A SHORT WAVE CONVERTER

MICROPHONES: TYPES AND CONSTRUCTION

Practical Wireless

9D EVERY MONTH

Editor F. J. CAMM

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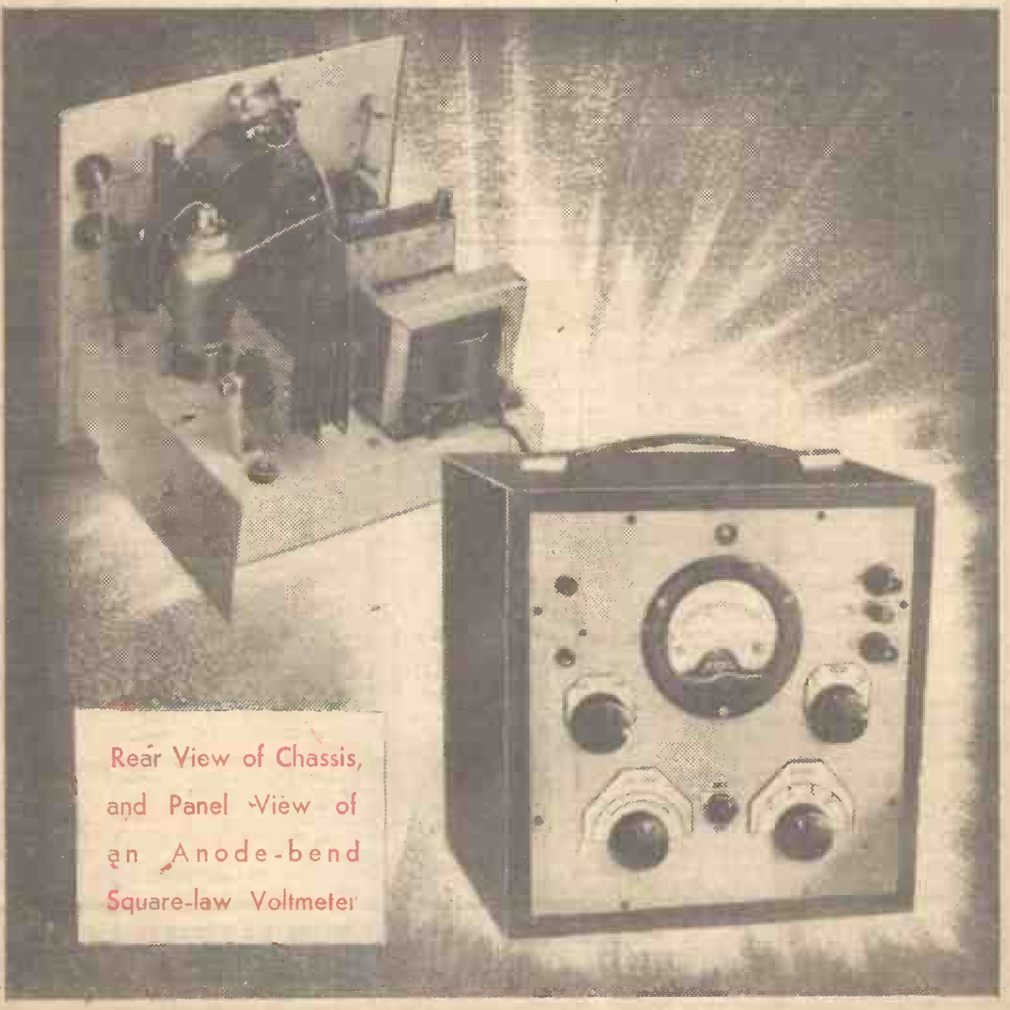

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Practical Wireless

and PRACTICAL TELEVISION

11th YEAR OF ISSUE

EVERY MONTH

Vol. XIX. No. 445. JULY, 1943.

Editor F. J. CAMM

COMMENTS OF THE MONTH — BY THE EDITOR

The Defence Regulations—A Warning

AS our readers know, it is quite illegal under the Defence Regulations for anyone to own or to operate a wireless transmitter. In the early days of the war all amateur licences were withdrawn, and the apparatus owned by those who operated amateur transmitting apparatus was confiscated by the Post Office. It is also illegal to have a radio installed in any car. It is, in fact, illegal to *carry* a wireless receiver in a car. Great publicity has been given to the Defence Regulations as they apply to the operation of transmitting sets or any receiver capable of being used as a transmitter.

The important point behind these Regulations is to prevent news leaving this country which might be of value to the enemy. An enthusiastic amateur who through ignorance may be operating a transmitter and radiating messages which to him may appear to be innocuous can, without knowing it, give the enemy valuable information. Our enemies have a large staff engaged in listening on all wavelengths, and particularly on those bands used by amateurs. A message in itself may seem harmless enough, but it may enable the enemy to piece together, in conjunction with other messages received, a picture of what may be happening in a particular district. It is not only in relation to leakage of information that the regulations are rigidly enforced. Such messages quite often interfere with Service communications.

This matter has been brought once again into the limelight by the successful prosecution of one who, illegally operating a transmitter in this country, was convicted for the offence. Publicity was given to the case, and offenders brought before the courts after this case, may not be so leniently treated. Now that the tide of war has changed we cannot too strongly deprecate the reprehensible practice indulged in by a selfish and thoughtless few of operating these illicit transmitters. These few are aiding the enemy and ignorance of the Defence Regulations cannot be pleaded by them. Even doctors have been deprived of all electro-medical apparatus that might radiate in a manner likely to cause interference with the very delicate and sensitive apparatus used by the various branches of the Services.

Some time ago, it will be remembered, we felt it to be our duty to draw attention to the fact that members of the Home Guard were under the erroneous impression that they were empowered to build and to operate transmitters. We received a large number of letters from officers in the Home Guard, some of them countersigned by the regional officers, asking for constructional details of fairly powerful transmitters. We investigated the matter with the War Office and the Home Guard head office, and as a result we pointed out in a leading article in our issue dated October, 1942, that the Home Guard were under a misapprehension regarding the matter, and the Defence Regulations equally applied to them.

The case to which we have referred discloses that there are still wilful and irresponsible people in this country who are using valve transmitting apparatus without authority.

It cannot be too strongly emphasised that a transmitter may not be used or operated except under the direct authority of the Postmaster-General, or of the Army, Navy or Air Force authorities. We are not suggesting that our readers are guilty of this serious offence. We do, however, appeal to them for co-operation, and if they are aware of anyone who is committing the offence innocently or otherwise we hope they will take steps to see that the offence is not repeated. In this way they will be rendering valuable aid to the Authorities in the difficult task they have of tracking down those whose activities in this direction are not innocent.

In the case in question the penalty was a short period of detention. Now that we have drawn attention to the matter we are entitled to expect magistrates and the police to deal severely with any offenders brought to book.

Shortage of Scientific Workers

SIR STAFFORD CRIPPS, Minister of Aircraft Production and chairman of the Radio Board, in the course of his address to the Convention of University Radio Teachers dealt with the advances made during recent years in the science of radio communication. He stressed the need for research and development, and trained scientific personnel. He said there was an urgent need for a completely fresh outlook on the more general aspect of technical higher education. When peace came, he said, we should have to re-establish our world position by the skill of our methods of production, and the ingenuity and the intelligence of our research and our inventive work. We should need a far greater output of university-trained scientists, drawn from all sections of society, and they must be the best of all sections, freely chosen on the ground of merit alone.

Before the war, the number of university *students* in Great Britain was just half the number of whole-time *staff* in American universities, and one twentieth of the United States students. The total university income in America was £100,000,000, compared with our university income of £6,500,000. As the population in the U.S.A. is roughly three times our own, these figures mean that the U.S.A. is spending about five times as much on six times as many students. Engineering figures showed up almost as badly.

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

ROUND THE WORLD OF WIRELESS

Deaf-aid Batteries

IT is reported that the Treasury proposes to make an order shortly that purchase tax shall not be chargeable on H.T. batteries of not less than 30 volts, designed for deaf-aid appliances, and using cells not exceeding 40 by 31½ millimetres in size.

B.I.R.E. Paper

AT a member's meeting of the British Institution of Radio Engineers (London Section), held at the Institution of Structural Engineers, Upper Belgrave Street, London, S.W.1, on May 26th, Mr. S. Hill, A.M.I.E.E., read a paper on "Application of Negative Feed-back in Design Principles."

Leslie Dixon and Co.: New Address

THE above firm inform us that they have now taken more spacious premises at 214, Queenstown Road, Battersea, S.W.8, where they have a full range of their many lines on show.

Black Dyke Mills Band

ONE of the oldest brass bands in England, Black Dyke Mills Band, formed in 1811, made its hundredth broadcast on May 21st, under conductor Arthur O. Pearce (appointed in 1912). The music was specially composed and arranged.

Monkey 'Plane Spotters

TWO South African monkeys that have taken on an essential job of war work were mentioned by Cyril Watling in a recent B.B.C. overseas talk. They've got the keenest eyesight and hearing, and they give warning of approaching aircraft minutes before any human can detect them. They have to be given some training, of course, but they seem to be very bright pupils.

One of these two, called Japie, is attached to the First Division. He's now back in the Union with troops on leave. But he was all through some of the biggest battles. He did his job as a spotter so well that many German 'planes were turned back before they could do any damage.

The second monkey—named Adonis—trained every day for months, down at Haartebeestsfontein, in the Transvaal. He has never made a mistake. Even vultures flying "way up" don't fool him. If he looks up at a black speck in the sky and stays on the ground eating his nuts, everyone knows it is only a vulture. If it is a 'plane, Adonis leaves everything, scrambles to the top of a tree and keeps on screaming till it has passed out of sight.

Developments in European Service

SINCE the end of March, the schedule of European transmissions has been entirely recast. For some time past it has been felt that, in order to extend the range of listening times available to the B.B.C.'s audience in most European countries, an expansion of this Service has become necessary. After careful consideration a number of new transmissions have been introduced. Under the expanded schedule there are now 18 daily transmissions in French for France, i.e., two more than hitherto. The daily broadcasts to Germany have been increased from 15 to 17; this includes an additional programme for women. The number of daily transmissions to Italy will be 13 instead of 11. A point to note with regard to the service in English is that the afternoon transmission, "London Calling Europe," will be half an hour earlier, at 13.00 G.M.T. The period, "America Calling Europe," in our English programmes has been extended from 10 minutes to a quarter of an hour.

"America Calling Europe"

AN important item in the new expansion is an extension of the "America Calling Europe" programmes in foreign languages. Hitherto the service has been directed once daily to Italy and Poland, twice daily to France and Germany, and three times a week to Finland. In addition, there will now be three transmissions a week to Czechoslovakia, Denmark, Greece, Sweden and Yugloslavia; six transmissions a week will be directed to Rumania and four to Norway. There will be daily transmissions to Finland (as well as three times a week), and also to Portugal.

Another aspect of the expansion is the increase in the broadcasting facilities accorded to the Allied Governments. The Governments of Poland, the Netherlands, Greece and Belgium, and the French National Committee already avail themselves of periods of "free time." The Government of Czechoslovakia now has two daily periods allotted to it; the Belgium Government will have an additional daily period.

Units of the United States Army keep in touch by portable wireless while in training in this country.

Radio as a "Ferry" Service

"FOR nearly 10 years after the first Transatlantic broadcast in 1926 the spanning of oceans by radio was something of a stunt. The listener was impressed by distance. That is no longer true. Americans who sat by their radios had a better view of the Coronation of King George VI than did many who sat in Westminster Abbey. People who heard the sound of German boots on the streets of Vienna, who travelled from London to Godesberg, to Munich, with Mr. Chamberlain, who have listened to the speeches of statesmen and puppets from nearly every corner of the world for the last 10 years, have come to expect of Transatlantic broadcasting something more than stunting or Transatlantic trickery. They expect to hear not only the news and the speeches of statesmen. They expect to hear the authentic accent of their allies. They want to hear not only the news but the political, social and economic climate in which it is made. Transatlantic broadcasting is becoming more and more a job of transportation. Transporting the individual listener from his home in Maine or Idaho by saying to him: 'Look, if you were over here this is what you'd find. This is the sort of thing you would hear, see, and smell. The kind of food you would eat; the people you would meet; the books you would read, and all the rest.'" (Edward R. Murrow, on "Transatlantic Broadcasting," in the B.B.C. Year Book, 1943.)

British Institution of Radio Engineers

THE B.I.R.E. reception held at 9, Bedford Square, W.C.1, on March 30th, marked the opening of the new headquarters of the institution, which have been necessitated by the continuous growth in membership and the expansion in activities in recent years. The occasion was also noteworthy in that it commemorated the eighteenth year of the institution's existence.

Founded in 1925, and incorporated in 1932, the British Institution of Radio Engineers is a professional body existing solely in the interests of the radio and electronic engineer. Membership is confined to those who have qualified either by passing the institution's graduateship examination, or certain exempting examinations, or who by virtue of their research or other qualifications are worthy of membership. Before attaining corporate membership, an applicant must also show evidence that he is regularly engaged in a responsible technical capacity in the radio and electronic field.

Members of the institution are engaged in radio and allied work in the various branches of the Services, in research and development establishments and in the radio industry, which is playing such an important part in the war effort.

The wide ramifications of radio, now applied to war purposes for offence and defence, but in future to be a means of improving the lot of the citizen in the world at peace, make it essential that the technical status and professional interests of the radio and electronic engineer must be the concern of a body which caters solely for his needs.

Purpose of B.I.R.E.

THE British Institution of Radio Engineers was founded for this purpose and to promote the advancement of radio and electronic science; its steady growth is evidence that its objects are being achieved. Further information on the history and development of the institution may be obtained from a leaflet.

The institution is to-day honoured by the presence of many leaders in the fields of radio research, industry, education and the radio branches of the Services.

Among those present at the reception were the following:

Mr. P. Adorjan; Air Vice-Marshal R. S. Aitken; Mr. J. L. Baird; Mr. W. G. Bass; Mr. F. G. Montfort-Bebb; Mr. L. D. Bennett (Philco Radio and Television); Lord Brabazon of Tara; Mr. F. Brundrett (D.S.R., the Admiralty); Mr. A. Burns (Masteradio); Major-General St. J. D. Arcedeckne-Butler; Lord Cherwell; Mr. H. de A. Donisthorpe; Mr. S. S. Eriks (Philips Lamps, Ltd.); Mr. V. Z. de Ferranti; Mr. G. R. Fountain; Captain Sir Ian Fraser; Lt.-Colonel W. French; Mr. P. Good (British Standards Institute); The Mayor of Holborn; Mr. N. S. Hecht (M.A.P.); Mr. A. Hubert (Radio Belgique); Group Captain D. H. Johnston; Mr. S. R. Mullard; Mr. F. H. McCrea; Sir Robert McLean; Mr. M. MacQueen; Mr. A. McVie; Mr. W. J. Nobbs; Lt.-Colonel P. A. O. Northey; Colonel G. D. Ozanne; Dr. C. C. Paterson; Mr. W. C. S. Phillips (Borough Polytechnic); Mr. E. J. Power (vice-chairman of the R.M.A.); the Secretary of the Radio Manufacturers Association; the Secretary of the Radio and Television Retailers Association; Mr. E. T. A. Rapson; Mr. J. W. Ridgeway; Dr. James Robinson; Mr. Edward E. Rosen; Mr. E. W. Salt, M.P.; Sir Louis Sterling; Lord Strabolgi; Professor G. P. Thomson; the Secretary of the British Valve Manufacturers Association; and Sir Robert Watson-Watt.

I.E.E. Papers

AT a meeting of the Wireless Section of the Institution of Electrical Engineers, held in the Lecture Theatre of the Institution, Savoy Place, Victoria Embankment, London, W.C.2, on May 5th, Mr. H. J. Findon read a paper on "The Frequency Synthesiser."

At an informal meeting of the Wireless Section of the Institution, held at the same place on May 11th, a discussion on "Factors Determining the Choice of Carrier Frequency for an Improved Television System" was opened by Mr. B. J. Edwards.

E.M.I. Appointment

SIR ALEXANDER AIKMAN has been appointed deputy chairman of Electrical and Musical Industries, Ltd. He joined the board early in 1941.

In connection with the recent convention of university teachers of radio in London, an exhibition was arranged of Army and R.A.F. Some leading manufacturers of radio equipment also visited the exhibition, which was held on the outskirts of London. Our illustration shows Dr. J. A. Harrison, commandant of the Radio School, talking to the quartermaster of the school.

Microphones: Their Types and Characteristics

Construction and Principles of Operation Explained. **By L. O. SPARKS**

ALL types of microphones are solely concerned with the conversion of sound energy into electrical energy; most of them are actuated by the *pressure* of the sound waves, the unit for such measurements being 1 dyne per square centimetre. It should, however, be noted that a sound pressure of 10 dynes per square centimetre is frequently used for certain types of instrument. There is an alternative method of measurement which is concerned with the *velocity* of a particle of air as the sound waves radiate from their source, and a microphone which depends for its operation on the *velocity* rather than the *pressure* of air will be described later.

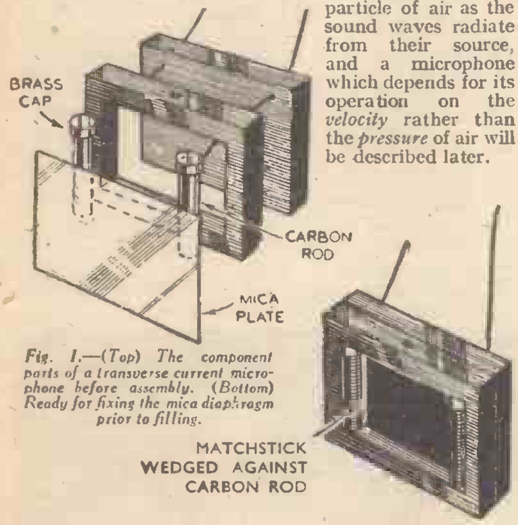


Fig. 1.—(Top) The component parts of a transverse current microphone before assembly. (Bottom) Ready for fixing the mica diaphragm prior to filling.

The names given to these two methods of measurement provide the two classes into which microphones can be divided, namely, *pressure* and *velocity* operated, and as the former is the more widely used we will consider the types coming within that class first, but before so doing, further division is necessary. For all practical purposes it is best to think of microphones in two groups: (1) low impedance, (2) high impedance. In the first group we can place the various types of granule or carbon instruments, the velocity—which is also widely known as *ribbon*, owing to its construction—and the moving-coil or dynamic microphones. The second group embraces the crystal and condenser types, the former being still further divided into "cell" and "diaphragm" models.

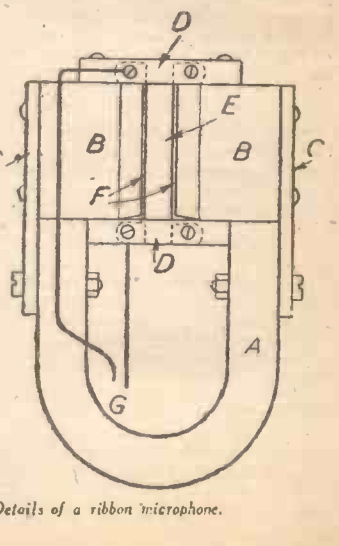
Low Impedance

In the low impedance group the carbon types of microphones are the most common. Without going into too much detail, we can split these into, say, two sections: those which make use of a metallic or carbon diaphragm and those which employ a diaphragm of mica or other similar non-conductive material. The former depend for their operation on carbon granules or shot varying the resistance in an electrical circuit formed between the back of the microphone body and the diaphragm, the carbon granules or shot being sandwiched, so to speak, between them. A low-tension D.C. voltage is applied through the primary of a suitable transformer, or, in some cases, through the winding of a telephone earpiece, to the back plate and the diaphragm. Sound waves cause the latter to vibrate, and this produces movement among the granules or shot which, in turn, causes the resistance, and likewise the current, to vary in sympathy with the original sound. The output of such instruments is high, and they are usually very sensitive, but, unfortunately, the quality of reproduction is relatively poor and inclined to be very "peaky."

Transverse Current

This type is undoubtedly the best in the carbon range. It is pressure operated, and depends on its non-conducting diaphragm vibrating in sympathy with the sound waves, and varying the resistance of a layer of very fine carbon granules which fill, or nearly so, the space between two carbon rods. Fig. 1 shows the fundamental component parts, and, incidentally, how a simple, cheap and effective microphone can be made. The current, in this type of instrument, flows from one carbon rod to the other, i.e., at right-angles to the direction of vibrations of the diaphragm, and the requisite low-tension is applied via the primary of a suitable microphone transformer. The output of a transverse current instrument is much lower than the other carbon types previously mentioned, but its frequency response is very definitely superior; in fact, for most general purposes a well-made instrument is quite satisfactory.

The main troubles with any of the carbon group of microphones are their susceptibility to "blasting"—i.e., unpleasant distortion during loud passages in music or speech—and "microphone howl." The latter can, of course, be experienced with any type of microphone, and it is not necessarily a fault of the design, but the more sensitive the instrument the more likely is it to be experienced, and, consequently, more care must be taken to prevent feed-back between input and output so far as sound is concerned.



A.—"U"-shaped magnet.
B.—Pole pieces.
C.—Fixing strips for B.
D.—Fixing clamps of insulating material.
E.—Aluminium strip or ribbon.
F.—Very narrow gap between E and B.
G.—Output connections.

Fig. 2.—Details of a ribbon microphone.

Velocity of Ribbon Microphone

We have seen that this type of microphone is operated by the volocity rather than the pressure of the air, and it may, therefore, seem out of place to introduce it at this stage when we are considering those in the latter group. The reason for so doing is because it comes in the low impedance class. Stripped of all refinements, this type of instrument consists of a small strip or ribbon—likewise the name usually given to it in this country—of aluminium, having a thickness of approximately .0001in., suspended by means of insulated supports, in a strong magnetic field. The latter is normally provided by a "U" or suitably shaped permanent magnet, to the pole-pieces of which have been fitted correctly formed metal extensions to ensure a gap of the right width and a concentration of the lines of force.

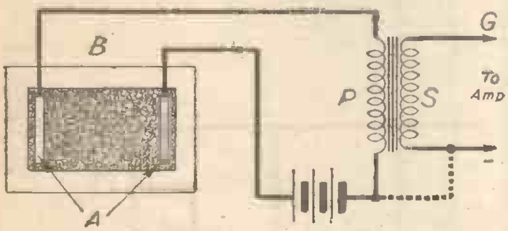
A very simple arrangement is shown in Fig. 2. This uses one "U"-shaped magnet, but if two are available they can be clamped together, with like poles opposite each other.

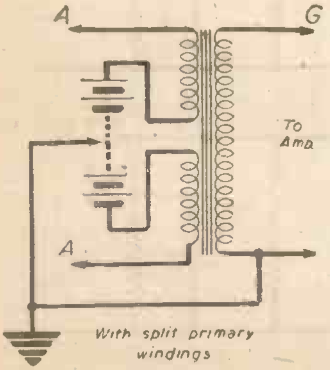
The output from the microphone is taken from each end of the aluminium, consequently the system has a *very low* resistance.

A.—Stretched metal diaphragm.
B.—Fixed electrode.
C.—Minute air gap between A and B.
Fig. 3.—Section of a high-impedance microphone.

Moving Coil Instrument

This type calls for little description, as its construction, so far as general principles are concerned, follows closely the lines of a moving-coil loudspeaker. It is pressure operated, and consists of three essential parts, namely, a diaphragm, coil—the counterpart of the speech-coil of a loudspeaker—and a powerful but small permanent magnet. It is, of course, possible to use a moving-coil speaker as a microphone, but results will fall far short of those obtained with a properly designed instrument. This is due, in the main, to the construction and weight of the cone and speech coil; for the microphone proper the cone is replaced by a small and very light aluminium diaphragm, and the coil which is fixed to the latter, and vibrates within the annular gap of the magnetic system, is usually wound with aluminium wire or strip of small cross-sectional area.





A.—Carbon rods.
B.—Carbon granules.

Fig. 5.—Connections for a transverse current microphone.

High-impedance Microphones

In this group we have condenser and crystal instruments. The first type, as its name implies, actually consists of a fixed condenser, one plate of which is formed by a metal diaphragm, and the other by a plate built into or forming part of the construction of the body of the microphone. The diaphragm is usually made from aluminium or aluminium-alloy, which is stretched and carefully tensioned, and it is separated from the back plate or fixed electrode by only one or two thousandths of an inch. The fundamental principle is shown in Fig. 3.

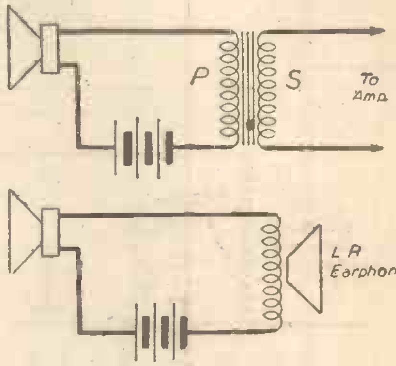


Fig. 4.—Connections for carbon microphones.

Crystal Microphones

These can be divided into two sections: 1, Diaphragm-operated; and 2, cell type. Both come within the pressure-operated group, and depend for their action on the piezo-electric properties of certain crystal formations. Quartz crystal or a form of Rochelle salt can be used, but the latter is more sensitive, and is, therefore, generally used for microphone work.

The crystal takes the form of a small slab or wafer, its surfaces being ground with great accuracy. With microphones, as with crystal pick-ups, use is made of the property of the crystal to convert mechanical energy into electrical energy, with the result that a "piezo-electric" voltage is produced.

With the diaphragm types, the pressure produced by the sound actuates a diaphragm in the normal manner, and by means of a quite simple arrangement, the vibrations are conveyed to the slab of crystal. In the "cell" types, however, the diaphragm is eliminated, and the sound acts directly on the crystal.

Characteristics and Connections

The first type of carbon microphones—those using carbon or metal diaphragms, etc.—have high output, a high degree of sensitivity, but response cannot be considered good owing to resonance peaks. They require an energising battery of 3 to 9 volts, according to type and use, and a step-up transformer having a ratio between 1 : 50 and 1 : 75. In certain cases, they are connected in series with a low-resistance headphone without any transformer, but with, of course, an energising battery. Connections shown in Fig. 4.

Transverse Current Models

Frequency response very satisfactory; in fact, some instruments are remarkably good. Sensitivity and output, lower than those mentioned above. An energising battery or source of voltage is required, usually in the region of 6 volts, together with a step-up transformer having a ratio of 1 : 25 to 1 : 50 according to impedance and operating conditions.

The connecting leads, which should be of the screened type for best results, between primary and microphone can be of quite reasonable length, say, up to 150 to 200 yards, but the connections between secondary and input of amplifier should be short and also screened. It is always advisable to house the microphone transformer and energising battery in a stout metal case, and keep it as remote as possible from any leads or components carrying raw A.C. Connections are shown in Fig. 5.

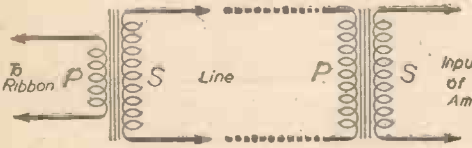


Fig. 6.—Matching of a ribbon microphone.

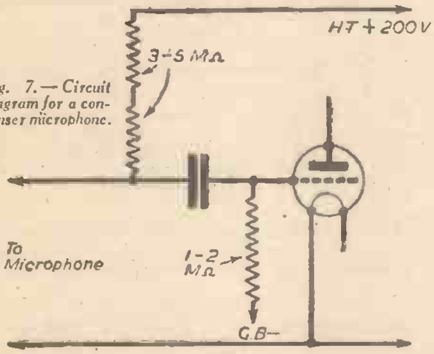


Fig. 7.—Circuit diagram for a condenser microphone.

The chief defects are: Danger of "blasting" on loud passages; feed-back due to instrument picking up sound radiated by loudspeakers handling the output; and "packing" of the carbon granules.

Velocity or Ribbon Instruments

The quality of the output from this type of microphone is very good, and it is therefore highly recommended, provided the amplifier is capable of giving high magnification to compensate for the low output of the instrument. To give an approximate comparison in this direction, a transverse current microphone has an output 10 times greater than that of a ribbon model.

It is more directional than those previously mentioned, as it is unaffected by sound waves other than those which strike the front or rear of the ribbon or strip. Owing to its low resistance, it is necessary to use a transformer to match up with the line to the amplifier. A ratio in the neighbourhood of 1 : 20 or 1 : 25 is usually satisfactory, but it is essential to mount the transformer very close to the microphone to keep the resistance of the primary circuit low. It is best to use a high-grade core for the transformer, so that its dimensions can be kept small, and mount the component in the housing of the microphone or, failing this, immediately underneath it on its supporting stand. A reasonable length of line is permissible between "mike" and amplifier input. At the latter, another transformer is required to match up the line with the grid input; this component should have a ratio of, say, 1 : 15 or 1 : 20, Fig. 6. No energising source is required.

The chief items to watch with these microphones are draughts; it will be realised that the ribbon would be quite sensitive to such air currents, therefore the "mike" housing should always be designed to prevent this; and secondly, it is better to provide sufficient amplification to allow the microphone to be placed, say, 24ins. away from the operator, than to reduce amplification and, likewise, the effective range. On speech, the reproduction can be unpleasant if the operator is very close to the instrument.

Moving Coil

With a properly designed instrument, reproduction is very satisfactory, but the writer has heard some which were inclined to be a little "wuffy," though it must be said in all fairness that this is not general, especially with the high-grade models. Very satisfactory on music and not too directional. Comparing sensitivity, once again with the transverse current microphone, the moving-coil "mike" is about 1/5th to 1/6th as sensitive. A transformer is necessary, the actual ratio of which will depend on the instrument, etc., but an average value is 1 : 50. No energising current required.

Condenser Microphone

Response very satisfactory; sensitivity varies with make, etc., but generally speaking they seem to be a shade below a good moving-coil. No transformer is needed; the grid of the first amplifying valve is taken, via a suitable fixed condenser, direct to one side of a high-resistance which is connected in series with the microphone and a polarising voltage. The grid of the valve has, of course, its own grid-leak to enable it to receive its required bias, Fig. 7.

To avoid undue capacity, it is usual to use a "pre" or "head-amplifier," consisting of a single—sometimes two—stage(s), actually built in the microphone supporting stand or, in some cases, the housing. The output from the pre-amplifier is then taken, by means of the usual line arrangements, to the main amplifier.

Crystal Instruments

Response of the diaphragm type is very good, but that of the "cell" pattern is even better, and deserves every consideration. No transformer or energising current is required. One side of the output of the microphone is taken direct to the grid of the input valve, and the other side of the common negative-earth line. It is important to remember that the crystal does not allow free passage to D.C., therefore the grid circuit must be provided with its own grid-leak. Connecting leads need not be kept short. (Fig. 8.) Sensitivity: the "cell" type is much less sensitive than the diaphragm model, and the latter compares favourably with a moving-coil instrument as regards output.

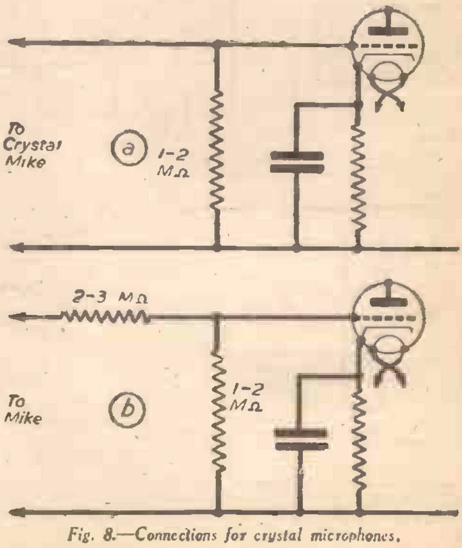


Fig. 8.—Connections for crystal microphones.

The Manufacture and Testing of Valves–1

Details of Construction of the Modern Radio Valve

BY L. A. WOODHEAD

IT has been stated that the valve is the "key" component of radio, and it is evident that none of the remarkable advance in the technique of radio reception and transmission could have been possible without the production of valves of increasingly higher efficiency specially designed for the purpose for which they are to be used. In nearly every case progress has been made by development from existing types, rathe than new design, and it will be interesting to follow the various stages from the experiencing of the need to the production of the finished article.

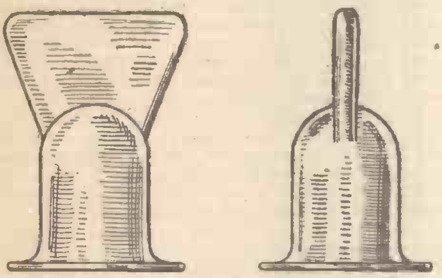


Fig. 1.—Glass flange—front and side views.

Initially, the research staff get busy. From accumulated data they work out mathematically the effect of, say, making a grid larger, or adding another grid, or altering the clearance between adjacent electrodes, or whatever is desired. They produce the desired result on paper and then proceed to put the theory into practice. In the research department there are facilities for the production of small quantities of parts to the required designs and smaller editions of the machines necessary in valve making. A very small number of the new type is produced and static and dynamic tests are made to ensure that results come up to expectation. The trial is repeated with a larger number and, provided everything is satisfactory, detail drawings of all parts are prepared.

The Planning Department

The planning department now takes over. They estimate the number of valves that may be required, compute the total amount of all the raw material needed, prepare jigs and tools for making the individual parts and allocate benches and machines.

The purchasing department is responsible for buying in the raw materials—nickel, tungsten, molybdenum, mica, glass, bulbs, bases, chemicals, etc. The chemical laboratory analyses the metals and chemicals to ensure that they are up to the very high standard of purity demanded in valve manufacture and samples are taken from every batch received. Certain physical tests are also made here, one of the more interesting being the determination of the percentage stretch of molybdenum wire used for grid winding. The need for this check will be evident when the manufacture of grids is described.

The production laboratory prepares the coatings which are to be sprayed on filaments, heaters and cathodes. In some cases this preparation is very prolonged, as it is necessary to grind or mill the constituents for 24 hours to obtain the requisite degree of fineness. Other work done by this laboratory consists of preparing the liquids required in plating baths, the graphite to be sprayed on certain types of screens and bulbs, the cement for fixing bases to bulbs and the etching chemicals used for marking type designations on bulbs.

Pre-production

As soon as possible after all the materials have been obtained a start is made with a pre-production unit which produces valves under normal factory conditions except that experts keep an eye on every stage. Minor alterations to the design or tools may be made if necessary, the sole purpose of the pre-production unit being to overcome "teething" troubles before large quantities are made. Final detail drawings are not made until stringent tests show that everything is satisfactory, and then full production commences.

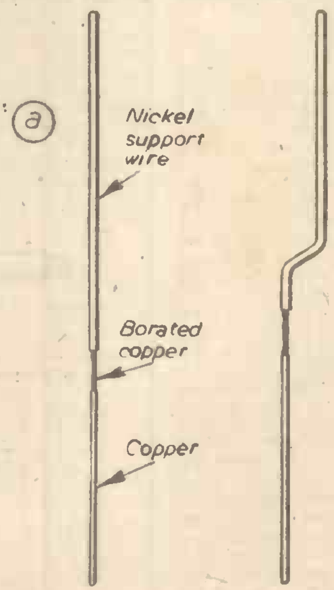


Fig. 2 (a).—Straight foot-wire. (b) Cranked foot-wire.

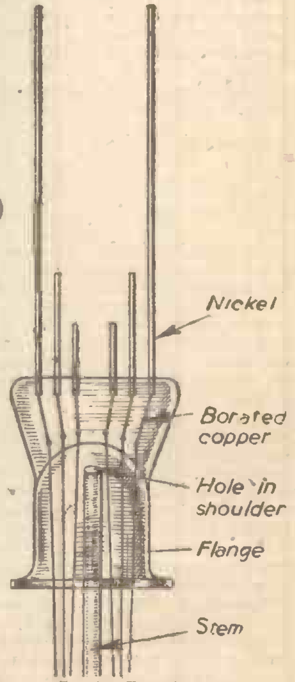


Fig. 3.—Turned-out foot.

The start of all modern valves (except those of very large size) is the foot. This begins as a glass tube which is automatically cut into short lengths, a representative size being 2in. long and ⅜in. diameter. These short pieces are fed into a rotating machine and heated by suitably placed gas jets. As the machine revolves a V-shaped tool is pressed into one end of the white-hot glass and automatically produces a flange. A pair of jaws flatten the other end until there is only a small gap remaining between the two sides. The result is shown in Fig. 1.

Working Glass

The heating and cooling of glass is not an easy matter if strains are to be avoided. Preliminary heating is done with the gas showing a yellow flame. As the glass heats up air is drawn in with the gas and the flame becomes the typical blue of a Bunsen jet. When extreme heat is required oxygen is burned with the gas and the flame becomes orange-red.

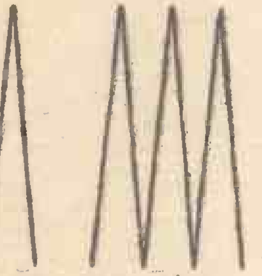


Fig. 4.—Types of filaments.

Fig. 5.—Straight and spiralised types of heater.

Cooling off must be done gradually, the finished work passing slowly through an annealing oven, the temperature of which falls gradually. This extreme care is taken when the flange is formed and must be repeated each time the glass of the foot or the bulb is heated. Strains in glass can readily be seen in a strain-viewer, in which white light is polarised by a Nicholl prism, the lines of stress showing up clearly in red.

Foot-making

The next process, called foot-making, consists of sealing in the flattened top of the flange all the wires required for supporting the assembly and those needed for making external connections to the pins in the base. The number of wires needed varies from four to nine, or occasionally more, and each wire consists of two or three sections joined together. The material used for the support wires inside the bulb is nickel, and that for the external connections is copper. Neither of these metals has the same coefficient of expansion as glass, and if either were sealed into the flat part of the flange the glass would crack on cooling or the seal would not be vacuum-tight when the valve got hot in use.

To overcome this difficulty a material called borated copper has been developed. This is pure copper wire with a coating which, under heat, fuses with glass and provides a good seal without imposing a strain. A normal foot-wire is therefore made of three pieces of different metal as shown in Fig. 2. A support wire not having an external connection—called a dummy—consists of the nickel and borated copper only.

These foot-wires are rapidly produced on an automatic wire-joining machine which feeds the nickel wire from a reel at one side and the plain copper wire from a reel at the other side. Predetermined lengths are cut off and held the correct distance apart. In the meantime, a small length of borated copper wire is clipped off and held in metal fingers exactly between the ends of the other two wires. Simultaneously two tiny flames of hydrogen shoot out and weld the three pieces of wire into one length which is dropped down a chute to form a neat pile. This intricate operation is done as rapidly as the eye can follow it and is a fascinating example of co-ordinated machine operation to be seen at several stages in valve manufacture. For different valves varying lengths of nickel are required and sometimes they need to be cranked as shown in Fig. 2b.

Adjustments on the machines allow of these variations being quickly made.

Foot-wire

The right types of foot-wire for the valve in production go to the foot-making machine where there are now the annealed flanges and a supply of glass stems or tubes, a representative size being 3½in. long and ¼in. diameter. The stem—held by a collar—is placed inside the flange which is supported by a cup. The foot-wires are placed inside the flattened top of the flange and precision-made jigs hold them at the correct distances apart and with the borated copper exactly in the right position. Gas-jets play on each side of the flange and when the glass is molten two jaws compress the flattened top, firmly securing the foot-wires in place. The same heat melts the stem into the wall of the flange and at an appropriate moment a current of hot air is forced up the stem, piercing a hole in the shoulder of the flange. This hole is of great importance when the time comes to evacuate the air from the inside of the bulb. The foot is now completed, except for annealing, and an example is shown in Fig. 3, although the number and shape of the nickel support wires varies according to the type of valve in production. All the work of foot-making is done on a rotating machine, and apart from feeding on the flange, stem and foot-wires, and taking off the finished foot, the operation is entirely automatic.

Before describing the mounting of the assembly on the foot it will first be necessary to deal with the manufacture of all the parts, and it is proposed to start at the centre of the valve and work outwards.

Valve Principles

In directly heated valves—which covers most of those used in battery operated receivers—the emission is obtained from a filament. An example may be noted here of the extraordinary advance that has been made in valve efficiency. Years ago filaments were made from uncoated tungsten. Later tungsten was combined with thorium to produce the thoriated tungsten filament. Nowadays filaments are generally made from a core of hard metal with a highly emissive coating of the oxides of barium, calcium and strontium. These filaments are frequently 150 times as efficient as the uncoated tungsten used 20 years ago. Cores are made from nickel, tungsten or an alloy of platinum and iridium, but the oxide coating—each manufacturer having a slightly different formula—is now universal.

Fig. 6.—Trimmed cathode tube.

The coating is applied in a filament coating machine which draws a continuous supply of the core wire through a shallow trough containing a mixture of the oxides in a solution of cellulose. This liquid has to be continuously agitated to ensure that it is evenly mixed. The wire becomes evenly covered and it is dried by passing it over a hot-plate before rewinding.

From the finished reel appropriate lengths are cut and the filaments are shaped by hand by winding the wire round pegs set into a flat plate. A small section at each end is scraped clear of coating so that the filament may subsequently be welded to the support wires coming from the foot. Varying shapes are formed according to the type of valve, and Fig. 4 shows some typical examples.

Indirectly Heated Valves

In indirectly heated valves—most of those used in mains receivers—the emission is obtained from a cathode tube which is heated by an internal heater. The heater is generally made from tungsten coated with an insulating material so that when it is inserted in the cathode tube no short-circuit takes place. The usual form of heater is a single loop of straight wire, like a hairpin (Fig. 5a), but in some valves the wire is spiralised as shown in Fig. 5b.

The method of making the spiral is ingenious. The fine tungsten wire is wound closely around a thin mandrel wire of steel or molybdenum which is subsequently dissolved away in a bath containing a mixture of nitric acid and hydrochloric acid, the tungsten spiral being unaffected by the acids.

One method of applying the coating is to place a number of the shaped wires in a brass hand-clamp and spray them by means of a compressed air spray gun with alumina (one form of aluminium oxide) in a solution of cellulose. The cellulose is dried out in a low temperature oven, after which the heaters are placed in small containers made from molybdenum and passed through an atmosphere of hydrogen in a sintering furnace at a temperature of 1,500 deg. centigrade. To assist the alumina to form a smooth cover to the wire during the sintering process the sprayed mixture contains a small amount of beryllium oxide which acts as a flux. The finished heaters now have a thin, hard, insulating coating resembling porcelain and, after the ends have been cleaned to permit of welding at a later date, they are ready for use.

The cathode used in all indirectly heated valves is a perfectly straight nickel tube, frequently flattened, a representative size being 2in. long, 3/32in. wide by 1/32in. thick. This is coated with a similar oxide coating to that used for filaments and it is generally applied automatically in a rotating machine having several spray guns which are continuously oscillating to ensure that the solution remains completely mixed. After drying in an oven the coating is trimmed at each end and the finished cathode looks like Fig. 6.

(To be continued)

A Short-wave Converter

Constructional Details of an Efficient Unit

By F. W. FRERK

THE usual converter combination is ideal for short-wave reception when properly used. There are, however, a few pitfalls which crop up and prevent listeners from being satisfied.

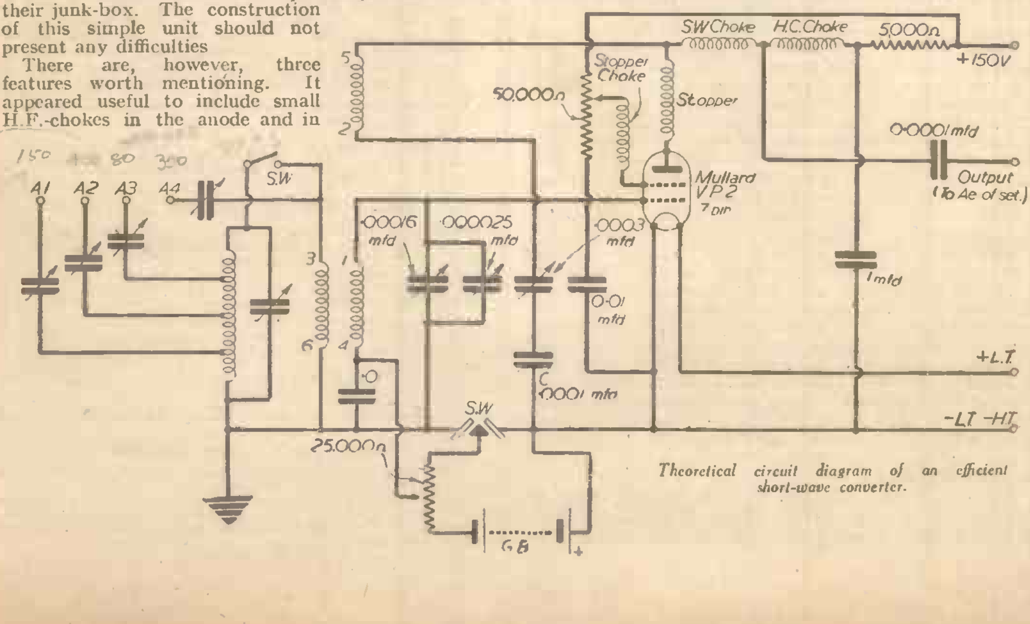
On the other hand, there is hardly a combination as efficient to ensure maximum short-wave results as a well-built converter plus a superhet set.

Two of the main pitfalls are instability of the combination and lack of selectivity, which latter is sometimes very annoying, especially on the "long" short-waves beyond the 40 metre-band. Although the performance of any receiver is determined by practice as well as theory, practice sometimes calls for the introduction of a feature which is not theoretically necessary. Here is the circuit (below) of the converter I have built and in use. The price of the necessary parts is low and most readers will probably have them in their junk-box. The construction of this simple unit should not present any difficulties

There are, however, three features worth mentioning. It appeared useful to include small H.F.-chokes in the anode and in the screen circuit to prevent instability. The chokes are of extremely simple type: 10 turns of thin wire wound on a ½in. diameter former. This method is very successful, despite its simplicity.

R.T. Aerial Circuit

To improve the selectivity I adopted the incorporation of a resonance-tuned aerial circuit according to Mr. A. W. Mann (PRACTICAL WIRELESS, November 25th, 1939, page 215), which proved to be a real asset. This tuner is a 1in. diameter six-ribbed ebonite coil former, slotted and wound for 26 turns of 22-gauge tinned copper wire, ⅛in. spacing between turns and a tuning condenser .0001 mfd. fitted with a slow motion dial. The coil can be tapped with a crocodile clip, and it is good advice to do so at first. Once, however, the efficient positions for the different wavebands are found it is better to solder



Theoretical circuit diagram of an efficient short-wave converter.

taps and connect them over the different pre-set condensers to special aerial terminals, which in this case should be on the front panel instead of the back. The aerial, ending in a banana plug, can then easily be inserted in the aerial terminal most suitable for the wavelength just to be used. Rigid mounting of the whole outfit is, of course, essential, and so is the earthed metal screen between the aerial resonance tuner and the other coil. The condenser should be a good short-wave condenser with ceramic insulation.

Reaction

To obtain a smooth reaction I introduced a fixed condenser C of .0001 mfd., which acts as a stopper for the anode voltage and which proved to be extremely useful.

As a matter of fact, the panel of the unit is rather bristling with knobs, but I saw no other way to make the unit as efficient as it is now, and the real OM was never afraid of knobs.

I restrict myself to the description of the short-wave converter only, actually I combined it with a pre-selector for middle and long-wave reception by introducing a few double-pole changeover switches in the usual way.

Operating Details

The superhet-set is switched over to long-wave reception. The dials are adjusted to the longest possible wavelength, where no long-wave transmitter may interfere. In my case I tune to the 2,000m. position. The output from the unit is taken from the free end of the fixed coupling condenser and fed into the receiver via the normal aerial terminal, the aerial proper being joined to one of the aerial-terminals of the converter unit. It is essential that the H.T. and L.T. negatives of the batteries feeding the receiver are common with the earth connection. The flex connecting the output from the unit with the aerial-terminal of the superhet should be as short as possible and braided, the braid connected to earth.

Initial Test

All subsequent tuning is now carried out on the converter. To run the initial test it is advisable to switch off the resonance tuning stage and to locate the various band positions on the dial, as covered by the different coils. Then tune the aerial tuner unit, adjust the tapping clip and slightly adjust the bandspread condenser and the reaction condenser to find out the best reception of a certain station. Try some more stations while adjusting the clip to other tappings until the best tapping for this special coil has been found, also adjust the pre-set condenser to the maximum volume. Then repeat the adjustment with the other coils and note all adjustments until the operator has become familiar with the operating of the combination as a whole. Sometimes it is useful to repeat the procedure after having tuned to another long-wave band. I found, e.g., that the short-waves up to 40m. are best received when the superhet has been tuned to 2,000 m., that all wavelengths over 40m., however, are better received when the superhet is tuned to 2,100m.

The potentiometers for the screen-voltage and for the grid bias should be handled very carefully. Only a slight turn of one of these knobs may often produce quite another station than that to which the unit is tuned.

At last a few notes from my log-book. My aerial is a so-called "non mast aerial"—sold for 4s. 6d. everywhere—fitted to a bamboo-pole (4 yds.) erected on the roof of a house in Kensington, London. The downlead (30ft.) has been kept well away from the surrounding earthed objects, and the wire is kept taut, so that the downlead is really a one-wire vertical aerial. It is not the ideal of an aerial, but it is the best one can do in a big town, and it is very efficient.

Stations Received

U.S.A. stations: WNBI, WRCA, WGEO, WGEA, WBOS, WCAB, WKRD, WLOW, WRUL, WRUW, WICA, WHL6 (22.5m.), etc.; Radio Nacional Rio de Janeiro, Brazil, 25.6m. and 31.58; American Telephone and Telegraph Cy. (Tests); Radio Maroc, Radio France (Algiers); Constantine, Budapest (32.88m.); Congo Belge (old sender 14.97); Leopoldsville (new sender on 25m. band); Helsinki; Radio España Independente 30.9 and 40.4m.; Moscow on the 25m., the 31m. and the 40m. bands, also on 48m. and 50m. band; all German stations, including the "soldier's sender, Belgrade," stations "Fritz" and "Wilhelm"; German-controlled Rakovice, Zagreb, Bratislava, Kiew and Baranowice); Lisbon; Radio Mexico 49.80 (obviously a German-controlled fake); Andorra; Radio Metropole; Radio Vatican on 19m. and 50m. band; Radio-Lausanne 48.66m.; Beromuenster; all Italian senders, which all come in excellently; Ankara 31.70m.; Kuibyshew, 43.23m.; Brazzaville 25.06m.; Radio Journal de France (Vichy); Sao Paolo 29.35m. (Brazil); GRC, London 102.9m.; VL13, Sydney 19.59m.; Chungking 48.86m.; Pernambuco, Brazil 49.92m.; Tokio 25m. band and 31m. band; Lourenco Marques 30.86m.; Oslo; Stockholm, New Delhi.

Furthermore, I had a good reception of the following *secret* senders, which are anti-Nazi: Kossuth-sender (Hungarian), 42m. band; Sturmadler, sender of the German youth (anti-Nazi), 25m. band; Deutscher Volkssender (German anti-Nazi), 31m. and 48m. band; Die Heimat ruft die Front (German anti-Nazi), 41m. and 48m.; Sender der SA-Fronde (German anti-Nazi), 31m., 41m., 48m. band; Oesterreich, formerly Ravag, 48m. band (Austrian anti-Nazi); Free Yugoslavia, 19m. band; Sender of "Yiddishes Komitet," Moscow, 42m. band (Yiddish); Sudetendeutscher Freiheits-Sender, 40m. band.

The signal strength of most of these stations was usually R9, only sometimes, when weather conditions were bad, it was R8. On the other hand, all the jamming produced by the Germans to jam the British, Free French and German anti-Nazi broadcasts has the same, and in this case rather awkward, signal strength.

LIST OF COMPONENTS

Three short-wave coils (Premier), 6 pins.
Four s.w. tuning condensers with s.m dials: .0001 mfd. resonance tuning, .00016 mfd. band-setter, .000025 mfd. bandspread, .0003 reaction.
Four pre-set condensers or trimmers: 45-150 mmfd., A1; 150-400 mmfd., A2; 50-80 mmfd., A3; 300 mmfd., A4.
Two potentiometers: 50,000Ω, 25,000Ω
One short-wave choke (Webb); one H.F. choke; one 5,000Ω non-inductive 1-watt fixed resistance; two fixed condensers .01 mfd.; two fixed condensers .0001 mfd.; one fixed condenser 1 mfd.; two 10 turns stopper chokes; one 3-point switch; one on-off switch; one valve, Mullard VP2, 7-pin.

PRIZE PROBLEMS

Problem No. 445

PARKINSON built a three-valve straight type short-wave set, but could not pick up any stations, and no reaction could be obtained. He tested the components, batteries and valves and found them to be in order. He eventually decided to take the set to his friend's house for a test out, and was surprised to find that satisfactory reception could be obtained. Why couldn't Parkinson pick up stations at his home?

Three books will be awarded to 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. 445 in the top left-hand corner, and must be posted to reach this office not later than the first post on Monday, June 21st, 1943.

Solution to Problem No. 444

Excessive voltage was applied to the screen of the pentode detector. This screen should have approximately 30 volts.

Three readers successfully solved Problem No. 443, and books have accordingly been forwarded to them: A. C. Cooper, 5, River Road, Littlehampton, Sussex; R. Swetterham, 8a, Clapham Road, Bedford; and J. R. Catt, 11, Clifton Road, Tunbridge Wells, Kent.

Radio Examination Papers—20

A Further Selection of "Test Yourself" Questions, with Suitable Answers by THE EXPERIMENTERS

QUESTIONS

1. *Draw an outline circuit of a cathode-coupled regenerative detector circuit. Compare it with a normal Reinartz arrangement, and point out any advantages which it displays.*
2. *An A.C. receiver was being operated temporarily from an accumulator and H.T. battery, after disconnecting the mains transformer and rectifier. It was found, however, that a 100 mA. fuse connected in series with the H.T.+ lead "blew" each time the set was switched on, despite the fact that the normal H.T. consumption was only 50 mA. Why was this, and how could the trouble be overcome without dispensing with the safety fuse?*
3. *What do you understand by a* double *superheterodyne and in what circumstances is a receiver of this kind better than an ordinary superhet?*
4. *How can effective reaction be obtained in conjunction with diode detection?*
5. *How could a portable battery superhet be used as a "straight" receiver in the event of the frequency-changer being unserviceable?*
6. *A rotary converter used to feed a powerful receiver is required to provide 250 volts, 100 mA. H.T. and 6.3 volts, 2.4 A. L.T. What is the total wattage output, and what input current would you expect if the converter were to operate from a 12-volt accumulator? What would you consider the minimum ampere-hour capacity rating of the accumulator for efficient service?*

1. Cathode-coupled Reaction

FIG. 1 shows the essentials of a cathode-coupled regenerative detector circuit. It will be seen that the indirectly-heated cathode is connected to a tapping on the tuned-grid coil, and that there is no reaction condenser in the usual sense. Use is made of an H.F. tetrode, and reaction control is provided by means of a screening-grid potentiometer. This, in fact, serves to vary the effective amplification of the valve. For comparison a Reinartz type of detector circuit is illustrated in Fig. 2. In this case there is a reaction winding in series with the tuned winding, this being fed back to the anode through a variable reaction condenser; for easy comparison, an H.F. tetrode is again shown.

In the cathode-coupled circuit, feed-back is obtained due to the fact that the cathode circuit is virtually a part of the anode circuit; the lower end of the tapped coil is fed back to the anode through condenser C.1. For a circuit of this nature to be effective it is necessary that the valve shall have a high "slope" or mutual conductance. That is why a tetrode or H.F. pentode is a practical essential.

The chief advantage of this type of circuit is its inherent stability: this is especially valuable on short waves. Another advantage is that tuning is practically unaffected by reaction adjustment. This also is of principal value on short waves.

2. H.T.-circuit Fusing

The reason for the fuse "blowing" is obviously that there is a heavy surge of current when the set is first switched on. This is accounted for by the charging of the high-capacity smoothing condensers invariably connected between H.T.+ and H.T.— in a mains-operated receiver. When the set is switched on a heavy current is passed for the fraction of a second taken to charge up these condensers.

The matter is aggravated by the fact that the valves do not pass any anode current until their cathodes heat up. The process of heating normally takes up to 30 seconds. If the valves were directly heated they would act as a high-resistance "bleeder" across the condensers, and so reduce the surge to some extent.

The simplest way to avoid the trouble would be to include a resistor in series with the H.T.+ lead. A value of about 250 ohms would generally be sufficient to prevent the trouble described, and this would not have any very serious effect on the voltage applied to the anodes. Alternatively, it might be possible to disconnect any smoothing condensers wired directly across the H.T. supply. The first-mentioned remedy would, however, be simpler, and would reduce the amount of alteration which it was necessary to make.

3. The Double Superheterodyne

This name is given to a receiver in which there are two frequency-changing valves, one after the other. The first may, for example, produce an intermediate frequency of one megacycle, while the second would give an intermediate frequency of, say, 110 or 465 kc/s.

By using this combination it is possible to obtain the advantages of both high and low intermediate frequencies. It has been explained in earlier answers in this series that a high I.F. tends to prevent second-channel

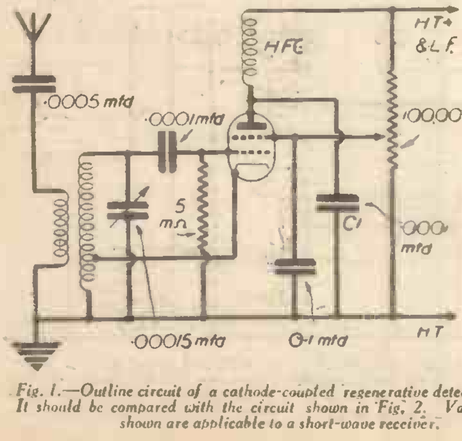


Fig. 1.—Outline circuit of a cathode-coupled regenerative detector. It should be compared with the circuit shown in Fig. 2. Values shown are applicable to a short-wave receiver.

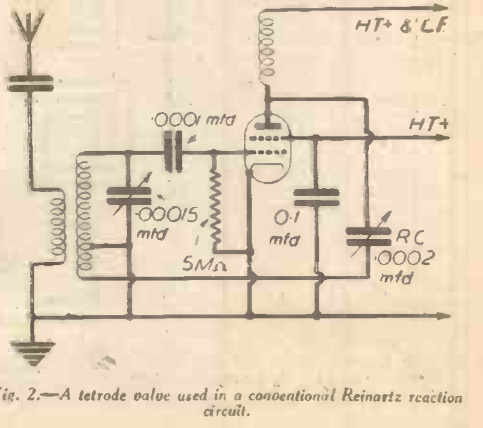


Fig. 2.—A tetrode valve used in a conventional Reinartz reaction circuit.

interference, while a low I.F. is an advantage when adjacent-channel interference is to be avoided. It is also possible to provide a very satisfactory means of fine tuning by varying the first intermediate frequency over a range of a few hundred kilocycles per second. This could be done by using a variable condenser in conjunction with the I.F. transformer following the first frequency-changer.

The advantages of double frequency-changing are of greatest value on ultra-short waves, where second-channel interference is more probable, and when a high degree of selectivity is generally more difficult to obtain. The system was adopted in certain receivers used for the reception of television sound, and also for modifying a superhet receiver of the broadcast type for use on short waves.

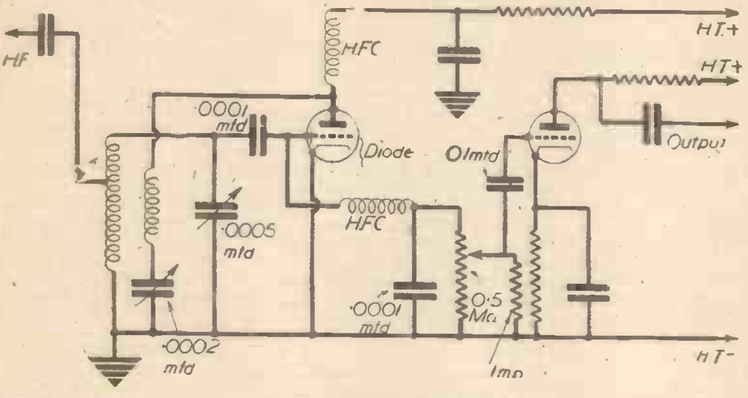


Fig. 3.—A triode used as a combined diode detector and oscillator. It is shown followed by a triode L.F. amplifier.

4. Reaction and Diode Detection

It is generally considered that reaction cannot be used with a diode detector, and this is true in a limited sense. Moreover, reaction is often quite unnecessary in a receiver having this form of detection, because an ample measure of amplification is obtained by other and more direct means. On the other hand, reaction is necessary for the reception of C.W. unless a separate oscillator is used.

One simple method of combining the two functions is by using a triode, of which the cathode and grid act as a diode, and the whole valve as a triode oscillator. A simple circuit is shown in Fig. 3. This circuit refers to a receiver with "straight" R.F. amplification, rather than to a superhet; for the latter circuit it would be necessary to add a reaction winding to the I.F. transformer feeding the diode detector, and that would not always be desirable.

It must be agreed that the circuit is rather in the nature of a "fake," since the triode is actually behaving as a separate oscillator, as well as acting as a diode. The circuit is not one which is normally recommended, but it is worth trying. If desired, a switch could be inserted in the H.T. lead to the anode of the valve, so that non-regenerative detection could be had when desired, the oscillator being brought into use only for C.W. reception.

5. Converting Superhet to "Straight."

A small battery superhet generally comprises a pentagrid frequency-changer followed by an H.F. pentode serving as I.F. amplifier, and by a double-diode-triode, with a pentode output valve. For purposes of the present question it would not be considered desirable to redesign or rebuild the receiver, since it would be anticipated that a new frequency-changer would eventually be procurable—despite the present difficulty in obtaining certain types of new valves!

If would therefore be most convenient to make modifications so that the H.F. pentode could be used as a regenerative detector. In addition, the triode portion of the double-diode-triode would be used as first L.F. amplifier, the double-diode portion being out of use. The pentode output valve would retain its original function.

To permit of this change the lead from the frame aerial to the grid of the frequency-changer would be removed and connected to the grid of the H.F. pentode through a grid condenser and grid leak, as shown in Fig. 4. This would be an easy matter when the grid was brought out to the top cap of the valve.

The primary of the second I.F. transformer could, possibly, be retained as an H.F. choke—although it would not be a very efficient choke, having a pre-set condenser in parallel with it—and an anode resistor of about 50,000 ohms could be inserted between the upper end of this primary winding and H.T.+. From the junction of the resistor and primary winding a lead could be taken to the point shown in Fig 4, after breaking the lead from the triode grid condenser and the load resistor, as indicated by a cross.

Reaction would be necessary not only to increase sensitivity, but also to sharpen the tuning. Where a few turns of wire are wound round the frame aerial for connecting an external aerial and earth, these could be used for reaction coupling by taking one end to the anode of the valve now used as detector and connecting the other end to earth through a .0001 mfd. reaction condenser. The connections are indicated in Fig. 4. If an external aerial were to be used, it could well be.

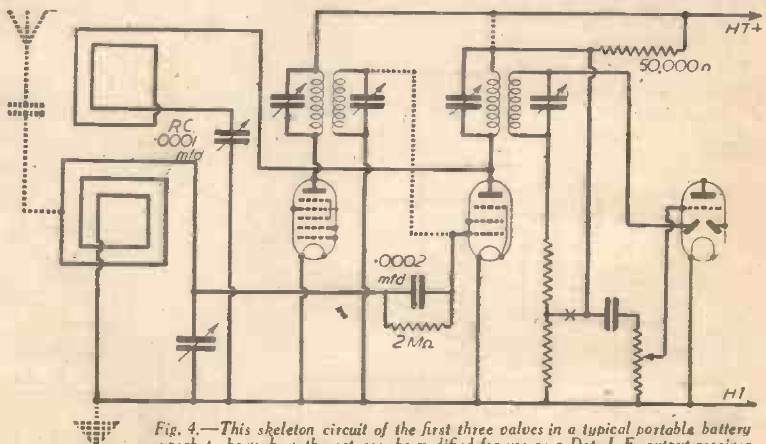


Fig. 4.—This skeleton circuit of the first three valves in a typical portable battery superhet shows how the set can be modified for use as a Det.-L.F.-output receiver in the event of failure of the frequency-changer. Broken lines indicate leads which are to be removed; available aerial-earth connections are also shown in broken lines.

taken to a tapping made on the frame winding, through a small fixed condenser.

It will be understood that the alterations mentioned are of a very general character, and that they must be adapted to the circuit of the particular set in use.

6. Wattage and Current

It will be remembered that power in watts is the product of current in amps. and voltage. The H.T. wattage of the receiver in question is 250 times .1, or 25 watts. The L.T. wattage is 6.3 times 2.4, or approximately 15.5 watts. Consequently, the total power consumption is about 40.5 watts.

It is reasonable to assume the efficiency of a rotary convertor of good type to be around 60 per cent. Knowing this, we can easily find the approximate input wattage. It is 40.5 divided by 60 and multiplied by 100, or $\frac{40.5}{60} \times \frac{100}{1}$. This gives an answer of about 68 watts.

Since wattage is the product of voltage and current, the input current can be found by dividing 68 by the supply voltage—12. This gives a figure of 5.6 A. This, then, would be a reasonable estimate of the current drain on the battery.

For efficient working, an accumulator should not be charged or discharged at a figure in excess of that given by the 10-hour rate. This is based on the accumulator being fully charged or discharged in 10 hours. Thus, the ampere-hour rating of the accumulator should be not less than 10 times 5.6 In practice, therefore, the accumulator should be rated at about 60 ampere-hours.

Directional Receiving System

Using a Frame or Loop Aerial for Cutting Out Unwanted Stations

SINCE the beginning of the war, many B.B.C. transmissions have been using "common waves"—that is, there are two or more transmitters sending the same programme on the same wavelength. The synchronism is maintained with great accuracy, but even so the waves arriving at a given point from the various stations do not maintain an exactly constant phase relationship. As a result, they assist each other at certain times, and oppose each other at intermediate moments, giving a fading effect. This effect is serious unless one of the stations is maintaining a field strength which is many times as great as that produced by the others. Apart from variations in intensity of the received signal, which could be largely compensated by automatic gain control, severe distortion is caused because the sidebands of the stations do not fade simultaneously with the carrier waves; in bad cases a receiver with automatic gain control is very much worse than one without it on account of this. The distortion is sufficient to ruin "high-fidelity" reproduction, even at distances as little as 30 miles from a transmitter.

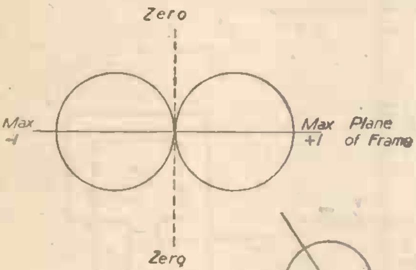


Fig. 1 (Above).—Diagram illustrating the response of a frame aerial.

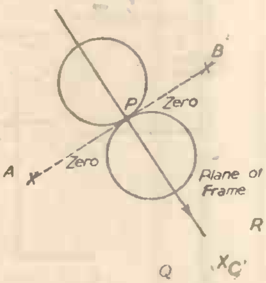


Fig. 2.—Indicating positions of frame aerial for separating three stations.

Directional Apparatus

It is clear that a possible way of eliminating this trouble is to use a directional apparatus, which is "blind" to the directions of the unwanted stations. The simplest such device is the frame or loop aerial, but this is rarely of value in the present instance owing to the number of stations involved. A frame aerial receives well stations in the plane of the frame, and is blind to those in a direction at right angles to it; in fact, its response varies with the angle according to a figure-of-eight curve (Fig. 1). Thus, if three stations, A, B, C (Fig. 2), were transmitting on a common wave, a frame aerial could only help in their separation if its site were about the points P, Q or R. Thus, at P, the frame could be directed to C, and would be blind to A and B. It is doubtful, however, whether such an arrangement would be satisfactory, as C would be the most remote of the three stations, and its signal probably the weakest.

A much more promising arrangement is that using the principle of the "sensefinder," in which the currents produced from a vertical aerial, after appropriate adjustment in magnitude and phase, are combined with those produced from a frame aerial. The response curve of an isolated vertical aerial is a circle—i.e., it is equally sensitive in all directions. If its output is superimposed upon that of a frame giving an equal output at its maxima, the response curve becomes that shown in Fig. 3 (c)—a cardioid. If the vertical aerial delivers only a fraction of the frame maximum, the curve becomes that shown in Fig. 4 (c). This has two zeros, which occur at equal angles θ with the plane of the frame, given by $\cos \theta = x$. If the value of x is nearly unity, the variation of response with angle round

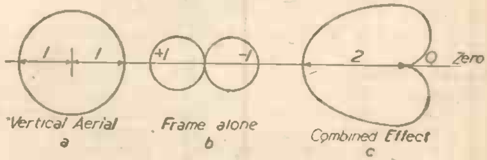


Fig. 3.—Principle of the cardioid response curve.

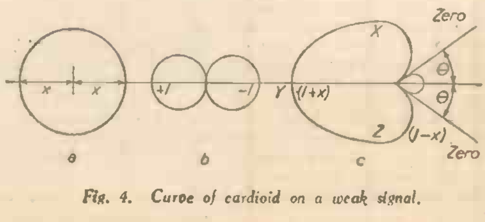


Fig. 4. Curve of cardioid on a weak signal.

about the minimum is very slow, so that a very accurate direction setting is not necessary.

Unwanted Stations

Such an arrangement therefore enables *two* unwanted stations to be eliminated, while preserving a considerable response in the zone XYZ, and it should be useful in many areas for eliminating or reducing common wave interference. For example, with three transmitters, A, B and C (Fig. 5), and a receiving site at S, B and C would be unwanted, and the frame would therefore bisect the angle BSC. The input from the vertical aerial would be adjusted so that $x = \cos \frac{BSC.}{2}$ The station A would be received strongly, and B and C not at all. The method would obviously be applicable at any point within the triangle ABC, and for certain points not very far outside it.

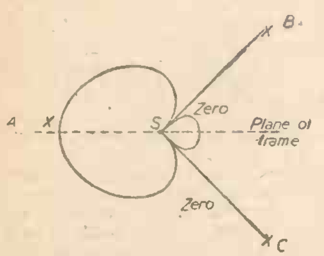


Fig. 5.—Response curve for medium-wave transmissions.

This can be put into practice without great difficulty, though some care is required to obtain the correct settings. It is desirable to use a tuned frame with centre point earthed, to avoid electrostatic effect between the vertical edges and earth from affecting the response curve. The E.M.F. from the vertical aerial is conveniently injected into the frame near the centre, as shown in Fig. 6. The circuit of the vertical aerial AE is accurately tuned with C_1; the current in L_1 is then in phase with the field of the incoming wave. The E.M.F. induced in L_2 is then 90 degrees out of phase with the wave field. The E.M.F. produced by the wave in the loop F is also 90 degrees out of phase with the wave field itself, so that the two E.M.F.s in the L_2—F circuit are in a condition to be combined as shown in Figs. 3 and 4. Adjustment of the mutual coupling between L_1 and L_2 adjusts the fraction x which settles the angle θ at which the zeros occur. The resistance R may also be used for this purpose; it is an advantage to keep R fairly high, as this flattens the tuning of AE, and so prevents the sidebands from receiving different treatment from the carrier wave. F (with L_2), tuned by C_2, constitutes the first tuned circuit of the receiver, and is connected to the input valve in the way shown. Small resistances up to about 20 ohms may be inserted in F to increase the damping so that the tuning is broad enough for high quality reproduction. It is not necessary to use a push-pull H.F. amplifier, though the zeros of response would probably be more perfect if this were done.

Practical Details

Some practical notes will be a guide to those interested in setting up this apparatus. For AE, though a vertical aerial, is ideal, almost any reasonably efficient external aerial will suffice. The horizontal portion does not produce deleterious effects except when the radiation to be eliminated contains a strong horizontally polarised component. This may occur at night if one of the unwanted stations is at a considerable distance away—150 miles or more, and in such a case the horizontal portion should be kept as small as possible. L_1 can be made of about 70 turns on a former 1½in. in diameter, which can be rotated within L_2 on the lines of the old-fashioned variometer, L_2 itself being about 8 turns with a centre tap. A suitable frame in this case consists of 12 turns approximately 2ft. 6in. square, divided into two sets of 6 turns for the purpose of the injection from L_2. C_1 and C_2 should be good quality tuning condensers, of capacity up to .0003 or .0005 microfarads. The frame described, and most aerials, will then tune to ordinary B.B.C. wavelengths. With an average outdoor aerial R can be about 200 ohms, and the aerial will still deliver sufficient at maximum coupling of L_1 and L_2 to equal the frame output and realise the cardioid response curve of Fig. 3 (c).

To obtain the correct settings of the apparatus, it is necessary to decide the "principal directions" of the room in which F is being used. This can be done with a compass, or by taking a bearing with F (alone) on some known station: this must not, of course, be a common wave station. It is then necessary to decide the directions of the unwanted B.B.C. stations. Information as to which stations are working upon which wavelengths is not published, presumably in the national interest: but it is quite easy to obtain this information by a process of inspired guesswork and by writing to friends who live in towns near the principal B.B.C. transmitters, asking for a report on reception conditions on the various wavelengths. It will then be possible to decide the correct direction for the frame, and to set it in this position with the help of the "principal directions" of the room. If the set has a visual indication of the received signal, such as a milliammeter or "magic eye," it will usually be possible to adjust C_1 and the coupling of L_1 and L_2 until the signal shows minimum variation with time. Small adjustments of F may then bring this minimum to a zero. A good deal of help in finding "one's way about" the apparatus can be gained by using it for the complete elimination of stations using exclusive frequencies, such as certain morse stations and various Continental transmitters. For a final and exact setting for the elimination of the unwanted stations on the common wave, it is necessary to be lucky enough to be listening when the local *wanted* transmitter cuts out, either for security reasons or on account of "circumstances beyond our control." An exact adjustment for

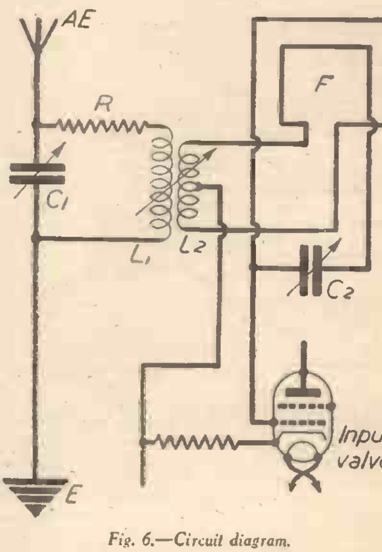


Fig. 6.—Circuit diagram.

zero or minimum signal can then be made, and noted for future use.

The author's experiments have been conducted at a site rather outside the triangle ABC of Fig. 5, both for the 449 and 342 metre transmissions. On an ordinary aerial, the 449 metre transmission is generally usable, even at night, though distortion is very severe at times, as the unwanted stations approach equality of field strength with the wanted. With the directional apparatus the unwanted signal is reduced to about 5 per cent. compared with the wanted at night, and is vanishingly small during the day.

ON YOUR WAVELENGTH

By THERMION

The Jazz Racket

A HOLLOW vessel makes most noise, it is said, and when, as I have been doing for the past years, you continue to rap, it is possible that a crack may occur. Now, I have been attacking for a long time this chromium-plated vessel of compressed hot ridm, which is turned out in considerable quantity from Tin Pan Alley and also from British publishers. Most of this tripe, the lyrics of which are insulting to the intelligence of a congenital imbecile, is, if we are to believe the title pages of the score, composed by at least three people, whilst the music is by at least three others. There are still those in this country who think that a fortune is to be made by writing some lilting lyric about ululating waters, mammies and Alabam, in which the only words you need to know are true, blue, love, above, hair, where, and a few homonyms. Of course, knowledgeable people know full well that song writers outside the select circle haven't much chance of getting a song accepted unless they pay for the publication themselves; and in this case they will find plenty of people who will print a few hundred copies, present the writer with a dozen copies for himself, and a royalty on each copy sold. Even though the small print is entirely sold out he will be out of pocket; and even though the song by some freak of fate becomes a staggering success or, as our dance band leaders would say, a *parpular sahng*, the would-be successful song writer will find other obstacles to fame and fortune. I am not, of course, referring to the long-established, reputable music publishers, who are beyond reproach.

Now, I think it is accepted by every member of the public that a song only becomes successful when it is plugged, which means to say that you must pay some popular singer to sing it for you, or get the conductor of a dance band to sicken the public to death with it. For successful song writing you merely have to have a knowledge of the three R's—rattle, rumba, and rhythmetic. (By the way, now that I have coined a word I quite expect someone to start a band such as Sam Snark and His Rhythmetics.)

I cannot be wrong in my assessment of the very low order of mentality necessary to compose jazz, no matter what new name is invented for it. I know that there are those who draw a fine distinction between jazz and swing. The B.B.C. described it as sentimental, debilitated slush, and it was amusing to notice the large numbers of band leaders who all supported the B.B.C. point of view, and thus by suggestion implied that they did not play slush. The fact is that all of them do. It may not be generally known that one band leader, far more intelligent than his fellows, openly admits that he does not understand one note of music, that he has not had any musical education and training, and that he cannot play even the simplest musical instrument; yet he conducts a famous band, and I understand his gramophone records sell in considerable quantities. So much for the ability required to conduct a dance band.

It is a tragedy that during the war, when everyone is talking about post-war developments and improving the standard of life, this parasitic branch of the musical industry, which battens itself like a barnacle upon the entertainment profession, should be still further degenerating itself and youth.

Jazz has been responsible to some extent for our lack of preparedness before this war started. Many have been dazzled by the large sums of money which can be earned from the simple accomplishment of playing a tap drum, which I am astonished to see classified as a musical instrument. They have learned that adenoidal crooners can earn colossal sums, and that by waggling a baton you can earn a large fortune. It is little wonder that men and women did not wish to be trained for the professions and trades which yielded a few pounds per week.

Now the hollow vessel to which I referred in my opening paragraph is beginning to give forth quaint noises, and to leaven the pabulum of ridm an obscure scribe who caters for the interests of malady makers has in recent articles been quoting me and my views on this important topic, and I am delighted that I am thus afforded this opportunity of having my views placed before our malady makers. The journal itself places great value upon my views on malady making, for to make quite sure that readers purchase next week's copy, and as an incentive, no doubt, to circulation raising, they are promising "more of Thermion next week."

Apparently these purveyors of noxious musical potions have been unable to pursuade other papers to take up the cudgels in defence. Now and again I do receive a letter from a member of a dance band. One such wrote to me the other day and signed himself "Yours Most Disgustingly." This piece of self-confession somewhat surprises me. I hope that the malady makers will print this article as a further contribution to their symposium of Thermion's views on jazz and jazz bands, and dance bands, which I hope shortly to publish as a monograph, and a record of the low depth to which music can descend.

Fee Snatchers

[Do not be cajoled into paying fees for "publication" to cover cost of seeing yourself in print.]

A sucker is born every minute, they say,
Whose function in life is to tip up his pay
To the sharks who surround him,
And stifle his doubt,
And persuade him they're giving him
"Summat fer nowt."

Cajoling and flattering our simpleton friend
By plausible yarns, to their schemes they soon bend.
They look on his cash
As rightly their own,
And soon from his pockets
To theirs it is flown.

Ah! be not deceived, for of this there's no doubt,
You always pay treble for "summat fer nowt."
And remember the saying
Amongst Yorkshire men:
"If tha does owt fer nowt,
Let it be for thysen."

"TORCH."

Our Roll of Merit

Readers on Active Service—Thirty-first List.

H. Miller (Sgt., R.A.F.).
J. H. Snowden (A.C.1, R.A.F.).
W. A. Hulbert (Works Squadron).
B. E. Curry, (Seaman, R.N.).
J. Walker (A.C., R.A.F.).
R. F. Andrews (A.C.2, R.A.F.).
H. Wooding (Pte., R.A.O.C.)
R. Hunter (Pte., Pioneer Corps).
W. A. Dowley (Lieut., R. Signals).
J. Marler (Cpl., R.A.F.).
R. A. Boughton (A.C.1, R.A.F.).
J. A. McDowall (Lieut., R.C.N.).

Frequency Modulation–1

Principles of Frequency and Phase Modulation.

By F. E. SCALES, Assoc.Brit.I.R.E.

A RADIO-FREQUENCY carrier wave in an unmodulated condition possesses constant amplitude, frequency, and phase. To modulate this carrier in order to convey intelligence to a distant point, the modulating voltage can be used to vary any one of these three properties.

The method of modulation that involves a change of amplitude is well known and in general use. The method of modulation that involves a change of frequency is not so well understood, but is coming into limited use. The third method, involving a change of phase, is more difficult to understand and operate, and will be discussed later.

In spite of the differences in the principles involved in these three methods, they have one thing in common, which may be expressed as follows: Whether the carrier amplitude, phase or frequency is made to deviate from its unmodulated condition the amount of the deviation must be proportional to the amplitude of the modulating voltage, and must follow faithfully every variation of the modulating voltage.

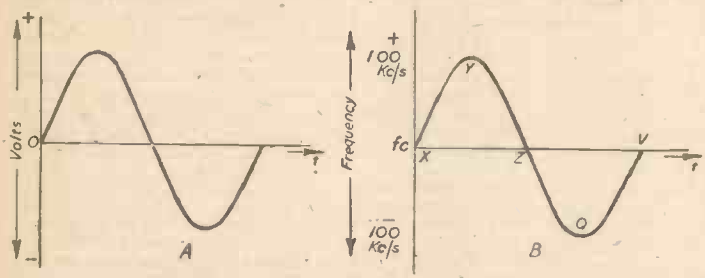


Fig. 1.—A illustrates the AF voltage plotted against time. B illustrates the corresponding variation in carrier frequency plotted against time.

In an amplitude modulated (AM) transmission, the carrier amplitude is varied above and below its original value. In the case of a frequency modulated (FM) transmission, the carrier amplitude is kept at a constant value, and the frequency is varied above and below its unmodulated value. Thus, to conform with the statement made in the previous paragraph, it will be seen that the amount by which the frequency rises and falls from its unmodulated state, depends solely on the amplitude of the modulation frequency, irrespective of the actual frequency itself. Therefore, should the amplitude of the modulation frequency vary, the deviation in carrier frequency will vary in sympathy.

A change of modulation frequency will not alter the amount by which the carrier frequency deviates, but will alter the *speed* of the deviation.

Supposing a carrier frequency of 10 mc/s is used, and it is desired that the maximum deviation shall be ± 100 kc/s. Then if the carrier is fully modulated by a modulation frequency (fm) of 1 kc, the carrier frequency will rise to 10.1 mc/s, fall to 9.9 mc/s, and return to 10 mc/s for every cycle of fm. This process will therefore be carried out 1,000 times per second in this case. Should the modulation frequency be raised to 5 kc/s, the process will be carried out 5,000 times per second. Figs. 1 and 2 illustrate this process graphically.

In order to produce a satisfactory response in the receiver it is necessary to vary the carrier frequency by an appreciable amount. A variation of a few cycles would evoke little response in the receiver. On the other hand, theoretically, the carrier frequency could be varied by a very large amount, with a considerable improvement in response.

It will be apparent from the above that it is difficult to define "percentage modulation," as is done with an amplitude modulated transmission. The depth of modulation is only limited by the band width of the tuned circuits employed in the transmitter. Thus if the tuned circuits were designed to give a level response over 100 kc/s, a frequency deviation of ±50 kc/s would be equivalent to 100 per cent. modulation. However, it will be appreciated that this modulation depth could be increased without change in carrier power, by alteration of the tuned circuits. A term that is often used in this connection, and which gives a clearer indication, is "deviation ratio," and is the ratio of the maximum frequency deviation to the highest modulation frequency used. For example, if the carrier frequency deviates ± 50 kc/s and the highest modulation frequency is 5 kc/s, the deviation ratio would be 50/5 = 10 : 1. The ratio does not normally exceed 5 : 1.

Phase Modulation

Before proceeding any farther, a definition of phase modulation will be of use, as it is in many ways akin to frequency modulation, but is nevertheless not the same thing.

From our original definition of modulation, we know that the phase of the carrier must be changed in sympathy with the modulation voltage. Now, it is a little difficult to conceive how the "phase" of the carrier can be changed, when there is only one sine wave (i.e., the carrier) present in the first place.

Let us imagine an alternating voltage of constant frequency (f), plotted on the usual volts/time graph (Fig. 3). If this alternating voltage were suddenly to jump ¼ cycle without altering frequency, thereafter it could be said to be leading on its original position by 90 deg. (see Fig. 3).

If we could arrange a carrier wave to advance and retard its phase as shown, in sympathy with the modulating voltage, phase modulation would be achieved, and a definition would be that the carrier changed its phase *with respect to its unmodulated condition*, in sympathy with the modulating voltage.

Now, a carrier wave cannot suddenly jump 90 deg. as shown above, and in any case the phase changes must be carried out slowly, if necessary, in order to follow the

(*Continued on page 327.*)

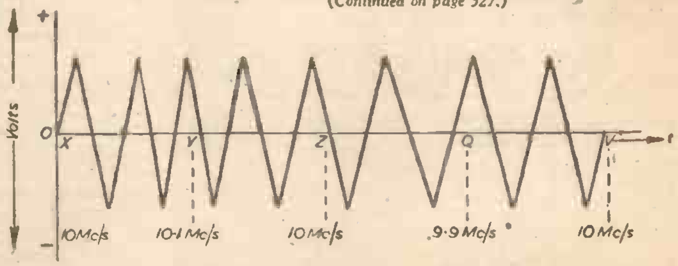


Fig. 2.—Variation of carrier frequency on modulation. This graph is another form of the graph shown in Fig. 1B, and the points X, Y, etc., correspond on the two graphs.

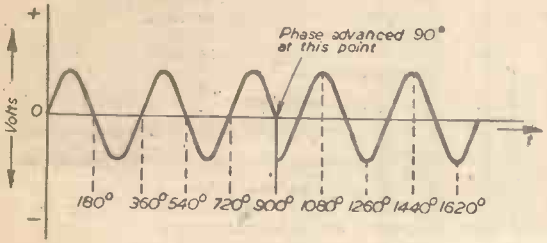
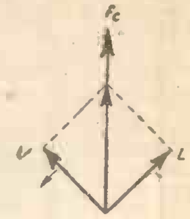


Fig. 3 (Left).—Ninety degrees gain in phase.

Fig. 4 (Right).—Vectors for an AM transmission.



modulation voltage. Supposing, however, the original carrier were to increase in frequency and then return to its original frequency. An increase in frequency of 10 kc/s would mean that the phase of the carrier, with respect to its unmodulated state, would be gaining by 10,000 × 360 deg. per second. If the carrier frequency is increased for 1/5,000 sec. and then returns to normal, its phase will be advanced by 360 × 10,000/5,000 = 720 deg. This advance will be maintained when the carrier frequency returns to normal, and can only be offset by a decrease in carrier frequency.

It will thus be seen that to achieve phase modulation, frequency modulation must take place, and vice versa. It will later be shown, however, that true frequency modulation does produce true phase modulation. The phase modulation produced is somewhat in the nature of a by-product.

Analysis of Frequency- and Phase-modulated Carrier Waves

It is well known that a transmission amplitude, modulated by a single sine wave, can be resolved into three separate radio-frequency components of constant amplitude, i.e., the carrier, the upper sideband, the lower sideband. This conclusion can be arrived at by reasonably simple mathematics. It remains to be seen whether similar sidebands arise when frequency modulation is used. The mathematical analysis in this case is rather beyond the scope of an article of this nature, but there are other ways of arriving at the same conclusion.

When frequency modulation takes place it is clear that considerable distortion of the original carrier will take place. This fact alone would suggest that additional frequency components will be introduced, but since there is no change in amplitude, these additional components must necessarily be rather different in nature from those in the amplitude modulated case. Now the three components of an AM transmission only combine to produce the familiar variation in carrier amplitude when there is a definite phase relationship between the three components. Should this phase relationship be altered by any means, the amplitude variations will be greatly decreased and removed entirely in extreme cases, and other effects will be introduced. The question is most easily investigated by means of a vector diagram.

Fig. 4 illustrates the vector diagram of a normal AM transmission. If the carrier is represented by *fc*, and the modulation frequency by *fm*, L (the lower sideband) will have a frequency equal to *fc*−*fm* c/s, and U (the upper sideband), a frequency equal to *fc*+*fm* c/s, and therefore vector L will be travelling at a speed *fm* c/s slower than that of *fc*.

Similarly, vector U will be travelling at a speed *fm* c/s faster than that of *fc*. It will be seen that the resultant of L and U is always in phase or in antiphase with *fc*, and will therefore cause its amplitude to rise and fall.

Now consider what would happen if L and U were moved round 90 deg. with respect to the carrier. The resultant would always be at right angles to *fc*, and would cause it to swing backwards and forwards pendulum fashion about its unmodulated position. This obviously indicates a gain and loss of phase, and by simply altering the phase relationship between carrier and sidebands, phase modulation and therefore frequency modulation has been produced. This process is illustrated in Fig. 5.

Examination of Fig. 5 shows that the carrier will be displaced by an angle ϕ ahead of or behind its unmodulated position. (Diagrams A and B.) Maximum displacement will occur in each case when the two sidebands are in phase with each other. The amount by which *fc* deviates will depend on the amplitude of the sidebands, and since this deviation represents a gain or loss of phase, it must also indicate an increase or decrease of frequency. Mathematical analysis shows that this diagram is, in effect, correct for frequency and phase modulation, and that the resultant of the sidebands spaced *fm* c/s above and below the carrier is always 90 deg. out of phase with *fc*. The diagram is, however, at the moment incomplete.

Let us now examine the diagrams from the frequency modulation point of view. The first point that arises is that as *fc* swings backwards and forwards, so does its amplitude rise and fall (constant amplitude is represented by the circle drawn with O as centre). In practice, however, the carrier amplitude does not change. Therefore, there must be some restraining influence not shown on the diagram. In point of fact, there are many more sidebands in addition to those shown, even when the modulation voltage is a simple sine wave. The mathematical analysis shows that an infinite number of sidebands are produced spaced from the carrier by the ollowing amounts: ±*fm* c/s, ±2*fm* c/s, ±3*fm* c/s, etc.

The odd sidebands (±*fm*, ±3*fm*, etc.) produce resultants which are 90 deg. out of phase with *fc* (as in Fig. 5). The even sidebands (±2*fm*, ±4*fm*, etc.) have resultants in phase or in antiphase with *fc*, and these tend to keep the amplitude of *fc* constant.

The second point is that if L and U (Fig. 5) remained constant in amplitude when the modulation frequency was varied, the angle ϕ would remain constant. This conforms to our definition of phase modulation, but not to frequency modulation, since here it is the frequency deviation and not the phase deviation that must remain constant. It should be clear that if the frequency deviation does remain constant, if we increase the *rate* at which the frequency deviates (i.e., we increase *fm*), then the carrier as it moves from its original position will not have so much time to gain in phase before it reaches the limit of its swing, and therefore the phase deviation (ϕ) will not be so great.

Thus, for true frequency modulation, as *fm* increases, the frequency deviation remains constant, but phase deviation (ϕ) decreases. It should be clear that from Fig. 5 that if ϕ decreases the amplitude of the sidebands L and U must decrease. Therefore the conclusion is reached that in an FM transmission the sidebands are

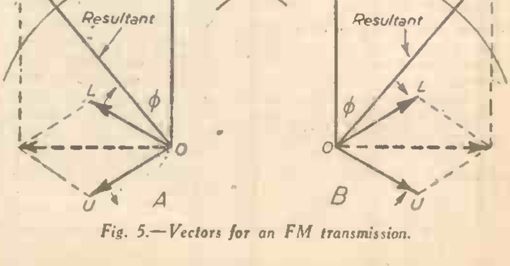


Fig. 5.—Vectors for an FM transmission.

much larger in amplitude when the modulation frequency is low than they are when it is high. They are also more numerous.

With certain modulation depths the carrier component of the modulated wave is reduced to a very small amplitude, the sidebands nearer the carrier being correspondingly large. The sum of carrier and sideband components will, of course, have the same amplitude as the unmodulated carrier.

The results are a little different in the case of phase modulation. Here the phase displacement (ϕ) is constant, and, therefore, as *fm* increases so will the frequency deviation increase. (This apparent frequency modulation is a by-product of phase modulation.) This point is of importance when discussing noise in a FM receiver, explained later.

Let df=deviation of carrier frequency and let fm= modulation frequency.

Then for true phase modulation $\frac{df}{fm}$ is constant.

For true frequency modulation df is a constant, and, therefore, $\frac{df}{fm}$ is obviously inversely proportional to fm.

Each system produces the other as a by-product, but the by-product is only true modulation when fm is a pure sine wave, which would never occur.

Examination Technique

Some Hints on Answering Examinations. By K. D. BOMFORD, M.Sc.

DURING the next few weeks thousands of students will be putting to the test the knowledge they have gained after many gruelling hours of hard work extending over the winter months. Just how well the student performs in the short space of perhaps only three hours will determine whether he is to reap the full fruits of his work or whether that work will be largely wasted, and must be repeated again while another year passes. The examination system is often attacked as unfair, but that doesn't concern us at the moment; what does matter very much is that every student entering an examination room should be able to put up the performance which will ensure a pass.

Many students penalise themselves because they concentrate solely on acquiring knowledge, but never consider how best they can put it down on paper under examination conditions. We might say that they "know their stuff," but never learn how to "do their stuff," or more politely they haven't any examination technique. It is surprising the number of ingenious ways that are found for losing marks, but perhaps the most common are, loss of time due to lack of method, carelessness in reading the rules and questions of the examination, general vagueness and untidiness, and above all, that "examination feeling" which seems to rob students of the power to think clearly, so that hours later they could kick themselves for not seeing how easy the questions are which they did not attempt.

The Preliminaries

During the few days before the examination everyone meets with conflicting advice; should you "swot" right up to the last minute, or should you leave off all work and have a rest? Obviously it depends partly on the student's temperament, but in the average case it is best to do a small amount of work, even if only to prevent you from worrying; but don't cram right up to the last minute. The guiding rule is to be fresh, and, incidentally, to be early and avoid any last-minute rush. You should also have found out beforehand what instruments are provided and what instruments you must provide yourself, and whether slide rules are permitted.

Now for those first vital few minutes with the question paper. The golden rule is—don't write a word for at least five minutes. Begin by reading very carefully the instructions at the head of the paper and note particularly the time allowed for each question, also watch out for any compulsory question. Next, read through each question slowly and as you read try to visualise the headings under which you would answer the question. This is an invaluable help in assessing the relative difficulty of the questions, and often one which at first sight appears difficult turns out to be comparatively easy. Mark those questions which you think you can answer satisfactorily and then choose about three which seem to be the easiest, and deal with these first. It is an added advantage, if the paper contains a mixture of mathematical and descriptive questions, to deal with the calculations first, because very often these take a shorter time and leave a little longer for the descriptive ones.

Timing

Remember that an examination is a race against the clock, so keep one eye on the time, and remember that 10 minutes extra time spent in polishing up one question may gain two marks, but will probably lose you five or 10 marks towards the end of the paper. Also watch that question which deals with work in which you may have specialised; you must limit your answer to the allotted time, however great the temptation to go on and show the examiner how exhaustive is your knowledge of this point.

Now what about that awful predicament that everybody finds themselves in at one time or another when the time has gone and the question is only half finished? If it is a descriptive question, then round it off quickly and briefly, but if it is a mathematical question which has "stuck," leave it at once, and if there is time, come back to it later. Very often the second attempt reveals the trouble immediately.

Tackling the Questions

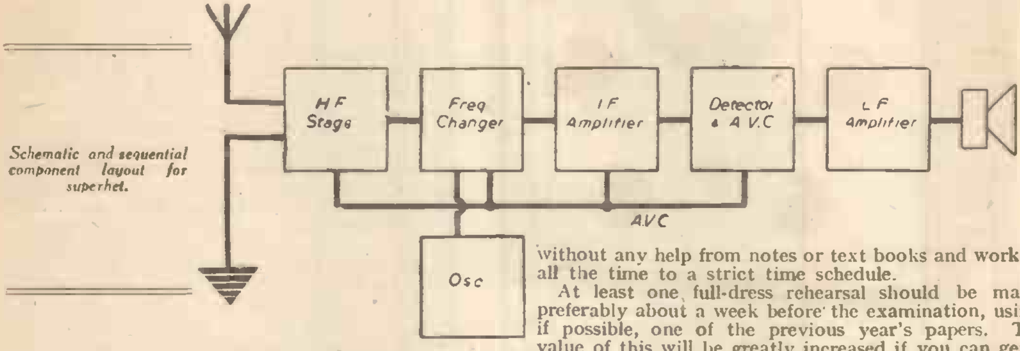
The points to bear in mind in setting down the answers to the questions must now be considered. In the first place you should be as neat as possible not only as regards handwriting, but also in the general layout of the question, because a certain number of marks are often given for these points and in any case the more favourably the examiner is impressed when he first sees your paper the better. The greatest asset which you can possess and one which you must strive hard to cultivate, is the ability to set down and develop your answer in a series of logical steps. There are two reasons for this, in the first place the examiner can follow your reasoning much more easily if your answer is just a collection of disconnected statements. In the second place, a logical development is the best way of making sure that all the necessary information required by the question is put down.

In the case of a mathematical type of question an orderly method is relatively easy to maintain because each step is usually based on the previous one. The following points must, however, be very carefully watched. Whenever a formula is used for the first time in a question you should put it down in full and add on one side of the paper what each letter represents, and, most important, what units are to be used. Never on any occasion substitute values into a formula without first setting it down and explaining it. Absolute accuracy of working is, of course, essential for full marks, so watch out for slips and take every opportunity for doing a cross check. Also look out for what is obviously a ridiculous answer, for example, if the inductance of a high-frequency tuned circuit comes out to 100 henries, it is obvious that you must check through the units of the quantities you have used, since the answer would almost certainly be 100 microhenries. The neatness of this type of question is greatly improved if you keep all the equal signs vertically under one another and keep all rough working well to one side of the paper. Don't forget to number equations or results which may have to be used later on in the question.

Such an orderly method as this makes the most complicated circuits relatively easy to draw.

Many students rarely, if ever, use block diagrams when describing the principles of a circuit. If we again take the case of the superheterodyne receiver and assume that a brief description is required, then a block diagram, as shown below, will not only save time, but will keep a picture of the circuit in front of you and help you to develop the answer in an orderly manner.

So far we have outlined the methods most likely to bring success, but unfortunately these methods do not come automatically. The only way to acquire them is to practise under examination conditions. This means taking one or more questions and answering them without any help from notes or text books and working all the time to a strict time schedule.



Schematic and sequential component layout for superhet.

At least one full-dress rehearsal should be made, preferably about a week before the examination, using, if possible, one of the previous year's papers. The value of this will be greatly increased if you can get a competent friend to mark it for you, and tell him to be as stiff as he can.

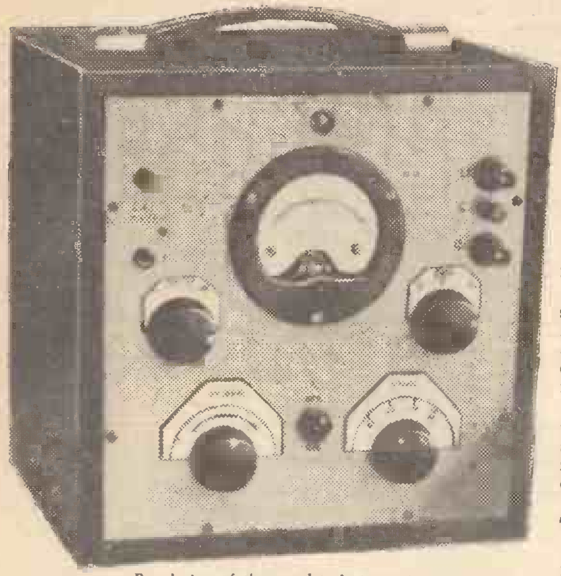
1. Avoid intensive swotting just before the examination.
2. Spend the first five minutes in carefully studying the paper.
3. Determine the sub-headings under which you are going to write your answer before starting on the answer.
4. Use sketches including block diagrams as much as possible.
5. Keep rigidly to the time allowed for each question.
6. Above all, practise beforehand answering questions under examination conditions.

The purely descriptive type of question often requires a great deal of forethought, if it is to be answered to the best advantage. The best way is first of all to make a list of subheadings under which you are going to give your answer. You will find that as you set these headings down they will suggest other points which you might otherwise have overlooked. The headings should then be arranged in the best order and the question answered. By subdividing the question in this way it is much easier to keep within the time limit allowed for each question—always a difficult point where descriptions are concerned. In general it is true to say that a brief and to the point answer, well illustrated with sketches, will score more marks than a long-winded discourse containing the same amount of information.

Illustrations

The value of an answer is greatly increased by the use of sketches and diagrams which not only give the examiner a good idea of the value of the answer at a single glance, but more often than not saves time. Many students fight shy of illustrations because they are afraid that their sketches will not be good enough, but remember there is no time to produce polished drawings such as you see in text books, for all that is required is a fairly neat free-hand sketch. It is worth while spending a little time in practising doing typical sketches, and you will be surprised how much improvement results after a very few attempts. A warning must be added here, however—watch the clock, because it is very easy to go on polishing up a drawing to an unnecessary extent and thus waste valuable time. Circuit diagrams usually give very little difficulty, mainly because anyone studying radio must be continuously reading and drawing them, but a few hints about tackling fairly complicated diagrams may be helpful.

For example, in the case of a circuit diagram of a superheterodyne receiver, first of all draw the valves suitably spaced in a straight line with straight lines above and below for the H.T. and earth. Then add all the straightforward elements, such as the decoupling and bias circuits; having done this you are free to concentrate on the more difficult parts of the circuit, such as the frequency changer and the A.V.C. circuits.



Panel view of the complete instrument.

YOUR SERVICE WORKSHOP—4.

A Valve

Constructional Details of an Anode-be

BEFORE dealing with the subject of this month's article, there are a few points which might be cleared up regarding the oscillator described in the last issue. Referring to V.R.1, the output control, it was stated that as this is not of the constant impedance type, calibration will not hold exactly for all settings of V.C.1. This should have read . . . for all settings of V.R.1. It is as well to make certain that this control really is at zero resistance when the knob is in that position. In quite a few of these components a small portion of the resistance element is still in circuit and while for some purposes it is useful—biasing variable mu H.F. valves, for example—it is the last thing one wants for a control which should reduce the output to nil. The desired effect may usually be achieved by adjusting the stops inside the component, either by bending or filing. Incidentally, the value of this control is not critical below that given and down to 100 ohms may be used, if convenient, with possibly some advantage in certain cases, providing it is of the carbon track type.

A point which may not be appreciated concerns the short-wave range to which the oscillator may be tuned. Although the lowest fundamental was stated to be approximately 40 metres, strong harmonics are available down to 20 metres and below, which makes the wave range practically continuous up to 3,000 metres.

If the service oscillator is used for any length of time, the heat generated inside the cabinet may be appreciable, and it is advisable to fit a small ventilator of perforated zinc to the back of the cabinet round about the region of the power pack.

The Valve Voltmeter

It will be seen that the next instrument to be described is the valve voltmeter, which is worthy of inclusion in the apparatus for the service workshop, inasmuch as it is the only type of voltmeter that is capable of making certain measurements. This advantage is made possible by reason of the instrument's extremely high input impedance, which in certain cases is due only to that existing across the valve electrodes and to the stray capacities of the wiring. At other times the limit is set by the value of the actual resistor joined across the input terminals, which is necessary when no conducting path is available in the circuit to which the valve voltmeter is connected, or for providing range switching. It will be appreciated, therefore, that when compared with even a very high resistance voltmeter of the ordinary type, the resistance or impedance of the valve voltmeter is infinitely higher. Coupled with this is the fact that it is independent of the frequency of the source to be measured. This means that the voltage developed across a tuning coil in a short-wave receiver may be measured as accurately as, say, an L.F. signal of 500 cycles. There are many types of valve voltmeter, both simple and complex, but the basic principle of operation is the same in all cases, namely, that of connecting a valve in such a manner that it operates as a rectifier. Any alternating voltage appearing across its grid and cathode causes a change in the valve's working conditions, this change being indicated on a sensitive meter; and since the valve is a unidirectional device, the indicator may be an ordinary D.C. milliammeter. Much the same sort of thing happens in a receiver

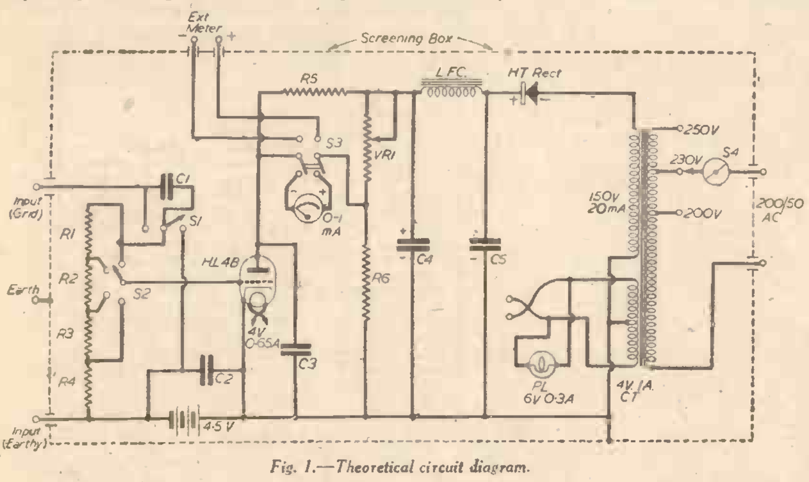


Fig. 1.—Theoretical circuit diagram.

R.1 — 0.5 mΩ	R.4 — 0.1 mΩ	V.R.1— 2,000 Ω	C.3 — 1.0 mfd.
R.2 — 0.3 mΩ	R.5 — 3,500Ω	C.1 — 0.02 mfd.	C.4 — 4.0 mfd.
R.3 — 0.1 mΩ	R.6 — 15,000 Ω	C.2 — 1.0 mfd.	C.5 — 4.0 mfd.

Voltmeter

Square Law Instrument. By S. BRASIER

employing anode-bend rectification. A suitable meter connected in the anode circuit of the detector valve would show a rise in current when a signal is tuned in, and the rise would be roughly proportional to the strength of the input signal.

Fig. 1 shows the theoretical circuit diagram of an anode-bend square law valve voltmeter. It is of a comparatively simple type which might not amply fulfil the requirements of the laboratory man, but for service work, where measurements are more often comparative than quantitive, the instrument is eminently suitable because of its robust nature and consequently its ability to stand up to hard work in the workshop. Referring to Fig. 1 it will be noted that a triode valve is used—actually a low capacity type Tungsram H.L.4G. with a top cap grid connection—and this is biased negatively by a grid battery. High-tension and heater voltage is derived from A.C. mains via a suitable transformer, while rectification is obtained by means of a metal rectifier, after which the power is smoothed by L.F.C.1 of roughly 30 henries in conjunction with C.4 and C.5. A switch, S.3, provides for the use of an external meter, the reason for which will be explained later. S.1 connects G. input either direct to grid of the H.L.4G. or via the 0.02 condenser C.1, while a third position short-circuits the input. A potential divider system, made up of C.1, C.2, C.3 and C.4 makes it possible to extend the voltage range of the instrument by manipulation of the 4-way switch S.2.

Choice of Components

At this stage some advice on the choice of components would no doubt be helpful. The mains transformer requires to deliver about 150 volts at approximately 10 milliamps from its H.T. secondary winding so that quite a small type may be employed. That used in the original was from an H.T. eliminator, and as the component had no low-tension winding it was necessary to provide for this by some means, so an extra winding was placed on the transformer to supply 4 volts at 1 amp. In case readers wish to adopt a similar method, it is important to note that the winding must be in the same direction as the existing one. Anyway, the transformer will have to be dismantled, so after removing the stampings it is easy to ascertain the direction of the turns by carefully unwinding the outer insulation. A rough estimation of the number of turns required may be gained from the cross-sectional area of the winding limb. For instance, if this is about ½in. it would be wise to allow about 12 turns per volt to start with, while a 1in. core would need about 8 t.p.v. It will be necessary to check the resultant voltage with an A.C. voltmeter—making any adjustments if necessary. For this purpose the core may be only temporarily replaced by inserting all the T's through the bobbin in one pile, and all the U's around the outside. The centre tap may be soldered in after ascertaining the correct number of turns, or, if this is difficult, a centre-tapped resistor or humdinger may be joined across the "outers." The use of the small metal rectifier is convenient in view of the comparatively low voltage/current required, but a half-wave valve rectifier would serve the purpose just as well, although in this case an extra low-tension winding would be required on the mains transformer. The smoothing system may be made up of any good quality L.F. choke and condensers, providing the latter are at least 4 mfd. each and the choke is not of too high resistance (which would cause an excessive voltage drop). Switches marked S.1 and S.2 should be of particularly good quality and of the low capacity type, especially if the instrument is to be used on the very high frequencies.

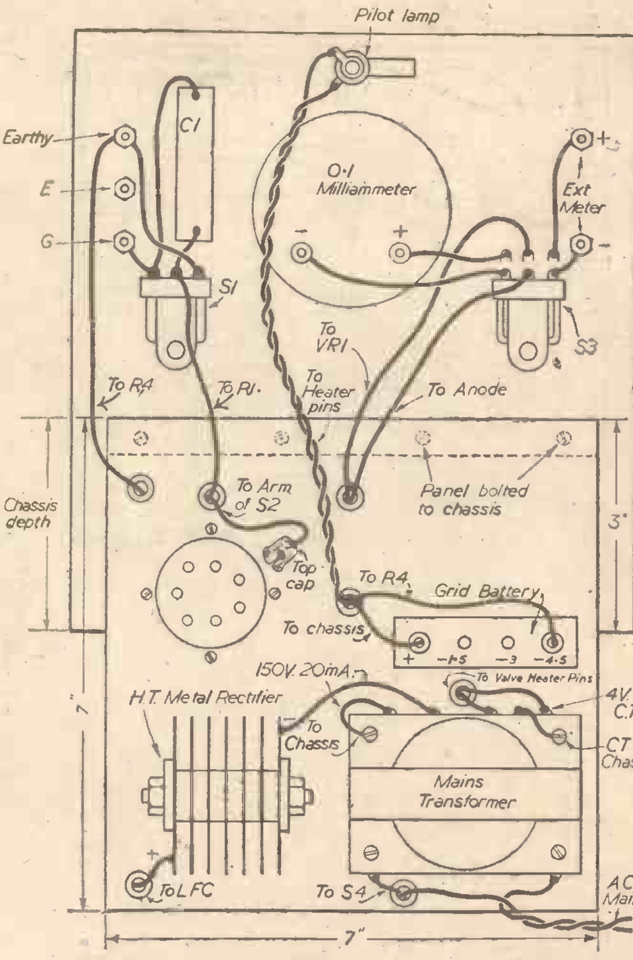


Fig. 2.—Panel and top of chassis layout and wiring diagram.

The tungsram valve specified is particularly suitable for the valve voltmeter, but if difficulty is experienced in obtaining it, it is suggested that use be made of the triode section of a double diode triode valve, which type appears to be in better supply than others. Connections are similar except that the metallised shielding is joined to pin number 2, the diodes would, of course, be left free.

Readers who are following this series will remember that the difficulty of obtaining suitable meters was discussed in the first article, and it is with the apparatus concerned that the lack of a suitable type may cause some inconvenience. So it was partly for this reason that a meter switch was incorporated, the idea being that if a separate 0-1 m/a meter is not on hand, the 1 m/a range of the universal test meter may be used (it was assumed that the service man possessed one) until such time as an additional movement became available, and space should be left on the instrument panel for this purpose. It is really advisable to possess more than one meter because a universal test set, although having perhaps 30 or more ranges, may be used only for one measurement at a time, so that even a versatile instrument of this type has limitations which, in more complex tests, may make themselves felt. Moving-coil milliammeters reading up to 25, 50 or 100 m/as are easier to secure than the low range type, and if one or two of these are handy it puts one in a position to use the universal test meter for the more important or precise measurements.

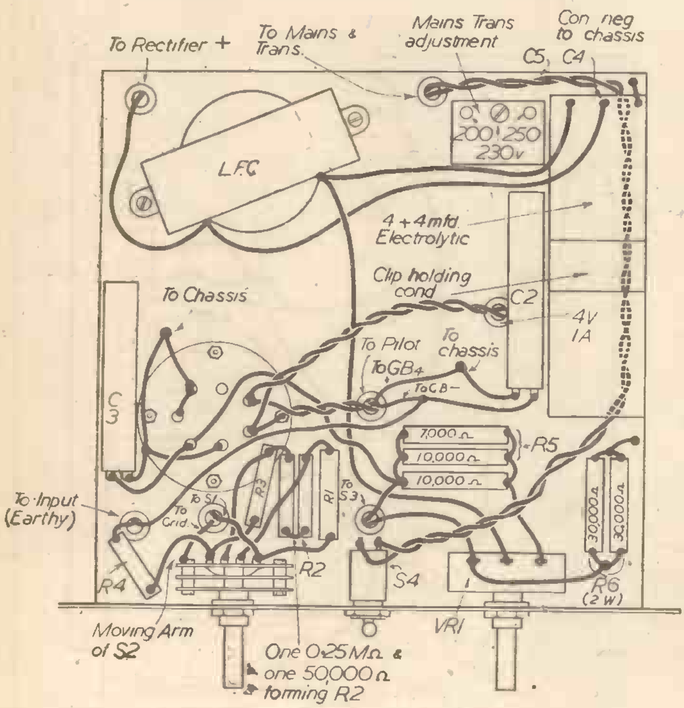


Fig. 3.—Under chassis layout and wiring.

Construction

The construction of this valve voltmeter is not at all difficult, as will be seen from the illustration and Figs. 2 and 3, although it is wise to make the chassis and panel of metal, as in the original. A point to watch regarding component mounting is that the fixing bush of all the switches and the potentiometer are dead and do not connect electrically with any of their contacts. The Ex. meter sockets and input sockets must also be of the insulated type, for although the low potential input socket is marked "earthy," it does not actually connect to earth. The depth of the chassis is rather greater than usual, i.e., 3ins., but this was done so that ample room was available for the L.F. choke, smoothing condensers, etc. The front edge of the chassis needs to be only about ½in. deep in order that the panel may be bolted to it along this edge.

Wiring

As in all test gear, wiring should be undertaken with extreme care, avoiding "dry" joints and unreliable connections. Particularly is this so in the case of the wiring to S.1 and the grid lead, where thick wire and good insulation should be used, and it is advantageous—at any rate in the case of very high-frequency measurements—to provide ample clearance in the chassis holes where the grid leads pass through it. A clip for the grid-bias battery is made from an odd piece of metal and soldered to the chassis in a convenient position. This battery, by the way, is of 4.5 volts, and may consist of a flash lamp battery, although that shown in the illustration is a half of an ordinary 9 volt G.B. which was cut into two, thus gaining the advantage of small size. Since no indication is otherwise given that the instrument is switched on (except, of course, when measurements are being taken) a pilot lamp is fitted. It is arranged so that part of the actual bulb protrudes through a suitable sized hole in the panel. Two of the resistors, R.5 and R.6, are of rather odd values and are therefore made up of two 1 watt resistors of 30,000 ohms joined in parallel (R.6) and of two 10,000 ohm and one 7,000 ohm in parallel (R.5). This method serves a double purpose because R.5 and R.6 need to be of the 2-watt type. Note that resistors R.1, R.2, R.3 and R.4, forming the input potentiometer, must be of the carbon type—not wire wound—and also that R.2, of 300,000 ohms, is made up of one 250,000 ohm and one 50,000 ohm resistors joined, this time, *in series*.

The panel indicator plates for the controls are cut from pieces of ivorine (Fig. 4), which material is readily obtainable in the form of large dial scales available from radio surplus stores. The old markings may be rubbed off with the aid of a little abrasive cleaning powder and new ones engraved in indian ink with a fine mapping pen. The cabinet should be lined with some screening material if 100 per cent. efficiency and accuracy is expected from the apparatus under all conditions, but for general service work this complete screening is not essential.

When construction has been completed and wiring checked, the valve voltmeter is ready for test and for this purpose the controls should be set as follows: Range switch to lowest position, i.e., 2 volts (more about this later); set zero control to maximum, i.e., clockwise; the grid switch to "short input," and the meter switch to "internal," unless an external meter is being used. Switching the instrument on will produce an initial "kick" from the meter needle, after which the current will rise as the valve warms up and it may be necessary to reduce the setting of the "set zero" control in order to stop the needle from going just off the scale. The instrument is now left for a few minutes in order that the valve may attain its correct working temperature and that the current may settle down to a steady value. Then the "set zero" control is turned anti-clockwise until the meter needle is brought back to exactly zero current. In this condition the valve voltmeter is ready for use. Its normal voltage measuring range, using a 0–1 m/a movement, is 0–2 volts, but this is increased to 4, 10 or 20 volts by the operation of the range switch S.2. The normal measuring range will also be affected by the type of meter employed. For instance, those readers who are fortunate in possessing a micro-ammeter—which may be joined to "Ext. meter" when required—will be able to get increased accuracy at small readings, say 0.1 volt, but at the expense of voltage range, while a 0–2 or 0–2.5 m/a movement will provide an increased range of measurement. Having explained this, it will be assumed that a 0–1 milliammeter is in use for the purposes of voltage checking, and for this it is convenient to use the 50 cycle mains supply (since the V.V. is independent of frequency) stepped down to a suitable voltage by a transformer. A normal centre tapped heater winding is ideal for the purpose because, with a centre-tapped humdinger or small resistance joined across one half of this winding, it is possible to first measure or check one and two volts on an ordinary A.C. voltmeter; and by scraping away the insulation, if any, from the resistor, points may be found where 0.5 volt and 1.5 volts may be checked. It is not a bad idea to make up a tapped potential divider using a suitable length of resistance wire wound on a strip of paxolin so that voltages in steps of, say, 0.1 or 0.2 are available when connected across a low voltage source of known accuracy. However, reverting to the first method the four voltages available are sufficient to check the V.V. and after applying two volts to the input sockets, the "grid" switch is turned to "direct" when the meter should read approximately full scale. Lower potentials will naturally give smaller deflections, but don't expect a linear scale calibration because the instrument is of the square law type, which means that indications will be proportional to the square of the input volts applied. It is an easy matter, though, to prepare a graph, plotting volts input against meter reading and from which intermediate values may be read off. The range switch increases readings by 2, 5 and 10 so that voltages up to 20 may be measured. The graph will be required therefore only for the low range. The range switch *should* be of the type that does not disconnect between its various positions, otherwise the bias circuit is broken and the needle flies over to full scale every time the switch position is altered. Therefore, if the required type is not available it must be remembered to switch off before changing.

The "short input" position on the grid switch S.1 is by way of being a safety device because the very act of gripping the grid input lead may, under certain conditions, send the needle over the meter scale in great haste and when using a micro-ammeter the effect might eventually cause damage, so that it is very advisable to leave S.1 in the above position until the reading is required.

Applications

The most useful applications of the valve voltmeter are, of course, in measuring high frequency; for instance, the radio frequency output of the service oscillator may be measured with this instrument, as also may the signal voltage developed across coils in the various stages of a receiver. It is necessary to take precautions where H.T. is superimposed on any signal voltage and for this purpose the switch S.1 is turned to "condenser"—the middle position—which action connects a 0.02 mfd. condenser in series with the grid lead. Coils may be checked for their inductance matching qualities and also their efficiency, and it is proposed in a later article to show how this and other tests may be carried out, using the valve voltmeter in conjunction with the service oscillator.

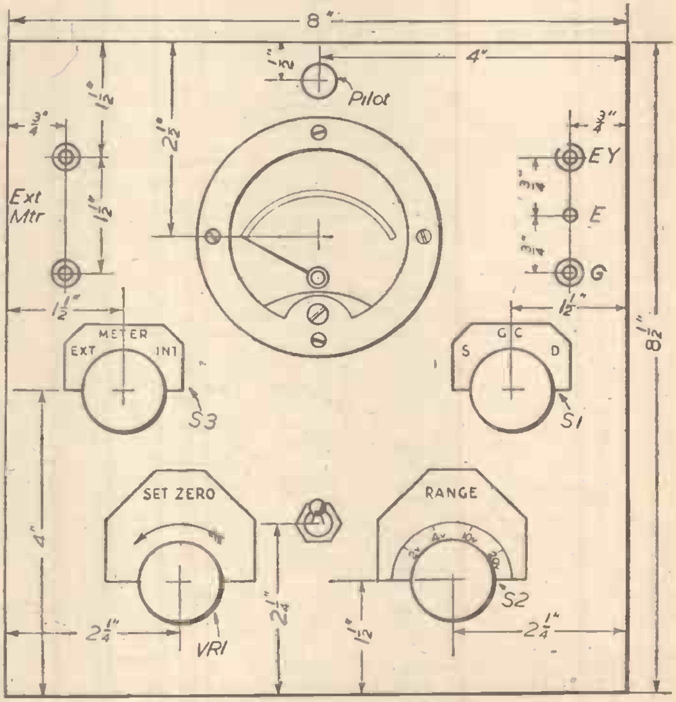


Fig. 4.—Panel layout and drilling measurements.

(To be continued.)

LIST OF COMPONENTS

One metal panel 8in. x 8½in.
One metal chassis 7in. x 7in. x 3in. deep.
One mains transformer, secondary 150 v. 10-20 m/a. 4 v. 1 a. (see text).
One metal rectifier, old type (style H.T.5).
One L.F. choke. 20-30 henries.
One 7-pin valve holder.
One pilot lamp 6 v. at .3 amp. with holder.
One milliammeter 0-1 (see text).
One Q.M.B. on-off toggle switch (S.4).
One D.P.D.T. changeover switch (S.3).
One S.P.D.T. changeover switch (S.1); (3 position type).
One 4-way rotary switch (S.2) see text.
One wire-wound potentiometer 2,000 ohms.
One G.B. battery 4.5 volts and clip for same.
Condensers: One 4 x 4 mfd. electrolytic block 250 v.w.; Two 1.0 mfd. Mansbridge type 250 v.w.; One 0.02 mfd. tubular 2,000 v.w.
Resistors: One 0.5 megohm, one 0.25 megohm, one 50,000 ohm, two 0.1 megohm (carbon type 1 watt); two 30,000 ohm, two 10,000 ohm, one 7,000 ohm (1 watt).
Cabinet, wire, screws, etc.

Pick-up Peculiarities

Various Causes of Inefficiency, and Their Remedies

A GOOD pick-up should give results not greatly inferior to that of the radio programmes. If it does not it is not always the fault of the pick-up, and it is definitely worth while trying to trace the actual fault in the set.

When a pick-up is connected this is equivalent to running a long lead from the grid of a valve in the first stage in the set, and this lead is liable to pick up hum, etc., as well as being a source of feed-back in the amplifier. It will be obvious that this lead should be kept as short as possible, that it be kept well away from the later stages of the set, and particularly that it is not allowed to approach the loudspeaker leads. Also, in the case of houses wired for A.C. current, that it is not allowed to approach the wires carrying A.C., whether these be in walls or in the form of flex going to electrical apparatus of any kind. The latter will, of course, give rise to hum, and a recognised cure is to shield the leads.

It is the more obscure causes of unsatisfactory results when using a gramophone pick-up, however, which puzzle the amateur. These fall into a variety of classes, and the following notes may prove helpful in tracking down any particular fault met with.

Coarse Reproduction

The most common cause of this is overloading. It is not usually the output valve which is overloaded, though this can, of course, happen, perhaps combined with overloading of other valves as well. The various resistors used in the set cut down the H.T. applied to the anode of the valves with the result that they cannot accept a big grid-swing. Modern pick-ups have a relatively big output, which may easily overload the detector—the valve which usually succeeds a pick-up. The remedy here is to cut down the volume at the source, i.e., at the pick-up itself. This may be done with a potentiometer, or even a variable resistance connected across the pick-up. It is impossible to state the value of the resistance required, as this will vary with the resistance of the actual pick-up. Coarse reproduction can also be caused by the L.F. amplifier going into a state of inaudible oscillation. This comes under the heading of instability.

Instability

This can be caused by many factors, and in the case of commercial apparatus the makers have usually incorporated the necessary condensers and resistances which ensure stable operation when a pick-up is fitted. The average amateur constructor, on the other hand, often connects a pick-up and hopes for the best.

A common form of instability is an L.F. howl. This occurs as soon as the set is switched on with the pick-up connected, though the set may be perfectly stable with the pick-up removed. If the set used for gramophone reproduction is of the 1—v—1 variety, with the detector transformer coupled to the output valve, a simple cure for this is to reverse the primary leads to the transformer. For the causes of this in detail you should turn up your copy of PRACTICAL WIRELESS dated February, 1943, where, on page 99, the whole question of transformer couplings is dealt with. Suffice it to say here that the phase of the signals reaching the transformer is reversed when a pick-up is connected to the detector valve, i.e., the leaky-grid detector automatically becomes an L.F. amplifier when a pick-up is connected. It is possible to "cure" a howl of this description by adequate, or in this case more than adequate, decoupling of the detector-cum-L.F. valve's anode circuit, and by various other expedients without reversing the leads to the transformer. But such a set can be described as doing its best to howl and not quite succeeding, and such inaudible instability is bound to "colour" all gramophone reproduction. The remedy, as already stated, is to reverse the transformer's primary leads. Howling can also be caused by bringing the pick-up leads too close to the loudspeaker leads. In this case the howl is due to feed-back and the remedy is obvious.

Inaudible Oscillation

Though this is a form of instability it is necessary to differentiate between the two. Inaudible oscillation is, as a rule, confined to the output valve, and is marked by a sharp rise in anode current of this valve. Tetrodes are more prone to this form of trouble than pentodes, lacking the stabilising influence of the latter's suppressor grid. A milliammeter will show if this condition exists. As the oscillations have the effect of reducing the grid-bias volts the valve will stand nearly double the proper grid-bias voltage without materially reducing the anode current. It is essential, however, to shunt the meter with a 2-mfd. condenser or the effect may be increased. The cure is to feed the auxiliary or priming grid through a 5,000 ohms resistance, and to earth this grid through a 2-mfd. condenser. A grid stopper of 100,000 ohms may also be tried. Quality is, of course, very bad when the output valve oscillates in this way, and for some reason the effect is more common when using a pick-up.

Other Effects

A whistle is sometimes heard when the leads to the pick-up are kept separate. They should be twisted together or be inside the same braiding. The low potential wire then acts as a shield to the other wire, and the tendency to whistle is much reduced. With a resistance-capacity-coupled amplifier coarse reproductuin may be due to the coupling condensers being leaky and letting H.T. get through to the grid of the following valve. All condensers in this position should be above suspicion. They can be tested by watching a milliammeter needle and applying different grid-bias voltages to the valve concerned. If the valve takes an unduly high G.B. voltage, or by increasing the voltage the anode current is not thereby lowered, then the condenser is faulty.

Practical Hints

A Novel Microphone

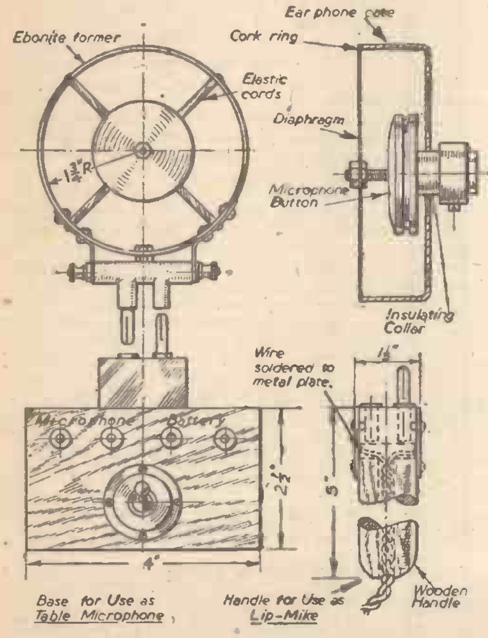
I RECENTLY constructed a cheap and efficient microphone out of a few parts found in the junk box. All that I required was an old earphone, an old type aerial coil of the plug-in type (with an ebonite former of a diameter of about 3½in.), some sockets, a midget switch, terminals, flex, wood. Also, a box about 2½in. × 4in. × 3in. is required, and a microphone button of the type illustrated (which cost about 9d.), and a flashlight battery.

The microphone can either be used as a table model or as a lip-mike. The advantages of the arrangement illustrated are:

(1) The plug-in mike can be moved easily, and can be quickly set up anywhere.

(2) The lip-mike is useful for remote use in positions where a battery and transformer would be inconvenient.

(3) The complete unit is small, cheap to build and maintain, and neat in appearance.



A novel microphone constructed from spare parts.

The constructional details are as follow:

The Microphone.—I removed the magnets, etc. from the earphone, and into the aluminium case I built the button, holding it in place with a ¼in. diameter collar with grub-screw. The two terminals were insulated from each other by a piece of fibre tube. Two thin pieces of insulated wire served as leads to the coil terminals. The diaphragm I used was the original earphone one, drilled to suit, but a thinner one may prove more efficient. The diaphragm is held in place by a small nut, which can be adjusted as required. The whole container was mounted on four elastic cords.

The Table Base.—This houses the transformer (75 : 1) or (50 : 1) and the battery. This I constructed as simply as possible from two old cigar-boxes.

The Lip-mike Handle.—This consists of a block of wood, 5in. × 1½in., cut to shape and drilled lengthwise. In one end I inserted a socket, and connected the flex to two plates at each side, which were, in turn, connected to the terminals of the socket. Further details should be clear from the accompanying sketches.—E. J. PEPPER (Swanland, E. Yorks).

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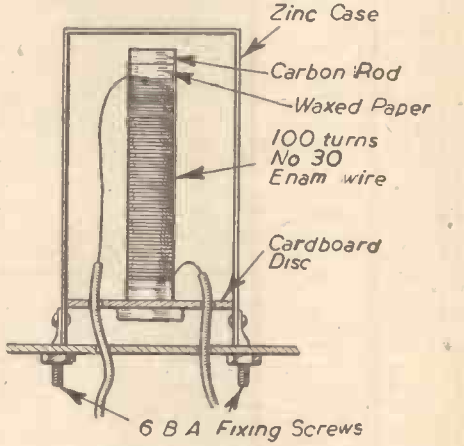
A Screened H.F. Choke

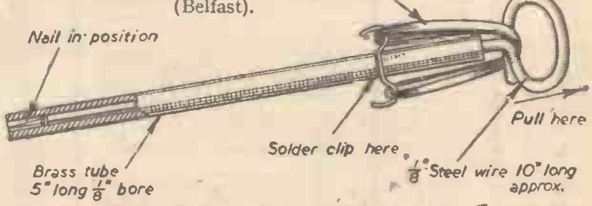
A NEAT screened S.W. H.F. choke can easily be made from an old U.2 flashlamp cell. With a pair of pliers remove the carbon rod, and clean the zinc container of its contents. Cover the carbon rod with waxed paper, and wind on about 100 turns of 30-gauge enamelled copper wire. The rod can be fixed in position with the cardboard disc taken from the top of the cell. Fixing feet are made from 6B.A. brass screws. If the leads are covered with sleeving only four small holes need be drilled in the chassis to take the choke.—F. FENSOME (Worksop).



A screened short-wave H.F. choke.

A Nail-driving Tool

WITH the aid of the device shown in the accompanying sketch sprigs and tacks can be driven in, even in the most awkward places, where it is impossible to use a hammer. After drawing out the bar a little insert the sprig into the end of the barrel, putting it on the spot required, pull out the bar, extending the rubber band, and then let go. The sprig can be driven home in the most delicate places. Details of construction of this simple tool are clearly shown in the sketch.—G. BALLANCE (Belfast).



A simple tool for driving small nails in awkward places.

Elementary Electricity and Radio—6

By J. J. WILLIAMSON

(Continued from page 284, June issue)

The Open Oscillatory Circuit

REFERRING to Fig. 8, let us open out the plates of the condenser as in Fig. 10 (a), and then replace them with two wires—Fig. 10 (b)—finally replace one wire with the surface of the earth.

In all three cases we still have an oscillatory circuit, the difference being in the fact that as we separate the plates—Fig. 10 (a)—more energy is transformed to electro-magnetic radiation or radio waves. In Fig. 10 (c) one plate of the condenser is the familiar aerial and the other the earth. The oscillatory circuit, now said to be "open," together with a source of energy of the correct frequency, constitutes a simple continuous wave transmitter.

General Examples

(1) A circuit has a capacity of 0.0004 μF and an inductance of $400 \mu H$. (a) What is its resonant frequency? (b) What must C be in order to give a resonant frequency of 400 kc/s p.s. ($2\pi = 6.28$).

(2) An alternating voltage of 10 volts and another of 50 volts having a phase difference of 90 deg. are applied to a circuit. What is the resultant voltage?

Answers for Article Four

1. (a) The direction of rotation reversed.
   (b) The direction of rotation unaffected.
   99.5 volts back E.M.F.

Valves

The study of valves is a very important subject and every effort should be made to understand them fully. The term "valve" implies a "one-way street," i.e., free electrons will pass through a valve in one direction only.

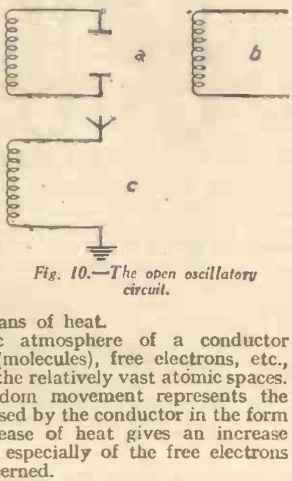


Fig. 10.—The open oscillatory circuit.

Thermionic Emission refers to the ejection of molecules, free electrons, ions, etc., from a material by means of heat.

Visualise the atomic atmosphere of a conductor with groups of atoms (molecules), free electrons, etc., drifting haphazardly in the relatively vast atomic spaces. This constant and random movement represents the amount of energy possessed by the conductor in the form of heat; thus an increase of heat gives an increase in atomic motion, and, especially of the free electrons with which we are concerned.

A state of tension exists at the surface of a material, representing a barrier to atomic particles; therefore, to enable free electrons to break through this barrier and exist as a "cloud" around the conductor, they require added energy which can be supplied by heating the material.

The Space-charge

The "cloud" of free electrons around a hot conductor is known as a "space-charge," and is negative in nature.

When a conductor emits a free electron, the conductor becomes less negative (positive), thus the space-charge is held around the conductor.

Before the space-charge can be utilised it is necessary to enclose the emitting conductor (emittor) in a vacuum to prevent oxidisation, heating being achieved by passing a current through the emittor in the case of "directly heated" valves, and by the use of a heater in the case of "indirectly heated" valves.

Indirectly and Directly heated Valves

A valve's emittor is termed a filament in the case of battery valves and a cathode in the case of mains valves. Fig. 11 shows a typical cathode with its heater. The indirectly heated valve's emitting assembly acts as a heat reservoir, so that rapid changes in the temperature of the heater due to fluctuations of the heater's supply voltage are absorbed because of the slow rate at which the cathode heats or cools.

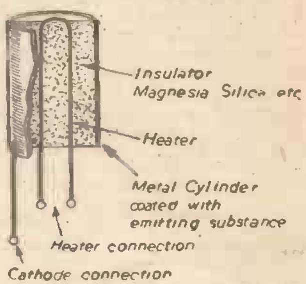


Fig. 11.—An indirectly heated cathode.

The Diode

Valves receive their names from the number of electrodes they possess, i.e., diode, triode, tetrode, pentode, etc.

In Fig. 12 we have a diode; and if a potential is applied across anode and filament so that the anode is positive, then electrons in the space-charge will be attracted to the anode and by virtue of the great speed they may attain, enter the anode, thereby causing a current to flow (anode current).

If the anode is made negative with respect to the filament, then the electrons of the space-charge are repelled and no anode current flows—free electrons cannot leave the anode to enter the anode-filament space because of the anode's surface tension. Thus we can call this device a valve!

Ia/Va Characteristic Curve of a Diode

If the voltage across anode and filament is varied and its values plotted against anode current (Va against Ia), the graph of Fig. 13 is obtained. This graph enables us to see at a glance just what can be done with that particular diode.

Notice that the current is in milliamperes, also that

(Continued on page 339.)

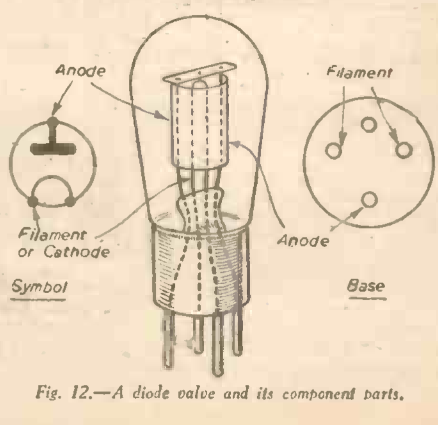


Fig. 12.—A diode valve and its component parts.

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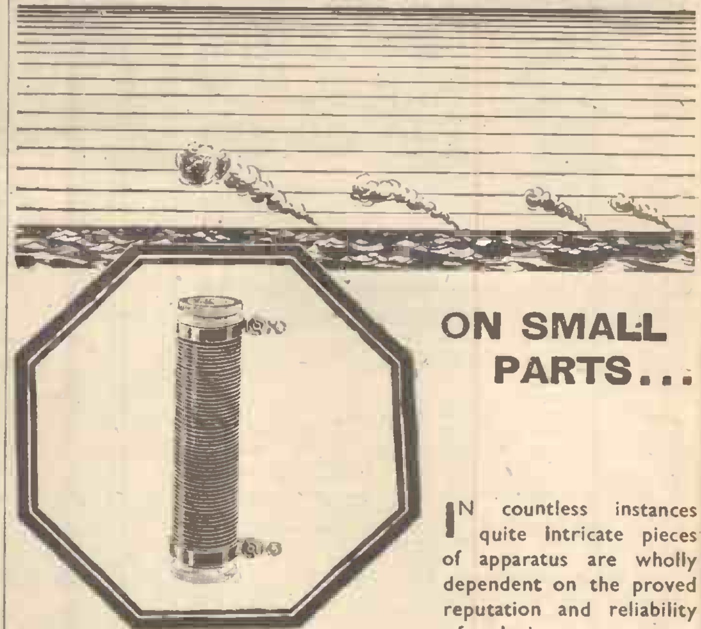

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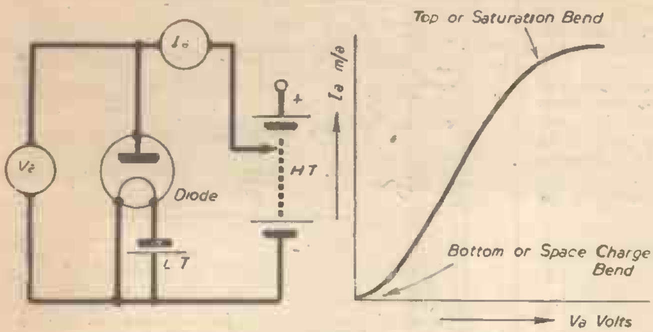
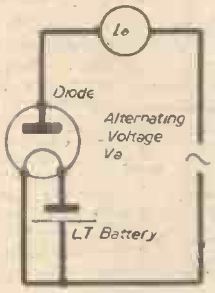


Fig. 13.—The Ia/Va characteristic curve of a diode.

there is a bend at the top and bottom of the characteristic curve.

The bottom bend is due to the space-charge; the anode current showing a rapid rise when the attraction of the positive anode just overcomes the attraction of the filament for the electrons of the space-charge. The bottom bend is sometimes termed the anode or space-charge bend.



The top bend is reached when the attraction of the anode potential is great enough to pull the electrons across the space in the valve as fast as the emittor emits them. Obviously an increase of anode potential will not cause a further increase of anode current; this can only be achieved by making the emittor (filament) hotter. The top bend is referred to as saturation bend, but is rarely reached in practice.

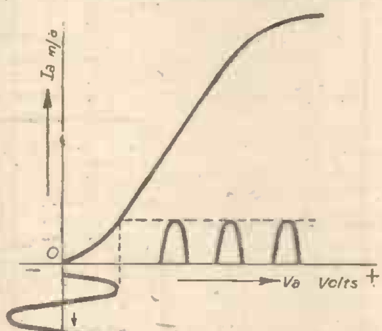


Fig. 14 (Left).—Rectification with a diode. (Above) Ia/Va curve of a diode showing rectification.

Rectification

Let us now place an alternating voltage across a diode instead of a battery's voltage, as in Fig. 14 (a). Fig. 14 (b) shows how the anode current varies with the voltage applied. It can be seen that when the anode is negative no current flows, thus pulses of current in one direction only, pass through the valve. Suitable circuits can smooth out the pulses, giving us direct current (D.C.).

This process whereby alternating voltage is converted to direct voltage or current is known as "rectification."

The Half-wave Rectifier

Fig. 15 (a) shows the circuit of a typical half-wave (the negative cycles of the waveform are not used) rectifier, the transformer is included to enable the required voltage to be obtained. C_1 is a reservoir condenser, while L_1 and C_2 in conjunction with C_1 form the smoothing circuit.

Fig. 15(b) represents the voltage across the terminals of the rectifier, marked "A" or "B." Fig. 15(c) shows the effect of placing C_1 across the rectifier's output terminals. The pulses of current passing every positive half-cycle charge up C_1 which then supplies energy to the circuit R (possibly a radio set) during the negative half-cycles. Because of the drain of energy from C_1 during the negative half-cycles its voltage falls, being restored upon the positive half-cycles; thus, the output voltage of the rectifier circuit fluctuates. This fluctuation would cause a "hum" in any set to which the rectifier was connected, but, as shown in Fig. 5(d) L_1 offers a high opposition to the fluctuations but a low opposition to the direct current, thus the fluctuations produce an alternating voltage across L_1 which forces alternating current around the circuit L_1 C_1 C_2, thus wasting the energy of these fluctuations.

The Full-wave Rectifier

A saving is achieved if both positive and negative half cycles of the waveform are used. Fig. 16(a) shows how this can be done; using a centre-tapped transformer, T_1, two diodes (or a double-diode valve) and the usual reservoir condenser C_1 and smoothing circuit, L_1 C_1 C_2.

Considering one cycle of the input voltage to T_1. Upon the positive half-cycle, A_1 becomes negative and A_2 positive (Fig. 16(a)), while the negative half-cycle causes A_1 to become positive and A_2 negative, thus, each diode passes alternate pulses of current, giving the effect shown in Fig. 16(b). The reservoir condenser and smoothing circuit operate as in the case of the half-wave rectifier. Note that the frequency of the fluctuations (ripple frequency) has been doubled.

The Triode Valve

In the case of the diode, reasonable control of the anode current could only be achieved by adjusting the anode voltage. Much greater control can be obtained by inserting a third electrode of "control-grid" between anode and filament. The valve now becomes a "triode."

Grid-filament Grid-anode Spacing

Visualise the attraction of the anode voltage in Fig. 17 upon the free-electrons at the filament. Say 120 volts acted through the anode-filament space. Now let us move the anode closer to the filament; surely, it follows that to maintain the same attraction the voltage

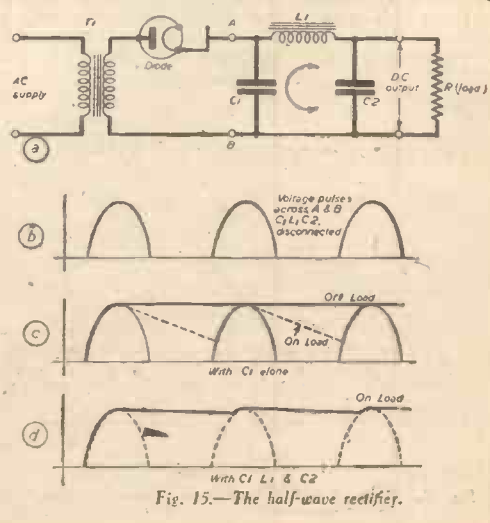


Fig. 15.—The half-wave rectifier.

of the anode would have to be reduced; thus, a smaller potential can have the same effect on the anode current provided that it acts through a smaller distance.

Now insert the grid; it follows that because the grid is closer to the filament than is the anode, a small voltage across grid and filament can have the same effect upon the anode-current as a larger voltage across anode and filament. Thus, a small voltage applied to the grid can cause the same change in anode current as a large change of anode voltage.

This property enables the triode valve to amplify the effects of grid-filament voltages.

Effect of Placing Voltages across Grid and Filament

Whenever a voltage is placed across grid and filament the free electrons of the space-charge are affected.

When the grid is positive, the pull upon the free-electrons is increased and the anode current rises, i.e., most of the electrons shoot through the grid's spaces and come under the influence of the anode voltage.

A negative grid voltage repels the electrons at the filament thus causing a reduction of anode current. If the negative potential applied to the grid is large enough then no electrons will pass the grid and the anode current falls to zero.

Too high a positive grid potential will attract the electrons at the filament as fast as they are emitted, i.e. saturation will occur—a considerable current flowing in the grid circuit.

Thus, a positive potential applied to grid will cause a rise of anode current and a negative potential a fall of anode current.

An alternating voltage applied to grid and filament would cause the anode current to rise and fall according to the waveform of the applied voltage and the distortion introduced by the valve. Notice that the anode current does not reverse its direction but falls in amplitude, when the grid potential is made more negative.

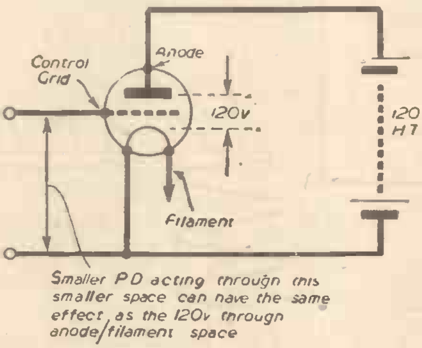


Fig. 17.—The triode, and its spacing effect.

Ia/Vg Characteristic Curve of a Triode

If we plot the anode current against grid-filament voltage (Vg) we obtain the graph of Fig. 18.

Notice that the grid can be made appreciably negative before the anode current is cut off at X. Also that saturation is not reached (because of the design of the emitter).

The second characteristic curve (dotted) would be the effect of increasing the anode voltage.

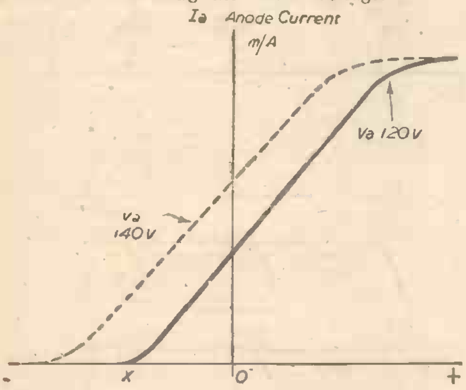


Fig. 18.—A typical Ia/Vg characteristic curve of a triode.

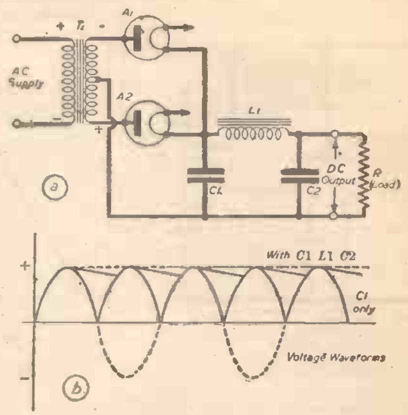


Fig. 16.—The all-wave rectifier.

μ, ra and gm

The Ia/Vg characteristic curve enables us to deduce important relationships concerning the triode's ability. Three of these relationships being the amplification factor (μ—*mu*—), the anode resistance (*ra*) and the mutual conductance (*gm*).

The amplification factor μ is a measure of the effect of the grid voltage compared with the anode voltage upon the anode current of the valve, and is stated as:

$$\mu = \frac{\text{Change of anode voltage for given change of anode current}}{\text{Change of grid voltage to give same change of anode current}}$$

or:

$$\left(\begin{matrix}\text{for same change}\\ \text{of anode current}\end{matrix}\right) \quad \frac{\Delta\ Va}{\Delta\ Vg} = \mu$$

Thus, if the anode voltage was increased by 20 volts and the anode current rose by 2 m/amps, and it was noticed that an increase of 2 volts upon the grid also caused a change of 2 m/amps,

$$\text{then } \mu = \frac{20}{2} = 10$$

i.e., the effects of the grid potential upon the anode current is amplified 10 times.

The anode resistance *ra* is a measure of the opposition encountered by changes of the anode current in passing through the valve.

$$ra = \frac{\text{Change of anode voltage}}{\text{Change of anode current produced}}$$

$$ra = \frac{\Delta\ Va}{\Delta\ Ia}$$

Thus if 20 volts change of anode voltage caused a 2 m/amp rise of anode current

$$ra = \frac{20}{\frac{2}{1000}} = 10{,}0000 \text{ ohms.}$$

The mutual conductance *gm* is the ability of the valve to "pass through" the effect of the grid voltage to the anode current.

$$gm = \frac{\text{Change of anode current}}{\text{Change of grid volts producing it}}$$

$$gm = \frac{\Delta\ Ia}{\Delta\ Vg}$$

thus, if 2 volts change of grid voltage causes a change of anode current of 2 m/amps.

then $gm = \frac{2}{2}$ m/amps = 1 m/amp change of anode current for 1 volt change on the grid, i.e.,

$gm = 1$ m/amp per volt.

A moment's thought should confirm that the valve constants only apply to the straight or linear part of the characteristic curve.

Notice also that the amplification factor is a measure of the steepness or slope of the characteristic curve.

The Optimum Anode Load

The most suitable value of load is one which will permit the voltage across itself to vary in exactly the same way as the voltages applied to grid and filament vary, i.e., the load must not introduce distortion. Also, the value of the load must permit maximum voltage production, or if for a power amplifier, maximum power to be obtained.

Maximum power is obtained from the anode load when the value of the load's opposition is equal to the anode resistance (ra) of the valve.

We are dealing with alternating voltages the source of which is the valve, thus maximum output power in the load is obtained when:

R (Load resistance) $= ra$ (Anode resistance)

In practice a compromise between maximum output and permissible distortion (not more than 5 per cent.) is obtained.

General Examples

1. Draw two Ia/Vg curves for the triode discussed in the text, assuming that $Ia = 3$ m/amps for 100 v. Va, and $Vg = 0$.

2. (a) The following values of Ia and Vg were obtained: plot the Ia/Vg curve of the valve and obtain its μ, gm and ra.

(b) What value of anode load would give maximum power output?

		+2	−0	−2	−4
$Va = 100$ volts	Vg	+2	−0	−2	−4
	Ia	11.2	8	4.8	1.6
$Va = 120$ volts	Vg	+2	0	−2	−4
	Ia	13	10	6.8	3.6

Answers to Examples of Article Five

1. (a) 398 kc/s (approx.)
   (b) 0.000396 μF.
2. 50.99 volts.

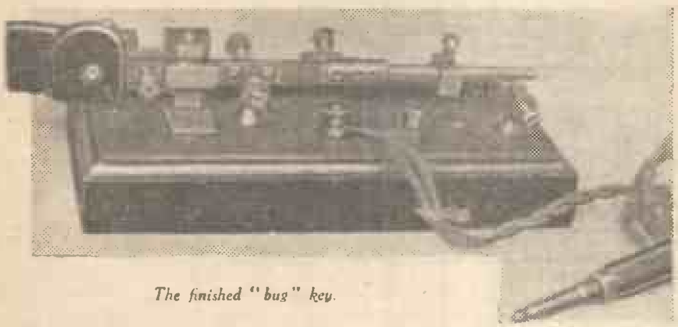
(To be continued).

Making a "Bug" Key

Constructional Details of a Serviceable Instrument Made with Odds and Ends

THE "Bug" key shown in the accompanying illustrations is constructed around a "straight" type Morse key of small pattern, the only tools required being a hacksaw, one or two B.A. taps (4B.A. and 6B.A. are the most suitable), and a file.

The movable bar of the straight key is cut in accordance with Fig. 1. A piece of stiff brass (a stout variable condenser vane of an old type can be utilised) is shaped as in Fig. 2. This work must be accurately done as this piece must fit closely over the bar A, and pivot on the slightly tapered pin C, without any side play.



The finished "bug" key.

The collars usually found sweated on to both sides of bar A, through which the pivot pin passes, will have to be accurately filed down until the whole assembly pivots freely inside the bridge B. The shaped brass piece will eventually carry the dash contact D (taken from the original key), and the paddles E, which are shaped from ¼in. ebonite or similar material.

Main Spring

The main spring G is shaped from a piece of springy phosphor-bronze — the rotor arm of an old rheostat or potentiometer flattened carefully and cut to size will do admirably. The main spring is then inserted into a slot cut into the bar A, and bolted rigidly into position, as shown.

Part H is an oddment of brass from the junk box, and was originally a large wire connector. It is slotted along half its length, and the spring G inserted and firmly secured by two bolts, one of which carries the "dot" spring J.

The dot spring can either be fashioned from a piece of watch spring, an electric bell contact spring, or as in the original, a contact taken from an old Ford spark coil cut down to shape. Into the other end of part H is screwed a length of brass rod K, carrying a movable weight L. K can be part of a brass "lead-in" rod, cut down to size, the part H being suitably tapped to receive it.

Weight L, the position of which on the rod governs the speed of transmission, is simply a suitable piece of brass, being a sliding fit on the rod K, and can be secured in any convenient position by its adjusting screw M.

The bridge B is drilled and tapped, to enable the base plate of ⅛in. brass to be bolted to it, care being taken that a hole is drilled in the base plate to clear the end of the pivot pin C.

Damper N is a small cup-shaped piece of brass into

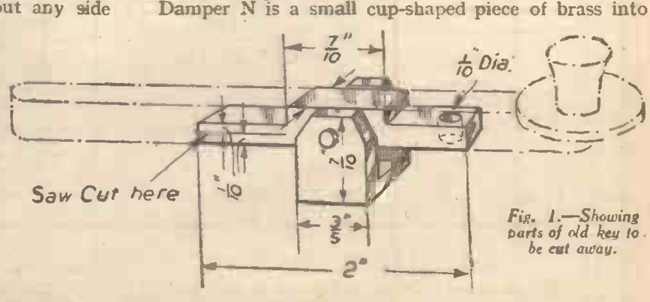


Fig. 1.—Showing parts of old key to be cut away.

which is wedged a rubber refill such as is fitted to the tops of propelling pencils.

Compression springs O and P are important. The originals were purchased for a few coppers from a hardware store, but can be home wound if piano wire of small gauge is available. The tension of these springs should not be too great or the free movement of the key will be impaired.

Supporting Pillars

The design of the pillars supporting the various contacts and adjustment screws can be left to the ingenuity of the reader. Those in the photograph were made from the tops of brass terminals and short pieces of brass tubing from the junk box. They are assembled by passing a bolt through the base of the key, through the terminal head and into the brass tubing which is tapped to size.

All adjusting screws, except W, are 4B.A., the locking nuts R being small milled terminal heads, to facilitate adjustment.

The fixed dash contact was taken from the original straight key, and mounted on a 4B.A. adjusting screw, that for the dot contact being taken from an electric bell.

The whole key is mounted on a switch block, into the base of which is fitted a sheet of lead or iron to weigh the key down, care being taken not to short the terminals, etc., which protrude beneath the base.

In wiring up, one terminal is connected to the bridge B, the other to the two fixed contacts S and T.

The 6B.A. bolt carrying the dash lever return spring P, must be a very loose fit in the main bar A, a small washer being placed between the spring and the bar. A terminal nut serves to adjust the tension of the spring.

If carefully constructed a sound mechanical job

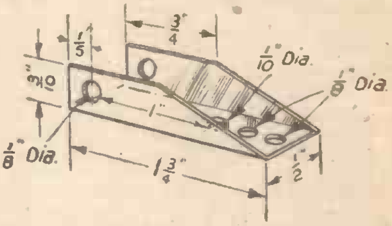


Fig. 2.—Details of metal bracket.

should result. If brass lacquer can be obtained, or should chromium plating facilities be handy, the whole key can be given quite a professional appearance.

Adjustment of the damper N should be such that movement of the rod K should cease after 8 to 10 dots have been produced when the dot lever is pressed.

Actual dimensions of the original "Bug" key, are given in the diagram, but these can, of course, be varied to suit the materials in hand.

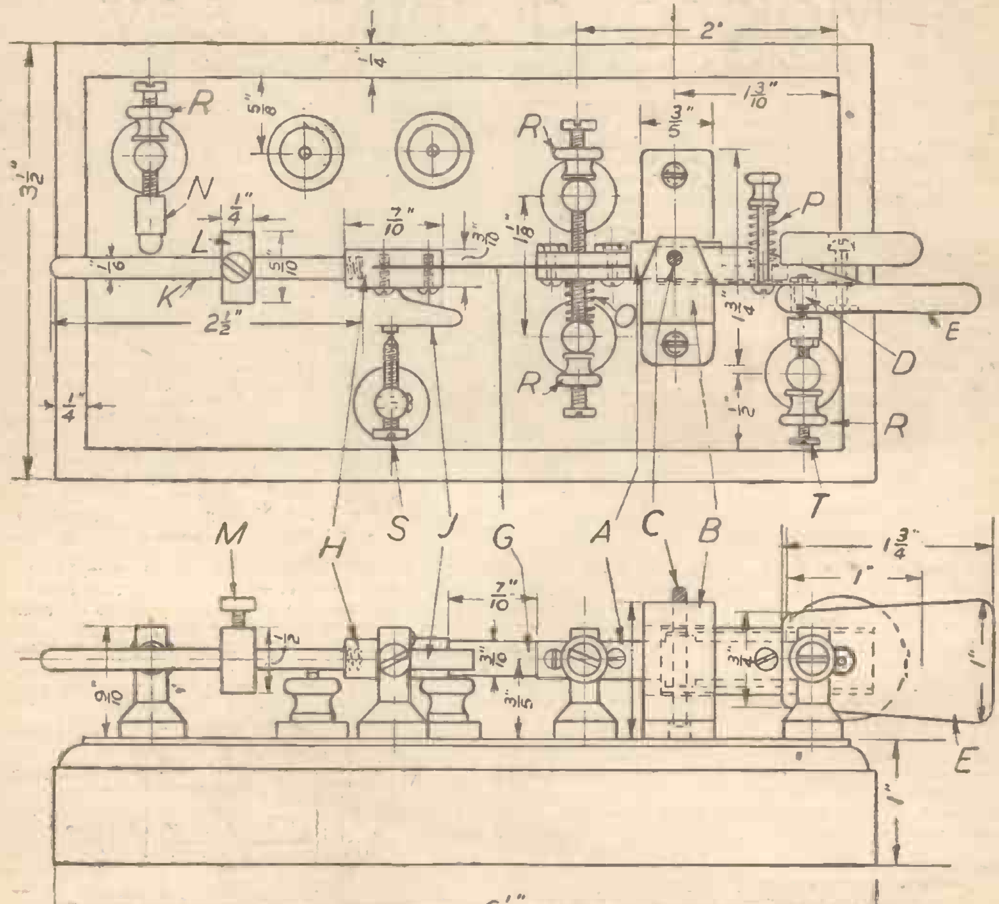


Fig. 3.—Plan and side elevation of the "bug" key described in the text.

Permanent Magnets—V

Special Magnets : Revolving Magnets : Alnico

By L. SANDERSON

(Continued from page 294, June issue)

THERE is a rather peculiar feature about the 35 per cent. cobalt magnet steel in the cast condition. After annealing at 750 deg. C., if the carbon content is between 0.8 and 0.9 per cent., a diamond Brinell hardness of about 440 is obtained, but if the carbon content is between 0.9 and 1.0 per cent. the hardness is round about 500. Yet in either instance the casting is capable of being machined, and apparently one condition presents no more difficulty than the other. It appears there are no other alloys capable of being machined when they possess Brinell hardnesses of this order.

Special Magnets

We may now consider some special magnets made in these materials before we consider the newer alloys, which do not necessarily replace altogether these cobalt

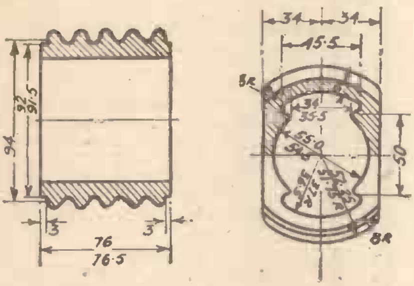


Fig. 1.—The design of a cast field magnet.

chromium alloys. Certain types of rotary transformers and power generators are made embodying permanent field magnets. The usual construction of the field system was with segmental magnets and laminated pole shoes. Since then there have been developed cast field magnets in which the whole system is made up of 35 per cent. cobalt steel magnets, so that a pole face of magnet steel is substituted for one made of iron laminations. It is found that with cast fields it is necessary to work with a slightly larger air gap between the armature and the pole faces, otherwise losses are caused due to eddy currents in the solid pole shoes. The air gap used is between ¾ and 1 mm., and this causes a small decrease in the working flux.

On the other hand, the pole shoe, being of magnet steel, enables a large reduction of the ripple to be effected. A large amount of this ripple in the ordinary way appears to be due to flux oscillations and flux swing in the pole shoes. This, of course, cannot take place when the pole shoes are made of a material with a high coercive force. Another advantage of a cast field system is that the high coercive force of pole shoes resists any flux distortion due to the load current in the armatures, and it is much easier to obtain sparkless commutation on a machine with a cast pole shoe than it is with a machine in which the pole shoe is made of soft iron.

Cast Field Magnet

Fig. 1 shows the design of one of these cast field magnets. The serrations are put on merely for the purpose of getting efficient hardening of the steel.

TABLE 1

Cast Converter Magnets 36 per cent. Cobalt

M/c	Total section of Magnet	Effective length	Required flux	Average flux obtained
			lines	
E	17.0 cm²	11.5 cm	105,000	115,000
E	16.5 cm²	11.5 cm	105,000	110,000
80W.. ..	17.5 cm²	10.0	100,000	130,000

The magnets are turned up before hardening, and no grinding is afterwards necessary. The spigots are turned up for the end plates to be fitted, and the bore turned up. The magnets are magnetised so that the top side is N and the bottom side S, with the armature in position. Table I gives particulars of the fluxes obtained and those required from a few machines. These magnets weigh approximately 4lb. each. All these flux measurements were made in a standard armature and not in the magnet, and may therefore be rather low on account of leakage. The leakage is probably in the order of 10 per cent.

This magnet for the 80 watt machine is proportionately somewhat superior to the others when reduced to flux per cm.² of magnet section. This is because its thickness is a trifle less than that of the other two, hence the greater efficiency per unit mass. These magnets are employed on several types of machines. One, which is a hand-driven generator for power supply to radio transmitting sets, is largely used for aircraft. It can supply both high tension and low tension current to a radio transmitter, and an automatic signalling device enables the transmission of a message to be carried out single-handed by an unskilled operator. These machines have proved of great value where aeroplanes have had to make forced landings far from civilisation.

The armature of the machine is provided with two distinct windings, insulated from one another, and two commutators. Power to the extent of 40 watts can be obtained; 800 volts and 30 milliamperes is the

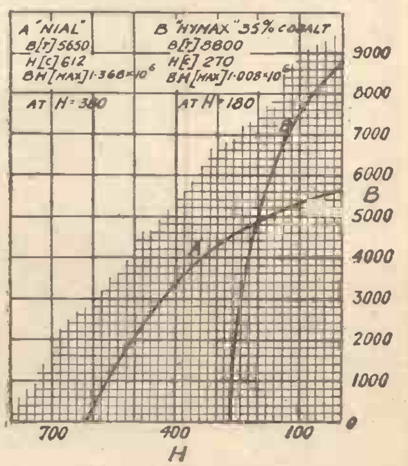


Fig. 2.—Graph showing the comparison of the B.H. values.

H.T. output, and 6 volts and 2.6 amps. the L.T. output. An armature speed of 2,800 r.p.m. is necessary to obtain this output. Other machines made in which this type of field system is employed are D.C. to A.C. rotary transformers, which provide current for A.C. mains-operated receivers where D.C. only is available.

Revolving Magnets

The revolving magneto magnet is another type. A magneto in which the magnet revolves and the armature is stationary has certain distinct advantages. That the windings are stationary means that they are not subjected to mechanical stresses, and can be constructed on robust lines. The revolving element, the magnet, is of much more robust mechanical construction than the revolving armature.

New Alloy

The next important stage in the manufacture of permanent magnets was the discovery by Dr. T. Mishima, of Tokyo, of a nickel iron aluminium alloy for permanent magnets. The peculiar physical properties of this material make it unforgeable, and magnets made from it could only be supplied as castings. The relative magnetic values (i.e., BH(max.) values), as compared with 35 per cent. cobalt steel magnets, are in the proportion of 1,350,000 to 1,000,000. Fig. 2 shows clearly the comparison of the BH values.

It will be observed that the nickel iron aluminium alloy (commonly termed "Alni" or "Nial"), has an extremely high coercive force value, coupled with a comparatively low remanence as compared with 35 per cent. cobalt steel. Therefore, the design for any given magnet will have, in Nial, an appreciably shorter mean length and a somewhat bigger cross-sectional area than it would have in cobalt steel. On account of this it follows that Nial is specially suitable for permanent magnets for moving coil loudspeakers and for small dynamos and electric motors.

In most instances, magnetic energy can be supplied at less cost in Nial material than in cobalt steel. Nial has also the advantage of being lighter, having a specific gravity of approximately 6.9 as compared with approximately 8.2 for 35 per cent. cobalt steel.

Alnico

Nial, however, did not by any means represent the last word in magnet development. In 1936, a still more powerful magnet alloy was discovered. This was obtained by simultaneously adding cobalt and copper to an alloy of nickel, aluminium, and iron. The new alloy was termed Alnico, and its magnetic properties were superior even to those of Nial. For example, taking the relative magnetic BH(max.) values, 35 per cent. cobalt steel gives 1,000,000 BH(max.), Nial gives 1,368,000, and Alnico 1,870,000.

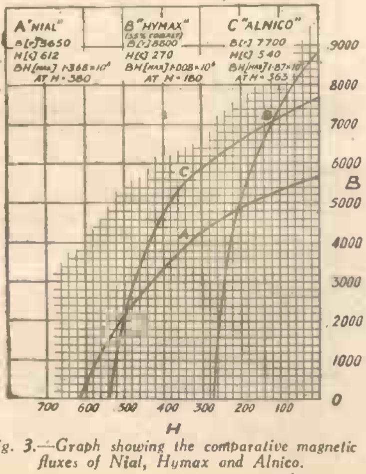


Fig. 3.—Graph showing the comparative magnetic fluxes of Nial, Hymax and Alnico.

The graph, Fig. 3, shows this comparison at a glance. The main feature of Alnico as compared with Nial is that while there is an equivalent coercive force, the remanence value is appreciably higher. Thus Alnico is extremely useful for certain purposes where limitations of space exist. Another advantage is that a still further saving in weight is obtained. Alnico is also distinctly tougher than Nial, which is again an advantage of no small importance. In first cost it is little more expensive than Nial, and is not more costly per unit of energy.

At present Alnico has peculiar physical properties that make it unforgeable, and Alnico magnets can only be supplied as castings. Its specific gravity is 7.24.

Alnico Bobbins

Attempts have sometimes been made to obtain Alnico bobbins with a soft iron core cast in position. Experience has shown that this is impracticable, as the material cannot be cast round mild steel. The

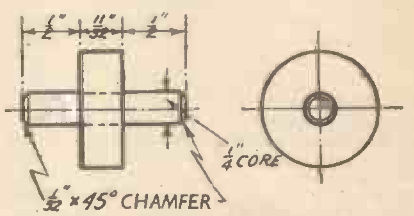


Fig. 4.—Details of Alnico bobbins.

alternatives are (a) to grind out the centre hole and make a spindle a push fit. This, however, is not usually practicable owing to the very small size of the centre hole; (b) to use a quality of Alnico that can be drilled, and drill a hole. Here again, however, owing to the very hard character of the material, it would seldom be possible to work to sufficiently fine limits to make the core a push fit; (c) the best method is to make a magnet with a cored hole filled with non-magnetic metal, and drill this out to a size to take the soft iron core as a push fit. This is the procedure in use at one works (see Fig. 4).

It should be noted, incidentally, that A.C. voltage is not suitable for magnetising magnets unless a special type of magnetism is used which automatically breaks the current at a peak. The usual method is to use a D.C. electro-magnet and place the magnet to be saturated across the poles.

Finishing the New Alloys

As regards the finishing of these newer alloys, Nial can only be ground. One quality of Alnico can be turned, drilled and ground, but not tapped. Both Nial and Alnico can only be cast, and in consequence cannot be supplied in bar form, i.e., as rolled. Small round or flat pieces can be ground for components. Moreover, it is not practicable to supply these alloys in sizes below, for example, 1/8in. thick or diameter, on account of their brittle character and coarse structure. It should, perhaps, be mentioned that the discovery of Alnico was due to the work of Horsburgh and Tetley. The composition of Alnico is approximately 18 per cent. nickel, 10 per cent. aluminium, 12 per cent. cobalt, 6 per cent. copper, and 54 per cent. iron. Holes of not less than approximately 5/16in. diameter can be cast in these alloys, but it is an advantage if sharp changes of section and thickness can be avoided, e.g., less than 1/4in. to 1/8in.

Magnetic Circuits

Before we can deal with the main principles of magnet design, it is necessary to consider certain aspects of magnetism with which we have not so far dealt. The magnetic circuit must be thoroughly understood, and while this can best be studied in one or other of the standard works on electro-magnetism, a brief summary may be given here as a guide to the reader with less time to spare on study.

In the first place, we must consider a particular formula used to determine the flux in a closed magnetic circuit of specific area, length, and permeability. This is as follows: $\Phi=\frac{1.257NI}{l/a\mu}$. In this equation, NI stands for the product of the number of turns and the current flowing therein of the magnetising coil, a is the area, l the length and μ the permeability. The figures 1.257 NI represent the magnetic potential difference

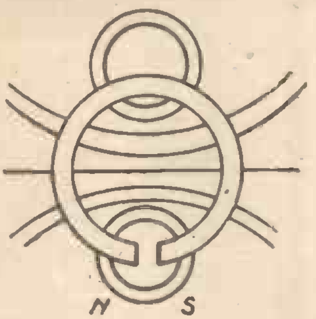


Fig. 5.—Diagram indicating leakage by atmospheric paths.

exercising an influence on the circuit, and this is divided by the magnetic resistance or "reluctance," for which the figure *P* is often used.

For our objects, it can be considered that when an electric circuit is enclosed in the atmosphere, it can be considered as virtually insulated, and in consequence the electric current is rigidly restricted to the wire constituting the circuit, but this is less true of a magnetic circuit, because the atmosphere is not by any means efficient as an insulating medium for a magnetic circuit. In consequence, if iron is the basis of the circuit, it is certain that some leakage will occur by way of the atmosphere. This is one of the reasons why it is by no means as easy to establish the flux in a magnetic circuit as it is to establish that in an electric circuit.

In this connection, it must be noted that such leakage as occurs by atmospheric paths is not along one narrow defined path, but as Fig. 5 shows, is variable, in different directions. This factor has to be taken into account, therefore, in all calculations.

We have in any event to establish the flux and to find proper dimensions for the magnet. This involves the use of further formulæ. The dimensions of the magnet and in consequence the quantity (i.e., the total volume) of magnetic alloy required to make it are obtained by means of the formula $V=\Phi/B \times M/H$. Here, V is the volume, Φ is the flux density, and B is a lower value of the flux density reduced by the M.M.F. across the circuit. M is the M.M.F. and H is the demagnetising force acting on the magnet. To find the flux, we must use the formula $\Phi=Ba$, a being the cross-sectional area of the magnet. To find the M.M.F., the formula is $M=Hl$, l being the magnet length.

The reader should bear in mind that the volume of magnet alloy needed to produce a specified flux is a minimum where BH is a maximum. This maximum value of BH can be obtained by representing in the form of a graph the products of the co-ordinates of the BH curve against B.

(To be continued.)

Impressions on the Wax

A Review of the Latest Gramophone Records

H.M.V.

OUR recent victory in Tunisia and the general position on the Russian Front enable one to take an optimistic view of the eventual termination of the present war, which cannot be so far distant. Thus, a topical question of the moment is what are our plans for after the war, and this important question was very well covered by the speech broadcast by the Prime Minister, The Right Hon. Winston Churchill, on March 21st, 1943. Those people who were unfortunate enough to miss this speech will now be able to hear it repeated on a set of records just released by H.M.V. The whole speech has been recorded on four 12in. discs—*H.M.V. C*3341/4, and the profits from the sale of these records are being paid to charities nominated by the Prime Minister.

Another set of H.M.V. records which should prove very popular is that of Mozart's "Concerto in D Major, K.218." The whole of this famous concerto has been recorded on three 12in. discs—*H.M.V. DB*6146/8—and features that well-known violin virtuoso, Yehudi Menuhin, as well as the Liverpool Philharmonic Orchestra, conducted by Dr. Malcolm Sargent.

A few months ago the music world learned with regret that Sergei Rachmaninoff, the famous Russian composer, had passed away. With his passing, however, he leaves behind him a memorial which will link his name with other famous composers, that of his many compositions. Two of his shorter compositions are this month recorded by H.M.V. on *H.M.V. DA*1771. They are "Humoresque, Op. 10, No. 5" and "Moment Musical, Op. 16," two pianoforte solos played by Rachmaninoff himself.

Medley Records

TWO interesting records in this class which I can recommend are "Reminiscences of Chopin," introducing "Polonaise, Op. 40, No. 1," "Nocturne in E Flat," "Waltz in C Sharp Minor," "Fantasia and Impromptu," "Prelude in C Minor," "Raindrop Prelude," "Minute Waltz in D Flat," and "Polonaise, Op. 40, No. 1." The pieces are played by Reginald Foort on the giant Moller concert organ. The number of the record is *H.M.V.* 1041. The other record—*H.M.V. B*9318—is an "Old Chelsea Selection," played by the New Mayfair Orchestra. It introduces such popular tunes as "Just a Little Gossip," "Your Love Could Be Everything To Me," "Why Did I Have To Awake From My Dreams," "If You Are In Love," "My Heart and I," "When a Boy Meets a Girl," "Music In My Heart," and "There Are Angels Outside Heaven." The orchestra is conducted by Richard Tauber.

Parlophone

OF outstanding note in the Parlophone new issues is one by that famous tenor, Richard Tauber. For his new recording he has chosen "Somewhere Over the Hills" and "Fascination," both songs being sung in English, with orchestra and chorus accompaniment. The record is *Parlophone RO*20521.

Dance music is supplied by Geraldo and his Orchestra with "Out of This World," from the film "Hello, Beautiful," and "Starlight Souvenirs," on *Parlophone F*1975; and "Stardust" and "The Darktown Strutters Ball," played by Harry Parry and his Radio Rhythm Club Sextet, on *Parlophone R*2870. The last record appears in the 1943 super rhythm style series.

Columbia

IF you like pianoforte solos then "Sonata in A Minor," featuring Denis Matthews at the piano, should make its appeal. The sonata has been recorded on four sides of two 12in. records—*Columbia DX*1114/5.

On the lighter side there is Turner Layton, singing "I Hear Your Voice" and "Piccaninny Mine, Good-night," on *Columbia FB*2919; Carroll Gibbons and the Savoy Hotel Orpheans, playing "I'm Gonna Get Lit Up" and "Why Don't You Fall in Love With Me," on *Columbia FB*2923.

Valve Data Sheets

MAZDA

1

BATTERY TYPES — H.F. SCREENED PENTODES

TYPE	Fil. Volts (Rating)	Fil. Current	Max. Anode Volts	Max. Screen Volts	Mutual Conductance	Anode Volts (Typical Operating Conditions)	Screen Volts	Grid Bias	Anode Current (mA.)	Mutual Conductance	Anode A.C. Resist. (Megs)	Base	Top Cap.
SP 141*	1.4	0.05	90	90	0.9	82	62	0	1.8	0.8	0.6	Octal	G1
SP 210	2	0.1	150	150	1.7	120	120	1.0	1.1	1.2	2.0	7-pin	A
VP 210	2	0.1	150	150	1.4	120	60	1.5	1.2	0.8	1.3	7-pin	A
SP 22*	2	0.1	150	150	1.7	120	120	1.0	1.1	1.2	1.35	Octal	G1
VP 22*	2	0.1	150	150	1.4	120	60	1.5	1.2	0.8	1.3	Octal	G1
VP 23	2	0.05	150	150	1.3	120	60	1.5	1.45	1.08	1.45	Octal	G1

A.C. MAINS TYPES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Max. Screen Volts	Mutual Conductance	Anode Volts	Screen Volts	Grid Bias	Anode Current (mA.)	Mutual Conductance	Anode A.C. Resist. (Megs)	Base	Top Cap.
AC/SP1*	4	1.0	250	250	2.7	200	200	3.0	4.9	2.65	0.12	7-pin	A
AC/SP3*	4	1.0	250	250	7.5	250	100	1.7	7.9	7.0	0.55	7-pin	G1
AC/VP1	4	0.65	250	250	3.0	250	200	2.8	7.5	2.0	1.0	7-pin	A
AC/VP2	4	0.65	250	250	3.0	250	200	2.8	7.5	2.0	1.0	7-pin	G1
VP/41	4	0.65	250	250	3.0	250	200	2.7	7.7	2.0	1.3	Octal	G1
SP 41	4	0.95	250	250	8.5	200	200	1.5	10.9	8.5	0.7	Octal	G1
SP 42*	4	0.95	200	200	9.0	200	115	1.25	20.0	—	—	Octal	G1

AC/DC TYPES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Max. Screen Volts	Mutual Conductance	Anode Volts	Screen Volts	Grid Bias	Anode Current (mA.)	Mutual Conductance	Anode A.C. Resist. (Megs)	Base	Top Cap.
VP 1321*	13	0.2	250	250	3.0	200	200	2.8	7.4	2.0	1.0	7-pin	A
VP 1322	13	0.2	250	250	3.0	200	200	2.8	7.4	2.0	1.0	7-pin	G1
VP 133	13	0.2	200	200	3.1	150	150	2.7	8.0	2.1	0.7	Octal	G1

3

AC/DC TYPES — FREQUENCY CHANGERS—*Continued*

TYPE	Fil. Volts (Rating)	Fil. C'rrent	Max. Anode Volts	Max. Screen Volts	Mutual Conduct'ce	Amp. F'ct'r	Anode Volts (Typical Operating Conditions)	Screen Volts	Grid Bias	Anode C'rrent	Conv'sn C'dct'ce (m.A/V)	Anode A.C. Res'ce (Megs)	Base	Top Cap.
TH 2320*	23	0.2	250	250	T. 5.3 H. 3.0	16 —	100 250	— 100	— 3.0	4.0 3.0	0.75	0.007 1.2	7-pin	G1
TH 2321	23	0.2	250	250	T. 5.3 H. 3.0	16 —	100 175	— 100	— 3.0	4.0 3.0	0.65	0.007 1.0	7-pin	G1
TH 233	23	0.2	250	250	T. 5.3 H. 3.0	16 —	100 175	— 100	— 3.0	4.0 2.6	0.65	0007 1..3	Oct'l	G1

BATTERY TYPES — TRIODES

TYPE	Fil. Volts (Rating)	Fil. Current	Max. Anode Volts	Mutual Conduct'ce	Amp. Factor	Impedance	H.T. Volts (Typical Operating Conditions)	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
HL2	2	0.1	150	1.5	32	21,000	120	1.5	0.4	75,000	4-pin	—
L2	2	0.1	150	1.9	19	10,000	120	1.5	1.0	50,000	4-pin	—
HL22*	2	0.1	150	1.5	32	21,000	120	1.5	0.4	75,000	Octal	—
HL23	2	0.05	150	1.5	32	21,000	120	1.5	0.5	50,000	Octal	—

A.C. MAINS TYPES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conduct'ce	Amp. Factor	Impedance	H.T. Volts	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
AC/HL	4	1.0	200	3.0	35	11,700	250	3.4	2.0	50,000	5-pin	—
AC/2HL	4	1.0	200	6.5	75	11,500	250	1.2	2.5	50,000	5-pin	—
HL41	4	0.65	250	3.5	36	10,300	250	3.1	2.2	50,000	Octal	—

An asterisk denotes types discontinued owing to war conditions.

2

BATTERY TYPES — FREQUENCY CHANGERS

TYPE	Fil. Volts (Rating)	Fil. C'rrent	Max. Anode Volts	Max. Screen Volts	Mutual Conduct'ce	Amp. F'ct'r	Anode Volts (Typical Operating Conditions)	Screen Volts	Grid Bias	Anode C'rrent	Conv'sn C'dct'ce (m.A/V)	Anode A.C. Res'ce (Megs)	Base	Top Cap.
FC 141*	1.4	0.05	90	90	Osc. 0.55 Tet. 0.6	— —	75 82	— 45	— 0	1.2 0.55	0.25	0.6	Oct'l	G4.
TP 22	2	0.25	150	150	T. 1.4 P. 1.3	34 —	100 120	— 60	— 1.5	0.8 1.2	0.45	0.035 1.6	9-pin	G1
TP 23	2	0.25	150	150	T. 2.1 P. 1.2	20 —	80 120	— 60	— 1.5	2.5 0.55	0.25	0.012 1.6	7-pin	G1
TP 25	2	0.2	150	150	T. 1.7 P. 1.06	18 —	80 120	— 60	— 1.5	2.5 0.53	0.26	0.013 1.3	Oct'l	G1
TP 26	2	0.2	150	150	T. 1.3 P. 1.55	28 —	65 103	— 65	— 2.0	0.9 1.2	0.55	0.03 1.4	Oct'l	G1

A.C. MAINS TYPES

TYPE	Fil. Volts	Fil. C'rrent	Max. Anode Volts	Max. Screen Volts	Mutual Conduct'ce	Amp. F'ct'r	Anode Volts	Screen Volts	Grid Bias	Anode C'rrent	Conv'sn C'dct'ce (m.A/V)	Anode A.C. Res'ce (Megs)	Base	Top Cap.
AC/TP	4	1.25	250	250	T. 1.4 P. 3.4	30 —	150 250	— 200	— 5.0	1.5 6.5	0.7	0.025 0.9	9-pin	G1
AC TH1	4	1.3	250	250	T. 5.3 H. 3.1	16 —	80 250	— 100	— 3.0	4.5 3.0	0.75	0.007 1.6	7-pin	G1
TH 41	4	1.3	250	250	T. 5.3 H. 3.1	16 —	80 250	— 100	— 3.0	4.5 3.0	0.75	0.007 1.6	Oct'l	G1

AC/DC TYPES

TYPE	Fil. Volts	Fil. C'rrent	Max. Anode Volts	Max. Screen Volts	Mutual Conduct'ce	Amp. F'ct'r	Anode Volts	Screen Volts	Grid Bias	Anode C'rrent	Conv'sn C'dct'ce (m.A/V)	Anode A.C. Res'ce (Megs)	Base	Top Cap.
TP 2620	26	0.2	250	250	T. 1.4 P. 3.4	30 —	150 200	— 200	— 5.0	1.5 6.5	0.65	0.025 0.7	9-pin	G1

4

A.C. MAINS TYPES — TRIODES—*Continued*

TYPE	Fil. Volts (Rating)	Fil. Current	Max. Anode Volts	Mutual Conduct'ce	Amp. Factor	Impedance	H.T. Volts (Typical Operating Conditions)	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
AC/P	4	1.0	200	3.75	10	2,650	200	15.0	5.0	8,000	5-pin	—
AC/P1	4	1.0	200	3.7	5.4	1,450	200	27.5	25.0	10,000	5-pin	—
AC/P4	4	1.0	700	7.0	20	2,860	Special Triode				5-pin	A
P41*	4	0.95	250	8.0	17	2,120	Special Triode				Octal	—
V312*	4	0.65	200	2.5	30	12,000	Special Triode				5-pin	G1

AC/DC TYPES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conduct'ce	Amp. Factor	Impedance	H.T. Volts	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
HL1320	13	0.2	250	3.0	30	10,000	200	2.0	1.8	50,000	7-pin	G1
HL133	13	0.2	250	3.4	36	10,600	165	1.9	1.5	50,000	Octal	G1

DIODES

TYPE	Fil. Volts	Fil. Current	Specification	Base
V914	4	0.3	A.C. Mains Double Diode	5-pin
DD41	4	0.5	A.C. Mains Double Diode (separate Cathodes)	Octal
DD620*	6	0.2	A.C./D.C. Double Diode	5-pin
DD101*	10	0.2	A.C./D.C. Double Diode (separate Cathodes)	Octal
DD207	2	0.075	Battery Double Diode	4-pin

Valve Data Sheets (*Continued*)

MAZDA

5

DIODE TRIODE

TYPE	Rating: Fil. Volts	Rating: Fil. Current	Rating: Max. Anode Volts	Rating: Mutual Conductance	Rating: Amp. Factor	Rating: Anode A.C. Resist. (Ohms)	Typical Operating Conditions: H.T. Volts	Typical Operating Conditions: Grid Bias	Typical Operating Conditions: Anode Current	Typical Operating Conditions: Load Resistance	Base	Top Cap.
H.141D*	1.4	0.05	90	0.48	65	135,000	82	0	0.065	500,000	Octal	G1

BATTERY TYPES DOUBLE-DIODE TRIODES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conductance	Amp. Factor	Anode A.C. Resist. (Ohms)	H.T. Volts	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
HL21/DD	2	0.15	150	1.5	32	21,000	120	1.5	0.5	50,000	5-pin	G1
L21/DD*	2	0.1	150	1.9	19	10,000	120	3.0	0.8	50,000	5-pin	G1
L22DD*	2	0.1	150	1.9	19	10,000	120	3.0	0.8	50,000	Octal	G1
HL23DD	2	0.05	150	1.2	25	21,000	120	1.5	0.6	50,000	Octal	G1

A.C. MAINS TYPES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conductance	Amp. Factor	Anode A.C. Resist. (Ohms)	H.T. Volts	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
AC HL.DD	4	1.0	250	2.6	36	13,800	250	2.7	2.0	50,000	7-pin	G1
HL41DD	4	0.65	250	2.5	30	12,000	250	3.1	2.2	50,000	Octal	G1
HL42DD	4	0.65	250	2.9	23	8,000	200	1.25	2.8	50,000	Octal	G1

AC/DC TYPES

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conductance	Amp. Factor	Anode A.C. Resist. (Ohms)	H.T. Volts	Grid Bias	Anode Current	Load Resistance	Base	Top Cap.
HL/DD1320	13	0.2	250	2.0	30	15,000	250	2.7	2.0	50,000	7-pin	G1
HL133DD	13	0.2	250	2.5	32	12,800	150	2.2	1.25	50,000	Octal	G1

6

BATTERY TYPES OUTPUT TRIODES

TYPE	Rating: Fil. Volts	Rating: Fil. Current	Rating: Max. Anode Volts	Rating: Mutual Conductance	Rating: Amp. Factor	Rating: Anode A.C. Resist (Ohms)	Typical Operating Conditions: Anode Volts	Typical Operating Conditions: Grid Bias	Typical Operating Conditions: Anode Current	Typical Operating Conditions: Optimum Load (Ohms)	Typical Operating Conditions: Power Output (Watts)	Base
P220	2.0	0.2	150	3.4	12.5	3,700	120	5.2	4.0	12,000	.082	5-pin

A.C. MAINS TYPES (Directly Heated)

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conductance	Amp. Factor	Anode A.C. Resist (Ohms)	Anode Volts	Grid Bias	Anode Current	Optimum Load (Ohms)	Power Output (Watts)	Base
PP3/250	4	1.0	300	6.5	6.5	1,000	300	37.0	48	3,000	4.2	4-pin
PA 20*	2	2.0	300	6.5	6.5	1,000	300	36.0	48	3,000	4.2	4-pin
PP5/400	4	2.0	400	6.0	9.0	1,500	400	32.0	62	2,700	6.0	4-pin
PA 40*	4	2.0	450	10.0	4.25	425	450	96.0	†110	†4,000	40.0	4-pin

† Two valves in push-pull

AC/DC TYPE (Indirectly Heated)

TYPE	Fil. Volts	Fil. Current	Max. Anode Volts	Mutual Conductance	Amp. Factor	Anode A.C. Resist (Ohms)	Anode Volts	Grid Bias	Anode Current	Optimum Load (Ohms)	Power Output (Watts)	Base
PP 3521*	35	0.2	250	10	6.0	600	175	22.5	60	2,800	1.5	7-pin

7

BATTERY TYPES OUTPUT PENTODES

TYPE	Rating: Fil. Volts	Rating: Fil. C'rrent	Rating: Max. Anode Volts	Rating: Max. Screen Volts	Rating: Mutual Conductance	Typical Operating Conditions: Anode Volts	Typical Operating Conditions: Screen Volts	Typical Operating Conditions: Grid Bias	Typical Operating Conditions: Anode C'rrent	Typical Operating Conditions: Optimum Load (Ohms)	Typical Operating Conditions: Power Output (Watts)	Base	Top Cap.
Pen 141*	1.4	0.1	90	90	1.75	82	82	8.1	5.0	10,000	0.21	Octal	—
Pen 24*	2	0.3	150	150	5.7	120	120	3.3	5.0	15,000	0.44	Octal	—
Pen 25	2	0.15	150	150	4.5	120	120	3.6	5.0	14,000	0.4	Octal	—
Pen 220	2	0.2	150	150	2.5	120	120	4.5	5.0	17,000	0.34	5-pin	—
Pen 231*	2	0.3	150	150	5.3	120	120	2.5	5.0	17,000	0.37	5-pin	—
†QP 230	2	0.3	150	150	3.0	120	120	9.6	4.65	17,000	0.86	7-pin	—
†QP 240*	2	0.4	150	150	4.0	120	103	9.0	3.0	17,000	1.1	9-pin	—
†QP 25	2	0.2	120	120	3.0	110	110	8.6	4.25	16,000	0.94	Octal	—

†Double Pentodes

A.C. MAINS TYPES

TYPE	Fil. Volts	Fil. C'rrent	Max. Anode Volts	Max. Screen Volts	Mutual Conductance	Anode Volts	Screen Volts	Grid Bias	Anode C'rrent	Optimum Load (Ohms)	Power Output (Watts)	Base	Top Cap.
AC/Pen	4	1.0	250	250	2.5	250	250	15.0	32	7,500	3.3	7-pin	—
AC.2/Pen	4	1.75	250	250	8.0	250	250	5.3	32	6,700	3.5	7-pin	—
AC.2/Pen.DD	4	2.0	250	250	8.0	250	250	5.31	32	6,700	3.5	7-pin	G1
AC.4/Pen	4	1.75	250	250	11.0	250	250	8.75	64	3,300	6.9	7-pin	—
AC.5/Pen	4	1.75	250	250	9.0	250	250	8.5	40	5,200	4.85	7-pin	—
AC.5/Pen.DD	4	2.0	250	250	9.0	250	250	8.5	40	5,200	4.85	7-pin	G1
AC.6/Pen	4	1.75	330	220	8.5	310	210	6.9	63	Special		7-pin	A
Pen.44	4	2.1	275	275	11.0	260	270	11.1	70	3,000	8.0	Octal	—
Pen.45	4	1.75	250	250	9.0	250	250	8.5	40	5,200	4.85	Octal	—
Pen.45.DD	4	2.0	250	250	9.0	250	250	8.5	40	5,200	4.85	Octal	—
Pen.46	4	1.75	330	220	8.5	315	210	6.9	63	Special		Octal	A

An asterisk denotes types discontinued owing to war conditions.

8

AC/DC TYPES OUTPUT PENTODES—*Continued*

TYPE	Rating: Fil. Volts	Rating: Fil. C'rrent	Rating: Max. Anode Volts	Rating: Max. Screen Volts	Rating: Mutual Conductance	Typical Operating Conditions: Anode Volts	Typical Operating Conditions: Screen Volts	Typical Operating Conditions: Grid Bias	Typical Operating Conditions: Anode C'rrent	Typical Operating Conditions: Optimum Load (Ohms)	Typical Operating Conditions: Power Output (Watts)	Base	Top Cap.
Pen.383	38	0.2	200	200	12.0	155	175	10.0	64	2,500	3.6	Octal	—
Pen 3520	35	0.2	250	250	7.0	200	200	8.0	40	4,400	3.0	7-pin	—
Pen 3820*	38	0.2	200	200	12.0	155	175	10	64	2,500	3.6	7-pin	—
Pen.DD4020	40	0.2	250	250	7.0	200	200	6.3	32	5,400	2.5	7-pin	G1
Pen.DD4021*	45	0.2	200	200	12.0	155	175	10	64	2,500	3.6	7-pin	G1
Pen.453.DD	45	0.2	200	200	12.0	155	175	10	64	2,500	3.6	Octal	G1

RECTIFIERS

TYPE	Fil. Volts	Fil. Current	Half or Full Wave	Max. Volts per Anode	Max. Current	Base	Top Cap.
UU 4*	4	2.2	Full	350	120	4-pin	—
UU 5	4	2.3	Full	500	120	4-pin	—
UU 6	4	1.4	Full	350	120	Octal	—
UU 7	4	2.3	Full	350	120	Octal	—
UU 8*	4	2.8	Full	350	250	Octal	—
U 4020	40	0.2	Half	250	120	5-pin	—
U 403	40	0.2	Half	250	120	Octal	—
U 21*	2	1.85	Half	4,500	5	4-pin	A
U 22*	2	2.0	Half	4,500	5	Octal	A
UD 41*	4	1.15	Volt. Doub.	550	35	7-pin	—
MU 2*	2	3.1	Half (M.V.)	5,000	5	4-pin	A

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).

Station PRL8 : S.W. Converter

SIR,—I recently wrote you concerning a S.W. converter and I said that the station at Rio de Janeiro was CRL8; it should have been PRL8.

My friends have asked me what valve was used; it is an Osram MHL4 and since I last wrote you I have made a battery version simply by omitting the cathode connections, and taking my L.T. and H.T. supplies from batteries. This version was just as successful.—D. M. WEBBER (South Brent).

"Army Expeditionary Station"

SIR,—Here is a piece of DXing news that may interest some readers. I have received a letter verifying a report sent to a station during February; the details of this station are:

It has no call-sign, but is named "The Army Expeditionary Station"; it also sometimes announces itself as "The Voice of the American Soldier and Sailor." Its location is given as "Someplace in Africa," its power being secret. The frequency is 7,935 kc/s, and the station is on the air from 10.00—21.30 G.M.T. in the 37-metre band. This station, which is operated by the United States Army, is used for the entertainment of Allied troops overseas, and it gives a very good selection of entertainment. I receive it R.S.T. 4.8.9x in the evenings. Can any reader inform me of the location of station Radio Congo-Belge on 25.6 metres, 11,720 mc/s. ?—R. ALLEN (Mottingham).

A Service Reader's Activities

SIR,—As one of your readers in the Services, I have just completed a seven days' leave, during which I found time to build two short-wave sets, one for battery operation, the other for A.C. mains.

I have not been able to test them fully, but will do so at the earliest opportunity. The room available at my home address is a den-cum-bedroom, and when I can get hold of some photographic plates I will send a photo of it. Part of my leave was taken up by altering the layout, and I also want to build a wave-meter as soon as the time presents itself.

I am also converting a 5-valve superhet diagram (PRACTICAL WIRELESS, December, 1942) for A.C. mains operation, which I am rather anxious to build.

The aerial is a vertical doublet, each section being about 8ft. long, and I think this arrangement is the best under the circumstances, as my room is in the front of the house, and consequently space is restricted for erecting a better outdoor aerial.—B. HOWARD (Brookwood).

The Eliminator Bug

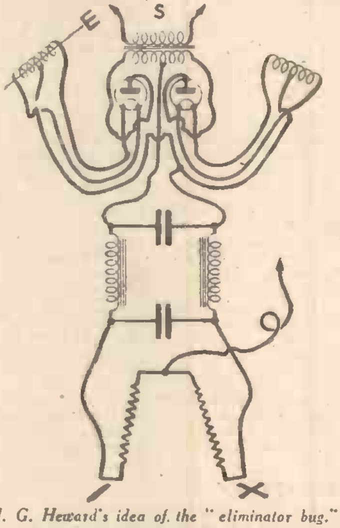
SIR,—I have been a regular reader of your excellent journal for some time, but I don't think I have ever seen in it anything like the accompanying diagram.

It is the kind of thing a radio enthusiast sees in his sleep, and yet it is an actual theoretical diagram.—I. G. HEWARD (Liverpool).

Stations Heard

SIR,—Here is a list of stations I heard recently, which may be of interest to other readers:

N. Africa, Radio Maroc, 21.4 m. and 23.38 m., at 1.30 p.m.; Radio Maroc, 33.03 m. and 37.33 m. in the evening; Algiers, Radio National, 24.75 m., afternoon and evening; ZNR, referred to as Rabat in a recent number of PRACTICAL WIRELESS, is really Aden, Arabia, and transmits from 5.30 to 6.30 p.m. in Arabic and French, with announcements in English every 15 minutes. It is often heterodyned by Algiers; ZNR is on 24.76 m., Algiers 24.75 m., Cairo, 38.14 m. in the evening: Godfrey Talbot generally comes on after 11 p.m.; Brazzaville, 25.06 m., in English, 5.45 p.m., for U.S.A., in English, 8.45 p.m., for England; Rio de Janeiro, Brazil, news in English, 1.30 a.m., 29.35 m. for U.S.A., news in English, 10 to 11 p.m., 25.58 m. This last transmission is beamed



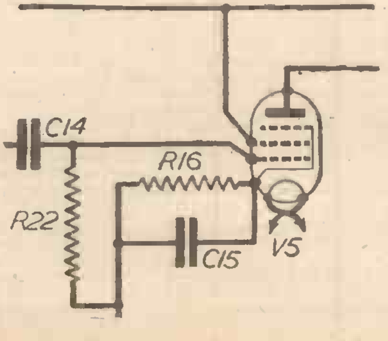
I. G. Heward's idea of the "eliminator bug."

to England and comes in as loud as the Americans, who come in so regularly that they are hardly worth recording.

Set used, 5-v. home-made superhet, indoor aerial 30-40ft. long, 25ft. above ground, location, Oxfordshire. —F. E. AVELING (Banbury).

Your Service Workshop—2: Correction

REFERENCE to the theoretical circuit, Fig. 9, page 227, May issue, will reveal that the connections to the grids of the resistance/capacity coupled output pentode are not correct. The connection made to the screening-grid should, of course, be taken to the control-grid. The H.T. must then be connected to the S/G, and not to the suppressor, as shown in Fig. 9. The correct wiring is shown below.



Replies to Queries

> **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.

High-note Buzzer

"I am trying to improve my morse and have been using an ordinary converted electric bell movement as a sounder. I find, however, that the low note is rather depressing when used for long periods, and I want a high note to coincide with some of the special code transmissions which I can pick up on my set. Is there any way I can convert the bell for a high note, or any simple way of making such a sounder?"—G. H. (Whitby).

THE armature of the bell is too heavy to vibrate at sufficient speed to produce a high note. The special miniature buzzers sold for the purpose are exceedingly light and give a very high note, and you could probably build a similar device in which your bell magnets could be incorporated. The armature must be very short and light to give the high note. A simple sounder may be made round an ordinary earphone, using the existing diaphragm with a lead soldered to it to act as the armature. A contact must be arranged to make and break at the centre of the diaphragm in order to obtain the buzzer effects.

Resistance Rating

"Kindly advise *re* the following: If a mains set specifies a ½-watt resistor and 1 watt is used, what is the effect in the set? Also, why in some battery sets 1 watt is used and yet in mains sets ½-watt is used."—P. J. W. (Hendon).

WATTAGE is the unit of power, and it is power which is required to drive the current through a resistance. The formula for calculating the power rating of the resistor (or in other words the wattage) is current squared times the resistance. Thus, 10 milliamps flowing through 10,000 ohms resistance would give .01 x .01 x 10,000 (current being expressed in amps.). The answer is 1 watt. Another way of arriving at the wattage is to calculate the voltage drop across the resistance (by multiplying the current in amps. by the resistance) and then multiplying that voltage by the current. Thus you will see that each resistance has to be considered alone, irrespective of whether it is in a battery or a mains set. You can use resistances with higher ratings—and this is desirable—but not with smaller ratings. If a 1-watt resistance is needed and you use a ½-watt component, it will probably be damaged or destroyed, due to the heat which would be generated.

Balanced Reproduction

"I am trying out some experiments in reproduction and wonder if you can give me any hints on obtaining better results. I have a large 10-inch moving coil and a small midget M.C. and should like to use both to obtain more even response of all frequencies. Should they be placed in any relative position regarding each other, or may they be placed side by side close together? Perhaps you can suggest some other scheme so that I could use these two units."—A. McH. (Glasgow).

THEORETICALLY the large speaker should handle the bass and the small speaker the treble, and if mounted side by side and fed with a common signal they may give very good results. Improvements may be carried out, however, by separating them or even by placing the large unit so that it is directed downwards and the small unit so that it is directed forwards. On the other hand, maximum results would no doubt be obtained if you built a special filter circuit designed to feed all frequencies up to a certain value to the large speaker and frequencies above that value to the small speaker. You should experiment with various transformers and fixed condensers in order to find a circuit suited to your speakers, your set and the general acoustics of the room.

Automatic Bias

"I have a six-valve superhet, battery set with output stage Class B. I run this from the D.C. mains with an eliminator. I find this fairly satisfactory only it uses one 16½-volt G.B. battery in less than a month, regulating it so that I get the required voltage. The set has only one G.B.— connection which should be 3½ volts. The output valve is P.M.2B. Would it be possible to use automatic G.B., and how can I fit it? I know it is something like G.B. over current in amps., but I am not sure how to find the milliamps of the valve or valves."—R. H. T. (Eastbourne).

AS the output valve is designed to operate with no applied bias, the G.B. tapping is obviously designed to feed the driver valve. It is very unusual for the grid battery to run out in such a very short time, and we suspect that there is some leakage. Connect a milliammeter in series with the G.B. tapping, and by this means see if there is any current flowing, both when the set is switched on and off. This will show whether there is a short-circuit, perhaps caused by negative lead coming into contact with the chassis or a short-circuit between the transformer secondary and the chassis. It is possible to fit automatic bias and for this purpose the G.B. terminal on the L.F. transformer should be connected to earth through two resistors in series, the first having a value of about .25 or .5 megohms, and the second (the one joined to earth) a value of about 500 ohms. To the junction of these two resistors the H.T. negative battery lead should be joined, and a large capacity condenser (1 or 2 mfd.) should then be connected from earth to the G.B. terminal on the L.F. transformer.

Colour Codes

"I have some resistances which have rings of colour round them, but no dots as mentioned in your list of colour codes which was published some time ago. Can you tell me whether these are standard colours or whether they follow some different scheme?"—J. W. F. (Harrow).

IN some cases, instead of colouring the body of the resistor, its tip and marking with a dot, three rings of colour are placed on it. In other cases, the body is coloured, but two rings of colour are then made to indicate the tip and the usual dot. The outer ring is the tip in this case. Where there are three rings the body colour is generally much wider, and the next two rings are read in the order, tip and dot.

Using Headphones

"What value resistance should be placed in the leads when connecting two pairs of 2,000 ohm headphones to the L.S. extension terminals of a five-valve superhet commercial receiver giving an output of about 3 watts—D.C. mains? How and where should this resistance be placed, and are any precautionary measures necessary against shocks?—S. C. (Clapham).

WE are not quite clear concerning the point which is troubling you. First, the impedance of the 'phones will more or less match the ordinary output valve, and thus no matching difficulty arises. Secondly, no current should flow through the extension point and thus no limiting resistance is needed. Therefore, the only point is that concerning a volume control to prevent an excessive signal from causing distress when tuning with the 'phones. This can be arranged by a parallel resistor, although the ordinary volume control fitted to the receiver should be quite sufficient. As the receiver is operated from the mains it is necessary to isolate the headphones in case of shocks, and a large capacity fixed condenser should be included in each 'phone lead. There is no doubt already one included in the extension circuit, but to avoid all risks one should be used in each lead.

Fitting Tone Control to Oscillator

"I am desirous of putting a tone control on my L.F. oscillator. Will you please advise me how I can do this?"—R. H. W. (Birmingham).

THE tone can be varied by fitting a small condenser across the grid and L.T. negative. Values must be determined by tone required. A similar effect can be obtained by fitting a filament rheostat in one lead to the filament of the valve. A value of 6-10 ohms will be satisfactory.

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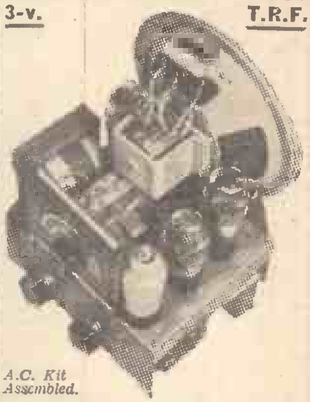

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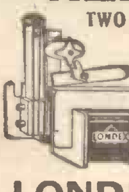

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Double-Diode-Triode Three (HF Pen, DDT, Pen)	PW23*
D.C. Ace (SG, D, Pen)	PW25
A.C. Three (SG, D, Pen)	PW29
A.C. Leader (HF Pen, D, Pow)	PW35C*
D.C. Premier (HF Pen, D, Pen)	PW35B
Unique (HF Pen, D (Pen), Pen)	PW36A
F. J. Camm's A.C. All-Wave Silver Souvenir Three (HF Pen, D, Pen)	PW50*
"All-Wave" A.C. Three (D, 2 LF (RC))	PW54*
A.C. 1936 Sonotone (HF Pen, HF Pen, Westector, Pen)	PW56
Mains Record All-Wave 3 (HF Pen, D, Pen)	PW70

Four-valve : Blueprints, 1s. each.

A.C. Fury Four (SG, SG, D, Pen)	PW20*
A.C. Fury Four Super (SG, SG, D, Pen)	PW34D
A.C. Hall-Mark (HF Pen, D, Push-Pull)	PW45*
Universal Hall-Mark (HF Pen, D, Push-Pull)	PW47

SUPERHETS.

Battery Sets : Blueprints, 1s. each.

F5 Superhet (Three-valve)	PW40
F. J. Camm's 2-valve Superhet	PW52

Mains Sets : Blueprints, 1s. each.

A.C. £5 Superhet (Three-valve)	PW43
D.C. £5 Superhet (Three-valve)	PW42
F. J. Camm's A.C. Superhet 4	PW59*
F. J. Camm's Universal £4 Superhet 4	PW60
"Qualitone" Universal Four	PW73*

Four-valve : Double-sided Blueprint, 1s. 6d.

Push Button 4, Battery Model / Push Button 4, A.C. Mains Model	PW95*

SHORT-WAVE SETS. Battery Operated.

One-valve : Blueprint, 1s.

Simple S.W. One-valver	PW88*

Two-valve : Blueprints, 1s. each.

Midget Short-wave Two (D, Pen)	PW38A
The "Fleet" Short-wave Two (D (HF Pen), Pen)	PW91*

Three-valve : Blueprints, 1s. each.

Experimenter's Short-wave Three (SG, D, Pow)	PW30A*
The Prefect 3 (D, 2 LF (RC and Trans))	PW63*
The Band-Spread S.W. Three (HF Pen, D (Pen), Pen)	PW68*

PORTABLES

Three-valve : Blueprints, 1s. each.

F. J. Camm's ELF Three-valve Portable (HF Pen, D, Pen)	PW65
Parvo Flyweight Midget Portable (SG, D, Pen)	PW77*

Four-valve : Blueprint, 1s.

"Imp" Portable 4 (D, LF LF (Pen))	PW86*

MISCELLANEOUS

Blueprint, 1s.

S. W. Converter-Adapter (1 valve)	PW48A*

AMATEUR WIRELESS AND WIRELESS MAGAZINE

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Blueprints, 6d. each.

Four-station Crystal Set	AW427
1934 Crystal Set	AW444
150-mile Crystal Set	AW450*

STRAIGHT SETS. Battery Operated.

One-valve : Blueprint, 1s.

B.B.C. Special One-valver	AW387

Two-valve : Blueprints, 1s. each.

Melody Ranger Two (D, Trans)	AW388
Full-volume Two (SG det, Pen)	AW392
A Modern Two-valver	WM409*

Three-valve : Blueprints, 1s. each.

£5 5s. S.G. 3 (SG, D, Trans)	AW412*
Lucerne Ranger (SG, D, Trans)	AW422*
£5 5s. Three De Luxe Version (SG, D, Trans)	AW435*
Transportable Three (SG, D, Pen)	WM271
Simple-Tune Three (SG, D, Pen)	WM327
Economy Pentode Three (SG, D, Pen)	WM337
"W.M." (1934 Standard Three (SG, D, Pen))	WM351*
£3 3s. Three (SG, D, Trans)	WM354
1935 £6 6s. Battery Three (SG, D, Pen)	WM371
PTP Three (Pen, D, Pen)	WM389
Certainty Three (SG, D, Pen)	WM393
Minitube Three (SG, D, Trans)	WM396*
All-wave Winning Three (SG, D, Pen)	WM400

Four-valve : Blueprints, 1s. 6d. each.

65s. Four (SG, D, RC, Trans)	AW370
Self-contained Four (SG, D, LF, Cl. B)	WM331
Lucerne Straight Four (SG, D, LF, Trans)	WM350
£5 5s. Battery Four (HF, D, 2LF)	WM381*
The H.K. Four (SG, SG, D, Pen)	WM384
The Auto Straight Four (HF, Pen, HF, Pen, DDT, Pen)	WM404*

Five-valve : Blueprints, 1s. 6d. each.

Super-quality Five (2 HF, D, RC, Trans)	WM320
Class B Quadradyne (2 SG, D, LF Class B)	WM344
New Class B Five (2 SG, D, LF Class B)	WM340

Mains Operated.

Two-valve : Blueprints, 1s. each.

Consoelectric Two (D, Pen) A.C.	AW403
Economy A.C. Two (D, Trans) A.C.	WM286

Three-valve : Blueprints, 1s. each.

Home Lover's New All-Electric Three (SG, D, Trans) A.C.	AW383*
Mantovani A.C. Three (H.F. Pen, D, Pen)	WM374
£15 15s. 1936 A.C. Radiogram (HF, D, Pen)	WM401

Four-valve : Blueprints, 1s. 6d. each.

All Metal Four (2 SG, D, Pen)	WM329
Harris' Jubilee Radiogram (HF, Pen D, LF, P)	WM386

SPECIAL NOTICE

THESE blueprints are drawn full size. The issues containing descriptions of these sets are now out of print, but an asterisk beside the blueprint number denotes that constructional details are available, free with the blueprint.

The index letters which precede the Blueprint Number indicate the periodical in which the description appears: Thus P.W. refers to PRACTICAL WIRELESS, A.W. to *Amateur Wireless*, W.M. to *Wireless Magazine*.

Send (preferably) a postal order to cover the cost of the Blueprint (stamps over 6d. unacceptable) to PRACTICAL WIRELESS Blueprint Dept., George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2.

SUPERHETS

Battery Sets : Blueprints, 1s. 6d. each.

'Varsity Four	WM395*
The Request All-Waver	WM407

Mains Sets : Blueprints, 1s. each.

Heptode Super Three A.C.	WM359*

PORTABLES

Four-valve : Blueprints, 1s. 6d. each.

Holiday Portable (SG, D, LF, Class B)	AW393
Family Portable (HF, D, RC, Trans)	AW447
Tyers Portable (SG, D, 2 Trans)	WM367

SHORT-WAVE SETS. Battery Operated

One-valve : Blueprints, 1s. each.

S.W. One-valver for America	AW429*
Roma Short-Waver	AW452

Two-valve : Blueprints, 1s. each.

Ultra-short Battery Two (SG, det Pen)	WM402*
Home-made Coil Two (D, Pen)	AW440

Three-valve : Blueprints, 1s. each.

Experimenter's 5-metre Set (D, Trans, Super-regen)	AW438
The Carrier Short-waver (SG, D, P.)	WM390

Four-valve : Blueprints, 1s. 6d. each.

A.W. Short-wave World-beater (HF, Pen, D, RC, Trans)	AW436
Standard Four-valver Short-waver (SG, D, LF, P)	WM383*

Superhet : Blueprint, 1s. 6d.

Simplified Short-wave Super	WM397*

Mains Operated

Two-valve : Blueprints, 1s. each.

Two-valve Mains Short-waver (D, Pen) A.C.	AW453*

Three-valve : Blueprints, 1s.

Emigrator (SG, D, Pen) A.C.	WM352

Four-valve : Blueprints, 1s. 6d.

Standard Four-valve A.C. Short-waver (SG, D, RC, Trans)	WM391*

MISCELLANEOUS

S.W. One-valve Converter (Price 6d.)	AW329
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Listener's 5-watt A.C. Amplifier (1/6)	WM392*
Radio Unit (2v.) for WM392 (1/-)	WM398*
Harris Electrogram battery amplifier (1/-)	WM399*
De Luxe Concert A.C. Electrogram (1/-)	WM403*
New Style Short-wave Adapter (1/-)	WM388
Short-wave Adapter (1/-)	AW456
B.L.D.L.C. Short-wave Converter (1/-)	WM405
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