POCKET REGENERATIVE RECEIVER

Practical Wireless

9D EVERY MONTH

Editor F. J. CAMM

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Rear-Admiral C. S. Holland, Director of Signals, talking to wireless telegraphists during a visit of inspection to a Naval signal station in Scotland

Practical Wireless
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EVERY MONTH
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COMMENTS OF THE MONTH BY THE EDITOR

Standardisation

AT the annual general meeting of the Radio Manufacturers' Association, the chairman of council referred to the co-operation of the association with other associations, and particularly with one new association—The Telecommunication Engineering and Manufacturing Association—commenting that in future the trade association would have a big part to play in expressing the unified views of the industry to the Government. There would have to be some form of organisation to bring every member in touch with the association.

We concur in the view that trade associations fulfil a valuable function in peace and war. Perhaps in peace-time there is a tendency towards rivalry between various trade associations which is not always to the benefit of the industry or the public. It can be argued that there are too many trade associations, and that there is a considerable over-lapping effort. Almost every branch of the radio trade is now represented by an association—the valve manufacturers, the set manufacturers, the cabinet manufacturers, the component manufacturers, wireless traders, service engineers, wire manufacturers; each have their own association. When a particular matter affecting one branch comes up for discussion, the impact of the conclusions reached, and the decisions made, may react favourably or otherwise upon other branches of the industry. This leads to a multiplicity of *vis-à-vis* committees, and often it is found that the decisions made are unworkable when they are discussed with members of another association. This results in waste of time and waste of effort. It therefore seems to us that there is need for some new body which embraces all of the associations which will retain their individual status under the guidance of a parent council.

Parent Body

IF we are to avoid the chaotic conditions which existed in the radio trade before the war, when each manufacturer created his own standards, and then called upon other manufacturers to conform to those standards, the time for the formation of such a parent body has arrived. In components particularly there was considerable confusion, and whilst the Radio Components Manufacturers' Federation had, to some extent, secured standardisation of certain parts they did not go far enough, in that they should have rejected altogether certain apparatus where it was merely found to be a variation of another standard part.

After all, the object of standardisation is to secure not only cheapness of manufacture and interchangeability, but also to avoid dealers having to carry large numbers of types. There is no particular reason why a fixed condenser should be manufactured in a variety of shapes. Every different size for a particular value means another set of tools.

H.T. Batteries

LAST month we dealt with the great variety of high tension batteries, which the battery manufacturers were called upon to make. Here we think the Battery Manufacturers' Association might have suggested to the radio trade that in a given time it should cease to employ high tension batteries and accumulators of a size which are uneconomical in use and give unsatisfactory performance. Such batteries do not enhance the reputation of the maker. Alternatively, the battery manufacturers could refuse to supply batteries of a size which they consider unsatisfactory. Materials for some time after the war will be in short supply, and thus we must make the best possible use of the materials available. Short-lived components waste material. We have had to reduce the numbers of types during the war, and this could usefully be done in peace. The servicing of receivers would be considerably simplified if this policy were adopted.

Replacements

THE U.S.A. War Production Board has announced that replacement parts for receivers are to be standardised to ensure the maintenance of over 90 per cent. of the receivers in use, and manufactured during the past few years.

The number of transformers and chokes are to be reduced from 155 types to 14 types, and this will include six power transformers; only 110 types of valves will be produced instead of 350. In 1939 there were over 700 types of American valve. After the war started this was reduced to 350, and this number now suffers a further cut.

The number of types in this country have been automatically cut during the war because they are unobtainable. Many, we hope, will never be re-introduced, for they are unnecessary.

Our Query Service—Special Notice

THE number of queries we receive has been steadily growing since the war began. To-day they have reached enormous proportions, and we now invite the co-operation of our readers in reducing the number of queries they submit to the minimum. This is purely a wartime measure, occasioned by a shortage of staff, and the many calls upon the time of members of the staff by various national services.

Before submitting a query we hope readers will go to the small amount of trouble of consulting past issues or one of the many textbooks on radio which we have published.

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The Editor will be pleased to consider articles of a practical nature suitable for publication in PRACTICAL WIRELESS. *Such articles should be written on one side of the paper only, and should contain the name and address of the sender. Whilst the Editor does not hold himself responsible for manuscripts, every effort will be made to return them if a stamped and addressed envelope is enclosed. All correspondence intended for the Editor should be addressed: The Editor,* PRACTICAL WIRELESS, *George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2.*

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.

The fact that goods made of raw materials in short supply owing to war conditions are advertised in this paper should not be taken as an indication that they are necessarily available for export.

ROUND THE WORLD OF WIRELESS

Recording Cars

THE B.B.C. recording cars—there are eleven of them—turn up in strange places, in the Tripolitanian Desert, on Dover cliffs, by hospital bedsides, on railway embankments and aerodromes, in docks, by the seashore, down the suburban street—anywhere that has a story for recording. Sound effects do not explain themselves automatically. A record of waves breaking will leave an audience guessing as to what it is. Played against a faint background of ships' sirens and faint seagulls it will instantly be placed. So composite pictures in sound are often needed to help the listener's memory. Other examples are the music of a running stream, the sighing of wind in the trees, the song of a bird, which almost always have to be supplemented in this way. Often, too, sounds must be represented, not as they are, but as people think they are. For instance, many trains arriving in termini come in silently. Dramatic programmes may require that they make the noise which people (other than railway experts) think they make.

Music While You Work

IN a recent case in which the Performing Right Society obtained an injunction to restrain a certain company from infringing the society's copyrights by broadcasting music in their factories without licence, the judge made it clear that such licences were necessary. In another case, recently heard, a certain company sought a declaration that the performance in their factory by broadcast of music, the copyright of which was held by the Performing Right Society, was not an infringement of copyright. Mr. Justice Bennett held that a broadcast to workers was a performance in public, and the society was entitled to impose a tariff on a factory amplifying its copyright music.

B.B.C. Thwart Mussolini's Ban

WITHIN 24 hours of the publication of Mussolini's recent decree, the B.B.C. told the Italian people how to get round the new ban on outside aerials. Broadcasts in the Italian language were transmitted giving simple instructions for the construction of indoor frame aerials equally efficient for receiving foreign broadcasts, with the added advantage of overcoming jamming.

Ex-B.B.C. Announcer's Award

SQUADRON-LEADER J. B. SELBY, R.A.F.V.R., ex-B.B.C. announcer, has just been awarded the D.S.O. in addition to his D.F.C.

Detecting Ships by Radiolocation

CONSIDERABLE progress has been made recently in the development of radiolocation by the Royal Navy. British ships now use radiolocation to detect the position of other ships or aircraft.

Radio Relay Subscribers

ACCORDING to figures now available, there was an increase of 15,858 subscribers to the radio relay exchanges in this country during the third quarter of last year. Up to the end of September, 1942, there were 414,843 subscribers to 278 exchanges.

B.B.C.'s Radio School

THE B.B.C.'s Radio School, the first of its kind in the world, has reopened after having been bombed in 1940. Here members of the B.B.C. staff and foreign radio experts learn how to become announcers and speakers. They study the newest developments of radio technique and all that goes to produce the ideal radio manner. Mr. E. A. Harding, the producer and feature writer, is the new director.

B.I.R.E. Paper and Discussion

AT a members' meeting of the British Institution of Radio Engineers (Midland Section), held in the English Theatre, The University, Edmund Street, Birmingham, on Friday, March 19th, Mr. J. H. Cozens, B.Sc., A.M.I.E.E., read a paper on Modern Condenser Technique, with special reference to electrolytic condensers.

A wireless mechanic of the R.A.O.C. testing a multi-valve set.

At another members' meeting of the B.I.R.E., held at the Institution of Structural Engineers, Upper Belgrave Street, London, S.W.1, on Friday, March 26th, an informal discussion was opened by G. A. V. Sowter, M.I.E.E., and A. J. Tyrrell, A.M.I.E.E., on Modern Magnetic Materials, with special reference to permanent magnets and high permeability alloys.

War Damage Act

THE Board of Trade announced in September, 1942, that, with the approval of the Treasury, it had been decided that the premium payable under the business scheme for the 12 months ending September 30th, 1943, would not exceed £1 per cent. For the period of six months to March 31st, 1943, the rate of premium was fixed at 10s. per cent.

Having regard to present conditions and to the amount already paid by way of premium, the Board have, with the approval of the Treasury, decided to fix the rate of premium for the whole of the year to September 30th, 1943, at 15s. per cent., so that the premium to be paid for the six months April 1st to September 30th, 1943, will be 5s. per cent.

Dr. Armstrong's Award

DR. EDWIN H. ARMSTRONG, the radio pioneer, has been selected by the American Institution of Electrical Engineers to receive the Edison Medal for 1942 for his distinguished contributions to the art of electric communication.

Anti-jamming Device!

A RADIO dealer in Holland has been doing a roaring trade with a device to counteract jamming. Impudently, in view of Gestapo watchfulness, he advertised that he could "make any receiver selective." And he made the meaning of his offer plain by the slogan: "If the din should be too loud, our experts can cut it out."

News from Enslaved Europe

LETTERS from the occupied countries of Europe continue to reach the various sections of the B.B.C.'s European service. Some tell news of long-past events, such as this: "A Dutch pastor, after hearing the official German estimate of casualties at Rotterdam, held a service 'in memory of the 300 dead of Rotterdam, 400 of whom were killed in my parish alone.'" Another refers to the Nazis' scrap metal campaign in Holland. When copper was the metal being specially rounded up, a customary question of one Dutchman to another was "How does your garden grow?" and the cryptic answer was something to the effect: "Not badly; it is turning green, but fortunately it hasn't come out yet."

How Listeners Help the B.B.C.

OVER the last three years one in every 30 people in Great Britain have had the experience of being "interviewed" about the broadcast programmes they listen to. In the early months of the war the B.B.C. decided that it was important for its programme planners to know how many people listened to each programme. The Corporation, therefore, set about the job scientifically, by organising a continuous Survey of Listening. Since then a fresh cross-section of the whole population in Great Britain has been interviewed each day, and a careful record made of the programmes they have heard within the previous 24 hours.

From the beginning "interviewing" has always been a part-time job for those engaged upon it—indeed an increasing number of interviewers do their work in addition to a full-time job in industry. This is made possible by limiting the task of the individual interviewer to a maximum of two and a half hours a day.

Survey of Listening

HITHERTO the interviewing for the Survey of Listening has been organised by the British Institute of Public Opinion on the B.B.C.'s behalf, but from March 1st the Corporation assumed direct responsibility for this side of the work, and it is completing its arrangements.

The general principles of the Survey will remain unchanged. Interviewing will continue to be a part-time activity on which some 50 people will be engaged at any one moment. They will be drawn from a "pool" approximately 250 strong, for interviewers are constantly varied so that all parts of Great Britain are adequately covered.

Interviewers have been immensely helped by the friendly attitude of the people they approach, and the readiness of the public to give the necessary information. The B.B.C. greatly appreciates this co-operation from its listeners.

British and U.S. Radio Link

THE extent of British and United States radio co-operation is shown in a report by B.B.C. engineers on overseas relays during 1942. Out of a total of 3,217 incoming relays no fewer than 1,712 came from America. For outgoing relays the proportion was even higher: 1,740 to America out of a total of 2,259.

Another striking fact in the report is a considerable extension in the total number of incoming relays. The figure of 3,217 for the year compares with 1,129 in 1941, 502 in 1940 and 469 in the year before the war. In an analysis of the year's inward relays, the engineers classify 2,880 as successful, 170 as partially successful and 167 unsuccessful. A successful relay is one considered satisfactory for immediate or delayed rebroadcasting. A partial success is also satisfactory for immediate or delayed rebroadcasting, but there may have been short periods of distortion or heavy noise, or the relay was sufficiently intelligible to produce a script for reading or the essential gist of it could be utilised in the news. Under the heading "Unsuccessful" would be general unintelligibility or prolonged periods of noise and distortion.

Important Speeches

INCIDENTALLY, it should be noted that the figures do not include programmes taken solely for listening or monitoring purposes.

Outstanding in the relays broadcast live in B.B.C. programmes during the year were speeches by President Roosevelt from the United States, Field-Marshal Smuts from South Africa, and the Duke of Gloucester, General Wavell and Sir Stafford Cripps from India.

For outgoing relays the total for 1942 of 2,259 contrasts with 2,231 in 1941, 1,836 in 1940 and 886 in 1939. Of the total, 2,170 came into the successful category, 35 were partially successful and only 54 unsuccessful. The 1942 total includes 43 two-way relays.

A keen squad of French volunteers in North Africa interested in a British wireless receiver.

A Single-valve Regenerative Receiver

Constructional Details of an Interesting Portable Set for the Ultra-short Waves

By A. C. SCOTT

I RECENTLY constructed a pocket-size one-valve ultra-short wave receiver, which may be of interest to other readers who have not experimented with this type of circuit. Although it was originally designed for use on the ultra-short waves, excellent results were obtained on all the short wave bands. In two nights I logged stations WNBI, WCBX, WGEA, WRUL and two stations which sounded like WLW and WCRC in the 16-metre band. Also I received many European and other unidentified stations. These results were obtained when using a 4-*foot aerial.*

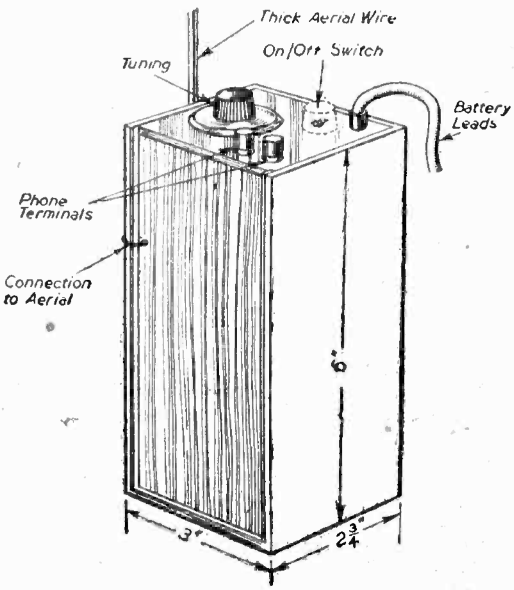


Fig. 1.—General view of the pocket-one-valve ultra-short wave receiver.

Although only one valve is employed, the circuit, known as the super-regenerative, permits extremely high amplification although it is very unselective. This, however, is an advantage, as no slow motion drive is used. The size of the set is 6in. x 2¾in. x 3in.

Construction

The construction and layout of the set will be clear from the diagrams, but the value of the grid-leak is best determined by experiment, as it is very *critical.* An on/off switch could be incorporated behind the 'phone terminals, if so desired. The valve used should be a high emission power valve for best results.

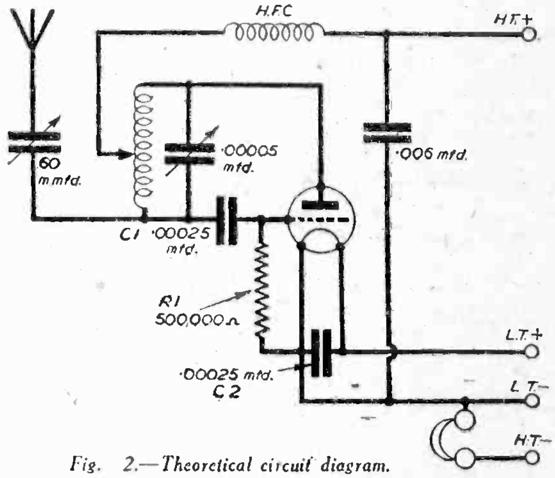


Fig. 2.—Theoretical circuit diagram.

Operation of the Set

After checking all wiring to ensure no damage to the valve, the H.T. and L.T. supplies can be switched on. If the circuit and wiring are in order, a loud hissing noise will be heard indicating the super-regenerative action. If the value of the grid leak is too high, a high-pitched whistle will be audible and the value of the leak should be lowered. When a station is tuned in, the hissing noise will either fade out completely or diminish considerably; it has, therefore, no detrimental effect on reception and should be looked on as a sign that the set is in good working order.

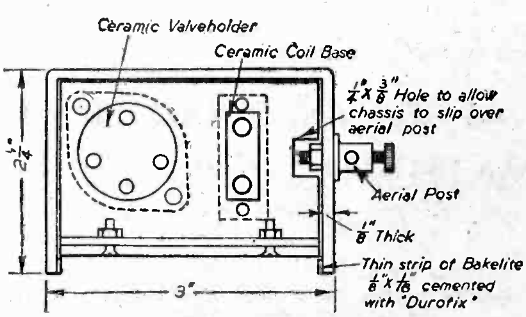


Fig. 5.—Section through chassis and casing.

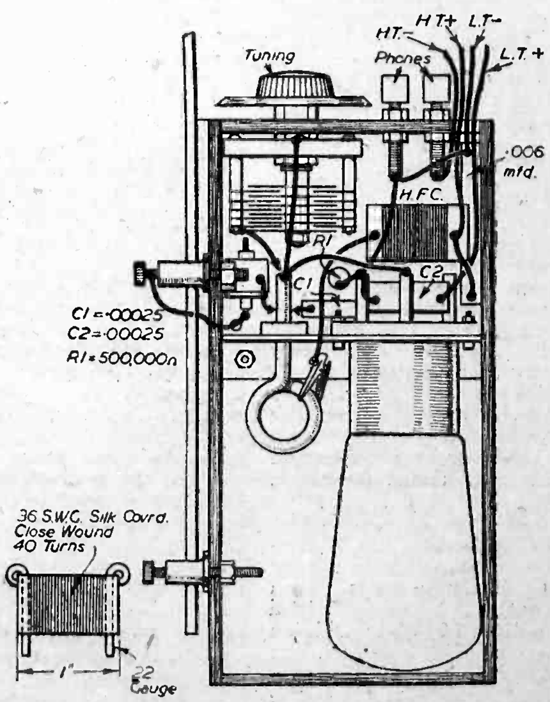


Fig. 3.—Section through receiver showing lay-out of components and wiring. Details of H.F. choke are given in inset.

Care should be taken in the operation of the set, as if too low a value of grid leak is used the set becomes a *low powered* transmitter which, apart from being *illegal*, can also become a source of annoyance to other listeners.

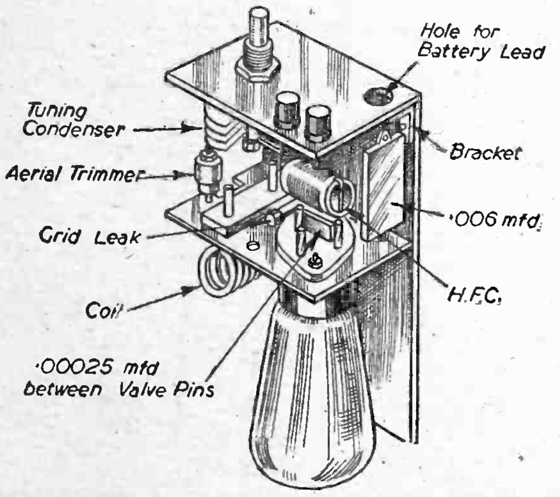


Fig. 4.—Perspective view of chassis with valve in position.

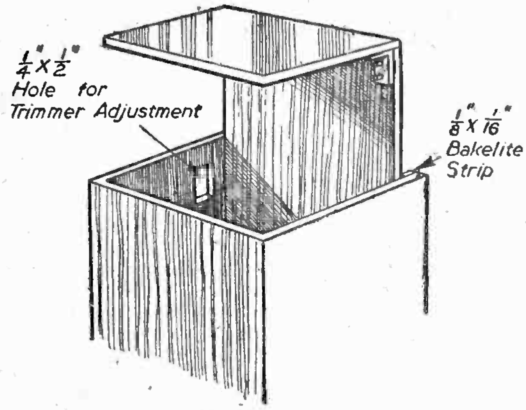


Fig. 6.—Details of casing.

LIST OF COMPONENTS

Trimmer condenser—Phillips.
One 50 mfd. midget variable condenser—Raymart.
One ceramic valve-holder—Raymart.
One 500,000 ohm resistor—Sator.
One .006 mfd. mica tag condenser—Dubilier.
One .00025 mica tag condenser—T.C.C.
One .00025 mica condenser—Hunt.
One H.F. choke (40 turns 36 S.W.G. silk covered wire wound on a $\frac{3}{8}$in. diameter bakelite rod).
Terminals, battery cord, etc.

Women Electric-lamp Workers

The Importance of This Group in the War Industry

AT the present time industrial concerns are among the largest users of electric lamps and yet few, if any, ever give a thought to the important work of lamp manufacture. That this state of affairs is, to say the least of it, rather unfair, is an under-statement, for what factory to-day could carry on without artificial light? Windows partially or entirely obscured by black-out make it, in many cases, as necessary during the day as at night, and all the time the highest quality lamps are essential if work is not to be interrupted by unexpected lamp failures and renewals and electricity is not to be wasted.

Broadcast by Workers

Too many people take electric lamps for granted, forgetting the skill, accuracy, ingenuity and research that go into the construction of each one of them, and therefore the Electric Lamp Manufacturers' Association warmly welcomed the opportunity provided by the B.B.C. recently for two women workers drawn from factories of its members, to broadcast in the Home Service in the series "Women You Don't Hear About."

The British Broadcasting Corporation has brought many interesting personalities before the microphone from little publicised war jobs, but perhaps never before women from an industry without which so many could not carry on.

New Types of Lighting

The members of E.L.M.A. number among them names which are household words for reliability in lamp manufacture, and these companies are responsible for the great bulk of the supply of lamps to H.M. Forces, Government Departments, and war industry. Together they spend large sums of money on research each year, and to them goes the credit for introducing new types of lighting which have revolutionised modern lighting practice.

The women who represented this vast concern on the air were Miss Daniels, aged 20, who has taken up lamp manufacture as her war work and welds filaments for the minute lamps used in radiolocation; and Miss Hilda Ramsay, who has 31 years' service at her lamp factory to her credit. Miss Ramsay's job is that of sealing and shaping the bulbs of naval gunsight lamps, a job on which she was also engaged in the last war. Not only must this be something of a record, but she and her sister between them can claim over 60 years' service in the same factory.

In the short time available on the air it was not possible to do more than outline a very small part of the story of lamp manufacture, but something was said of the accuracy and complexity of the many processes involved, to make workers in other industries realise how much they depend on their fellows in the lamp industry; it was felt that an important point had been made in bringing into the limelight a group of war workers who have been carrying on, through as many difficulties as have beset any other industry, to deliver the lamps which are indispensable to the war effort.

Your Service Workshop–2

A Reliable, Adaptable Receiver is an Essential Part of the Equipment. A Tested and Versatile Design is Described by S. BRASIER in this Article.

THE question of power supplies is one that has to be decided on when planning the apparatus for the workshop. The usual question is, should one install a mains power pack and distribute voltages to various convenient points, or should each piece of apparatus have its own internal power supply? The first method saves one or two mains transformers, etc., but voltage regulation would present quite a problem due to the fact that it would be difficult to maintain a constant current load. Also the instruments would be tied to the workshop and could not be taken on outside work, therefore, all things considered, it is more convenient to adopt the latter plan.

The nature of the supply is usually decided for us, and, since this is invariably alternating current, the apparatus described in this series will be suitable for that supply. The man who has D.C. mains is rather unfortunate from the servicing point of view, unless he goes to the expense of a rotary converter.

Turning now to the question of the workshop receiver, it will be readily appreciated that a reliable set, maintained in good working order, must form a necessary item of equipment. In servicing or experimenting it is often required to test a speaker unit or pick-up under actual working conditions, or make comparative tests of signal strength, etc.; also, when using simple signal tracing equipment a receiver of some sort is essential.

Bearing these points in mind, it may be found that an ordinary domestic receiver will not entirely be convenient, and that a set incorporating special features is desirable. The receiver should be of average sensitivity and have a reasonably powerful undistorted output *of good quality*. It is useful, also—in view of the above remarks—to make provision for alternative circuit combinations. For various reasons, but mostly because of the component difficulty, a superheterodyne receiver was ruled out and the T.R.F. circuit arrangement shown in Fig. 9 was decided upon. At first glance it may appear to be complicated, but actually this is not so, as it consists of a stage of high-frequency amplification (variable Mu) choke-coupled to a screened-grid detector, which, in turn, is coupled to either of three alternative outputs, viz.: (1) direct to phones (no L.F. stage); (2) to resistance capacity coupled pentode, or (3) to transformer coupled push-pull power valves.

A Flexible Circuit

This arrangement is extremely convenient when making comparative tests or for taking measurements of stage gain, etc., and for these purposes also it will be seen that the aerial may be transferred to the input of the detector, and by so doing the high-frequency valve is, in effect, removed from circuit. Without enumerating all of them, it will be seen that very many circuit combinations are available, such as 1-v-0, 0-v-1/1, 1-v-1, etc. An examination of the circuit diagram will also reveal that provision is made for the testing of energised speaker units having field resistances of 500, 1,000, 1,500 and 2,000 ohms, as well as the permanent magnet type. Under any of the above conditions the high-tension voltage appearing at X in Fig. 9 remains the same.

The L.F. outputs are selected by a plug and socket arrangement (called S1, 2, 3, for convenience) situated on the chassis behind the gang condenser. S1 enables 'phones or any test apparatus to be made use of straight from the detector and cutting out any L.F. stage. With the plug in S3 position the R.C.C. pentode stage comes into use, but the two push-pull valves must not be in their holders. Similarly, with S2 connected for push-pull operation the pentode valve must be removed. This method was considered preferable to the adoption of switching for input and heater circuits which would only tend to complicate matters. It is advisable to select a pentode valve that consumes approximately the same high-tension current as the two push-pull valves together. This is not very difficult, because the M.P.41's, for instance, take roughly 24 milliamps apiece and an average pentode consumes about 50 milliamps. This balancing of current is, of course, necessary in order to maintain a similar high-tension voltage when using either output. Perhaps a little judicious juggling of bias resistors may help in this direction. And, incidentally, if it happens that the value of the bias resistor for the pentode is the same value as for one of the push-pull valves, the pentode cathode may be connected directly to one of the push-pull valve cathodes, thus saving a resistor and electrolytic condenser.

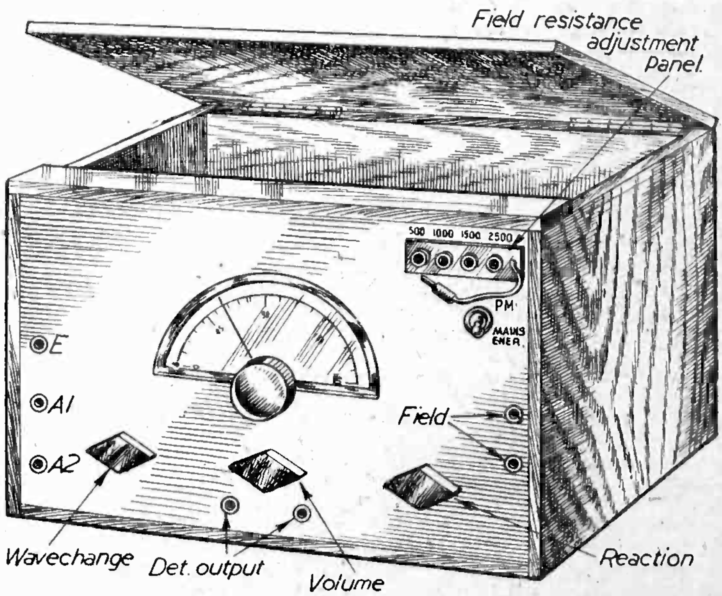


Fig. 8.—Showing the layout of the panel controls, and the type of cabinet employed.

Using the "Universal Output Unit"

It will be noticed that no output transformer is indicated in the diagram or incorporated in the receiver. This is because the set is used in conjunction with the "Universal Output Unit," which is essentially an output transformer, the ratios of which may be selected instantly by means of push buttons. Choke capacity output and variable tone control are also features of this unit, therefore the latter has also been omitted from the receiver under consideration. A full description of the "U.O.U." was given in issue No. 437, where it will be seen that the scope of tests available on the workshop set is greatly increased when used with the "U.O.U." It is necessary in servicing to arrange apparatus so that all sorts of tests may be carried out as quickly as possible and with a minimum of trouble. For this reason, also, it is convenient to construct the receiver in such a manner that all testing points are accessible, therefore a chassis and panel system has been adopted. Figs. 10 and 8 give a good idea of the layout, etc., while Fig. 11 shows the disposition of the under chassis components. The layout should be adhered to as closely as possible, for although the set is not super-critical in this direction, the various parts have been arranged with due regard to efficiency and simplicity of wiring. The connections to S1, 2 and 3 and the dual output stage should receive special attention, since damage to valves may result if mistakes are made. Note should be taken also of the wiring on and to the paxolin group board, on which are mounted various resistors and condensers. And to avoid trouble at some future date, the whole set should be carefully wired and really good soldered connections made. It is most annoying to have to delay work on a particular job in order to locate a fault in the workshop equipment.

The panel may be of ebonite or metal, but if the latter material is used it will be necessary to ensure that such points as aerial sockets, loudspeaker field adjustment switch, etc., are thoroughly insulated. All the components are of more or less standard type and no difficulty should be encountered in procuring them. The H.F. choke (H.F.C.1) must be of good quality and high inductance—preferably screened. A useful tip regarding this component is to employ an I.F. transformer of the 110 k/cs type. The windings must be joined in series and any trimmers either disconnected or removed. This expedient was adopted in the original set and has proved to be entirely satisfactory. The reason why the 110 k/cs type is advisable is because of the greater number of turns, therefore higher inductance.

Regarding the tuning arrangements, it was at first decided to include some form of band-pass aerial circuit, but owing to the difficulty of obtaining matched coils and suitable condensers this refinement was discarded in favour of the system shown in the diagram, which is more tolerant of any slight mismatching of the tuning coils. A pair of Lissen dual range screened coils—which, incidentally, are extremely efficient—are specified. If these coils are used, or for that matter any coils with terminals on the base, it will be more convenient to ignore them and make connection direct to the soldering tags at the base, bringing the wires through a hole in the chassis. Coils play a large part in the ultimate efficiency of a receiver, but so long as good quality ones are chosen it is not necessary to adhere to this particular type, in which case it is most unlikely that the numbered connections would be the same.

The L.F. transformer is parallel fed and almost any good quality component will be suitable. It will be noticed that the use of a special push-pull transformer has been avoided by the adoption of the potential divider system joined across the secondary terminals. This component may be the cause of some hum due to interaction with the mains transformer, therefore it is advisable to make some temporary provision for its orientation as the position for negligible interaction is often quite critical.

Ample decoupling of the earlier stages is provided for, and in this connection it might be advisable to refer to the block condenser mounted on the chassis. Its value is 2+2+1 mfd. and serves to decouple the anode (4 mfd.) and screen (1.0 mfd.) of the detector valve. It is not essential to use a block condenser and the electrolytic type will be suitable if this is more convenient.

A point to note about the valves is that whereas the top cap of the H.F. valve (VP4B) is grid, that of the detector (MS4B) is anode. If an H.F. pentode be used in the latter position, do not forget that the suppressor grid must be joined to earth, and that the top cap will in all probability be grid.

The mains transformer is a standard component which in conjunction with V6 gives a full-wave rectified

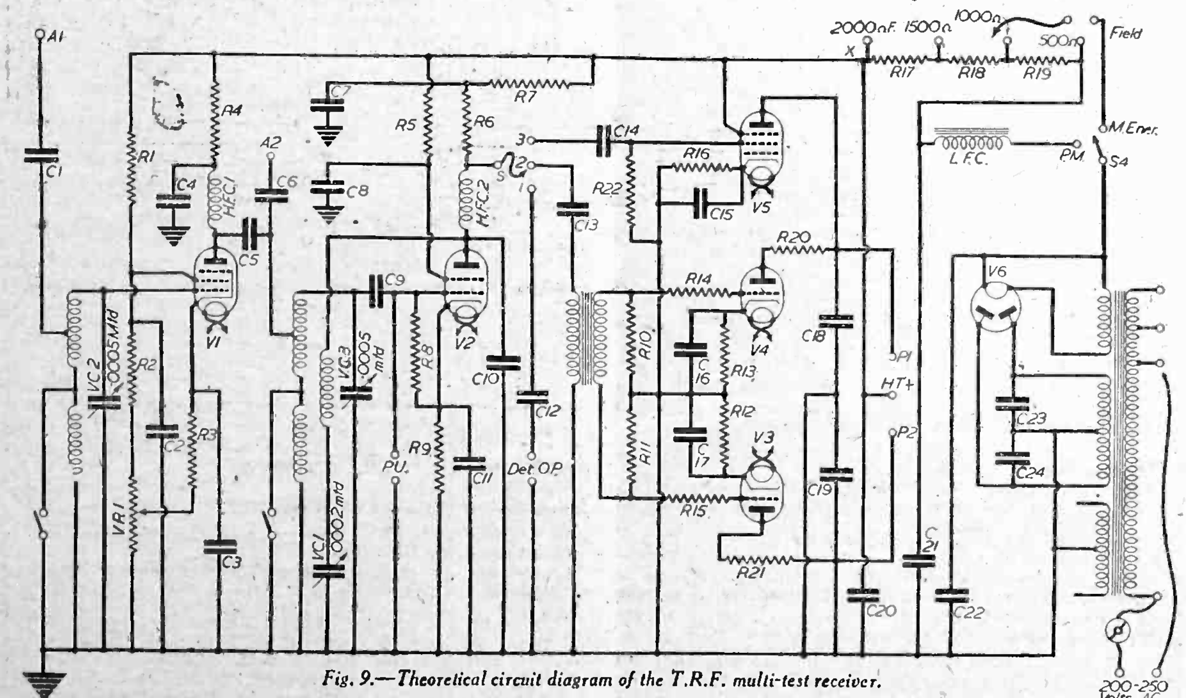


Fig. 9.—Theoretical circuit diagram of the T.R.F. multi-test receiver.

COMPONENT VALUES.

C 1 .00005	C 6 .00005	C 11 25.0	C 16 50.0	C 21 4.0	R 1 30,000Ω	R 6 .1 MΩ	R 11 1 MΩ	R 16 150Ω
C 2 .1	C 7 4.0	C 12 1.0	C 17 50.0	C 22 8.0	R 2 20,000Ω	R 7 20,000Ω	R 12 300Ω	R 17 500Ω R 18 500Ω
C 3 .1	C 8 1.0	C 13 .5	C 18 .001	C 23 .01	R 3 50Ω	R 8 1.0 MΩ	R 13 300Ω	R 19 500Ω
C 4 .1	C 9 .0001	C 14 .1	C 19 .001	C 24 .01	R 4 1,000Ω	R 9 1,000Ω	R 14 .25 MΩ	R 20 2000Ω R 21 2000Ω
C 5 .00005	C 10 .0002	C 15 50.0	C 20 8.0	V.R.1.5000Ω	R 5 .5 MΩ	R 10 1 MΩ	R 15 .25 MΩ	R 22 1 MΩ

output of about 350 volts. This drops to about 250 after smoothing, so that slightly more than 200 volts appears at the push-pull anodes. This is correct for most indirectly heated power valves and should not be exceeded to any great extent, otherwise a gradual deterioration must be expected due to the valves eventually going "soft."

The tuning dial is a simple affair, consisting merely of a pointer travelling round a scale of 180 deg. marked out on a piece of stiff card or celluloid. From this a calibration chart can be made out. Incidentally, the gang condenser used was of the integral slow-motion type which facilitated the dial arrangements.

Operation

Regarding operation there is nothing much one can say except that the trimmers must be adjusted when testing out and also that all switching—field resistance, output stages, etc.—must be made with the set switched off. The output transformer arrangements are provided for the "Universal Output Unit." For example, for pentode output, the plug switch in the receiver is put to the S3 position, and on the U.O.U., the button giving the required ratio pressed in (say 80—1 assuming a 2-ohm speech coil). For push-pull the switch in the receiver would go to S2, while on the U.O.U. the button marked "push-pull" is depressed, thus the extra anode (P2) is automatically connected in circuit. If the U.O.U. is not made use of it will become necessary to provide for the alternative outputs in the form of a transformer tapped for pentode and push-pull, possibly with simple plug switching.

For reasons of accessibility it is best to arrange the cabinet more on the earlier style, i.e., with a hinged lid, so that any adjustments may be effected with the minimum inconvenience. (See Fig. 8.)

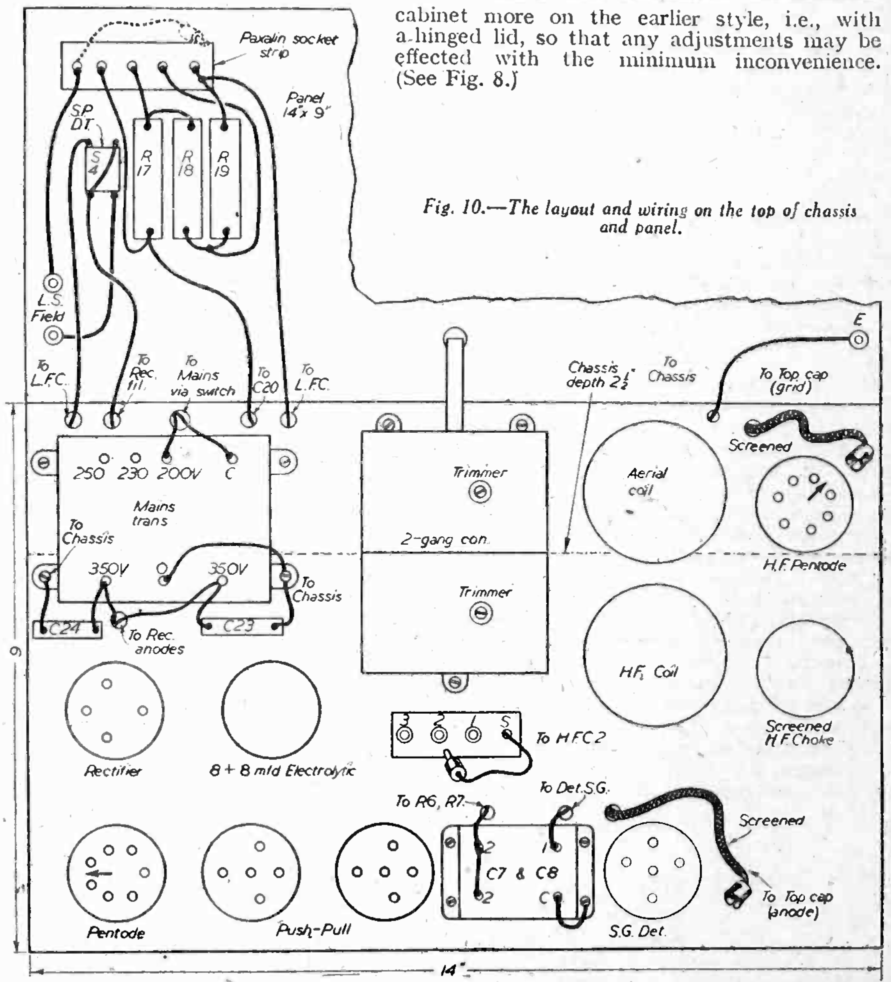


Fig. 10.—The layout and wiring on the top of chassis and panel.

The design of a workshop receiver is a matter upon which there are probably many varied opinions, but the writer feels that he cannot do better than describe his own apparatus which is giving efficient and reliable service. Incidentally, this receiver arranged for push-pull operation and with slight modifications, is ideal for domestic use, since the quality is exceptionally good and the power more than sufficient for normal requirements.

LIST OF COMPONENTS

One chassis 14in. x 9in. x 2½in.
One panel 14in. x 9in. (See text.)
One 2-gang condenser, .0005 x .0003 mfd. (preferably integral slow motion).
Two coils (aerial and H.F. Lissen).
Two 7-pin valve-holders.
Four 5-pin valve-holders.
One mains transformer, 350-0-350 volts, 4 v. 2 a. (at 60 m/a), 4 v. 5 a.
One L.F. choke, 20 henries 500 ohms (approx.).
Two H.F. chokes, preferably screened. (See text.)
One L.F. transformer, 3.5-1 Varley "Nicore."
One 5,000 ohm volume control with switch.
One reaction condenser, .0002 mfd.
One rotary wave-change switch, D.P.D.T.
One Q.M.B. change-over switch, S.P.D.T. (Bulgin).
One Paxolin group board.
One 2-way Paxolin socket strip (pick-up).
Two 3-way Paxolin socket strips (S1, 2, 3). (Pl. H.T., P2).
One 4-way Paxolin socket strip (field adjustment).
Seven plugs and sockets.
One Mullard V.P.4 B. (V1).
One Osram M.S.4 B. (V2).
Two Cossor 41 M.P. (V3, V4).
One Output pentode (V5).
One Osram M.U.14 V6).
Condensers: One 8+8 mfd. 450 V.W. (can type electrolytic). One 4 mfd. 450 V.W. (block electrolytic). Three 50 mfd. 25 V.W. (electrolytic). One 25 mfd. 12 V.W. (electrolytic). Three .00005 mfd. (tubular). One .0001 mfd. (tubular). One .0002 mfd. (tubular). Two .001 mfd. (tubular). Two .01 mfd. (tubular, 750 V.W.). Four .1 mfd. (tubular, 750 V.W.). One .5 mfd. (tubular, 750 V.W.). One 2+2+1 mfd. block (but see text). One 1.0 mfd. (Mansbridge type, 250 V.W.).
Resistors: One 50 ohm. One 150 ohm. Two 300 ohm. Three 500 ohm (5 watt each). Two 1,000 ohm. Two 2,000 ohm (2 watt). Two 20,000 ohm. One 30,000 ohm. One 0.1 megohm. Two 0.25 megohm. One 0.5 megohm. Four 1.0 megohm.
Cabinet, wire, screws, etc.

This completes the description and operational details of the multi-test receiver, and for the benefit of new readers it may be mentioned that in last month's issue particulars were given of the layout and equipment of the radio workshop. The choice of a suitable room, its lighting and heating, and the positions of the bench and other fitments were dealt with.

Constructional details of the bench and particulars of the tools required in the workshop were also given, together with some useful information on a suitable lighting system. It was pointed out that apart from the main light, a movable lamp arranged to travel the length of the bench, at a convenient height above it, should be arranged so as to get the light in the right place for an awkward job.

(To be continued.)

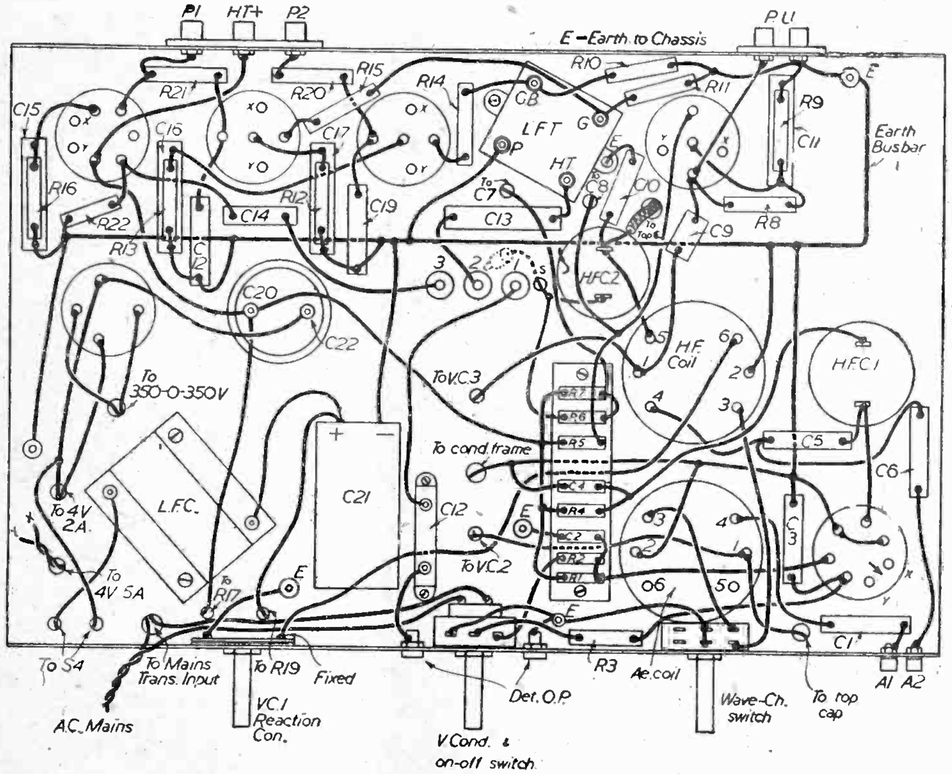


Fig. 11.—Under-chassis wiring and component layout.

"Off the Record"

Interesting Particulars of the B.B.C.'s Gramophone Radio Service

THE gramophone concert gives the listener something—a work or a performer or an interpretation—that he might never get in any other way. War conditions have prevented many great artists from visiting this country. Though concerts by Toscanini or Kussevitzky can no longer be heard in Britain, under ideal conditions, broadcast records offer their superb interpretations.

Gramophone recitals on the air are no mere substitutes for "live" equivalents, indeed a record is never used, except in special circumstances, if the artist who made it is himself on the spot.

The gramophone alone makes it possible to bring great artists of the most varied kinds—Douglas Byng and Larry Adler and Pachmann and Gracie Fields—into one brief programme. Used with plastic imagination, records can be used—either with "live" voices, as in Frederick Piffard's series "Fables of the Forties," or, without, to build up a type of entertainment peculiar to this sort of programme.

Another type of programme in which the gramophone is indispensable is the "talk on music," either classical or jazz. An interesting development in this direction was the discussion on the merits of Berlioz, broadcast some weeks ago, a discussion which attracted widespread notice and which is to be followed by others on Liszt, Franck, and other "debatable" masters.

The B.B.C.'s Gramophone Library feeds the producers of every type of broadcast programme—except news—with anything they demand. Music suggestive of the Wailing Wall of Jerusalem, of a Thames tug-boat chugging up river, or reminiscent of a French pastorale of the eighteenth century are just a few of the incidental requests.

Frequently asked for by programme producers is "atmosphere" music; for "curtains" between the acts of a play or feature. Only a few bars from each of several records may be taken, but they must be in character with the theme and sustain the mood of the drama. One of the most exacting calls of this nature was for interval music for Dorothy Sayers' series "The Man Born to be King." That strange, seemingly Eastern blend of strings and woodwind came from Ravel's Introduction and Allegro for harp, strings and woodwind.

For "Building Through the Ages," a programme for overseas listeners by Terry Gompertz, the Library staff made an intensive tour of buildings of the many types referred to, in order to provide records appropriate to each.

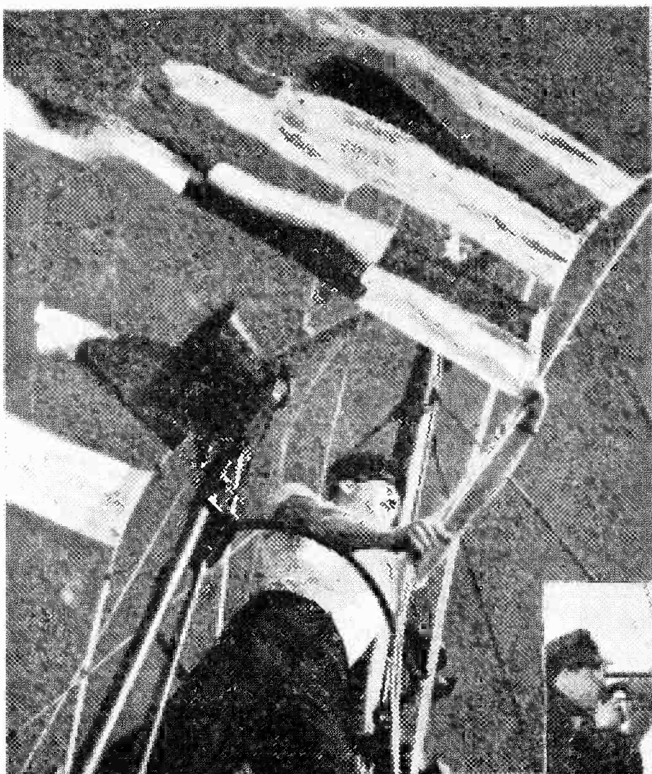
The Library disc which, beyond all others, has made history is probably Beethoven's Fifth Symphony—supplied to the B.B.C. European Service as the call sign of the V campaign.

Every musical link in the series "In Town To-night" came from the Library. Each was chosen as an apt introduction to the individual broadcaster: a pastoral air to herald a shepherd, racing music to precede a dirt-track rider's appearance at the microphone, etc.

The Library has been assembling records almost since the B.B.C. came into being twenty years ago. It is now probably the largest and most comprehensive record museum in the world. It has more than 80,000 discs, which include, apart from those in the English catalogues, many foreign ones. In the "archives" are to be found records of the earliest days—even phonographic cylinders. Madame Albani, Sir Charles Santley, Grieg, Coletti, and many more are to be found.

Signalling in the Services

Notes on the Apparatus Used



A signaller on one of our coastal defence craft.

VARIOUS forms of signalling, and particularly wireless telephony, play an important part in maintaining essential communications in the Army, Navy, and the Royal Air Force. Often under most hazardous conditions communication has to be maintained between a control centre and a number of gun posts on the battle-field, or between a warship and its base, or from ship to ship during manœuvres, or in action. There is also the system of radio signals between an aircraft and its base, and between a squadron leader and the aircraft he leads.

Visual Signalling

In the Navy, visual signalling is used to a large extent by means of flags, semaphore, and flashing. Flag signalling is carried out by means of flags and pendants, hoisted by halliards at the masts and yards of the ship.

Semaphore signalling is used extensively, both at sea, and in harbour, and by this method messages can be rapidly transmitted which are not liable to interception by the enemy. The semaphore consists of two arms pivotally mounted at the top of a short mast, and is not unlike an ordinary railway signal, or semaphore, in appearance. At the lower end of the mast are two short operating levers which are attached by means of rods to the semaphore arms.

Signalling by Flashing

This method of transmitting messages is much more rapid than flag signalling which, in any case, cannot be used at night. For flash signalling by day, special projectors of various sizes are used, and when signalling with aircraft, the Aldis Lamp is employed. One of the latter is seen in

Reading wireless messages aboard a motor gun-boat.

operation in the right-hand illustration on this page. This lamp projects a bright flash, the lamp being fed from a dry battery contained in a small portable barrel fitted with a pistol grip and a sight, the beam from the lamp being directed along the line of sight by the movement of a mirror-reflector, operated by a trigger.

Wireless telegraphy is extensively used in the Navy, both for internal and external communications, but for certain purposes, such as communication with fast-moving units such as aircraft, E-boats, and destroyers, wireless telephony is used.

(Left) The control centre for six-inch howitzers from which instructions are transmitted to the guns.

Radio Examination Papers—18

Another Random Collection of Questions, with Typical Answers by THE EXPERIMENTERS

QUESTIONS

1. *If it were found that the performance of an A.C. receiver improved very considerably after connecting the 240-volt A.C. mains supply to the "200-210-volt" transformer primary tapping, what faults would you suspect?*
2. *Explain briefly the difference between class A, class B and class A-B amplification, as applied to broadcast receivers.*
3. *Two different connections for a grid-stopper resistor are shown in Figs. 2 and 3. Which is correct, and what is the objection to the use of that described as incorrect?*
4. *Why is the intermediate frequency of 465 kc/s alsmost universally employed in commercial superheterodynes intended for broadcast reception?*
5. *Explain why, in the case of a simple regenerative detector circuit, tuning is normally affected by variation in reaction adjustment.*
6. *Fig. 4 shows, in outline, the L.T. and H.T. supply circuits of an A.C./D.C. receiver. Find the value of resistance required between points A and B for the operation of the 6-volt dial light shown. The dial light is rated at .15 A., and the valve heaters are all rated at .3 A.*

1. Transformer Primary Tapping

STEPPING down the primary tapping, as described in the question, could point to one of three different faults. First, the mains voltage may be below the normal value; secondly, the rectifier could be defective, with the result that its output voltage was low because of low emission; thirdly, the output valve may have low emission, so that the valve is overloaded unless the anode voltage is raised above the normal figure.

In any case, it will be evident that the immediate result of using the lower primary tapping is to increase the output voltage from the secondary windings. Thus, if the rectifier voltage had fallen off, the application of a higher A.C. input voltage would tend to increase the D.C. output. It is this fault which would be most likely to arise in practice, and a check could be made by replacing the rectifier, if a new one were available. Alternatively, measurement of the D.C. voltage applied to the smoothing system would give an indication of the nature of the fault. The measurement should be made with a high-resistance voltmeter after the set has been switched-on sufficiently long for the valve heaters to have attained their working temperature.

If the D.C. output were correct for the applied input A.C. voltage, it would be reasonable to suppose that the output valve was faulty. It is possible, although not very probable, that one of the earlier valves may be at fault, and giving rise to the behaviour explained. It is also possible that all valves may be in order and that the value of the cathode bias resistor of one of the valves (probably that in the output stage) may have developed a high internal resistance; that would cause the application of an excessive bias, which would be partially offset by the higher H.T. voltage after using the lower tapping.

2. Classes of L.F. Amplification

In class A amplification the output valve is so biased that grid current will not flow and the grid voltage will not be driven below 'cut-off' whatever value of working signal voltage is applied to the grid. In other words, it is biased to a point about half-way along the straight portion of the anode current-grid volts curve which lies between zero grid volts and cut-off.

There are two varying forms of class B amplification: one in which grid current is allowed to flow on peak positive swings of signal input, and one in which the valve is normally biased almost to cut-off, and where only a very small anode current is allowed to flow until the grid is swung more positive by the positive half-waves of signal voltage. Both forms of class B amplification are normally used with a push-pull stage, in order to avoid the distortion which would otherwise occur due to the flattening of one half of the anode-current wave.

As the name suggests, class A-B amplification is rather a compromise between the other two systems described. The valves (in push-pull) are biased back to a point about half-way between cut-off and the centre of the straight portion of the curve. (See Fig. 1.)

3. Grid-stopper Connections

Of the two methods of connecting a grid-stopper resistor shown in Figs. 2 and 3, that shown in Fig. 2 is correct, and that in Fig 3 is incorrect. Examination of Fig. 3 will show that, of the total audio-frequency voltage between points A and B, only that proportion which is developed across the 250,000-ohm grid leak is applied to the following L.F. valve.

Since the stopper resistor has a value of 100,000 ohms, it can be seen that only five-sevenths of the available audio-frequency voltage is applied between grid and cathode of the valve. In the case illustrated in Fig. 2, the whole of the A.F. voltage is fed to the valve, since there is no voltage drop across the stopper resistor—which does not carry any current, provided that the valve is correctly biased.

Resistance Ratio

The proportion of audio-frequency voltage usefully employed in Fig. 3 depends entirely upon the ratio between the resistance of the stopper resistor and the resistance of the grid leak, but in all cases there must be a loss.

Another way of explaining this is that the two resistors act as a fixed volume-control potentiometer.

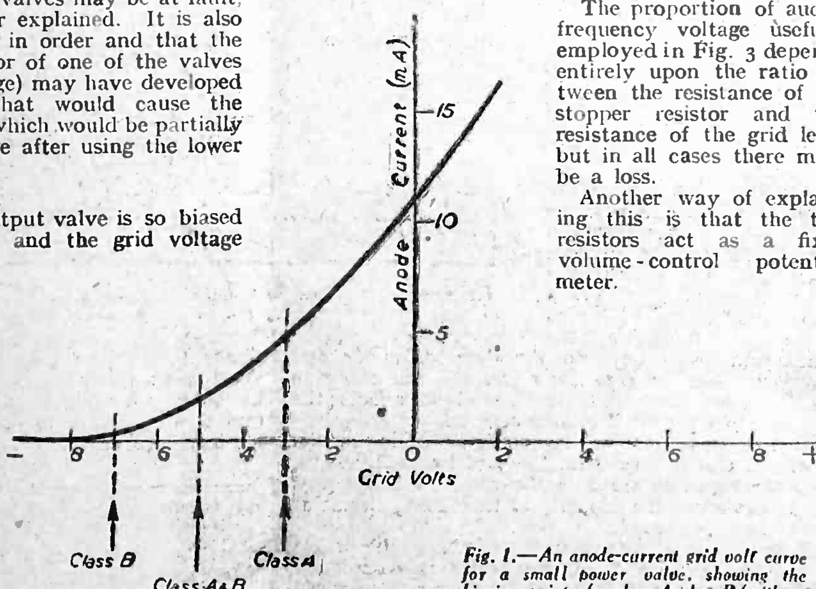


Fig. 1.—An anode-current grid volt curve for a small power valve, showing the biasing points for class A, class B (without grid current) and class A-B amplification.

4. Intermediate Frequency

There are two main items which determine the best choice of intermediate frequency. One is the selectivity required, and the other is the freedom from second-channel interference. Maximum selectivity is obtained with a low I.F., and the selectivity of the I.F. stages of a superhet is largely governed by the frequency employed. Additionally, the gain obtained is somewhat greater at lower intermediate frequencies.

But with an I.F. of, say, 100 kc/s there is some danger of second-channel interference by a signal separated from the required signal by a frequency of 200 kc/s. The reason for interference here is that if we are receiving on, say, 1,000 kc/s and the oscillator is tuned to 1,100 kc/s we could also obtain a 100 kc/s beat from a signal on 1,200 kc/s.

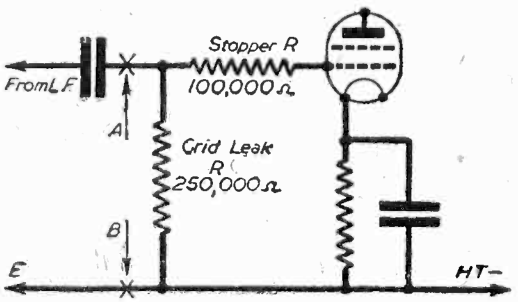


Fig. 2.—The correct method of wiring a grid-stopper resistor.

There is far less likelihood of second-channel interference when using an I.F. of 465 kc/s because in that case the only signal which could produce it would be on 1,930 kc/s, again supposing the required signal to be on 1,000 kc/s. Even a flatly-tuned input tuning circuit would fail to "accept" a signal of almost twice the frequency of that to which it was tuned!

Another reason for choosing 465 kc/s is that it falls outside the normal tuning range of a broadcast receiver, this frequency being equivalent to a wavelength of approximately 644 metres. If the intermediate frequency were a frequency covered by the input tuning circuits there would be a possibility of interference due to direct pick-up by the I.F. stages, and also of the signal running "straight through" the frequency-changer.

5. Effect of Reaction on Tuning

In the case of the old-fashioned "swinging-coil" reaction, tuning of the grid circuit was effected by the movement of the reaction coil toward and away from it. The movement of the coil, which was coupled to the tuning coil, caused small variations in inductance of the tuner. Although not quite so obvious, the same thing applies when using the present-day system of reaction in which the reaction winding is fixed in position in relation to the tuning winding.

Reaction is varied by altering the capacity of a variable condenser in series with the reaction winding, the two being in series between the detector anode and earth. Alteration in capacity alters the frequency to which the reaction circuit tunes, and so affects the tuning coil, to which it is closely coupled.

In each instance, increase in reaction coupling results in a reduction in frequency of the tuned circuit. Thus, to keep the receiver tuned to the required signal it is necessary to reduce the capacity of the tuning circuit as regeneration is increased.

Various methods of preventing this undesirable occurrence have been tried, but none is completely successful. In one, a differential condenser is so wired that as the capacity of the reaction circuit is increased, the capacity directly between the anode of the detector and earth is correspondingly reduced, and vice versa. This helps, but is not a complete cure because the resonant frequency of the reaction circuit itself still varies with the setting of the control.

Another method, which is generally more satisfactory consists of having a fixed reaction circuit (fixed coil, fixed condenser) and varying the anode voltage by means of a variable resistor or potentiometer. In that way, reaction is controlled by the variation in mutual conductance of the valve.

6. Voltage for Dial Light

The total L.T. current for the valve heaters, which are in series, is passed through the two voltage-dropping resistors shown in Fig. 4. To find the voltage drop between points A and B it is therefore necessary only to multiply the value of resistance between those points by the current—.3 amp.

Conversely, to find the necessary value of resistance the required voltage must be divided by .3. We see, therefore, that the answer is 6 divided by .3, or 20 ohms.

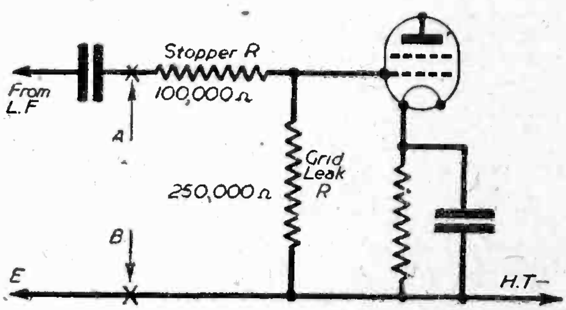


Fig. 3.—The incorrect method of wiring a grid-stopper resistor.

That method of calculation would be satisfactory for most practical purposes, but it is not difficult to see that the actual voltage applied across the filament of the light bulb will be somewhat less than 6. This is because the resistance of the lamp is in parallel with the voltage-dropping resistor. If necessary, a correction could be made because, knowing the voltage and current ratings of the bulb, the resistance of the filament could easily be found; it is 6 divided by .15, or 40 ohms. The total resistance of the two resistances in parallel is only about 13 ohms, so the voltage actually applied across the filament would be 3.9. If it were important to have a voltage of exactly 6 the overall resistance would have to be 20 ohms, and therefore the resistance between A and B would have to be the same as that of the lamp filament—40 ohms.

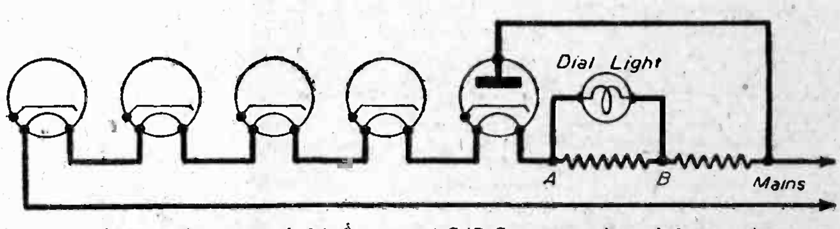


Fig. 4.—Supply voltage for a dial light in an A.C./D.C. receiver obtained from a dropping resistor in the L.T. supply circuit.

The Cathode Follower

A Brief Survey of its Functioning and Uses

By S. A. KNIGHT

FEW articles have been written on the cathode follower, especially in its connection as an extreme case of a negative feedback amplifier. A certain amount has been said on its advantages and disadvantages, and there has been controversy regarding the mathematics of the subject. In this particular article the writer does not intend to write for or against any particular ideas, but simply to cover the fundamentals of the matter. A certain amount of study of this subject has shown him that there seems to be no hard and fast rules for writing about it at all.

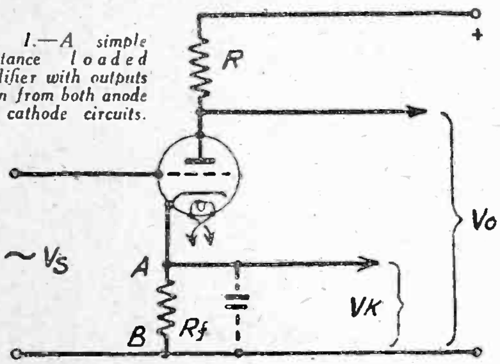


Fig. 1.—A simple resistance loaded amplifier with outputs taken from both anode and cathode circuits.

Negative Feed-back Devices

Consider first the circuit of Fig. 1, a simple resistance-loaded amplifier employing normal cathode biasing. In ordinary cases the cathode resistor is shunted by a large capacity condenser, the object of this being, as well as a reducer of hum, to ensure that at the frequency of operation the voltage developed between *A* and *B* is substantially D.C. As, in low-frequency stages, the frequency concerned generally lies between, say, 100 and 10,000 cycles per second, a condenser of a capacity in the region of 25 mfd. or above has a small reactance and fulfils the purpose assigned to it.

Now if we assume the condenser is removed, the voltage developed between *A* and *B* will have both D.C. and A.C. components; as the input voltage *Vs* rises towards a maximum, anode current will rise and so also will *A* relative to *B*. Consequently the grid-cathode change of *p.d.* will not be simply *Vs* as in a normal case, but *Vs* combined with the change in cathode potential due to the A.C. component of the voltage developed across the cathode resistor *Rf*.

Since the cathode potential obviously rises as the grid *p.d.* rises, the effect of the A.C. component will be to diminish the effect of the signal input; thus the A.C. component of the voltage developed across *Rf* will be *Vk* when the grid-cathode change of *p.d.* will be (*Vs*—*Vk*). Hence *Vk* is termed the negative feedback voltage.

Therefore, as will be readily seen, *Vk* will be in phase with *Vs*, whilst *Vo*, the anode-earth change of *p.d.*, will be anti-phase to *Vs*.

The Cathode Follower Case

One of the best ways of describing this is to say simply that it is an amplifier type circuit in which the load *Rf* is common to both anode and grid circuits. (Fig. 2.)

We have seen that the presence of R.F. causes an A.C. component of voltage to be developed between cathode and earth, consequently *Rf* may be regarded as an A.C. generator so far as its feedback function is concerned. This is represented in Fig. 3 along with a potential level diagram. It will be seen that a change in cathode potential will cause changes in *Va* and *Vg* equal in magnitude to *dVk*. The potential level diagram shows that a rise in the cathode potential by this amount, *DVk*, causes *Va* to diminish, whilst the grid is effectively more negative than it was before with respect to the cathode.

Hence we may say:

$$dVa = dVg = -dVk$$

Now it can be shown, and most readers will no doubt know, that for any amplifier

$$di_a = gm.\ dVg + 1/Ra.\ dVa$$

So in the cathode follower case we have:

$$di_a = gm(-dVk) + 1/Ra(-dVk)$$
$$di_a/-dVk = gm + 1/Ra$$
$$-dVk/di_a = 1/(gm + 1/Ra)$$
$$= zk$$

zk = The cathode impedance.

Then from this result we can see that the output impedance of a cathode follower is *zk* in parallel with *Rf*.

Now
$$zk = 1/(gm + 1/Ra)$$
$$= 1/(\mu/Ra + 1/Ra)$$
$$= Ra/\mu + 1$$

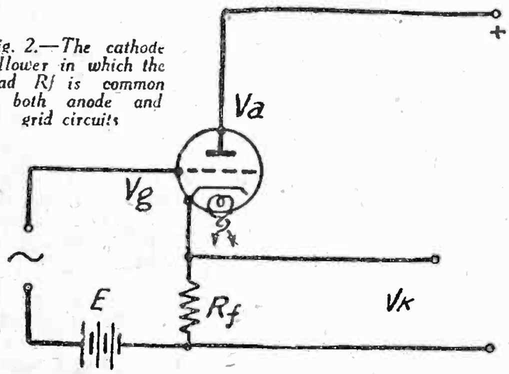


Fig. 2.—The cathode follower in which the load Rf is common to both anode and grid circuits

which is approximately equal to $1/gm$ provided μ is much greater than unity.

Thus, since $1/gm$ will be of the order of a few hundred ohms, the output impedance of a cathode follower must be very low. This is an important point to understand, as we shall see later.

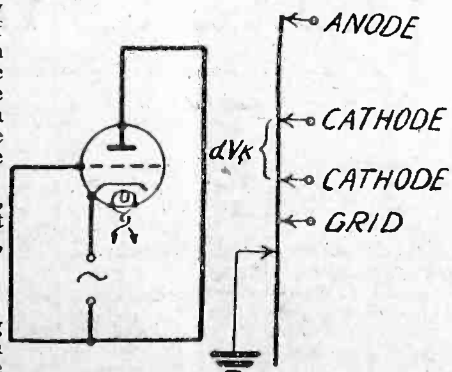


Fig. 3.—Equivalent circuit with its potential level diagram when the load Rf is regarded as an A.C. generator.

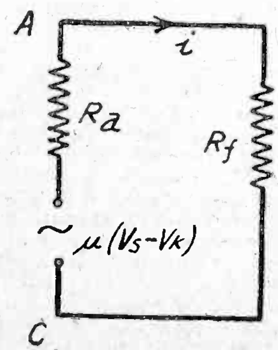


Fig. 4.—The simple equivalent circuit of the cathode follower shown in Fig. 2.

Voltage Amplification Factor

Consider the cathode follower of Fig. 2 reduced to its simple equivalent circuit of Fig. 4. Then we may say:

$i = \mu(Vs - Vk)/Ra + Rf$

$Vk = Rf.i$

$= \mu Rf(Vs - Vk) \quad /Ra + Rf$

$(Ra + Rf)Vk = \mu Rf.Vs = \mu Rf.Vk$

$(Ra + Rf + \mu Rf)Vk = \mu Rf.Vs$

$V.A.F. = Vk/Vs$

$= \mu Rf/Ra + (1 + \mu)Rf$

This result *must* be less than one.

Dividing top and bottom by *Rf*, we obtain:

$V.A.F. = \mu/(Ra \div Rf) + (1 + \mu)$

Thus it will be observed that for the voltage amplification factor to be as near to one as possible the following points must be considered:

(i) μ must be much greater than 1.

(ii) *Rf* must be greater than *Ra*.

This latter condition is obviously quite frequently impracticable.

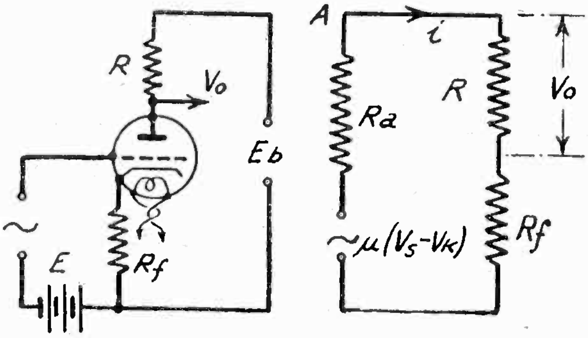


Fig. 5.—Series feedback circuit with its simple equivalent circuit.

Input Impedance

It can be shown that the input impedance of the cathode follower is very high, due to its very low input capacitance.

This capacitance, *Ci*, is given by:

$Cga + (Cgc/\mu)$

Cga and *Cgc* being the grid-anode and the grid-cathode inter-electrode capacities of the valve, respectively.

Distortion is less with a cathode follower than with a normal amplifier.

Practical Uses

Keeping the foregoing points in mind, it will be readily appreciated that, among many others, the cathode follower stage can be employed in practice for the following functions:

1. As a form of electronic transformer. It has a high impedance input and a low impedance output, and couples these advantages together without the voltage reduction inherent in a normal step-down transformer.

2. In quality amplifier work—particularly on the television side—the overall frequency response characteristic can be considerably improved by employing stages which are alternately amplifier-cathode follower. The low input capacitance of the latter prevents a falling off of response at the upper limits of frequency, due to the common shunt capacity effect, while its low output impedance reduces the effect of the high input capacitance of the following amplifier stage.

3. The effect of the low output impedance can be usefully employed when pulse signals are fed to a capacitive device such as a cathode ray tube, distortion of the pulse thereby being reduced.

4. The cathode follower can be used as a voltage stabiliser for power units where an accurately regulated output is of prime importance.

Feedback Circuits

We will conclude with a brief mathematical survey of the two main types of negative feedback circuits, that is, the current (or series) feedback and the voltage (or parallel) feedback. The series type is shown in Fig. 5, together with the simple equivalent circuit. Now, from the latter, we can see that:

$i = \mu\ (Vs - Vk)/Ra + R + Rf$

$Vo = \mu R(Vs - Vk)/Ra + R + Rf$

Now we know that:

$Vk = Rf.i$ and $Vo = Ri$

$\therefore Vo/vk = Ri/Rf.i$

$\therefore Vk = Rf.\ Vo/R$

$\therefore Vo\ (Ra + R + Rf) = \mu R\ (Vs - (Rf.Vo/R))$

$\therefore Vo\ (Ra + R + Rf) = \mu R.Vs = \mu Rf.Vo$

$Vo\ (Ra + R + Rf + \mu Rf) = \mu R.Vs$

$V.A.F. = Vo/Vs = \mu R/Ra + R + (1 + \mu)Rf$

So

$$\frac{Vk}{Vs} = \frac{Rf}{R} \times \frac{Vo}{sV} = \frac{\mu Rf}{Ra + R + (1+)\mu Rf}$$

Special cases of the above occur in the following instances:

(i) When $R = Rf$. $(Vo/Vs) = Vk/Vs = \mu R/Ra + (2 + \mu)R$

This is known as the phase splitter circuit condition, in which outputs are taken from both anode and cathode, these outputs being, as we saw earlier, equal and opposite in phase.

This is obvious from Fig. 6, where any increase in anode current due to a rise in *Vg* will cause the cathode *p.d.* to rise similarly, but the anode *p.d.* to fall, due to the increased voltage drop across the anode load.

(ii) When $R =$ zero

$Vk/Vs = \mu Rf/Ra + (1 + \mu)Rf$

which, as readers will see, is the cathode follower case already discussed.

In the consideration of parallel or voltage feedback (Fig. 7) we see that $R_1 + Rf$ is generally so large that the current flowing in them is negligible. In practice, R_1 often approaches 10 megohms or more. There is then fed back into the grid circuit a fraction a equal to $Rf/R_1 + Rf$ of the anode voltage. Since, of course, the anode voltage is antiphase to the signal the feedback is negative in sign.

The general equation for the case is

$Vg = Vs - E + aVa$

Neglecting *E* and *Vs*

$dVg = dVaa$

and $DVa = dVg/a$

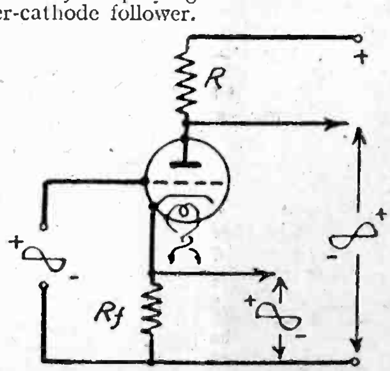


Fig.6.—Phase splitting, where the cathode output is in phase and the anode output antiphase to the grid input. (R=Rf).

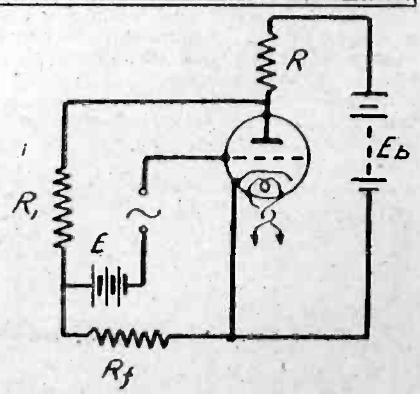


Fig. 7.—Parallel feedback where a portion of the anode voltage is fed back antiphase to the grid input.

ON YOUR WAVELENGTH

By THERMION

Broadcast Science

AT a recent meeting of scientists, one of the speakers deplored the fact that none of our daily newspapers has a science editor, and that the general developments in the various scientific fields pass by unnoticed. On the few occasions when newspapers deign to report scientific achievements at all the result is usually unhappy from the point of view of the achievement, and ludicrous from the point of view of the reader. Mr. Churchill, in his broadcast on Sunday, March 21st, drew attention to the great development which would take place after the war in the industry with which you and I are so closely connected. He made particular reference to television, and we all know that television is the inevitable next step. Many of us are aware that the difficulties have, or are being overcome, and that it is only a matter of industrial adaptation and circumventing the difficulties which may take place in the changeover from the sightless to the optical broadcasts before television largely supersedes the present aural system of broadcasting.

Technical Journals

INCIDENTALLY, an indirect compliment has been paid in recent weeks to the technical journals which alone disseminate the scientific developments in particular fields. I do not know whether newspapers will accept the hint and appoint scientific editors. I do not necessarily agree that it is within the province of a newspaper to cover the scientific fields. It is my view that a newspaper should be what its name implies —a paper containing news. Before the war our newspapers were becoming daily periodicals; they had their fashions editors, gardening editors, wireless editors, motoring and cycling editors, aviation editors, sports editors, news editors, leader writers, and so on. It is therefore not quite accurate to say that editors of daily newspapers adopted an air of aloof detachment from scientific matters; although it is correct to say that in the remoter fields of scientific endeavour they ignored developments. Perhaps to some extent this is due to the scientists themselves, whose snobbish disregard and contempt for what they regard as "publicity" was responsible for newspapers ignoring important developments. It is within the experience of every newspaper reporter that when he calls upon a scientist for the news of some scientific achievement of which the reporter has gained news by the methods which are best known to Fleet Street, he quite often is met by a rude refusal for an interview, and the door is slammed in his face. Even when interviews are granted the information imparted is usually expressed in technical language quite outside the education of the average reporter, and certainly beyond the ken of the average newspaper reader.

Criticism of the B.B.C.

CRITICISM along these lines has also been made of the B.B.C., which within recent months has endeavoured to fill the lacuna with a feature known as the Brains Trust. We are told, however, that this item is intended for our entertainment, and not to provide a scientific pabulum. The explanation has really been unnecessary, because it is very apparent from the questions asked, and the answers given, that the feature is intended as light entertainment. Even the members of the Brains Trust have protested against the type of questions they have been asked. There is room in the B.B.C. programmes for a scientific broadcast, but I do not think that the present Brains Trust should be entrusted with it. Science is not a matter for the philosopher, nor is it a matter for the zoologist, or the much travelled sailor. It is strictly the province of those who deal with facts, not merely opinions. It is a matter for those whose minds have been prepared to deal with scientific matters by a sound scientific education.

It is all to the good that this matter is being raised in scientific circles, for I have always felt that the scientist works for the benefit of humanity, but is ill-rewarded for his efforts. A scientist may discover a new means of curing a disease, but the man who gains the reward is he who sells it in a tastefully decorated bottle; and so with inventors. For them the thorny paths of penury, with opposition from commercial interests, and no encouragement from the State.

Technicians

IT is nice to know that at long last the technician is coming into his own. I do not feel that the newspapers will be able to help the matter along. The average newspaper is more concerned with politics and news (or it should be) to be able to spare much space for scientific news. Moreover, the average newspaper editor not understanding scientific things imagines that his readers equally dislike them. Unless the editor of a paper has a sympathy with the subject it is difficult to persuade him to deal with it. As I have said earlier I do not necessarily agree that it is within the province of a newspaper to deal with it. Science is not the only pebble on the beach of life. *Homo sapiens* has other interests, and if the newspapers are expected to cover everything we may expect newspapers to appoint plumbing editors, farming editors, house decoration editors, and, in fact, to have editors for the whole gamut of human requirements. After all, in these days of specialism, the specialist looks to the specialist journals, and I do not think that their place can be usurped by a daily dose of hurriedly prepared, popular pot-boiling stuff written in the belief that the man in the street is a congenital idiot.

Wanted, a New Scholastic Degree.

PROFESSORS of this and professors of that,
And professors of all the rest;
In fact, there's such floods of professors,
They're reaching a positive pest.

For when most of 'em finish "professing,"
We're just where we were to begin;
They've most of 'em gathered some knowledge—
But wisdom has seldom crept in.

And what is the use of the knowledge,
When wisdom is so ignored?
A parrot soon learns to say "Polly,"
But listeners soon become bored.

We know that these eminent doctors,
Retentive memories have got,
But most of their stuff's repetition,
And that doesn't help us a lot.

Psychology, bunk, and codology,
To most of us smack of offence,
In the terrible times which we live in,
Our need is—
Some doctors of common horse-sense!

"TORCH."

Elementary Electricity and Radio—4

Magnetism, Electro-magnetism, Electric Motors and Generators

By J. J. WILLIAMSON, A.Brit.I.R.E.

(*Continued from page* 190, *April issue*)

THE exact nature of a magnetic field is unknown, but it is recognised as a force which acts over a distance, especially where certain metals such as iron nickel, cobalt, etc., are concerned. The molecules of these substances appear to act as miniature magnets, and the relative positions of these "molecular magnets" give rise to the "molecular theory of magnetism."

Fig. 1 (a) shows a bar of iron with the molecules

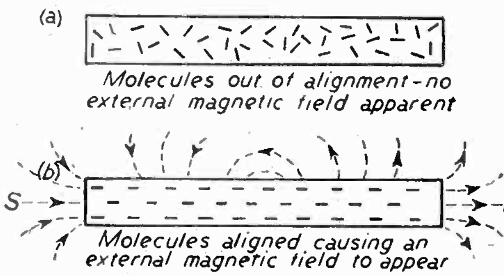


Fig. 1.—Diagram illustrating the molecular theory of magnetism.

"all over the place." It is obvious that the magnetic force of the individual molecules will *not* be additive—one pole cancelling the effect of the next—and hence the bar, as a whole, will not reveal any magnetism.

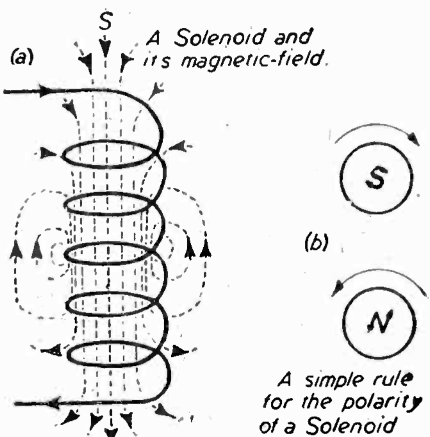


Fig. 2.—The magnetic field of a solenoid.

Fig. 1 (b) shows the molecules aligned and, therefore, the fields of the individual molecules are additive and the bar reveals magnetism.

Consideration will show the truth of this theory: (1) there are no "free poles" at the centre of the bar, thus no magnetism should appear there; (2) striking or heating a "magnetised" bar should shake the molecules out of line, causing the bar to lose its magnetism; (3) a soft iron bar should be easily magnetised by another source of magnetism, which is capable of drawing the molecular magnets into line. Experiment proves these considerations.

For the purposes of calculation we name the poles of a magnet according to the direction in which they will point if the magnet is suspended at its centre and is free to turn. As like repels like, and unlikes attract one another, the North-pole of the earth attracts the South-pole of the magnet; this South-pole is called a North-seeking pole and is stamped with an "N"—a point which often leads to confusion.

As it has been shown, a magnet of "soft" iron (loosely packed molecules) can easily gain or lose magnetism, and therefore would be of no use as a permanent magnet, thus steel or a suitable alloy is chosen.

Electro-magnetism

We have already seen that if a current is passed through a conductor a magnetic field is produced. If we make a coil or "solenoid" of the conductor—Fig. 2 (a)—then the solenoid has a magnetic field just like a bar-magnet. The lines-of-force shown are the lines formed by iron filings sprinkled upon a piece of card held over the source of the magnetic field to be investigated. These so-called lines-of-force repel one another and individually act like taut elastic-bands. Increasing the current through the solenoid increases the strength of the field, whilst reversing the direction of the current reverses the polarity of the field; hence we have an easily controlled source of magnetism. Fig. 2 (b) shows a simple method of ascertaining the polarity of a solenoid.

If we now place an iron core into the solenoid, the strength of the magnetic field becomes much stronger, i.e., the molecules of the core are pulled into line by the electro-magnetism and hence add their magnetism to the existing field.

Faraday's Law states that the E.M.F. induced in a conductor by means of a magnetic field is directly

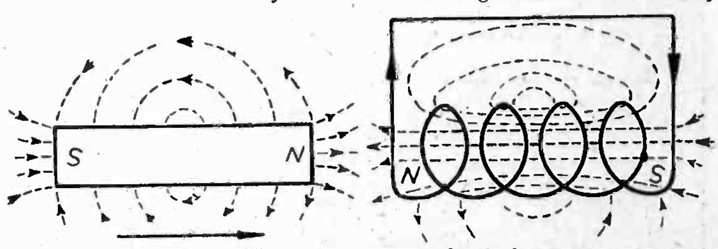


Fig. 3.—Diagrams illustrating Lenz's Law.

proportional to the rate at which lines of magnetic force cut the conductor.

Lenz's Law tells us that if we produce an E.M.F. by magnetic means, that "induced" E.M.F. will oppose the force producing it; or, in practical terms, "we can't get something for nothing."

Thus, in Fig. 3 the faster we approach the bar-magnet to the coil of wire the greater will be the voltage induced in the coil (Faraday's Law), but the voltage would—if

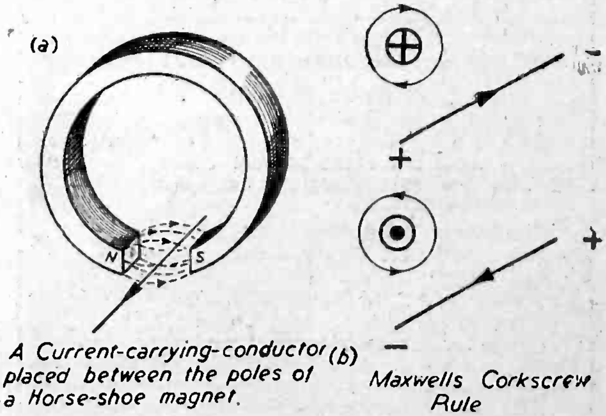


Fig. 4.—Direction of magnetic field in a conductor.

(*Continued on page* 239.)

there was a complete circuit—produce a current the magnet field of which would try to *repel* the bar, i.e., oppose its motion. (Lenz's Law.)

The Motor Principle

Let us consider a current-carrying conductor placed between the poles of a horse-shoe-shaped magnet, Fig. 4 (a).

The direction in which a magnetic field is said to act is in that direction in which an isolated N-pole tends to travel, i.e., N. to S.

The direction of a magnetic field around a conductor is given by Maxwell's Corkscrew Rule, Fig. 4 (b), which states that if a corkscrew is screwed in the direction of the current then the direction of rotation of the corkscrew is the direction in which the magnetic field acts.

Thus, in Fig. 5 (a) we have the direction of the lines-

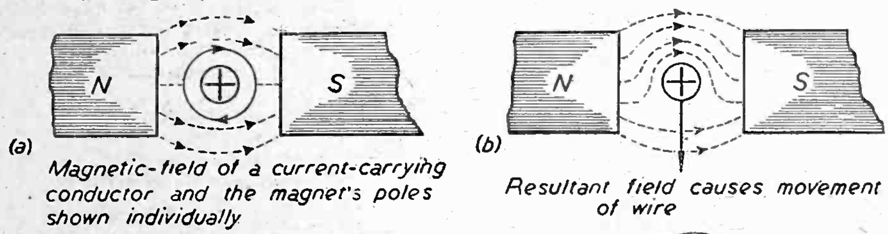
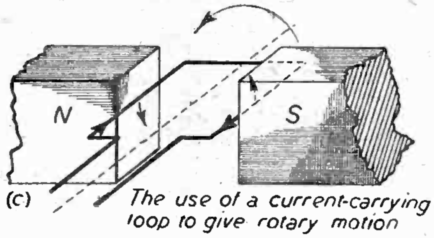


Fig. 5.—Diagrams illustrating the motor principle.

of-force due to the horse-shoe magnet's poles and the current-carrying conductor, which is shown in cross-section. Obviously, these fields do not exist separately, but combine to give the resultant field shown in Fig. 5 (b), leaving a "high-pressure" area above the wire, and "low-pressure" area below the wire, thereby causing a downward movement.



Flemings Left- and Right-hand Rules

As it can be seen from Fig. 5 (b), there is a definite relationship between the direction of the main magnetic field, current and movement of the conductor. This can be illustrated by letting the forefinger represent the direction of the main field; the middle finger—bent—the direction of the current, and the thumb the direction in which the conductor moves. Current flow is taken as positive to negative.

The left-hand rule is used when dealing with motors, and the right-hand rule when dealing with generators.

To obtain a rotary motion by means of the motor principle a loop of wire is pivoted between the poles of the magnet, Fig. 5 (c). As the current flows down one side of the loop and up the other thus one wire tries to move up and the other down, causing the loop to rotate—but only until the loop is at right-angles to the field. A moment's thought shows that the current must now be reversed, when the loop will continue for another half-revolution. Thus the current through the loop must be reversed every half-revolution.

Commutation

A reversing switch or "commutator" is fitted to the shaft of the loop, and carbon contacts or "brushes" arranged to press lightly against it, so that the current can be conveyed from a supply to the moving loop or "armature." Fig. 6 (a) shows the construction of the commutator and Fig. 6 (b) its action.

In the case of alternating current (A.C.), where the direction of flow is continually reversing, the commutator is replaced by "slip-rings," which merely serve to convey the current to the armature, Fig. 6 (c).

Practical Considerations

The power of the motor is governed by (1) the strength of the main magnetic field, (2) the number of conductors or loops, and (3) the strength of the current in the armature.

We have already seen (under electro-magnetism) that the more iron or alloy we can place in the path of the magnetism the stronger the magnetic field will become; thus the loop is wound on a "laminated" iron core (lamination reduces losses), a "double path" is often provided, and shaped "pole-pieces" improve matters, Fig. 7.

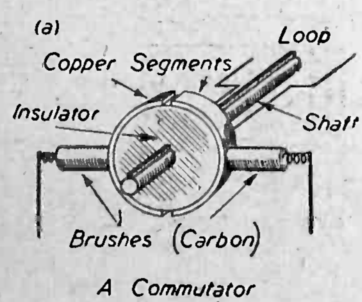
Also, we know that a coil of wire carrying a current produces a magnetic field, thus we can wind the coil around the pole-pieces, thereby intensifying the main field and gaining easy control of it; enabling both power and direction of rotation to be adjusted (Fleming's Left-hand Rule).

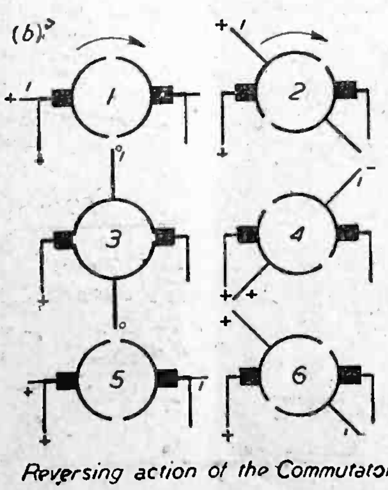
The many loops of wire are usually placed in slots or tunnels in the iron core and their ends connected to the copper segments on the commutator.

Back E.M.F.

Whenever a conductor cuts or is cut by a line of magnetic force an E.M.F. is induced across that conductor—the loops of the motor's armature are conductors revolving in a magnetic field and thus an E.M.F. will be induced in them; this E.M.F., by Lenz's Law, opposes the applied E.M.F., thereby reducing the current which flows through the armature windings.

When the motor is at rest, the back E.M.F. is at zero, and with the motor running at full speed the back E.M.F. is at its maximum, i.e., nearly the value of the applied E.M.F. The voltage actually causing a flow of current through the armature is the difference between the applied and back E.M.F.,





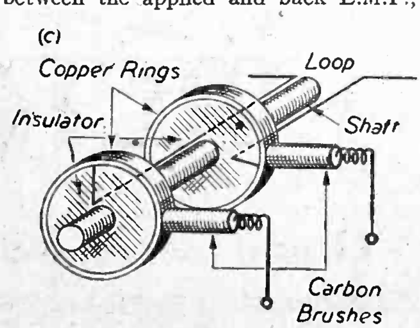


Fig. 6.—Diagrams illustrating the principles of commutators and slip rings.

being maximum when the motor starts and minimum when the motor is running at full speed.

Any increase of mechanical load on the motor will cause the speed to fall, the back E.M.F. falls, the resultant E.M.F. rises: thus the armature current increases, supplying the energy required for the increase of mechanical load.

Taking a simple example: If the resistance of the armature is .1Ω and the motor requires 100 volts. Then at the *instant* of starting (machine at rest) the back E.M.F. is zero and the resultant E.M.F. 100 volts, thus by Ohm's Law:

$$I=\frac{V}{R}=\frac{100}{.1}=1{,}000 \text{ amperes,}$$

would try to flow. The motor speeds up and the back E.M.F. rises, thus this very heavy current could not

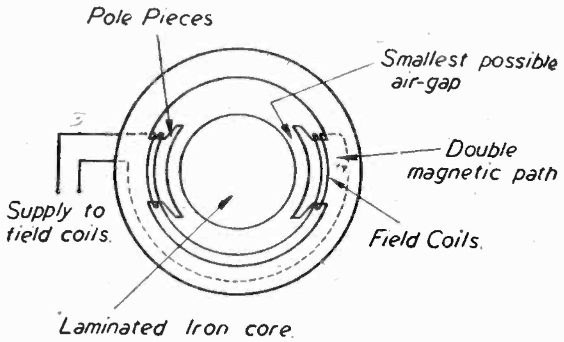


Fig. 7.—Increasing the magnetic field.

flow for long and usually would not reach the calculated value; but it can be seen that at the instant of starting a dangerously heavy current will try to flow, causing unnecessary mechanical strain on the motor, drain of energy from the supply, a possibility of damage to the armature or commutator, and, most important, the value at which the circuit may be "fused" is considerably increased, thereby permitting currents dangerous to the machine.

Principle of a Motor Starter

If we are to reduce the starting current we must increase the resistance in the armature circuit during the starting period. Fig. 8 shows a very simple "starter" for this purpose. "R" is the resistance that serves to limit the armature current and "S" provides the means of switching "R" out of the circuit when the machine has gained speed.

Generator Principle

Generators depend for their action upon the fact that a conductor cutting lines of magnetic force will have an E.M.F. induced across it. A motor can be effectively used as a generator with very little modification.

Motor-generators or Rotary Transformers

A machine of this type consists of the usual magnetic system; but the armature has two separate windings, a commutator being provided for each. Thus current flowing in one winding causes the armature to rotate, and the second winding thereby has an E.M.F. induced in it, which is utilised via the second commutator.

These machines are used mainly when we wish to change the voltage of a supply to a required value, the voltage transformation depending upon the number of loops in the second winding with respect to the number of loops in the first.

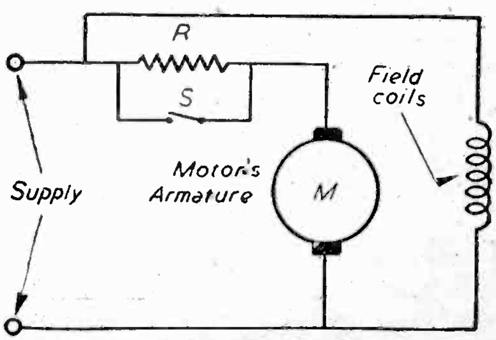


Fig. 8.—Simple motor starter.

Transformer Principle

An E.M.F. is induced in a conductor whenever the conductor cuts—as in generators—or is cut by lines of magnetic force.

The transformer employs the latter method, i.e., the lines-of-force move instead of the conductor.

The lines-of-force are made to move, by continually varying the strength of the current in the primary coil of the transformer (Fig. 9), i.e., the transformer requires alternating current. Visualise the lines of magnetic force like an elongated bubble, expanding and contracting around the coils as the current varies; obviously the secondary coil is being cut by the lines-of-force and thus there will be an E.M.F. induced in it.

The transformation of voltage through the transformer depends upon—as in the case of the motor-generator or rotary-transformer—the number of turns of wire in the secondary with respect to the number of turns in the primary.

In Fig. 9 the primary has 50 turns and the secondary 100 turns. Ten volts force an alternating current of 2 amperes through the primary. There are twice as many turns in the secondary as in the primary—a ratio of 2 to 1—thus 20 volts can be obtained across the secondary.

Notice that we do not gain any power; the wattage dissipated in the primary is

$$P=IV=2\times 10=20 \text{ watts,}$$

if no losses occur in the transformer then 20 watts should be available at the secondary. Knowing the "turns ratio," i.e., 2 : 1, and hence the secondary's voltage (20 volts) it follows that the current available will be: from $W=IV$,

$$I=\frac{W}{V}=\frac{20}{20}=1 \text{ ampere,}$$

thus a transformer will step-up voltage or current at the expense of the other.

General Examples

1. What happens if we reverse the polarity of the supply to:
   (a) A D.C. motor having no electro-magnetic field, i.e., a permanent magnet machine.
   (b) A D.C. motor having an electro-magnetic field.
2. A motor running from a 100-volt supply takes 1 ampere at full speed. Armature resistance 0.5 ohm. What is the back E.M.F. developed?

Answers for Article Three

1. 45 per cent. efficient.
2. Specific gravity 1.150 at 60 degs. F.
3. (1) Open circuit.
   (2) Normal.
   (3) Sulphation.
   (4) Partial short-circuit.

(To be continued.)

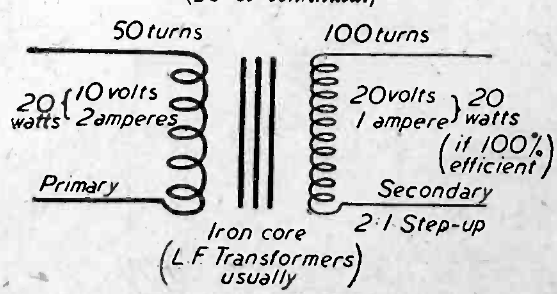
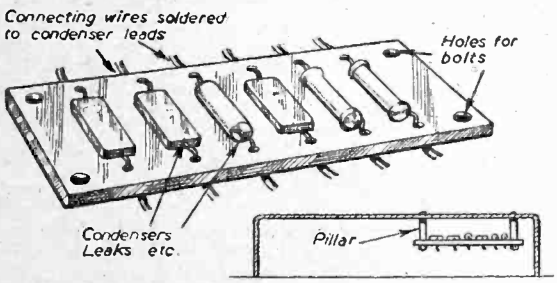


Fig. 9.—The transformer principle.

Practical Hints

A Neat Condenser Unit

ONE way of fixing small fixed condensers, resistors, etc., which are usually suspended by their own wiring, thereby putting the constructor to some inconvenience, is to procure a strip of ebonite cut to the desired size, and drill a number of small holes down each side, corresponding to the number of components to be mounted on the strip. Anchor the condensers to it by passing each wire through the drilled holes. The connecting wires can then be soldered on to the projecting leads underneath the ebonite. The whole unit can be fixed to the chassis by means of long bolts passing through short pieces of tubing such as found on spade terminals.—P. WAY (Harrogate).



A neat sub-panel arrangement for mounting small components.

THAT DODGE OF YOURS!

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

SPECIAL NOTICE

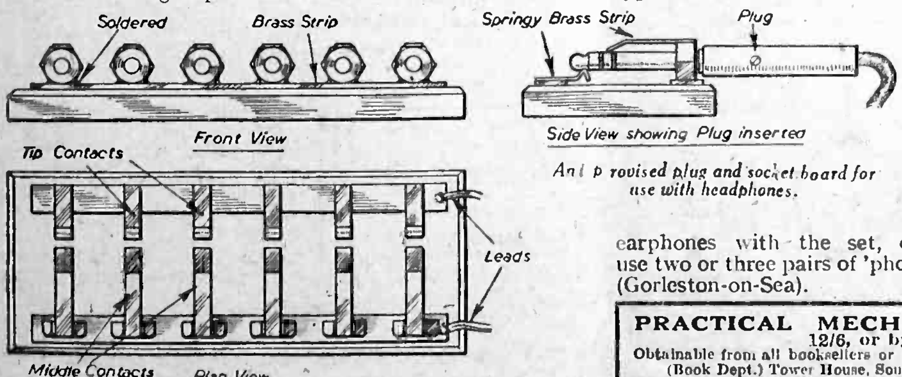
All hints must be accompanied by the coupon cut from page iii of cover.

Multiple Plug and Socket Board

THE accompanying diagrams illustrate a multiple plug and socket arrangement, which can be used for connecting any desired number of headphones in the output of a morse oscillator.

The sockets are made from ¼in. brass nuts drilled to the correct size of the plugs and soldered to a brass strip, as shown in the sketch. Another brass strip, holding the "tip" contacts is fixed to the baseboard the required distance from the sockets. This can be done exactly by inserting a plug into the sockets and adjusting the rear strip until it is at the required distance.

Some plugs employ three contacts, i.e., tip, body and earth, and to provide for this a short length of springy brass strip the required length is soldered to the "nut" sockets, so as to press on the "middle" portion of the plug when inserted. Any desired number of sockets can be employed by using a sufficient number of nuts, and the number of headphones which can be used should be sufficient for a group of learners. The rest of the details should be self-evident from the sketches.—A. R. THOMSON (London, E.).

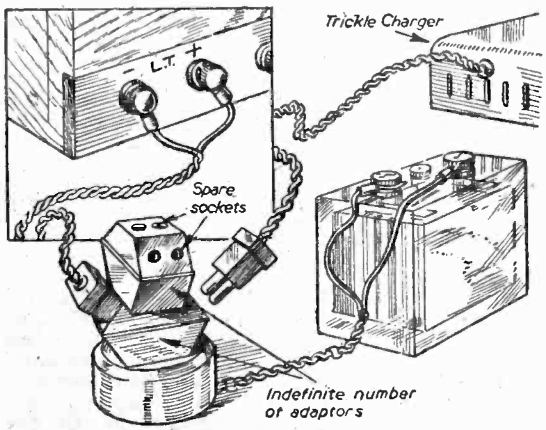


An improvised plug and socket board for use with headphones.

Using Adaptors for Quick Connections

I EVOLVED the following simple system for the saving of time and patience, and the necessity of coupling and decoupling my accumulator every time it is used. First of all, connect the accumulator with some good thick flex to a 5 amp. socket (counterpart of 5 amp. plug). Screw this socket down firmly near the accumulator. Now attach 5 amp. plugs to the L.T. leads on any set you may want to have working. Obtain from any electrical shop two or three of the 5 amp. plug adaptors which enable you to plug three 5 amp. plugs in on the one socket. Place one of these adaptors in the accumulator socket, and there are now three sets of holes available. On placing the other adaptor in the top set of holes, you have five, and so on.

When you wish to run a set you simply plug into any one of these sets of holes.



Method of using adaptors for making quick connections

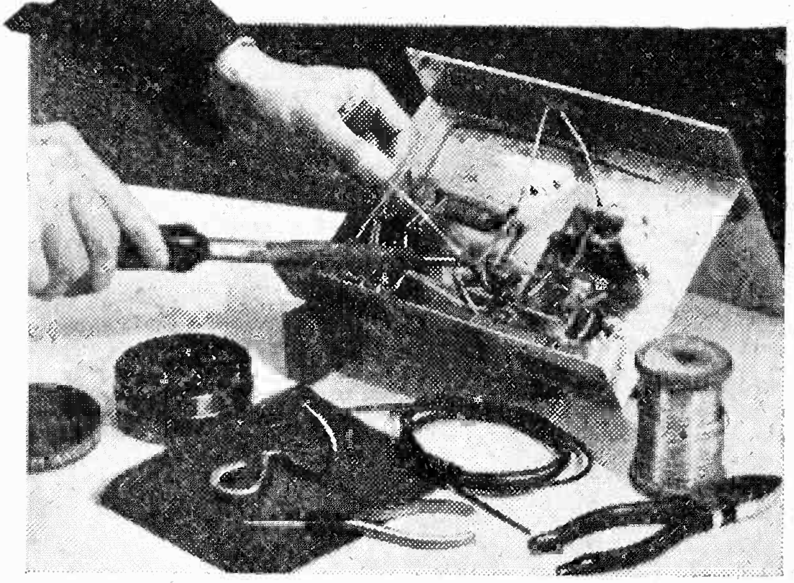
When the accumulator needs charging a lead can be taken from the trickle charger and plugged into one of the sets of holes.

A word of warning, however; sooner or later, if you use 2-pin sockets for power also you will find yourself plugging one unit into the mains, so keep the double plug and socket for the L.T., and the electric light plug type for the mains.

A variation of this method of using 5 amp. plugs is to attach them to all loudspeakers and earphones, and fix a permanent 5 amp. socket to a stout piece of wood, and take wires from this socket to the L.S. terminals of the set. It is then easy to use any loudspeaker or pair of earphones with the set, or by using an adaptor to use two or three pairs of 'phones with one set.—E. BRUCE (Gorleston-on-Sea).

Efficient Wirir

Neat and Efficient Wiring Calls fc
by Good Soldering, as



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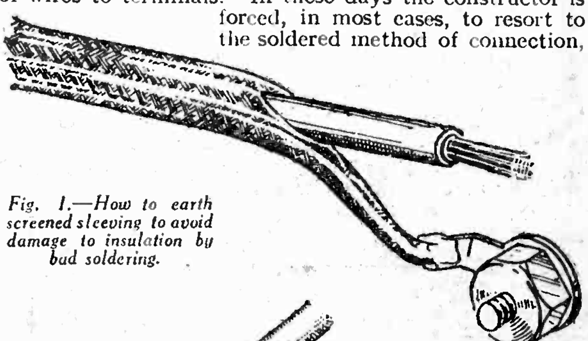

Fig. 1.—How to earth screened sleeving to avoid damage to insulation by bad soldering.

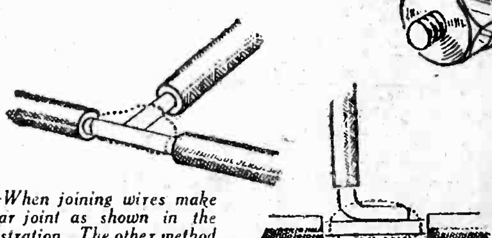

Fig. 3.—When joining wires make an angular joint as shown in the lower illustration. The other method is not so strong.

Insulated Leads

Let us look at a modern commercial receiver and see what principles are adopted on the wiring side. Firstly, insulated sleeving is freely used. This material is quite reasonable to buy, may be obtained in various colours, and simplifies testing by identifying certain leads. This sleeving is slipped over bare tinned copper wire such as is generally employed for connection purposes. There is, however, another type of wire which is readily obtainable, and this is of the covered type. It is sold under many different names—"Quickwyre," "push-back" and so on. The outer covering may be pushed back very easily, and in use the required length is cut off and the inner tinned wire bared for soldering merely by pushing along the insulated coating.

Stretch the Wire

Before commencing wiring, it is advisable to cut off, say, a 6ft. length of the tinned copper wire and, after securely fastening one end to a suitable anchoring point, grip the other with pliers and apply a steady pull until the wire stretches and becomes perfectly straight and slightly stiffer. Cut the wire into lengths of 3ft. for ease of handling during wiring operations.

When using the insulated sleeving the best plan is to cut the exact length of wire required for the connections and then cut off a piece of sleeving ¼in. shorter, slip it down over the wire, and hold the wire against the soldering tags or other points to which it is to be attached, whilst it is soldered in position. The excess wire is then cut off with a pair of end cutters. In this way the sleeving will cover all parts of the wire and there will not be a quarter of an inch or so of bare wire at the end.

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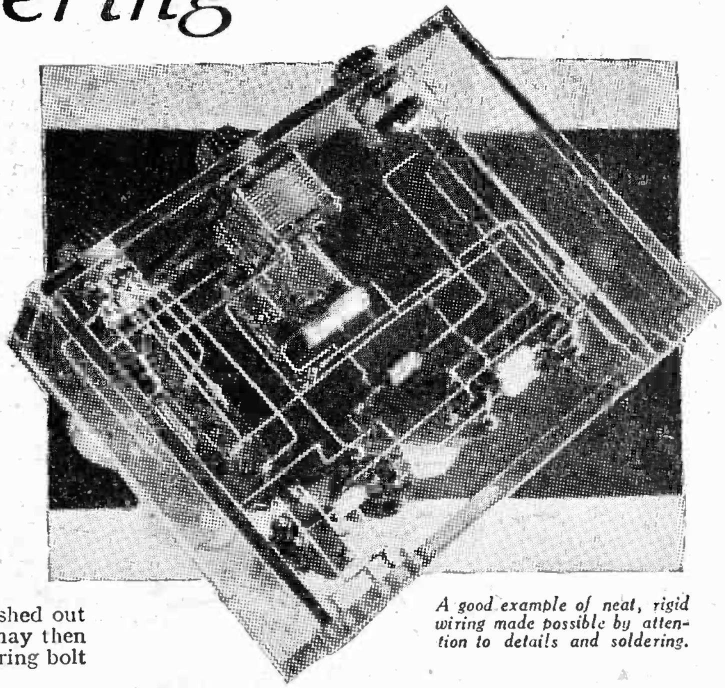
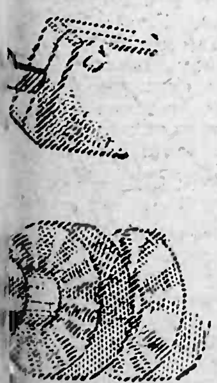


A good example of neat, rigid wiring made possible by attention to details and soldering.

Soldering Tags

To attach leads to certain components, soldering tags are provided. These may be anchored beneath terminal heads or may be riveted to the actual component. Where terminals are used, and soldering tags are added, double- or treble-ended tags may be used to simplify the connection of more than one lead. This will avoid the risk of the first one coming adrift when a second is added. In this connection it is often found difficult, when wiring according to some schemes, to attach a second or third wire or component to one point, as the previous connections are unsoldered if the iron is held in place too long. When soldering is properly carried out, however, it is possible to attach a second lead or more to the same point and the iron is held just long enough for the top part of the solder to run and a good joint to be formed before the first lead is loosened. However, a simple and effective way of overcoming this difficulty is to attach a short length of thick wire to the point in question, and let this stand up vertical. Any additional components or leads may then be attached at different points along this single wire, the joint being made before the heat has travelled along the wire and loosened others. The idea is shown in Fig. 2. An alternative scheme, and one which is often adopted by some constructors, is to twist all the wires and parts together and solder them into one piece, but the resultant thickness may be such that it cannot be attached to some parts—such, for instance, as a valve leg on an octal valve-base, where there is not much clearance.



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When joining two wires together, one end should be bent so that it runs parallel with the remaining wire, as shown in Fig. 3. Do not place the end of the wire at right angles to its partner and expect a good sound joint to result. The overlap need only be about ¼in. and the joint will be perfectly sound. When making this type of joint leave the iron long enough to ensure that the solder has run down between the two adjacent surfaces, and if too much flux is employed it may run into this space and burn and thereby prevent the two from being in good electrical contact. This is one of the rules of soldering—do not use too much flux. A good flux is very essential, but you need only a trace. The surface should be cleaned, preferably by rubbing with fine emery cloth.

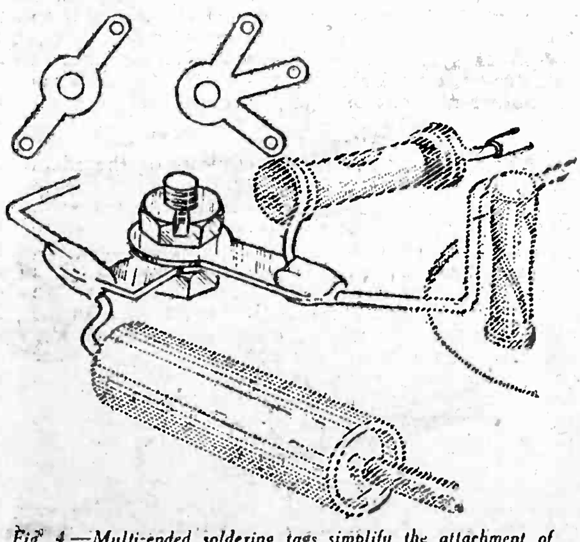
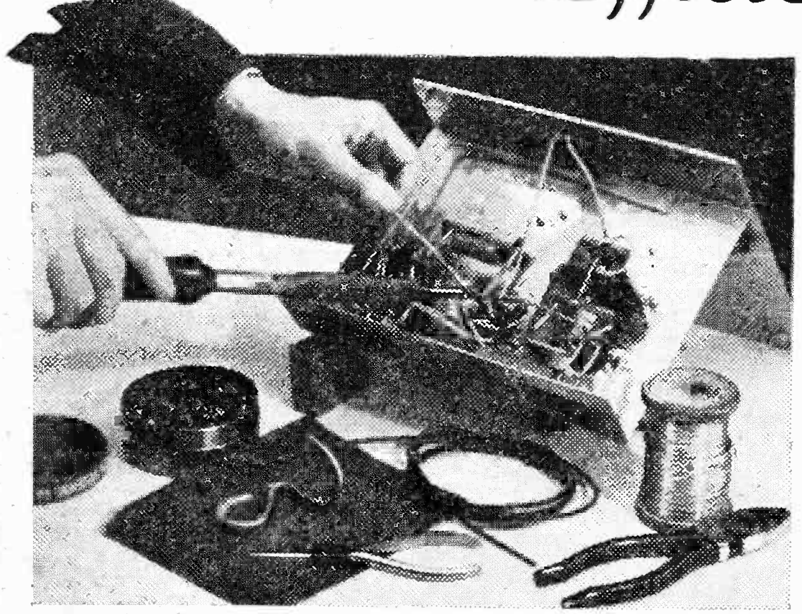


Fig. 4.—Multi-ended soldering tags simplify the attachment of several parts to a given point.

Efficient Wiring and Soldering

Neat and Efficient Wiring Calls for Perfect Joints, and These can be Provided by Good Soldering, as Explained in This Instructive Article



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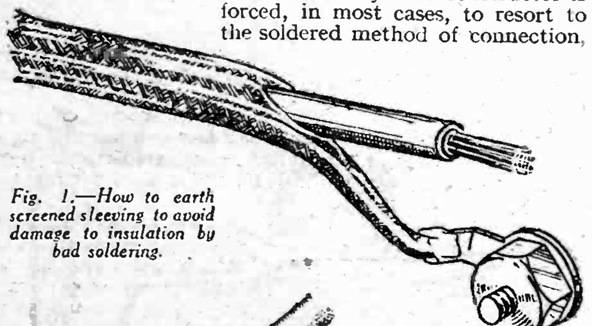

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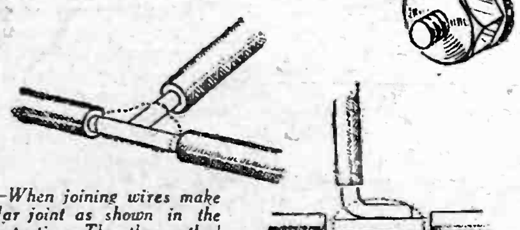

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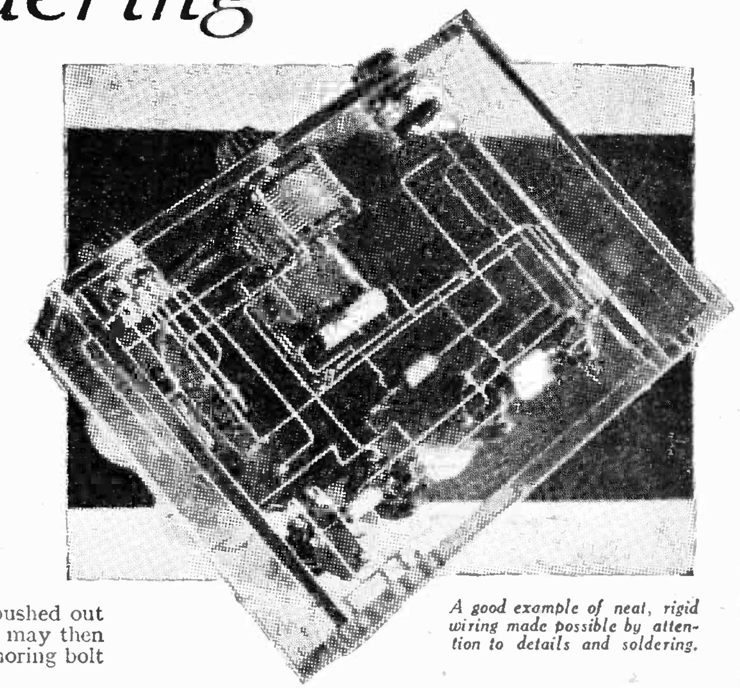

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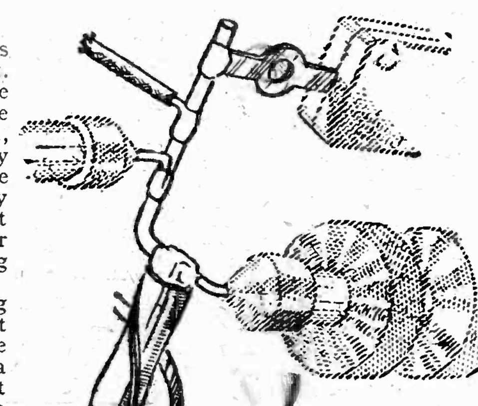

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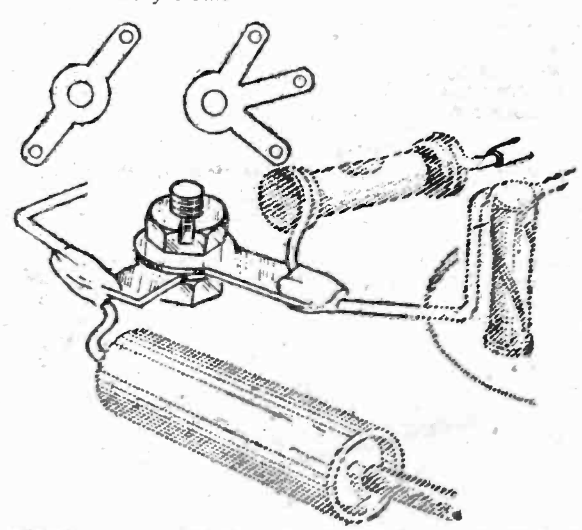


Fig. 4.—Multi-ended soldering tags simplify the attachment of several parts to a given point.

Cleanliness

Draw the wire or tag through the cloth until it is bright and clean. Next apply the thin film of flux, using a match-stick or other thin piece of wood—not your fingers as these will convey grease to the object. Now take the hot iron—if it is an electric iron which has been switched on for some time, it will be at a suitable heat. If you are heating an ordinary iron by the gas, the heat will be right when the flame round the bit is a bright yellowish green. Draw the tip of the iron across a sheet of fine emery laid on the bench—just to remove any trace of dirt or burnt material which might be on it. Place the end of a stick of solder on the tip and it should immediately commence to run. If properly cleaned the iron will carry quite a large quantity of solder, far more than is needed for normal soldering in a radio set, so don't pick up too much. Carry this to the point to be soldered and as soon as this is touched the flux on the job should give off a short, loud hiss and the solder should almost immediately run right round the joint and maintain its bright silver colour. Leave the two parts in contact (if they are being held whilst the soldering is taking place) until the surface is seen to dull slightly. This will indicate that the joint has cooled and that it may now be moved.

Suitable Solder

To facilitate the picking up of sufficient solder on the tip of the iron, the stick of solder should be bent as shown in the top left illustration on page 242. The most suitable solder for normal radio-constructional work is that known as tinman's or blow-pipe solder. The latter is very thin, but melts very quickly. Tinman's is sold in heavier sticks, but with a good electric iron is perfectly suitable for radio work and is slightly stronger than blow-pipe—containing more lead. Resin-cored solder is also available and removes the necessity of flux, but this material is preferably applied to the point of the iron, whilst the latter is in contact with the joint, and the resin then flows to the joint and assists in making good contact. A few experiments with some odd lengths of wire will soon enable you to accomplish the "knack" of judging the iron temperature, amount of flux and solder to use, and you will then agree that soldering is quicker than the older method of wiring and is much more reliable.

B.B.C. Engineering in Wartime

THE first wartime problem which the B.B.C. engineers had to face was the need for changes in the system of medium and long-wave transmission, so as to avoid giving navigational assistance to the enemy.

A plan was ready before war broke out, and when the orders to put the scheme in operation were received at 6 p.m. on September 1st, 1939, the whole system went over to it, and was working on service in 90 minutes. The old National and Regional programme system died in an evening, and was replaced for the time being with a single programme only. The Forces programme did not open until December, 1939. However, the extension in the number and coverage of overseas services was rapid. By February, 1941, new short-wave transmitters had been put into service, and in order that Europe might be adequately covered, additional medium-wave transmitters, all of considerable power, were put in by the engineering division, which freed various Regional programme transmitters for the Forces programme.

In the summer of 1940 it was considered desirable to try to duplicate the Home Service transmitter network. A low-power system was constructed as labour and manufacturing considerations made it impossible to build another network of high-power stations.

Provincial Studio Facilities

The dispersal, at Government request, of the main programme departments from London has led to enormous expansion of studio facilities in the provinces. The B.B.C. now has the equivalent of peace-time London studio facilities in three provincial centres. More studios have been built since war broke out than there were in the whole system before the war. In addition, every vulnerable control room had to be duplicated with a somewhat condensed, but equally serviceable, control room in a security area. No fewer than 20 additional control rooms have been built in such areas since the war began. Moreover, a number of additional control rooms have been built to pick up alternative land-line routes, so that if, for example, there was a heavy raid on Manchester the circuits which pass through the city could be picked up north, south, east or west of it, and the programme fed by way of an outer circle along a quiet route.

New Headquarters

As the number of services to Europe grew it became necessary to form a complete new headquarters and studio centre for broadcasting to neutral and enemy countries. Fifteen studios, with a very large control room, have been built, and this centre alone is now transmitting programmes in 23 different languages.

Again, on the studio side, it became necessary to find a new home for the greatly expanded service to the Empire. A vast amount of additional strengthening of floors was carried out in a building acquired for the purpose, and the basement and sub-basement of this building have been completely equipped with eight studios, four recording channels and an extensive control room.

All these developments have, in their turn, made it necessary for the operations department to be organised on a 24-hour day working basis. At the outbreak of war, the B.B.C. was running six separate programme services—National programme ($13\frac{3}{4}$ hours a day), Regional programme ($13\frac{3}{4}$ hours a day), Empire programme ($18\frac{1}{4}$ hours a day), a News and Information programme for Europe directed to Germany, Italy, France and the Iberian Peninsula (3 hours a day), the Arabic service (1 hour a day) and the Latin-American programme service (3 hours a day). They were also running the first television service in the world for five hours a day.

Programme Services

To-day the B.B.C. is transmitting seven programme services, namely, Home programme ($17\frac{1}{2}$ hours a day), Forces programme ($16\frac{1}{2}$ hours a day), Empire service in English, Red Network ($21\frac{1}{4}$ hours a day), Empire service in non-English languages, Green Network ($3\frac{1}{4}$ hours a day), News and Information service to Europe, Blue Network ($20\frac{3}{4}$ hours a day), Supplementary European service, Yellow Network ($10\frac{1}{4}$ hours a day), Latin-American service, Brown Network ($4\frac{3}{4}$ hours a day), together with a vast increase in such activities as recording. In the near future the number of networks is expected to increase to 13, and the general tendency is to fill up the hours of transmission of each service until they cover a major part of the 24 hours.

The peace-time staff of the operations department was approximately 1,000, of whom 800 were trained engineers. To-day the staff is 2,600, of which only 500 are trained engineers.

The engineering division has formed its own training school, through which nearly 1,000 newcomers have already passed.

Auto-bias for H.F. Valves

By Using Variable and Fixed Automatic Grid-bias Circuits, the G.B. Battery can be Eliminated

By W. NIMMONS

MANY constructors have added automatic grid bias to the output valve of their sets. This is a great advantage both from the point of view of dispensing with the grid battery, and from the point of view of keeping the bias voltage in step with the H.T. voltage; as the H.T. battery runs down, so also does the bias voltage decrease.

Most sets incorporating simple automatic bias arrangements have a plain H.F. stage, i.e., non-variable-mu, volume control being obtained by other means than varying the bias to the H.F. valve. When the constructor comes to adapt his set to use a variable-mu valve, he finds himself up against the difficulty, how to get a varying voltage on the grid of the H.F. valve, bearing in mind that the automatic bias obtained for the output valve is a fixed quantity.

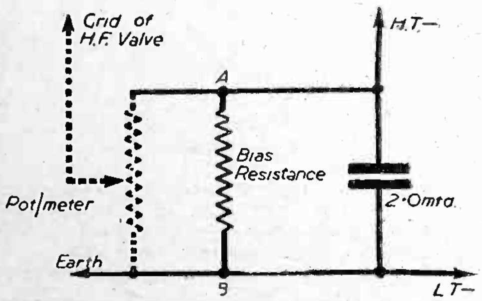


Fig. 1.—The wrong method of applying a variable bias from a fixed voltage.

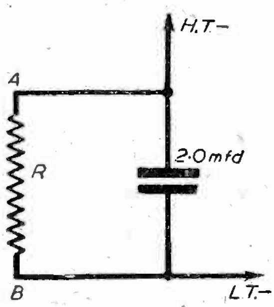


Fig. 2.—A progressive negative voltage is developed across the resistance R from B to A.

He may reason that since a voltage exists between the points A and B (Fig. 1), all he has to do is to connect a potentiometer across these two points, the slider going to the grid of the H.F. valve. Such a procedure will not do, however, as the resistance of the potentiometer then constitutes a decoupling resistance and violent motor-boating is obtained when the potentiometer is manipulated. It is obvious, therefore, that some other method must be devised to obtain a varying voltage from the fixed voltage of the auto-bias system.

One way is as follows. The bias resistor is of quite a low ohmage, being of the order of 600 ohms. The exact ohmage can be worked out by multiplying the bias voltage required by 1,000 and dividing by the current in milliamps. Thus, suppose we want a bias of 6 volts: 6 x 1,000=6,000. Divide this by 10 (being the supposititious current) and this gives 600, the value of the required resistor.

At a point A in Fig. 2 there will be 6 volts negative, while at point B there will be zero grid bias volts. This voltage (6 volts) will be progressive all along the resistance R; thus at half-way along its length there will be 3 volts negative, at one-sixth along its length counting from point B, there will be 1 volt negative, and at five-sixths, also counting from point B, there will be 5 volts negative. Thus, if we could introduce a slider on the resistance we could obtain anything from 0 to 6 volts grid bias.

From the point of view of obtaining a potential it does not matter (in this case, at least) whether the potentiometer has a resistance of 600 ohms, 6,000 ohms, 60,000 ohms; but since we are limited to 600 ohms for the bias resistor, we can use this to supply a bias both to the output valve (across the whole resistor), or by means of a slider to the H.F. valve, thereby giving the latter 0—6 volts grid bias. There are many potentiometers on the market with a resistance of 600 ohms, and one of these can be used as shown in Fig. 3. It is most important that a large capacity condenser, in good condition, be inserted close to the coil through which the bias voltage will flow, and that a resistance of 100,000 ohms be included in series with the bias lead supplying the H.F. valve.

If the particular bias resistance needed has a different resistance from 600 ohms, say 250 ohms or 1,000 ohms, then a potentiometer having a total resistance equal to the bias resistance of the particular receiver in use should be used.

If the total voltage drop across the resistance is too

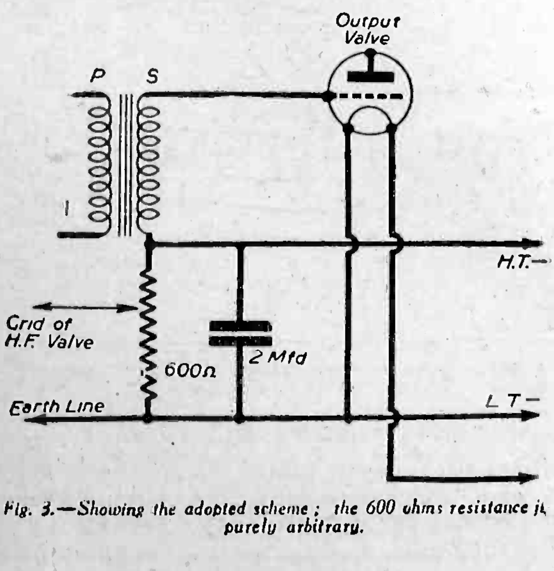


Fig. 3.—Showing the adopted scheme; the 600 ohms resistance is purely arbitrary.

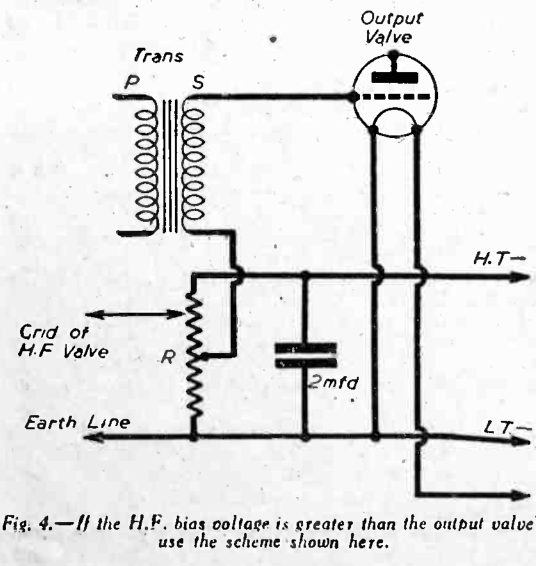


Fig. 4.—If the H.F. bias voltage is greater than the output valve's use the scheme shown here.

low to provide satisfactory volume control, then a slightly different scheme should be used. If, for example, the output valve only needs 4½ volts grid bias, and it would take 9 volts grid bias for satisfactory volume control, the following scheme should be utilised. This will mean modifying the potentiometer, but since all such instruments of the resistance needed are wire-wound, this will not be a difficult matter.

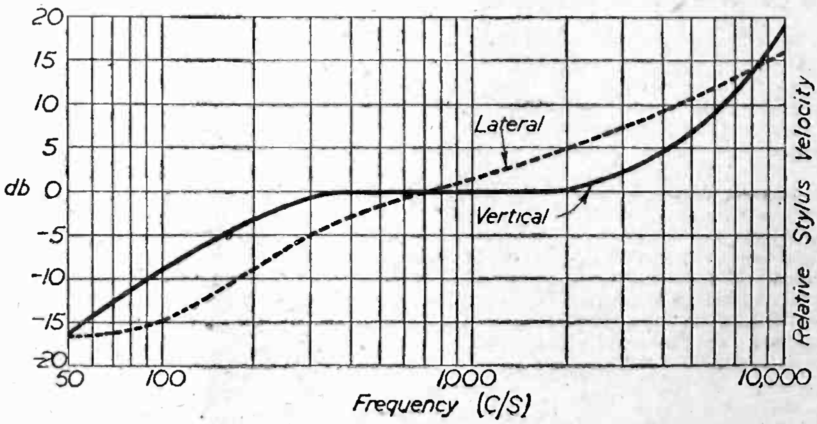
In the case mentioned in the above paragraph, we choose a potentiometer of *double* the resistance which would be needed for the output valve alone. This would give 9 volts bias, which can be used for the H.F. valve; the 4½ volts necessary (fixed) can be obtained by making a permanent connection half-way along the potentiometer, as shown in Fig. 4, either by means of a crocodile clip, taking care that it does not foul the slider, or by soldering. If the latter, the soldered joint should not be in the path of the slider. If no potentiometer can be found with the precise resistance value, it would be worth while to make one, using the appropriate gauge of resistance wire to suit requirements.

Disc Recording and Reproduction Standards

Factors Essential to High Quality Reproduction. By DONALD W. ALDOUS, M.Inst.E.

THE general absence of standards for electrical transcription, i.e., disc recording and reproduction for broadcasting, has resulted in the use of as many as ten equalising networks by some United States radio stations. The National Association of Broadcasters in America has co-ordinated the work of a special committee, consisting of representatives of all interested organisations, which has prepared a series of standards, the first sixteen of which have already been adopted and submitted to the industry. The B.B.C. has requested full details of the standards.

It is not proposed to give full information of all the points mentioned in the report, as many of these, e.g., diameters of outer and inner grooves, number of starting grooves, dimensions of centre hole, uniformity of groove spacing, etc., are details that are not likely to be of general interest. However, there are several recommendations containing figures of interest to anyone concerned with the design of pick-ups, and which throw light on factors essential to high-quality record reproduction.



Recording characteristics for vertical (full line) and lateral (broken line) transcription Permissible tolerance ± 2 db.

Frequency Characteristics

The recommendations regarding frequency characteristics are given in the form of curves for both vertical ("hill-and-dale") and lateral recording, and are shown in the accompanying diagram. The marked rise in the curve at the high-frequency end of the scale is noteworthy, as this measure has undoubtedly been taken to give a lower surface noise after tone-correction in the playback amplifier.

The text of the important sections dealing with noise and programme levels are worth quoting at length:

"17. It shall be standard that the programme level measured by the standard volume indicator shall be the same as the level required to record a 1,000 c/s note at a velocity of 5 cm./sec. This allows for the 10 db. margin usually present between signal and reading of volume indicator. This standard contemplates peaks running as high as 15 cm./sec., which is the maximum velocity that can be traced without distortion in the inner radius of a 33⅓ r.p.m. record.

"18. It shall be standard that the noise level measured when reproducing a record over a frequency range of 500-8,000 c/s shall be at least 36 db. below the level obtained under the same conditions when using a 1,000 c/s note at 5 cm./sec. This measurement is intended to give a fixed reference level for measuring noise, and does not take into account programme level actually recorded or programme dynamic range. Pre-emphasis, i.e., equalisation, will improve the S/N ratio a further 8 db."

Weight of Pick-up

It is also stated that the maximum vertical force (weight) required by the pick-up shall be 1½ oz. (42 gm.). The maximum instantaneous deviation from the mean speed of the reproducing turntable, i.e., the so-called "wow" factor, must not exceed ± 0.3 per cent. of the mean speed. The label of the disc is required to contain details of the speed and type of recording, inside or outside start, and the recording frequency characteristic. This last requirement might well be followed by commercial companies, as the printing of the recording frequency characteristic on the record label would assist enthusiasts in obtaining optimum quality reproduction with discs of varying types. In addition to these standards the committee recommend the adoption of a glossary of recording standards, which includes most of the terms peculiar to the subject, but this is not available at present.

Permanent Magnets–III

The Hysteresis Loop : Heat Treatment of Tungsten Steel : Harmful Effect of Annealing

By L. SANDERSON

(Continued from page 204, April issue.)

THE following equation will give permeability only when complete saturation of the material has been obtained :

$$\mu = \frac{\text{B flux density}}{\text{H magnetising force}}$$

Dynamo magnet steel in the form of castings is a low carbon steel and is used extensively. Fig. 1 shows a curve indicating the magnetic induction of this steel for varying values of magnetising force.

From figures already given, it will be remarked that with very soft iron a greater lifting power for a given magnetising force is obtained so long as the magnetic field is maintained by the current traversing the circuit. Because of its high permeability value, a greater number of lines of force are induced in the material, but the moment the force H is withdrawn by switching off the current the lines of force that constitute the lifting power in an electro-magnet almost entirely disappear, with the result that the load sustained by the magnet is released and falls to the ground.

In comparing different types of magnet steels and materials, it is essential that magnetic tests should be carried out to ascertain their relative values, but much controversy has waged as to what constitutes a trustworthy guide for measuring the value of a magnetic material designed for permanent magnets.

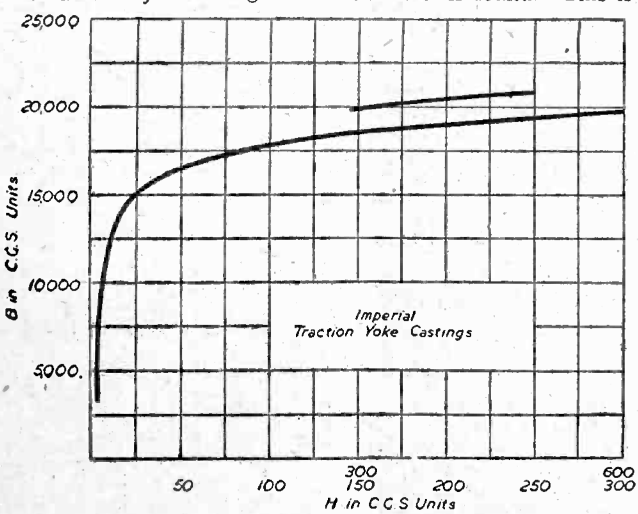


Fig. 1—Permeability curve for dynamo magnet steel traction yoke steel casting.

Specimen curve compiled from the average of the following test figures.

Test Piece H.	D595/4. B.	A946/8. B.
2	3.300	3.500
3	6.000	6.200
5	9.150	9.300
7	10.900	10.880
10	12.410	12.380
15	13.740	13.700
20	14.590	14.490
30	15.510	15.340
50	16.380	16.270
70	16.950	16.890
100	17.600	17.570
150	18.360	18.380
200	18.980	18.980
250	19.520	—
300		19.930
400		20.570
500		21.000

Inadequate Specifications

Some foreign magnet manufacturers, without stipulating the size and design of the magnet, demand that a magnet shall lift so many times its own weight. This gives extremely little guidance to the efficiency of a magnet, for the reason that if a ½in. square section of steel is ordered, and the specification stipulates that a magnet made from this lifts 10 times its own weight, the success or failure of the test depends on the volume of steel the maker puts into the magnet, and also on its shape. For example, two horseshoe magnets may be made, one weighing 8 ozs. and the other 1 lb. If both have the same cross-sectional area, the lighter magnet will have to lift 5 lbs., whereas the heavier magnet will have to lift 10 lbs. Therefore, assuming equal saturation intensity in both instances, one magnet has to do twice the work that the other has. This test can, for this reason, be dismissed as wholly unsatisfactory except as a means of comparing magnets of identical design magnetised under identical conditions.

The value that actually provides a trustworthy measure of the efficiency of a permanent magnet is the form of the hysteresis loop or figures obtained from this, namely remanence, coercive force and B-H max.

The Hysteresis Loop

So that the reader may obtain a clear conception of what these properties are, Fig. 2 is a sketch of the curve of the hysteresis loop. A magnetising force is applied by placing the specimen in a magnetic field created by an electric current traversing a wound solenoid. This produces lines of force that progressively increase with the application of increased current until full saturation is reached, but they do not increase proportionately with the application of increased current. With each known increase of current, a reading in linkages is obtained by a search coil, and is registered on the ballistic galvanometer, which is converted into values of B and plotted against H. This will give a magnetising curve as marked X on Fig. 2.

Having obtained an intensity of saturation that is not materially increased by further additions of current, the magnetising force is then reduced by stages, and it is found that the points plotted in coming down do not follow the original line of the magnetisation curve, but give a higher value of B. This procedure is followed until the current is at zero, and a value of B retained by the steel is found. This is remanence or residual magnetism, marked B, on the loop, and is a value giving some indication of the suitability of the steel for permanent magnets. The test is now further continued by reversing the current until the remanent flux has been extracted ; when this has been attained, the negative value of H is a measure of the force necessary to bring the steel back into its normal state, and is known as the coercive force (Marked H_c in Fig. 2). This gives another important indication of the value of the steel for permanent magnets. The remanence of a magnet is greatest immediately after demagnetisation, and becomes less in course of time. This is due to the demagnetisation of the ends and a slow change in the molecular orientation of the material, but eventually the magnetism settles down to almost a permanent value. This condition may be artificially acquired by boiling the magnet in water.

BH (max.) Value

The value BH (max.) can be worked out from the demagnetisation curve, but the area and shape of the hysteresis loop form a ready means of comparison of the magnetic values of different steels. The greater the area of the loop, the more suitable the material for the requirements of a permanent magnet.

High carbon steels and numerous alloy steels are found to give a fairly good value of remanence and coercive force, but the old steel that was principally employed for permanent magnets was a tungsten-chromium-carbon steel which gave, when correctly hardened, a coercive force of 65-75 and a remanence of 10,000-11,000, with a BH (max.) of 250,000-300,000. This steel gave reasonably satisfactory results for telephone magnets, though, as stated, there were considerable heat treatment difficulties. Heat treatment had, in fact, a decisive influence on the ultimate results, and it was therefore, and still is, where this material is employed as it sometimes is, necessary to give it careful attention.

Heat Treatment of Tungsten Steel

In order to obtain the most satisfactory results, it should be heated to 760 deg. C. and quenched in water. In this condition the highest value of coercive force is obtained. Any tempering is accompanied by a consequent drop in coercive force values. Over-heating, i.e., retention at high temperatures, allowing grain growth, detrimentally affects the magnetic properties of the steel.

Tungsten magnet steel in the quenched condition will give, after complete saturation, the following approximate values: H_c—65; B (rem.)—10,000; BH (max.)—250,000, but on tempering at very low temperatures there is a progressive fall of the coercive force until at 300 deg. C. the H_c value has fallen to 25 or 30. Tempering should, therefore, be carefully avoided.

Another point in connection with these steels is worthy of note. Annealing, far from improving their quality, actually impairs the coercive force so seriously as to make them unsuitable for their purpose. Moreover, they cannot by any method of heat treatment be made as good as annealed steel. The steel is in its best condition for hardening and magnetising when "as rolled," i.e., in the condition in which it leaves the rolls in the hot-rolling operation at the mill, being merely cooled in air without any annealing.

The theory by which this fact is interpreted is this. Although magnetism is presumably a function of the electrons of a metal, it is apparently promoted by regularity and uniformity of arrangement of the atoms. This is natural, as there must be some optimum condition of the steel for magnetisability, and it would be advantageous to have this condition throughout the mass of the metal. Since carbon is essential to magnet steels, and plays so important a part in the hardening, it is probably desirable for this carbon to be as evenly distributed as possible. Uniform distribution means fine division of the carbide particles, or there would probably be concentration gradients around the carbide regions after hardening, caused by incomplete diffusion.

Harmful Effect of Annealing

It is most probably here that annealing exercises its most harmful effect. When the steel has just been rolled, it is in the most satisfactory condition for uniformity, the carbides being fine and the grains small. Thus, when hardened it exhibits the best magnetic properties. But if annealed before hardening, the carbide particles have an opportunity to grow to considerable size, or new and larger ones are formed.

In the later hardening, the carbide diffusion is then not swift enough to give thorough uniformity.

Sometimes the steel as rolled is not soft enough to allow of cold shearing in later manufacturing operations. It is then sometimes necessary to semi-anneal, corresponding to a low temperature tempering. This, however, must be carried out with the utmost care, and even so will always reduce the coercive force to some extent. When machining or blanking operations have to be carried out, a compromise must be effected between desirable machining properties, which demand annealing, and the desirable magnetic properties that prohibit it.

A good deal of testing carried out on finished permanent magnets depends for its results on a composite figure of quality, which is not directly related either to coercive force or residual induction. It is believed by many manufacturers of magnet materials that when coercive force is reduced in value below a certain amount, the percentage gain that may have been obtained in residual induction will not offset the reduction in coercive force. On the other hand, if the magnet steel is treated in such a way in its different manufacturing stages that its coercive force is very high and the residual induction low, the magnet, if of tungsten steel, will not be of satisfactory quality. For a good tungsten magnet steel, therefore, it appears that neither the

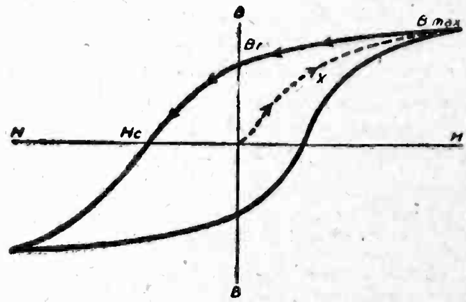


Fig. 2.—Curve showing hysteresis loop.

residual induction nor the coercive force should be at a maximum, but that a high average value of both should be obtained.

Table I gives a list of the characteristics of various magnet *steels*, but not of the later *alloys*, which will be discussed in due course.

New Cobalt Magnet Steel

After the war of 1914-1918, there arose a greatly increased demand for high quality permanent magnet steels in the form of bars and castings. In the automobile industry, the tendency was to produce various components much lighter in weight, but fully as efficient as the corresponding heavier parts. The magneto, which had been a quite cumbersome apparatus, contained a large permanent magnet which was necessary to give the requisite energy to produce the spark. The other parts of the magneto had, therefore, to be correspondingly large.

It proved, however, possible to obtain permanent magnets of quite small dimensions possessing the necessary energy, so that the magneto manufacturer was

(*Continued on page 251.*)

TABLE I. CHARACTERISTICS OF MAGNET STEELS

Material.	Composition. C.	Cr.	Co.	W.		Coercive Force.	Remanence.	Characteristic Product.	Usable Ergs.
Soft Iron	0.	0.	0.	0		1.35	11,350	15.322	
Steel. 5 Nickel	0.1	0.	0.	0	Ni 5%	0.6	6.500	3.900	
Carbon Steel	0.9	0.	0.	0		60	6,500	390,500	
Chrome Steel	1.0	2.	0.	0		55	10,000	550.000	8,700
Chrome Steel	0.75	5.	0.	0	Mn. 1%	70	9,000	630.000	
Chrome Tungsten Steel ..	0.5	0.5	0.	5		65	12,000	780.000	11,140
Cobalt Tungsten Chrome Steel	0.7	1.5–3	30 40	5 9		280/300	9,000–10,000	2.700,000 (app.)	35,000 (app.)

able to produce small, but highly efficient machines. With the increasing popularity of radio, a good demand also arose for small but efficient permanent magnets for loud speakers of both fixed and moving coil types.

Certain types of permanent magnet generators for lighting purposes containing the generator and lamp in one self-contained unit call for small but highly effective permanent magnets. These could not be manufactured until the effect on the magnetic properties of iron produced by the addition to it of cobalt was discovered.

In 1912 Professor P. Weiss discovered that an alloy of iron and cobalt corresponding to the formula Fe_2Co possessed a specific saturation some 10 per cent. greater than that of ordinary iron. Honda and Tagaki in Japan, working on the lines of the discovery of Professor Weiss, discovered in 1917, to use Professor Honda's own words: "a remarkable steel alloy possessing an extremely high coercive force and a strong residual magnetism."

Effect of Cobalt

The effect of this addition of cobalt to an alloy of iron, chromium and carbon was to increase its coercive force and so increase the amount of energy a magnet made from this material was capable of storing.

The tungsten and chromium magnet steels solely used up to that point were developed before the significance of the BH(max). value was fully appreciated, and the demand was for steels giving this maximum flux per unit of cross section, the magnets themselves being made long enough for them to be reasonably permanent. When the cobalt steels arrived, less importance was attached to obtaining a high value of B_{rem}, but the much increased coercive force obtained gave a very much higher BH(max.) value.

Cobalt magnet steels are divisible into two classes: (a) air hardening; (b) oil hardening. We shall deal with these in the following section.

(To be continued.)

The First Ten Microseconds

What Causes Oscillations in an Electrical Circuit? The Answer is Given in this Interesting Article. By C. WILLIAMS

MANY textbooks which deal quite adequately with circuits in a state of continuous oscillation, give very little attention to the way in which oscillations commence. It is sometimes stated that any sudden disturbance, such as that caused by closing the high tension switch, will start oscillations. This statement seems to invite further examination, and an examination of it can, in fact, throw a good deal of light on the working of an oscillating circuit.

It is well known that if a condenser is charged and then disconnected from the battery and connected to the terminals of a suitable inductance, the discharge of the condenser will be oscillatory. But in practical oscillating circuits the condenser and inductance are usually permanently connected, forming a parallel combination across which the battery is then connected by the closing of a switch. Will oscillations commence under these conditions? The answer is that they will if, and only if, a sufficiently high resistance is interposed between the resonant circuit and the battery.

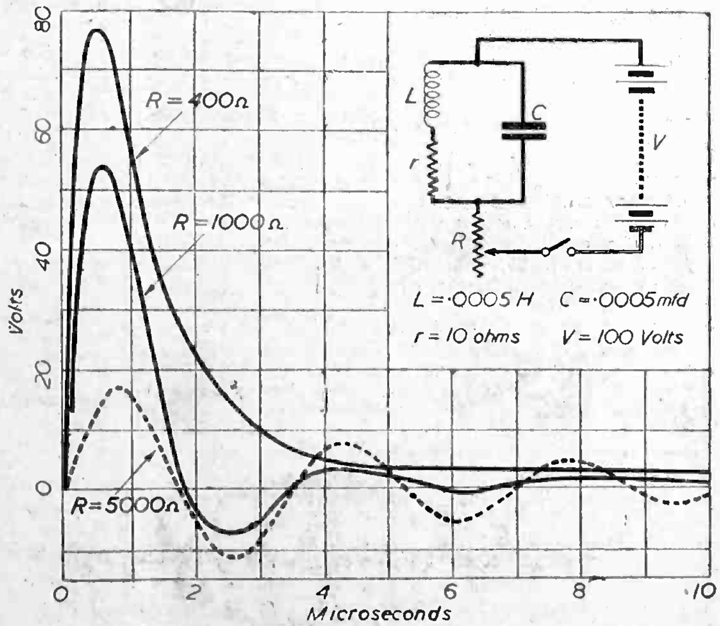
Consider the circuit shown in the accompanying diagram. For the sake of clearness definite values have been assigned to the circuit constants. L is an inductance of 500 microhenrys, having a high frequency resistance of 10 ohms. C is a condenser of .0005 microfarad capacity. R is a variable resistance. When the switch is closed a constant E.M.F. of 100 volts is applied to the circuit.

It is evident that if the resistance R is short-circuited oscillations cannot commence; for oscillation consists of the periodic discharging and recharging of the condenser through the inductance, which implies a periodic change of voltage across C. This cannot occur because, with R short-circuited, the voltage across C is at all times the constant voltage of the battery. With R in circuit, any variation in the current supplied by the battery will cause a corresponding variation in the voltage drop across R, and changes in the voltage on the condenser will become possible.

The Value of R

It can also fairly easily be seen that R must have a definite minimum value, as will now be shown. It will make matters clearer if we first consider the conditions at the moment of closing the switch; and then the conditions when oscillations, if any, have been damped out. Initially, that is at the moment that the switch is just closing, no current has flowed, and there is no charge on the condenser, and, consequently, no voltage across it. The full battery voltage, therefore, exists across the resistance R, and the initial current is in accordance with Ohm's law V/R. Also, if there is no voltage across C, neither can there be any voltage across L, which is in parallel with it.

It follows, then, that initially the current in the inductance is zero, and all the current V/R, which passes through the resistance, goes to the condenser as charging current. As soon as it begins to flow, a charge builds up on the condenser, a rising voltage exists across the



Voltage curves for the first ten microseconds after closing the switch, with three values for R. (Inset) The oscillatory circuit used for the experiments.

resonant circuit, and consequently a decreasing voltage across the resistance R. The total current must therefore decrease, and of this decreased current a part will now begin to flow through the inductance, still further decreasing the charging current to the condenser.

When a steady state is finally reached (oscillations, if they occur having been damped out) only direct current will be flowing. There will, therefore, be no current in the condenser, and a current in accordance with Ohm's law, $V/(R+r)$ through the resistance and coil. The voltage drop across the coil will then be r multiplied by this current, that is, $rV/(R+r)$, which if R is large will be only a small fraction of the battery voltage. If, for example, the value of R is 400 ohms, with the constants already given $rV/(R+r)$ will be equal to 2.4 volts, while if R is 5,000 ohms the final voltage across the coil will be just under 0.2 volt.

As to voltage, we begin, therefore, with no voltage across the coil and condenser, and end with a voltage $rV/(R+r)$. As to current, we begin with all the current in the condenser, and end with the total current, now slightly decreased, in the coil. What happens between these two states depends on the value of R.

Effect of Reactance

In the accompanying diagram, voltage curves for the first ten microseconds after closing the switch have been drawn, for the cases in which R has the values 400, 1,000 and 5,000 ohms respectively. It will be seen that in each case within the first microsecond the voltage across the condenser and coil has risen to many times its final value—in the case of $R=400$ to nearly 80 volts, whereas its final value will be just under $2\frac{1}{2}$ volts. This is because so long as the current in the coil is increasing, there is a reactance drop across the coil which may be much larger than the ohmic drop.

Physically, what is happening is that the growth of current in the coil is being opposed by its reactance, and therefore a much larger portion of the total current is going to charge the condenser than would do so if the coil were replaced by a pure resistance. The sharp peak in the voltage curve corresponds to the moment when the current in the coil is increasing most rapidly.

Starting,, then, from the moment when the voltage has this maximum value, we have the case of a charged condenser connected to an inductance, which, as was stated in the first paragraph, should lead to an oscillating discharge. But there is one important difference; the battery circuit has not been disconnected. The effect of this may most simply be studied by the aid of an artifice which is often useful. The battery cannot produce oscillations. So long, therefore, as we are concerned with oscillations only, and disregard any steady current on which they may be superimposed, we may suppress the battery, and deal with a circuit containing the charged condenser, the coil, and the resistance R. Imagine, therefore, that the battery is short-circuited. The resistance R is then effectively connected directly across the oscillating circuit.

When a circuit oscillates, energy is at each cycle transferred from the condenser to the inductance and back again. Part, at least, of this energy is lost in the resistance R. Each time the condenser discharges part of the current which should build up a reactance voltage on the coil goes through the parallel path R instead. Each time the coil reactance voltage begins to recharge the condenser, part of the charging current again goes through R, and is wasted; and the lower the resistance of this shunt path, the greater will be the proportion of current wasted. If the resistance is low enough the reactance voltage of the coil, in the equivalent circuit which we are considering, will never recharge the condenser, and there will be no oscillations.

If r, the resistance of the coil itself, is small enough to be neglected, the critical value of R is easily found. The natural frequency of an ideal resonant circuit without resistance is given by $\omega^2 = 1/LC$. With a *parallel* resistance R, this becomes $\omega^2 = 1/LC - 1/4R^2C^2$. This last expression becomes zero when $4R^2C^2=LC$, that is, when $R=\frac{1}{2}\sqrt{L/C}$. If R has a value less than this ω^2 becomes negative, and there can be no real frequency. Physically, this means that the first oscillation can never be completed, even in infinite time.

For the particular circuit we are considering $\frac{1}{2}\sqrt{L/C}$ is equal to 500 ohms, and we shall, therefore, not expect oscillations if R is only 400 ohms. From the curve for 400 ohms we see that, after its peak value, the voltage falls steadily towards its final value. There is no alternate discharge and recharge of the condenser.

The curve for 1,000 ohms shows oscillation just beginning. Because of the higher value of R the condenser receives less charging current in the first microsecond, and the peak is not so high as in the previous curve. Thereafter the curve falls more steeply and becomes negative. This means that the reactance voltage on the coil has been able to give the condenser a small charge in the reverse direction, thus commencing oscillation. The oscillations in this case are, however, very rapidly damped out. Incidentally, this curve illustrates the distorting effect of heavy damping. There is a definite frequency, but the maxima and minima are not symmetrically disposed between the "zero" values.

The curve for 5,000 ohms shows oscillations well established, but still, of course, damped.

The Valve as a Generator

It is instructive to consider under what circumstances the circuit with which we have been dealing could be made to produce continuous undamped oscillations. It has been shown that the function of the resistance R is to make possible a varying voltage drop between the battery and the oscillating circuit. This varying drop is produced by the pulsating current in R. The energy which produces the pulsations cannot come directly from the battery. Power can only be supplied to an oscillating current by a source of E.M.F. oscillating at the same frequency. In this case power is supplied at the expense of the energy which was initially stored in the condenser, and this energy is lost from the oscillating circuit. Every time the voltage across the condenser rises, the voltage across R, and, therefore, the current in R, must fall. The current in R is, therefore, 180 degrees out of phase with the voltage on the condenser. If the phase of this current could be reversed energy could be supplied to the oscillating circuit instead of taken from it. The only way to do this would be to vary the value of the resistance R itself at the oscillating frequency.

If it were possible to decrease the value of R each time the voltage on the condenser rises the current in R, which is the total current supplied by the battery to the oscillating circuit, could be made to rise and fall in phase with the condenser voltage, and power would be supplied to the circuit. The use of a sliding contact operating at radio frequency is naturally impossible, but there exists a device, the resistance of which can be varied at almost any desired frequency—the triode valve.

The anode current in a triode is controlled by space charge. When a negative charge is placed on the grid this holds a large number of electrons in the space between the grid and the cathode. These electrons in turn oppose the emission of more electrons from the cathode, thus increasing the resistance of the valve. Further discussion of the action of the valve as an oscillator would be outside the scope of this article. It is only mentioned here to show that a tuned anode oscillating circuit is essentially the same as the circuit shown in the diagram, with R variable, and that the same initial conditions apply.

If the anode and cathode of a valve are connected in place of R, and the anode resistance of the valve is 5,000 ohms, then when the switch is closed damped oscillations will occur in the tuned anode circuit, exactly as in the third curve in the diagram. If also by suitable feed-back arrangements to the grid, the resistance of the valve is caused to decrease whenever the condenser voltage rises, the oscillations can be maintained continuously.

A Refresher Course in Mathematics

By F. J. CAMM

(*Continued from page 212, April issue.*)

Integration

THE normal meaning of the term "to integrate" is "to make into one whole," and in mathematics the meaning is similar, but is perhaps more accurately defined as "to determine the whole from a knowledge of the relations between its infinitely small parts." This definition hints at the converse relation between integration and differentiation, which is a determination of the relations between infinitely small parts. In what circumstances is it necessary to deduce the whole from consideration of its infinitely small parts? An important example may be understood by reference to Fig. 1.

Suppose that it is required to know the area of the figure $ABCD$, in which AD and BC are perpendicular to DC and AB is curved. An easy way of determining the approximate value of the area is to divide it into vertical strips by the lines EN, FP and GQ, to join AE, EF, FG and GB by straight lines and to add together the areas of the four strips. (The area of each strip is equal to its horizontal width multiplied by the average of the heights of its sides.) The area so determined is actually greater than the area required, because the lines AE, EF, FG and GB all lie *above* the original curve AB.

Now suppose that a straight line HJ is drawn to touch the original curve at a point half-way between A and E, JK is drawn touching the curve between E and F and KL and LM are similarly located. Then the total area of the four strips bounded at their tips by HJ, JK, KL and LM may be determined as before and this is *less* than the required area because HJ, JK, KL and LM all lie *below* the curve AB.

It is clear from the diagram that the difference between the total area of the larger strips and the total area of the shorter strips is small and therefore that the area below the curve AB, although not *exactly* determined, is known within reasonably narrow limits of error. It is also fairly obvious that if the original figure were divided into (say) eight strips instead of four, the limits of error would be even narrower because the differences between curve, chord and tangent are reduced when a shorter piece of the curve is considered. It can be said, in fact, that the difference between the total area of the strips and the area under the curve can be reduced to any desired amount by dividing the given figure into a sufficiently large number of strips. If an *infinitely* large number of strips be used, the difference becomes zero, or, in other words, the method of adding areas of strips becomes accurate.

If there is a known mathematical relation between the ordinate of the curve (i.e., its height above DC) at any point and the horizontal distance of the point from AD, the integral calculus provides a means of adding together the areas of an infinite number of infinitely narrow strips —an operation that is otherwise impracticable. It is necessary to state here, however, that whilst the strict straightforward process of integration can often be carried out with no difficulty, and sometimes with a certain amount of difficulty, there are circumstances in which it cannot be carried out at all. In other words, there are mathematical functions that cannot be integrated accurately, and in such cases it may be essential to adopt the graphical method of determining the area, using any conveniently large number of strips for the purpose. There is thus a sharp distinction between differentiation and integration in that whilst every mathematical function can be differentiated, by following certain fairly simple rules, it is quite easy to write down any number of functions that, in the strict mathematical sense, cannot be integrated at all.

Relation Between Integration and Differentiation

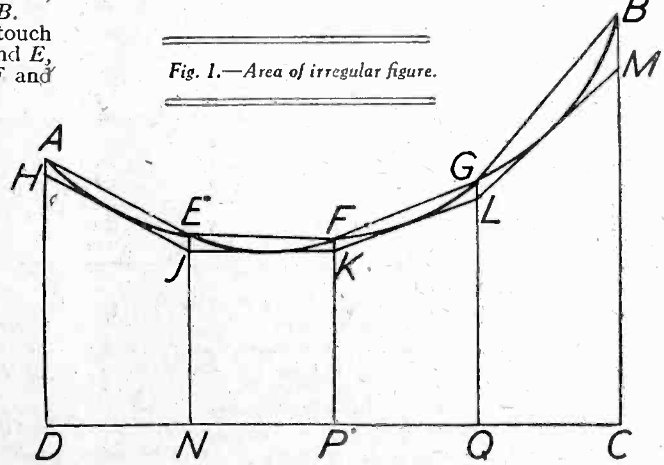
In Fig. 2 the upper curve is one that is defined by a known mathematical relation (for example, $y=3x^2$) between the height y of the curve at a point distant x from AO. The point B is any typical one; $BD=y$ and OD is x. The area of the figure bounded by the straight lines AO, OD and DB and the curve itself between A and B is denoted by c. Since the area depends on the distance between AO and BD, the value of c depends on OD, or, in other words, C is a function of x.

Now consider an ordinate CE, a little to the right of BD. The short distance DE may be regarded as a small change in x and denoted by dx. The height CE will be slightly different from BD and may be denoted by $y+dy$. The area under the curve between A and C is slightly greater than c and the difference may be denoted by dc. This difference is the area of the strip $DBCE$, whose width is dx and whose mean height is between y and $(y+dy)$. When BD and CE are infinitely close together, dy is infinitely small, so that y and $(y+dy)$ are equal, the mean height of the strip is y, and its area is ydx. Hence:

$$dc=ydx, \text{ or } \frac{dc}{dx}=y.$$

The differential coefficient of c with respect to x is therefore y, but as the function c is at present unknown, whereas y is a known function of x, the relation $\frac{dc}{dx}=y$ expresses the fact that c is the function of x whose differential coefficient with respect to x is equal to y. The mathematical process of "integrating" the areas of the strips thus resolves itself into finding the function

Fig. 1.—Area of irregular figure.



which, when differentiated, will give y. The relation between integration and differentiation is similar to that between division and multiplication, because when we divide P by Q, we find the quantity which when multiplied by Q will give P.

Symbol for Integration

The area c under the curve AB is the sum of the areas of an infinitely large number of strips (whose individual areas are each $dc=ydx$) lying between the ordinate AO (for which $x=0$) and the ordinate BD (for which $x=OD$). This is expressed in mathematical shorthand by writing

$$c=\int_{x=0}^{x=OD} ydx$$

The symbol $\int$ means "the sum of." The symbol dx shows that x is the independent variable. This indication must always be given because the sign $\int$ is meaningless without it. The quantity y (which must in any particular case be represented as a function of x) is the quantity to be integrated. The notes $x=0$ and $x=OD$ indicate the "limits" between which the integration is to be carried out. The mathematical operations involved in determining c by this integral formula are:

(1) Determine the function of x whose differential coefficient with respect to x is y.
(2) Find the value of that function when $x=OD$.

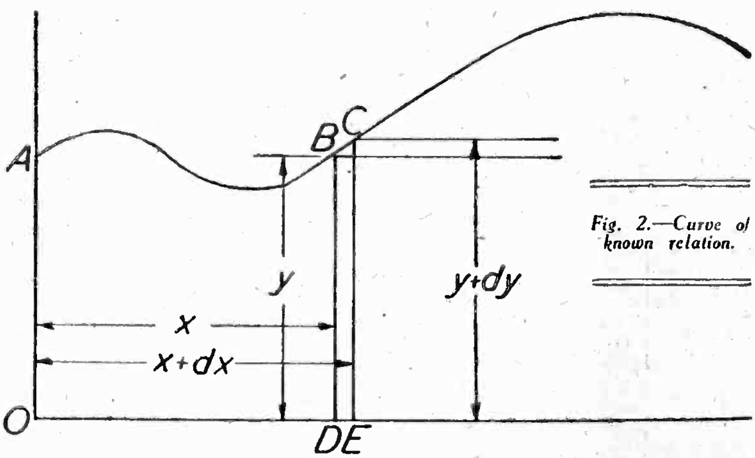


Fig. 2.—Curve of known relation.

(3) Find the value of that function when $x=0$.
(4) Subtract the second value from the first value.

The reason why this procedure is correct is that any ordinate of the curve is equal to the differential coefficient (with respect to x) of the area under the curve up to that ordinate.

Limits of Integration

The last statement above is true irrespective of the position of the left-hand limit of the curve and consequently integration, interpreted as reversed differentiation, cannot determine the area under the curve unless both left- and right-hand limits are defined. This is in accordance with the fact that the addition of a constant to a function of x does not alter the differential coefficient of that function of x with respect to x, because the differential coefficient of a constant is zero. If the limits are not defined, the value of the integral must be expressed with the addition of an "arbitrary constant" whose value must be determined with the aid of some additional information.

In the following list of some standard integrals, the arbitary constant is denoted in each case by C.

Some Standard Integrals

$$\int (ax+b)^n dx = \frac{(ax+b)^{n+1}}{a(n+1)}+C \qquad (16)$$

$$\int a\sin(nx+b)dx = \frac{-a\cos(nx+b)}{n}+C \qquad (17)$$

$$\int a\cos(nx+b)dx = \frac{a\sin(nx+b)}{n}+C \qquad (18)$$

$$\int a\sec^2(nx+b)dx = \frac{a\tan(nx+b)}{n}+C \qquad (19)$$

$$\int a\tan(nx=b)dx = \frac{a}{n}\log_e\cos(nx+b)+C \qquad (20)$$

$$\int ab^{(cx+d)}dx = \frac{ab^{(cx+d)}}{c\log_e b}+C \qquad (21)$$

If u, v, w, etc. are functions of x:

$$\int (u+v+w+\text{etc.})dx=\int udx+\int vdx+\int wdx+\text{etc.}+C \qquad (22)$$

$$\int uvdx=v\int udx-\int\left(\int udx\right)\frac{dv}{dx}dx+C \qquad (23)$$

For example, using (22), (17), and (18),

$$\int (3\sin 2x+2\cos 2x)dx$$

$$=\int 3\sin 2x\,dx+\int 2\cos 2xdx$$

$$=\frac{-3\cos 2x}{2}=C_1+\frac{2\sin 2x}{2}+C_2$$

$$=-\frac{3}{2}\cos 2x+\sin 2x+C$$

Each integral gives rise to an arbitrary constant (denoted by C_1 and C_2), but the sum of any number of arbitrary constants is only one arbitrary constant and this is denoted by C.

Using (16),

$$\int_{x=1}^{x=2}(-2x+1)^2dx$$

$$=\left[\frac{(-2x+1)^3}{(-2)\times 3}\right]_{x-1}^{x=2}$$

$$=\frac{(-2\times 2+1)^3}{-6}-\frac{(-2\times 1+1)^3}{-6}$$

$$=4\cdot 5-\tfrac{1}{6}=4\cdot 333.$$

Equation (23) is occasionally useful in evaluating the integral of the product of two functions of x. It must be emphasised, however, that it is not certain to help in any particular case because it merely substitutes the integral of the product of two other functions of x for the original integral. It is useful only if the second term in the right-hand side is easier to evaluate than is

$$\int uvdx.$$

It may be mentioned again that there are many mathematical functions that cannot be strictly integrated inasmuch as no function can be found on differentiation to give the original function. In such a case, however, the numerical value of the integral between specified limits may be found by plotting the curve of the function between those limits and determining the area under the curve by dividing it into strips, or by use of the planimeter. Here the approximate method gives an answer, whereas the exact method fails to work at all. What we may call the "separate strip" method always gives a result of adequate accuracy; sometimes the integral calculus can be used and when it can it is usually quicker and more accurate.

Moment of Inertia

The energy possessed by a body by virtue of velocity is called its "kinetic energy" and is equal to half the mass multiplied by the square of its velocity. If a body is rotating about a fixed axis, different parts of it have different velocities, and consequently it is more difficult to calculate its kinetic energy. To take the simplest case—that of a disc rotating about its axis—points on the curved surface have the greatest velocity of any, whilst points on the axis have no velocity at all.

The velocity of any point is equal to the angular velocity of the disc multiplied by the distance of the point from the axis. Consequently, all points at any particular radius may be lumped together in calculating kinetic energy because they have a common velocity. Further, all points lying in a cylindrical ring (as shown in Fig. 3) whose inner and outer radii are r and $(r+dr)$ lie at nearly the same radius r if dr is very small. The volume of such a ring is equal to the circumference multiplied by the thickness multiplied by the width, and the mass is equal to that product multiplied by the density of the material, or

$$\text{Mass}=2\pi\ r\ dr\ w\ s, \text{ where } s \text{ is the density.}$$

The velocity of the ring is equal to r times the angular velocity, assuming that the value r is taken as a sufficiently close approximation to the distances of the axis from the various particles of material which actually range from r to $(r+dr)$. If the angular velocity is A, the square of the velocity of the ring is A^2r^2 and the kinetic energy is

$$\tfrac{1}{2}\ \text{Mass}\ x\ (\text{Velocity})^2=\pi\ A^2s\ w\ r^3\ dr.$$

The same expression, with suitable values of w and r, applies to any ring. The values of π, A, and s are common to all rings. (In the particular case shown, that of a flat-sided disc, the value of w is also common to all rings.)

The total kinetic energy of the whole disc is the sum of the values of this expression for all rings or

$$=A^2\ s\ w\ (\text{Sum of } r^3\ dr \text{ for all rings}).$$

The value of the quantity within the bracket may be estimated by dividing the disc into thin rings and adding together $r^3\ dr$ for all of them. For example, if the radius of the disc is 10, and it is decided to consider rings of thickness 1, then $dr=1$, and the calculation of r^3dr would proceed thus—

r	r^3	dr	r^3dr
0	0	1	0
1	1	1	1
2	8	1	8
3	27	1	27
4	64	1	64
5	125	1	125
6	216	1	216
7	343	1	343
8	512	1	512
9	729	1	729
			Total $r^3dr=2025$

On the other hand, if it were decided to use rings of thickness 2, then $dr=2$, and the calculation would proceed—

r	r^3	dr	r^3dr
0	0	2	0
2	8	2	16
4	64	2	128
6	216	2	432
8	512	2	1024
			Total $r^3dr=1600$

This gives a smaller result than before, because the steps are coarser. Thus for the ring whose inner and outer radii are 2 and 4, the value of r^3dr is $2^3\times2=16$. The corresponding value on the basis of $dr=1$ is derived from a ring for which $r=2$ and another for which $r=3$, and is

$$2^3\times1+3^3\times1=35.$$

It is true to say that the thinner the rings the greater will the total $r^3\ dr$ become, and it may be expected that the choice of infinitely small rings will yield a definite value for $r^3\ dr$ because that is actually the only perfectly correct procedure.

The integral calculus enables that summation to be effected because the expression $\int_{r=a}^{r=b} r^3\ dr$ means "the sum of the quantities $r^3\ dr$ between $r=a$ and $r=b$ when dr is infinitely small" and because there is a mathematical process for finding the value of that expression. In the special case just considered the maximum and minimum values (the limits) of r are 10 and 0, and so $b=10$ and $a=0$. Hence:

$$\int_{r=0}^{r=10} r^3\ dr=\left[\frac{r^4}{4}\right]_{r=0}^{r=10}=\frac{10000}{4}-\frac{0}{4}=2500$$

So the sum of r^3dr calculated on $dr=2$ is 1600, on $dr=1$ it is 2025 and on $dr=\frac{1}{2}$ it will be something greater than 2025, whilst the integral calculus tells us (what we could not find by the simple arithmetical method) that if $dr=0$ the sum of $r^3\ dr=2500$, and this is the correct answer.

The quantity $\pi s\int w\ r^3\ dr$ is called the "moment of inertia" of the disc about its axis.

If w is constant for all rings, then $\int w\ r^3\ dr=w\int r^3\ dr$, and the integral is easily evaluated as was done above.

If w is not constant but can be expressed in terms of r, it may, or may not, be possible to evaluate the integral according to the complexity of the expression wr^3. If it *is* possible, the value of the integral may be expressed as a general formula in terms of the outer radius of the disc or, in the case of a ring, in terms of its outer and inner radii. If it is *not* possible, the arithmetical method based on rings must be used and the thinner the rings, the more accurate will be the result.

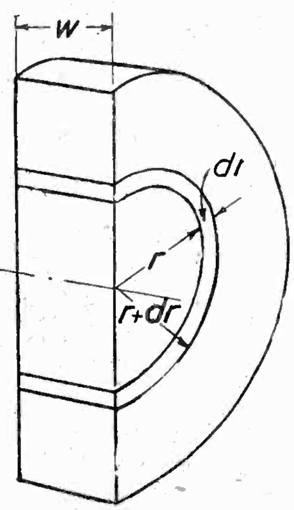


Fig. 3.—Cylindrical ring.

Mean Values

What is meant in general by a "mean value" is well illustrated by the case of mean velocity. If the velocity of a body varies over a given interval of time the mean velocity for that period is equal to the total distance covered divided by the time. If the distance covered cannot be determined by actual measurement, it can be calculated, if the variation of velocity with time is known, by dividing the whole interval into very short intervals, multiplying the velocity at the middle of the short interval by the length of the short interval (this giving the distance covered during that interval), and adding together all the quantities so obtained. The result divided by the whole interval is the mean velocity during the interval.

Here again it may be surmised that the calculated value of the mean velocity will depend on the shortness of the intervals chosen for the basis of the calculation. The shorter (and therefore the more numerous) the intervals, the more accurate will be the result, and if the velocity can be expressed mathematically in terms of time the integral calculus will be able to give the mean velocity with perfect accuracy if the mathematical function is one that can be strictly integrated.

In general, if a quantity y depends on a quantity x, the mean value of y while x changes from a to b is

$$\left(\int_{x=a}^{x=b} y\,dx\right)\Big/(b-a).$$

For example, if $y=\frac{1}{2}x^3$, the mean value of y between $x=2$ and $x=4$ is

$$\left(\int_{x=2}^{x=4} \tfrac{1}{2}x^3\,dx\right)\Big/(4-2)$$

$$=\left(\left[\frac{x}{8}\right]_{x=2}^{x=4}\right)\Big/2=(32-2)/2=15$$

when $x=2$, $y=\frac{8}{2}=4$, and when $x=4$, $y=32$.

The arithmetic mean of the smallest and greatest values of y is $\frac{1}{2}(4+32)=18$, and this is seen to be greater than the true mean value of y.

As usual $\int_{x=a}^{x=b} y\,dx$ represents the area under the curve of y between the limits $x=a$ and $x=b$, and so even if the integral cannot be evaluated mathematically, it can be evaluated by drawing the curve and determining the appropriate area by any convenient method.

The sine curve is important in several branches of engineering, and it is instructive to consider the application of the integral calculus to the determination of its mean value. It is illustrated in Fig. 4, which shows a complete "wave-length", w of a sine curve whose "amplitude" is b. This means that the value of y varies between $+b$ and $-b$.

The equation of the curve shown, i.e., the relation between the x and y of any point on it, is

$$y=b\sin 2\pi\frac{x}{w}$$

(As x increases from 0 to w, y rises from 0 to 1, falls to -1, and rises again to 0.)

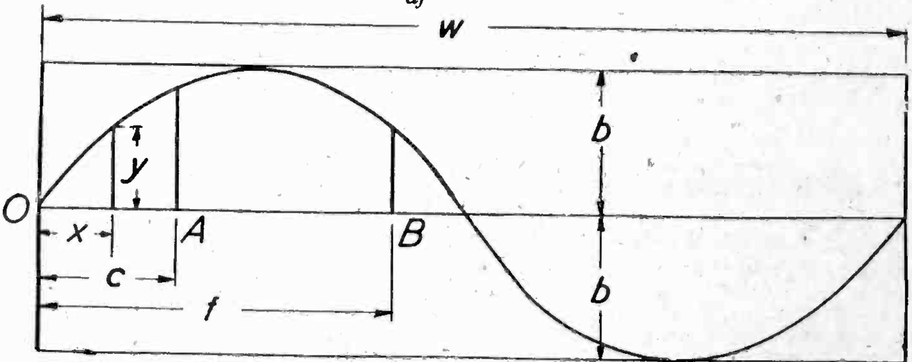


Fig. 4.—The sine curve.

Now the mean height of the curve between any two points A and B whose distances from 0 are c and f is, according to the general formula

$$\left(\int_{x=c}^{x=f} b\sin 2\pi\frac{x}{w}\,dx\right)\Big/(f-c).$$

The integration of $b\sin 2\pi\frac{x}{w}$ is a special case of (17) where $a=b$, $n=\frac{2\pi}{w}$, and $b=0$. As the limits $x=f$ and $x=c$ are defined, no arbitrary constant appears. Therefore

$$\text{Mean height}=\left[-b\frac{w}{2}\cos 2\frac{x}{w}\right]_{x=c}^{x=f}\Big/(f-c)$$

$$=\frac{bw}{2\pi(f-c)}\left[\left(-\cos 2\pi\frac{f}{w}\right)-\left(-\cos 2\pi\frac{c}{w}\right)\right] \quad (24)$$

If the lower limit $c=0$, i.e., if A coincides with 0, the expression becomes simplified because the second term in the square bracket is then the cosine of zero, which is unity, and we have

$$H=\text{Mean height}=\frac{bw}{2\pi f}\left[1-\cos 2\pi\frac{f}{w}\right] \quad \ldots\ldots (25)$$

The following special values of f may be noted. If $f=w$, $H=0$. This is because in a complete wave-length there is as much positive as negative, and the total is nothing.

If $\quad f=\frac{1}{2}w$, $H=\frac{2b}{\pi}=0\ 637b$

If $\quad f=\frac{1}{4}w$, $H=\frac{2b}{\pi}=0.637b$

These values of H are the same because the second quarter of the wavelength is the mirror image of the first quarter and the two have the same height.

It is interesting to apply the differential calculus to (25) in order to determine what length of the curve, starting from 0, will give the greatest mean height. In this operation f is the independent variable and H the dependent variable. Consequently it is necessary to differentiate H with respect to f, and this is an example of use of the formula (8), where

$$u=1-\cos 2\pi\frac{f}{w} \text{ and } v=f.$$

The quantity $\frac{bw}{\pi}$ is a multiplying constant and remains unchanged on differentiation.

In differentiating μ, the differential coefficient of 1 is zero. The second term is a special case of (3) where

$$a=-1,\ n=\frac{2\pi}{w} \text{ and } b=0$$

So $$\frac{du}{df}=\frac{2\pi}{w}\sin 2\pi\frac{f}{w}$$

$$\frac{dv}{df}=1.$$

Therefore,

$$\frac{dH}{df}=\frac{bw}{\pi}\left[f\frac{2\pi}{w}\sin 2\pi\frac{f}{w}-\left(1-\cos 2\pi\frac{f}{w}\right)\right]\Big/f$$

Using the trigonometrical transformations,

$$\sin\theta=2\sin\frac{\theta}{2}\cos\frac{\theta}{2}$$

and $$1-\cos\theta=2\sin^2\frac{\theta}{2}$$

$$\frac{dH}{df}=2\frac{bw}{\pi}\sin\frac{\pi f}{w}\left[2\pi\frac{f}{w}\cos\pi\frac{f}{w}-\sin\frac{\pi f}{w}\right]$$

For a maximum value of H, the quantity in the square bracket is zero, and this means that

$$\tan\frac{\pi f}{w}=2\frac{\pi f}{w}$$

This equation cannot be solved directly, but examination of the trig. tables shows that it is satisfied if

$$\frac{f}{w}=1.162 \text{ approximately},$$

or if $$f=0.37w.$$

Inserting this value of f in (25), it is found that the maximum value of the mean height is

$$H_{max}=\frac{b}{2{,}324}\left[1+0{,}684\right]=0{,}723b,$$

occurring at a distance $0.37w$ from the start.

If the values of H be plotted for a range of values of f, the curve is found to be a sine curve with constantly diminishing amplitude, and the value $H=0.723b$ at $f=0.37w$ is the crest of the first and highest wave.

(To be continued.)

BRITISH LONG DISTANCE LISTENERS' CLUB

Radio Troubles and Problems Are Common to Many Members; Therefore This Month We Deal with One of the Subjects which Appears to be Most General

ONE of the commonest troubles met with in receivers is a background of crackles accompanying every programme. It must be realised at the outset that normal atmospheric disturbances can give rise to this trouble, and local electrical apparatus or machinery may also cause crackles, and thus the listener often puts up with the trouble in the mistaken belief that it is beyond his control. Unfortunately, normal atmospheric disturbances of the type mentioned cannot be cured, and the more powerful the receiver the more prominent become these noises. It is a simple matter,

Fig. 1.—A broken strand in an aerial can cause crackling noises.

Fig. 2.—Badly soldered flex leads are a common cause of crackling.

however, for the listener to ascertain in a few moments whether the trouble comes from an outside source or is due to a defect in his equipment, and all that is necessary for this purpose is to disconnect both aerial and earth leads. Signals will naturally cease, and if at the same time the crackling noises also cease then a cure is probably beyond you, or some special type of aerial will have to be employed. We are not concerned with this at the moment, but rather with the generation of the noises in the set, although perhaps it would be as well to remember that a defective aerial or earth lead may be the cause of the trouble. Therefore, the first step, if removal of the aerial and earth stops the noise, is to replace them singly. Should one of them alone restore the noise, then carefully examine that lead from one end to the other and search for a defect.

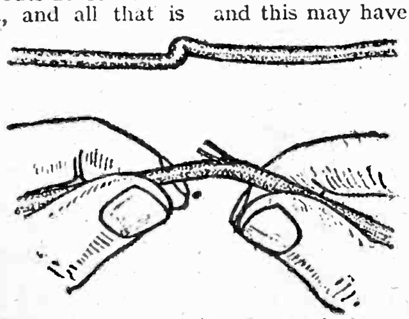


Fig. 3.—Kinks in flex often result in a broken strand which may be located as shown here.

Broken Strands

IF a stranded wire is used in either position the noises may be caused merely by a single broken strand. The two ends at the break, when vibrated, will make and break, and the result is a crackle in the loudspeaker or headphones. A similar fracture in a battery lead, or in fact in any flexible lead, will give rise to the same trouble, as will be explained later. If the earth wire is bare, or an insulated covering is bared in one place, and it comes into contact with an earth point, it may also result in a crackle should the point of juncture be made and broken. If the earth lead from the receiver is attached to a gas or water pipe and this runs through the house, there is also a possibility of crackling background noises being produced if the pipe in question touches any other pipe, but it may also be found in such a case that a reduction in volume will accompany the crackles, due to the effects of the tuning shift resulting from the doubling of the earth connection.

Faulty Components

IF, as already mentioned, removal of the aerial and earth make no difference to the noises, then the source will be found in the receiver or speaker and they must accordingly be examined stage by stage. It is a simple matter to connect 'phones in the detector stage to cut out L.F. stages, and to transfer the aerial to a detector stage to cut out H.F. stages, and this will, in most cases, enable the stage in which the fault exists to be located. On the other hand, meters will sometimes assist as they will show the source of the crackles by indicating a fluctuating current. It is not always possible, however, to see the results of an intermittent connection on a meter, as in some cases the L.F. circuit may be the source of the trouble, and no current may be present. It must be assumed, however, that in the majority of cases the crackles will only be caused when the intermittent circuit is one in which a current is flowing. This narrows down the tracking of the trouble, and the first components to be suspected are fixed or variable resistors, chokes and transformers. Condensers are hardly likely to give rise to the trouble, except in the case of certain types of tubular fixed condenser where a leading-out wire is provided, and this may have come partly adrift from the internal plates. In some cases the faulty item may be identified by gently tapping each component in turn, but some types of fixed resistor, for instance, will not have any loose part which will indicate by tapping that they are the cause of the crackles.

Connections

AMONG some of the unsuspicious details which may be mentioned as causing crackling, we will quote a few taken from our laboratory notes. A very common cause is where a flexible lead has been soldered to the tag of a component. It is difficult to make a really sound soldered connection to old flex, or some types of flex, owing to the fact that the sulphur in the rubber has made the wire dirty and

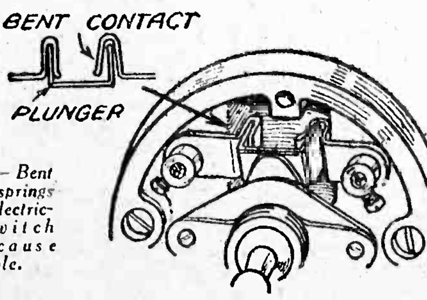


Fig. 4.—Bent contact springs on an electric-light switch often cause trouble.

prevented it from taking the solder. Each strand has to be scraped or otherwise cleaned in order to make a clean connection, and it has been found that a blob of solder will sometimes run right round such a joint, but one or more wires inside the joint will not be attached and they will vibrate inside the solder and thus give rise to the crackling noise.

In other cases a dirty bolt or nut on the chassis will vibrate by speaker or other sounds impinging on it and this will cause an intermittent earth connection which will cause crackles, although as mentioned in the case of the double earth this sometimes leads to tuning shift.

Plugs and Sockets

PLUG and socket connections, or any similar arrangement where electrical continuity is provided by touching metallic parts, may be the source of the trouble, and therefore these should receive attention. These general rules cover practically every part of a standard receiver, and before concluding it may be mentioned that there are two or three outside sources which can give rise to crackles, although not connected with the receiver. One very difficult case which was recently experienced was where crackling was noticed intermittently. The usual procedure was adopted, namely, removal of aerial and earth, but the noise continued. When the detector stage alone was in use the noise was still there and every component and the valve was tested without success. The mains section was substituted, and after each component had been replaced, in case of some fault which was not revealed by standard test methods, it was found that it still existed. Obviously, then, it was outside the set, and eventually it was found that an electric-light switch was causing it. The spring arm into which the contact presses was opened, and vibration from passing traffic caused the contact to be made and broken in such a manner that before it could come to rest from one passing vehicle, another had passed, and this produced a continuous crackle. The small arc which resulted radiated sufficient energy to be picked up by the wiring of the detector stage in the same room, and this was eventually proved by placing the stage in a metal box, when all noise stopped. The contacts in the switch were, of course, made good, and the trouble was cured.

Resistance Colour Code

IT may seem surprising that many members are not familiar with the colour code used to indicate the values of resistors, but according to the number of inquiries we receive on the subject, it is certainly true. Every constructor, and especially every member of the B.L.D.L.C., should know how to apply the code and, of course, how it is used in connection with condensers, mains transformer leads and battery cords. We cannot deal with the complete subject on these pages, therefore we would draw attention to the "Radio Engineer's Vest Pocket Book," price 3s. 6d. or by post 3s. 9d. which contains, together with other much valuable data which should be within reach of every radio amateur, complete information concerning colour codes and their application.

For fixed resistors the code consists of three colours, and although these are sometimes given in the form of three bands or dots on the component the standard way which is most generally adopted is to colour the entire body of the component for the first colour, one of the tips for the second colour, and to display the third in the form of a dot or band on the centre of the body. This is the order in which the colours are read, and the colours in each case stand for the figures from 0 to 9. The complete reference table is as follows:

Colour	Fig.	No. of Noughts.
Black	0	None
Brown	1	0
Red	2	00
Orange	3	000
Yellow	4	0000
Green	5	00000
Blue	6	000000
Violet	7	
Grey	8	
White	9	

An example will make the scheme quite clear. Suppose we have a resistance with a red body, a black tip and an orange spot or band. Then the value will be 2 (red body) followed by one nought (indicated by the black tip), followed by three noughts, or in other words 20,000 ohms. If it is found that a resistance does not bear a dot or band on the body it indicates that the dot is of the same colour as the body.

Ganging Coils

WHERE it is found difficult to gang two or more coils, if the coils and condenser are of the type designed to match and gang accurately, the inter-circuit wiring whould be suspected. The stray capacities introduced in this way may in some cases upset matching but may be balanced by connecting one of the midget padding condensers across the low section. Tests will, of course, have to be made to find which section is low, and a suitable trimmer joined across the tuning condenser —not across the coil.

PRIZE PROBLEMS

Problem No. 443.

JONES made a three-valver of the 1-V-1 type. The output obtained from the local transmitter was too great so he decided to use a variable-mu valve in place of the straight S.G. he had in the H.F. stage. He disconnected the earth end of the first coil from the earth line and connected it to the moving arm of a 50,000 ohm potentiometer, the side terminals of which were connected to earth and the 9 volt (negative) socket of a G.B. battery. He then connected a 0.1 mfd. condenser between the earth terminal and the earthy end of the coil—in the usual manner—but he was very surprised to find that, although good control was obtained on the long-wave band, no control could be effected when the receiver was switched over to the medium waves. Where had Jones slipped up?

Three books will be awarded for the first three correct solutions opened. Entries should 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. 443 in the top left-hand corner, and must be posted to reach this office not later than the first post on Monday, April 19th, 1943.

Solution to Problem No. 442

When a simple autodyne converter is used, all stations will be heard at two settings of the tuning dial, corresponding to the difference in frequency both above and below the station setting. Hawkins, therefore, was wasting his time trying to cut out one of the tuning points of each transmission received.

Only one reader successfully solved Problem No. 441, and a book has accordingly been forwarded to him. T. P. Evans, Mena House, 16, Pentreedyn Street, Machynlleth.

Impressions on the Wax

Review of the Latest Gramophone Records

TWO 12in. records released by Columbia this month are representative of what good modern recording can offer. One, in particular, namely *Columbia DX*1110, on which is recorded Howard Barlow conducting the Columbia Broadcasting Symphony Orchestra playing "Beautiful Galathea" Overture (Die Schöne Galathee)—Suppé—is outstanding both in a musical and technical recording sense. The second record, *Columbia DX*1109, is by Harriet Cohen, who plays so admirably two modern pianoforte compositions by Sir Arnold Bax, "A Hill Tune" and "A Mountain Mood." Two delightful pieces having a strong lyrical feeling which reveal the composer's complete understanding of tonal subtleties.

From the DB 10in. records I recommend "Dancing In the Dark" and "With a Song in My Heart," played by André Kostelanetz and his Orchestra on *Columbia DB*2107.

The Albert Sandler Trio, on *Columbia DB*2106, have made a fine recording entitled "The Student Prince"—Selection—and it is well worthy of special mention. Part 1 introduces "Deep in My Heart," "Serenade," "Drinking Song," and these are followed —on Part 2—by "Come, Boys," "Waltz (Just We Two)," and "Serenade."

Turner Layton has two more numbers to offer, namely, "As Time Goes By"—featured in the film "Casablanca"—and, on the other side of the disc, "You Were Never Lovelier," which is featured in the film of the same name. Two rather attractive numbers, performed in true Turner Layton style, and they are to be heard on *Columbia FB*2901.

Celia Lipton has also selected a song from the last-mentioned film, but her choice is entitled "Dearly Beloved," which she links up with "For Me and My Gal," which is also another hit from the films. Celia, who is accompanied by an orchestra under the conductorship of Phil Green, gives a fine performance.

Carroll Gibbons at the piano offers another selection of popular tunes in "Carroll Calls the Tunes" (No. 23) series, and, as usual, I have added the record which, by the way, is *Columbia FB*2896, to my stock and recommend it to all who enjoy the restfully lazy playing of this popular artist. He introduces "May I Have the Next Romance With You?" "There Isn't Any Limit to My Love," "I'm in a Dancing Mood," and "Everything's in Rhythm With My Heart."

On *Columbia FB*2903 we can hear Carroll and the Savoy Hotel Orpheans playing "Let's Get Lost" and "Happy Go Lucky," two good foxtrots which should be included in every dance record section. Both the tunes are featured in the film "Happy Go Lucky."

Felix Mendelssohn and his Hawaiian Serenaders have made a good recording of "Dinah" and "Nobody's Sweetheart" on *Columbia FB*2895.

H.M.V.

MAGGIE TEYTE—soprano—has made a superb recording, in French, on *H.M.V. DA*1831, of "Nell" and "Lydia" (de Lisle-Fauré). She is accompanied on the piano by Gerald Moore. Highly recommended.

Webster Booth is responsible for another fine vocal record, namely, *H.M.V. B*9315, on which he has recorded —in first-class style—"Impatience" (Schubert) and "On Wings of Song" (England-Mendelssohn). Two good songs well sung.

Reginald Foort, on his Giant Moller organ, has made a recording, on *H.M.V. BD*1034, of "Waltzing With Strauss" (two parts), in which are introduced "Blue Danube," "Vienna Blood," "Night Birds," "Artist's Life," "The Kiss," "Lagoon," "Wine, Women and Song," "Tales from Vienna Woods," "Voices of Spring," and finishes with a spot more of the "Blue Danube." Personally, I thoroughly enjoy a selection of this type, and as the one in question is performed in such a masterly manner, it has double appeal and calls for strong recommendation.

"Hutch" has selected for his contribution this month "Starlight Souvenirs" and "Daybreak." The record is *H.M.V. BD*1033.

The New Mayfair Orchestra, under the direction of Debroy Somers, has made a fine recording of "Vienna Bon-Bons" and "Maidens of Baden," on *H.M.V. B*9316. These are two waltzes of attractive composition, and I think the record will be welcomed and enjoyed by all.

Here are a couple of good foxtrots, played in true R.A.O.C. Blue Rockets Dance Orchestra style, which I recommend to all dance enthusiasts. They are "My Melancholy Baby" and "Easter Parade," and you can hear them on *H.M.V. BD*5790.

"Sophisticated Lady" linked with "Star Dust" are the titles of the two numbers sung by Dinah Shore, on *H.M.V. BD*1035. The first one, which as all rhythm fans will know, is by Duke Ellington, and Dinah sings it in a pleasing blues style. She is most ably supported by Henry Levine and his Dixieland Octet. The second number, "Star Dust," is rendered in recitative fashion, at least the verse, and she introduces that rather fascinating gliding effect from high to low notes, a style which is characteristically her own. She is accompanied by Paul Laval and his Woodwindy Ten. It will be remembered that both of the bands in this recording have for so long played in Dinah Shore's N.B.C. programmes of the Chamber Music Society of Lower Basin Street.

Joe Loss and his Orchestra make a hit with his latest recording, which is on *H.M.V. BD*5792. He gives a fine performance of "Mary's a Grand Old Name" and "Yankee Doodle Boy;" a foxtrot and quick-step respectively.

Parlophone

AT the top of the Parlophone list I am placing *RO*20519, as this is the number of the record on which is recorded "If You Are In Love" and "There Are Angels Outside Heaven," two fine numbers from "Old Chelsea." The first is sung by Nancy Brown and Richard Tauber, and the second by Carole Lynne, Nancy Brown and Richard Tauber. Both recordings are fine examples of Tauber's skill as a singer and composer, and he is most ably supported by artists possessing great capabilities. A fine record.

The remaining records on my list are for dance enthusiasts, and for those followers of the "Tin Pan Alley Medley" series there is No. 53, which is recorded on *Parlophone F*1966. As usual, Ivor Moreton and Dave Kaye, on two pianos with string bass and drums, pick the right numbers necessary for a good medley. In No. 53 they introduce "You Are My Sunshine," "(I've Got a Girl In Kalamazoo," "My Devotion," "Moonlight Becomes You," "Daybreak," and "Manhattan Serenade."

Geraldo and his Orchestra give us some first-rate orchestration in the presentation of "Nain, Nain" and "When the Lights Go On Again," two good pieces in foxtrot tempo. These are on *Parlophone F*1968.

The 1943 Super Rhythm-Style Series are most popular among those who like "hot" modern interpretations; on *Parlophone R*2864—which forms Nos. 67 and 68 of the series—there are two numbers played by Benny Goodman and his Orchestra, which I am sure will meet with great approval. Benny has selected "Six Flats Unfurnished" and "Why Don't You Do Right?"

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).

"P.W." in New Zealand

SIR,—I notice that in the November, 1942 issue of PRACTICAL WIRELESS you invite letters from remote parts of the world. Well, New Zealand isn't by any means remote, but it is quite a long distance away from London.

I get your magazine regularly, and have enjoyed it ever since I received my first copy in 1939. I was rather disappointed when you commenced publishing the magazine monthly, but the standard definitely went up. I think most of your readers are waiting till "victory," when weekly publication will return.

It is a pity that your magazine takes so long to get out to New Zealand (I have just received the November issue), but I suppose we are lucky to be able to get it at all.

In New Zealand and Australia, American type valves are most commonly used. As your circulation must include a good few subscribers in these countries, as well as in Canada and U.S.A., could you not give American type valve alternatives in your descriptions of receivers, amplifiers, etc.? Such valve types as AC/VP1, ML4 and AC_2/PEN are unobtainable in New Zealand.

The matter printed in PRACTICAL WIRELESS is of a high standard, and I hope it will be continued.—W. R. HAMER (Palmerston North, New Zealand).

Reception on Crystal Sets

SIR,—I have observed, in past issues that I have received, references to reception on crystal sets at speaker strength. When I first became interested in wireless construction, early in 1938, the first few sets I built were all crystal sets, and I found that, using a large diameter coil, a "Red-diamond" detector, and an outdoor aerial about 50ft. long and 25ft. high, signals from Midland Regional and Droitwich National were strong enough to operate an old balanced-armature speaker to be fully audible in a fairly large bedroom. The location was about two miles south of Birmingham. However, after this circuit had been dismantled for some months, a similar circuit was made up, and results were definitely inferior to those first obtained. Thinking the detector may have been damaged whilst lying in the junk-box, I bought another, but could obtain no improvement. The same aerial and earth system were used, and both were in sound condition. Perhaps another reader will be able to suggest a reason.

The coupling coils on standard 6-p in S.W. coils appear to be only satisfactory when the aerial is only about 10 or 12 feet long; a longer aerial always caused erratic reaction in any S.W. set I built.—M. SHIRLEY (M.E.F.).

An Experimenter's Activities

SIR,—I am a keen radio enthusiast, and have recently returned to Britain after spending a few years in New Zealand. I was delighted to find, on my return, that PRACTICAL WIRELESS was still going strong, and I get it every month. I think the new size is, if anything, an improvement, and it is still full of interesting reading.

My "den" is a corner of my bedroom, where I have a work-table, and cupboards and drawers to hold parts, tools, etc. I spend most of my spare time making up circuits and experimenting with them. I have a permanent unit which consists of an A.C. power supply, and a 3-stage receiver (untuned R.F. pentode, triode detector and triode output). The only controls are six push-buttons and a volume control (reaction is pre-set). Two of the buttons give me "Home" and "Forces," the third and fourth convert the circuit to a 1- and 2-stage amplifier respectively; the fifth switches the power to outlet sockets; and the sixth is "off." To switch on I simply push the appropriate button. There is also a 'phone jack, which cuts out the speaker. The unit is fairly compact, measuring $10\frac{1}{2}$in. $\times$ 5in. $\times$ 7in. overall.

I have also a 2-valve (o-v-1) battery receiver, using all-wave plug-in coils, which gives its maximum performance on only 9 volts H.T. This is due to the fact that I use two American type 49 battery tetrodes, and for these a dry cell and a grid-bias battery are the only batteries needed. This type of receiver is very popular in New Zealand, where thousands are in regular use.

I recently carried out some experiments with a crystal set, and made up a receiver using plug-in coils. To my surprise, I was able to hear several of the louder short-wave transmissions clearly, principally on 49 and 31 metres; yet my aerial and earth are by no means good. I should be interested to know if anyone else has had any experiences with a crystal set on short waves. —P. D. THOMAS (Ayr, Scotland).

Simple S.W. One-valver

SIR,—Recently I built your simple short-wave one-valver (P.W.88), and, although I had not all the parts as prescribed, I am very pleased with the performance. Some of the first log of Americans are WBOS, WSEO, WBL, RWL, and others at loud speaker strength, as I coupled it up with my all-electric receiver via a transformer. I get very good reception of Radio City, New York, NBC. I am using a 10ft. indoor aerial. Recently I received Radio National Rio de Janeiro (Brazil) on 25.6 metres with very slight fading intervals. They stated they used directional beam to England.—R. WRIGHT (West Hartlepool).

Yugo-Slav Freedom Station

SIR,—With reference to your Stranraer correspondent's letter in the March issue of PRACTICAL WIRELESS concerning the reception of the Yugo-Slav Freedom Station, I recently received the station which he mentions on the 25-metre band, the announcer describing activities of Yugo-Slav patriots. The set is an o-v-1 of my own construction.

Also, I should like to know the whereabouts of a station calling itself "The Voice of Free India," which broadcasts at 4.30 p.m. (approximately) every day on twin wavelengths of 26.16 and 31.20 metres.—P. DEVLIN (Belfast).

Replies to Queries

Reduction of Mains Voltage

"I have an electric soldering iron made to work on 110 volts A.C. and I wish to know if there is any way it can be used (without having to rewire it) on 230 volts A.C. If so I would be glad if you would enlighten me on how to go about it."—J. T. B. (Lancs).

THE safest method to adopt would be to use a step-down transformer between the mains supply and the soldering iron.

Messrs. Premier Radio, of Jubilee Works, 167, Lower Clapton Road, London, E.5, might be able to supply a suitable component.

L.F. Choke Formulæ

"I am trying out some tone control circuits for my moving-iron gramophone pick-up, and wish to construct two tone control chokes of inductance 0.54 henry and 0.15 henry respectively. If these values can be obtained by winding on a plain air-cored former, could you give me a formula for deriving the diameter and number of turns of wire required in each case?

"Or, alternatively, perhaps you could indicate the approximate dimensions for the particular case I have mentioned?"—P. L. B. (Lanarkshire).

IT is difficult for us to provide formulæ connected with the design and construction of L.F. chokes, as the subject is rather comprehensive and, in view of the complicated calculations involved, it is usually better to make use of tables, or a series of Abacs, to determine the governing factors. Bearing in mind the inductance you wish to obtain, we think it would be better if you considered using an iron core choke, otherwise the winding is bound to be rather bulky. As a rough guide, we would mention that for normal tone control purposes, a choke having an inductance of 3 henries tapped at suitable points is very useful. A component such as this can be constructed around a ½in. diameter laminated core, using a bobbin 1½in. in length, fitted with 1½in. diameter cheeks; 3,000 turns of 32 S.W.G. enamelled wire, tapped at every 500th turn, will be required.

"Component Details"

"In the January issue of 'Practical Wireless' a most interesting A.C./D.C. set appeared, and as I am keen on building it, will you answer the following queries:

"1. What is B, at back of speaker?

"2. What is A, at back of speaker?

"3. 8D2 is not listed, what other substitute?

"4. Resistances are to be ¼ or ½ or 1 watt?

"5. What length of line cord, and can same be knotted inside of chassis so as to stop it being pulled out, and how many ohms per foot?

"6. Can the cardboard type of 8+8 mfd. be used instead of the can type now in this district unprocurable?

"Can you supply the back Nos. 436 and 438, which would assist me a great deal?"—Mr. M. (Nr. Bedford).

THE items marked A and B are small strips of insulating material used to anchor the sockets of the terminals to carry the connections shown on the diagram.

According to our list, the Brimar Valve 8D2 is still listed. Alternative types are—the Mullard SP13C, or the Cossor 13SPA.

All the resistances, excepting the mains-dropping component, can be of the 1-watt type.

The length of line cord will be determined by the types of valves used in the heater circuit, and the type of line cord. It is not advisable to knot it.

It will be in order to use the cardboard type of condenser block.

The back numbers you require are out of print.

Coil for Parvo Portable

"I recently purchased blueprint No. P.W.77, 'Parvo Flyweight Midget Portable.' On looking for the leads to the various batteries, I find only one lead for the grid bias, that from the L.F. transformer to G.B.—. I can find no lead for G.B.+. I also notice that no G.B. battery is called for in the list of components. Can you also inform me as to where I can obtain a 'Parvo' aerial coil?"—K. D. (Leicester).

THE G.B. positive connection should be made to the L.T. or H.T. negative part of the circuit. Only one negative grid bias lead is required, and that is connected to one side of the secondary of the L.F. transformer, and, of course, the appropriate socket in the G.B. battery.

The specified coil is now unobtainable; therefore, we can only suggest that you modify the circuit slightly to enable you to use any midget dual-range coil which you might now be able to secure.

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.

Operating a Car Radio off A.C.

"I wish to run a Phillips 6-volt car radio (type 247B) from 220 A.C. mains, and should be obliged if you could inform me where I can obtain the necessary converter, or if I can obtain instructions for making same, and list of parts required."—J. M. D. (S.E.9).

MESSRS. Electradix Radios, of 19, Broughton Street, Queenstown Road, London, S.W.8, might be able to supply a suitable converter, but if you should experience any difficulty in obtaining such apparatus then we would suggest that you consider using an L.T. charger in conjunction with a 6-volt accumulator for operation of the set. The charger could consist of a suitable Westinghouse metal rectifier and a mains transformer, the purpose of the unit being to maintain the accumulator in a fully-charged condition, thus giving you in effect an all-electric operation.

Energised Speaker with A.W.453

"I am constructing your A.C. short-wave two-valver (A.W.453), and I wish to incorporate a mains energised speaker with a field resistance of 7,500 ohms. How can I do this, providing I use a larger mains transformer, say, 350-0-350 v. 120 m/a?"—D. G. C. (Surrey).

IF you use a larger mains transformer and rectifying valve, i.e., one capable of giving 350 volts at 120 milliamps, you could try the speaker in parallel across the H.T. supply.

Had the resistance of the field winding been lower, say, in the region of 2,500 ohms, then it would have been better to connect it in series with the H.T.

The "Home Service Two"

"With reference to the 'Home Service Two,' described in your issue of 'Practical Wireless,' September 23rd, 1939, I would be very grateful if you could supply me with constructional details of the tuning coil of the same. You recommend a B.T.S. 'One Shot' inductor type. I have the rest of the components but am unable to obtain a coil anywhere.—P. B. (Milbourne).

WE would advise you to make use of a suitable plug-in coil such as that obtainable from Messrs. Premier Radio, of Jubilee Works, 167, Lower Clapton Road, London, E.5. If, however, you wish to wind one yourself, then we would suggest 79 turns of 28 S.W.G. enamelled wire on a 1½in. diameter former for the grid winding; 20 turns of 32 S.W.G. for the primary winding, and approximately 40 turns of 32 S.W.G. for the reaction winding. The primary section can be wound over the grid coil near the earthy-end, and the reaction winding should be spaced, say, ⅜in. from the earthy-end of the grid coil.

A.C. Set on D.C. Mains

"I have a three-valve set for A.C. mains, but find the power is D.C. 220 v. Can this set be converted to D.C., and if so, how?"—A. B. (Birmingham).

IT is not an easy matter to convert an A.C. receiver to D.C. operation, as it means using high voltage filament valves and wiring them in series, and incorporating a suitable resistance between the mains supply and the heater circuit to reduce the mains voltage. In normal times, it was possible to obtain rotary converters to convert the D.C. to A.C., and these were simple to use as they did not involve any alteration to the set.

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SLEEVING. 3½d. per yard length. 1 doz. lengths, 3/-. Braided sleeving, 8d. per yard length, 7/- doz. lengths.
T.C.C. Tubulars, 0.1 mfd., 7d. each, 6/6 doz., also .01 mfd at 6d. each, 6/- doz.
CONNECTING WIRE. Heat resisting, tinned copper, as used by Government, 6d. coil of 12 ft.
TRIMMERS, 50 m.mfd., 3d. each. Also 250 m.mfd., 3d. each.
VOLUME CONTROLS, less switch, new, ½ meg., 3/3 each.
VOLUME CONTROLS, few only, various sizes, some with switch, second-hand, 1/- each.
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(Continued in column 3.)

F.H. WILSON

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