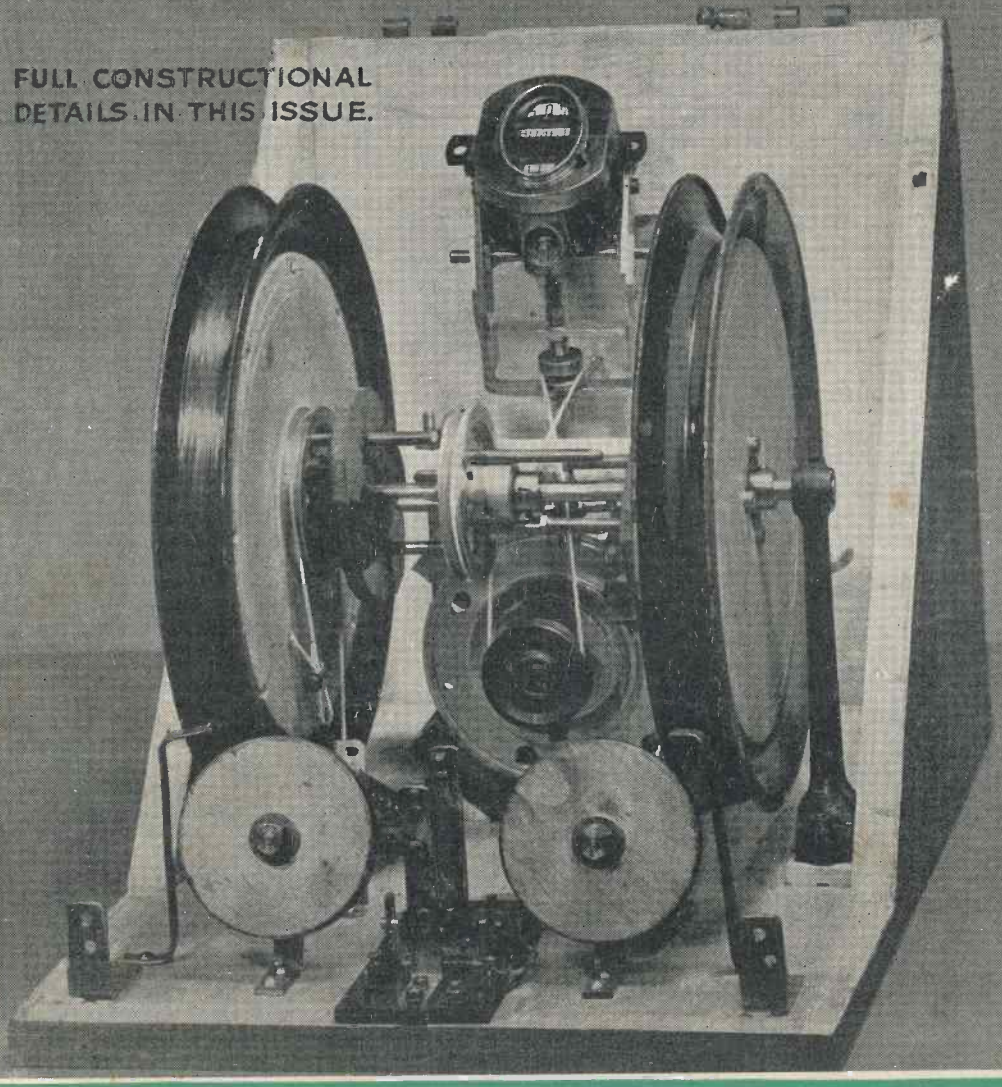
ELECTRONICS AND TELEVISION & SHORT-WAVE WORLD

JANUARY, 1940

1/6

STEEL-WIRE RECORDING APPARATUS

FULL CONSTRUCTIONAL DETAILS IN THIS ISSUE.



THE FIRST TELEVISION JOURNAL IN THE WORLD

BERNARD JONES PUBLICATIONS LIMITED LONDON

No. 143. Vol. XIII. JANUARY, 1940.

Electronics AND TELEVISION AND SHORT-WAVE WORLD

EDITORIAL, ADVERTISING AND PUBLISHING OFFICES
CHANSITOR HOUSE, 37/38, CHANCERY LANE, W.C.I

Editor-in-Chief : BERNARD E. JONES
Editor : H. CORBISHLEY, F.T.S.

Telephone : HOLBORN 6158, 6159 & 2857
Telegrams : BeeJaPee, Holb., London

Subscription Rates ; Post Paid to any part of the world—3 months, 5/– ; 6 months 10/– ; 12 months, 20/–. Published monthly, 1/6 net, first day of the month. Proprietors : BERNARD JONES PUBLICATIONS LIMITED.

News and Views

Valve Restrictions

THE new order issued by the Postmaster-General under the Defence Regulations, which is given elsewhere in this journal, has caused great inconvenience and some justifiable criticism in certain quarters. The clause which restricts the sale of both receiving and transmitting valves above 10 watts dissipation has imposed extra work and delay on the already worried radio trade. It would seem that the regulation has been framed by an official who is in possession of a battery receiver and who was not aware that 90 per cent. of mains operated sets have power output valves in excess of 10 watts. It means that the owners of receivers requiring valve replacements will have to fill up a form for permission to buy a new valve. The retailer will in turn fill up his form entitling him to sell the valve, and the wholesaler will send in a third form for permission to obtain the valve from the manufacturer. In the meantime the unfortunate listener is without his radio.

By the time this appears in print the Radio Valve Manufacturers' Association will possibly have taken steps to improve the position as far as possible. So far as restricting unauthorised transmission of messages is concerned, it is doubtful whether any such restrictions would have an effect on a determined enemy agent. Even an inexpert transmitting amateur would be capable of fitting up an emergency set with small valves and dismantling it immediately the message had been sent.

In the meantime, amateurs are advised not to try and dispose of their "junk" without due regard for form-filling, or they may find themselves at Bow Street.

"Most Worthwhile Development."—An astonishing result has been noted in the replies to the question: "What is considered to be the most worthwhile development in broadcasting during the last ten years?" The votes of U.S. radio engineers showed that 44 per cent. thought stabilised feedback the most important, 20 per cent. thought modern valves to be a main development, and only 5 per cent. voted for television! Presumably this census was taken before the U.S. television service had begun to operate. British radio engineers would have a different opinion. Readers are invited to send their views on a post card to the Editor.

Television and Radio Receiver Sales in U.S.A.—According to Dr. W. R. G. Baker, of the General Electric Company, New York, purchases of radio receivers during 1939 were seriously affected by the introduction of a television service in New York City, and this resulted in depressing the entire national market. Reaction to the great amount of publicity on television, plus the opening of the New York station, made it difficult to convert the potential purchaser of a radio receiver into an immediate buyer.

However, during the latter part of August and the first part of September, because of war news, the American public became radio-conscious as it had never been before, and the immediate effect was a very serious shortage of receivers.

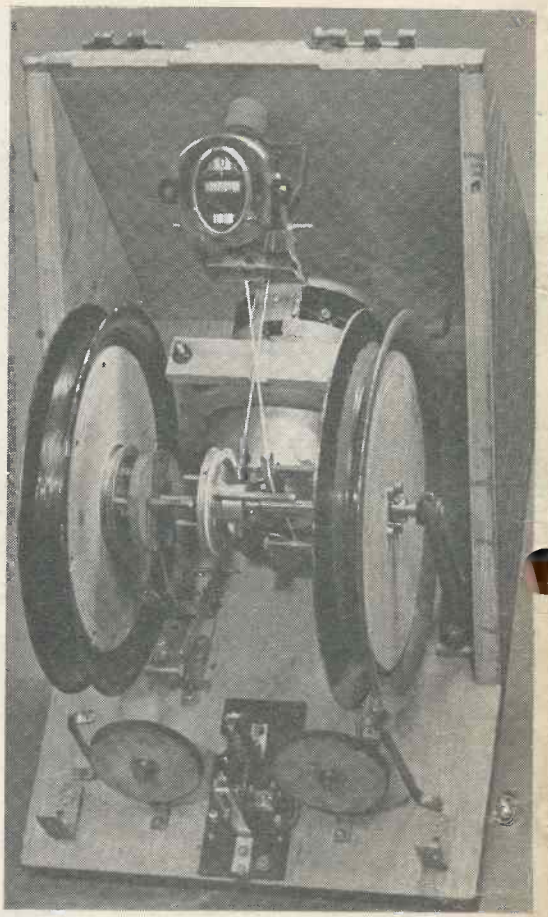
Frequency Modulation.—The Armstrong frequency modulated wave system of broadcasting recently introduced in U.S.A., has, as yet, had little effect on radio receiver sales. This system of broadcasting, which is simply explained on other pages of this issue, has three distinct advantages—high fidelity, considerable reduction in static, and extension of the service area of ultra-high frequency transmission. The general opinion is that when a frequency-modulated wave service is available on a national basis it may be expected that the present type of broadcast receiver will be gradually replaced by equipment capable of receiving both amplitude and frequency-modulated wave transmissions.

Robot Valve Tester.—An ingenious electrical circuit tester has been devised by the G.E.C. which automatically tests up to 50 individual circuits on a receiver and indicates which circuits are faulty. A selector switch is used to connect each circuit in turn, and all the 50 circuits are checked within one minute. The basis of each test is a form of bridge circuit in which the chassis circuit is checked against a standard. In the case of a fault a voltage is developed and amplified to operate a drop indicator or a neon indicator.

Construction of Apparatus for Recording Sound on Steel Wire

By Ronald L. Mansi, M.R.C.S., L.R.C.P., D.M.R.E. (Camb).

We believe this to be the first published description of apparatus, other than commercial, for recording sound on steel wire. Readers will appreciate that the field of application is very wide for practical, experimental and entertainment purposes.



View of recording machine. Note the wire coming off the drums round the guide wheels, and the simple arrangement for reversing.

THE construction of a machine for recording speech, music, etc., on steel wire or tape, although based on well-known principles and used commercially with great success, may be considered by some interested experimenters to be beyond their ability mainly on account of the mechanical problems involved.

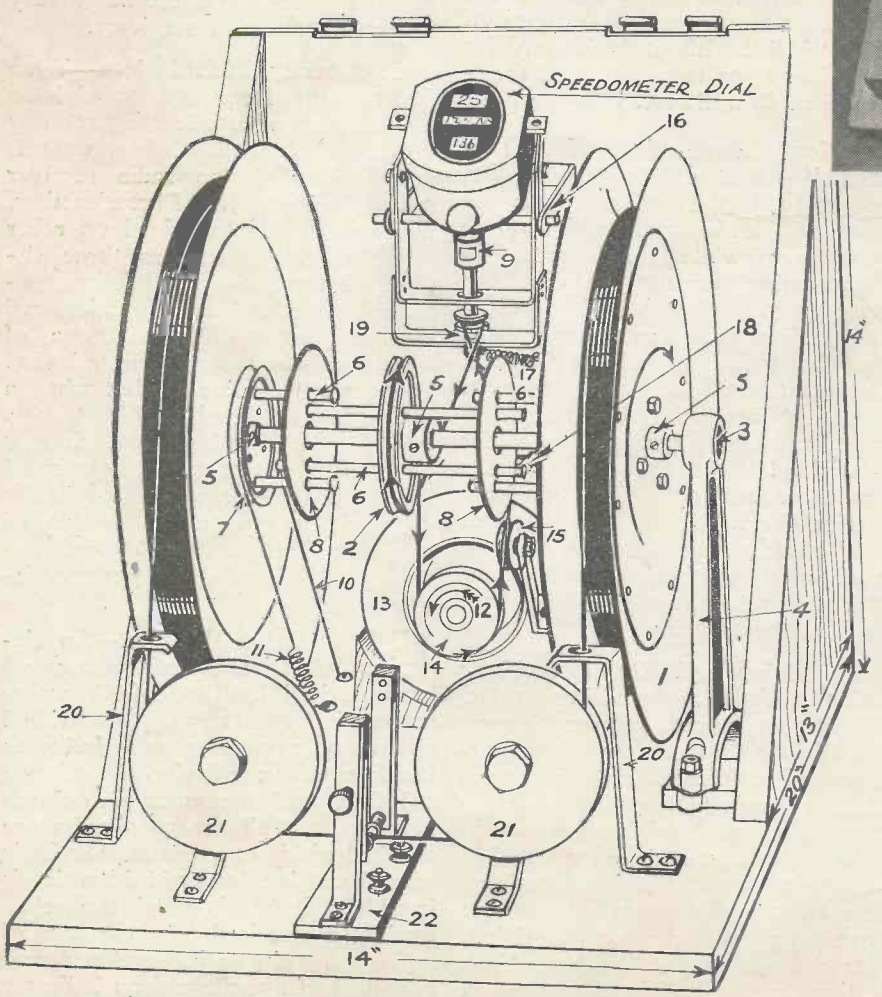


Fig. 1. This drawing shows the layout of units of the recorder. The numbers are referred to in the text later.

It is true that the commercial machine is a highly developed and expensive precision instrument but it has to cater for a greater diversity of circumstances than would be met with in limited use. It is, however, quite possible to build a successful machine with the tools and equipment found in the average home workshop and at a very moderate cost, considering the nature of the machine, since there are no specialised pieces of apparatus to buy.

The following is a description of a machine constructed by the author for such a purpose, and whilst a good deal of latitude may be allowed in the choice of some of the components, values and sizes given, there are a few details which must be rigidly adhered to for successful results and these will be noted in their place. If this is done, the constructor will find he has a machine which will give him amazingly faithful reproduction and hours of interesting experiment and entertainment.

It might be opportune to mention at this juncture that the author had no detailed data available of the commercial type of machine; the one constructed being worked out on first prin-

Magnetic Recording

ciples combined with considerable trial and error methods. The writer, therefore, makes no excuses for the type of construction described other than the results fully justify the work entailed.

It is proposed firstly to outline briefly the principles involved and the choice of components, etc., and then to proceed to the details of construction with diagrams.

Principles of Operation

The voice or music is picked up by a microphone in the usual way and passes through an amplifier. The output is then led to the recording head of the machine which consists briefly of one or two small electro-magnets of special type between the poles of which passes a steel wire or tape at a speed of approximately one to three yards per second, the speed varying according to whether speech or music, etc., is being recorded.

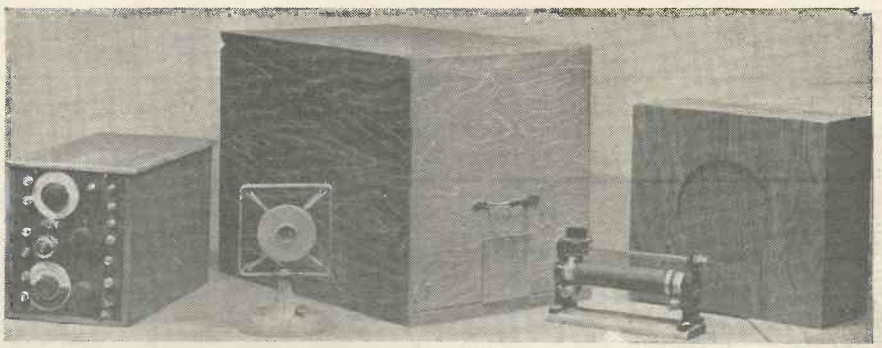
The speech, etc., is thus impressed on the wire or tape in the form of minute areas of magnetism varying in number, spacing, etc., according to the frequency of the sound vibrations being impressed. The wire or tape is reeled off a drum and after passing through the head is wound on to another drum and may be stored for an indefinite time until required. It should be noted that no visible or mechanical sound tracts whatever are impressed on the wire or tape which, to the eye, has the same appearance after as well as before a recording has been made on it.

When required to reproduce the recording, it is passed through the same head or another similar head in the same direction as recorded, the varying magnetism of the wire or tape so influencing the field of the electro-magnets that a faithful reproduction of the frequencies impressed on the wire or tape is produced in the electro-magnets in the form of minute electric currents varying in strength according to the frequencies picked up from the wire or tape. These minute currents are then passed through an amplifier to a loudspeaker in the usual way.

It should be noted that the quality or strength of any given recording on the wire or tape is not affected to any appreciable degree by repeated play backs.

When it is desired to wipe out a recording, the wire or tape is passed through a constant localised magnetic field which may well take the form of a head similar to the recording head through which passes a small constant current. The same length of wire may then be used again for further recording.

This treatment does not affect the recording properties of the wire in any way, in fact, the author has used the same length of wire for literally hundreds of different recordings without the slightest deterioration in quality or volume.



General view of the recording machine and associated apparatus (without battery). The microphone is the original carbon diaphragm type. Amplifier is on the left, loudspeaker on the right, machine in centre and time control variable resistance in foreground.

In some systems, a small magnetising current is used during recording to "set" the wire or tape at its correct magnetic "threshold" for making the most satisfactory recording, but the author found after repeated experiment that it was not necessary with the type of wire and machine to be described; in fact it was difficult to control, apt to introduce background noises and added to the complication of the machine which it was desired to avoid.

This, of course, does not imply that it is unnecessary in some types of machine, but merely that it was not found necessary with the type of wire used by the author.

Advantages of Magnetic Recording

The advantages of this method of recording over the usual metal or composition disc and needle recording method are many, perhaps the foremost being the ability to wipe out a recording and use the same wire again. This may not appear at first thought to be such an advantage, but anyone who has done considerable recording on discs will recall the large number of discs that accumulate which have been spoiled in recording (the writer's experience). Good quality coated glass discs are expensive, surface noise is difficult to eradicate consistently, and actually there are not such a large variety of home recordings that one would wish to keep permanently. In addition disc recordings undoubtedly suffer after being played several times, and care must be used in handling them.

The chief value of recording machines, apart from their scientific interest, is to provide good entertainment. The machine described will record speech continuously for nearly three-quarters of an hour if necessary (for music a somewhat shorted period), and there is no reason why, with a few modifications, it could not be made to record for a longer time.

If there is any particular recording that it is desired to keep, it is reeled off the drum, wound on a separate spool and stored away.

In the commercial machines, interchangeable drums are used, but this method is unwieldly on account of the size of the drums, and the author thought it desirable to exert the best efforts in making two efficient, accurate winding drums as permanent parts of the machine and to reel off any recording it was desired to keep permanently on to a smaller reel. When required it is wound back on to the main drum, and it must be ceded here that this is the one point in which wire or tape recording suffers by comparison with sound tracked disc.

However, there is nothing to prevent the construction of a set of interchangeable drums, or rims, in which case this disadvantage vanishes. The drums could be made quite cheaply as presently described.

With careful construction the reproduction in magnetic recording is amazingly true to the original and the background noise can be so reduced as to be negligible.

The steel wire used is exceedingly tough and strong for its size and the author has been unable to detect any signs of wear, even under the microscope, after hundreds of recordings. Incidentally all the guides for the wire are made of easily replaceable brass fittings which take the brunt of all the wear.

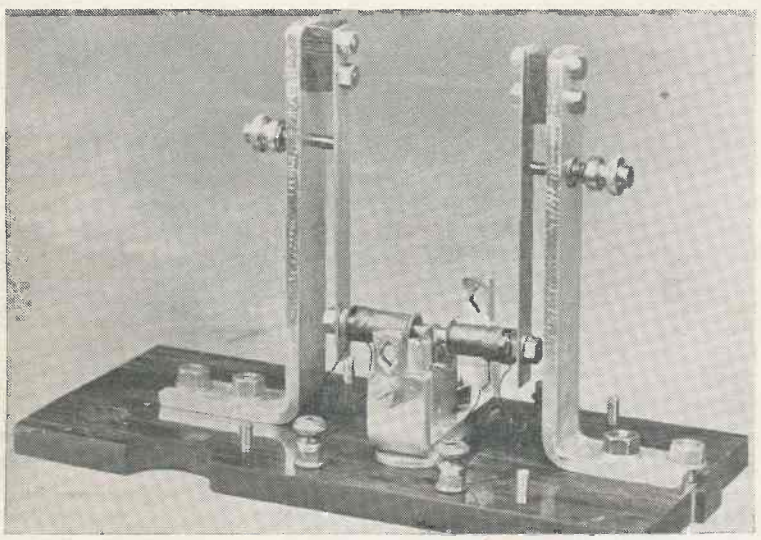
Another useful point is that rough handling of the wire (apart from kinking) will not affect the recording on it, about the only thing that will remove it being a localised magnetic field and, of course, high temperature (red heat).

There is no appreciable deterioration in quality or volume on repeated play backs and in addition the machine can be stopped, started or played back at any point in its run without detriment to the wire or the recording. The

One-hour Records

length of run obtainable without interruption, as occurs with the changing of a disc recording, is very useful especially with long musical passages.

The cost need not be excessive. Wireless parts for the amplifier are easily obtainable. The local car-breaker's yard provided the author with most of the heavier parts, including the driving motor, for a few shillings and the sixpenny stores provided many useful smaller parts. Although the possession of a lathe is a useful asset, there is no fine machining to be done, most of the fine work being done by hand.



Close-up of sound head. Felt pads on guide removed for clarity. This photograph shows a pair of experimental detachable guides screwed to the two outside limbs of the guide assembly. Packing piece shown inserted between the guide base and ebonite base is for adjusting height of wire. Pins projecting through base adjacent to the terminals are for holding the iron shields in place. (See text.)

The Wire

Since the wire might be called the heart of the machine it is considered opportune to describe it first. The author chose steel wire instead of steel tape for use in the machine for two main reasons.

(1) The cost of wire is very much less than steel tape and easier to obtain. It is true that the tape has been specially developed for this type of recording as regards magnetic characteristics, etc., but steel wire is thoroughly satisfactory in use. The author has had an opportunity of testing out some steel tape to compare it with wire and found that while it gave some increase in volume (which incidentally is easily made up in the amplifier when using wire) no doubt due to its greater area, the slightly improved quality did not justify the cost of a satisfactory length.

(2) Ease of winding and of compensating increase in winding drum diameter as it fills with wire.

In the machines utilising tape, the tape is wound on the drum layer upon layer similar to cinematograph film on a reel. It will be appreciated therefore that if the drum drives the tape by pulling it through the machine, as the tape piles up, the circumference of the spool gradually increases and thus the speed of the tape increases if the drum axle speed remains constant. Therefore, means of automatically governing the speed of the drums or separate driving wheels with the drums driven through slipping clutches have to be provided. All this can be avoided in using wire by starting with large diameter drums, say, ten to twelve inches diameter, and with fairly wide flanges, say, about one inch wide and about one inch deep.

It will then be found that hundreds of yards of wire can be accommodated in the groove and that the difference in the diameter at the beginning and end of a complete run is scarcely an inch (according to the length wound). As this difference forms but a small percentage relatively of the number of yards of wire passing through per second, it will be found in practice that this difference may be ignored. Therefore for recordings up to about one hour (speech or music) no provision need be made for compensation.

This simplifies the winding mechanism enormously and it will be found that the turns of wire pile themselves up side by side, on top and across each other in a seemingly hopeless tangle, but they always unwind without jamming if the few hints presently described are followed.

It is an interesting point to note that although the turns of wire on the drum are in close contact with one another, the magnetism on any one turn does not appear to interfere with or influence that on the adjacent turn to the slighest degree.

The wire should be of about 30 (thirty) gauge, that is .0124 in. diameter. The author used this gauge because it was found that weight for weight one obtains many more yards of wire (approximately 800 yards to the pound weight) than, say, 28 gauge with only a small relative increase in price and the wire, being more flexible, is easier to handle and to run through guides, etc., and round small pulleys.

In addition, since a wire has essentially a round section, there is much more "packing" space relatively wasted on a drum wound with a thicker gauge than with a thinner one, and the problem of drive compensation will creep in if a really long length is contemplated.

Thinner gauges than No. 30 are impracticable, since there is more chance of the wire breaking, kinking or binding.

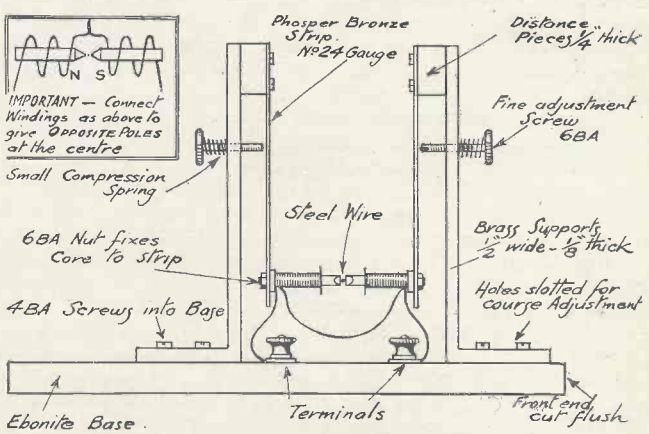


Fig. 2. Details of sound head. Approximately half full size.

Carbon Content

The carbon content of the wire is

Effect of Wire Speed

perhaps the most important item in the whole machine. It should lie between .8 and 1.2 per cent. Any wide deviation from this will court failure. If the percentage is too high the wire will be too brittle and will break easily; in addition it will be more difficult to magnetise with the speech currents. If the percentage is too low the wire will not retain the magnetic variations recorded on it. That type of wire known in the trade as "music wire" and used for making banjo strings, etc., will be found suitable but the carbon content should be first ascertained.

Speed of the Wire

The lowest speed of the wire consistent with good quality recording should be about one-and-a-half yards per second for speech and about three yards per second for music. This will be found to vary somewhat. Thus, a bass male voice will be found to make a good recording at a slower speed than a high-pitched lady's voice and so on. There is no noticeable improvement in quality of recording at speeds above those mentioned, although the author has noted, curiously enough, that there is an increase in volume on the play back coincident with increased recording speed, a fact which he has not seen described elsewhere. This is probably due to the fact that since, say, one syllable is spread over a longer length of wire in the faster recording, the effect is cumulative on the play back.

Conversely, there is a falling off in volume at the slower speeds, but it is interesting to note that even at very slow speeds one can still obtain intelligible speech but not quite recognisable as the original person's voice.

To provide this speed of wire, a drum of, say, ten inches diameter would only need to revolve at approximately one-and-a-half to two revolutions per second which is quite slow and facilitates the operation of the machine considerably, especially as regards the handling of the wire and mechanical silence. The author has bitter memories of his earlier machines with small high speed drums, which, should the driving drum inadvertently stop, produced considerable overrunning of the wire on the driven drum due to its momentum, with a resultant tangle of wire, cut fingers, etc. Incidentally, should such a mishap occur, which is extremely unlikely on this model, it is much wiser to cut out the tangled section than to attempt to straighten it, since the resultant length is always irregular and produces such loud crackles, etc., in the speaker as to render that length useless for recording. The two cut ends can be very simply brazed together in the following manner.

Joining the Wire

The two ends of the wire to be brazed are lightly clamped to a piece of non-metallic fireproof material (the author uses a small glazed tile) so that the two ends overlap for about 3/16 in. The smallest possible sliver of brazing spelter is carefully laid in the groove between the two overlapping ends, a pinch of brazing flux (borax) sprinkled on top, and a small pointed blowpipe flame directed upon it. The flame from a good spirit lamp or Bunsen burner used with a small mouth blowpipe (costing a few pence) is ample for this procedure and the knack is soon acquired after a few attempts. Direct only the tip of the flame on the proposed weld, trying not to let the flame encroach on the adjacent wire, and apply it only long enough for the spelter to run. The result is a good strong joint which has not destroyed the temper of the wire enough to make it too brittle for service. The author has not yet had one of these welds break in service; care, however, should be taken that the weld is not bent too acutely, in which case the adjacent wire will break but not the weld. File off any excess of spelter and bevel the ends of the wire, but perfection need not be aimed at here as provision is made in the recording head and guides to allow the welds to pass through without mishap.

Do not attempt to weld the wire by the oxy-acetylene flame, or by arc-welding, as the steel combines rapidly with the oxygen and burns like an indoor firework.

Since the wire, as purchased, is usually in hanks of about 200 yards it will be necessary to braze up several hanks according to the length of run desired, and here is a tip for getting the wire off a hank on to the drum. Do not hold the hank in the hand and reel it off in this manner. A tangle is sure to result; it takes a long time, and most important of all, it goes on to the drum with a continuous twist or torsion along its whole length. It thus acts like a long spring under tension on the drum and is bound to give trouble. It is better to make a small wooden split reel or pulley, the hank fitting snugly into the flange, which should be deep, and the two halves are then screwed together. A rod or screwdriver is slipped through a centre hole in the reel and clamped in the vice. The wire will then reel off easily and not under any torsion on to the drum. The beginning of the next hank can then be welded to the end and treated in like manner.

The Driving Motor

A spring-driven motor as used in some gramophone recording machines is out of the question here on account of the length of run and so an electric drive must be employed.

The author did not use a mains-driven motor for the following reasons.

A variable speed motor must be used which rules out a brushless motor, for example, an induction motor. Cheap fractional horsepower universal motors, that is, with brushes and commutator, are notoriously noisy mechanically and create a great deal of electrical interference, most undesirable in this case on account of its close proximity to the pick up head. Furthermore as the speed is cut down by means of a variable resistance the power or torque falls off considerably. Gearing must be employed to reduce the motor speed in addition to the variable resistance in order to provide a slow but powerful steady drive for the drums which adds to the complication and noise.

The author found the following type of motor answered excellently. For a few shillings a car-type dynamo was purchased from the local car breaker's yard. Most car dynamos are exceedingly well made with accurate multi-section, ball bearing armatures and long heavy brushes that give out very little electrical interference when used as a motor if a few precautions are taken.

A dynamo with third brush control was chosen for the following reasons. It will be appreciated that supposing a half-hour's recording has just been made and it is desired to play it back, if the audience have to wait half-an-hour whilst the wire is wound backwards to the starting point it will rather detract from the value of the entertainment. With a third brush control the motor speed can be varied from practically a standstill to full speed and with, what is most important, no serious falling off of torque, this varying, of course, with the type of dynamo used.

This is ideal for winding back the wire at many times the speed at which it recorded, completing in a few minutes what would otherwise be an inconvenient delay.

The third brush control is rather coarse for giving the fine speed variations necessary for the best recording, so that for this purpose, the brush control is left in its lowest speed position and the fine control accomplished by means of a variable resistance of about

The Sound Head

four ohms maximum and capable of carrying up to six amperes and connected in series with one of the main battery leads which should be of heavy wire.

The constructor will find that he is always faced with the compromise of getting the right speed consistent with good quality for different recordings, speech, solo instruments, bands, etc., and trying to make his wire run as long as possible, that is at the slowest speed. It is here that the fine control is of great value, and the knack soon acquired.

Some simple alteration in the wiring of the dynamo may be necessary. The author found it necessary to alter the

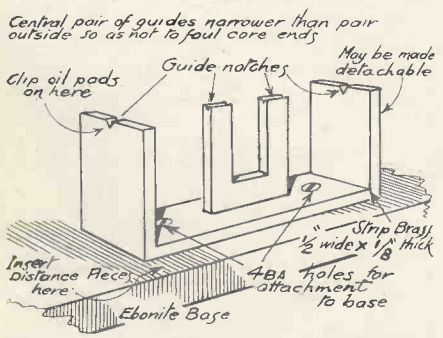


Fig. 3. General scheme of guide assembly placed at right angles to long axis of electro magnets.

winding from a compound series to a shunt winding. At recording speeds the motor will tick over silently and slowly with powerful torque and is connected to the drum drive by belt and pulley without any intermediate reducing gear.

A small metal arm with pointer attached is screwed to the third brush rocker gear and extends out of the side of the motor casing. This makes alteration of the position of the brush simple and the pointer indicates on a scale the setting of the moment. The current is derived from a 12-volt car-type accumulator and consumption is 2 to 3 amps. at recording speeds.

The method used to drive each drum alternately is described in the section on construction.

It is an added but not an essential refinement to incorporate some type of tachometer in the drive. For a further few shillings, the author purchased from the same car breaker's yard a car speedometer in good condition. With a few alterations (which will vary, of course, with the type purchased) this was suitably mounted in the drive and gives an accurate record of the speed of the drums, a very important factor in saving wire and at the same time obtaining good quality recording.

In addition to recording the speed, the trip recorder fractional mileage number (the red one) gives a useful record of the yards of wire used for, say, different recordings on the same run and enables the operator to start from, or return to, any required point. This reading is easily returned to zero when required by the usual small projecting lever.

The above remarks are meant to be representative of the type of motor used and designed to assist the constructor in adapting any motor he may have at hand, for example, a six-volt motor could be used with a probable increase in current consumption, or possibly a good quality silent mains motor with provision for varying the speed within wide limits.

The Recording Head

In the commercial machines it is customary to use three heads of somewhat similar construction; one for recording, one for playing back and one for wiping out the recording. It is thus possible to listen to the speech, etc., and check its quality, etc., as it comes from the recording head through the pick-up head.

The author found, however, that one head could be made to perform all three functions quite efficiently and thus save enormously on time, space, complication and maintenance, especially as the making of the recording head is probably the most delicate and tedious operation in the construction of the whole machine.

The advantages of a separate pick-up head are not so apparent for home recording for the following reasons.

(1) It must be clearly understood that the strength of current picked up directly from the wire is exceedingly minute and requires very considerable amplification to give good loudspeaker strength. Therefore, to give even good headphone strength from a separate pick-up whilst recording is going on, a separate amplifier will be necessary, the main amplifier, of course, being in use for the actual recording. This adds more complication.

(2) Since most home recording and playing back is done in the same room, it will be found that the actual voice of the person recording as he speaks into the microphone will interfere with and mask the finer variations of the same voice as it is picked up on headphones from a separate pick-up head, and if the pick-up head is any distance from the recording head the voice, of course, will be a trifle late in synchronism.

The author has found that after a little practice with the settings and controls, etc., one can obtain consistently good recordings without having to listen on a separate pick-up head to the recording being made.

A useful point, however, in this connection, at the beginning of a recording session, is to rest a small high-resistance bobbin (e.g., a 1,000-ohm headphone bobbin) on top of one of the recording electromagnets and connect the bobbin to a good pair of high resistance phones. Connect up the amplifier as for recording but without the machine running, put on the phones and speak into the microphone.

One soon learns, from previous experience, to distinguish the necessary strength and quality of the voice as it comes from the head and is induced in the bobbin lying on top, and to separate

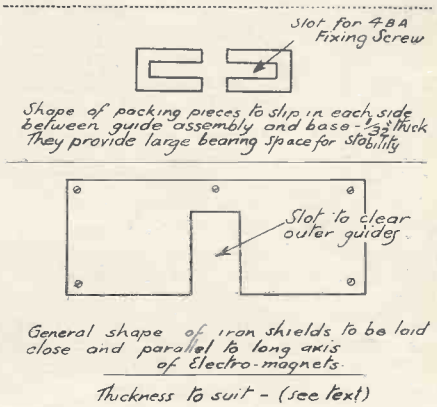


Fig. 4. General shape of iron shields to be laid close and parallel to long axis of electro magnets. Thickness to suit. (See text.)

it from the actual voice emanating from the mouth to the microphone. This is a true test of the voice as it will be impressed on the wire and is better than actually connecting the phones somewhere in the amplifier circuit, since this may upset the characteristics of the circuit and give a false impression of the resultant quality, besides probably being too loud. Any wide deviation from the previously known characteristics will then be immediately noted and adjustments made accordingly.

As regards the type of winding to be used on the electro-magnets of the head, no doubt the most efficient would be a high-resistance winding connected directly to the grid circuit of the first valve on the amplifier for playing back, or alternatively in the output for recording. These electro-magnets, however, being of special shape have to be wound, and the author decided on the following alternative method. The electro-magnets were wound with a few turns of a thicker gauge wire, the total resistance being only a few ohms and the output led to the secondary (the low resistance side) of a good quality moving coil speaker transformer, the

The Amplifier

primary being connected to the amplifier.

Since this gives good results it was decided not to experiment further, although some trial was necessary to find the correct number of turns on the electro-magnets in order to match the impedance of the transformer used.

By using this method, in addition to simplifying construction, one is not so deterred from making another pair when, after considerable use of the machine it may be found necessary to renew the iron cores which take the wear of the wire. In this connection it was decided not to make the cores detachable as it is most important to have the winding in close contact with the core and in this case the only insulation used on the core was one thin layer of tough waxed paper. In any case a fresh pair is soon and easily made.

The details of the actual head used are given later and it will be seen that the resultant form of the electro-magnets is perhaps not the ideal theoretical shape for its size, being somewhat too long for its diameter. The final form was due, however, to the fact that originally the magnets were wound with considerably more wire and turns were removed until the correct impedance was found. Since, however, the results were satisfactory, this shape was retained.

Briefly the design of the head evolved by the author is as follows. The two electro-magnets are held opposite each other on long, flat strips of springy phosphor bronze. The wire passes on suitable guides between the two opposed pole pieces which are chisel-shaped and which bear lightly on the wire by means of the slight pressure exerted by the phosphor bronze strips. This spring action also allows the electro-magnets to give way to any welds or irregularities in the wire so that they pass between the poles without damaging them, and in addition the springs bring the electro-magnets back accurately into line after any such deflection. Somewhat similar provision is made in the guides.

The Recording Magnets

Phosphor bronze springs are used instead of steel springs since it is most important to rigidly exclude any form of steel or magnetic retaining material in the construction in close proximity to the head, as these might retain some magnetism from the wipe-out current, etc., and interfere with the recording, besides introducing background noise. In this connection it is also most important that the cores of the electro-magnets be made only from the finest soft Swedish charcoal iron and to make doubly sure they should be carefully annealed in the fire after being made.

Provision is made to adjust the pressure of the cores on the wire and whilst on this subject it might be well to discuss the question of whether to have the wire touching the poles or separated from them by a minute distance as is adopted in some types of the machine.

The author found after considerable experiment that even with the wire running just the minutest distance clear of the pole pieces, the drop in volume both on recording and play back was so great as to absolutely negative the one advantage gained, namely, absence of wear on the ends of the pole pieces. In addition this method always appeared to set up a curious rumbling background noise on the play back, due no doubt, to the slight wavering of the wire from side to side as it passes through the minute air gap, causing the electrical system to be continually unbalanced and apparently impossible to eradicate. This is immediately rectified by having the pole pieces bear lightly on the wire since the slight pressure steadies the wire, preventing it from wavering or whipping and greatly simplifies the construction of the guides. If the wipe-out current has been of the correct strength there is no appreciable background hiss on play back, but should one creep in, as sometimes, happens after repeated play backs, it can immediately be wiped out by bringing a weak magnetic field of correct polarity to a suitable distance opposite one of the pole pieces (the author uses a small bar magnet). The gain in quality and volume of this method of using light pressure of the pole pieces on the wire will be at once appreciated.

The wire being of very hard steel does not itself wear, but after a considerable time will wear a groove in the pole pieces until eventually they will touch. Since most of the magnetic lines of force will then begin to pass directly from pole to pole without having to go through the wire, the volume will gradually fall to a minimum with loss of quality. In the design devised by the author, since the pole pieces have chisel edges, it is possible and but the work of a few moments, to shift the whole support carrying the wire guides so that the wire will now bear on a fresh ungrooved surface of the pole pieces. It does not appear to affect the quality or volume of the recording in what position the wire is running on the face of the pole pieces, whether at the top, middle or bottom.

On the pole pieces used there is enough room for five different positions of the wire, and since at least twenty runs of about half-an-hour each can be obtained before the wire has to be moved to a new position, it will be seen that some fifty hours of recording and play back can be had before it is necessary to take off the electro-magnets and regrind the ends of the pole pieces to shape. This is a fairly simple procedure and then the pole pieces are ready for further hours of recording. Since there is enough metal purposely left on the pole pieces to withstand a dozen or so grindings it will probably be months or even a year or so with average use before there will be any necessity to make a new pair of magnets.

There is provision also for a pair of small felt oil pads on the head through which the wire passes. A few drops of oil on these occasionally will aid considerably in lessening the wear and what is equally important, prevent the wire from rusting, which otherwise it is rather prone to do. This is very useful, because a rusty wire literally grinds the pole pieces away and introduces background noise.

Provision is also made for slipping a soft iron shield over the head to shield it from any stray induced current from the driving motor or neighbouring mains apparatus. The author experienced such trouble from a battery charger; the shield must be made of the softest iron and in this case Stalloy stampings were utilised.

The Amplifier

After much consideration the author decided to use a battery amplifier since this at once eliminates the problem of suppressing mains hum which in this machine is a big problem, as the slightest background hum, etc., is faithfully recorded on the wire and reproduced as such. Again, the head being very sensitive when connected for playing back will pick up hum from any neighbouring mains apparatus even if several feet away and shielded.

Considerable amplification without distortion is necessary so that a battery amplifier of about two watts output employing a class B output was constructed. The author rather hesitated to set forth here the circuit diagram as it employs two stages of transformer coupling followed by the class B output, and might rouse the experts to remonstrate and argue that resistance coupling would have been better as regards quality reproduction.

It should be realised, however, that in a battery amplifier there is no power to spare, as in a mains amplifier, and since all the gain possible is needed, with careful design and choice of components, transformer coupling can be successfully employed. In support of this it was considered that since the input from the recording head to the

grid of the first valve is so exceedingly minute it could not possibly overload the first valve and transformer or even the second as would happen in a wireless set where the detector is usually preceded by one or two stages of high-frequency screened grid valves and the input is already powerful. In this case the first stage thus merely acts as a kind of preliminary "head" amplifier or boost for the microphone or pick-up head.

The writer tried out both methods, and the gain in volume, using good quality transformers, over resistance coupling amplification together with excellent quality was so marked as to be the deciding factor in retaining the transformer coupling method.

These remarks, of course, may not apply to a mains amplifier with plenty of power in hand, but no experience of this has been gained, for the reasons stated above.

It should be realised that one of the main considerations when making this machine and associated gear was to keep the cost down as much as possible, and so material that was at hand was utilised. No doubt an amplifier employing a push-pull pentode output would have given a volume equal to that obtained, without the first stage being necessary, but the choice is left to the discretion of the constructor.

It is most important that the leads from the output to the pick-up head are well shielded, the shielding being earthed, and this also applies to the microphone leads.

Provision is made in the amplifier for the following special factors.

(1) Control of the wipe out current. This is derived from the 2-volt filament accumulator, very little current being needed.

(2) Multi-contact switch for switching from recording to play back in one operation.

(3) Special tone control system and volume control.

(4) Provision for preventing feed back whistle, etc., from the output leads to the input grid leads, etc., which must of necessity come close together on the multi-change switch.

Other small points to be observed will be described in their place.

Microphones

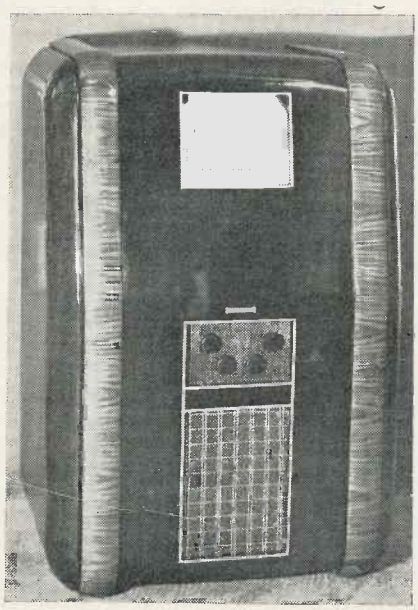
In his first experiments the writer used a carbon microphone of the carbon diaphragm type and not the "button" type. The latter does not seem to respond so well to the musical frequencies. The former type of carbon microphone gives good results, speech being crisp and clear, but it is always difficult to consistently obtain just the right voltage on the microphone so that enough volume is obtained without the familiar "frying" background of the microphone battery creeping in. When the correct factors are obtained, however, the results are excellent and can be recommended to the constructor, but the necessary voltage adjustment is very delicate and appears to vary from day to day, enough to spoil the recording; however, it is still used by the author as a standby.

The microphone in use at the moment is not strictly a microphone but a piezo-crystal loudspeaker. This is used in its original form without any alteration whatever, the recorder merely speaking close into the large 8-in. diaphragm. Not a very neat microphone it is true, but the results are the best to date. The writer tried it out in the hope of obtaining a similar purity to a real crystal microphone which is well known for its faithful response but which, at the same time, is a very expensive instrument. The loudspeaker was obtained for a few shillings from an advertiser in this journal, and although possibly not quite as good as the real thing, the results are very satisfactory. Incidentally the volume is about equal to that of the carbon microphone which although capable of giving a much greater volume, has to be cut down for the reasons stated above.

A small pad of cotton wool fixed so as to exert light pressure over the centre of the diaphragm helps to stop any "blasting" that may creep in on loud top notes. In addition this type of microphone is insensitive to other sounds only a few feet away, which is an advantage, since if it is used in the same room as the recording machine it will not tend to pick up any mechanical noise that may come from the machine.

Similarly a small 3-in. diaphragm permanent-magnet moving-coil speaker is being tried out as a moving-coil microphone, because of the expense of the real thing, but there are one or two factors yet to be solved, as the reproduction is not so good as with the crystal microphone, due, no doubt, to its design as a loudspeaker and not as a microphone.

(*To be continued next month.*)



Television receiver designed by Allocchio, Bacchini & Co., Milan.

An Italian Television Receiver

We have received from the firm of Allocchio, Bacchini & Co., of Milan, details of their new televisor which is shown in the accompanying photographs.

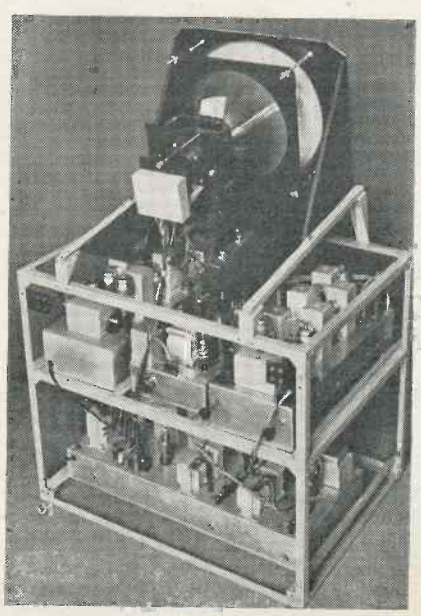
The receiver employs a direct-vision magnetically-focused and scanned cathode-ray tube 35 cm. diameter. The deflecting coils are of the new elliptical type, the advantages of which have been recently discussed in this Journal.

The vision receiver is a superheterodyne with one stage of R.F. amplification, two I.F. stages and two video stages. The I.F. is tuned to 13 mc. with a band width of 10-16 mc.

The sync. pulses are separated by means of a special secondary emission valve.

In the sound receiver there are two I.F. stages in addition to an R.F. stage, and the output valve is arranged for negative feed-back to improve the frequency response.

The bottom chassis contains all the H.T. supplies, that for the tube being 6,000 volts.



A rear view of the chassis, showing arrangement of the units.

The Augetron and Its Applications

By the Technical Staff of Vacuum Science Products, Ltd.

THE Augetron is a multi-stage electron multiplier which has been developed by Vacuum Science Products, Ltd., as a solution of a problem which is confronting valve designers. Modern circuit design requires valves with a high mutual conductance relative to the standing anode current and the conventional valve is limited in this respect both by geometric design and by mechanical considerations.

Augetron multipliers have been designed employing either a thermionic or a photo-electric cathode, as primary emitter, but the present article will be confined to a description of the thermionic type, in some detail, in order to assist readers in the application of these tubes. The general arrangement of electrodes in a six-stage Augetron is illustrated in Fig. 1. It will be seen that the indirectly heated cathode is followed first by a control grid and then by an accelerator plate. This plate is maintained at the same potential as the first secondary cathode. Each secondary cathode is at a potential some 300 volts more positive than the preceding one.

It will be noticed that the position of the final secondary cathode and collector have been interchanged. This arrangement has been adopted since it enables a much higher multiplication factor to be obtained from the final secondary cathode. The construction of the secondary cathodes has already been described and, for the purpose of this explanation, it may be assumed that

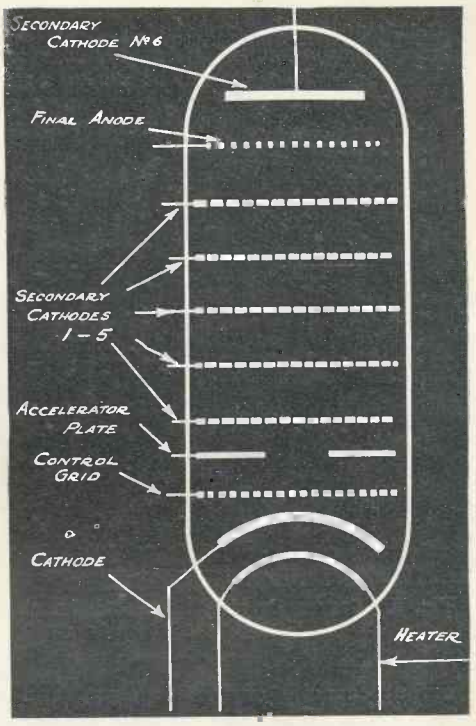
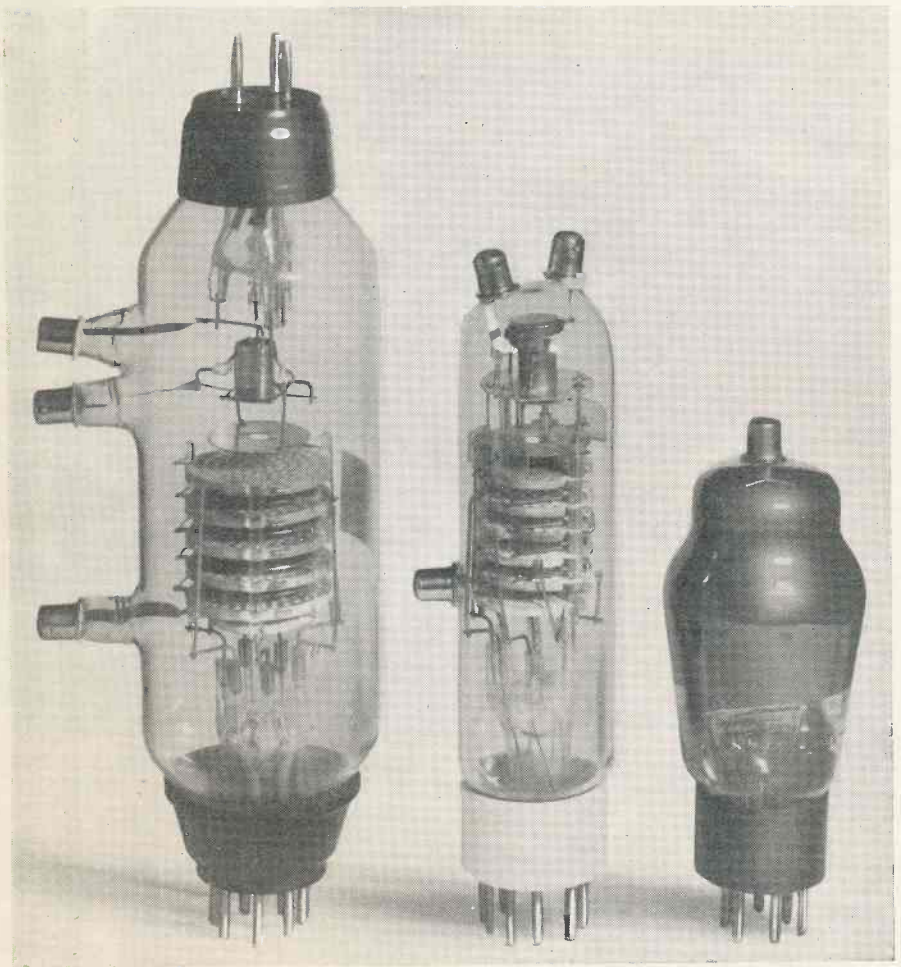


Fig. 1. General arrangement of electrodes in a six-stage Augetron type A206/7.



These photographs show two types of Augetron compared with an ordinary valve.

these plates constitute a system which multiplies the cathode current and the cathode grid slope by a factor of the order of 1,000 times. This current multiplication does not, in itself, yield any increase in voltage amplification and has no direct connection with the stage gain obtainable from the tube.

In the Augetron cathode, currents of the order of 10 microamperes are used. This enables a cathode of much smaller area than usual to be employed, thereby reducing the input capacity and the high-frequency input damping to very low figures. This feature is in itself a very big advantage for high-frequency amplification.

The main functions of the multiplier may best be understood from the curves in Fig. 2. In these primary current and slope are plotted against control grid voltage. In order to obtain a high slope valve of reasonable power dissipation it is necessary to improve the ratio of slope to anode current. It will be seen from the curve that ratios as high as 6 to 1 may be obtained at very low cathode currents.

Now, if these low currents are increased by a linear multiplying device, these ratios will be retained at normal anode currents. The question then arises as to how much multiplication is desirable. This will depend upon the circuit in which the Augetron is to be used. A typical case is that in which an Augetron is required to give as much amplification as possible in a wide band amplifier. In such a circuit the load resistance, and hence the gain, will be dependent upon the

A TELEVISION RANGE FINDER

THE accuracy of a range finder depends upon the length of its base, a 9 ft. range finder giving a distance accuracy of about 1 per cent. at 10,000 yards. Range finders of greater accuracy having base lengths up to or even exceeding 15 ft. have been made, but a limit to the base length is imposed by practical considerations; in addition, the viewing angle gets smaller as the optical length increases.

By using two television cameras which produce a composite image on a screen, it is possible to make a range finder of almost unlimited length, and further, the viewing angle is not dependent upon the distance between the two cameras.

Such a range finder would be, of course, in the nature of a permanent installation but has the additional advantage that it could be used generally for observation work with a viewing angle of from 35 to 40 deg. A distance measurement of an object could be made more accurately by increasing the scan, so effectively reducing the viewing angle.

The receiving screen on which the composite images are formed could be either:

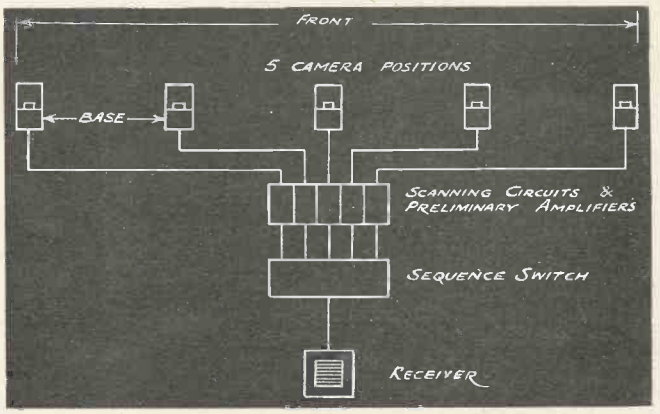
(a) Cathode-ray tube with pictures superimposed in well-known manner.

(b) Cathode-ray tube with two separate images formed alternately one above the other with switching means for the two camera circuits.

(c) Cathode-ray tube with two beams forming two separate images continuously.

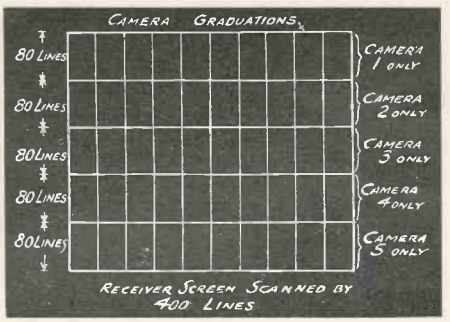
However, unless the equipment is to be used for aerial observation the height to width ratio of the received image will be small and the television images need be composed, therefore, of relatively little detail in the vertical direction. This would enable more than two images to be formed in sequence on one viewing screen and observation over a long front could be maintained by using a number of cameras and an equal number of images. Any two or more images could still be used, of course, for a distance measurement of a particular detail.

In operation, a measurement of the amount of shift of the scan in two cameras required to bring the two images into coincidence, could be interpreted as a measurement of range. This arrangement is essentially the same as that used in an optical range view finder but it would be preferable, especially with a long front using a number of cameras, to use the separation distances of the images on the viewing screen as an indication of the range.



Arrangement of cameras for television range finder

In order to facilitate measurement



in the latter case an auxiliary optical system would be fitted to each camera which projects graduating lines of fixed separation on to the mosaic. The images of the graduations would be adjusted into line on the receiver screen, adjustments of line waveform of the camera being made as required. This method has the advantage of removing errors due to waveform differences.

Five Cameras

The accompanying drawing shows diagrammatically the arrangement of a television range finder as applied to a long front using five cameras. If the base length between two cameras is 500 yards the widest angle we can realise at present will enable distance measurements to be made down to a minimum of 750 yards. Assuming that the Emitron is capable of resolving 1,000 lines definition in the width of its mosaic, it is anticipated that a distance accuracy of 0.25 per cent. will be realised at a range of 10,000 yards.

This development is reported from the E.M.I. Research Laboratories.

"The Applications of the Augetron"

(*Continued from preceding page*)

1 mc. with perfect stability.

The tube should be screened from light, particularly if this is modulated, since some of the electrodes are photo-sensitive. The temperature rise in the chassis or screening box should not exceed 50° C.

It will be seen from the foregoing information that a tube having considerable possibilities for wideband amplification has been evolved. It is proposed in a further article to give full details and characteristics of the high-frequency performances of the Augetron.

The Augetron is covered comprehensively by a series of patents in this country and abroad, and all patent rights are held by Vacuum Science Products, Ltd.

The "Diavisor"

A misunderstanding has occurred regarding the name of the new television transmitting tube developed and patented by Scophony, Limited, and described on pages 686, 687, 688 and 689 of the December issue. Scophony, Limited, inform us that it was not their intention to use the name "Diavisor" in connection with this device. The name of the new tube has not been decided upon.

The British Kinematograph Society's monthly meetings have been resumed. The meetings will, as usual, be held, by courtesy of the G.B. Picture Corporation, at the G.B. Theatre, Film House, Wardour Street.

THE NEW FREQUENCY MODULATION — A SIMPLE EXPLANATION

By John F. Rider

This account of the new development of frequency modulation by the well-known writer on radio and radio servicing, will be of interest to readers who have not yet studied the principles on which the system is based.

DESPITE the great improvement in broadcast transmitters and receivers during the past decade, in some localities reception even from powerful local stations is often marred by noise. Under the present system of amplitude modulation of broadcast transmitters, the most effective means of overcoming this obstacle is by making the signal much stronger than the noise. Since this requires a great deal of power at the transmitter, this method is uneconomical and, further, interference is often caused in nearby receivers.

To overcome these limitations, a new system of broadcasting by frequency modulation is now being introduced by several broadcasting stations in America. In this system, which was devised by Major E. H. Armstrong, the carrier frequency of the transmitter is varied or "wobbled" by the audio modulation, while the strength of the carrier remains constant.

The principal advantages of frequency modulation over amplitude modulation are an improved signal-to-noise ratio, particularly in poor reception areas where the signal strength of the transmitter is weak, and a reduction in interference when two frequency modulated transmitters are geographically separated but operating on the same frequency. In receiving, better fidelity is usually more easily obtained from frequency-modulated transmissions.

Since the carrier frequency in frequency-modulated broadcasting is varied over a wide band, wide channels are necessary for transmission. Present channels are 200 kc. wide and have been allocated in ultra-high frequency bands to avoid interference with other services which would result if channels of such width were assigned within the standard broadcast band. The actual carrier frequency variation is limited to one-half the channel width, as with amplitude modulation, since the frequency of the carrier varies above and below the nominal assigned value when audio modulation is applied. In present frequency-modulated broadcast transmissions, the maximum frequency deviation is held to approximately plus or minus 75 kc. during audio modulation.

The Principle

The manner in which frequency modulation reduces noise may be understood by remembering that most electrical noises change the amplitude of the signal but not its frequency. Now, in the amplitude modulation method of broadcasting, both noise and audio modulation act to vary the carrier signal voltage so that the two are combined in the signal detected by the receiver.

In frequency modulation, however, the audio modulation varies only the frequency of the carrier signal and not its amplitude. Noise, on the other hand, will cause no change in the carrier frequency, though it will affect its amplitude. If, then, the receiver is designed to detect only variations in signal frequency and not variations in amplitude, noise resulting from amplitude modulation is eliminated. Frequency modulation is not perfect, but a very great reduction in noise is secured by this method.

Fig. 1. Block diagram of a receiver designed for the reception of frequency-modulated signals. With the exception of the limiter stage, the lineup is similar to that of a conventional superheterodyne receiver.

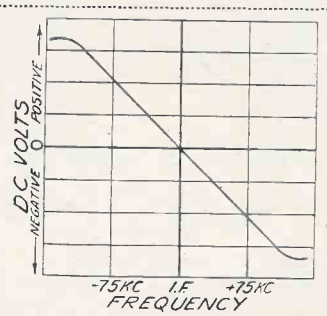


Fig. 2. The output voltage of the frequency demodulator or second detector varies in accordance with the amount by which signal frequency differs from the intermediate frequency.

Conventional broadcast receivers are designed only for the reception of amplitude-modulated transmissions and are, therefore, not suitable for receiving frequency-modulated broadcast signals. The principal differences in the latter are in the design of the detector and in the limiter stage which precedes the detector.

A typical stage-by-stage diagram for a frequency modulation receiver, is shown in Fig. 1. This shows an R.F. amplifier, converter, 3-stage I.F. amplifier, limiter, detector and A.F. amplifier.

Since the transmitted frequency varies about 75 kc. above and below the point to which the receiver is tuned and flat amplification is necessary for high-quality reproduction, the carrier-amplifying stages and the converter must be designed to pass a 150 kc. band without frequency discrimination. Ordinary tuned circuits are usually far too sharp for this purpose, particularly in I.F. circuits, so we find in the frequency modulation receiver that low-Q circuits are necessarily employed to achieve broad tuning.

In the I.F. stages, broad-band reception is secured by using a high intermediate frequency, usually of the order of 3 megacycles, and by broadening the I.F. transformer response by resistance shunted across one or more windings.

The Limiter Stage

The limiter stage requires detailed consideration. Its purpose is to smooth out any variations in carrier amplitude so that it may pass on to the detector circuit a signal which is constant in voltage but varies in frequency. This is done by designing the circuit and operating the valve so that it overloads even when a weak signal is being received. Then any increase in signal voltage will not cause an increase in the carrier signal voltage which appears across the tuned circuit forming the limiter stage anode load.

The high gain in the R.F., converter and I.F. stages provides sufficient amplification even for weak signals so that the actual signal voltage at the limiter grid during reception will always be several volts. Any applied signal voltage greater than the overload point causes rectification in the grid circuit. A resistor in series with the grid return of the limiter input circuit is installed so that the grid current resulting from rectification in this circuit causes a voltage drop across the resistor which can be utilised to provide A.V.C.

A Frequency-modulation Receiver

action. This A.V.C. voltage is applied through appropriate filters, to preceding I.F., converter and R.F. stages.

Since, in frequency modulation, the A.F. modulation causes a variation in carrier frequency, we need a type of detector which will convert these frequency variations into the A.F. signal voltages which originally produced these carrier frequency variations, and in this way restore the original modulation. Ordinary detector circuits are not suitable, since they give an output voltage which is proportional to the amplitude of the carrier modulation and not to the carrier frequency. Since the voltage output of the discriminator circuits employed in A.F.C. designs negative. Since a 400-cycle note is being broadcast, the carrier frequency increases and decreases and the output voltage of the discriminator becomes positive and negative at the same rate, 400 cycles per second, as that of the original broadcast note. Now, if we apply this rapidly varying voltage to the grid of an amplifying valve, the voltage across its output load will vary at the same rate. Since this is precisely what occurs when an A.C. signal is applied to a grid, we see that in this manner detection of frequency-modulated signals is effected.

Once the frequency-modulated signal is converted into audio frequencies, any type of conventional audio amplifier is quency band without frequency discrimination.

The I.F. stages are designed to give a band width of 300 kc. This is done by using a high intermediate frequency (3,000 kc.) and by shunting each I.F. transformer primary winding with a 15,000-ohm resistor.

The last I.F. stage operates as a limiter. The limiting effect is secured by using a 6SJ7 valve in this stage and operating it with zero control grid bias and only 65 volts on the anode and screen. Under these operating conditions, the valve overloads with a relatively small applied signal. The high overall gain of the stages preceding the limiter valve provides sufficient ampli-

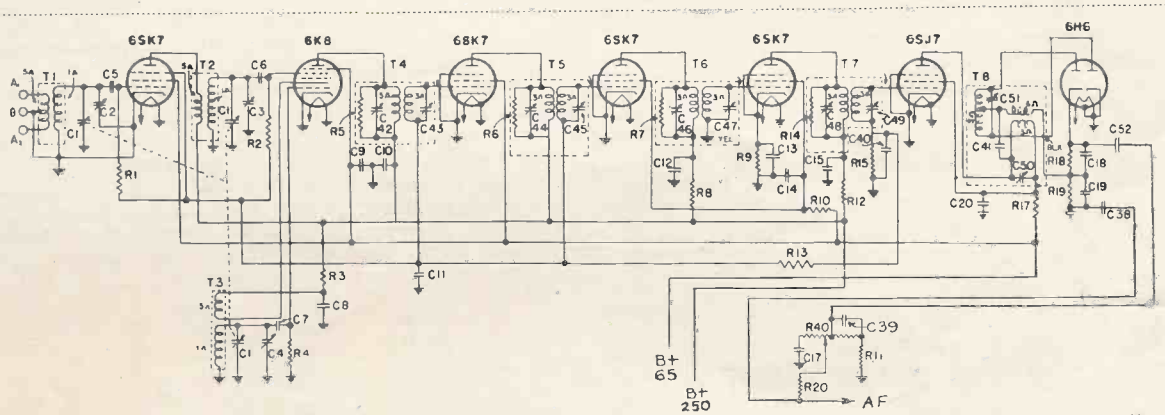


Fig. 3. A partial schematic of the G-E model GM125 receiver, showing the R.F. stage, converter, four I.F. stages and the frequency-demodulating second detector. The 6SJ7 4th I.F. valve acts as a limiter and AVC valve.

varies with the frequency shift of the applied carrier signal, it serves as an ideal device for the detection of frequency-modulated signals.

Now let us see how the A.F.C. circuit serves to supply an audio signal to actuate the A.F. amplifier of the receiver. We have seen, in frequency-modulated transmissions, that the carrier frequency changes at a rate which is in accordance with the audio modulation impressed upon the carrier. Let us assume that a 400-cycle audio note is being broadcast and the nominal frequency of the transmitter is 42 mc. On the positive half of the 400-cycle modulation, the carrier frequency may be increased, while on the negative halt it may decrease. If the modulating voltage is sufficient, this may cause a maximum increase of carrier frequency of 75 kc. so that the maximum frequency at the peak of the positive half of the wave becomes 42 mc. + 75 kc. and, at the peak of the negative half ot the cycle, to 42 mc. — 75 mc.

Now, referring to Fig. 2, we see that a carrier frequency shift in a negative direction will cause the output voltage of the discriminator to become positive whereas an increase in carrier frequency will cause this output voltage to become suitable. Since the fidelity of reproduction in a carefully designed receiver is exceptional, high-grade A.F. amplifiers and speakers are usually employed.

A Typical Receiver Circuit

Fig. 3 shows the circuit of the G-E model GM125 receiver, which is designed for frequency-modulation reception. This is a 12-valve, single-band receiver which covers a frequency range of from 37 to 44 megacycles. A single R.F. stage feeds the 6K8 converter; four I.F. stages are employed, the fourth stage acting as the "limiter." The detector is similar to the A.F.C. discriminator previously described. The triode section of a 6Q7G is employed as the first A.F. amplifier and feeds a 6J5G phase inverter which drives the push-pull 6L6G output valves.

The R.F. and converter stages are similar to those which could be employed in conventional designs for the same frequency band, except that no effort has been made to acquire selectivity in the tuned stages since this would be undesirable in a receiver which is required to pass a wide fre-

fication so that even a weak signal in the aerial circuit is built up to a voltage sufficient to overload the limiter.

When the signal strength is sufficient to overload the limiter stage, grid current flows through the 330,000-ohm resistor, R15, in the grid return circuit of the 6SJ7. The resulting voltage drop across R15 is used to provide A.V.C. action and thus prevent overloading of preceding stages. By incorporating A.V.C. in this stage, there can be no A.V.C. action until the limiter is overloaded, which is its required operating condition. When such is the case, an increase in signal voltage applied to the limiter grid will cause no increase in the output signal voltage across its anode load but the grid current will increase, thereby assuring an increasing A.V.C. voltage.

The discriminator-type detector converts the frequency variations of the I.F. signal output to a voltage which varies in amplitude at the audio frequency rate. The essential difference between this type of discriminator and one used solely for A.F.C. purposes is that the audio component is not filtered out. This must be done when such circuits are used for A.F.C. applications

(*Continued in 3rd col. of page 23*)

THE SHORT-WAVE RADIO WORLD

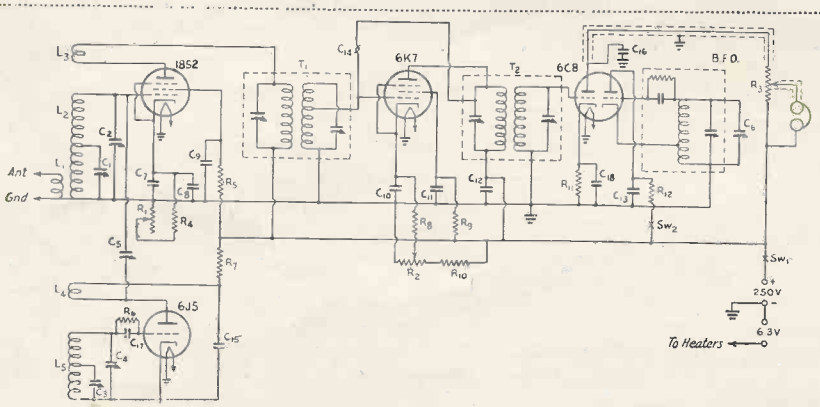
A Review of the Most Important Features of the World's Short-wave Developments

Four-valve Super-het

B. GOODMAN, in December, 1939, QST, describes a neat 4-valve superhet using an 1852 for mixer, a 6J5 separate oscillator and 6K7 and 6C8. Half the latter is used as a second detector with headphones and the other half is used as a b.f.o. The circuit is shown below, with the values of the components

The designer claims that the 1852 is the best choice for a mixer in a small receiver on account of its gain and high signal-noise ratio.

The mixer is made regenerative by a small coil in the anode circuit coupling back into the input circuit, but the receiver should first be built *without* the mixer regeneration and this added after everything is working. By doing this, there is no confusion in fault finding for if the mixer regeneration is left out, any that shows up must first be eliminated before it is deliberately introduced.



Circuit diagram of the Goodman 4-valve super-het.

The 1852 mixer feeds into one stage of regenerative 1,600-kc. amplification. He states: "We had some doubts at first as to the degree of single-signal reception that could be obtained with regeneration at 1,600 kc., but it surpassed our highest hopes and, with care in adjustment, an S7 signal will be down to S3 on the other side of zero beat. This degree of single-signal, coupled with the fact that the 1,600-kc. i.f. gives a much better image ratio than a 450-kc. one would, is full justification for the high-frequency i.f."

The second detector is one-half of a 6C8G, and the other half of the valve is used as the b.f.o. Plenty of headphone volume is obtained out of the second detector, and no audio amplification is included in the receiver.

CIRCUIT OF THE FOUR-VALVE SUPERHET

C1—15-$\mu\mu$fd. midget, mixer tuning condenser (Hammarlund HF-15).
C2—35 $\mu\mu$fd. midget, mixer bandset condenser (Hammarlund HF-35).
C3—35-$\mu\mu$fd. midget, oscillator tuning condenser (Hammarlund MC-35-S).
C4—100-$\mu\mu$fd. midget, oscillator bandset condenser (Hammarlund HF-100).
C5—30-$\mu\mu$fd. adjustable mica (National M-30).
C6—15-$\mu\mu$fd. midget b.f.o. trimmer (Hammarlund HF-15).
C7 to C13—0.1-μfd. 400-volt paper.
C14—Push-back wire twisted together.
C15, C16—0.005-μfd. mica.
C17—0.0001-μfd. mica.
C18—5-μfd. 25-volt electrolytic.
R1—1,000-ohm wire wound variable.
R2—10,000-ohm wire-wound variable.
R3—50,000-ohm variable.
R4, R8—300 ohms, ½-watt.
R5—150,000 ohms, 1-watt.
R6—0.1 megohms, ½-watt.
R7—15,000 ohms, 1-watt.
R9—50,000 ohms, ½-watt.
R10—65,000 ohms, 1-watt.
R11—40,000 ohms, ½-watt.
R12—1,000 ohms, ½-watt.
T1—1,600-kc. I.F. transformer.
T2—1,600-kc. I.F. transformer with grid connection moved to top of coil.

COIL DATA FOR THE FOUR-VALVE SUPERHET

3.5 Mc.
L1—7 turns No. 24 d.c.c. close-wound next to L2.
L2—27 turns No. 24 d.s.c. wound to occupy 1⅛ inches, tapped at the 25th turn.
L3—None. Wire jumper used.
L4—6 turns No. 20 enam. wound to occupy ⅜ inches, ½ inch away from L5.
L5—14 turns No. 20 enam. wound to occupy 1 inch, tapped at the 13th turn.

7 Mc.
L1—6 turns No. 24 d.c.c. close-wound ¼ inch from L2.
L2—19 turns No. 20 enam. wound to occupy 1⅛ inches, tapped at 11th turn.
L3—½ turn No. 18 enam., mounted inside of coil form.
L4—2 turns No. 20 enam. close-wound ½ inch from L5.
L5—10 turns No. 20 enam. spaced to occupy 1 in, tapped at 5th turn.

14 Mc.
L1—6 turns No. 24 d.c.c. close-wound ¼ inch from L2.
L2—9 turns No. 18 enam. spaced to occupy 1 inch, tapped at 4th turn.
L3—1 turn No. 18 enam. ⅝-inch diam., mounted inside of coil form at level of ground end of L2.
L4—2 turns No. 18 enam. close-wound ¾ inches from L5.
L5—6 turns No. 18 enam. wound to occupy 1¼ inches, tapped at 2nd turn.

28 Mc.
L1—3 turns 24 d.c.c. close-wound ⅛ inch from L2.
L2—3 turns No. 18 enam. wound to occupy ¾ inches, tapped at 2⅛ turns.
L3—1 turn No. 18 enam. ⅝-inch diam. inside form at level of ground end of L2.
L4—1 turn No. 18¼ inch from L5.
L5—2 turns No. 18 enam. wound to occupy ⅝ inch, tapped at 1⅛ turns.

All coils wound on 1½-inch forms (Hammarlund SWF). 6-prong for mixer coils, 5-prong for oscillator coils.

The above are in U.S. wire gauge.—ED.

R.C.A. Miniature Battery Valves

With the intention of making possible further reduction in the weight and size of portable receivers, R.C.A. has developed four miniature valves, all glass, for operation with a 45-volt H.T. supply.

A valve of the new design occupies only about one-fifth as much space as the smallest conventional type. The diameter is slightly under ¾ in. and the overall length is less than 2½ in. No base is used, but 0.040 in. wires from the seal serve as pin connections to the socket. The stem is similar to the stem which has been used in metal valves for some years, the seven leads being arranged in a circle, with an eighth lead omitted to provide for location. A feature of this type of seal is that it requires only about ⅛ in. space from the top of the base pins to the electrode leads inside the tube. The exhaust tube is located at the top of the bulb, and all types are of the single-ended construction with no top cap connection.

The pins on each side of the missing eighth pin are filament connections. The negative filament, pin No. 1, has tied to it suppressor grids, and whatever shielding is incorporated. Pin No. 1, therefore, is intended to be the ground connection. Pin No. 7 goes to the positive filament. Filament current is 0.05 amp. for all except the 1S4, which is 0.1 amp.

1R5 (Converter).—The design of the miniature 1R5 converter type is based on that of the 6SA7. The use of this design principle provides much better performance at low anode voltage than any other conventional pentagrid converter designed for the same low voltage. The 1R5 has a remote cut-off voltage of -9 volts, and an improved mutual conductance of 1,200 microhms.

1T4 (R-F Pentode).—International shielding is incorporated in the 1T4 so that a bulb shield is not required. The grid-to-anode capacitance is less than 0.01 mmfd when the valve is used with a shielded socket.

1S5 (Diode Pentode).—Consideration was given to the design of a diode triode, but the higher gain which can be obtained from a pentode at low B-supply voltage was an important advantage. The 1S5 will give about three times the amplification of a triode designed to give ample output at the life end point of a 45-volt battery. Electron coupling and capacitance coupling between the diode and pentode sections have been kept at a minimum.

1S4 (Power Output Pentode).—Although the other valves are intended for operation at zero bias, a bias is necessary for satisfactory operation of a power output pentode. The 1S4, when operating self-bias at a bias equivalent to -4 volts, gives a power output of 50 milli-watts, with only 3.5 milliamperes anode current. (*Radio Retailing, November*, 1939.)

International Amateur Radio Union

With the closing down of the South African stations at the end of October, amateur radio activity in the British Empire is now completely suspended. News has been received of the suspension or alteration in activities of other countries as follows:—

Germany.—The D.A.S.D. (Deutscher Amateur Sende-und-Empfangs Dienst) has suspended publication of their journals except "CQ" which will appear every other month. Meetings of local clubs have been discontinued.

France.—The Reseau des Emetteurs Francais has closed down and the journal is suspended. The QSL Bureau is no longer in operation.

Australia.—The W.I.A. is making every effort to continue its normal activities, including meetings, at which receiving problems and allied subjects will be given principal attention. Here, again, amateurs are serving their country; not only have those amateurs affiliated with the air force wireless reserve reported for active duty, but the amateur society has offered the services of its remaining operators to the P.M.G. Department for monitoring purposes, should they be desired. If the proposal is accepted, each division will undertake to monitor a portion of the short-wave spectrum. In addition, code classes are being offered by the New South Wales Division to improve the operating abilities of members.

Canada.—Several Canadian amateur clubs are determined to carry on, with technical development as their main thought. Shielded loops, directive receiving antennas, noise limiters, audio selectivity—these are some of the subjects to receive attention. The example is an excellent one for amateur groups in all affected countries to follow.

New Zealand.—The executive branch of the N.Z.A.R.T., watching the position of amateur radio very closely, states that it is too early to decide what the future of the association will be. Meanwhile, all activities not affected by the ban will be continued as far as possible. An attempt is being made to keep up publication of the magazine "Break-In," even though reduced in size. The executive is urging all branches to continue their meetings. It was, of course, necessary to cancel all arrangements for the Australia-New Zealand centenal DX contests.

Series Cathode Modulation

A system of class A modulation using the modulator tube in series with the modulated amplifier, called "series anode" modulation, is not commonly used because the modulator valve must be run straight class A, with consequent low anode efficiency, and because the anode supply voltage must be the sum of the modulator anode voltage and the voltage it

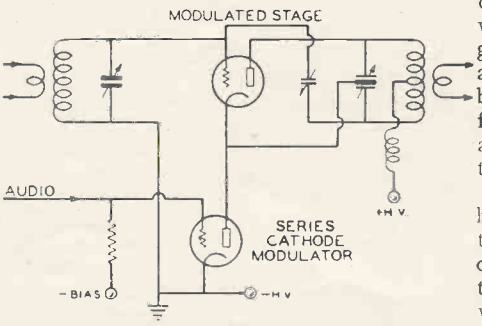


Fig. 2. The grid return for the modulated stage is connected to earth instead of to the cathode to make series cathode modulation from series plate modulation.

is desired to run on the modulated amplifier. Also, the modulator tube must have a very great amount of anode resistance change with modulating voltage. Apart from these considerations the system operates in a very much similar manner to parallel constant-current modulation (commonly called the *Heising* system).

However, if the grid return of the modulated stage is made to earth instead of to the cathode circuit of the modulated amplifier, we have the basis of a system of cathode modulation which has many inherent advantages.

This system can be called *series* cathode modulation to differentiate it both from conventional series modulation and from previous systems of cathode modulation. For cathode modulation of an amplifier the A.C. voltage required in the cathode circuit is very much less than would be needed for plate modulation of the same amplifier. It has been found that any conventional amplifier (up to 1 kilowatt) will require from 100 to 300 peak volts in the cathode circuit for complete modulation. To get this amount of swing across the modulator valves, from approximately 175 to 450 volts drop will be required, the drop being the effective "anode voltage" on the modulators.

It will be noticed by reference to the figure that the voltage drop across the cathode modulator valve appears as grid bias on the modulated amplifier. This means that we have automatic cathode bias on the stage, equal to the drop across the series cathode valve. Experience has shown that when the proper drop across the series cathode valve for the production of the desired amount of audio modulating voltage has been determined this value of cathode drop will be a satisfactory amount of D.C. grid bias for the modulated stage. No additional grid-leak or power supply bias will be required. This has been found to hold true for all triodes with an amplification factor of from 15 to 35.

With practically all medium and high μ valves, no provision for limiting the anode current of the amplifier in cases of excitation failure need be made; the resistance of the series modulator will be ample to limit the anode current to a safe value. (*R. L. Dawley—Radio*, Dec., 1939.)

Frequency-modulator Transmitter

One of the latest to undertake the construction of a frequency-modulated transmitter is Stromberg-Carlson, who will use it to transmit programmes originating at WHAM. The new transmitter in Rochester, U.S.A., will operate on 43.2 megacycles at 1,000 watts, and will use an aerial system designed to give it power equivalent to 4,000 watts. Audible frequencies up to 15,000 cycles are carried over the new system. These signals are similar to television transmissions in that they are limited to line-of-sight. The company plans to make a receiver which can be used in conjunction with the audio and speaker end of its standard broadcast sets.

"Frequency Modulation"

(*Continued from page 21*)

to avoid modulating the oscillator at the audio frequency. The discriminator load by-pass condensers, C18, C19, are accordingly only 22 mmfd. each in this circuit, so there is no by-passing of the higher audio frequencies.

The output of the frequency-demodulator is coupled to a tone control network composed of R11, R20, R40 and the shunt and series condensers C39 and C17. Operation of R40 provides attenuation of either high or low frequencies, as desired. The output of this network connects to the volume control, which returns to earth through an inverse-feedback network. The remainder of the audio system is conventional.

News Brevities—

Commercial and Technical

ACTUAL sales of television receivers in America up to the present have been extremely limited. Many reasons have been advanced and all are undoubtedly correct to a degree. Some of the causes advanced for the poor sales are the limited programme hours, the type and quality of programmes, the prices of receivers, and the relatively small trade discounts as compared to radio.

In spite of the limited sales, however, it is the general opinion that the New York experiment has demonstrated that a television service can be given over the area originally estimated, and that with suitable programmes such service provides real entertainment value and opens up great possibilities.

* * *

Mr. S. Sagall, managing director of Scophony, Limited, and one of the pioneers of television in this country, has started a campaign for the reintroduction of television transmissions. Should transmission by radio be proved impracticable because of defence reasons, Mr. Sagall is of the opinion that the introduction of television by wire is completely feasible. Technical data available in this country and abroad, he says, completely justifies such a view, even though further research may be required. Technical experts whom he has consulted gave it as their opinion that the difficulties involved are not insuperable.

The project is not intended to benefit any particular company but the whole of the television industry, and Mr. Sagall has also been assured of the co-operation of the cinema industry. We understand that it is Mr. Sagall's intention to approach the Postmaster-General and Lord Cadman in the near future.

* * *

A remote control unit has been produced in U.S.A. which provides for the operation of a transmitter as much as several miles distant and the amplification and selection of signals from remote pickup receivers. This self-contained unit will control, mix, and monitor combinations of the following six audio channels: two remote pickup receivers, telephone line, velocity microphone, tone oscillator, and monitor receiver. It will feed at zero level a 500 ohm audio line to the transmitter with automatic level control and broadcast station quality. In addition, this unit will control individually over the same line the filament and plate power circuits of the remote transmitter and will monitor both aurally and visually the radio frequency emission of the transmitter as well as its audio frequency input. The unit has broad application in the police and public utility fields where the dispatching point is frequently at some distance from the main transmitter and associated "talk-back" receiving system.

* * *

It is not often appreciated that light falling on a neon or other discharge tube will alter its striking characteristics.

Tests made by A. K. Baker, of Harvard, showed that a normal discharge voltage of 70 in a neon lamp was reduced to 62 in daylight and 55 under strong artificial light. It is suggested that neon discharge lamps adjusted to a point slightly below the striking voltage under given illumination conditions may act as light relays, although their sensitivity cannot compare with that of a photocell.

* * *

The 1940 edition of the well-known A.R.R.L. handbook which has just been issued, is fully up-to-date and merits the publishers' description of being an entirely new handbook for radio amateurs.

The contents have been completely revised and rearranged and the chapters have been increased to 32 to cover all phases of radio transmitting and receiving. A thorough account is given of aerial arrays and details of ultra-short wave aerials are included.

All the designs in the book have been tested before publication, and it is easy to see that they have been evolved by radio experts who appreciate the requirements of the amateur and who are capable of giving him a first-class job. Although transmitting is temporarily barred in this country, amateurs should read this book with the assurance that they are being kept right up-to-date by the information contained in it. It is published at $1.25 and can be obtained at the English equivalent price from Webb's Radio, Soho Street.

* * *

The smallest television transmitter units in the world have recently been developed by NBC and RCA engineers and are now undergoing a gruelling test period. The development of this type of unit is regarded as one of the most important in the new industry during the past year, as the mobility of the new apparatus will bring within easy range many previously impossible pick-ups.

The new "vestpocket" units are built in small cases for convenience in transportation. A complete basic unit which can be carried in a taxicab weighs less than 275 pounds for a one camera assembly, exclusive of camera and connecting cables. The total weight of a two-camera assembly is less than 550 pounds.

Following the trial period of testing in the New York City area, the new units will be put into use in the regular television transmissions from Station W2XBS.

* * *

Two general types of television dipole aerials have been developed in U.S.A. One is compact, light and low priced. It is of a wood and metal construction eight feet long, but tunes to an equivalent of ten feet. This is well suited for the average installation. In case additional directivity is required, this type of dipole is supplied with a reflector.

The second type of dipole antenna was designed with the idea of building the best aerial possible regardless of cost. This is a metal dipole ten and one-half feet long, and can also be combined with a reflector (HT-10-G). For regions of low signal and high local noise levels, where the requirements are most severe, a balanced array of four dipole units has been produced.

* * *

The piezo-crystal pick-up is electrically equivalent to a condenser of about .0015 mfd. A load of 5 meg. has no appreciable effect on the frequency response, but as the load is reduced the characteristic falls off in the bass. It is suggested that to avoid excessive bass a variable resistance of 2 megohms be connected across the

pickup volume control. An alternative arrangement to level the response in the bass is to connect a condenser of .001 mfd. in series with the volume control, the condenser being shunted by a resistance of 2-3 meg. Needless to say, a piezo-crystal cannot be connected in series with another condenser in the grid circuit of the amplifying valve.

* * *

To some listeners the words "communications receiver" imply a complicated box of components with innumerable controls designed to bring in a signal at whisper strength from the other side of the globe. That this is not the case is shown by the reviews of modern communications receivers which have appeared from time to time in this journal.

The monopoly which America held in this type has now been challenged in this country, and the results obtained fully justify the buyer in keeping his money on this side of the Atlantic. The demand for an alternative programme is growing every day among listeners and a good short-wave receiver will give them hours of entertainment from all parts of the world.

It is sometimes said that the communications receiver sacrifices quality to sensitivity, but this need not necessarily follow. The loudspeaker is primarily designed for reproduction of speech and morse signals, but it is an easy matter to connect a larger model in place of the existing one when music is the main requirement of the listener.

* * *

No. 2, Vol. 3, of the Television Society's Journal, is now being circulated to members, and contains the following articles and original papers:

Electron Optics (The Kerr Memorial Lecture) L. M. Myers.

Television Facts and Problems (Major C. H. Bell).

In Praise of Television.

In a message from the officers of the Society to the members it is stated that the Society's headquarters will continue to be available for use and reference purposes. The work of data collection and the museum is continuing.

Members who have not received their copy should write at once to the Editor, Mr. W. G. Mitchell, at "Lynton," Newbury, Berks.

* * *

Due to the unique features of the DuMont electronic switch—a single cathode-ray oscillograph for simultaneous observation, operating also as a square-wave generator—it is now feasible to amplify D.C. signals through A.C. circuits in a simple manner. The D.C. signals are first amplified through the D.C. amplifiers of the electronic switch and then through the conventional resistance-capacity coupled amplifiers which are normally used in standard cathode-ray oscillographs. In this manner both qualitative and quantitative measurements of small D.C. potentials may be made without the necessity for unwieldy and expensive high-gain D.C. amplifiers. Also, the stability problem normally encountered in D.C. amplifiers does not exist with this new method.

Although the general principles involved in this amplification of D.C. signals through D.C. amplifiers have been tried many times, it is now possible to use standard and relatively inexpensive equipment to achieve the desired results. Amplification of direct-current signals is obtained with such circuits by electrically chopping the signal and subsequently passing same through standard A.C. amplifiers. Instead of using mechanical devices in conjunction with thermo-couple outputs, photo-electric cell outputs and the like, which are limited by mechanically moving parts and varying contact potentials of metallic parts, the electronic switch accomplishes this chopping by means of an electronic multivibrator circuit which makes the amplifier to which the desired D.C. signals are applied, sensitive and insensitive in rapid succession, and with a periodicity sufficiently high so that the resulting square waves of suitable frequency may be transmitted by conventional resistance-capacity coupled amplifiers.

* * *

The General Electric Company, Ltd., announce the reintroduction of hire purchase facilities for radio, refrigerators, cookers and household appliances. This step has been taken in order to exploit the full possibilities of development now that rationing of electricity seems unlikely to be imposed.

Radio & Defence Regulations

THE Postmaster-General, in the exercise of powers conferred on him by the Defence Regulations, 1939, has issued orders that no person shall, except under the authority of a permit granted by the Postmaster-General for the purpose, sell, purchase, let, hire, supply, dispose of, acquire or distribute any of the undermentioned articles:—

(a) Wireless transmitters which are designed to be used or are capable of being used for communicating by wireless telegraphy, wireless telephony or wireless television; or as navigational beacons, or landing beacons, or otherwise for the purpose of indicating position or direction; or for the purpose of the remote control of machinery.

(b) The following articles intended for use as parts of wireless transmitters, namely, high frequency inductors, spark coils, quenched and rotary spark gaps.

(c) Any wireless receiving apparatus which is designed to be used also as a wireless transmitter or which can be adapted for the purpose of being used as a wireless transmitter by the operation of a switch or by the changing of screwed or plug connections.

(d) Line carrier telegraph equipment or line carrier telephone equipment.

(e) High frequency equipment (being equipment which generates or uses high frequency current at frequencies greater than 10,000 cycles per second and having a maximum output exceeding 10 watts) including such equipment intended for use in connection with furnaces and medical apparatus.

(f) Electronic valves capable of an anode dissipation exceeding 10 watts.

(g) Piezo electric quartz plates or piezo electric tourmaline plates cut to oscillate at any specified frequency.

Permits

Applications for permits should be made to the Engineer-in-Chief of the Post Office, on forms obtainable at any Head Post Office or from the Engineer-in-Chief, stating full particulars of the article concerned, the purpose for which it is required and the name, address and occupation of the person or company who wishes to obtain it and of the person or company from whom it would be obtained.

NEW CALL SIGNS FOR SHORT-WAVE STATIONS

The Federation Communications Commission has announced final changes in the call letters of U.S. International Short Wave stations.

	Old Letters	New Letters
Chicago Federation of Labor, Chicago	W9XAA	WCBI
Crosley Corporation, Cincinnati	W8XAL	WLWO
General Electric Company, Schenectady	W2XAD	WGEA
General Electric Company, Schenectady	W2XAF	WGEO
General Electric Company, San Francisco	W6XBE	KGEI
Isle of Dreams Broadcasting Corporation, Miami	W4XB	WDJM
National Broadcasting Company, New York	W3XAL	WRCA
National Broadcasting Company, New York	W3XL	WNBI
WCAU Broadcasting Company, Philadelphia	W3XAU	WCAB
Westinghouse E. & M. Company, Boston	W1XK	WBOS
Westinghouse E. & M. Company, Pittsburgh	W8XK	WPIT
World Wide Broadcasting Corporation, Boston	W1XAL	WRUL
Columbia Broadcasting System, New York	W2XE	WCBX