the variations border on boring one. There are, of course, works which reveal exceptional originality, calling for great skill to weave such diverse and beautiful patterns around a simple theme. High in this class must be placed "Variations on a Theme of Joseph Haydn" by Brahms, which has been recorded by Malcolm Sargent and the Hallé Orchestra on *Columbia DX1105* and 1106, as it is an amazing work and beautiful to listen to.

To open up the dance music from the *Columbia* releases I have selected *FB2884*, on which Victor Silvester and his Ballroom Orchestra have recorded "Serenade in Blue"—slow fox-trot—and "9.20 Special" quick step. I follow this with another of his recordings, "My Devotion"—slow fox-trot—and "Constantly"—quick step—on *Columbia FB2883*. Four good tunes in strict dance tempo.

Carroll Gibbons and the Savoy Hotel Orpheans give us their version of "Praise the Lord and Pass the Ammunition" and "Serenade in Blue" on *Columbia FB2887*. Both are fox-trots.

In the vocals there is Turner Layton at the piano singing "Daybreak" and "Will o' the Wisp" on *Columbia FB2886*. A nice record.

Monte Rey—with orchestra—has made a good recording of "Romanesca" and "My Serenade." The number is *Columbia FB2881*. "Der Fuehrer's Face," featured in the film of the same name, is one of the numbers selected by Tommy Trinder for *Columbia FB2885*. On the other side, this star comedian of the new London Palladium show, "Best Bib and Tucker," records the song out of his big scene, in which he burlesques Carmen Miranda, the Brazilian Bombshell, "No, No, No, No, Columbus." Remember the number, *Columbia FB2885*.

### Decca

ON *Decca K1029* Moura Lympany, the noted pianist, has recorded two more preludes in the series "Rachmaninoff: 24 Preludes," and, as with previous recordings, shows great understanding of this composer's works. The two preludes selected for this record are No. 15 in E minor (Op. 32, No. 4) and No. 16 in G major (Op. 32, No. 5).

The Merry Macs have made a good record with "Idaho" and "Praise the Lord and Pass the Ammunition" on *Decca* 8249.

In "The Music While You Work" series, Nos. 13 and 14 are recordings made by Billy Mayerl and his Forte Fingers, for which they selected "Marigold" and "Sweet William." Recommended.

Ambrose and his Orchestra, on *Decca F8245*, give us "A Taxi Driver's Serenade" and "Praise the Lord and Pass the Ammunition." I shall soon begin to realise that the latter *is popular*; still, Ambrose makes the most of both numbers, and I suggest that you hear it for yourselves.

For a vocal we have Anne Shelton—with orchestral accompaniment—singing "Constantly" and "At Last," the former from "The Road to Morocco" and the latter from "Orchestra Wives."

### Parlophone

GERALDO and his Orchestra presents two good arrangements of "My Devotion"—slow fox-trot—and "Der Fuehrer's Face"—as a quick step—on *Parlophone F1960*.

"Tin Pan Alley Medley, No. 52"—Ivor Moreton and Dave Kaye on two pianos—is on *Parlophone F1958*, and a very pleasing medley it is.

The Organ, the Dance Band and Me offer "Three Minutes of Heaven"—fox-trot—and "Fox-trot Medley" on *Parlophone F1959*. Recommended.

In the 1943 Super Rhythm-style Series, Nos. 59 and 60 are recordings of "Boogi" and "Ain't Misbehavin'" by Harry Parry and his Radio Rhythm Club Sextet. The record is *Parlophone R2860*.

### Brunswick

A GOOD record by Bing Crosby is *Brunswick 03410A—B*, and I recommend it to all who like this popular artist's style. He sings "The Road to Morocco" and "Moonlight Becomes You."

### Regal

GEORGE FORMBY—with, of course, his ukulele—has recorded two bright and breezy numbers on *Regal MR3672*. They are "When the Waterworks Caught Fire" and "The Baby Show." A good record to chase away the blues.

### Urgent

THERE is a great shortage of material for making records.

All your old and unwanted records are required. Take any H.M.V., Columbia, Parlophone and Regal-Zonophone to the nearest record dealer: he will make you an allowance for them.

# 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).

## The "Harkness" Reflex Circuit

SIR,—I have been extremely interested in some of the old circuits you have revived. Some I remember trying out were "Hopwood," "Chitos," and "Trinadine." I tried out the suggested Reflex one-valver described in June, 1941 (page 282), which you had not tried out. I find it exceptionally good both in volume and quality and it is not too critical in this position; moving the cats-whisker does not make the set burst into oscillation. I kept the two tuned circuits at each end of set and did *not* gang them. I wonder if any reader has tried the "Harkness" circuit, shown in the accompanying diagram. The grid coil is directly grounded and there is also the addition of a grid bias battery. I can get quite comfortable reception on the loudspeaker with a Lissen G.P. valve.—N. A. WEBB (York).

## Yugo-slav Freedom Station

SIR,—I wonder if any readers have heard a Freedom Station in Yugoslavia broadcasting in English? I heard this station at 2.30 p.m. on Saturday, January 9th, giving details of the guerilla fighting in Yugoslavia. The announcement ended with these words, "You are listening to the Freedom Station of Yugolavia, on the 25 metre band."

In conclusion I hope you will keep up the fine standard maintained in PRACTICAL WIRELESS. It is a fine paper, and has taught me all I know about radio.—J. McCLOY (Stranraer).

## Two Kinds of Electricity?

SIR,—Scientists have proved beyond doubt that all atoms of any substance are made up of a certain number of electrons, stated to be "negative" electricity and a number of protons, which are particles of "positive" electricity. Apparently our old friend Thermion, along with Mr. Andrews, who delivered the Cantor lecture this year, do not agree upon this even, for they state that there is only one kind of electricity. In the case of an atom of hydrogen, which is a single substance, whose atomic number is one, and which, unless I am mistaken, consists of one proton only, in the nucleus, and one electron rotating round this proton, and which is attracted to it, thereby balancing the whole atom perfectly, this atom could not exist at all if Thermion's statements were correct, namely, that there is only one kind of electricity, as the two particles would have no attraction for one another. Wishing your paper all success in the coming year.—A. STAPLETON (Derby).

[*A most unconvincing argument!*—ED.]

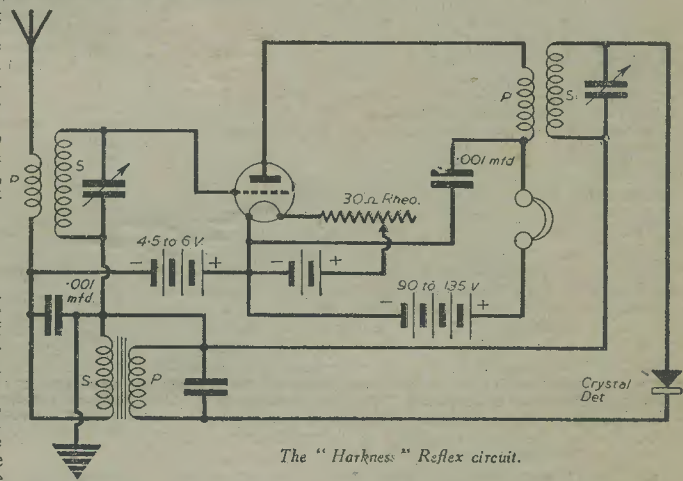
## S.W. Listening: Condenser Calculations

SIR,—After reading the "Open to Discussion" section in the January issue of PRACTICAL WIRELESS, I would like to air my opinion on subjects discussed by two of your correspondents.

First, I do not think there is any mystery attached to the fact that similar coils do not always cover the same wave-bands. I am sure the majority of readers will agree that this is brought about by the use of tuning condensers, which, although rated at the same capacity, have different minimum values. The layout of the receiver also has a great effect on the waveband coverage on short waves.

Power factor of condensers was the other point brought up. This would appear to have most bearing on the electrolytic type of condenser, whether wet or dry, and gives an indication of the "goodness" of the condenser, a good condenser having a low power factor. Of course, discretion must be used in judging condensers this way, as high capacity condensers such as are used in bias circuits may have a power factor of 30 or more (as measured on a Hunt's Analyser) and still be quite satisfactory. The power factor, of course, has no direct bearing on the capacity of a condenser.

There are many obscure factors that affect the power factor of condensers, but I believe the most important is the increase in the series resistance caused by drying up of the electrolyte.—ALEX BARTHOLOMEW (Chapel by Kirkcaldy).




*The "Harkness" Reflex circuit.*

## Cossor Coils

SIR,—In the February issue of PRACTICAL WIRELESS I note that one of your querists is desirous of information relating to a pair of coils numbered F.C. 1109 and F.C. 1110. These two coils were produced by Messrs. A. C. Cossor for use in their "Melody Maker" Model 234, which was a screen-grid detector, power circuit, coil No. F.C.1109 being employed as aerial coil and No. F.C. 1110 as H.F. transformer between the S.G. H.F. stage and the detector. Both coils tune the L.W. and M.W. bands.—E. HORTON (W. Bromwich).

## An Appreciation

SIR,—I would like to express my appreciation of this extremely handy little journal, and I like the present size much better than the old one. I was very pleased at the series of Maths. articles, and I also enjoy "Thermion's" notes; his remarks are very entertaining.—A. J. CRICKMERE (Newmarket).

# Replies to Queries

### Cutting Out Rectifier

**"I have an A.C./D.C. set which has been used on A.C., but the rectifier valve has now broken down. I am told I can cut out rectifier and use set on D.C. Please will you tell me how to do this, also if there is any extra resistance needed in place of valve?"—R. R. (Brighton).**

IF the receiver is to be used solely on D.C. supplies then the rectifier can be eliminated. To do this it will be necessary to connect the positive side of the supply to the rectifier side of the smoothing equipment in the H.T. line. A resistance must be inserted in series with the heater supply to compensate for the removal of the valve. The actual value of the resistance will depend on the current consumed by the heater of the rectifier.

### S.G. Detector and P.U.

**"I purpose constructing a two-valve (all mains) as a spare and for use with a gramophone pick-up. I thought of using an S.G. valve as a detector. How is this wired up and is it advisable with a pick-up? If not, I will cut out the pick-up.**

**"I have just obtained blueprint of A.C. Twin (D. (Pen.) Pen.) P.W.18 and should like to try this circuit, but cannot obtain the 300 HV choke. Can substitutes be used instead?"—R. G. (S.E.6).**

IT is quite in order to use a screened grid, or an H.F. pentode, in the detector position, provided care is taken to select the right operating voltage for the screen. A low value in the neighbourhood of 20-36 volts is usually sufficient.

If you contemplate using a magnetic type of pick-up, it would be advisable to connect a volume control across it, otherwise there will be the danger of overloading the S.G. valve.

In place of the high inductance L.F. choke a resistor could be used; we would suggest a value of 80,000 ohms.

### Midget Universal Receiver

**"With reference to the Midget Universal Receiver appearing in the current issue, all valves in the heater chain are rated at 0.2 amp. with the exception of the Tungsram PP2018, which has a rating of 0.18 amp., and in the case of this valve the excess current of 0.02 amp. is absorbed by a shunt resistance of 1,000 ohms.**

**"Under the circumstances, why have 6-volt .3 amp. pilot lamps been specified in the component list? Pilot lamps wired in series with the valves must have a current rating identical with the valve heaters, and so, in the case in question, the .3 amp. bulbs would not illuminate to capacity."—H. C. S. (Surrey).**

THE use of the pilot lamps is quite in order, as it is usually advisable to under-run them to prevent breakdown. In many Universal circuits trouble is often experienced through the collapse of the pilot bulb filament, and the writer of the article in question evidently had this in mind.

### L.T. From D.C. Mains

**"I have for some time been trying to get a unit that would work from D.C. mains supply and do away with using accumulators. The unit, of course, must be 2 volts. I was looking through the list of blueprints in "Practical Wireless" and noticed that there is one advertised as a Radio Unit 2v. for WM392 (No. 398), price 1s. I shall be pleased if you will let me know if this unit would suit my purpose, also, if it is for D.C. mains."—C. R. (Shoreditch).**

THE blueprint to which you refer is of an A.C.-operated two-valve radio unit (receiver 1-V), for use in conjunction with an amplifier.

We have not published any constructional details of a unit suitable for use on D.C. mains for the supply of the filament voltage; in fact, we do not recommend such procedure, owing to the fluctuations which are experienced and the possible danger to the valves.

### Microphone Howl

**"Could you please answer the following queries? I have just purchased a G.E.C. Home Broadcaster microphone, and wish to use as an amplifier an Ekco A.C. mains 2-valve radio, model No. 312. Unfortunately, I am experiencing a lot of trouble with "howl back," even on low volume, between speaker and microphone. The G.E.C. people suggest in their leaflet that "howl back" can be cut out by having the microphone at a distance from the speaker, preferably in another room. This is impossible for the use to which I wish to put it, so could you please make any alternative suggestions?"—J. H. S. (Hull).**

THE trouble is due to the fact that you are using the microphone and the loudspeaker in the same room. To eliminate the feed back it is essential to provide adequate sound screening between the microphone and the speaker, otherwise the sound from the latter will be fed back into the circuit via the microphone. If this takes place, a form of L.F. instability is created, which manifests its presence by the howl to which you refer.

Try placing the "mike" behind the speaker, and arrange some form of "sound screen" (curtains, etc.) between the two components.

## RULES

**We wish to draw the reader's attention to the fact that the Queries Service is intended only for the solution of problems or difficulties arising from the construction of receivers described in our pages, from articles appearing in our pages, or on general wireless matters. We regret that we cannot, for obvious reasons:—**

(1) Supply circuit diagrams of complete multi-valve receivers.
(2) Suggest alterations or modifications of receivers described in our contemporaries.
(3) Suggest alterations or modifications to commercial receivers.
(4) Answer queries over the telephone.
(5) Grant interviews to querists.

A stamped, addressed envelope must be enclosed for the reply. All sketches and drawings which are sent to us should bear the name and address of the sender.

Requests for Blueprints must not be enclosed with queries, as they are dealt with by a separate department.

Send your queries to the Editor, PRACTICAL WIRELESS, George Newnes, Ltd., Tower House, Southampton Street, Strand, London, W.C.2. The Coupon on page iii of cover must be enclosed with every query.

### Modifying a Meter

**"I was looking over my spare parts and came across an old milliammeter having a full scale reading of 500 mA.**

**"I wish to rewind the moving coil so that the maximum reading will be 1 mA. The coil former dimensions are 13/32in. x 10/32in. x 3/32in.**

**"What gauge of wire should I use and how many turns will be required for the new coil? I am going to try and make up the Multi-range test meter, which was in the March issue, 1942."—J. O. H. (Surrey).**

FROM the details provided, we cannot determine the number of turns required to reduce the maximum scale reading of the meter from 500 mAs to 1 mA. If you noted the number of turns you removed from the moving coil former, you should be able to approximate the number required, but in view of the great difference between the two scale readings, it is doubtful whether there will be sufficient room on the existing coil former to accommodate the new winding.

### Coil Connections

**"In the receiver I have just built I have come across a difficulty. The circuit is the 'A.C. Leader,' P.W. 35c. Unable to buy the specified coils I am using the home-made coils described in your book 'Wireless Coils, Chokes and Transformers.'**

**"All I can get out of the set is a low-pitched hum. The valves, being new, are above suspicion, and I think it is something to do with the coil connections. On the mains transformer, there is a lead marked S.P., could you please tell me to where it is connected?"—A. W. (Farncombe).**

THE theoretical circuit you enclosed appears to be fundamentally correct; therefore, we are wondering if some fault exists in the coil connections. If you have not already tried a pick-up across the detector circuit, we would advise you to do so, as it would prove whether the detector and L.F. stages are in order. Should satisfactory results be obtained, then the aerial could be connected to the H.F. coupling condenser, thus using the receiver as a two-valver. This would enable you to prove if the H.F. coil, reaction circuit and detector are operating normally. If no faults are evident, the aerial can then be transferred to the aerial coil and the H.F. stage brought into circuit.

The lead marked S.P. is evidently intended to denote the connection of the screen between the primary and secondary windings; it should be connected to earth.

### P.W. 94

**"I purchased a Wireless Blueprint No. 94, and in the constructional notes, the list of components includes a fixed condenser of 0001 mfd., but in the blueprint I cannot see where it should be connected. Will you please explain."—J. C. C. (Essex).**

THE fixed condenser is included in the list of components for use if any interference is experienced from stations other than that to which the receiver is tuned. If the condenser is connected in series with the aerial lead-in, the selectivity will be improved, but the signal strength will be reduced slightly.

## Classified Advertisements

### LITERATURE, MAPS, etc.

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