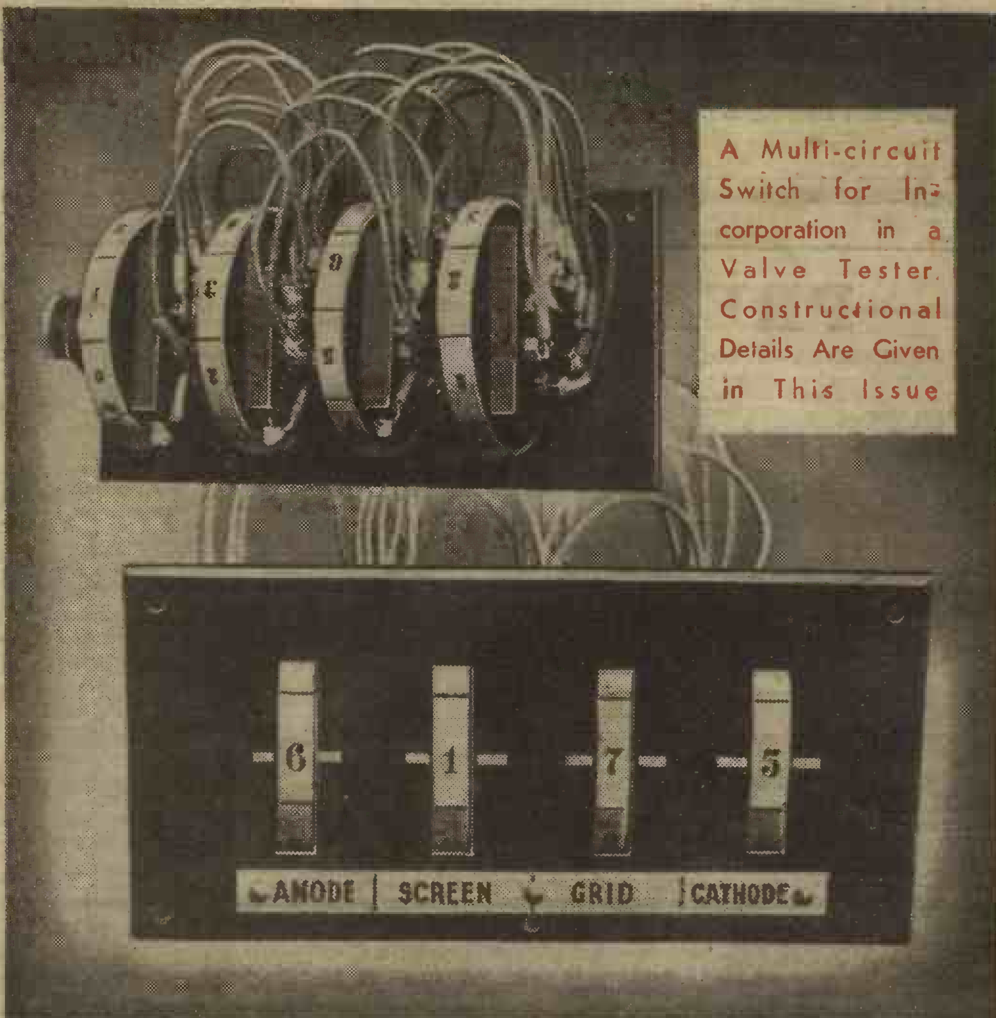
FRENCY MODULATION

Practical Wireless

9D EVERY MONTH

Editor F. J. CAMM

Vol. 19. No. 446 NEW SERIES. AUGUST, 1943



A Multi-circuit Switch for Incorporation in a Valve Tester. Constructional Details Are Given in This Issue

Practical Wireless

and PRACTICAL TELEVISION

11th YEAR OF ISSUE

EVERY MONTH

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COMMENTS OF THE MONTH — BY THE EDITOR

Lease-lend Sets

AS we go to press the President of the Board of Trade has informed the House of Commons that American sets may be imported in the near future, but that we should not have utility sets until next year. This was in reply to Mr. De La Bere, who asked whether any information could be released as to progress in the manufacture and design of utility radio sets.

Mr. Dalton, President of the Board of Trade, said that 90,000 domestic wireless sets were in process of manufacture, and they would be completed and released during this year. In addition to this, arrangements have been made to import supplies from the United States for early delivery. He has decided that after the sets in process of manufacture have been completed any new domestic sets made here shall be of simple standard designs. Discussions on this are now proceeding with the trade, but no sets of this type could be available until next year.

Mr. De La Bere also asked the Government whether they were in a position to make an announcement in connection with a policy to safeguard the interests of the small trader after the cessation of hostilities. In his reply, Mr. Dalton said that on the subject of whether or not, and if so, subject to what modifications, the present arrangements for the licensing of shops shall continue after the war, he had invited the views of the principal organisations concerned, and other problems affecting the future of retail trade are also being considered in relation to the Government post-war policy as a whole. Mr. De La Bere thought that protective legislation to safeguard the businesses of small shopkeepers will have to be introduced when the war is over, and the matter of the small shopkeeper cannot be lightly dismissed.

Radio Research

MEMBERS of Parliament are alive to the need for keeping this country ahead in wireless and television research. Rear-Admiral Beamish recently asked the Minister of Production how radio research and expenditure in this country compared with that of America, and whether he proposed to initiate comparative developments in this country. Mr. Garro Jones, replying for the Government, said that no details are available of comparable American expenditure, and it would not be in the national interests to give particulars of the scope of our research in the radio field, nor of the expenditure upon it. A vast amount of work has been done, and is being done, in this field by Government Departments, by the B.B.C. and industry, and close contact has been maintained with America. It was stated that America is spending £7,000,000 per year on research, but we are assured that we are not behind America in achievement.

In this connection it should be recorded that the Institution of Electrical Engineers has just issued a report which contains a suggestion for the establishment of a British Electrical Research Board, in order to obtain rapid progress in the application of scientific research in industry after the war. The report goes on to say that, as post-war industry is expected to be on the same competitive basis as before this war, there appears small scope for beneficial reorganisation of research, and it envisages post-war industry being established on co-operative lines. The report makes it clear that they have not in mind Government control of the radio and electrical industry. They consider that a co-ordinating body should be formed which should not, itself, conduct research work. One of the duties of the Board, the report suggests, should be to train personnel in universities and in individual laboratories.

We need, however, to be a little cautious before we approve any of these so-called co-operative schemes. We want to avoid anything in the nature of a cartel, and we certainly do not wish to see the trustification of the radio industry, for trusts seldom operate for the benefit of the consumer.

Refresher Course in Mathematics

OUR readers will remember the series of articles recently published in this journal entitled "Refresher Course in Mathematics." This series has now been published in book form at 8s. 6d., or by post 9s. from the offices of this journal.

Much matter additional to the series of articles has been included in this 240-page book, which contains an 11-page index. The chapters are: Mathematical Terms and Signs; Fractions; Continued Fractions; Approximations; Decimals; Duodecimals; Square Root and Cube Root; Some Short Cuts; Logarithms; The Metric System; Progression: Arithmetical, Geometrical, and Harmonical; Averages—Ratio and Proportion—Percentages; Interest—Discount — Present Value—Annuities; Algebra; Simple Equations; Simultaneous Equations; Permutations and Combinations; The Binomial Theorem; Algebraic Factors; Indices; Algebraic Fractions, H.C.F. and L.C.M.; Quadratic and Cubic Equations; Graphs; Mensuration—Trigonometry Areas of Circle, Triangles and and Quadrilaterals; Volume—Weight—Mass—Density—Solids; The Infinitesimal Calculus: Differentiation; Integration; Mathematical and General Constants; Trigonometrical Tables; and Logarithms.

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

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

ROUND THE WORLD OF WIRELESS

Utility Sets

WITH reference to the reports which have appeared in the daily press forecasting the early appearance of utility wireless sets on the market, the Board of Trade have issued a statement to the effect that there is no likelihood of utility radio sets being put on the market in the near future. There has been no decision yet to make utility sets, and wireless equipment is so vital a necessity for the Services that material and labour cannot be spared to make civilian sets in any quantity

Radio Artificers for Canadian Navy

IT is reported that the Royal Canadian Navy has recently introduced the rating of radio artificer—a branch of the Service in which men will be engaged on the maintenance of radio apparatus and direction-finding equipment ashore and afloat.

New-laid News

IN one number of Colin Wills's "Australian Newsletter," broadcast weekly from the B.B.C., he told of a queer happening at Babinda, Queensland. Somebody presented a newsagent there with an egg. After leaving it on ice for twenty-four hours, he put it in his shop window. Next morning he found the window space had become the happy hunting ground of a lively young crocodile.

New Belgian Radio Station Opened

A NEW broadcasting station, installed by the Belgian Government at Leopoldville, in the Belgian Congo, was inaugurated on May 16th.

The putting into operation of this station by one of the United Nations whose territory is occupied by the enemy and whose Government is in exile, is a striking event. Though the station is installed in the Congo it is, nevertheless, on Belgian territory, whence programmes directed to the Belgian homeland will henceforth be broadcast, thus creating yet another link between Belgians at home and overseas.

At the opening ceremony addresses were broadcast by the Belgian Premier, M. Hubert Pierlot; the Minister of Justice and Information, M. Antoine Delfosse; the Minister for the Colonies, M. Albert de Vleeschauwer; and the Governor-General of the Congo, M. Pierre Ryckmans. Mr. Anthony Eden, British Foreign Secretary, also broadcast a message directed to the Belgian people.

The new station will operate on two short wavelengths — 25.70 and 16.88 metres — and will transmit intermittently for 8½ hours daily, the programmes being presented under the following three headings:

Les Belges vous parlent de Londres.
Les Belges vous parlent de New York.
Les Belges vous parlent du Congo.

Rainbow Censorship

"THE best example of Press censorship is to be seen in Czechoslovakia," A. J. van Velden said recently, when reviewing the book, "The Goebbels Experiment," in a B.B.C. overseas talk. This is why he thought so: "Goebbels can't trust the journalists there, so that Press conferences and directives are not enough. . . . There are Press offices in every small town in Czechoslovakia. In 1939 a circular was sent round to all Czech journalists. It ended with these words: 'The censors of the Central Press Bureau use brown pencils; the German military censors use red and green pencils; and the censors in the local Press offices use blue and purple pencils.' The items left uncoloured by the views—and the pencils—of the censor, presumably appeared in the newspapers."

After five months of Axis occupation the people of Tunis hear the truth. Army broadcasting vans tour the streets giving the news bulletins in French, Arabic and English. Our illustration shows one of the vans in the main street of Tunis, Avenue Jules Ferry. In the background part of the cathedral can be seen.

B.I.R.E. Paper

AT a members' meeting of the British Institution of Radio Engineers (North-Eastern Section), held at Rutherford Technical College, Bath Lane, Newcastle-on-Tyne, on June 4th, Mr. L. C. Pocock, A.M.I.E.E., read a paper on "Microphones and Receivers," with special reference to speech communication.

No Retailers Supplied

IN accordance with instructions which have reached Messrs. J. Bull and Sons, of 246, High Street, Harlesden, London N.W.10, they will in future not be permitted to supply other retailers. They are therefore confining their sales strictly to the general public and members of H.M. Forces.

Imperial Greatness

CHRISTINA FOYLE, broadcasting in the B.B.C. overseas series, "Speaking Personally," mentioned some of the queer mistakes made by people over book titles. One order she had received recently was for a copy of "The Decline and Fall of the Holborn Empire."

They will include relays of the French and Flemish programmes emanating from the B.B.C. at 7.15 p.m. and 8.30 p.m., respectively.

Austerity of Other Days

MARGARET RAWLINGS, London stage star, talked the other day in the B.B.C. overseas service about the early days of touring repertory companies. Each actor or actress, she said, was engaged under a specific heading—" Leading Lady," " Juvenile," and so forth. At the bottom of the list came one who was known as the " Utility Gentleman."

A.T.S. Signals School

THE luxury hotels in a village in the Scottish Highlands are still filled to capacity—but what was once a centre for holidaymakers and tourists is now a training centre for A.T.S. girls who are going into the Signals as teleprinter operators, switchboard operators and O.W.L.s (Service name for operators, wireless and line). Four training Signals offices set up in different parts of the village are in communication with each other by wireless, teleprinter and telephone, and operate as if they were hundreds of miles apart. Most of the students come to the school direct from their three weeks' course at a basic training centre. Teleprinters take an eight weeks' course and O.W.L.s take a 14 weeks' course. There is a course for A.T.S. officers, who learn to take charge of Signal offices. In seven weeks they acquire a thorough working knowledge of the routine and instruments of a Signals office, telephone switchboard, teleprinters, and wireless receiving and transmitting sets.

"Transatlantic Call"

REPORTS from the United States indicate that " Transatlantic Call," which has now been running for 20 weeks, and is heard over there by listeners to the Columbia Broadcasting System, as well as by listeners in this country, is the most successful Anglo-American radio series to date. Columbia's station managers have sent in highly complimentary letters, singling out the B.B.C. contributions for special praise.

A report from Columbus, Georgia, states that: " The programme has proven to be a high-light in our Sunday morning schedule, offering the people in this area a clearer insight into the friendly relations which exist between the people of Britain and the United States."

And from Charleston, West Virginia: " The general reaction, especially among university and professional people, is that ' Transatlantic Call ' is an excellent way for us to better understand our English Allies."

From Ithaca, New York: " More interest has been evinced by the broadcasts coming from England. It does seem that the British portion of the broadcast has been more successful in presenting a colourful picture of the folks on the other side of the water."

From Syracuse, New York: " The British programmes give an intimate and authentic picture of wartime England."

And so on, from Florida, and Iowa, and Minnesota and Arizona. All over the United States they are listening to these programmes and learning something of the real Britain. Meanwhile, listeners in this country, much as they seem to enjoy the British contributions, are learning in the same way about the United States. Listener research reports show that the vastness and variety of America and her peoples are being vividly brought home to the British public.

Pupils at a teleprinting class at the A.T.S. Signals School in the Scottish Highlands.

Expansion in Overseas Service

BRITISH fighting forces now spread over the greater part of the globe will, however remote they may be, be kept in minute-to-minute touch with the homeland by a big expansion of the B.B.C.'s Overseas Service which came into operation on June 13th.

For their benefit the B.B.C. has planned a world-wide service of home news and light entertainment, to be known from this date as the General Overseas Service, specially designed to provide the best type of listening material for the conditions under which men and women on active service live. No matter where they may be —with the R.A.F. in China, in the jungles of Malaya, in the deserts of Iraq and North Africa, in training camps of Canada, or in the tropical heat of West Africa—London will call them for 12¾ hours a day, bringing them tuneful music, the nostalgic chimes of Big Ben, news from home, and favourites of the Home Service, such as " Shipmates Ashore," B.B.C. Dancing Club, " Happidrome," " Marching On," and " The Stage Presents."

Link with Home News

THIS service, which extends the previous Overseas Forces service, will be available, of course, for civilians also and all who in those regions look for an especially close link with home news of Great Britain.

With the introduction of this General Overseas Service, the Overseas Services of the B.B.C. (excluding the European Service) will now number seven. This will allow greater specialisation in the broadcasts directed to individual regions, especially in the Eastern Service.

Selectivity in S.W. Receivers

Some Suggestions on How to Improve the Selectivity of Simple Sets

By WILLIAM NIMMONS

THE simple, single-circuit short-wave receiver usually suffers from a lack of selectivity. It is often thought that, because the tuning appears to be sharp, this class of receiver is inherently selective. Nothing could be farther from the truth. A combination of weak signals and the crowding of many kilocycles into the band covered by the average condenser may suggest a spurious selectivity. When conditions are good, and the powerful European transmissions come in at good strength, the true selectivity of such sets is revealed. It is no uncommon thing to find that a signal spreads up to 50 kilocycles on either side of its proper tuning point, thus blotting out the weaker transmissions within its spread.

The reasons for this state of affairs are rather complicated. The main one is that, with a plain coil and condenser the optimum selectivity is obtained at resonance with weak signals only; with strong signals the resonant point is not sharply defined. You have only to compare the results given on the medium waves with a plain coil, with the aerial connected to the top of the coil through a .0005 mfd. fixed condenser, to realise how unselective a similar arrangement is on the short waves. True, we employ a condenser much smaller in the latter case—something in the region of 50 mmfd.—but the higher frequency makes the smaller condenser just as efficient in transferring energy from the aerial, so that we are no better off in the end.

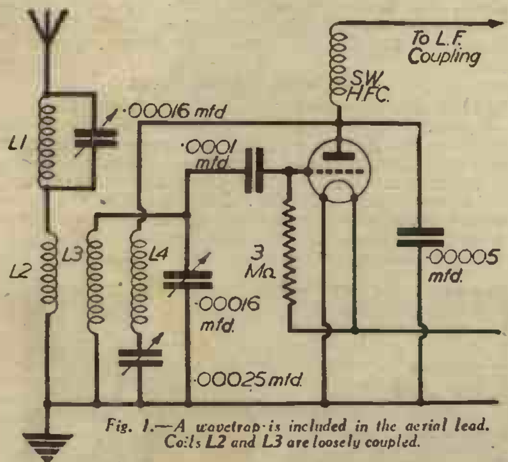


Fig. 1.—A wavetrap is included in the aerial lead. Coils L2 and L3 are loosely coupled.

The remedy for this state of affairs depends upon how much time, skill and money you are prepared to expend. I know that, with a variable aerial condenser and/or a variable aerial coil, much can be done to combat the nuisance. But the fact remains that the plain coil and condenser is inherently unselective, but it should be mentioned that the aerial has a profound effect upon the selectivity of the simple set, but is of much less importance in those cases where a pre-selector or other form of H.F. amplification is employed.

First, as regards the simple detector, a wavetrap may be employed to cut out the interfering station, as shown in Fig. 1. The coil L_1 should be of the same dimensions and the same number of turns as the coil L_3, and tuned by an air-spaced condenser. It is best to put the wavetrap in a metal box to prevent interaction between it and the coil in the set.

Band-pass Circuits

Band-pass operation provides a way out of some of the difficulties encountered. Figs. 2 and 3 give two band-pass circuits which are suitable for short-wave work. Fig. 2 uses standard plug-in coils, but the second coil must have three windings, viz., the grid winding, the reaction winding, and the winding which is one component of the band-pass coupler. The latter may be the aerial winding of the conventional six-pin coil.

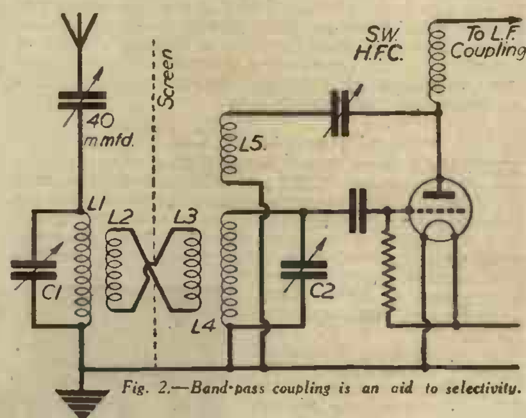


Fig. 2.—Band-pass coupling is an aid to selectivity.

L_1 is similar to the grid coil, L_4, and L_2 and L_3 are also similar. It is desirable to put up a screen between the two sets of coils if best results are to be obtained. Fig. 3 is suitable for operation from a di-pole aerial with twisted feeders. In both cases the variable condensers, C_1 and C_2, can be ganged for ease of operation, but it is as well to have a small trimmer on at least one of them

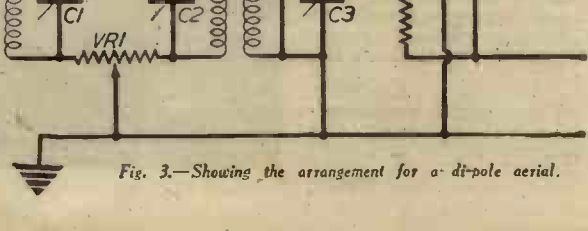


Fig. 3.—Showing the arrangement for a di-pole aerial.

to balance out stray capacities. This can take the form of a small 15 mmfd. variable condenser, which is manipulated to bring the signal up to strength after tuning with the main condenser. As the reaction setting alters the tuning, some form of padding condenser is an essential item when ganged condensers are used. If two separate tuning condensers are used then, of course, no padding condenser is needed.

A well-designed H.F. amplifier, however, will be found to give better results. This should be tuned, and it need not be a passenger if the proper precautions are taken; in fact, with a well-designed amplifier a gain of from 10 to 20 times can be expected, and it will increase the selectivity.

The secret of success in an amplifier of this kind is short wiring, low-loss ceramics foil the coil former, coil holder and the valve holder. An H.F. pentode is better than a screen-grid valve at high frequencies. There can be little doubt, also, that a certain amount of regeneration helps matters—it not only sharpens the tuning, but increases the amplification as well. The valve should never be allowed to oscillate, of course, but a discriminate use of reaction in the H.F. amplifier makes a wonderful improvement.

H.F. Amplification

Either one or two stages of H.F. amplification can be employed. The ideal solution is to make up a unit complete in a screened box; this does away at once with all chances of interaction between the H.F. amplifier and the rest of the set. The circuit for such an amplifier is shown in Fig. 4; this is a two-stage affair, but one stage is often sufficient. In the latter case, a short-wave H.F. choke is inserted in the anode lead to the first valve, and the output to the set taken from the anode through a .0001 mfd. condenser. Note also, how regeneration is obtained by means of a neutralising condenser from the screen of the pentode. This condenser can have a maximum capacity of 15–25 mmfd., and need not be mounted on the panel. A fixed amount of regeneration, so arranged that the valve does not oscillate at any setting of the main tuning controls, is all that is required. Four-pin or six-pin coils can be used, but the aerial coil must have three windings. A pre-amplifier of this kind—also called a pre-selector when associated with image suppression in a short-wave superheterodyne—is also useful for short-wave work when conditions are not too good, and, paradoxically enough, when conditions are too good.

The latter statement may seem strange to many, but there is little doubt that conditions can be too good from the selectivity point of view with simple sets, for reasons already explained. With such a pre-amplifier as shown in Fig. 4 one can readily adjust the input to the set proper by means of the volume control VR_1 on such occasions, and, at the same time, the selectivity is ample for all requirements.

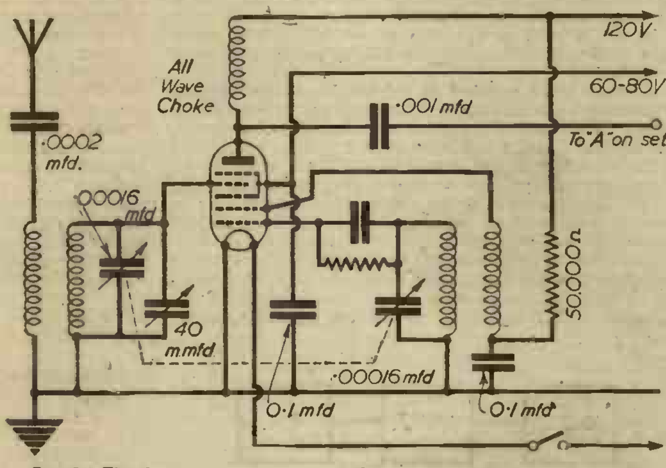


Fig. 5.—The short-wave converter is an ideal solution of the selectivity problem.

S.W. Converter

Another solution is the short-wave converter, a circuit of which is shown in Fig. 5. This makes use of a heptode frequency-changer valve, and also utilises all the valves in the set proper, the whole combination forming a superheterodyne receiver. A few words in explanation of Fig. 5 may be helpful to those who have never built or operated such a converter.

The circuit shows very simply how the converter works. The aerial is fed via a .0002 mfd. condenser to the primary of the aerial coil, the secondary of which is in the grid circuit of the detector portion of the heptode. The oscillator section of the heptode valve includes another coil which has its secondary used as the grid winding and the primary as the anode (reaction) winding. Both these secondaries are tuned by a .00016 mfd. ganged condenser, with a .00004 mfd. (40 mmfd.) trimmer across the first section to obtain the necessary frequency shift. Mixing is done in the electron stream inside the valve, and what emerges at the anode is a heterodyne of the short-wave signals, which is passed on the receiver by a .001 mfd. condenser. The short-wave signals are converted into a long-wave heterodyne, ready to be amplified by the HF. valve of the broadcast receiver.

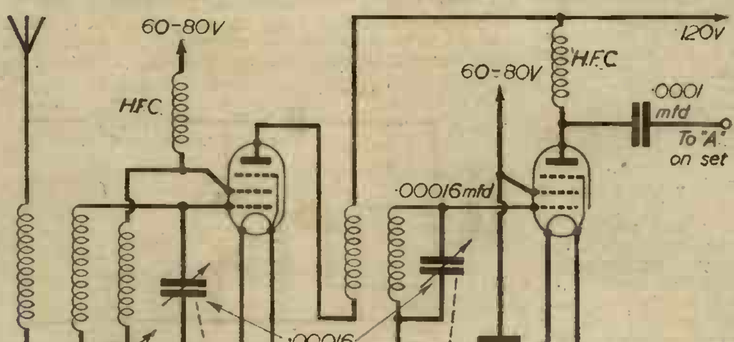


Fig. 4.—A pre-amplifier of this kind increases selectivity and sensitivity.

Frequency Modulation—2

Advantages and Disadvantages : FM Transmitter and Modulation Systems

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

(Continued from page 328, July issue.)

IN the previous article it has been shown that a FM transmission can be resolved into a carrier and a large number of sidebands—many more, in fact, than are present in the case of an AM transmission. This factor, unfortunately, limits the use of frequency modulation.

When a large number of sidebands are present, in order to get the minimum amount of distortion (which means that most of the sidebands should be received), the receiver circuits will have to be capable of receiving a fairly wide band of frequencies. Thus in order to allow a reasonably large number of stations to be on the air at the same time, transmission must be confined to the very high frequencies, so that there can be sufficient separation between stations. A second reason why transmission must be confined to the very high frequency ranges, is that reception must be via the direct ray only. If the indirect (i.e., reflected) ray were used, signals via different routes would arrive at the receiving aerial,

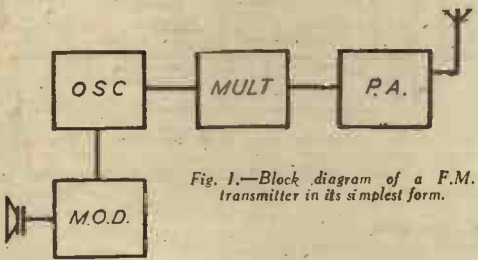


Fig. 1.—Block diagram of a F.M. transmitter in its simplest form.

sometimes in phase, sometimes in antiphase, causing "selective" fading with resultant distortion.

This effect is unpleasant enough when amplitude modulation is used, but in the case of frequency modulation, where so many more sidebands are present, use of the indirect ray is ruled out, since distortionless reception would become almost impossible. This constitutes the greatest disadvantage of a FM system, since confining transmission to the V.H.F. ranges means that only local reception is possible.

Advantages

There are, however, several important advantages. In the first place, only a small amount of audio frequency power is required to modulate a high-powered transmitter, because modulation does not bring about any change in power output.

In a normal AM transmitter, it is not possible to modulate the oscillator stage, because frequency changes would be introduced. In a FM transmitter, frequency changes are required, and modulation can therefore be carried out at the oscillator stage. As will be seen later, they can be carried out with a low-powered oscillator working on a low frequency, subsequent stages amplifying and multiplying the frequency of the oscillator output. The transmitter can also be designed to operate more efficiently, since no provision has to be made in the power amplifying stage for change in carrier amplitude.

The main advantage of frequency modulation is that a greatly increased signal to noise ratio is possible, and, therefore, satisfactory reception can be obtained from weaker transmissions, and portions of a transmission where the modulating voltage is small can be more clearly received. (The noise referred to here is that produced by the receiver and not external noise.)

Noise voltages are produced by conductors and valves and occur at radio and audio frequencies. These RF voltages heterodyne each other and the result is detected in the normal way. The FM receiver, however, does not respond to any amplitude variations, and it would therefore appear that no noise would be apparent in the FM receiver. An investigation of the heterodyne process reveals that heterodyning also produces phase changes (equivalent to phase modulation), and since phase modulation produces frequency modulation as a by-product, there will be some noise output in the receiver.

It will be remembered from our previous discussion on phase modulation that df/fm is a constant, i.e., the higher the modulation frequency the greater the frequency deviation produced. Thus noise voltages heterodyning and producing low audio frequency beats will not produce much output, so that the range of frequencies that can produce any noise output is small and, therefore, the total noise will be greatly reduced.

Signal/Noise Ratio

When a signal is received, the results are even better, since if the signal amplitude is large compared with the noise voltages, the noise produced by these voltages heterodyning each other becomes ineffective or "demodulated." This occurs with both AM and FM systems, and may briefly be explained as follows.

If two noise voltages spaced by more than an audio frequency away from the desired signal heterodyne and produce an AF beat note, and are applied to the detector at the same time as the desired signal, then, if the desired signal is large, the only audio frequency component in the output will be that associated with the signal. To develop the noise voltages a second detector would be necessary, as in a superhet. Thus only noise voltages within audio frequency range of the desired carrier can produce noise output, since they will heterodyne with the carrier itself. It will, therefore, be seen that a wide-deviation FM system can be employed to give a large output using flatly tuned circuits without introducing any additional noise, and a high signal/noise ratio will be achieved. It should be

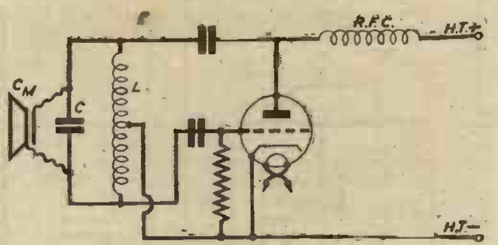


Fig. 2.—Illustrates how capacity can be used, i.e., a condenser microphone, to produce the desired modulation.

noted that when the input signal is weak (no greater than the noise voltages) the noise voltages will be able to heterodyne each other and produce AF output, and the advantages are lost.

A somewhat simpler way of regarding the above effect is to disregard the carrier and sideband theory, and to imagine the transmission purely as a carrier varying in frequency. As it sweeps backwards and forwards it will only be within AF range of any single noise voltage for a small period of time and the net effect of the noise voltages will be greatly reduced.

Another important point is the question of adjacent channel selectivity when frequency modulation is employed. Although FM transmissions occupy a wide frequency band (the amplitude of the nearer sidebands sometimes exceeding that of the carrier), it is possible to operate two stations with a fairly small frequency separation, provided the desired signal is strong compared with the undesired signal.

To sum up, we can say that an FM system employing a wide deviation offers great advantages over an A.M. system in that a much more favourable signal/noise ratio is obtainable, unless the signal strength is very weak, when a narrow deviation system is preferable. It provides an excellent system where local high-quality reception is required, and makes possible a much more efficient transmitter. It also has several commercial applications not connected with communication.

The FM Transmitter

We now have to consider the practical aspect of frequency modulation—that is, the methods by which it can be achieved. The main differences between FM and AM transmitters will obviously be in the modulator itself and that portion of the transmitter will be dealt with in some detail.

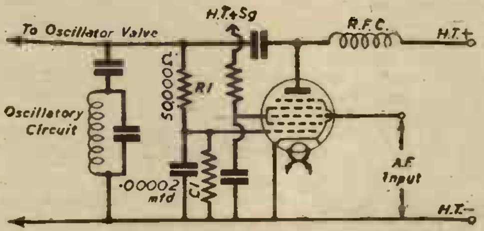


Fig. 3.—A valve used as a variable reactance to form a "reactance modulator."

The obvious place where control can be exercised over the frequency transmitted is at the oscillator, and it is here that modulation will be carried out. The oscillator will normally be working at a lower frequency than the final output frequency, and will be followed by frequency multiplier stages, which also serve to increase the final frequency deviation.

In order to ensure linearity when modulating, it will normally only be possible to vary the oscillator frequency by a small amount. A large frequency deviation, however, is required, and as the frequency is increased by multiplying stages, so will the deviation increase.

For example, suppose the oscillator generates a frequency of 10 mc/s, variable ± 3 kc/s, when modulation is applied. The frequency will therefore vary between 10,003 and 9,997 kc/s. Now, if this stage is followed by two frequency multiplier stages giving a multiplication of six times, the final output frequency will be 60 mc/s ± 18 kc/s, and the deviation frequency is now ± 18 kc/s.

Fig. 1 shows a block diagram of the transmitter in its simplest form. The oscillator may be any of the common types, with the exception of the crystal-controlled oscillator, and a Hartley will be quite suitable.

Now, the frequency of the voltages produced by an oscillator depends mainly on the components in the oscillatory circuit (i.e., inductance and capacity). Therefore it will be seen that alteration in the value of either of these components will produce a change in the frequency generated, and if the inductance or capacity can be caused to vary in sympathy with the modulating voltages, frequency modulation will have been achieved. The simplest way to do this would be to use a microphone in the form of a condenser, utilising the capacity between the diaphragm and a fixed plate. The capacity so formed could be placed in parallel with the normal tuned circuit capacity, and when sound waves caused the diaphragm to vibrate, a change of capacity would be produced and therefore a change in the frequency of the oscillation. This method is illustrated in Fig. 2.

Modulation

This simple system, however, would not be very satisfactory. In the first place, the capacity of the microphone (Cm) would be very small, and the changes in the Cm brought about by the operation of the microphone would be so minute that very little change of frequency would result. Also, to obviate difficulties due to stray capacities (in microphone leads, etc.), it would be necessary to design the oscillator and microphone all in one unit, a feature which renders it very undesirable.

Some improvement could be obtained if Cm were a variable condenser operated by a relay controlled by the microphone voltages, the microphone being of the normal type and situated some distance from the oscillator. This system, however, would not prove to be entirely satisfactory since only small changes of frequency would result as before.

A more effective and popular method is to utilise a valve as a variable reactance. This is connected in parallel with the tuned circuit of the oscillator, and will act in a manner similar to a variable capacity or inductance, and will therefore affect the frequency of the oscillator. A typical circuit for this "reactance modulator" is shown in Fig. 3.

A pentagrid valve is used as modulator, and the tuned circuit of the oscillator is connected between anode and cathode of this valve. An additional valve is used for producing the oscillation. In parallel with the oscillatory circuit there is a resistance R1, and condenser C1, and the values of these two components must be carefully chosen. It is desirable that the current flowing through R1/C1, due to the oscillatory voltage, should be, as near as possible, in phase with the oscillatory voltage. To enable this to take place, the circuit R1/C1 must be predominantly resistive, i.e., R1 must be large compared with the reactance of C1 at the particular frequency in use.

It is a property of a pure capacity that the voltage drop across it will lag the current "through" it by 90 deg. (voltage and current will be 90 deg. out of phase). Therefore, in the case of C1, the voltage across it, which is also the voltage applied between grid and filament of the pentagrid, will be 90 deg. out of phase with the current previously mentioned. This grid voltage will cause variations of anode current that are in phase with it. Therefore the RF anode current variations will lag on the current through R1/C1 by 90 deg., and will therefore lag on the oscillatory voltage applied between anode and cathode by 90 deg. This relationship between RF anode voltage and RF anode current makes the valve behave as an inductance, which is placed across the tuned circuit. If the value of the anode current is changed, the value of this apparent inductance will also change.

Hence, if AF voltages are applied between the third grid and cathode of the pentagrid, we have, in effect, an inductance varying at audio frequency connected across the oscillatory circuit, and therefore the frequency of the oscillator will vary at AF The amount by which the frequency varies will be dependent upon the amplitude of the AF voltages applied to the pentagrid.

A tetrode could be used instead of a pentagrid, and the AF and RF voltages both applied to the control grid, but this would introduce undesirable couplings.

Saturated Cores

The Function of the "Swinging" Choke

IN a previous article on "Rectifier Circuits," mention was made of an H.T. supply unit which was designed to give a D.C. output of about 120 volts from 230 volt A.C. mains. The point raised at that time was the excessive D.C. voltage due to the capacity of the smoothing condenser. Various methods were considered of correcting this, the first coming to mind being (a) a simple resistance to get the required voltage drop, (b) a volume-control type of resistance connected as a bleeder across the second of the two smoothing condensers, with a potentiometer tapping, (c) a choke similar to (a), and (d) a very much larger smoothing choke. However, none of these were available at the

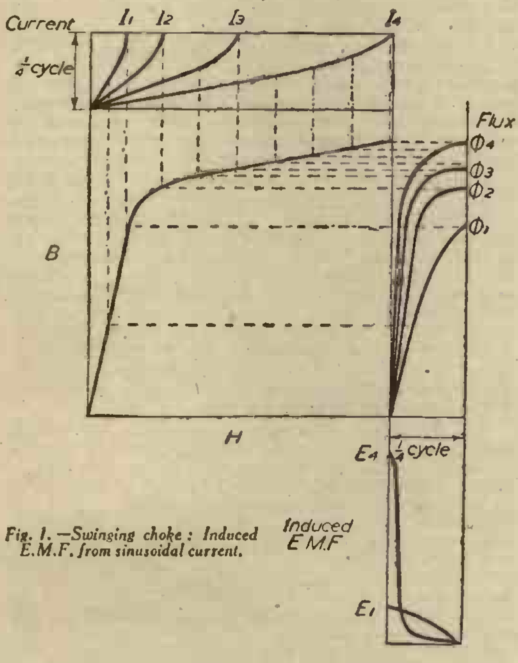


Fig. 1.—Swinging choke: Induced E.M.F. from sinusoidal current.

time, and it was required to get the unit into commission as soon as possible, even if only temporarily. In the circumstances the trouble was corrected by removing some of the laminations which formed the core of the transformer, and as this resort is not widely known, it may be as well to elaborate on this point. It cannot be too strongly emphasised that this is not an alteration to be lightly undertaken, and for reasons which will be made apparent, most stringent temperature tests should be made before the transformer is put into commission.

"Swinging Choke"

Most radio amateurs will be familiar with the "swinging" choke, the inductance of which drops as the current in its coils increases. They are often used in choke-input filters, where they give a fairly constant potential drop whatever the load current may be. These are the most common examples in electrical work of an inductance with an overloaded or saturated core, and form a useful starting-point for an explanation.

It is probably unnecessary to remind the majority of readers that a choke opposes the passage of an electric current by reason of the counter-E.M.F. set up in its coils by the changing magnetic flux which cuts them. This counter-E.M.F., and consequently the reactance, is directly proportional to the rate of change of the flux; this is proportional to the frequency of the alternations and the maximum value of the flux; and the maximum value of the flux is proportional to the current in the coils and the permeability of the core.

The fundamental difference between an ordinary and a swinging choke is that in the former the permeability of the core is practically constant, while in the latter it is not. This is effected by having a core of smaller cross-sectional area for the same length, turns and current than in the former case, the non-linear B/H curve for the iron distorting the wave-form of the flux or current or both. This is illustrated in Figs. 1 and 2.

Applied to problems in this subject, mathematical calculation is difficult and unreliable, and can be definitely misleading. Firstly, it would be extremely difficult to evolve a formula which would cover a B/H curve, and at the same time be convenient to handle in the various operations of differentiation and integration necessary. Secondly, the ordinary formulæ for inductance and reactance assume a sinusoidal waveform in all cases, and to convert these for more general use would necessitate further work in evolving the average and R.M.S. values of some very complicated waveforms. Altogether, it simply is not worth while. For this reason the writer proposes to confine his observations to general principles, and to use the method of graphical construction to illustrate them.

Magnetising Current

In Figs. 1 and 2 the B/H curve for the material used is drawn, the hysteresis lag, which does not immediately concern us, being ignored. In Fig. 1 parts of sine waves of various amplitudes, representing various values of magnetising current, are superimposed in such a way that the corresponding values of the flux may be found by projection. The values of the induced E.M.F. are found by plotting to the same time-base abscissæ the values of the slope of the flux/time curve.

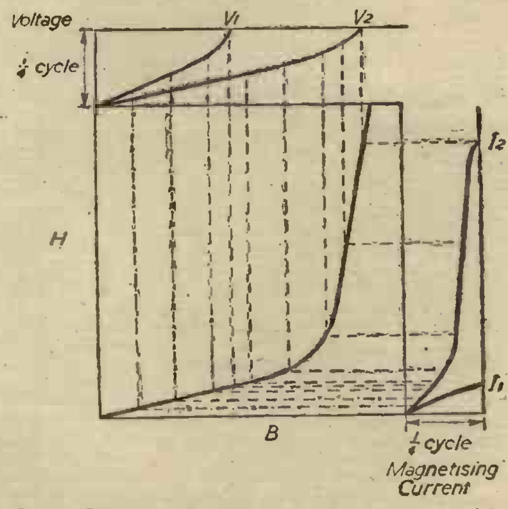


Fig. 2.—Swinging choke: Magnetising current from sinusoidal voltage.

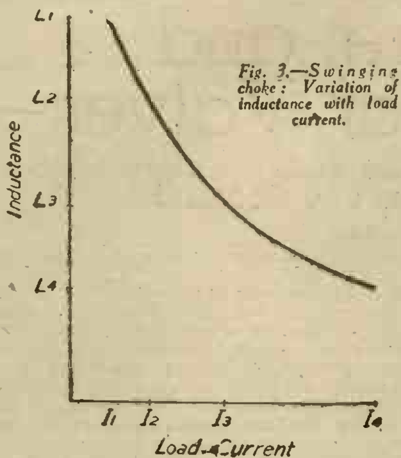


Fig. 3.—Swinging choke: Variation of inductance with load current.

In Fig. 2 the flux is assumed to be sinusoidal and the corresponding values for the magnetising current are found.

In Fig. 3 the values of the currents in Fig. 1 are plotted against the reactances, calculated from the R.M.S. currents and the estimated R.M.S. voltages.

In the case which we are considering the iron core of a transformer was reduced in area with the idea of decreasing the output voltage. We are now in a position to understand how this comes about.

The primary winding acts as a choke, and when the core becomes saturated the coil current necessary to counter the constant, sinusoidal applied voltage begins to increase rapidly and also to become very peaky in form, as in Fig. 2. When a load is applied to the secondary winding, the current which flows has a demagnetising effect, and this causes a further increase in the current in the primary.

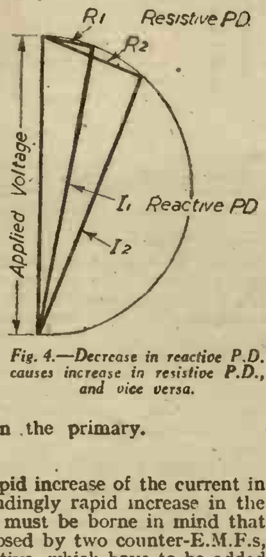


Fig. 4.—Decrease in reactive P.D. causes increase in resistive P.D., and vice versa.

Voltage Drop

The first result of the rapid increase of the current in the primary is a correspondingly rapid increase in the resistive voltage drop. It must be borne in mind that the applied voltage is opposed by two counter-E.M.F.s, the resistive and the inductive, which have to be added vectorially. Of these, only the inductive has a magnetising effect. Fig. 4 shows how a drop in the inductance of the primary, by causing an increase in the primary current, causes an increase in the resistive voltage drop, a decrease in the reactive voltage drop, and also, though this may not be so apparent, a further deformation of the current waveform. A better way of expressing this may be to say that the reactive voltage waveform becomes slightly flattened (Fig. 5), though this does not amount to very much.

Further losses which occur are the hysteresis losses in the iron core. The loss of energy per cubic cm. per cycle is proportional to the area of the B/H loop, and though the volume of iron used is decreased, if the iron is heavily saturated it is by no means impossible for the iron losses to increase. (Fig. 6.)

The E.M.F. induced in the secondary winding is proportional to the reactive voltage in the primary and, of course, to the ratio of the number of turns on primary and secondary. On load, the output voltage is lower than this by the usual impedance voltage drop.

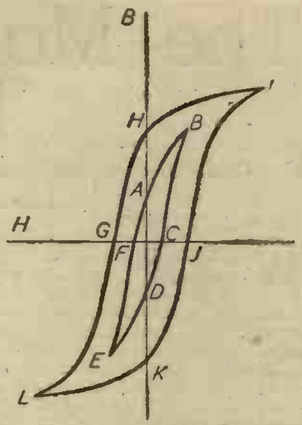


Fig. 6.—Swinging choke: Saturation causes increased iron losses.

The extent to which the core can be reduced in safety is limited by the temperature rise of the windings resulting from the comparatively heavy currents flowing. In the case being considered, the transformer has been wound by an amateur who had chosen his wire by the empirical rule of 1,000 amperes per square inch cross-section, and his core by the formula turns-per-volt x area in square inches = 8. He had thus a conveniently heavy guage of wire and a very low flux density. This proved useful, for the core was reduced to about one-quarter of its original area before a 10 per cent. drop in the output voltage was obtained, and a smaller gauge of wire would probably have overheated.

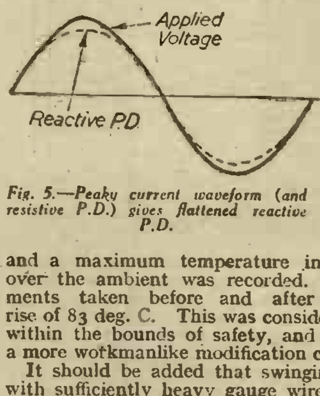


Fig. 5.—Peaky current waveform (and resistive P.D.) gives flattened reactive P.D.

The transformer was given a heat run of ten hours at full load, with a thermometer stuck inside the core with Plasticine, and a maximum temperature increase of 79 deg. C over the ambient was recorded. Resistance measurements taken before and after gave a calculated rise of 83 deg. C. This was considered to be just about within the bounds of safety, and was used thus until a more workmanlike modification could be arranged.

It should be added that swinging chokes are wound with sufficiently heavy gauge wire to take the current for which they are intended, but in this case the heating represented a serious waste of power, which would not be tolerable permanently.

The Manufacture and Testing of Valves—2

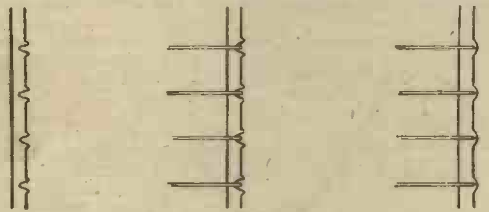
Grid Winding and Stretching : Cooling Fins and Anodes : General Production Methods and Assembly

By L. A. WOODHEAD

(Continued from page 317, July issue.)

WORKING outwards from the filament or cathode, the next component is the control grid. In triode valves this is the only grid, but there is a wide variety of valves which have several grids and/or screens, all made in a similar manner but having different physical dimensions. Originally, the grid turns were individually spot welded to the support wires; a much more secure method of fixing is now in use.

An automatic grid winding machine holds two parallel lengths of nickel or copper wire—called the "backing wires"—and rotates them rapidly. As the wires turn, a sharpened circular disc cuts minute slots at accurately measured intervals. Fine molybdenum wire is wound into the slots, and the ridges at the edges of the slot are then turned down so that the grid wire is securely held. This takes far longer to describe than to accomplish, the operations of slot cutting, wire winding and turning down being done as fast as the eye can follow them. Fig. 7 gives a magnified idea of the three stages. The grids are made in lengths of 30 or 40 ins. and then cut to size with a hand-operated guillotine. To facilitate subsequent operations it is possible during the winding to suspend the final operation, that is, turning in, at fixed distances. As an illustration, if the valve in production called for a grid with 60 turns, the machine can be set to wind and secure that number and then leave 10 turns loose, followed by 60 turns securely fixed, and so on. The guillotining takes place in the middle of the unsecured turns, which can readily be removed to prepare the grid for welding to the foot wires. Adjustments are provided on the machine for varying the distance between the nickel backing wires; for altering the pitch of the molybdenum winding wire; and for changing the number and position of loose turns.



A B C

Fig. 7.—Three stages in grid winding: (A) Slots cut in backing wire. (B) Winding wire in position. (C) Slots turned in.

Shaping the Grids

As the grids come from the machine they are flat sided, but many forms of modern grids and screens are oval or circular in cross section, and this shaping is done on a grid stretcher. This consists of accurately shaped steel pieces, divided into two, and capable of being expanded with a parallel action by the operation of a lever. This process not only shapes the grids to exact dimensions, but the slight stretching of the molybdenum wire causes it to stiffen and thus obviate the risk of sagging turns. Finished grids and screens, and examples of cross-sectional shapes, are shown in Fig. 8.

A general requirement in all valves is the necessity of preventing grid emission, and one method of making the grids less emissive is to gold-plate them. They are first cleaned in acid, and then held in clips in a solution of potassium cyanide. Also in the solution is a small block of gold, and a low voltage is passed between the clips and the gold. After a very short period the grids are removed from the bath, washed and dried and can then be used.

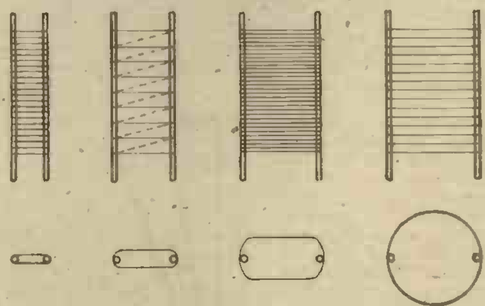


Fig. 8.—Types of grids and screens with cross-sectional views.

Grid Cooling Fins

The chief cause of grid emission is due to the grid becoming hot from the heat radiated by the filament or heater. To combat this, many valves have grid cooling fins welded either at the top or bottom of the grid. These fins frequently take the form of a small, stamped nickel box which has been carbonised or blackened in order to draw the heat away from the grid. Fig. 9 shows examples of grid cooling fins. Copper is occasionally used for grid backing wires because of its heat conducting properties, the heat being carried away from the grid wires. Also, the screens in some valves are sprayed with graphite in order that they may absorb heat, thus leaving the grid cool.

In many valves it is absolutely essential to have the turns of a grid precisely lined up with the turns of a screen, and to do this it is necessary to ensure that the pitch of the turns on the two components is identical. As it is a difficult matter to obtain good lining up when the parts are assembled, means have to

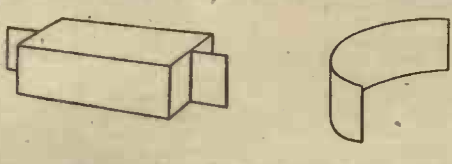


Fig. 9 (above).—Types of cooling fins.

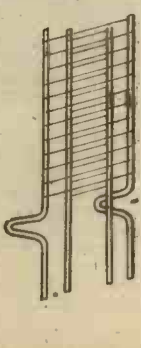


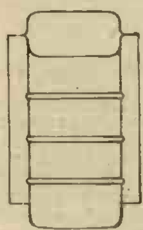
Fig. 10 (right).—Loops welded to screen backing wires to permit adjustment of screen and grid lining up.

be taken to adjust the grid and screen laterally after assembly. One way of doing this is to weld the backing wires of the screen to looped extensions to the nickel foot wires. By squeezing the loops with tweezers it is possible to lower the screen with respect to the grid until the turns of each exactly coincide. Fig. 10 shows the method.

Anodes

Anodes take a variety of size and shapes, but they are generally stamped from strip nickel, and often made in two halves which are subsequently welded together into box form. Frequently nickel gauze is used, principally when the electrodes are designed to have very small clearances and it becomes very necessary to keep the grid as cool as possible. Fig. 11 shows a number of anodes, and it will be seen that most of them are stamped with ribs to prevent distortion.

In certain valves, especially those handling a heavy wattage, the anodes are carbonised, either on the outside only or on both sides. Carbonising is applied to the nickel strip before the anodes are stamped, and is done by passing the strip through an electric furnace in an atmosphere of benzine. According to the general type of valve, the carbonising may have a very fine or coarse grain, the latter generally being associated with a bright nickel interior to the anode. In order to carbonise one side of the nickel only, two strips are spot welded together at the edges before passing through the benzine vapour. When the anodes are stamped the two inner surfaces are not carbonised. The stamping of the various shapes is done by hand operated or power presses, and in many cases there is an automatic feed of the strip so that large quantities can be produced quickly.



The shields which are used in such valves as beam electrodes and the screening caps or skirts used in H.F. pentodes are made in a similar manner to anodes and are also frequently carbonised. Examples of shields are shown in Fig. 12.

De-greasing and De-gassing

It is necessary for stamped metal parts to have a clean surface and this is done in a de-greasing tank. The parts are placed in wire baskets and held in a liquid called trichlorethylene, which quickly dissolves all grease.

De-gassing is another process which is very essential with most of the component parts of valves. Metals have a porous nature and it has been found that large volumes of atmospheric gases are absorbed by them. These gases would have a very detrimental effect on the vacuum of the finished valve and although further out-gassing takes place during subsequent pumping operations, it is necessary to remove as much gas as possible before assembly. The parts are placed in small nickel containers and passed, in an atmosphere of hydrogen, through an electric de-gassing furnace, the temperature of which is generally around 900 deg. C. Another method of de-gassing is to heat the parts to a similar temperature in a vacuum.

Mica Supports or Bridges

Mica is used for two main purposes in valve manufacture. Primarily it is a very good insulator, but of almost equal importance is its use as a support for assemblies. It is light in weight, it can be obtained very thin and it can be stamped to shape or pierced with great accuracy. Fig. 13 shows a few of the many forms used, those with serrated edges being employed to fit inside the dome at the top of the bulb for many modern valves, thus giving great rigidity to the whole assembly. Owing largely to the laminated nature of mica it is necessary for it to be thoroughly de-gassed in a similar manner to metal parts before use. To provide an increased leakage path micas for high voltage valves are frequently sprayed with magnesium carbonate, which leaves a slightly roughened surface. To facilitate later operations small nickel eyelets are generally inserted in the holes through which will pass main support rods.

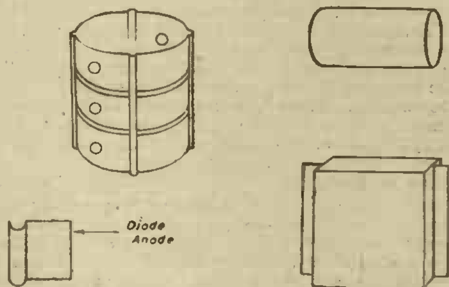


Fig. 11.—Types of anode construction.

There are sundry other small items which must be obtained before assembly can begin, and these include filament support springs, which exert tension on the filament, keeping it taut and clear of the grid; filament hooks, which are minute parts sprayed with alumina, and later welded to the grid supports to prevent vibration of the filament (Fig. 14 shows a filament and grid assembly using these items); various straight and bent lengths of nickel wire to make inter-connections between electrodes; and "getter" holders, which generally consist of a nickel disc or shallow pan on which the getter pellet is held by another disc of nickel or nickel gauze, the two parts being crimped or welded at the edges.

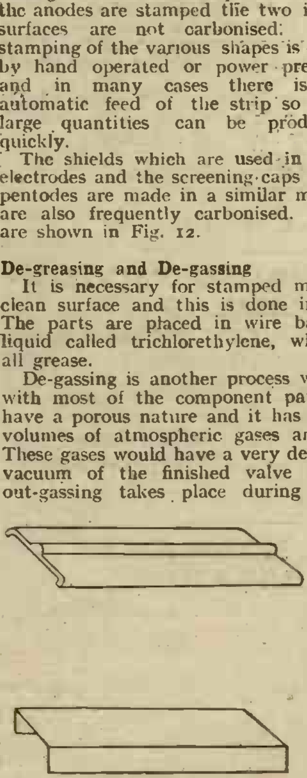


Fig. 12.—Shields used in beam tetrodes.

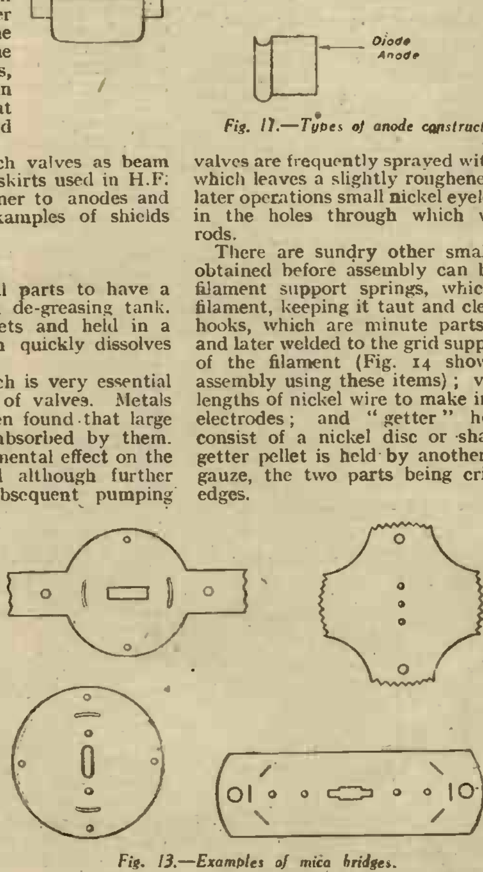


Fig. 13.—Examples of mica bridges.

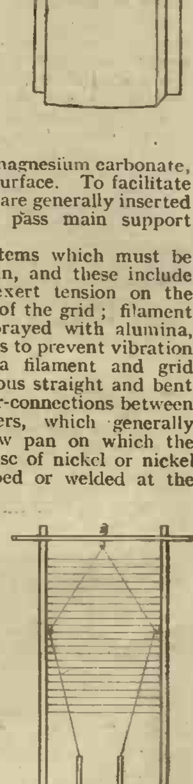


Fig. 14.—Filament and grid assembly showing filament tensioning spring and side hooks.

Welding Component Parts

All the separate metal components of a valve are electrically welded in one or more places and a brief description of the process of welding may be helpful. An electric welder is a bench unit containing a tapped transformer, which is adjusted to pass a heavy current at low voltages between the tips of two copper electrodes when they are brought together by means of a foot-operated treadle. The electrodes are made from ¼in. copper rod, and the tips are flattened, pointed or bent so that they come together just where they are needed. In operation the parts to be welded are rested on the bottom electrode, and the upper electrode is brought down by pressure on the treadle. At the point of contact a heavy current flows momentarily, and securely welds the components together, the process being instantaneous.

To ensure accuracy and consistency in assembly, each type of valve has its own jigs, which are used to hold the parts rigidly in position until they are welded. These jigs are made of steel, copper or brass, and considerable care is devoted to their design and manufacture.

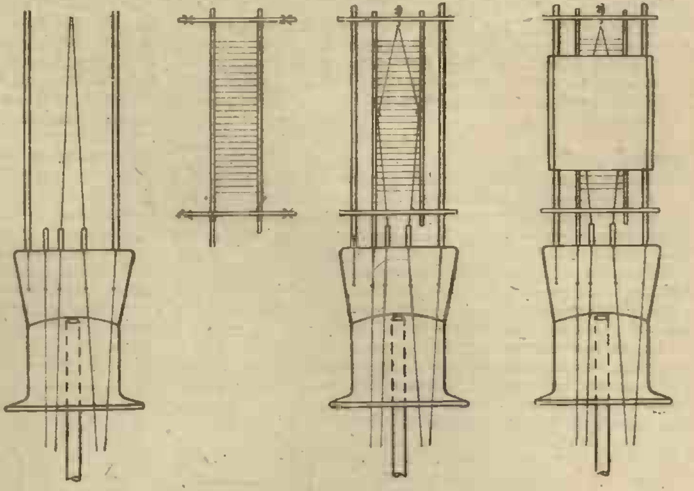


Fig. 15.—Four stages in mounting simple triode assembly.

Order of Assembly

The actual work of mounting is generally done in sections called sub-assemblies, and, of course, varies considerably with different types of valves. For instance, the schedule for a simple directly-heated triode would be: Weld the filament on to the appropriate foot wires; fix the grid top and bottom to mica bridges; slip the grid over the filament; weld the eyelets in the micas to the anode support rods; pass the hook of the filament spring through a hole in the top mica; place the filament on the hook and catch the filament around the insulated hooks welded to the grid backing wires; weld one-half of the anode to the support rods, and then weld the other half. Fig. 15 shows the stages.

In more complicated indirectly-heated valves the sub-assembly would consist of two or more grids and screens, each being accurately fixed in holes in the mica bridges, and always starting from the grid nearest to the cathode. Pentagrids and triode-hexodes call for extreme care, because of the number of grids used, but the stamped holes in the micas are accurate to one-thousandth of an inch, and the grids, as previously mentioned, are stretched to definite limits, so that very exact clearances may be maintained. A plan of a typical multi-grid assembly is shown in Fig. 16, together with the top mica bridge. Considerable rigidity is obtained with this method of mounting, thus ensuring that the characteristics of the valve remain constant throughout life.

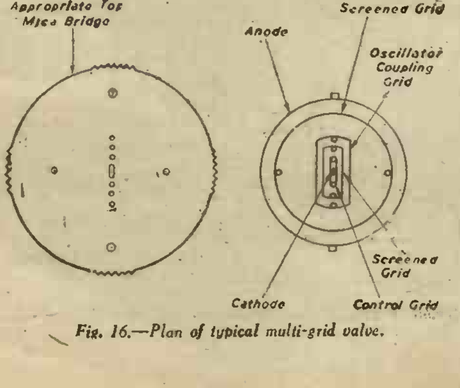


Fig. 16.—Plan of typical multi-grid valve.

During the process of mounting all the operators are required to wear white cotton gloves, which are changed daily. This is to prevent any contamination by perspiration or grease. Before the mount is finished any necessary inter-connections are welded on. These include connections from shields to cathode, suppressor grid to cathode, screened grid to screening cap, etc. Where the valve has an external top cap connection a suitable lead of borated copper wire is welded to the anode or grid according to the type.

At this stage a very thorough inspection of the construction of the mount is made. All the raw materials and manufactured parts have been examined previously when faults could be rectified, or, at any rate, faulty parts rejected, but with the mount now ready to be sealed into the bulb the last opportunity of adjustment has been reached.

(To be continued.)

THE USE OF RADIO VALVES IN EQUIPMENT

War Emergency British Standard Code of Practice

THIS Code of Practice has been drafted by the British Radio Valve Manufacturers' Association, and has been endorsed as a War Emergency British Standard by the Electrical Industry Committee of the B.S.I. on the recommendation of the Technical Committee on Wireless Apparatus and Components. It is obtainable from the British Standards Institution, 28, Victoria Street, London, S.W.1, price 1s. net.

VARLEY MOTOR-CYCLE ACCUMULATORS

THE new motor-cycle type dry accumulator produced by Varley Dry Accumulators, Ltd., By-pass Road, Barking, Essex, is made in 12-ampere capacity, at the 20-hour rate. The type number is MC7/12, and the list price is 27s. 6d. It is supplied either charged or uncharged.

The size is identical with the ordinary standard motor-cycle accumulator, the advantages of which have already been mentioned in these pages. One of the greatest advantages is their solid construction, which prevents the breaking of the plates. They have been in production for some time, and we understand from Varley Dry Accumulators, Ltd., that the demand has been so great that they cannot guarantee immediate delivery.

Secondary Batteries—1

Lead Acid and Alkaline : Chemical Action : Temperature Correction : Voltage and Capacity

By G. A. T. BURDETT, A.M.I.I.A.

THERE are two main types of secondary storage batteries now in general use—lead acid and alkaline.

These can be further sub-divided into two groups under the headings "wet" and "dry." An outstanding popular example of the latter is the "Fuller" cell.

Lead Acid Batteries

In order to appreciate the procedure adopted in the maintenance of batteries it is first necessary to have some knowledge of the fundamentals of secondary batteries. Each cell of a battery, whether lead acid or alkaline, must have three components—the plates, elements or electrodes; the electrolyte, the medium through which the chemical action of the cell takes place; and the vessel or cell which holds the electrolyte in which the plates are immersed. In lead acid cells the plates consist of two sets, positive and negative, both of which are composed of a proportion of lead. When in a fully charged state the positive plates are formed of lead peroxide (PbO_2) Fig. 1(a), and are of chocolate brown colour, while the negative plates are of pure lead (Pb) the colour of which when charged, is slate to purple grey. When discharged, Fig. 1(b), both positive and negative plates change into lead sulphate ($PbSO_4$), due to the removal during discharge of a mixture composed of sulphur and oxygen, (SO_4) from the electrolyte, viz., sulphuric acid (H_2SO_4). Plates in a discharged condition are easily determined visually by the white appearance of the lead sulphate on the plates. Containers of glass, celluloid or other transparent material allow such visual inspection, but as car, aircraft and many radio batteries have cases of a non-transparent compound it is impossible to determine by the colour, except through the vent hole, whether the plates have sulphated to any degree. In practice the visual test cannot be depended upon to determine the state of a battery, for while, if the plates have sulphated immediate attention must be given to the battery, an absence of sulphation does not necessarily indicate that the battery is fully charged, particularly when the battery is new. As batteries are reaching a discharged condition the lead sulphate which appears on the plates and disappears again during periods of charge is known as "normal" sulphation, and is quite harmless. When batteries are left in a discharged condition a hard core of sulphate adheres to the plates and *does not* disappear when the battery is again charged. The battery has then lost much of its initial capacity, while its efficiency has also dropped. Mild cases of sulphation may be remedied by special treatment, but when the sulphation has a "firm hold" batteries are usually ruined, and require scrapping. This is one of the main reasons why lead acid batteries must be carefully "nursed" and charged as frequently as possible.

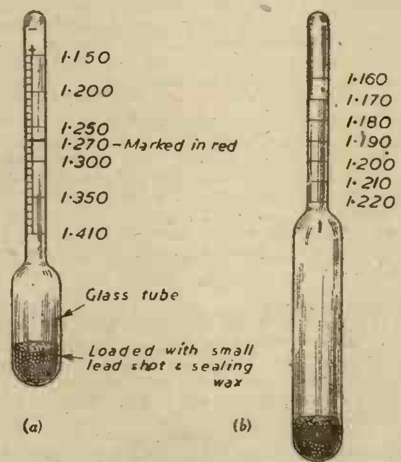


Fig. 2.—(a) "Lead acid" hydrometer for use with a syringe type (b) For "alkaline" cells.

The Electrolyte

The electrolyte in lead acid batteries consists of a solution of sulphuric acid (H_2SO_4) diluted to the correct S.G. (specific gravity) by the addition of evaporated, or distilled, water. In some instances, e.g., to reduce bulk in view of transport problems, sulphuric acid having a S.G. of 1.840 is transported, and must be broken down by the consignee. The S.G. of the sulphuric acid when placed in batteries varies according to the make of battery, and is usually printed by the manufacturers on the case of the battery. In British batteries this may be between 1.225 S.G. and 1.285 S.G., but American batteries are usually filled with electrolyte having a higher S.G. up to about 1.350. When dealing with American batteries this point must be remembered, otherwise a discharged battery may be confused, when testing the electrolyte, with a charged battery of British

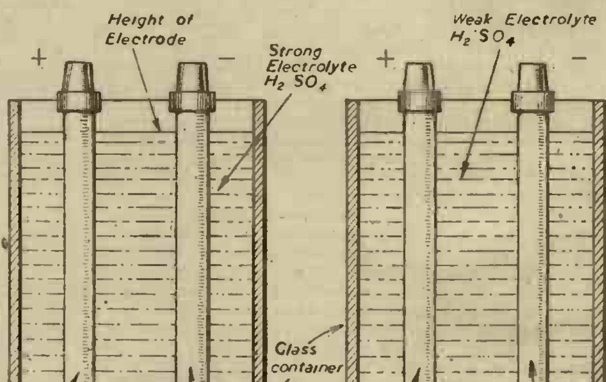


Fig. 1.—Simple "lead acid" cell in a fully charged and discharged state.

manufacture. In general, under normal working conditions the S.G. of the electrolyte of a fully-charged British battery is 1.270 and of a fully-discharged one 1.150.

Temperature Correction of Electrolyte

These values are for a typical battery having a glass or rubber compound container, and are taken when the temperature of the electrolyte is at 60 deg. F. From the table 1a it will be noted that the readings must be corrected for different temperatures. Table 1b gives the value of a typical battery having a celluloid base. As celluloid is highly inflammable, the operating S.G. is comparatively lower, to ensure a lower average temperature of the electrolyte during charging. The true state of a battery, whether charged or discharged, may be determined accurately by measuring the S.G. of the electrolyte with a hydrometer, see Fig. 2(a) and (b) and Fig. 3. This, together with the voltmeter "on load" test, are the most usual and the most accurate methods applied in practice.

TABLE 1A.

Ebonite or Glass Case for Use in Temperate Climate.

State of Cell	40°	50°	60°	70°	80°	90°	100°
Fully charged ..	1.278	1.274	1.270	1.266	1,262	1.258	1.254
Three-quarter charged ..	1.258	1.254	1.250	1.246	1.242	1.238	1.234
Half charged ..	1.218	1.214	1.210	1.206	1.202	1.198	1.194
Quarter charged..	1.188	1.184	1.180	1.176	1.172	1.168	1.164
Fully discharged	1.158	1.154	1.150	1.146	1.142	1.138	1.134

TABLE 1B

Celluloid Case for Use in Temperate Climate

State of Cell	40°	50°	60°	70°	80°	90°	100°
Fully charged ..	1.258	1.254	1.250	1.246	1.242	1.238	1.234
Three-quarter charged ..	1.208	1.204	1.200	1.196	1.192	1.188	1.184
Half charged ..	1.188	1.184	1.180	1.176	1.172	1.168	1.164
Quarter charged	1.158	1.154	1.150	1.146	1.142	1.138	1.134
Fully discharged	1.118	1.114	1.110	1.106	1.102	1.098	1.094

As the sulphation of the plates of the cell during discharge is due to certain chemical actions which remove the SO_4, a compound of sulphur and oxygen, from the electrolyte, the more discharged the cell the greater the quantity of SO_4 removed and the lower the density of the electrolyte. During charging the compound of sulphur and oxygen is returned to the electrolyte, which again accounts for the higher S.G. of electrolyte in a charged battery. Although batteries are filled initially with electrolyte of 1.250 S.G. to 1.285 S.G. A gradual decrease will take place during the life of the battery. This is due to loss through evaporation during charging, particularly during periods of "over-charging," when excessive "gasing" takes place. Each time the battery is "topped up" with distilled water to replace evaporated acid (from spraying during gasing) so is the electrolyte further diluted. When a battery is ill-used and left in a discharged condition, so causing the plates to be coated with permanent sulphate, which is not returned to the electrolyte during the next period of charge, the proportion of the SO_4 which is permanently "removed" from the electrolyte further results in a reduced specific gravity. Under certain conditions batteries may be topped up with sulphuric acid, but this practice *must not be resorted to* without first ascertaining whether the low density of the electrolyte is due to evaporation or not. A complete inspection and overhaul of the battery and a change of electrolyte is usually indicated in such circumstances.

Alkaline Batteries

In view of the increase in popularity of alkaline batteries for radio work, particularly where long periods of stand-by are essential, a general description of these will not be out of place. The plates of this type of battery are positive-nickel (Ni), and negative-iron (Fe). The active material of the positive plate is composed of layers of green nickel hydrate ($NiOH_2$) and metallic flakes of nickel (Ni), while that of the negative plate is composed of rust (oxide of iron—Fe_2O_3). A small proportion of oxide of mercury is mixed with the oxide of iron to increase the conductivity of the latter. Cadmium oxide has been introduced into the negative plate and has resulted in this type being known as the nickel-cadmium instead of nickel-iron. The "introduction" of cadmium has increased the watt-hour efficiency of alkaline batteries. Its voltage during discharge is a little lower than the former type, but will stand heavier rates of discharge without appreciable drops in voltage. Electrolyte is alkaline, composed of a solution of potassium hydroxide diluted to the required S.G. by the addition, if necessary, of distilled water. The container is made of steel and is "alive," being in direct contact with the negative plates.

The Electrolyte

Unlike that of lead acid batteries, the electrolyte of alkaline batteries does not vary during charge or discharge. The operating specific gravity is also lower and a special hydrometer is used for testing (see Fig. 2(b)). In some makes of battery the S.G. is at 1.170. The battery should not be operated with the S.G. above 1.190 or below 1.160. The operating S.G. of the electrolyte in other makes of battery may vary a little but the limits are the same. Although when initially filled the S.G. of the electrolyte is 1.170, this will gradually decrease over a period of 12 months until the minimum limit of 1.160 is reached. Electrolyte is changed after each period of 12 months unless the battery has been used only intermittently, when a period up to two years is permissible.

Voltage and Capacity

The P.D. per cell is approximately 1.2 volts as compared with the 2 volts per cell of the lead acid. The weight of the former in lbs. per ampere-hour capacity is much less than that of the latter and compensates somewhat for the lower voltage. For this reason alkaline batteries are not used where voltage is the primary factor, e.g., radio, H.T. applications, but are used instead where capacity in ampere-hours is of more importance, e.g., electrically-propelled vehicle application where transport of cells is of primary consideration.

Advantages

The chief advantages of alkaline batteries are: They may be discharged completely without damage to the

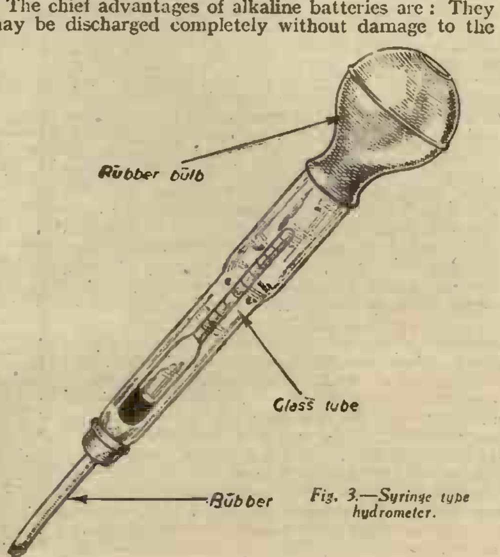


Fig. 3.—Syringe type hydrometer.

plates and short-circuits will not damage them; may be overcharged without damage and, in fact, periodic "overcharging" is beneficial; if they are inadvertently charged the reverse way round, i.e., positive of supply connected to negative of battery, and vice versa, they will suffer no damage; may be left standing idle in any state of discharge for periods of up to 12 months and will still "hold" most of the charge during such periods; where stored in clean, dry places and the filler caps are closed they will not corrode, nor will they damage, through corrosion, objects stored near them; they will stand considerable rough usage and are therefore particularly adaptable to war conditions, especially in the fighting services. As there is no sulphuric acid content in the electrolyte the plates do not sulphate and generally for this reason the alkaline battery does not have to be "nursed." Charging, too, is facilitated and may be carried out effectively by persons having very little experience. Frequent attention to the charging currents is not necessary, while hydrometer readings need only be taken at infrequent periods, and then only to determine whether the electrolyte should be changed.

Chemical Terms

Below is given a short table defining most of the chemical language used in this article:

Substance.	Symbol.
Green nickel hydrate	$NiOH_2$
Hydrogen	H
Iron	Fe
Lead	Pb
Lead peroxide	PbO_2
Lead sulphate	$PbSO_4$
Nickel	Ni
Oxygen	O
Rust (oxide of iron)	Fe_2O_3
"Sulphate"	SO_4
Sulphur	S
Sulphuric acid	H_2SO_4
Water	H_2O

(To be continued.)

Vectors Applied to Radio Circuits

This Subject has Been Discussed in Recent Issues, but in View of its Importance We Publish this Article, which Deals with the Matter in a Simple but Concise Manner

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

A VECTOR quantity is a quantity that has magnitude and direction, and since an alternating current is such a quantity, vector diagrams can be usefully applied to A.C. circuits, often giving a clear illustration that could otherwise only be obtained by laborious mathematical or graphical calculations.

For the purpose of this article it is assumed that the reader has some knowledge of elementary A.C. theory, and the following is only intended to assist in the application of that knowledge.

Imagine a line AB (Fig. 1) pivoted at A and rotating in an anti-clockwise direction. At any instant it makes

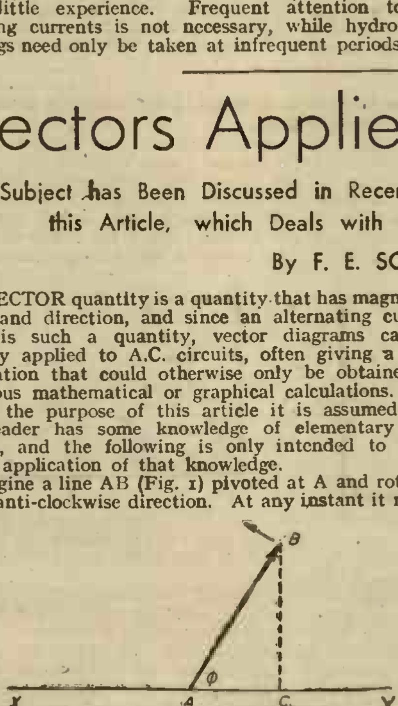


Fig. 1.—The imaginary line AB rotating in an anti-clockwise direction.

an angle ϕ with the reference line XY. Now, if a perpendicular BC is dropped from B to XY, it will be seen that when AB is coincident with XY, the length of the perpendicular is zero. As AB rotates, BC gradually increases in magnitude until, when AB is vertical, BC is a maximum, and is equal to AB. Beyond this point BC gradually decreases again to zero, and the foregoing process is repeated below the line XY, BC now being negative.

If all these values of BC are plotted against corresponding values of ϕ, the graph shown in Fig. 2 will result. It will at once be seen that this graph is similar to the familiar graph of an alternating current. (If AB=1, it is also a graph of sin ϕ.)

It should be clear that this diagram (Fig. 1) can be used to represent an alternating current, AB indicating the peak value of the A.C., and BC the instantaneous values. The number of revolutions of AB per second is equal to the frequency of the A.C. and the diagram can be called the vector diagram of the alternating current, since any vector quantity can be represented by a straight line magnitude being indicated by the length of the line, and the direction by the position of the line.

Henceforth we shall cease to consider the perpendicular BC, remembering that we can always ascertain the instantaneous value if required by dropping this perpendicular. Normally, however, when using these diagrams we are not concerned with instantaneous values.

Addition of Vectors

A vector diagram only becomes of value when two or more quantities are involved. Consider two alternating currents flowing in the same circuit, but 90 deg. out of phase (Fig. 3). The nett effect of these two currents (A and B) could be obtained by adding the two together graphically, as shown, current C being the result. This, however, is rather a long process if any degree of accuracy is required. Fortunately, the same result can be obtained much more easily by means of a vector diagram. First draw to scale a line OA to represent the peak value of current A. Now draw a vector OB to the same scale to represent the peak value of current B. This is shown in Fig. 4. It will be seen from Fig. 3 that current B lags on current A by 90 deg. This must be shown on the diagram, and the two vectors will therefore be drawn at right angles to one another, and since current B lags, vector OB must be behind OA in the direction of rotation.

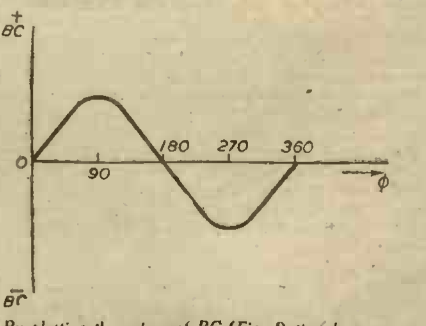


Fig. 2.—By plotting the values of BC (Fig. 1) the above curve is produced.

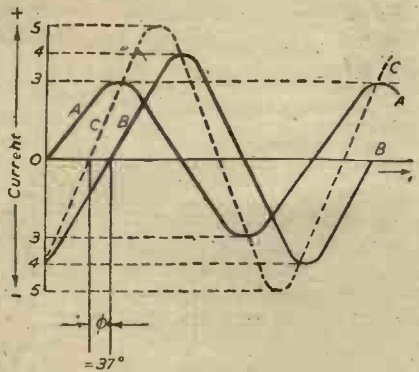


Fig. 3.—Graphical representation of two A.C. currents 90 deg. out of phase.

It now remains to add the two currents vectorially, and to do this BC is drawn parallel to OA, and AC parallel to OB. The diagonal OC now represents the resultant current in magnitude and phase, i.e., a current proportional in amplitude to the length of OC, and leading current B by an angle ϕ, which can be measured.

If figures are used the correctness of this calculation will be apparent. If current A is 3 amperes, and current B is 4 amperes, the resultant (C) is found to be 5 amperes.

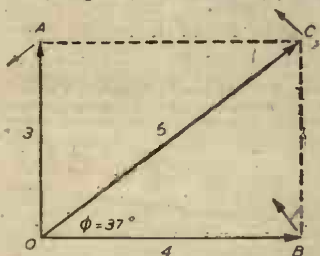


Fig. 4 (left).—Verification of Fig. 3 by vector.

Fig. 5 (right).—Series circuit containing inductance and resistance.

The addition has also been carried out graphically in Fig. 3, and the value of 5 amperes again obtained, thus proving the vector addition. The angle ϕ can also be measured (37 deg. approx.) and agrees with the angle graphically obtained in Fig. 3.

It should clearly be understood that the two currents (or voltages) must be of the same frequency if it is desired to add them vectorially. Also, as shown later, care must be taken not to confuse voltage vectors with current vectors, since it is obviously impossible to add a current to a voltage.

The principles just discussed can now be applied to some practical examples.

Circuit Containing Inductance and Resistance

The first case to be discussed is that of an alternating voltage applied to a circuit containing inductance and resistance (Fig. 5). Since this is a series circuit the current must be the same in all parts of it, and therefore the current vector is drawn first (OB). The voltage across the inductance will lead the current by 90 deg. and therefore this vector (OA) is drawn 90 deg. ahead of the current vector. The voltage across the resistance will be in phase with the current, and therefore this vector (OD) will be drawn parallel with the current vector. The two *voltage* vectors must now be added, and the resultant OC is obtained. This vector represents the total voltage across the circuit, which is, of course, the voltage applied.

The vector diagram is now complete, and some important information can be obtained from it. In the first place it will be seen that the voltage now leads the current by an angle ϕ, which is less than 90 deg.

The formula for the impedance of the circuit can be also obtained from this diagram. The total voltage across the circuit will be equal to IZ (current × impedance). The voltage across the inductance will be equal to IX_L (current × inductive reactance), and voltage across the resistance will be equal to IR (current × resistance). Using Pythagoras' Theorem it will be seen from the diagram that:

$$(IZ)^2=(IR)^2+(IX_L)^2, \quad \therefore Z^2=R^2+(X_L)^2$$

$$\text{or } Z=\sqrt{R^2+(X_L)^2},$$

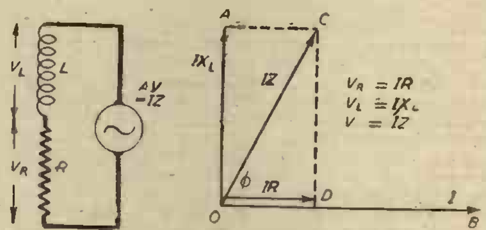
which is the familiar formula for the impedance of a circuit of this nature.

The foregoing procedure can be applied when dealing with a circuit containing capacity and resistance in series, with the resultant voltage now lagging on the current by some angle that is less than 90 deg. The reader should be able to work out this diagram for himself on the lines already indicated. A more important case is that in which capacity, inductance and resistance are present, either in series or parallel, and these cases will now be discussed.

Circuits Containing Capacity, Inductance and Resistance (a) In series (Fig 6).

Once again the current is the same in all parts of the circuit, and so the current vector is again drawn first (OB). The voltage across the inductance (V_L) will be the same as before, and its vector (OA) is drawn at right angles to OB. Similarly, the vector OD will again represent the voltage across the resistance.

We have still to consider the voltage across the



condenser. Since this will lag on the current by 90 deg., the vector representing this voltage must be drawn at right angles to the current vector OB, and will therefore be drawn at OC.

It should be clear that the addition of three vectors must now be carried out, and this can be done in any order. In the diagram shown, OC is first added to OA, and the resultant added to OD. In adding OC to OA subtraction is necessary, since the two voltages are in antiphase, and as OA is larger than OC, the result of the "addition" will be OX, which, when added to OD, gives the final resultant OY.

Let us see what information can be derived from this

(Continued on page 371)

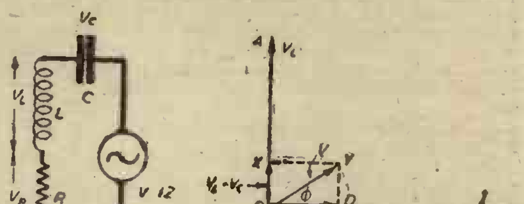


Fig. 6.—Circuits containing inductance, capacity and resistance in series.

diagram. In the first place it will be seen that the voltage still leads the current by an angle ϕ, as in Fig. 5, showing that, although capacity is present in the circuit, the circuit is behaving nevertheless as a circuit containing only inductance and resistance.

Secondly, if the voltage across the capacity (V_C) were larger than that across the inductance, the resultant current would lead the applied voltage, and the circuit would behave as a capacity and resistance in series.

Now it should be clear that it is possible, by suitable adjustment of the circuit, to make the voltage across the inductance equal to that across the capacity, in which case the two vectors OA and OC would cancel out, leaving only the voltage across the resistance. This voltage would be the applied voltage, and the circuit would be behaving as a pure resistance. Under such conditions the circuit is said to be at *resonance* with the frequency of the voltage applied.

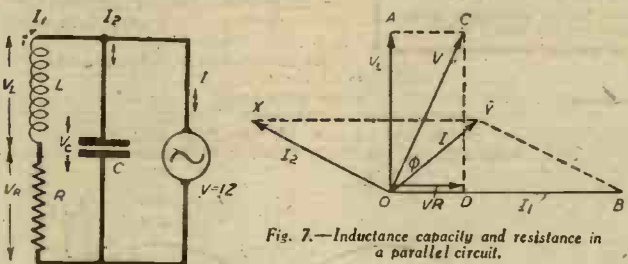


Fig. 7.—Inductance capacity and resistance in a parallel circuit.

An expression for the impedance of the circuit can be derived from Fig. 6, since,

$$(OY)^2=(OX)^2+(OD)^2,$$
$$\therefore (IZ)^2=(IX_L-IX_C)^2+(IR)^2$$
$$\therefore Z^2={}^*(X_L-X_C)^2+R^2$$
$$\therefore Z=\sqrt{R^2+(X_L-X_C)^2},$$

which is the impedance of the circuit.

* This becomes $(X_C-X_L)^2$ if X_C is greater than X_L.

Under resonance conditions, V_L is equal to V_C, and, therefore, $X_L=X_C$. Thus, the expression for the impedance becomes $Z=R$, and the circuit is purely resistive.

(b) In parallel (Fig. 7)

There is more than one way of dealing with this circuit, but the method shown is considered to be the simplest to understand. The left-hand branch will be dealt with first as a series circuit, and the results obtained will be similar to those obtained in Fig. 5. OB is the vector representing the current through the circuit, and vectors OA, OD and OC follow as before. Vector OC will then represent the applied voltage, which is also the voltage across the condenser. Therefore the vector representing the current through the condenser (I_2) can be drawn at right angles to OC, since the current will lead by 90 deg. This is the line OX, and to find the total current the two currents, I_1 and I_2, must be added vectorially, giving a resultant OY lagging on the applied voltage by an angle ϕ. If current I_2 had been much larger the resultant current would have led the applied voltage. Therefore, it will again be possible to adjust the circuit so that the nett current is in phase with the applied voltage and produce the condition of resonance, where the circuit behaves as a resistance. The formula for the impedance in this case cannot be derived from the vector diagram.

Other Circuits

The foregoing will have given the reader some idea of how the vector diagram can be applied to some common circuits. There are, however, numerous cases where these diagrams can be applied, and will yield useful information. They are frequently met with in such cases as the explanation of the action of an oscillator, and the behaviour of a transformer with varying loads, and although these cases may be more complicated than those dealt with in this article, they should not prove to be too difficult.

It was stated early on in this article that only currents or voltages of the same frequency could be added vectorially. There are, however, cases where a vector diagram is of assistance where the quantities are not of the same frequency. In these cases, however, it is necessary to state the instant of time in the cycle of operations that the diagram represents, since a fraction of a second later the phase relationships will of necessity be quite different.

Such a case is that of an amplitude modulated transmission, which is known to be composed of three constant amplitude radio-frequency voltages, whose frequencies are different. These three voltages can be represented by three vectors in the usual manner, but any such diagram will only be true for one instant of time. If several of these diagrams are drawn it will be seen that on adding the three vectors together the nett result is that the amplitude of the carrier will rise and fall.

In this connection it is often useful to imagine certain vectors as travelling in a *clockwise* direction. For example, if we have two frequency components, one at 10 mc/s, and the other at 10.1 mc/s, it may prove helpful to regard the 10.1 mc/s vector as stationary and the 10 mc/s vector as moving at a relative speed o .1 mc/s in a clockwise direction. By drawing many vector diagrams at several instants of time, a fairly complete picture of what is happening may be obtained.

PRIZE PROBLEMS

Problem No. 446

JONES constructed a four-valver several months ago. Its line-up was 2-V-1, and it gave very satisfactory service until the slow-motion drive on the ganged condensers started to slip. Jones decided to fit a new drive, but, unfortunately, when he was in the middle of the change-over he was interrupted and had to complete the job in a hurry. Next day he tested the set, and was amazed to find that only one station could be received no matter which way he turned the tuning control. Checks revealed that all connections were O.K. What would you have done if you had been Jones?

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

Solution to Problem No. 445.

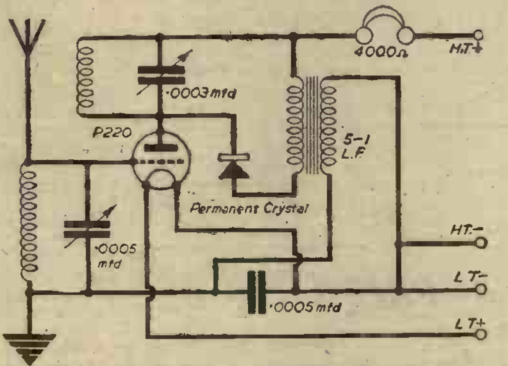
The damping effect of Parkinson's aerial was excessive, thereby preventing the detector circuit from oscillating. He should use a shorter aerial or connect a .0001 mfd. variable condenser in series with the lead-in.

The following three readers successfully solved Problem No. 444, and books have accordingly been forwarded to them. D. E. Street, South View, East Comer, Worcester; E. M. Kelsey, Anglesey, Wellington College, Berks; F. S. West, Heatherview, Heyshott, Midhurst, Sussex.

Practical Hints

Single-valve Reflex Set

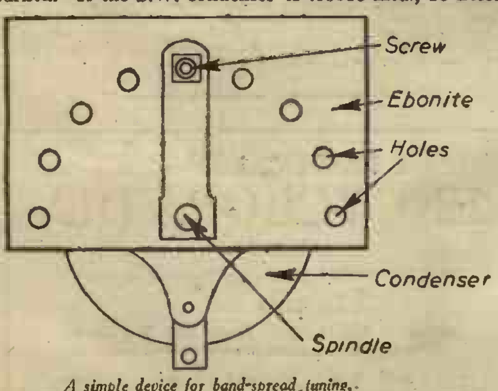
I HAVE lately been conducting some experiments with a one-valve and crystal reflex set, the circuit diagram of which is given in the accompanying diagram. Plug-in coils were used, and the valve is a P 220 Mazda output triode. Using an inverted L aerial, 70ft. long and 30ft. from the ground, in a residential district, I tried the set with 18 volts anode voltage. This gave good, strong signals in the 'phones. I then reduced the anode voltage to 1.5 volts and even at this level the Home Service was quite audible. For normal listening an anode voltage of 4.5 volts is quite satisfactory. The set also produced results on the short-wave band, but as I was unable to calibrate the set, I have no check on the stations. A Cossor 210 Det. will work the set with 6 volts on the anode, but the Mazda valve is best.—R. J. AMBLIN (Bath).



Circuit diagram of a single-valve reflex set.

Band-spread Tuning

THE accompanying diagram shows a system of band-spread tuning I have used with success. On the spindle of the S.W. condenser is a springy piece of tin, which is soldered on. In the other end is a round-headed screw, held by two nuts. On the fixing screw is a piece of ebonite (wood could be used) about ¼in. thick, and holes have been partly drilled in this, so that the screw in the end of the metal just rests in each when turned. If the S.W. condenser is .00016 mfd., 10 holes will be sufficient, and a band-spreading condenser of about 18 mmfd. should be used. The condenser will, of course, have to be mounted on a bracket. If a knob with a pointer on is used, numbers can be marked on and then it is a simple matter to retune a station time after time by using the two settings.—F. CROWTHER (Olton).

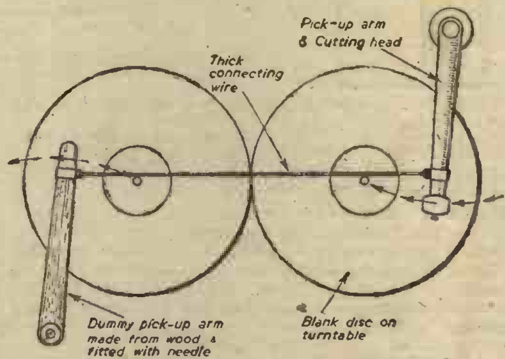


A simple device for band-spread tuning.

Simple Recording Tracker

NOTICING in the April issue that R. F. R. (Southampton) wishes to obtain a simple tracking device for home recording, I submit the following idea which may help him and other readers.

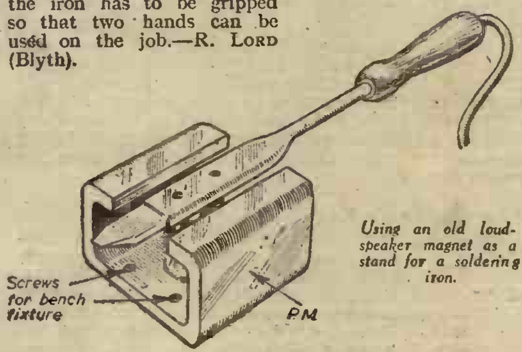
As shown in the diagram, an old record is made use of for tracking a blank disc. The turntable can be made from wood or an old one can be used from another gramophone. The dummy turntable is driven by friction off the edge of the recording turntable, and a fairly thick wire connects both arms together, it being looped at both ends to allow movement.—T. A. THOMAS (Wrexham).



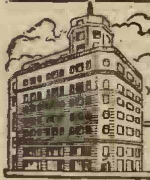
A novel tracking device for home recording.

Rest for Soldering Iron

I FIND it very handy when soldering to use the magnet off an old P.M. speaker as the rest for the electric soldering iron, as shown in the accompanying sketch. This idea saves time when wiring up as the iron cannot roll or be knocked off the magnet. It also saves the use of a vice when the iron has to be gripped so that two hands can be used on the job.—R. LORD (Blyth).



Using an old loud-speaker magnet as a stand for a soldering iron.



ON YOUR WAVELENGTH

By THERMION

B.B.C—nunciation

IN these days of standardisation the efforts of the B.B.C. to standardise the pronunciation of words and place names is all to the good. They have a Committee which decides these things, and although we may criticise the fact that a Scotsman, a Welshman, and an Irishman are on that Committee we must remember that the great variety of programmes radiated by the B.B.C. necessitates the services of those well versed in the languages spoken in the British Isles. It would be offensive, for example, for an Irishman to hear in an Irish programme some Irish word anglicised. A Scot would go off his haggis unless you gave the correct Scottish pronunciation of a Scottish word and strongly rerutilate the r. There is, however, still in the B.B.C. announcements a great variation, and particularly amongst the announcers, who presumably should know the B.B.C. standard, even though we may excuse lapses on the part of artists.

Stuart Hibberd enjoys pronouncing Pantellaria, which he enunciates as Pantell-ah-rear. Other announcers, however, pronounce it as Pan-tellair-ear. I do not know which is correct. Another announcer annoys me by referring to the Ukryne, whereas it is quite correctly pronounced as Ukraine. Which shows that you must be careful in your selection of advisers on pronunciation. The idiomatic is not good enough, and neither is the colloquial. You want the pure language of the country. For example, a Yorkshireman pronounces book as booopok. Were he engaged as an adviser on pronunciation to the Russian Government no doubt the Russian propaganda in English would give that pronunciation. Place names, I know, are difficult, but there can only be one way of pronouncing them.

In this connection I do not know why *England* should become Angleterre to the French. Surely names of countries and place names should be spelt universally. London becomes Londres, and so on. Why?

Lyric Writers

I HAVE received a letter from the Spearman Organisation, of Ashgrove Road, Goodmayes, Essex, which speaks for itself.

"I read with considerable interest your remarks on lyric writers and composers in your January issue. As so often quoted, 'The job seems to be in Tin Pan Alley—not to let a new man in, but to keep him *out*.' It is estimated that there are about half a million amateur song writers in this country, and a small percentage of them belong to our 'British Songwriter Club.' As chairman of this small but growing organisation, I can testify that some of the work submitted for our competitions is quite up to the standard of songs already in print, and I go so far as to say, a very great deal better in my opinion than much of the tripe emitting from Tin Pan Alley. What happens? A budding song writer tries practically every publisher, but is turned down, one of the reasons being, I suppose, that most of the publishers are themselves song writers, or their grandmother's uncles band leaders. Then the amateur reads an advertisement in some obscure weekly, inviting him to submit his material to a famous composer (who incidentally collects five guineas from him for a setting and promises to find a publisher). This he certainly does, but the publisher wants up to 20 guineas for publication. Vanity Publishers, as we term them, are outside the traffic of usual trade channels, so apart from a few free (?) copies, the song writer gets nothing.

"We are not a philanthropic society, for it is obvious that we have to earn our own living. But we endeavour to run the club on trade union lines. Further, we have just laid the foundations for a new venture, which we call the B.S.C. Portfolio. Realising that it is of no use at all publishing a number unless a circulation is created, any more than publishing a magazine, we invite the public to subscribe five shillings a year, for which they receive one *good* song every two months. These songs are the work of our members and are published at *our* expense. Work selected for inclusion is paid for on a fair royalty basis, and the sole requirement for publication, apart from membership, is *merit*. The first number sent to press under this scheme was a religious song, 'The Giver of all Good Things'; we are keeping off the 'Popular' type, as we are anxious to encourage art and culture. If there are any songwriter readers among your readership, without wishing to gain a cheap advertisement, we shall be glad to advise and help without obligation, providing a stamped addressed envelope is enclosed.

"I might add that material selected for publication has to pass an executive of at least five members."

Dance Band Leaders

[Press Item.—One band leader openly admits that he does not know one note of music, has had no musical education or training, and cannot play even the simplest musical instrument; yet he conducts a famous dance band.]

Too many scarcely know the signs
Denoting flats or sharps,
And all they know of music
Lies in playing on jews' harps!

But, boy! Oh! Can't they wave their arms
In manner most superior!
And shake their heads and roll their eyes
In manner most D.T.-rior.

They leap about upon the stage
In manner most athletic,
Though their ignorance of music
For us is most pathetic.

Since we have it forced upon us,
When, per radio, they plug,
Till we'd love to pour some vitriol,
On their nappers from a jug.

Their most inflated vanity
Receives a nasty jolt
If you tell them their ability's
Not that of Adrian Boult.

Nor that of Thomas Beecham,
Or that of Henry Wood.
They say, "Pooh! Simply titled guys
At jazz they'd be no good!

"Give us a drum to bang upon,
An empty tin for smiting,
An adenoidal crooner,
And you'll think tom-cats are fighting.

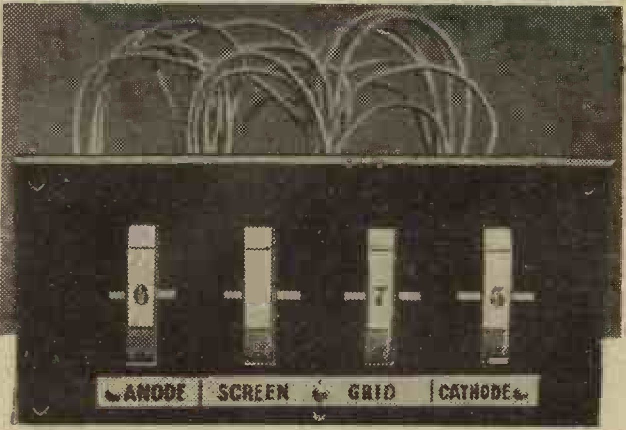
"And we train our boys to sway about
And grimace as they toot;
So it's most unkind when critics say,
The lot should get the boot."

"TORCH."

Our Roll of Merit

Readers on Active Service—Thirty-second List.

John Rombaut (Sign., Royal Corps of Signals).
W. Saunders (L.A.C., R.A.F.).
John F. Tatem (Royal Marines).
A. Davies (L.A.C., R.A.F.).
M. Falk (Cpl., R.E.M.E.).
B. H. Pound (L.A.C., R.A.F.).
R. Roberts (Cpl., R.A.F.).



The switch assembly mounted on its panel, showing the four disc drives.

YOUR SERVICE WORKSHOP—5

A Valve

Preliminary Details of Co

WHEN servicing radio receivers, it frequently happens that valves of all types come under suspicion. It is not always convenient, or possible, to test them in the receiver so that a valve tester of some sort is of a practical necessity in the workshop. Although valve structure is of comparatively delicate and complicated design, it is amazingly robust and its length of life considerable, but a fault may develop due either to its long service or some mishandling. These faults may be summarised mainly as follows: (1) burnt-out filament or heater; (2) short circuit or partial breakdown of insulation between electrodes; (3) loose electrodes; (4) development of grid current (softness); (5) loss of emission of filament or heater.

A valve may be tested to ensure that these faults do not exist, but in an endeavour to ascertain the state of affairs regarding fault No. 5, it is not unusual to take a simple measurement of the anode current flowing. The above test—with certain exceptions—is not good enough, for it does not tell us exactly what we want to know. It certainly proves that the valve is not a complete dud and, where the current approaches closely that given by the makers, one can be fairly certain that it will function, but it does not give any proof as to its goodness factor or whether the valve is still operating at full efficiency. It is a well-known fact that two exactly similar types of valves may not give the same reading of anode current when operating under similar conditions; it may vary by 20 per cent. or —in extreme cases—by 25 per cent. For example, one valve of, say, the medium power class may show an anode current of 10 mAs, whilst another of the same make and type would show perhaps 7.5 mAs. It is easy to understand, therefore, that if at some later date the valve which previously gave a reading of 10 mA, then shows 7.5 mA, it would be quite reasonable—not knowing its previous reading—to assume that it was in good condition, whereas actually its emission would be 25 per cent. down, which proves that the test is very misleading. The above method is quite sound where readings have previously been taken when the valve was new, but obviously this is only possible in the case of one's own valves.

An Essential Test

A positive method of ascertaining the goodness factor of a valve—with certain exceptions—is to measure the change of anode current brought about by a change of

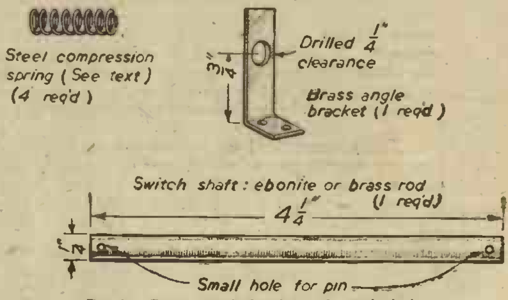


Fig. 2.—Spring, angle bracket and switch shaft.

grid voltage, or, in other words, to check the valve's mutual conductance. A figure for this is always given by the manufacturers, where applicable, and it is a simple matter to compare the test figure with the

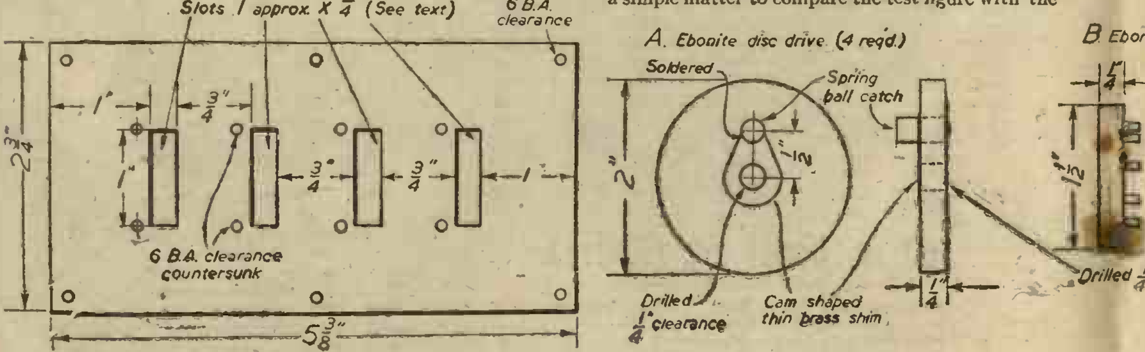


Fig. 1.—Details of panel, ebonite disc and contact base.

testing Unit

nstruction. By S. BRASIER

maker's original one. In spite of the foregoing observations it is often desirable to make full emission tests in a valve tester as it is necessary for some purposes.

It will be understood, therefore, that the design of a valve tester is no easy task, especially if provision is to be made for all the tests enumerated, and also if the tester is to be kept down to reasonable proportions. Another problem associated with the design of an instrument of this nature is how best to provide for the connection of the various power supplies to the valve electrodes, bearing in mind the varying types with which one has to deal. A simple method, of course, is to make use of a plug and socket system, but this suffers from the disadvantage that no quick or orderly system of valve checking may be put into use and unless the connections are memorised, one has to look them up every time a valve is tested, except perhaps when dealing with the simple types.

Switching

What is wanted is some method of switching whereby

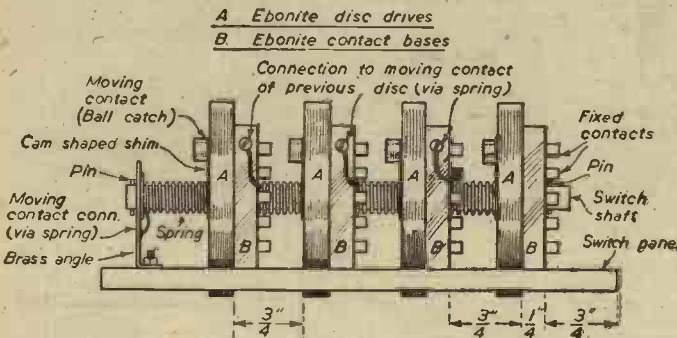
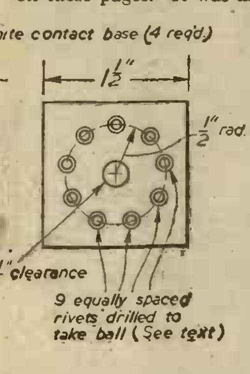
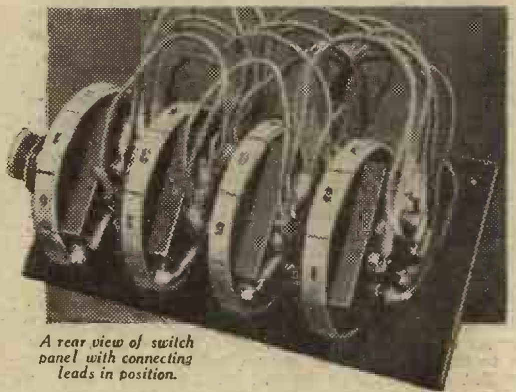


Fig. 3.—Side elevation of the switch.

the switch may be set to a particular position for all valves of the same type. This little problem led the writer to design the valve electrode switch illustrated on these pages. It was made for the valve tester to be described next month, and intending constructors may, if they wish, get ahead with the making of the switch, which although not difficult will naturally take a little time to construct. Incidentally, it may be used satisfactorily with any valve tester that the reader may have in mind.



The switch is actually a bank of four single-pole 9-way switches, so arranged that either may be operated independently by a thumb control action from the front of the panel. No special material or parts are required



A rear view of switch panel with connecting leads in position.

for construction—indeed most, if not all of them, may already be on hand.

Component Parts

The component parts of the switch are shown in Figs. 1 and 2 while the order of complete assembly is shown in Fig. 3. The contact bases B and the disc drives A are made from ¼in. ebonite; the panel may also be of this thickness, although in the original it was $^3/_{16}$in. A start may be made by cutting out the square pieces B and the discs A to measurements shown in Fig. 1. The moving contact on the disc consists of a ¼in. spring ball catch of the type which is often fitted to the closing edge of small cabinets, cupboards, etc. It is advisable to select those in which the ball protrudes to the furthest degree, for they seem to vary in this respect. The shoulder on the ball catch, which should be countersunk flush with the ebonite, prevents it from passing right through the hole in the disc. A cam-shaped thin brass washer is soldered to the ball catch on the other side of the disc in the position shown. The central hole in the discs and washers is of a size that permits them to turn freely on the shaft but with no appreciable "play."

The square contact bases are drilled to take nine contacts equidistantly spaced around the circumference of a 1in. diameter circle, and it is important that the distance of each contact from the centre is exactly similar, i.e. ½in.; likewise the distance from the ball catch to the centre of the ebonite discs. In the model shown the fixed contacts are copper rivets with countersunk heads which fit flush into the holes in the contact bases. In the exact centre of the head of each rivet a hole is drilled of a size that will allow the ball—when pressed home against the rivets—to be a nice snug fit whilst still maintaining pressure, i.e., the ball depressed to just over half its extent. The switch pairs may be tested for their action by slipping them temporarily over the switch shaft and rotating the disc whilst pressing it to the contacts. What is needed is a nice positive snap action which may only be secured by ensuring that the contacts, both fixed and moving, are positioned exactly, and this, like many other things, is not as difficult as one would suppose from the description. In one model the writer made up the contacts consisted of ordinary cheese-head 6 B.A. bolts sunk slightly into the ebonite, but in this case the electrical connection between them and the ball was not very positive, due to the very small area of contact. However, there is no reason why tinned iron rivets, which are easier to obtain, should not be used. Countersunk 4 B.A. bolts may be utilised, drilling them to receive the ball. Aluminium rivets must be ruled out, as it will be necessary to solder a connection to each of the contacts at a later stage.

Assembly

Having made sure that the four switch pairs are working satisfactorily, the switch panel is prepared as shown in Fig. 1. The length of each slot or window will depend upon the thickness of the material used around the edges of the discs (for numbering purposes) so that it is as well to cut them a little short until the setting up of the discs gives the ultimate length required. It is necessary, of course, to chamfer the short underside edges of each slot to allow for the curve of the edge of the disc and to ensure a neat fitting. This will be appreciated upon reference to Fig. 4.

The contact bases B are secured to the panel in the position shown by means of 6 B.A. bolts, for which purpose they are drilled and tapped. If a 6 B.A. tap is not to hand, one can be improvised by using a length of 6 B.A. rod, tapering the end slightly on four sides as in Fig. 5. Alternatively, shoulders may be left on the lower edge of the contact base so that ordinary bolts and nuts may be used for securing. Whatever method is used, it is essential to see that all the bases B are

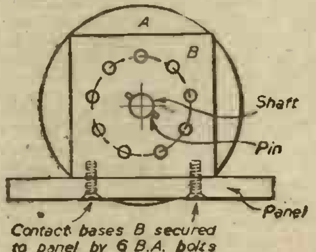


Fig. 4.—End view of switch.

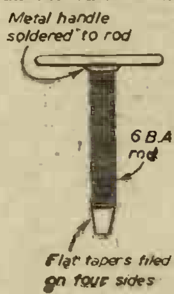


Fig. 5.—An improvised tap for ebonite.

firmly fixed at right angles to the panel. Pressure of the discs against the contacts is maintained by a short steel spring of a diameter that will allow it to slip freely over the shaft—about 5/16in. to ⅜in. diameter is right, while the gauge of the actual wire is equivalent to about 18 s.w.g. to 20 s.w.g. A fairly strong one is necessary, of the compression type; the writer made use of a motor-cycle expansion spring, which was stretched out and the required lengths cut off. These springs also provide the electrical connection from the moving contact via the cam-shaped brass washer. Therefore, before assembling the springs a short length of ordinary tinned copper wire is soldered to the end of each, remote from the discs. When all is assembled, each wire (well insulated by sleeving) lies snugly between two of the fixed contacts at the back of the next contact base and is anchored to a bolt tapped into the ebonite at some convenient place. The connection from the last spring

WINDING DATA

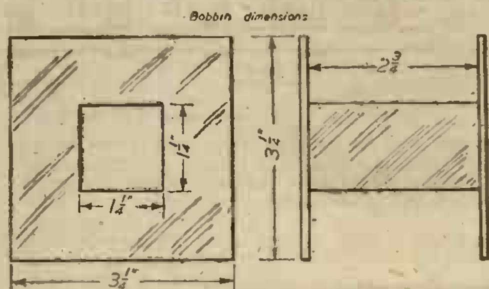
Primary—Input 200/250 v. A.C.
Turns per volt 6.
Total No. of turns 1,500 (250 v.).
Tapping at 1,380 turns (230 v.).
Tapping at 1,260 turns (200 v.).
Wire—26 s.w.g. enamelled.

Secondary—Outputs 2, 4, 5, 6, 6.3, 7.5, 13, 14, 20, 24, 25, 26, 30, 35, 40 volts.
Total No. of turns 240.
Tappings at 12, 24, 30, 36, 37.8, 45, 78, 84, 120, 144, 150, 156, 180, 210 turns.
Wire—20 s.w.g. enamelled.
Secondary current output 2 amps.

Fig. 6.—The completed filament transformer.

is taken to the brass angle bracket used at the end of the assembly. Thus the springs remain stationary whilst the discs are turned and connection with the moving contact is maintained without the necessity of moving or flexible leads.

With the assembly complete the discs may now be numbered, and since it is difficult for the amateur to engrave ebonite successfully, it is better to fit strips of white ivorine or card round the outside. Four strips ⅜in. wide and long enough to fit exactly round the outside of each disc are required. Using Indian ink, each strip is divided off into nine equal spaces, and in the centre of each space the figures 0-8 are printed. The discs on the switch are set so that the moving contacts all connect with the same fixed contact of each section—it does not matter which—then the position for the numbered strips may be marked on the discs so that the same number appears centrally in each window. After removal of the discs the strips may be



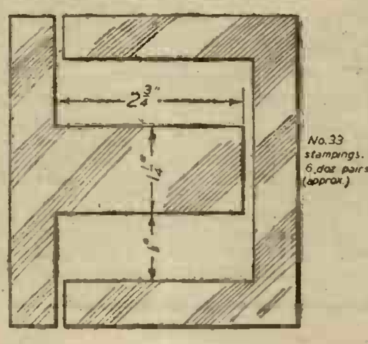


Fig. 7.—The essential details are given here for constructing the bobbin used for the universal filament transformer. The dimensions of the stampings are shown on the left.

fitted (with another strip of clear celluloid over them) by little brass pins which are a good push fit into small holes reamed into the edge of the discs. The wiring is easier to do before the final assembly, although clearance of the moving parts must be allowed for. The fixed contacts which connect when o shows in the windows are left free. The remaining contacts of each section are then joined together, i.e., all number 1s joined, all number 2s joined, and so on to number 8. The illustrations show the completed switch wired up ready for use. A test may be made by connecting an ohm-meter or similar indicating device between each moving contact connection and the end fixed contacts, turning the appropriate disc to the correct number for each stud. The function of the switch and its connection in the valve tester will be explained in the next issue.

Filament Transformer

An essential component in a valve tester, if it is to be universal, is a transformer designed to supply the correct voltage from A.C. mains to the heater of any valve. The construction of such a component (Fig. 6) was described in PRACTICAL WIRELESS for August, 1942, but, since this was some time ago, the essential details are again shown in Fig. 7, because the transformer is used in the valve tester to be described. It will be seen that the output voltages available cover all practical requirements, but additional voltages may be included, if required, by calculating it from the turns per volt. Transformers are not difficult to construct, but there *are* snags, particularly in a model of this type with so many tappings, but the component is unprocurable commercially so that it becomes necessary for the constructor to make it himself. The bobbin is of thin plywood in order to provide adequate strength. On the primary side it is advisable to interleave with paper every few layers and the secondary winding at every layer. Tappings—which should be labelled as they are made—must be taken from the exact point on the winding and it is important to see that the wires, as they lead out across the winding, are well insulated, and cannot short-circuit that portion of the winding which they traverse. Owing to the numerous tappings of thick wire it is essential to even up the bulk of the winding by leading the tappings out of both ends of the bobbin, but one must also be sure that these ends of the bobbin will not be fouled by the core which ultimately surrounds it.

The broad principles exhibited in this switch are similar to those of the valve switch selector used in the Valve Tester of the Automatic Coil Winder and Electrical Equipment Co., Ltd. (Patent number 510098).

Impressions on the Wax

A Review of the Latest Gramophone Records

Columbia

HEADING the Columbia releases for this month is a first recording of a delightful work, arranged and scored by the late Sir Hamilton Harty, one of the greatest conductors this country has produced, from unspecified pianoforte pieces by John Field. It is given the title "A John Field Suite" and it has been performed by Dr. Malcolm Sargent conducting the Liverpool Philharmonic Orchestra, and recorded on *Columbia DX*1118, *DX*1119 and *DX*1120.

It consists of four movements: Polka, Nocturne, Slow Waltz and Rondo, and is recorded in five parts; side six of the third record contains "Serious Doll"—Elgar (No. 2 from "Nursery Suite").

John Field—born in Dublin, 1782—is one of the interesting characters in the musical history of the last century. He had a very varied career, and it was not until he settled in St. Petersburg that he commenced what might be termed serious work as a composer-pianist. His output was prolific; his works were varied and possessed great beauty and undoubtedly exerted great influence on the composers who followed.

A John Field Suite as a whole is distinctly outstanding, its charm placing it well to the fore in the recorded music of the last few months, and needless to say the Liverpool Philharmonic Orchestra, under the baton of Dr. Malcolm Sargent, make a recording which calls for every recommendation.

Grieg was born at Bergen, Norway, on June 15th, 1843, and his centenary has been marked, in a most fitting manner, by Eileen Joyce by making, what I think to be, one of her best recordings. She selected Ballade Op. 24—Grieg—a superb work, which she plays in a faultless manner. The composition consists of a set of variations on a grave and characteristic theme, and reveals the mastery of Grieg as a composer of pianoforte music. "Ballade (Op. 24)"—Grieg. Four Parts. *Columbia DX*1116-7.

Another fine pianoforte recording is on *Columbia DB*2112. It is a piano duet by Rawicz and Landauer playing "Prince Igor Dances" (Borodin—arr. Rawicz and Landauer). These two popular artists give a splendid performance, their skill and co-operation being brilliant.

Albert Sandler Trio, on *Columbia DB*2113, offer "Smoke Gets In Your Eyes" (Kern) and "Lover Come Back To Me" (Romberg) from "The New Moon." Two pleasing pieces of the evergreen variety, played in first-class style as one would expect from this famous Trio.

H.M.V.

THE Grieg Centenary is also marked in the H.M.V. releases for this month, by their recording of the Budapest String Quartet (Roismann Quartet) playing Grieg's "Quartet in G Minor. Op. 27." The work is in four movements, and embodies all the characteristics which one associates with this great composer. *H.M.V. DB*3135-3138

During his recent flying visit to this country, Yehudi Menuhin spent one day in the H.M.V. studios, during which he worked for nearly seven hours with only a few minutes break for light refreshment. For most artists, recording is no rest cure; one has to be at concert pitch the whole time, and the experience is naturally tiring and exacting. During the above session, Menuhin recorded "Caprice Viennois" (Kreisler) and "Pièce en forme d'Habanera" (Ravel), and it is very evident from the wonderful performance he gave that he must be tireless as his playing is as beautiful and sure as ever.

Whenever I see the names of Anne Ziegler and Webster Booth announced I take a keen interest, as, as I have stated in these reviews before, these two great and popular artists form the perfect duettists. This month, on *H.M.V. B*9326, they give us "Without Your Love" from "The Dubarry" and "What is Done" from "The Lilac Domino." Two fine numbers beautifully sung.

Before I get on to the dance records, there are two which I would like to mention. The first is by "Hutch" singing "Where's My Love" and "A Letter From Home" on *H.M.V. BD*1042, and the second is another recording by Felix Mendelssohn and his Hawaiian Serenaders. They have recorded "Hawaiian Memories No. 2" on *H.M.V. FB*2925, and I am pleased to note (or hear) that they have included tunes which I think are more suited to the title and instruments than, say, some of the modern dance numbers.

Now for the dance music. "Fats" Waller and his Rhythm tempt those who like their music "hot" with "Up Jumped You With Love" and "Romance à la Mode," both being foxtrots, on *H.M.V. BD*1045.

Joe Loss and his Orchestra give us two slow foxtrots, namely, "There's A Harbour Of Dreamboats" and "Where's My Love," *H.M.V. BD*5799. "Time on My Hands" and "On The Sunny Side Of The Street" have been selected by The R.A.O.C. Blue Rockets Dance Orchestra, and they have made a fine recording of both pieces. The number is *H.M.V. BD*5803.

Carrol Gibbons and the Savoy Hotel Orpheans give a fine performance of "The Lady Who Didn't Believe in Love" and "I've Heard That Song Before"—both foxtrots on *H.M.V. FB*2926.

Alternating Current

Application of A.C. to Circuit Arrangements

(*Continued from page 296, June issue*)

IN practical A.C. calculations, where several vectors are involved, it is general to select one of the quantities and refer to this as the reference vector. The other quantities then lead or lag on the selected vector, and are drawn accordingly. In the figure, if the arm *A* for instance was chosen as the reference vector, then we should say that the arm *C* lags on *A* and that the arm *B* lags on *A* also. Again, if *C* was chosen as the reference vector, then *A* would lead *C*, while *B* would lag *C*. In actual problems, it is simply a matter of practice in deciding which quantity to choose as the reference vector and difficulty is seldom experienced in this direction

Resistance Only

In a purely resistive circuit, having no reactive elements of any kind, the current rises and falls in step with the applied p.d.; it will be zero when the p.d. is zero and a maximum when the p.d. is maximum.

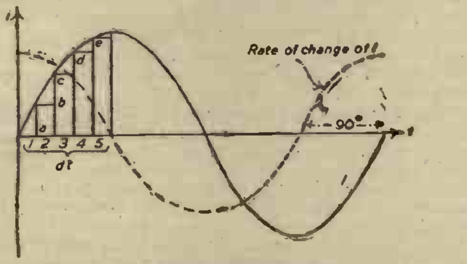


Fig. 6.—How the quantity di/dt gives the rate of change of the current curve in an inductive circuit.

This condition is shown in Fig. 5, and the waves are said to be in phase.

Let $e=\hat{e} \sin \omega t$

But $i=e/r$

$\therefore i=\hat{e}/r. \sin \omega t.$

Inductance Only

The effect of inductance is to oppose the rise and fall of the current due to the back e.m.f. effect. Any change of current in an inductive circuit is accompanied by a back e.m.f., which opposes the current producing it; the applied p.d. must therefore be such that the effect of this back e.m.f. is overcome and current can be driven against the opposition. Consequently the p.d. must at every instant be exactly equal and opposite to the back e.m.f.

In circuits containing inductance we are interested in the quantity *di/dt*, or the rate of change of the sine curve over a complete cycle. In Fig. 6, where one cycle of A.C. current is drawn in a full line, we may divide the time or horizontal scale up into very small sections, each of these being a small increment of time *dt*. It will be seen that during each of these small sections of time the sine curve is continually changing, and consequently the value of the current *i* also is changing. Now, as we move along the time scale 1, 2, 3, etc., we see that the amount by which the current changes is a variable quantity *ab*, *bc*, *cd* and so on, each of these small increments of current *di* getting smaller and smaller as the sine curve approaches its peak. The quantity *di/dt* is therefore the rate of change of the current, and this rate of change gradually decreases as the current curve increases; when the current is at its maximum possible value the rate of change of current is then a zero, the curve being momentarily "steady" as it passes over the crest.

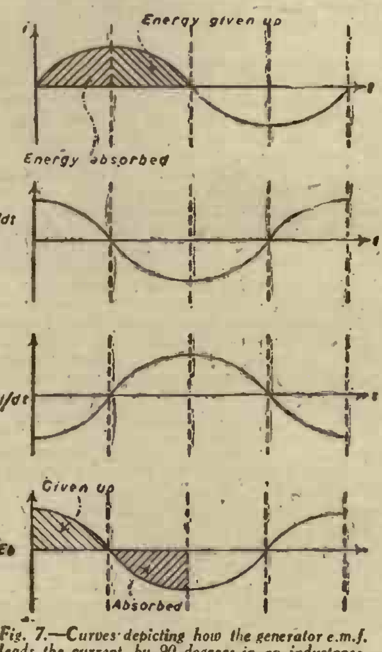
If this process is followed out over the complete cycle a result will be obtained as shown in the figure, where the rate of change of the current will be seen to be a sine wave of the same frequency as the current curve, leading it by an angle of 90 deg. It is fairly obvious that the rate of change of the curve depends on the frequency; the amplitude of the rate of change curve is given by:

$$\omega\hat{i}=2\pi f\hat{i}$$

where *f* is the frequency of the current curve. It can be shown, employing the calculus, that the quantity *di/dt* is represented by the expression:

$$di/dt=\omega\hat{i} \cos \omega t$$
$$=\omega\hat{i} \sin (\omega t+90^\circ)$$

Referring back again to the circuit containing inductance only, consider the curves of Fig. 7, the first being a current curve where $i=\hat{i} \sin \omega t$. The second curve depicts the quantity $di/dt=\sin (t+90^\circ)$, which leads the current curve by 90 deg. as we have already seen; the third curve shows the back e.m.f. given by



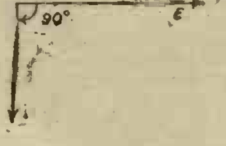


Fig. 8.—Vector representation of I lagging E by 90 degrees.

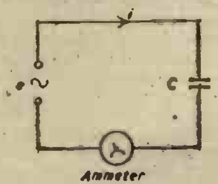


Fig. 9.—Capacity in an A.C. circuit.

Fig. 7.—Curves depicting how the generator e.m.f. leads the current by 90 degrees in an inductance.

$-L.\ di/dt$, which is equal and opposite to the e.m.f. of the supply *Eb.*

Thus it is simple to see from the fourth curve which is that of the applied p.d. (since this is 180 deg.—or antiphase—to the back e.m f. at any instant), that the generator e.m.f. *leads* the current curve by an angle of 90 deg., and that during a complete half cycle the generator does not give up any energy.

Vector Representation

Consider Fig. 8, and let the vector *E* represent the R.M.S. value of the generator e.m.f. Vector *I* is then drawn in the position shown, its magnitude being equal to the R.M.S. value of the current and having a lag of 90 deg. on the vector *E*.

Now we have:

$$i = \hat{\imath} \sin \omega t$$

$$\text{But } e = L\ di/dt = L\hat{\imath}\ \omega \sin (\omega t + 90^\circ)$$

Crest value of current $= \hat{\imath}$

Crest value of e.m.f. $= L\ \omega\ \hat{\imath}$

$\therefore \quad = L\ \omega\ \hat{\imath}/\hat{\imath}$

$= \omega L$

But $\hat{e} = E\sqrt{2}$ and $\hat{\imath} = I\sqrt{2}$

$\therefore\ E/I = \omega L$

The quantity ωL (or $2\pi fL$) is an important one in A.C. theory, since it determines the R.M.S. current which flows through an inductance when an R.M.S. voltage is applied. This quantity is known as the reactance *X* of the inductance, being measured in ohms. Reactance can be likened to pure resistance in some ways, since it has a limiting effect on the current which may flow for a given potential, but it must be noticed that, whereas resistance is a constant quantity, reactance in an inductance increases as the frequency increases.

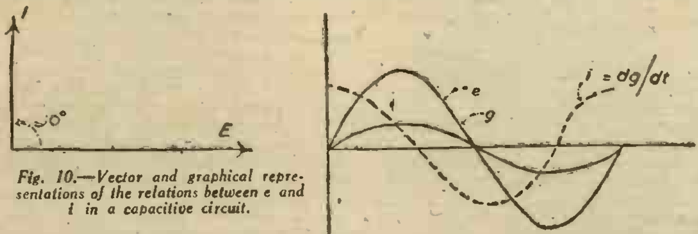


Fig. 10.—Vector and graphical representations of the relations between e and i in a capacitive circuit.

Capacity in an A.C. Circuit

A condenser is a complete barrier to D.C. current; after the first momentary flow of the charging current further current is impossible and the flow ceases. This is not so in the case of an A.C. circuit, however, and a condenser connected as in Fig. 9 across an A.C. supply will be found to cause an ammeter, appropriately connected, to deflect. This is because each plate is alternately receiving negative and positive charges, each alternate quarter cycle charging and discharging the condenser. Energy given by one quarter cycle to the condenser is returned during the next quarter cycle to the generator, each complete half cycle charging and discharging the component. Over the complete cycle each plate has been charged in opposite polarities.

The current does not actually pass through the condenser in the case of A.C. any more than it does in the case of D.C. Electrons do not move through the dielectric, but simply cause an equivalent number of electrons to be discharged from the other plate.

We are interested in the quantity dq/dt in the case of capacitive circuits; in Fig. 10 the relation between the applied p.d. and the charge on the condenser is shown by the *e* and *q* curves respectively, from which it will be seen that these are in phase with each other.

The current flowing in the circuit is measured by the rate of flow of electric charges. If the time scale is divided into small intervals of time, *dt*, as in the case of the inductive circuit, and a curve is drawn showing the rate of change of the charge curve, then the expression dq/dt will represent the current in the circuit. This will be found to be a sine curve of the same frequency as the applied p.d. but leading the charge curve by an angle of 90 deg. This is the same as saying that the current leads the applied p.d. by 90 deg., since the charge curve and the applied p.d. curve are in phase with each other.

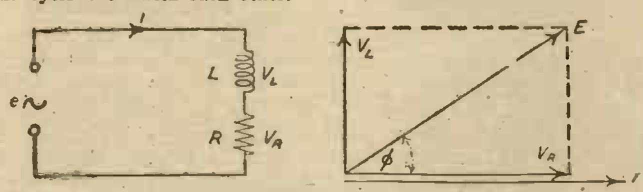


Fig. 11.—The phase angle φ existing between e and i in a resistance-inductance combination.

The result is the opposite to that existing in an inductive circuit.

The magnitude of the current flowing depends not only on the magnitude of the applied p.d. but also upon the capacity of the condenser. As we have seen, the charge on the condenser is a maximum when the applied p.d. is a maximum, therefore, as most readers are aware:

$$Q \text{ max.} = \hat{e}C.$$

Now $e = \hat{e} \sin \omega t$

$q = C\hat{e} \sin \omega t$

$i = dq/dt = d/dt\ (C\hat{e} \sin \omega t)$

$= \omega C\hat{e} \cos \omega t$

$\therefore\ i = \omega C\hat{e} \sin (\omega t + 90^\circ)$

From what has gone before:

When $t = 0$, $\hat{\imath} = \omega\ C\hat{e}$

$\therefore\ \hat{e}/\hat{\imath} = 1/\omega C = E/I$

The quantity $1/\omega C$ or $1/2\pi fC$ determines the R.M.S. current which flows when an R.M.S. voltage is applied and is called the reactance *X* of the capacitance. This reactance, again, is dependant upon frequency, though, unlike the inductive effect, its value *decreases* as the frequency increases. *X* is measured in ohms.

Mixed Circuits

We have now dealt with the effect of resistance, inductance and capacitance when each is separately connected in an A.C. circuit. We have seen in the case of a pure resistance that the current and voltage are in phase with each other, in a pure inductance that the voltage leads the current by 90 deg., and in a pure capacitance that the current leads the voltage by the same amount.

We will now consider cases where two or more of the above are present in one circuit, and later on how the results we shall obtain are used in radio circuits.

Circuit Containing Inductance and Resistance in Series

Since no coil is ever perfect, it must possess some resistance and an inductance is more correctly drawn as shown in Fig. 11, where it is represented as being in series with a pure resistance. When the circuit is connected as shown a certain current *I* will flow through the combination, and it is required to determine the exact relation which exists between this current and the applied p.d. Suppose we let the current flowing be represented by a reference vector *I*. We know that the voltage across the resistance *VR* will be in phase with this current, while the voltage across the inductance *VL* will lead it by 90 deg. These are drawn as shown, and the resultant of these two voltages is obtained by completing the parallelogram (a rectangle), taking the diagonal to represent this resultant in magnitude and direction.

(To be continued)

Permanent Magnets—VI

Flux Values : Magnetic Flux Leakage : Metal Magnets and Moving-coil Magnets

By L. SANDERSON

(Continued from page 345, July issue.)

A FORMULA that will sometimes serve to determine the permeability of a magnet, so long as only the normal curve of magnetisation is being dealt with, is the following: $\mu = F(B_s - B)$. In this equation, B_s corresponds to the saturation density of the material; B represents the induction value corresponding to μ, and F is a constant.

There is, however, a point to be noted, which is that this equation does not hold good close to the starting point of the magnetisation curve, i.e., before the known inflection point of a normal magnetisation curve begins. (See Fig. 1.)

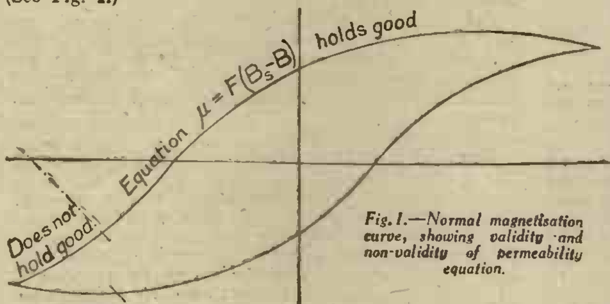


Fig. 1.—Normal magnetisation curve, showing validity and non-validity of permeability equation.

Magnet Dimensions

In designing magnets, it is essentail to know what size of magnet embodying the least possible volume of magnetic alloy will give a specified flux in a specified circuit. There are two ways in which this can be ascertained. The first is to find the BH (max.) value by graphical means. Before we deal with this method, it may be as well to state clearly what B and H respectively represent. B is the total number of magnetic lines of force passing through a substance. These lines of force are produced in two ways, by the magnetising force (H) and by the intensity of magnetisation. If, therefore, we draw a graph showing the relation of B (total lines of force) to H (magnetising force), we shall obtain a BH curve. (See Fig. 2.)

If, then, we take the products of the co-ordinates of the BH curve and plot them against B, the result will be a curve of the type shown in Fig. 3, by means of which we may obtain the value of B that will give the BH (max.), and it is this value that is the most effective for producing a given flux density, while it is, as already stated, an indication of the maximum energy a particular magnet will produce.

There is, however, another method, this time of geometrical type. In this, use is made of the formula $B/H = -B_r/H_c$. A BH curve of the type shown in Fig. 2 is plotted, and a diagonal X—O is drawn. This intersects the curve at the BH (max.) co-ordinates, and gives the requisite B value.

Flux Values

We must now consider how to establish the flux in any specific portion of the magnetic circuit. It is not necessary to inflict upon the reader the mathematical steps by which this is achieved. Given a BH curve of the type shown in Fig. 2, the problem is to find curves that, intersecting with it, will give the value of B in the magnet and, as a result, the value of the flux in any portion of the magnetic circuit. These intersecting curves may be obtained by means of Spreadbury's equation:

$$H = \frac{ab}{l}\left(\frac{l_g}{a_g} + \frac{l_1}{a_1\mu} + \frac{l_2}{a_2\mu_2} + \text{etc.}\right)$$

In this equation, a_g represents the air gap of the magnet, l_g is the length of the gap, μ is the permeability, and l the length of the magnet. From this equation it is possible to determine the value of H by giving hypothetical values to B. Taking the relation between these B and H values, and representing it graphically as in Fig. 4, the flux value can be obtained.

Having cleared the ground in this way, it now becomes possible to turn to the immediate and practical problems of satisfactorily designing a permanent magnet to fulfil a specified function. In the first place, there are two types of magnets, those in which there is no air gap (e.g., magnetic chucks and traction yokes), and those in which an air gap exists. It is the latter with which we are more particularly concerned. The work a permanent magnet has to do is to initiate a flux in a specified air gap. The actual flux value will be determined by the apparatus connected with the air gap.

When a magnet has an air gap, i.e., a discontinuity in the magnetic circuit compelling the magnetic flux to

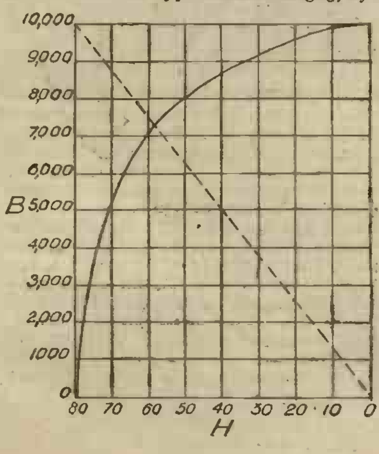
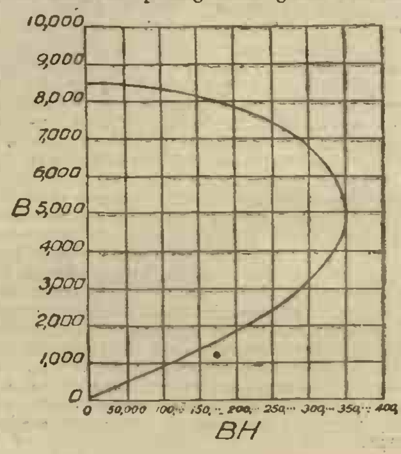


Fig. 2.—(Left) BH magnetisation curve, and B value diagonal.

Fig. 3.—(Right) Flux density determination curve.



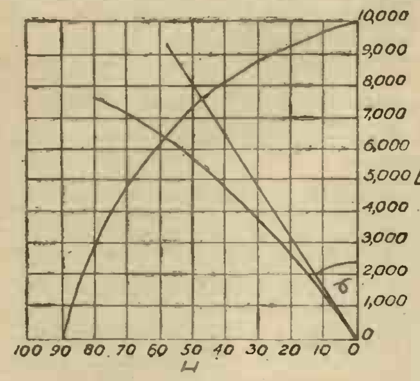


Fig. 4.—Flux value curve.

pass through an air space between the magnetic ends of the circuit, it is first necessary to know of what size the magnet must be in order to produce a specified flux value. In calculating this, it is essential to make allowance for magnetic flux leakages, and this can be done in two different ways.

Magnetic Flux Leakage

The first method assumes a certain amount of previous experience with the proposed form of permanent magnet, enabling a value to be assigned for leakage. This leakage coefficient is then employed in the calculation of magnet size. On the other hand, if the reluctance of the total number of magnetic leakage paths is calculated, it then becomes possible to estimate the leakage and make use of this in the later computations. Actually, it is quite common for both methods to be used.

The second method, however, will not be of much help to the reader unless he is familiar with the way in which the reluctance of the leakage path is calculated. To indicate the principles on which this calculation is based, Fig. 5 should be studied. Here a bar magnet is shown and is assumed to have been brought into contact with a mass of iron filings. The result, as any reader may test for himself, will be that the filings will cluster for the most part over two localised areas. These areas constitute the "poles" of the magnet. If these two areas of major concentration of the filings are linked together by a theoretical straight line, this line will constitute the "magnetic axis" of the magnet. It is assumed that between the two poles of the magnet run "lines of force" by means of which the magnetic force is sent from one magnet to another. These lines are, of course, merely a polite fiction, serving only to facilitate understanding of magnetic action.

Lines of Force

The lines of force are supposed to pass through the magnet, thus constituting an unbroken ring or circuit. In Fig. 5 these circuits made up of lines of force are roughly represented by actual lines of printers' ink, but, of course, we repeat, they have no real existence as *lines*. The point to bear in mind in regard to this illustration is that the lines correspond in reality to directions of magnetic force at any particular point in the magnetic circuit.

It will be observed that these magnetic circuits are not true circles or even true ellipses. To estimate leakage path reluctance it is necessary, however, to know the form of the lines of force constituting the boundary of the leakage path. Since these forms are not true geometrically, it is customary to replace them for purposes of computation by simpler geometrical curves. This is because knowledge of the leakage path boundaries cannot in any event be exact, and must be dependent on calculations based on observation and experiment.

Leakage, incidentally, is that portion of the magnetic flux that follows a path ineffective for the purpose of the magnet. It occurs in a horseshoe magnet and pole-pieces by reason of the fact that about 40 per cent. of the magnetic flux will not pass over the air gap; about 17 per cent. will be lost between the legs of the magnet and set up marginal fluxes on the sides of the pole-shoes; while from 2 to 3 per cent. will leak round the curved portion of the magnet. Obviously, these leakages must be established before the necessary design calculations can be made. In practice, however, the leakage round the curved portion of the magnet is often ignored because of its relatively small extent.

Reluctance, it must be remembered, is the property possessed by a magnetic circuit that renders necessary a magneto-motive force to produce a magnetic flux in the circuit. The reluctance is given by the formula $\frac{l}{\mu} \times A$, l being the length of the magnet, and μ the permeability, A being the area.

Magnetic Fringe Effect

The marginal flux or spread, often known as the magnetic fringe effect, is allowed for by using a gap coefficient. The path of the magnetic flux through the air gap is such as to minimise the reluctance, i.e., to give the greatest possible total flux and energy stored up in the magnetic circuit. The flux is evenly distributed when the air gap is long in proportion to the slot opening; but when the air gap is short, the greater part of the flux is concentrated in the gap opposite the teeth. F. W. Carter's method of calculating the effective air gap area is to average out the number of teeth within the magnetic field of the pole, and from this to compute the top surface area of the teeth, adding a proportion governed by the ratio of slot width to gap length. Thus, air gap area is then determined by the equation $A = T \times (1 \text{ plus } k)$. Here, A is the air gap area, T the tooth area, and k is Carter's gap coefficient, according to the values given in Table I.

TABLE I

Slot-width / Gap-length	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
Gap-coefficient k=	0.9	0.82	0.76	0.72	0.67	0.625	0.58	0.55

If the permeability of the gap is 1.0 so that $B = H =$ (amp. turns/cms.) $4\pi/10$, the excitation (M.M.F. in amp. turns) needed to maintain a specific flux density can be computed after allowance has been made for the fringe flux effect.

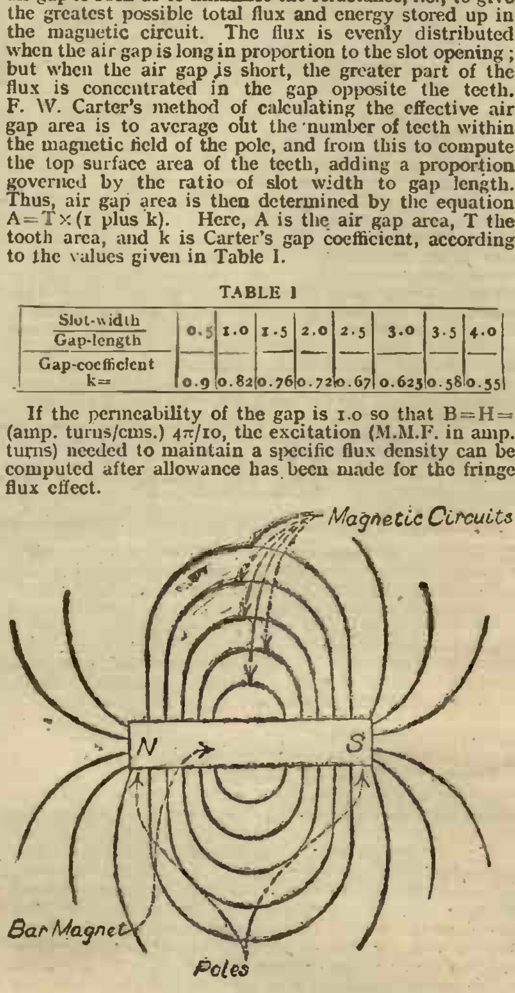


Fig. 5.—Lines of force.

Flux Density

To produce a specified flux in a given air gap a magnet of a certain length is required. Flux density being the magnetic flux per unit area is, as we have seen, normally represented by the letter B. In the air gap of a permanent magnet, flux densities usually have lower values than those obtaining in electro-magnets, being between three-quarters and one-half of the latter. The magnet length is, as a rule, in proportion to the gap flux density, and is determined from the equation $l=\frac{\Phi_g l_g}{A_g H}$, Φ being the total magnetic flux and A_g the air gap. H is, of course, the magnetising force, usually as established by the economic flux density of the magnet alloy.

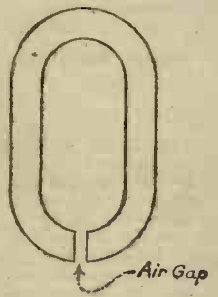


Fig. 6.—Electric meter brake magnet.

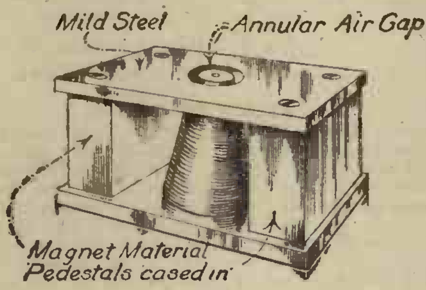


Fig. 7.—Moving coil magnet.

Electric Meter Magnets

A most important function for permanent magnets is in connection with electric supply meters, watt-meters, induction type ammeters, voltmeters, etc. Here they act as brake magnets for the driving magnetism that records the consumption of current. A typical brake magnet is shown in Fig. 6. The air gap is approximately 2-3 mm., and a brake disc of aluminium or copper is so mounted on the moving system that it projects into the air gap of the magnet, in which it rotates, being driven by a motor caused to function by part of the energy to be measured. The centre of the magnet pole faces is approximately 80 per cent. of the radius of the disc distant from the axis of rotation. By means of appropriate gearing the number of revolutions is registered on the meter dial.

The driving torque of the motor will be proportional to the product VI, V being the supply pressure and I the consumer's current. The braking torque exerted by the eddy currents induced in the brake disc is in proportion to the speed. This speed is represented by the equation S=kVIt, where S is the total number of revolutions in time t, and k a typical constant of the meter, ascertainable by calculation. Consequently, the revolutions made by the disc in a specific period of time will be a measure of the quantity of electrical energy, i.e., VIt watt-seconds, with which the consumer is supplied.

Magnets of this type are never provided with pole shoes.

Moving Coil Magnets

Another vital function of permanent magnets is in moving coil loudspeakers and similar instruments. A typical, though not necessarily current, moving coil magnet is shown in Fig. 7. In this the air gap is of ring form, and appears in the upper portion of the construction. The magnet material is employed for two supporting pedestals, which are housed in a surrounding cover to give a neater appearance. The top and bottom plates are of mild steel, as is the central pole. This steel is low in carbon content.

Characteristic figures for a moving coil magnet of this type are as follow: Induction in the air gap, 7,000 lines per sq.cm.; central pole diameter at the air gap, 1in.; radial length of air gap, 0.045in.; depth of air gap, 3/16in. The moving coil supported in the gap comprises approximately 80 turns of No. 38 s.w.g. enamelled copper wire, coil resistance being approximately 2 ohms.

In moving coil instruments it is usual to achieve damping by means of eddy currents induced in the metal former on which the moving coil is wound. The damping torque is in proportion to the square of the air gap flux density.

With magnets of this type the annular form of the gap makes estimation of the leakage much more difficult.

(To be continued.)

Solder and Soldering

A Multicored Self-fluxing Solder Which Eliminates the Chief Snags in Soldering and Ensures Perfect Joints

PERFECT contacts are essential before satisfactory operation can be obtained with any radio circuit. This point has been stressed in these pages many times, and the constructor has always been advised to make soldered joints wherever possible.

Many articles which have appeared in past issues have shown how to make a perfect soldered joint, but little mention is ever made of the materials without which soldering would be impossible.

Flux

Before any tinning, and consequently soldering, can be undertaken, some agent must be provided to prevent oxidation of the material, and, what is not so widely known among amateurs, to ensure an intimate contact and penetration between the materials being soldered and the solder. The latter is known as "wetting," and the desired conditions are obtained by the use of a flux, such as rosin and certain pastes put up under various trade names. Rosin approaches the ideal, and it is used most extensively for all work of an electrical nature, as it is *acid free*, cannot harm the most delicate wires, and is clean, i.e., non-greasy, in use.

The correct application of the flux has always been a snag with some amateurs, and, shall we say, inconvenient to the more professional users of the soldering iron. To secure the correct proportions and application of solder and rosin, a rosin-cored solder was made available several years ago which contributed greatly to better and easier soldering. Unfortunately, however, single cored rosin-solder has an inherent defect; it is practically impossible to guarantee that rosin will be present throughout the whole length of the solder tube.

An outstanding British invention and production has made one of the greatest contributions to soldering. It is known as Ersin Multicore solder, and it takes the form of a high-grade solder wire having three cores of non-corrosive Ersin activated flux. Ersin flux is a pure high quality rosin which has been subjected to a complex chemical process to increase its fluxing action to the highest possible degree without impairing in any way the well-known non-corrosive and protective properties of the original rosin. By virtue of its three cores and the special flux, Ersin Multicore solder provides a self-fluxing wire solder which ensures a guaranteed continuity and satisfactory proportion of flux to solder, and it can be used with complete safety on the most delicate work. More complete information can be obtained from Messrs. Multicore Solders, Ltd., Bush House, London, W.C.2.

Radio Examination Papers—21

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

QUESTIONS

1. *How would you deal with an accumulator, the terminals of which were so badly corroded that the nuts could not be loosened without the danger of shearing the terminal shanks?*
2. *Explain the differences between "Marconi," "Hertz" and "Beveridge" aerial systems.*
3. *What would be the effect of (a) connecting a 110-volt mains transformer to a 230-volt A.C. supply? (b) Connecting the primary windings of two 110-volt transformers in series across 220-volt A.C. mains?*
4. *If the transformer of a low-resistance moving-coil loudspeaker were open-circuited, what other type of transformer could be used as a temporary replacement?*
5. *Compare, briefly, the advantages and disadvantages of anode-bend, leaky-grid and diode detection circuits.*
6. *What faults would you look for in a simple type of superhet if instability made accurate setting of the trimmers and padders impossible?*
7. *What should be the length of a quarter-wave aerial for use on 7.5 mc/s, and how long should the arms of a half-wave doublet aerial be for use on 4.0 mc/s?*

1. Corroded Accumulator Terminals

MOST of the corrosive deposit or verdigris is found on the positive terminal, and if an accumulator has been badly neglected this deposit may have the effect of locking the nut solidly on to the terminal shank. It is dangerous to apply force to a terminal so corroded, because either the shank will shear off, or the whole terminal will break away from the plate assembly. What is required, then, is a means of dissolving, or at least softening, the deposit.

Hot water is generally effective if allowed to soak well into the verdigris. When the deposit is not very heavy it is often sufficient to soak a piece of rag in very hot water and then to bind it round the terminal. It should be allowed to remain for an hour or more. If the deposit is very thick, it may be better to start by carefully scraping and chipping some of it away. After that, a "cup" should be made from Plasticine or clay and placed round the terminal. A small amount of boiling water can then be poured into this receptacle; if necessary, this treatment may be repeated a few times, pouring out the water when it becomes cold.

If the water is made alkaline by the addition of a few drops of ammonia, it will prove rather more effective. When the deposit has been softened, a good deal of it can be wiped off with an old rag. After that, it should be safe to apply a pair of pliers to the nut and unscrew it. Force must not be used, however.

When the nut has been removed, apply a smear of Vaseline or grease to the terminal shank, and put a rather more liberal quantity around the base of the terminal. If the nut is then put on and screwed backward and forward a number of times it will be found to be quite free.

Occasional application of Vaseline or grease will prevent the formation of the deposit—"prevention is better than cure!"

2. Aerial Arrays

For most requirements, a half-wave aerial is most effective, because the maximum voltage can be developed between its ends. This maximum voltage appears between the peak of the positive half-cycle and the peak of the negative half-cycle, as shown in Fig. 1.

The "Hertz" aerial—more frequently referred to as a dipole—is one-half a wavelength long, and consists of two arms, each of which is one-quarter wavelength in length. So that the effective length is not altered by the down-lead, a special form of lead-in must be employed. This may take the form of two twisted wires, a co-axial feeder or other corresponding device. The general arrangement is shown in Fig. 2.

Despite what has just been written, the "Marconi" aerial is only one-quarter wavelength long; and yet it acts as a half-wave aerial. This is explained by the fact that by using an earth connection (which is not employed with the strict "Hertz" aerial) the effect is obtained of another quarter-wave aerial running vertically into the ground. This is referred to as an "image" aerial. Fig. 3 helps to explain this.

It may be argued that the "Marconi" aerial is not always just a vertical wire as indicated, but actually consists of a horizontal wire with a more or less vertical lead-in. But it is the vertical portion which should be considered, the horizontal member being regarded simply as a bent-over portion of the vertical aerial.

Both types of aerial referred to are equally suitable for most purposes, although it is obvious that a "Hertz" aerial would be very cumbersome on medium and long waves. On very short waves it is inclined to be rather more satisfactory than the "Marconi." It should be mentioned in passing that it is not customary to cut aerials for particular wavelengths when they are for use with receivers, although it is an advantage to make the length right for the middle of the band to be covered, especially when dealing with short waves.

The "Beveridge" aerial is seldom, if ever, used to-day. It consists of a wire four to six wavelengths in length, running parallel to the ground and only a few feet

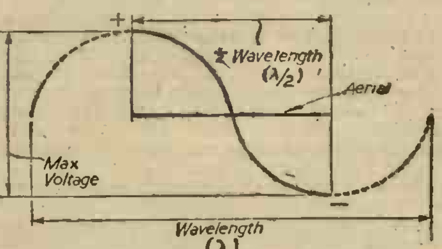


Fig. 1.—This diagram shows why a half-wave aerial is most efficient for the majority of purposes.

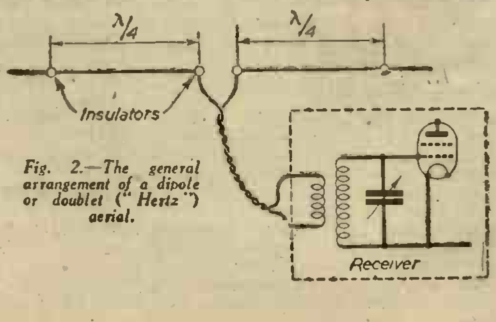


Fig. 2.—The general arrangement of a dipole or doublet ("Hertz") aerial.

above it. The end remote from the receiver is earthed through a resistance. In the earlier days of wireless it was often used as an "anti-static" pick-up device, and for directional reception. Some of the "Beveridge" aerials used were a few miles in length.

3. Mains Transformer Problems

The immediate effect of connecting the primary winding of a 110-volt transformer to 230-volt A.C. mains would normally be pronounced over-heating. With a really well-made transformer, however, this may not be serious provided that the secondary load was small in relation to that for which the transformer was designed.

Another effect which would inevitably be present is that the voltage provided by the secondary windings would be just over twice that for which the component was intended.

It is not necessary to stress the fact that it would be most unwise in any event to use a transformer in this manner. Care must therefore be taken when buying secondhand transformers, especially those taken from American wireless equipment, since 110-volt A.C. supplies are not unusual in America and Canada.

At first sight it would seem that by connecting two 110-volt windings in series across 220-volt mains the two transformers could be used in a normal manner, or that the secondary winding of one only could be employed. But this is not true, because the primary current is determined by the load on the secondary. And if both primary currents were not the same, the transformer requiring the heavier current could not operate. In practice, therefore, it is satisfactory to use the series-primary connection only when both transformers are similar, and both are supplying the same output. Even then, the arrangement is seldom satisfactory, because any variation in load on either will affect the functioning of the other.

4. Speaker-transformer Replacement

The normal loudspeaker transformer has a ratio between about 20 : 1 and 60 : 1, depending upon the optimum load of the output stage and the impedance of the speaker speech coil. It will be remembered that the correct ratio may be found by dividing the optimum load of the output stage by the speech coil impedance and taking the square root of the result. For example, if the power output valve had an optimum load of 4,000 ohms and the speech coil had an impedance of 10 ohms, the correct matching ratio would be the square root of 4,000 divided by 10, which is 20 : 1.

An average mains pentode or tetrode output valve has an optimum load in the region of 8,000 ohms, while the average speech coil impedance is 10 ohms. It can be seen, therefore, that the correct ratio to provide matching between the two is about 27 : 1.

What transformer, other than a speaker transformer, has a ratio approximating to this, and has at the same time, a low-resistance secondary? There are several mains transformers which would serve. For example, a transformer with 200 volt primary and 6.3 volt secondary provides a ratio of rather more than 30 : 1; that would serve our purpose fairly well. Alternatively, a transformer with 110 volt secondary and a 4 volt secondary could be employed by using the H.T. secondary as a primary winding. Other alternatives will suggest themselves to readers.

5. Detection Methods

The anode-bend detector is less sensitive than the leaky-grid, but rather more sensitive than the diode. Additionally, reaction can easily be applied when using this form of detector. At the same time, it will handle only small signal voltages, and its only real advantage is its high input impedance, which means that it offers less damping to the preceding tuned circuit. Its use is nowadays mainly confined to valve voltmeters and certain types of wavemeter.

The grid-leak detector is very sensitive, can readily be used with a reaction circuit, and has a moderate "handling" capacity. It introduces only a very small amount of distortion, and is employed almost universally in "straight" circuits.

Diode detection is generally most suitable in a superhet. Reasons are that it will handle very large signal voltages, such as are provided after frequency-changing and intermediate-frequency amplification, and it provides a ready means of A.V.C. It is virtually distortionless, and is ideal in a receiver with ample pre-detector amplification and when good-quality reproduction is required.

6. Superhet Instability

Occasionally, the type of instability referred to in the question is due to a defective I.F. valve, but more often lack of decoupling is responsible. This may occur, even in a properly designed receiver, if one of the by-pass condensers becomes open-circuited. One condenser which is important in this respect is that connected between the screens of the frequency-changer and earth. In simple receivers, the same condenser is sometimes used to by-pass H.F. from the screens of both the frequency-changer and the I.F. amplifier; it is then even more important that it should be in good condition.

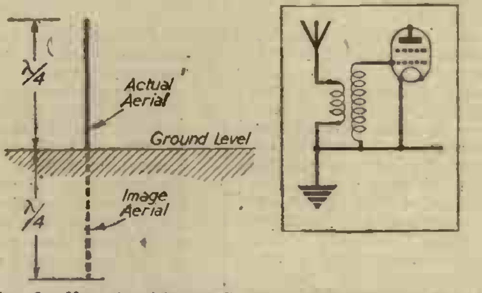


Fig. 3.—How the "Marconi" aerial, although one-quarter wavelength long, acts as a half-wave device. Inset shows the aerial and earth connections to the receiver.

If the trimming of the I.F. transformers has been done by rough-and-ready methods (that is, without using a signal generator) it might be found that incipient oscillation cannot be prevented. In some commercial receivers it is actually necessary slightly to detune one of the I.F. transformers to maintain stable operation.

Another possible cause of instability is poor earthing of the coil and I.F. transformer screening cans. In battery sets, a run-down battery may produce similar symptoms, particularly if it is not shunted by a high-capacity condenser; an 8-mfd. electrolytic is often desirable.

7. Frequency and Aerial Length

This question will be better understood after reading the answer to question number two. It is obvious that a quarter-wave aerial is one whose length is one-quarter of the wavelength on which it is to be used. It is therefore necessary to convert the frequency in megacycles per second into wavelength in metres before going any further. Since a wavelength of 300 metres is equivalent to a frequency of one megacycle per second, the simplest method of conversion is by dividing the frequency in megacycles, into 300. If we divide 7.5 into 300 we get 40 as the answer. The wavelength is therefore 40 metres. A quarter-wave aerial should thus be 10 metres in length. We can convert this to feet if it is remembered that one metre is approximately 3ft. 3in. Thus, our aerial should have a length of 32ft. 6in.

Using the same method of calculation as before, we find that the wavelength corresponding to 4 megacycles per second is 75 metres. If the whole aerial is to have a length of one-half the wavelength it will be 37.5 metres. Each arm of the doublet will therefore require to have a length of 18.75 metres. By calculation it will be found that this is approximately equivalent to 61ft.

Elementary Electricity and Radio—7

The Valve as an Amplifier : Oscillators and Neutralising

By J. J. WILLIAMSON

(Continued from page 341, July issue)

The Anode Load

So far we have considered the properties of the valve itself without reference to its use in practice, i.e., we have been using the "static" instead of the "dynamic" characteristic curves.

Having caused large changes of anode current for small changes of grid voltage (amplified the grid voltage effects), we must reproduce voltages in the anode circuit in order to be able to use the rippling or changing anode current.

As $V=IR, IZ$ or IX_L then the insertion of a resistance, impedance or reactance (inductive) in the anode circuit will cause the required voltage to appear. The opposition placed in the anode circuit is known as the anode load. Figs. 19 (a), (b), (c) and (d) show several types of anode load, the type used depending upon circuit requirements. Obviously a condenser could not be used because it would block the path of the D.C. through the valve.

The alternating voltage produced across the anode load can now be fed to another valve or pair of telephones, etc., the mode of doing this being termed the coupling of the circuit. Methods of coupling will be discussed in a later article.

The Triode as an Amplifier

By use of the Ia/Vg characteristic curve of a triode we can deduce just what voltages must be applied to the valve in order that its amplification shall be as distortionless as possible.

Reference to a typical Ia/Vg curve (Fig. 20 (A)) shows how the anode current would vary with changes of grid voltage. Obviously, if the waveform of the variations of the anode current is to be the same as the waveform of the voltage applied to grid and filament, then the variations of anode current must take place over the straight or linear part of the characteristic curve.

For the curve shown the alternating voltage applied to grid and filament would cause the anode current to vary in such a way that distortion occurs—indicated by the difference between the shapes of the two waveforms.

In order to make the alternating grid/filament voltages act from the centre of the straight portion of the characteristic curve (greatest possible linear variation obtainable) a steady voltage, known as the "grid-bias," must be applied to the grid and filament. Fig. 20 (B) represents a simple low-frequency amplifier with suitable grid-bias applied by the battery "A."

The point on the characteristic curve about which variation occurs is known as the operating point; the variation of grid-bias causes the operating point to move. The dotted lines of Fig. 20 (A) indicate the correct condition for amplification.

Class A, B and C

To denote the operating conditions for various purposes three main conditions are chosen, namely, A, B and C.

Class A occurs when anode current varies at all times for an alternating voltage applied to grid and filament. This condition has been discussed under "The Triode as an Amplifier."

Class B is obtained when a valve is biased approximately to cut-off point, X in Fig. 20 (A). Anode current flows mainly during the positive half-cycles of the alternating voltage applied to grid and filament.

Class C occurs when only a portion of the positive half-cycles of the alternating grid/filament voltages causes anode current to flow, i.e., the valve is biased beyond cut-off.

In Figs. 21 (A) and (B) an alternating voltage together with a biasing voltage has been applied to grid and filament of a valve. Notice that in Fig. 21 (A) only positive half-cycles affect the anode current, i.e., Class B operation. In Fig. 21 (B) the "peaks" of the positive half-cycles cause a flow of anode current, i.e., Class C operation.

The Triode as an Oscillator

In the fifth article of this series the closed and open oscillatory circuits were discussed, and their action explained in some detail by means of the "flywheel and spring analogy." It is to be remembered that the oscillatory current in these circuits would rapidly die away owing to the energy-loss, thus if continuous oscillation is to be maintained, timed pulses of energy must be supplied in order to replace the losses, even as

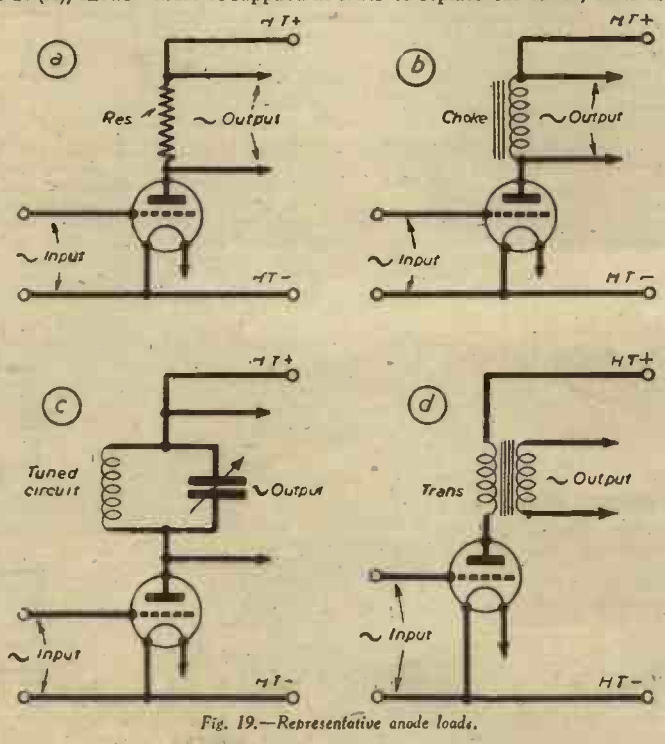


Fig. 19.—Representative anode loads.

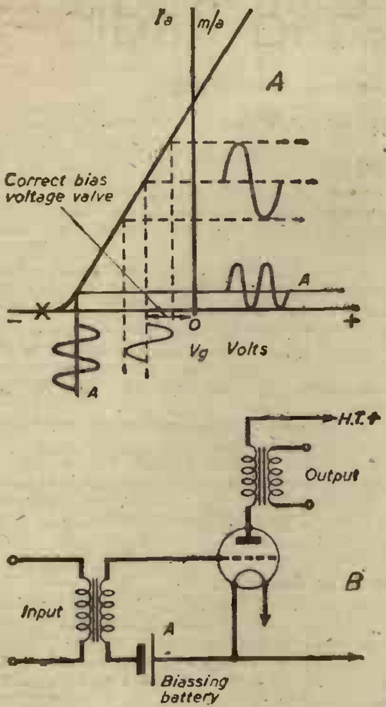
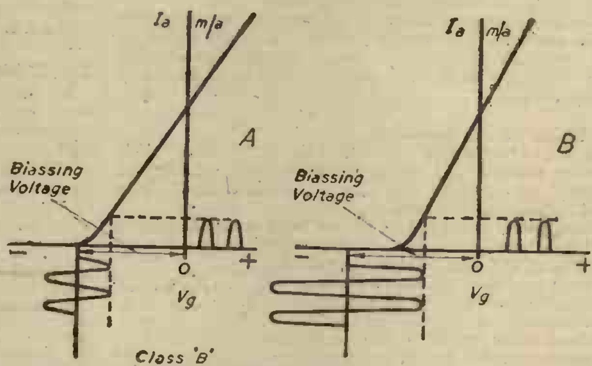


Fig. 20 (above)—Ia/Vg curve of a triode, and a simple amplifier with applied bias.

Fig. 21 (Right).—Class "B" and "C" operating curves.



a swing has to be pushed at definite intervals if it is to be kept in motion.

From whence shall the "timing" of the pulses be supplied? Obviously there can be no better source than the oscillatory circuit itself. Again if we take energy from the oscillatory circuit for "timing" purposes then we shall have to give extra energy back to the circuit if we wish to make up for losses. The triode valve, because it can amplify the timing pulses, will enable us to do this.

The Hartley Oscillator

Fig. 22 (A) shows a Hartley oscillator, wherein the coil is tapped, voltages from one section are fed to grid and filament of the triode (timing pulses) whilst the anode current of the valve flows through the other part of the coil, thus supplying energy as this current varies under the influence of the grid/filament voltages.

The Colpitts Oscillator

Instead of "splitting" the coil, the condenser is "tapped" by using two condensers of a suitable value in series. One half of the condenser combination supplies the timing pulses which are fed to grid and filament; the valve's anode current once again flows through the coil, thereby enabling energy pulses to be supplied to the oscillatory circuit (Fig. 22 (B)).

The radio-frequency choke (R.F.C.) is placed in the circuit to prevent the supply from causing an R.F. short-circuit across grid and filament. Notice that no grid-bias battery is included, biasing being obtained automatically by the action of C_3 and R_1; also, if the energy applied to grid and filament is in the incorrect phase, then no oscillation will occur—a condition analagous to pulling a swing when it should be pushed and vice versa. (Grid and anode changes of potential should be 180 deg. out-of-phase.)

The Tuned-anode Tuned-grid Oscillator

The T.A.T.G. oscillator employs a slightly different method of providing the grid/filament timing voltages. Fig. 23 (A).

The anode circuit L_1 C_1 is the circuit to be maintained in oscillation, whilst the grid circuit L_2 C_2 is the "timing" circuit.

On switching on the oscillator, C_1 charges up, causing oscillations to occur in the anode tuned-circuit, energy from this circuit is supplied via the capacity existing between the anode and grid of the valve, i.e., *Cag* (interelectrode-capacity), to the grid circuit, causing it to oscillate. The alternating voltage across the grid circuit being applied to grid and filament of the valve, thus maintaining the anode circuit's oscillation because of the periodic variation of anode current through L_1.

Fig. 23 (B) shows the equivalent circuit of a T.A.T.G. oscillator; the mode of energy transference from anode to grid circuits, via the *Cag* of the valve can clearly be seen.

Crystals and Their Use

All the above-mentioned oscillators suffer from the disadvantage that their frequency will vary with least change of the values of inductance or capacity in their circuits, due to temperature variation, vibration, humidity and the effect of near-by objects.

If an oscillator could be controlled by a stable frequency source, this instability would greatly be reduced

(*Continued on page 392.*)

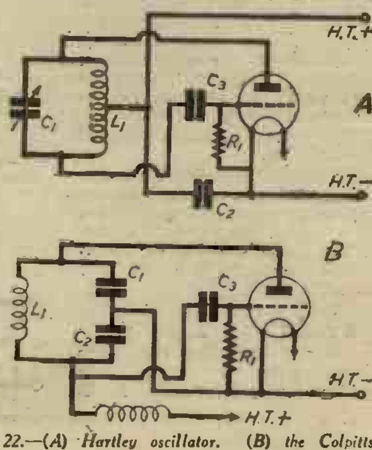


Fig. 22.—(A) Hartley oscillator. (B) the Colpitts circuit.

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—a very important consideration. Such a source lies in a correctly cut crystal, quartz being generally employed.

A natural quartz crystal is shown in Fig. 24, but very few perfect quartz crystals are to be found; specially selected specimens being used for radio purposes.

A slice of crystal, correctly cut, has the property of vibrating mechanically if a P.D. is applied to it. Conversely, a sudden tension across the crystal slice will cause a P.D. to appear, oscillations occurring until the energy supplied is lost, i.e., a damped wave-train is produced. Thus, a P.D. applied to a crystal will cause both mechanical and electrical vibrations, the frequency of which depend mainly on the physical dimensions of the crystal.

The Tuned-anode Crystal-grid Oscillator

In the T.A.X.G. (Xtal) oscillator, Fig. 25, the voltage pulse produced across the crystal by the anode current at the instant of switching on the oscillator, will cause the crystal to produce alternating voltages which act across grid and filament, which, in turn, making the anode current "ripple," will set the anode tuned-circuit oscillating. The oscillatory voltage across the anode

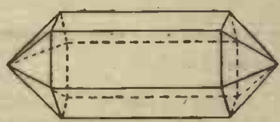


Fig. 24.—Simplified structure of natural quartz crystal.

circuit maintains the crystal's oscillation in the same way as described in the T.A.T.G. oscillator, e.g. via the *Cag* of the valve.

The frequency generated by the T.A.T.G. and the T.A.X.G. is not *quite* the same as the resonant frequency of the grid circuit or crystal, due to certain factors which are beyond the scope of these articles.

Radio-frequency Amplification

As soon as we attempt to use the triode as a radio-

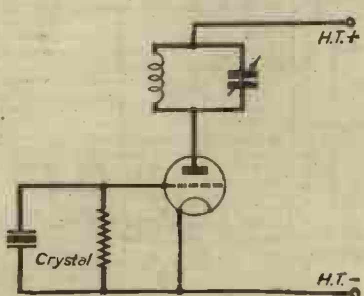


Fig. 25.—Crystal-grid tuned anode oscillator.

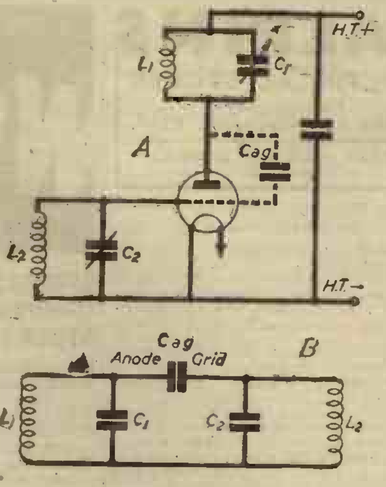
frequency amplifier, we discover that the amplification is lower than would be expected, and that instability occurs.

The amplification is lower because of the "short-circuiting" effect of the capacity between grid and filament (*Cgf*); this effect increases with the frequency, i.e., the reactance of a condenser gets smaller as the frequency is increased.

We rarely require a radio-frequency amplifier that can amplify evenly all frequencies; a narrow band of frequencies or one particular frequency being the usual requirement.

High amplification from such an amplifier can be obtained by the use of grid and anode tuned-circuits, when it becomes possible to tune or pick out the band of frequencies or single frequency—according to the circuit design—that it is desired to amplify.

Let us investigate the cause of the instability ex-



Equivalent circuit of T.A.-T.b..

Fig. 23.—The tuned anode tuned-grid oscillator.

perienced when using a triode with grid and anode tuned-circuits as an R.F. amplifier. Referring to Fig. 23, it can be seen that there is little difference between a T.A.T.G. oscillator and the tuned radio-frequency amplifier using a triode, thus it becomes apparent that our R.F. amplifier can oscillate, thereby causing instability. Now, the prime factor of a T.A.T.G. oscillator's ability to oscillate is the coupling together of grid and anode tuned-circuits by the *Cag* of the triode, therefore, if we could, in some way, overcome or neutralise the effects of this interelectrode-capacity, then the oscillatory action would not occur. There are two ways of achieving this: (1) by neutralising; (2) by the use of a tetrode (four-electrode) or screen-grid valve.

(*To be continued.*)

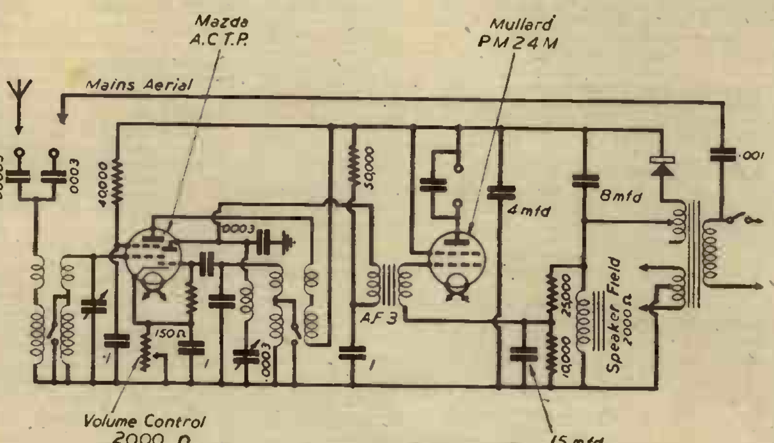
Open to Discussion

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).

An Efficient Two-valve Mains Receiver

SIR,—The accompanying circuit diagram is of a very efficient two-valve mains receiver which I have recently constructed and which may be of interest to other readers. There is nothing new in the design, but very little use seems to be made of the triode-pentode valve other than in superhet work. This set, which is quite easily constructed, is equal to some commercial three-valve sets which I have had for repair, and it also gives plenty of scope for experiments. The 2,000 ohms volume control was the only wire-wound component I had, but one of 10,000 ohms would be much better. The mains transformer is of the "Stal" eliminator type with H.T. secondary and full wave rectifier filament winding, but the extra load on the filament winding, by using it for two valves, does not affect it in any way. The Westinghouse rectifier is of the H.T. 10 or 17 type, and H.T. output is 150 volts at about 25 milliamps, so that anyone with a suitable mains transformer could get still better results. The coils are Telsen iron-core type (W.349), and I used two sections of a three-gang condenser for tuning. All the parts, except valves, are out of my "junk box." The output pentode is a little over-biased by the potentiometer arrangement across the speaker field, but is not noticeable in the reproduction, which is quite good for a small set. Reaction is not required for any but foreign stations, and there is no instability at full volume, although the strength of stations below 250 metres suggests that a little instability would be present if a higher voltage was used. To conclude, I might add that selectivity is very good and, on the .00005 mfd. aerial tapping, using reaction for volume, is nearly up to superhet standard.

I think an improved model of this circuit would be ideal for the "Utility" sets which we have heard about, but not seen yet.—JOHN R. LEEMING (Blackburn).



Theoretical circuit diagram of two-valve mains receiver.

Station Identification

SIR,—In the June issue of PRACTICAL WIRELESS I noticed a letter from Thos. Wilson, of Kirkconnel, mentioning a list of Press stations. Being a Morse enthusiast, I wonder if he would oblige me by letting me have a list. I have one or two English Press stations. I copy Morse every night in Italian, French, German and English, just to speed up my receiving, which is about 18 w.p.m. Also, can any reader supply any information concerning one or two stations which I have heard recently but cannot identify? On June 5th, I picked up a station on the 29-metre band, and in French the announcer said: "Here is Radio France." He then spoke some numbers like this: 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, zero, all in French. This was at 23.35 hrs. D.B.S.T. Then on June 6th, at 00.07 hrs., on 31.2 metres, an American was reading the news. He announced at the end: "This is Allied Forces H.Q., North Africa." When I heard him on the following day he was reading the news again, and he said: "This is Martin for Reuter, London." Then, after reading the same news again, he said: "This is T. Brown for Reuter's, London." He read out some news again and said: "This is for Associated Press, New York and London." But I missed the call sign. On June 7th, at 23.05 hrs., I heard an American station on 23 metres. The dialogue was: "This is the Voice of America, one of the United Nations, Station WKRB."—A. J. NEWMAN (London).

ELEMENTARY ELECTRICITY AND RADIO: A CORRECTION.

IN the article under the above heading which appears in the June issue (page 284), the formula at the foot of the left-hand column should read:

$$Xc = \frac{1}{2\pi fc} \text{ not } Xc = \frac{1}{2\pi\sqrt{LC}}$$

Immediately below this the formula should read

$$2\pi fL = \frac{1}{2\pi fC}$$

$$f^2 = \frac{1}{2^2\pi^2 LC}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Also under the paragraph headed "Capacity and Inductance in Parallel" the formula should read:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

Replies to Queries

P.U. With an A.C./D.C. Set

"I would like to use a pick-up with my radio, but am told that this is not possible as the set is the A.C./D.C. or Universal type. If it is possible to use a pick-up, could you please state what condensers, etc., are needed, also where to connect the negative side of the pick-up, as I would very much like to use the set on the gram. until it is possible to obtain parts for a radiogram."—J. R. (Leicester).

PARTICULAR care has to be taken when connecting a pick-up to A.C./D.C. receivers, owing to the fact that one side of the mains is common with the chassis.

The component is connected to the grid of the detector and chassis but, to protect the operator from shocks at mains voltage, *each* connection must be made through a small mica dielectric fixed condenser. Suitable values come between 0.0005 mfd. and .01 mfd.

It is essential to see that the grid of the valve is still provided with its normal grid-leak connection to cathode or common negative line, as the condensers prevent the flow of any D.C., therefore, if the leak is removed, the grid will not receive its correct bias.

U.31 Connections

"I have here an Osram U.31 rectifier valve. It has five pins. Two are for filaments and two for plates. What is the other for? Where would the fifth pin be connected on a transformer? I am drawing a diagram of the valve pins, which I hope you will identify for me. As I only require 150 volts, should the H.T. winding be stepped down, or could I use resistors for my purpose?"—H. K. (Benwell).

THE U.31 is designed for use in A.C./D.C. circuits, and is of the half-wave type. If, however, you wish to use it with a mains transformer you must make sure that the secondary supplying the heater is designed to give 26 volts at 0.3 amps., and the H.T. secondary 250 volts at 100 mA.s.

The connection about which you are not too clear is the cathode. This represents the D.C. output of the rectifier, and must, therefore, be connected to one side of the smoothing circuit, in place of the usual centre tap of the heater winding. If you do not require a full 250 volts, a suitable resistor should be connected in series with the D.C. H.T. line to produce the required voltage drop.

S.W. Converter Two

"I am seriously thinking of building the 'S.W. Converter Two,' described in your July, 1942, issue, for use in conjunction with a 1-v-1 set based on your 'Three Valve Emergency Receiver' described in an earlier issue. The three-valver does not cover long waves, the coils being wound for medium waves only. Would it be possible to use the converter unit in conjunction with such a set?

"Also, would the efficiency of the converter unit be greatly enhanced by the use of an H.F. Pen. in place of the S.G. valve specified?"—S. E. (Surrey).

THE converter can be used with the receiver, provided the latter tunes to, say, 500 metres. Better results will be obtained if the maximum wavelength of the two tuned circuits can be increased to 650 metres; assuming 500 metres to be their maximum, the approximate results could be obtained by connecting across each tuning condenser in the receiver, trimmers or pre-sets having a capacity of, say, .0001 mfd. each. It is essential that the tuning of the two circuits is identical.

We do not think any great increase in efficiency would be experienced by using an H.F. Pen.

H.F. Losses

"I have built a short-wave receiver as shown on the diagram accompanying this letter, but find it very difficult to get down to the very low wavelengths. Just above 25 metres things are all right, but then the set refuses to oscillate below that. I have tried different H.T. voltages, changed the aerial and earth, and put various condensers in the aerial lead. I even bought a variable grid leak to see if the value of that would help matters, but I am unable to get the low waves. Is it possible to suggest from the sketch how I can improve matters?"—G. B. (Boscombe).

THE diagram shows that the receiver is built upon a metallised or foil-covered chassis, and that a large number of earth returns are taken to this chassis. There is a possibility that the junction between the connecting wires and the chassis is badly made or that corrosion has set in and thus certain points are separated by a resistance set up by the poor connection. We therefore suggest that you connect together each of the earthing points, using good heavy tinned copper wire, and soldering the wire to the earthing screws or bolts. This is probably the only fault present in the receiver.

> **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.
>
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>
> 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.
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> 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.

Condenser Breakdown

"I am always getting trouble with my A.C. set which seems impossible to avoid. The set is a five-valve with push-pull output, and the trouble concerns certain condensers. These are always breaking down, and I have tried all sorts of voltage ratings, even up to three times the working voltage. Is there any way in which I can avoid this trouble, without going to a lot of expense?"—H. O. (Ladywell).

IF the working voltage rating of the condenser is correctly chosen the trouble should not arise, and we therefore assume that there is some peculiar feature in the design of the mains section which results in a very heavy surge when switching on.

Delayed Action

"I have a battery-operated three-valve receiver, and on switching on I have to wait a few seconds before I hear any sound, and there is a corresponding delay when switching off. Also, I have a pentode output valve about which I am anxious. During operation, the filament glows red and the plate glows green. Is anything wrong? I would add that reception is perfect."—R. P. (Thornton Heath).

THE delay is due to the fact that the output valve has a rather thick filament and takes a moment or so to obtain incandescence. Similarly, when switching off, it does not cool instantly. The red glow from the filament is in order, but the green colour you refer to is probably due to the fact that the valve is slightly soft, or you are applying too much H.T. or too little G.B. Generally the colour is a rich blue, but as it is probably rather faint, it appears green. Examine the H.T. and G.B. circuits and check up with the valve-maker's instructions. If they are O.K. it would probably be advisable to have the valve tested.

Lack of Power

"I have built a 3-valve battery set. I think it is capable of getting a fair number of stations, but I can only get them very faintly, and then only when the set is on the oscillation point. Can you advise me how to bring them out?"—J. F. (Bexley).

THERE may be many causes for the lack of volume. Obviously, the signal strength is very low if two L.F. stages are insufficient to provide good signals. Look to the aerial and earth system; the H.T. applied to the detector; test the valves; examine the batteries, and generally make quite certain that the receiver is correctly designed. If you care to send a circuit diagram, with all details clearly marked, we will check it over for you.

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- F. J. Camm's Silver Souvenir (HF Pen, D (Pen), Pen) (All-Wave Three) .. .. .. — PW49
- Cameo Midget Three (D, 2 LF (Trans)) .. .. .. — PW51
- 1936 Sonotone Three-Four (HF Pen, HF Pen, Westector, Pen) — PW53
- Battery All-Wave Three (D, 2 LF (RC)) .. .. .. — PW55
- The Monitor (HF Pen, D, Pen) .. — PW61
- The Tutor Three (HF Pen, D, Pen) — PW62
- The Centaur Three (SG, D, P) .. — PW64
- F. J. Camm's Record All-Wave Three (HF Pen, D, Pen) — PW69*
- The "Colt" All-Wave Three (D, 2 LF (RC & Trans)) .. .. — PW72*
- The "Rapide" Straight 3 (D, 2 LF (RC & Trans)) .. .. — PW82*
- F. J. Camm's Oracle All-Wave Three (HF, Det, Pen) .. .. — PW78
- 1938 "Triband" All-Wave Three (HF Pen, D, Pen) .. .. — PW84
- The "Hurricane" All-Wave Three (SG, D (Pen), Pen) .. .. — PW89
- F. J. Camm's "Push-Button" Three (HF Pen, D (Pen), Tet) — PW92*

Four-valve: Blueprints, 1s. each

- Beta Universal Four (SG, D, LF, Cl.B) .. .. .. — PW17
- Nucleon Class B Four (SG, D (SG), LF, Cl. B) .. .. — PW34B
- Fury Four Super (SG, SG, D, Pen) — PW34C
- Battery Hall-Mark 4 (HF Pen, D, Push-Pull) .. .. — PW46
- "Acme" All-Wave 4 (HF Pen, D (Pen), LF, Cl. B) .. .. — PW83
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Mains Operated

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- Selectone A.C. Radiogram Two (D, Pow) .. .. .. — PW19

Three-valve: Blueprints, 1s. each.

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- 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.

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- 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

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- F. J. Camm's 2-valve Superhet .. — PW52

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- D.C. £5 Superhet (Three-valve) .. — PW42
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MISCELLANEOUS

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The index letters which precede the Blueprint Number indicates 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.

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