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Editor :
HUGH S. POCOCK.

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Telegrams : "Autocar, Coventry."
Telephone : 5210 Coventry.

BIRMINGHAM :
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As many of the circuits and apparatus described in these pages are covered by patents, readers are advised, before making use of them, to satisfy themselves that they would not be infringing patents.

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EDITORIAL COMMENT

Wire or Wireless?

Feeding the Television Relays

IT would appear that the Radio Manufacturers' Association's offer to bear any financial loss consequent on extension of the television service to the Birmingham area has been generally misunderstood. In a supplementary statement subsequently issued by the Association the details are elaborated, and it is made clear that the offer is confined to reimbursing those concerned for the cost, in the event of the experiment proving unsuccessful, of a wireless link for supplying the proposed Midland transmitter with modulation from the London television headquarters.

It is rightly stressed in the R.M.A. statement that the transmitting station itself will in any case be required sooner or later, and so there is no real excuse for delay in beginning construction. The transmitter that would be built can in no sense of the word be described as experimental, and it would be equally suitable for operating with picture signals supplied either by co-axial cable or a radio link.

Sir Noel Ashbridge, Chief Engineer of the B.B.C., has expressed himself publicly as being in favour of cables for television extensions, as he considers that they provide a neater and more workmanlike solution of the problem, and, above all, one that does not occupy valuable space in the ether. Although it may sound like heresy to admit it in a wireless journal, this is an opinion with which one cannot disagree, at any rate as applied to the permanent system that will, we may be sure, eventually supply the whole of this country with a television service. But for experimental extensions in the early stages the wireless link seems to

have much in its favour; its cost is considerably less than that of a cable and it is certainly more flexible.

In the opinion of the technical advisers of the R.M.A. there are no unsurmountable obstacles to the use of wireless, and this opinion is endorsed by Mr. Ralph R. Beal, Research Director of the Radio Corporation of America, who recently said: "R.C.A. engineers are confident that American cities will be linked by means of automatic radio relays, employing ultra-high frequencies. The practicability of such relays has been proved by exhaustive experiments."

If this country is to retain the lead it has gained something must be done quickly, and, from this point of view, the outstanding attraction of the wireless method of distribution is that it can be installed more quickly than cables.

Battery Portables

The "All-dry-cell" Type

ALTHOUGH America was slow in taking up the self-contained battery-fed portable receiver, she has, in one important detail, made amends for her tardiness. As described by a correspondent on another page, the latest American portables are equipped with dry-cell low-tension batteries.

We have for some time urged the use of this form of LT supply for broadcast receivers—and other apparatus—that is intended solely for intermittent and occasional use. Of course, over long periods of operation the accumulator remains the most effective and by far the most economical source of current, in spite of the improvement that has taken place in the better type of dry cell.

Auto Transformers

THEIR OPERATION EXPLAINED

By N. PARTRIDGE

THE auto transformer is a much maligned piece of apparatus. When recommending such an instrument, it is not at all unusual to be met by the retort: "Oh, I want a proper transformer, not a tapped choke." Remarks of this sort are nothing short of libellous. Not only is the auto directly descended from the greatly respected double-wound transformer, but it is an amazingly energetic offspring. It will handle more power, weight for weight, than its revered ancestor could contem-

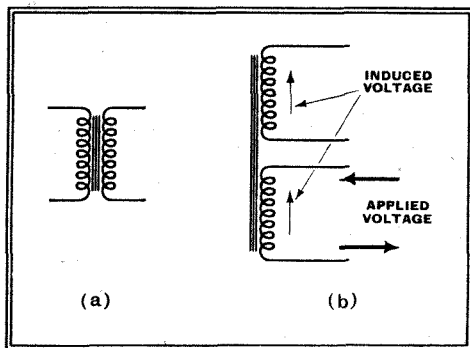


Fig. 1.—Two ways of symbolising a double-wound transformer; (a) is the more usual way but that of (b) serves better to follow the explanation given in the text.

plate without acquiring a feverish temperature and other symptoms of distress.

Fig. 1(a) shows the usual diagram representing a double-wound transformer. In order to make the ensuing discussion more readily understandable, we will redraw it in the form of Fig. 1(b). There is no reason why both windings should not be drawn on the same side of the core, and this proceeding involves less mental readjustment when we join the windings together and thus make an auto of it.

Suppose the primary, which we will assume is the lower winding in the diagram, is rated at, say, 100 v., 1 a., i.e., 100 watts. The DC resistance of this winding would be a matter of only 2 to 3 ohms. Yet, when 100 v. AC is applied (the secondary remaining open circuited) only quite a small current flows. On the face of it, Ohm's Law appears to be in error!

The explanation is that as soon as an alternating current passes round a coil it sets up an alternating magnetic flux in the iron core of the transformer. This in turn induces an opposing voltage in the coil which tends to prevent current from flowing. The state of affairs can be pictured by looking at the arrows in Fig. 1(b). The heavy external arrows indicate the applied voltage at any instant, while the

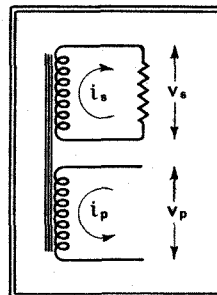
light arrow suggests the internally generated voltage. These two are pushing in reverse directions and almost cancel each other. The induced EMF is always slightly smaller than the applied voltage owing to losses and the inefficiency of the magnetic circuit, and, therefore, a small no-load current flows from the external supply.

It is not necessary for the reader to worry about the technicalities of how all these things come to pass, but it is extremely important to thoroughly understand that an opposing voltage is generated within the winding, and that it is this voltage that prevents a heavy current from flowing.

Since both the windings on our imaginary transformer are wound upon the same magnetic core, it is reasonable to expect that if a voltage is induced in one it will also be induced in the other. Such, indeed, is the case, as the application of a voltmeter to the open-circuited coil will readily prove. The induced voltage is found experimentally (and can be proved theoretically) to be proportional to the number of turns on the coil. In other words, a definite voltage is induced in each turn of the winding, and the total voltage exhibited by the coil will be the voltage per turn multiplied by the number of turns.

When the mains are applied to the primary of a transformer, everybody

Fig. 2.—The induced secondary current in a double-wound transformer flows in the opposite direction to the primary current.



knows that the various secondaries become "alive." But we have just discovered a vital point that normal experience does not reveal, namely, the direction of the voltage. The induced EMF in the secondary is always in the reverse sense to that of the voltage applied to the primary. If the secondary circuit be completed through a suitable load, current will flow through the winding in such a direction as to oppose the magnetising effect of the small no-load primary current. As soon as this occurs the back voltage in the primary falls and the primary current consequently increases (see Fig. 2).

Were this a serial story it would be a suitable moment to terminate the episode at this juncture, with the secondary doing its best to demagnetise the core, and the

THE main features of an auto transformer are explained in this article and it is then shown that a considerable saving in cost can be effected when conditions permit the use of components of this kind.

primary speedily drawing excess current in a desperate effort to hold its own. However, the sequel must be divulged at once and, as is not unusual with these things, it is somewhat disappointing. The invariable result of the struggle is a draw. The excess primary current ends up by exactly balancing the demagnetising effect of the secondary current, and the small initial primary current that flowed in the no-load condition continues its monotonous occupation of producing an alternating magnetic flux in the core.

Primary Current

It will be noted that the primary current (on load) consists of two parts. Namely, the magnetising or no-load current and the load current. The former is only a small percentage of the latter in a well-designed component, and can be left out of one's calculations so long as its presence is not entirely forgotten. Henceforth we will ignore its existence.

The magnetising effect of a current passing round a coil is proportional to the current multiplied by the number of turns in the coil. Since, under load, primary and secondary always balance one another magnetically, it follows that

$$i_p T_p = i_s T_s \dots \dots (1)$$

where T_p and T_s are the turns on the primary and secondary windings, and i_p and i_s are the corresponding currents. It has already been stated that the voltages of the windings are proportional to the turns and, therefore, it follows that

$$i_p v_p = i_s v_s \dots \dots (2)$$

which is to say that the watts put into the primary equal the watts going out of the secondary. This condition would be substantiated if iron and copper losses were

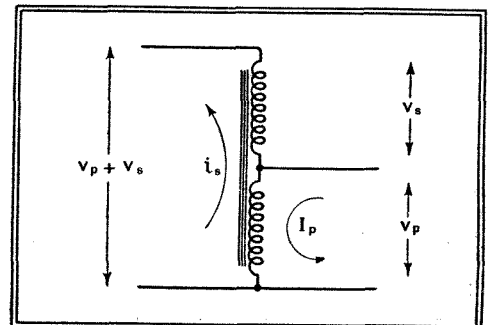


Fig. 3.—By connecting primary and secondary in series it becomes an auto transformer.

Auto Transformers—

non-existent, and it is approximately true in practical experience if the transformer is a good one.

Having understood the general principles of transformer action, it is easy to grasp what occurs when the windings are auto connected. Fig. 3 shows the transformer of Fig. 2, arranged in auto fashion with v_p and v_s the original primary and secondary voltages. Under the new scheme the total output voltage becomes $(v_p + v_s)$ since the windings are joined together with their induced voltages in the same sense. I_p and i_s represent the load current drawn from the mains and that passing through the secondary load. Note carefully that I_p is the current drawn from the mains and not necessarily the current passing through the primary section of the winding.

Current in Auto Transformer

A critical examination of Fig. 3 will reveal that while the upper section of the winding, i.e., the original secondary, carries the secondary load current (i_s), the lower section, i.e., the original primary, carries both the input load current (I_p) and also the secondary current (i_s). These two currents are in reverse directions and the true current passing through the conductors of the primary winding is $(I_p - i_s)$. If we can show that $(I_p - i_s) = i_p$ the transformer will function quite happily because the currents carried by the upper and lower

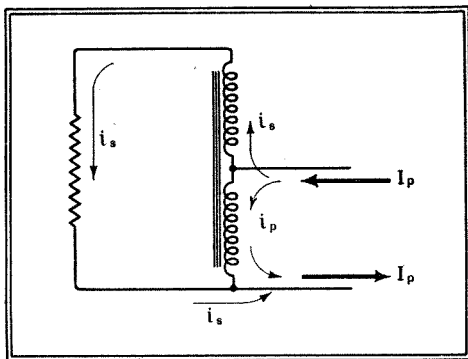


Fig. 4.—The current flow and voltages in an auto transformer are shown here.

sections of the winding will be the same as they were originally, although the output has been increased from $i_s v_s$ to $i_s (v_p + v_s)$ watts.

The proof is not very difficult. For a condition of equilibrium we know that a state of "magnetic balance" must exist between the two sections of the winding. The demagnetising effect of the secondary is proportional to $i_s T_s$ and the magnetising effect of the primary is $(I_p - i_s) T_p$. It follows that

$$i_s T_s = (I_p - i_s) T_p \dots \dots \dots (3)$$

Earlier it was shown that "magnetic balance" resulted when $i_p T_p$ equalled $i_s T_s$ (see equation 1). Thus by substituting in equation (3) we conclude that

$$i_p T_p = (I_p - i_s) T_p$$

and if both sides are now divided by T_p we achieve our object by proving that:—

$$i_p = I_p - i_s \dots \dots \dots (4)$$

A common sense method of visualising

what happens without fussing around with algebraical symbols is illustrated in Fig. 4. The load current drawn from the mains (I_p) splits into two parts when it reaches the transformer at the junction of the two windings. One part turns to the right and becomes the secondary load current (i_s), while the remaining part (i_p) goes to the left through the lower or primary winding. Hence $i_p = I_p - i_s$ as before. These two currents, i_p and i_s having completed their various journeyings, link up again on

wound. Note that when the transformation ratio is 2 : 1 the current through both sections of the winding is the same, and hence the same gauge of wire can be used throughout. This is the practice adopted for autos designed to operate between the 100 to 120 V and the 200 to 250 V ranges.

Example 3.—Input 230 V, output 4 V, 40 watts.

The input current is 40 divided by 230, which is 0.174 amp., and the output current is 10 amps. ($40 \div 4$). The current

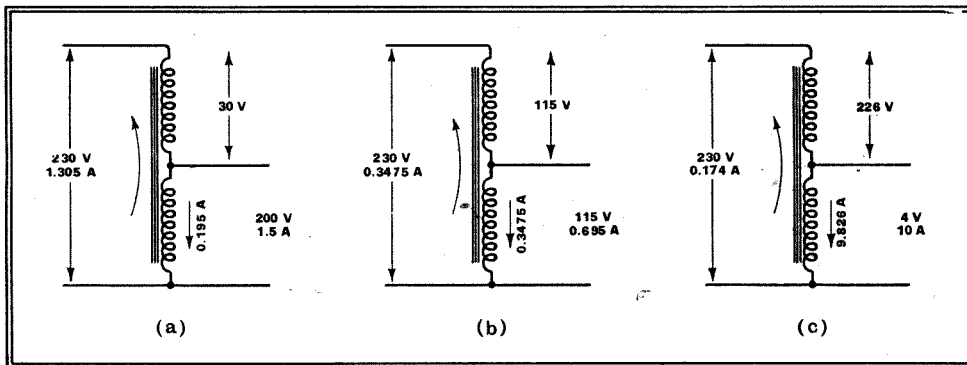


Fig. 5.—Three examples of auto transformer; the method of calculating current distribution is explained in the text.

leaving the transformer and proceed home to the local power station as one (I_p).

Having elucidated the problem of how an auto works, the solution should not be discarded in the manner of a finished crossword puzzle. The fact that i_p equals $I_p - i_s$ can be extremely useful and transformer manufacturers who know about it can often save a lot of money by its conscientious application. A few examples will make this clear.

Example 1.—Input voltage 200 V, output 230 V; 300 watts. The input current will be 300 divided by 200 which equals 1.5 amps, and the output current is 300 divided by 230 which equals 1.305 A. Current through the common portion of the winding becomes $1.5 - 1.305 = 0.195$ amp. (see Fig. 5 (a)). The apparent wattage of each section of the winding is: $200 \times 0.195 = 30 \times 1.305 = 39$ watts.

It follows that this 300-watt auto transformer could be assembled on a core that would accommodate only 40 watts if double-wound.

Example 2.—Input voltage 115V; output 230 V, 80 watts.

The input current will be 80 divided by 115 = 0.695 amp., and the output current 80 divided by 230 = 0.3475 amp. Current through the common portion of the winding becomes $0.695 - 0.3475 = 0.3475$ amp. (see Fig. 5 (b)). The apparent wattage of each section of the winding is: $115 \times 0.3475 = 115 \times 0.3475 = 40$ watts.

Again the core required will be one capable of handling 40 watts when double

through the common portion of the winding is therefore $10 - 0.174 = 9.826$ amps., and the apparent wattage of each portion of the winding is:—

$$226 \times 0.174 = 4 \times 9.826 = 40 \text{ (approx.)}$$

It is evident from the above calculations that the saving is greatest when the input and output voltages are of the same order, i.e. when the transformation ratio approaches unity. In fact, when the ratio is unity the transformer vanishes and is not wanted at all whatever the power! At the other end of the scale, Example 3 indicates that little advantage is to be gained by auto connecting when the ratio is large. A point that might well be mentioned here is that for the purpose of preliminary calculations it does not matter which way the auto transformer is working, i.e. stepping up or down. This will influence only the

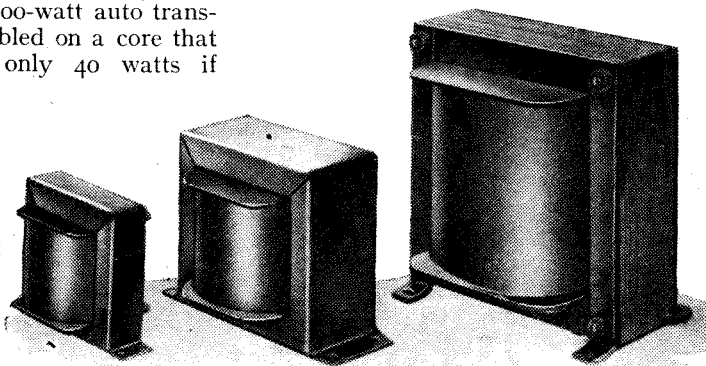


Fig. 6.—All these transformers handle the same wattage but the smallest and medium-size models are auto-wound. The largest weighs 29½ lb., the medium-size one 12 lb. and the smallest 3¼ lb.

small allowance that should be made in the final design for the voltage dropped in the windings.

The photograph shown in Fig. 6 brings out in a striking manner the economy that can be effected by the use of properly de-

Auto Transformers—

signed auto transformers. Each of the three transformers illustrated is rated at 500 watts and the complete electrical de-

The reader can verify his understanding of the foregoing by calculating from the information given in Fig. 7 what wattage could be accommodated on the two smaller

knob in an anti-clockwise direction the spindle B moves towards minimum, and at a point near minimum the pin P enters the slot S. Spindle A then starts to move. This is only possible due to the fact that the cam face C at this point ceases to lock with cam D, as indicated at (b). In diagram (c) spindle B has moved nearer to minimum and spindle A has completed half its travel. At the point when the pin is about to leave the end of the slot, spindles A and B have both reached minimum. Throughout these movements both spindles remain interlocked either by the slot and pin or the cam surfaces, and stops at minimum and maximum of control B prevent the pin P from leaving the slot S.

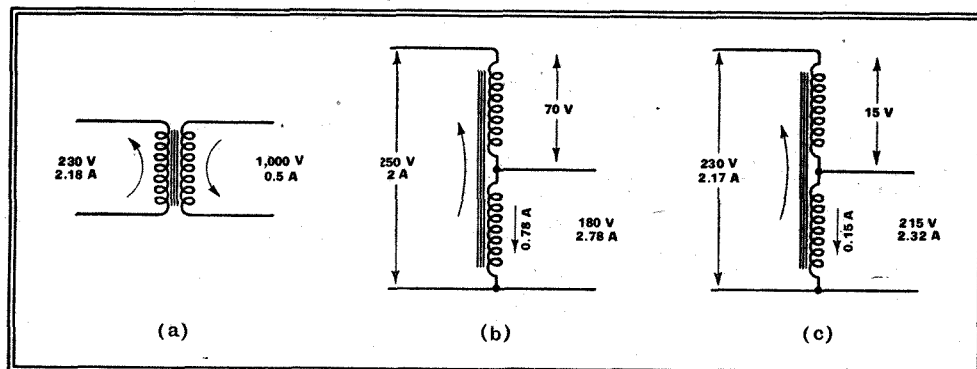


Fig. 7.—Voltages and currents of the three transformers illustrated in Fig. 6 (a) the large model, (b) the medium-size one and (c) the smallest.

tails are indicated in Fig. 7. Were the two smaller items double wound they would have been the same size as the large one.

transformers if they were double wound. The answer is approximately 140 and 33 watts.

Single-knob Sensitivity Adjustment

COUPLING DEVICE FOR CONTROL SPINDLES

IT is nearly always found necessary to provide two controls for simple TRF receivers to enable, on the one hand, excessive input from strong local transmitters to be cut down, and, on the other, to provide adequate sensitivity for the reception of very weak stations.

In the interests of simplicity, it is highly desirable that these two controls should be operated from the same knob. This can be achieved by means of:—

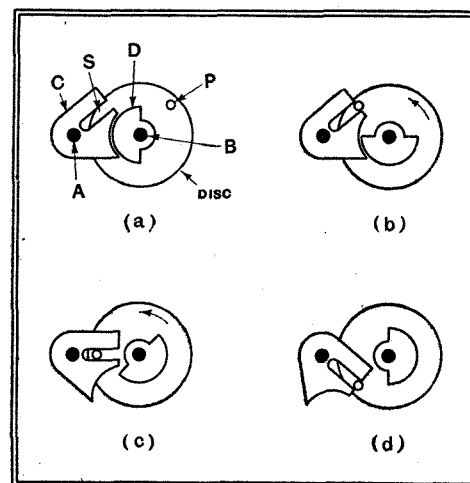
- (1) a three-electrode differential condenser;
- (2) a tapped potentiometer;
- (3) concentric knobs;
- (4) two controls ganged together.

Methods (1) and (2) have various technical disadvantages, and method (3) is not a complete solution. Method (4) may have the following disadvantages:—

- (a) Undue space may be taken up in attempting to couple two standard components.
- (b) To overcome disadvantage (a) it will be necessary to design special controls having a common spindle.
- (c) Unless components of special design are used both controls will operate simultaneously, whereas it is desirable that one should complete its travel before the second comes into effect. Further, the second should be brought near zero before the first commences to reduce the input.

A mechanism has been evolved which overcomes these three difficulties. It is simple in operation and takes up very little space.

It couples two spindles, mounted in parallel planes, in such a manner that the



Showing different stages in the operation of the coupling mechanism described in the text. The coupling would be suitable for linking, say, an RF gain potentiometer and a reaction condenser in a simple "straight" receiver.

first control moves to maximum before the second advances considerably, and remains at maximum while the second continues on its travel towards maximum. On returning the second control to minimum the first control does not start to decrease until the second has almost reached a minimum value itself. The mechanism is shown in the accompanying sketch in four positions in order to make clear the principle of operation.

The two controls have spindles A and B respectively. On spindle A a cam is mounted, having a slot S. On spindle B a cam and disc are mounted. A pin P is fixed to the disc. The knob is mounted on the spindle B. At (a) both controls are shown at maximum. On rotating the

PROBLEM CORNER—18

An extract from Henry Farrad's correspondence, published to give readers an opportunity of testing their own powers of deduction:—

All Hallows School,
Berkhamsted.

Dear Henry,

During the hols. my people were having a refrigerator put in ready for the summer, and as it made quite a row in the domestic radio I thought I would have a shot at suppressing it. I wanted to use the smallest coils possible, but the current-carrying capacity question then arose. As I haven't an AC ammeter I tried working it out from the house meter, and although the coils I got should be all right I find they get quite hot. Would you mind checking over my line of thought, because I can't see anything wrong with it?

The meter is marked "900 revs per kWh," and the voltage is 240. When the fridge is on (and nothing else) it does two revs in exactly one minute. That would be 120 revs in an hour, so the watts ought to be $\frac{1,000 \times 120}{900}$, which I think is just over 133.

So the current ought to be $\frac{133}{240}$, which I make to be 0.55 amp. Seeing that the thing doesn't run continuously I should have thought coils advertised to carry half an amp would have been quite good enough, wouldn't you? Or have I slipped up somewhere?

Yours ever,
Tony.

Has he? And, if so, where? Turn to page 416.

"The Wireless Engineer"

THE properties and advantages of a new "all-glass" valve construction are given in the May issue of *The Wireless Engineer*, which is published at 2s. 6d. and is obtainable from booksellers or from the Publishers, Dorset House, Stamford Street, London, S.E.1. Among other articles in this issue is one in which the input impedance of self-biased amplifiers is discussed.

Editorial comment is made on an apparatus recently introduced in Germany for the direct measurement of the "quality" of coils. A monthly feature of *The Wireless Engineer* is the Abstracts and References section, compiled by the Radio Research Board, in which is given abstracts of the articles on wireless and allied subjects published in the World's technical press.

Frequency Modulation

ANTI-NOISE BROADCASTING AND HOW IT WORKS

Again

TWO years ago¹ I had something to say about the Armstrong frequency modulation system. It was not new even then, but it is only in the last month or two that it has attained the supreme rank of "front-page stuff," as the lay Press has it. I am not now attempting to compete with the well-known organs of journalism in the matter of picturesqueness of description or the wealth of imagination with which they decorate these highly technical matters, but perhaps the tendency for this enthusiasm to lead to a loss of proportion needs some corrective. For example, the solution of some great technical problem that has exercised the minds of the experts for a generation is much more likely to qualify for the status of "front-page stuff" if an unimportant by-product of the thing happens to cause tabby cats to turn light blue and refuse fish. To appreciate the really important features of a technical achievement it is generally necessary to know something about the subject, and the lay writer suffers from the handicap of being unable to assume even the desire for knowledge except of the most superficial kind.

The Basic Problem

My readers, on the other hand, probably know already that the problem in radio nowadays is not so much how to get the "signal" across as how to exclude "noise." "Noise" in this sense means interference due to a great variety of causes—atmospherics, disturbances caused by electrical appliances, other stations, valve and circuit fluctuations, and so on. It isn't an ideal term, I know, but the American "static" is far worse (*static* means "at rest"). Put concisely, signal/noise ratio is more important than signal strength. If it were not for noise, the range of even a low-power transmitting station would be almost unlimited. If

you have ever worked an extremely—one might perhaps say *excessively*—sensitive receiver you will have realised that almost every station in the world can be brought in, but only a few of them are worth having. On a thundery day it may be that only the local station is clear of noise; perhaps not even the local station.

Hitherto, the method of tackling this problem has been to use brute force. The power of the largest broadcasting stations, which used to be $1\frac{1}{2}$ kW, has gone up in turn to 5, 10, 25, 50, 100, 120, 150, and even 500, in the attempt to keep above the rising flood of noise. Of course, this tends to increase the interference trouble. Already one of the 500 kW fellows—Cincinnati — has been told to come down to a more reasonable level.

The main object of frequency modulation is to cut through the noise without excessive power. It has been demonstrated that a frequency modulation station of, say, 1 kW, gives as good a service as an amplitude modulation station of perhaps 20 kW or more. Why? Well, it is not at all easy to see exactly, but some idea can be got by considering how "noise" affects a receiver of the ordinary type. Looking at Fig. 1, (a) shows a typical sample of the waveform received from a broadcasting station. The sound is conveyed by variations in the *amplitude* of the carrier wave; in other words, it is amplitude-modulated. Most of the noises have waveforms something like (b); often much stronger than the transmitter's wave, but very short-lived. The effect of these sudden blows is to jerk the tuned circuits of the receiver into oscillation at whichever frequency they are tuned. The signal amplitude is therefore disturbed, and besides the broadcast programme one hears crackles and bangs.

Now contrast the reception of a frequency-modulated station. The receiver is of a special design, and is arranged to be unresponsive to variations in amplitude. So ordinary stations and noise are not heard. At least, not nearly so much.

The transmitter sends out a carrier wave of constant strength, and the sound is imposed on it by causing its frequency to vary to and fro around the normal frequency. The receiver is designed to translate these frequency variations back into sound.

That is a very rough and ready explanation.

By "CATHODE RAY"

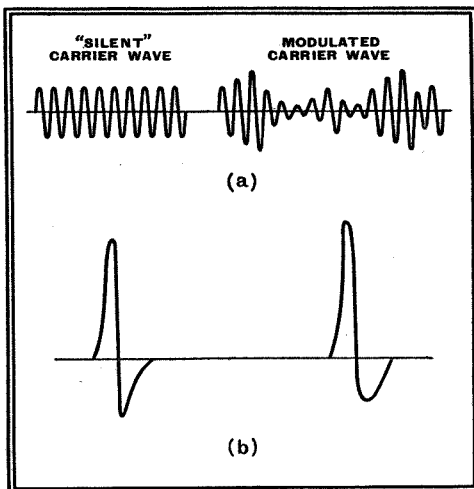


Fig. 1.—The waveforms of (a), an ordinary broadcasting station and (b) noise.

tion. Actually, there is very much more in Armstrong's system. It would be possible theoretically to convey a programme with only a small variation in frequency, but the discrimination against noise would then be small, too. To get the full benefit of the method the frequency is made to vary over a wide band—about 60,000 cycles each side of normal. That covers the space allotted to about a dozen ordinary broadcasting stations, so a frequency-modulated station has to be treated like a television station and pushed into the ultra-short wave department where a hundred kilocycles or so doesn't matter very much.

The Methods Compared

Those who have forgotten my previous article on frequency modulation, or never read it, may be a bit confused about the difference between these two methods of modulation, knowing that the common or amplitude modulation system also covers a band of frequencies. That is quite true. Any elementary textbook on radio explains how a variation in amplitude of a constant-frequency wave, as shown in Fig. 1 (a), is equivalent to the combination of a constant amplitude wave and waves of slightly different frequencies (the "sidebands"). But here is the distinction—in such a system the difference in

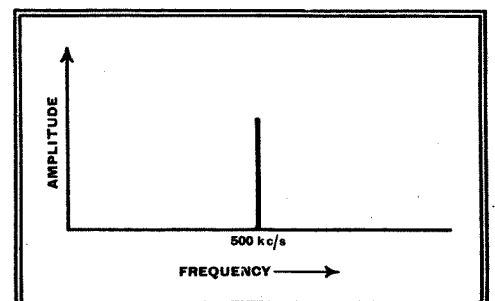


Fig. 2.—Amplitude/frequency diagram of a silent carrier wave transmitting at 500 kc/s.

¹ "Noise," January 15th, 1937.

"Frequency Modulation," July 16th, 1937.

Frequency Modulation Again—

frequency between the original carrier frequency and these sidebands is fixed by the frequency of the modulation; whereas in frequency modulation the frequency of the carrier wave itself fluctuates, to an extent that has nothing to do with the frequency of the modulation. It sounds very confusing in words, I'm afraid, but the idea is easy to grasp from simple diagrams representing the result of broadcasting a 1,000-cycle tuning note on a 500-kc carrier wave. In either system the unmodulated carrier wave would be represented as in Fig. 2—a single fixed frequency. In the common AM system the effect of varying the amplitude at a frequency of 1,000 c/s is to produce two more waves, differing 1,000 c/s from the carrier (Fig. 3). A strong sound is shown by (a), a weak one by (b). In FM the frequency of the carrier is varied to and fro 1,000 times a second (Fig. 4). The extent of the variation corresponds to the strength of the sound, so strong and weak are again shown by (a) and (b) respectively. Suppose now that the frequency of the modulation—that is to say, of the sound that is heard—is raised to 2,000 c/s; the effect in Fig. 3 is that the two outside vertical lines spread out twice as far from the centre line, whereas in Fig. 4 there is no visible change, but the line has to be imagined to vibrate to and fro twice as many times per second.

The above simple explanation is rather misleading, because it would lead one to suppose that a frequency-modulated

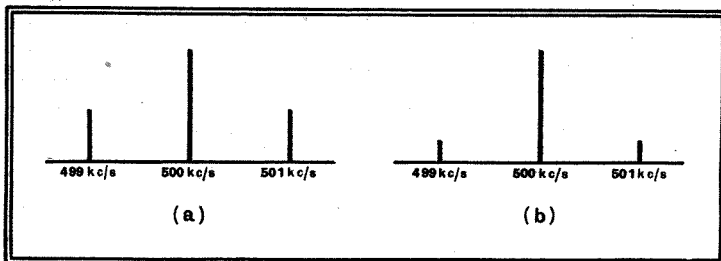


Fig. 3.—The same carrier wave as in Fig. 2 when modulated by a 1,000 c/s note, (a) strong, (b) weak.

station could be made to operate within a narrower band of frequencies than an A-M station. In fact, even the experts thought so at one time, until a certain Mr. Carson proved mathematically that the frequency band covered by a transmitter could never be less than twice the greatest modulation frequency; which put a permanent end to hopes of packing stations closer together in the frequency scale. However, that is not what Armstrong was after.

High-Power Tests

In his most recent demonstrations he used two ultra-short wave transmitters; one high-power station, 40 kW on 42.8 Mc/s (just about half-way between the Alexandra Palace sound and vision frequencies), and a low-power station, 0.6 kW, on the still higher frequency of 110 Mc/s (about $2\frac{3}{4}$ metres). The first ought to be pretty good, of course, being of far

higher power than any other ultra-short wave station in the world, though less than the average medium-wave "main" broadcasting station; and it has been received consistently at 275 miles distance. But at 50 miles even the low-power station gives results better than ordinary broadcasting stations a hundred times more powerful, at the same distance, the superiority being more marked the worse the conditions of noise prevailing at the receiving station.

Another advantage is that there is a further saving at the transmitter due to the very nature of the modulation. As the amplitude is kept constant the transmitter does not have to be designed to cope with the peaks of amplitude that occur in amplitude modulation, and which for a given average radiated power necessitate far larger and more expensive valves, power plant, etc. Then, for the same reason—constancy of amplitude—there is no objection to the use of "Class C" amplification in the output stage of the transmitter, giving a higher power efficiency than the methods that are generally necessary for really high quality in amplitude modulation. Still another point in favour of FM, so far as the transmitter is concerned, is that no drastic results follow if there is accidental

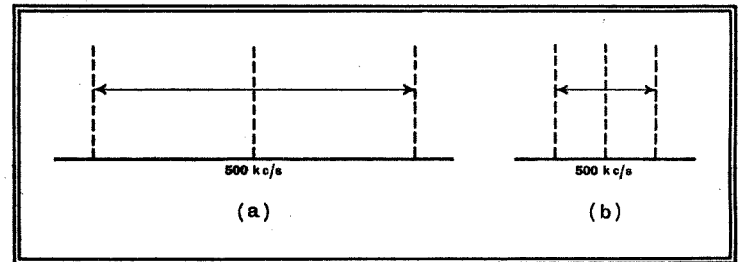


Fig. 4.—Diagrams, corresponding to Fig. 3, for a frequency modulation transmitter.

over-modulation. With the AM transmitters the control engineers have to be extremely vigilant in preventing the audio signal supplied to the transmitter for modulation from exceeding a certain amount. Not only would it cause distortion, but it might

lead to serious and expensive damage and breakdown. In a demonstration of the Armstrong system the modulation was increased up to nearly six times the normal limits, and there was not even noticeable distortion up to three times. Much smaller increases would be absolutely fatal in AM.

On the other side of the balance sheet, the system is far more complicated, and about 50 valves are used in the preliminary stages. That may sound a lot, but remember the 1,079-valve receiver I referred to a few weeks ago. And, although they are at the transmitting end, these preliminary valves can be small receiving types, and it would not be uneconomical to duplicate the whole system for guarding against breakdown. The original oscillation is at 200 kc/s (same as Droitwich long-wave station); and modulation is introduced at this stage, producing a small shift in phase, that is to say, a fraction of each cycle. The carrier fre-

quency is then multiplied time after time till it reaches 12,800 kc/s; it is whisked back to 891.6 kc/s by a frequency-changer stage as in a superhet; and then multiplied again until it reaches the final 42,800 kc/s. By the time all this has been done the modulation is 120,000 c/s wide (60,000 each side of normal). Then the power is amplified in several stages up to the full output.

At the receiver there is no constructional

advantage; in fact, it seems inevitable that it must be rather more complicated and costly than an AM receiver. From information available, however, it does not look as if the extra cost need be out of proportion to the increase in performance. This advantage in performance consists, first, as I said, of cutting out most of the noise. Listeners at the demonstrations were greatly impressed by the dead quiet background. The other thing that impressed them was the extremely high fidelity of the reproduction. This was made possible by working in the ultra-short waveband, allowing frequencies up to 15,000 c/s without the interference that would be inevitable at 50-mile range in the medium band. Of course, that is no monopoly of frequency modulation; any ultra-short wave station can be allowed to spread enough to take in the highest programme frequencies. But, with AM, the wider the band the more liable to noise,

Our cover illustration shows the aerial tower of Major Armstrong's experimental frequency-modulated station at Alpine, New Jersey. The radiating system, relatively insignificant in size as compared with the tower, can just be seen between the extremities of the upper and intermediate arms.

whereas the opposite applies to FM of the Armstrong brand; and a lot of the naturalness of reproduction was stated to be due to the complete absence of background. So FM can be said to improve the quality actually attainable under working conditions at a distance from the transmitter.

The one type of interference that has been found to break through—though much less badly than with AM—is car ignition, because, as ill-luck would have it, this is the type of interference that FM is least effective against, as well as being by far the most vicious on USW.

Well, it would be very nice to have some FM stations for the quality merchants to practise on, but the B.B.C. will have their hands full for some time to come develop-

Frequency Modulation Again—
ing the television service, and are not likely to put up stations that would be of no use to existing receivers. On the other hand, it seems hardly likely that such a worked-out invention will be allowed to lapse. One must certainly congratulate Armstrong and his co-workers on their achievement in the face of all previous

theoretical assumptions and established precedent.

By the way, seeing that the Alexandra Palace station is systematically received in U.S.A., is it not time that somebody reported the much more powerful Armstrong station over here? Given a suitable receiver, the FM characteristics ought to give good reception.

Cheap Valve Voltmeter

SIMPLE WIDE-RANGE MEASURING INSTRUMENT
USING A DIODE

TO the serious experimenter, a valve voltmeter of fairly wide voltage range and reasonable accuracy is a very necessary instrument. It has an enormous number of uses, for both audio- and radio-frequency measurements. Unfortunately, many voltmeters of a suitable type are expensive. With a view to producing a valve voltmeter of sufficient accuracy for the normal needs of the experimenter, and which may be easily constructed and calibrated, the instrument described below has been designed.

Perhaps the simplest voltmeter to construct is the leaky grid or anode-bend triode type. The anode current, or rather the change in anode current, is a measure of the AC voltage applied to the grid of the triode and usually this involves the use of a calibration chart or curve. Anyone who has used this type of meter knows that, although great accuracy can be obtained, the calibration curve can be a great nuisance and unless permanently fastened to the meter in some way, has a nasty habit of getting lost. In any event if great accuracy is not required and speed is important a direct reading meter saves a great deal of time.

The writers, therefore, have overcome these difficulties by designing a meter, having a reasonable input impedance, with which any alternating voltage from between 1 volt to 300 volts can be easily read directly on the scale of the meter.

To make the instrument as simple as

possible a 2-volt triode is used connected as a diode. A diode of the type used for rectification in superheterodynes, or for supplying AVC was not used, as it was found that the zero space current is too high.

The most expensive item in all instruments of this type is usually the meter used to read the current flowing through the diode. To obtain a fairly wide range at a reasonably high input impedance it

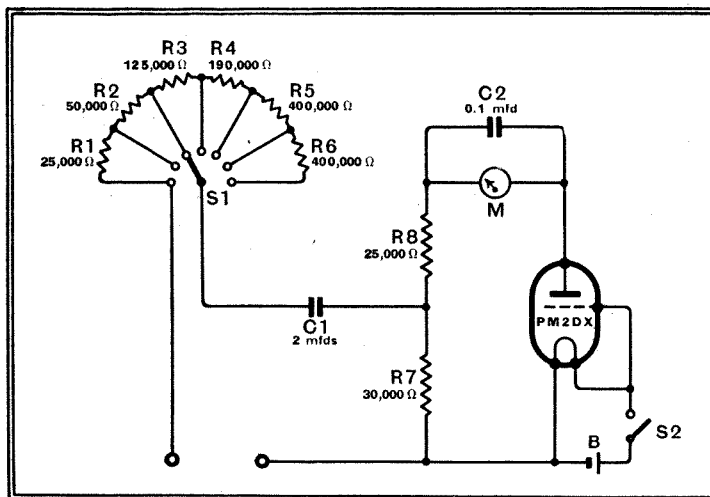


Fig. 1.—The voltmeter itself is of fixed range and a wide variety of input voltages is catered for by the input potentiometer, which is controlled by the 7-way switch S1.

was decided to use a meter having a maximum reading of 50 microamperes.

The particular instrument used is

The underside of the panel is shown here together with the LT accumulator.



An exterior view of the instrument.

obtainable at a low price and has the required accuracy; it is a Leslie Dixon 0-50 microammeter. The circuit diagram of the voltmeter is shown in Fig. 1 and the photographs show the completed instrument. It will be seen that it is self-contained and very compact.

A Mullard Type PM2DX valve is used, but any valve having similar characteristics may, of course, be employed. It will be noted from an examination of Fig. 1 that the control grid is connected to the positive end of the filament. This is done to reduce the standing space current. It was found that with the grid connected to the anode the space current was about 5 microamps, but with the connections as shown this value dropped to about 1 microamp.

The ranges of the meter illustrated are as follows: 5, 10, 20, 50, 100, 200, 300 volts maximum, using a seven position switch, but these may, of course, be altered to suit individual requirements. As the meter is scaled 0-50, no calibration curve is necessary and the voltage reading is obtained by multiplying by a simple factor. It was found that the readings were accurate to about plus or minus 5 per cent. using standard resistances.

Calibration, that is to say, checking the accuracy of the ranges, was carried out at 50 c/s using an Avometer, and it is felt that this is probably the best method.

The frequency characteristic of the instrument is good and the writers feel confident that in view of its extreme simplicity the time and money spent on its construction will be well repaid.

Apart from the general uses at radio-frequency the meter is suitable for all audio-frequency work and, of course, for checking valve heater voltages.

