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TELEVISION - COMMUNICATIONS - SERVICE - SOUND

VOL. 14, No. 7

SEPTEMBER, 1959

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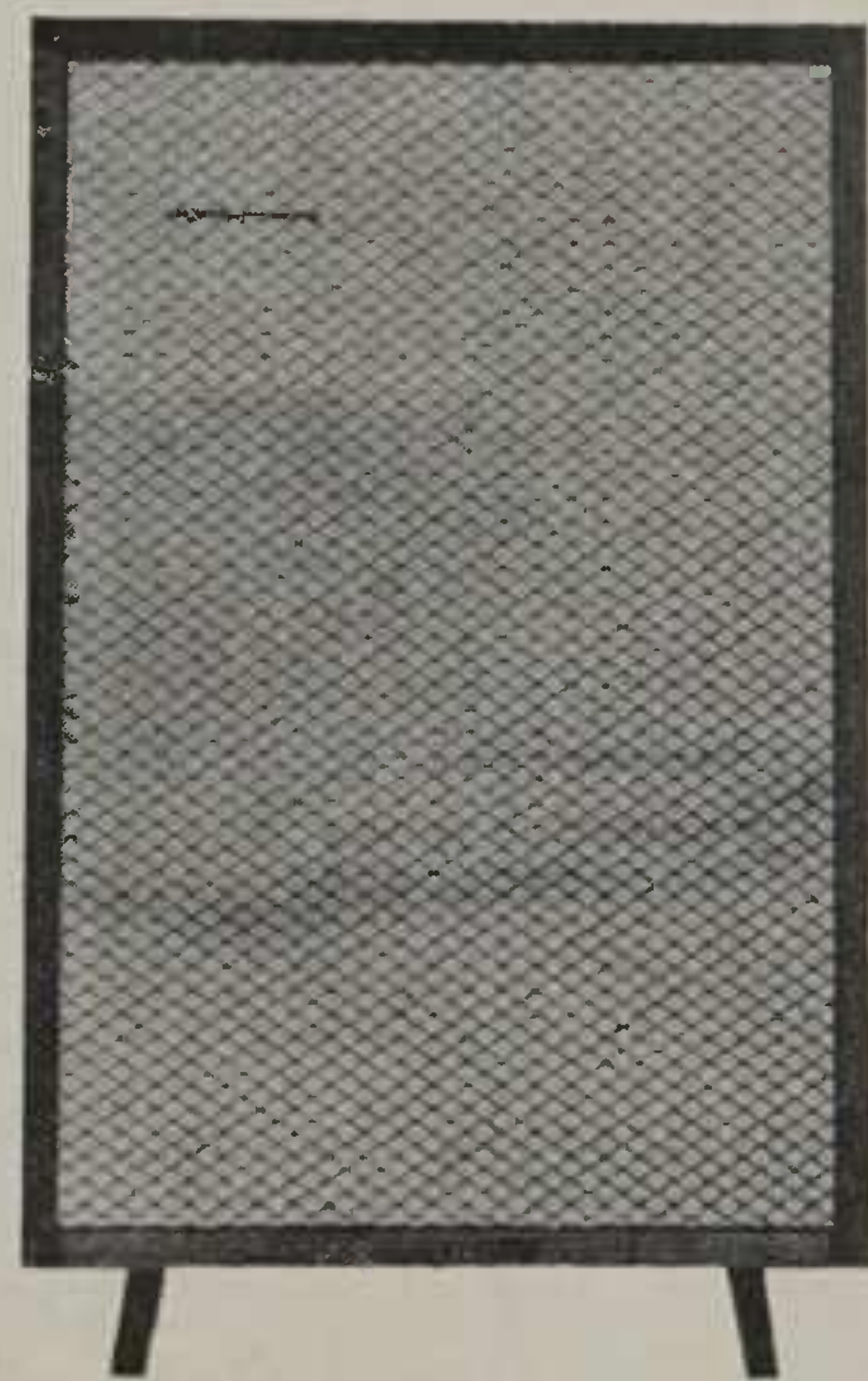
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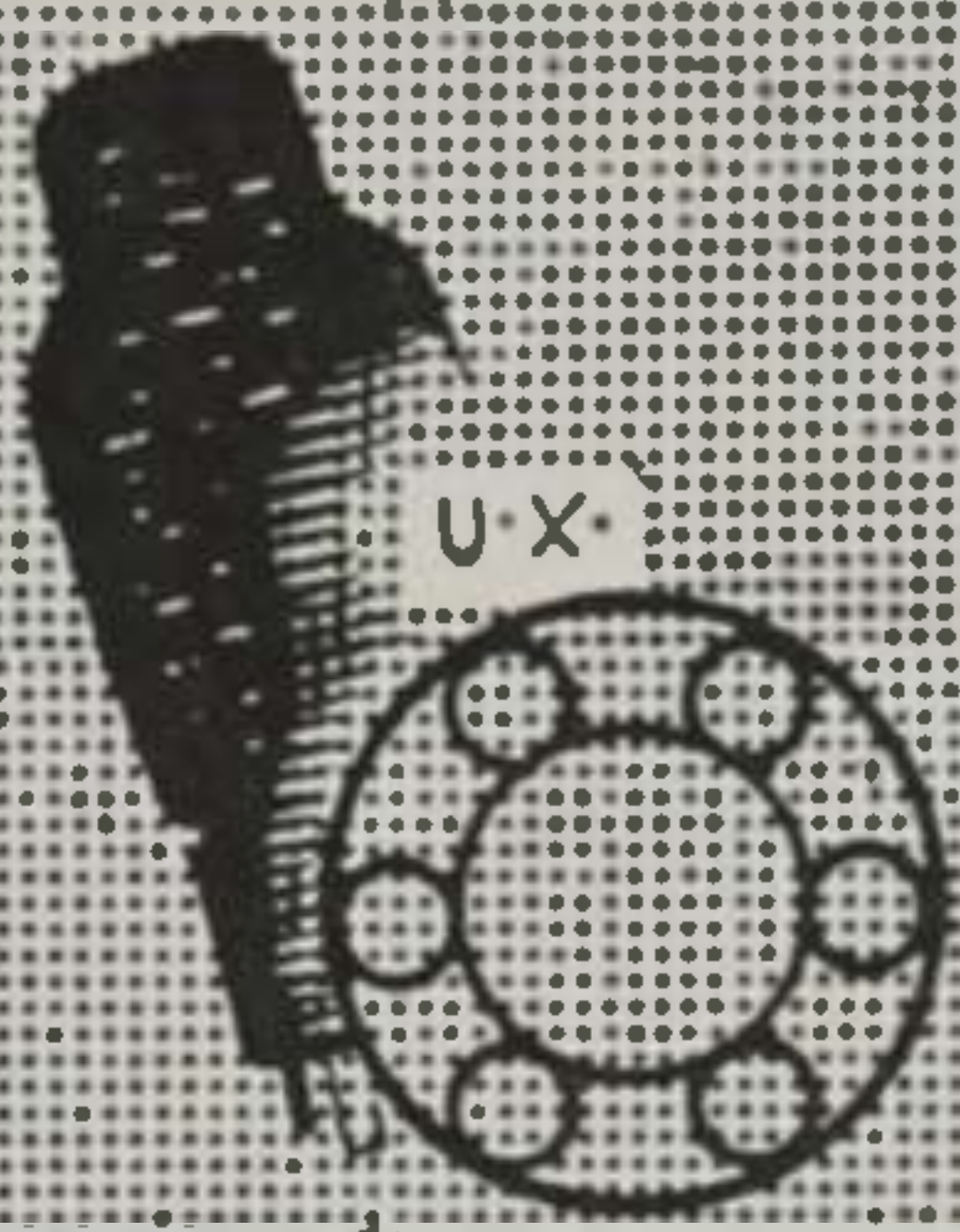


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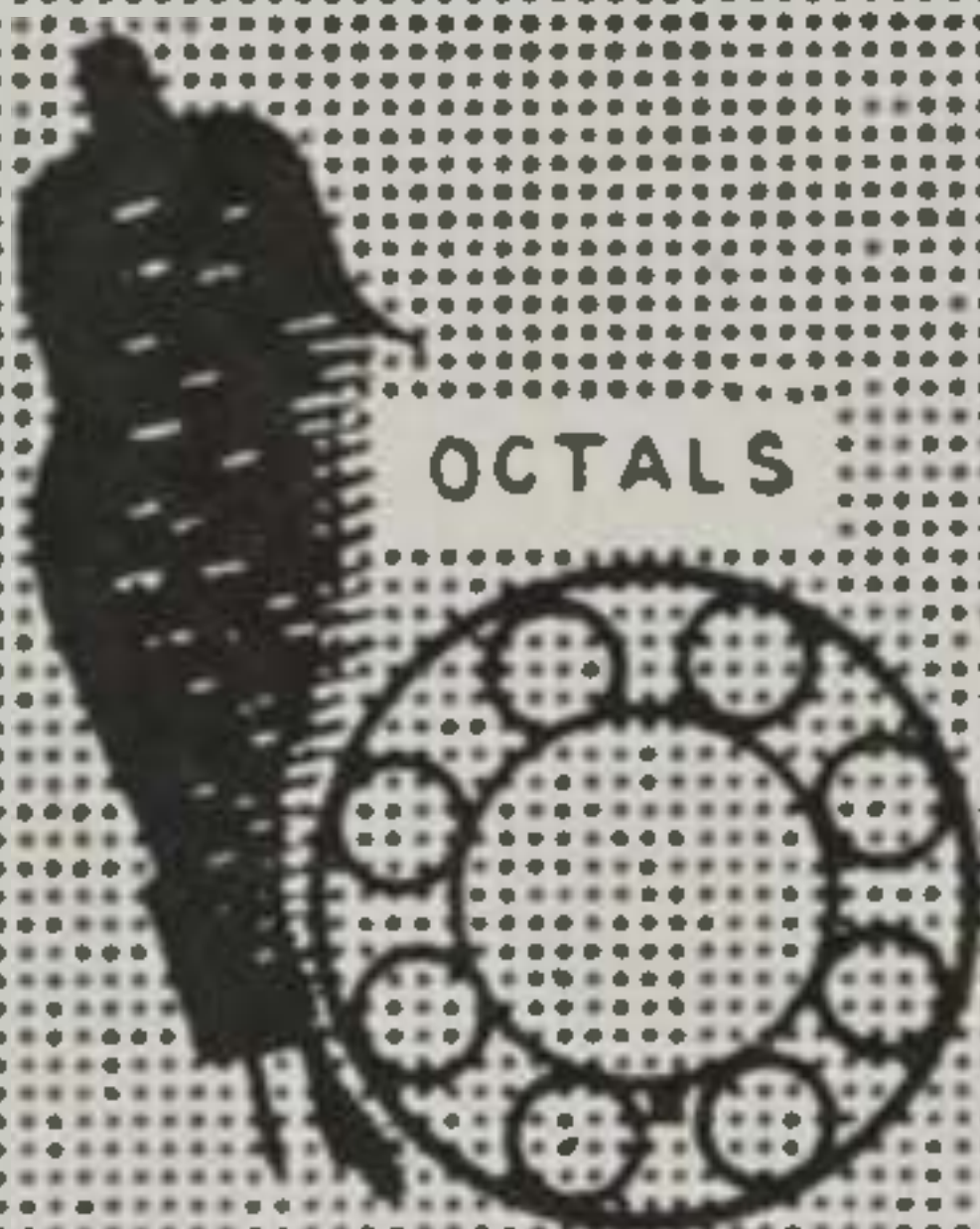


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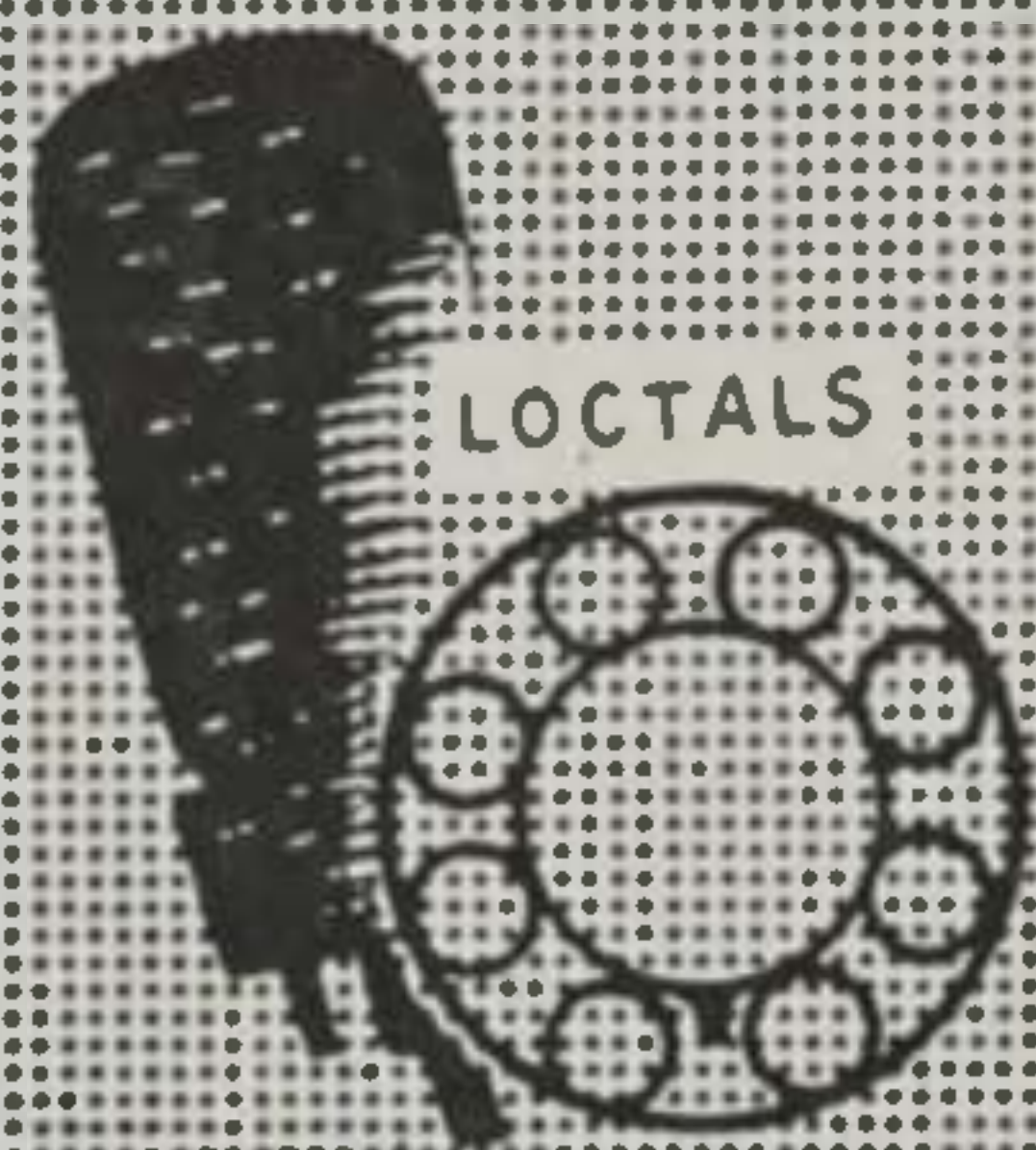
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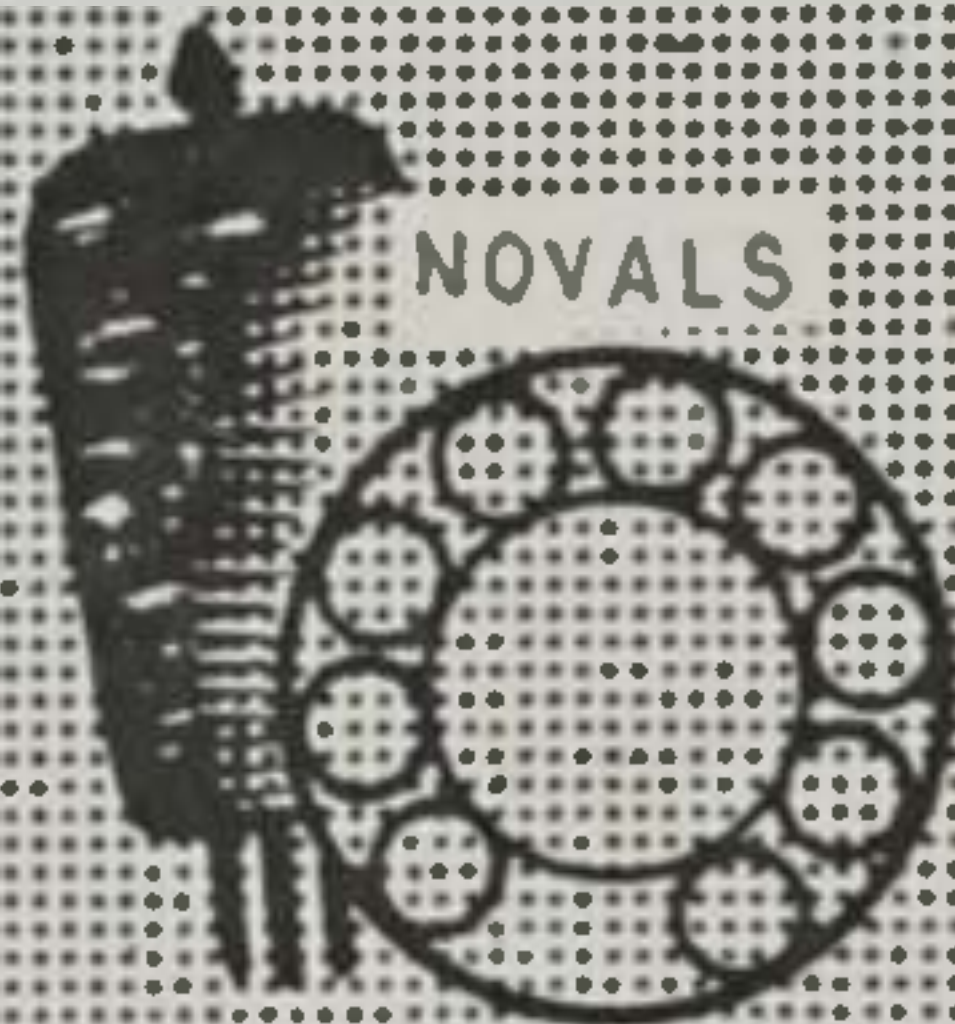
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Radio and Electrical Review

Vol. 14, No. 7

SEPTEMBER, 1959

Official Journal of
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Attracting Boys to the Radio Industry

At the recent annual conference of the New Zealand Radio and Television Manufacturers' Federation, a member pointed out that recently, the members of vocation guidance committees had been shown round various Wellington factories, and that as a direct result, vocational guidance officers were refraining from recommending boys leaving school to seek employment in the industry, on the grounds that it is far too technical and scientific in nature for boys of ordinary accomplishments to consider taking up.

This is an astonishing state of affairs, to say the least. Radio and its allied fields have been almost traditional avenues of employment for the scientific-minded youth of this country. New Zealand leads the world in its density of amateur transmitters, even if what we said about them last month on this page is true. Practically every man engaged in the technical side of the industry today arrived there via radio as a hobby. These are facts which hardly indicate that the industry is too advanced a one for any but near-geniuses to consider taking up! Indeed, if we had not heard the story seriously put to a responsible body of men from the industry, we would almost have failed to believe that such gross ignorance of an important secondary industry could exist among a group of people whose business it is to know something, however slight, about every industry in the country, if they are to do their jobs properly.

Of course, some of the blame must be laid at the door of the industry itself: in conducting the vocational guidance authorities round their factories, the Wellington members were at least doing their best to disseminate a little knowledge of the radio industry in quarters where presumably it could do the most good. It is astonishing that such an attempt should have mis-fired in the way it apparently did, and the industry can hardly be blamed for that. It looks as if the industry will have to indulge in some public relations work in order to put the record straight, and to attract to itself the right type of boy leaving school.

Recruits are needed by the industry—of that there is no doubt. Nor can it be doubted that more still will be needed as television shows its somewhat coy face! The industry cannot afford to have it spread abroad that it is to abstruse an occupation for the average youngster leaving school. Nothing could be farther from the truth, and it behoves us all to tell the world about it, or the electronics business will become the cinderella of our secondary industries, at least as far as personnel is concerned.

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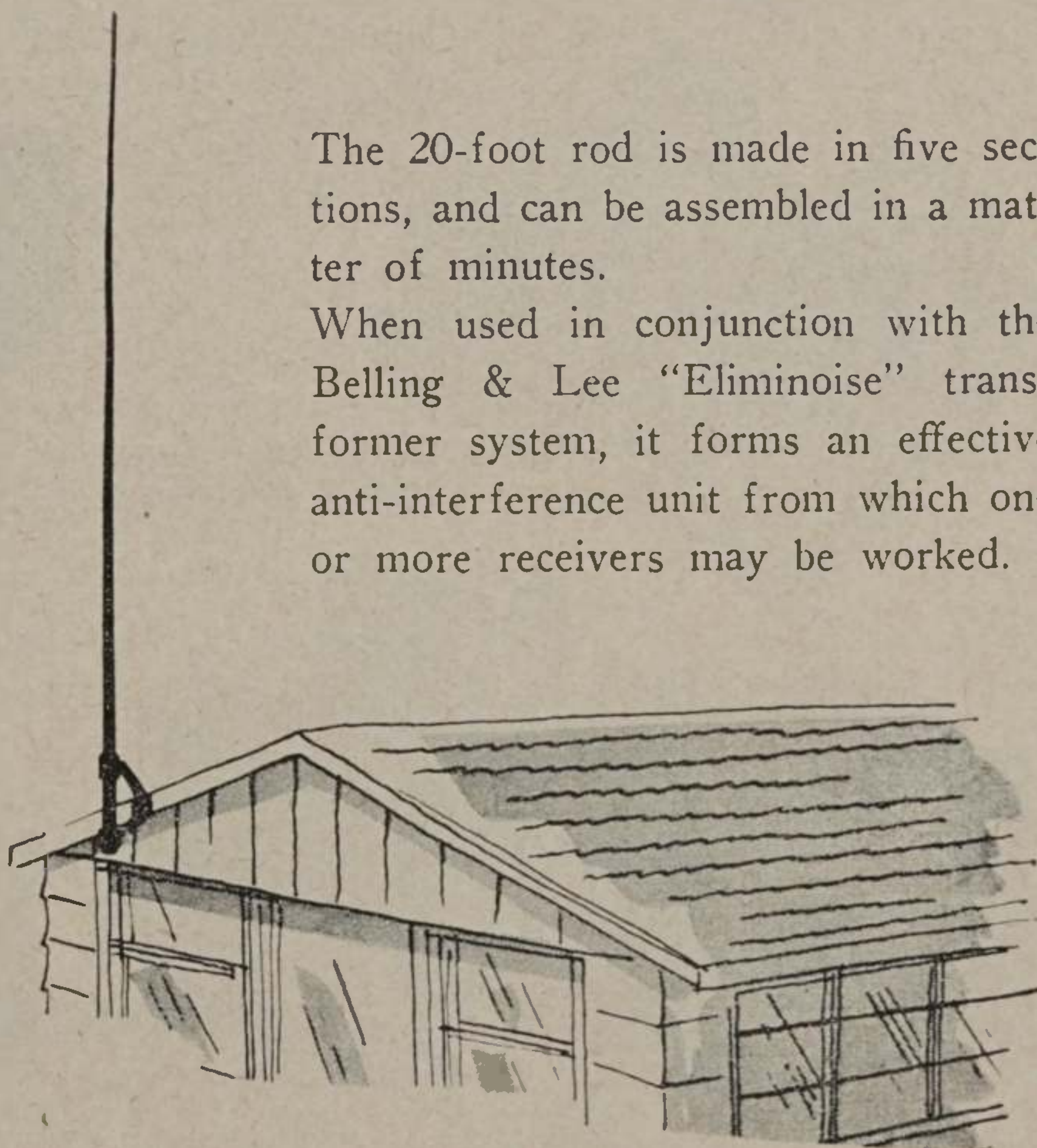
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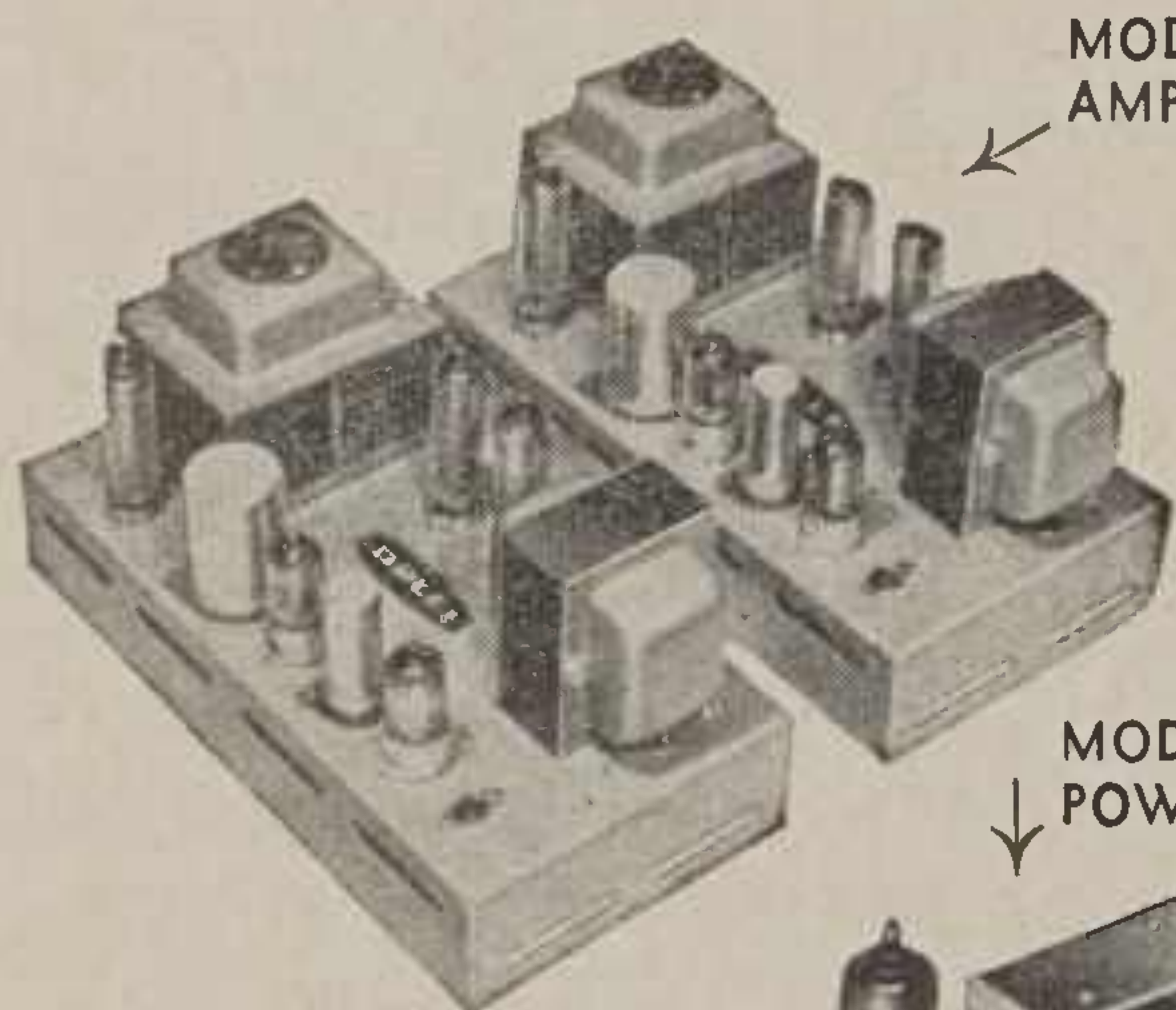
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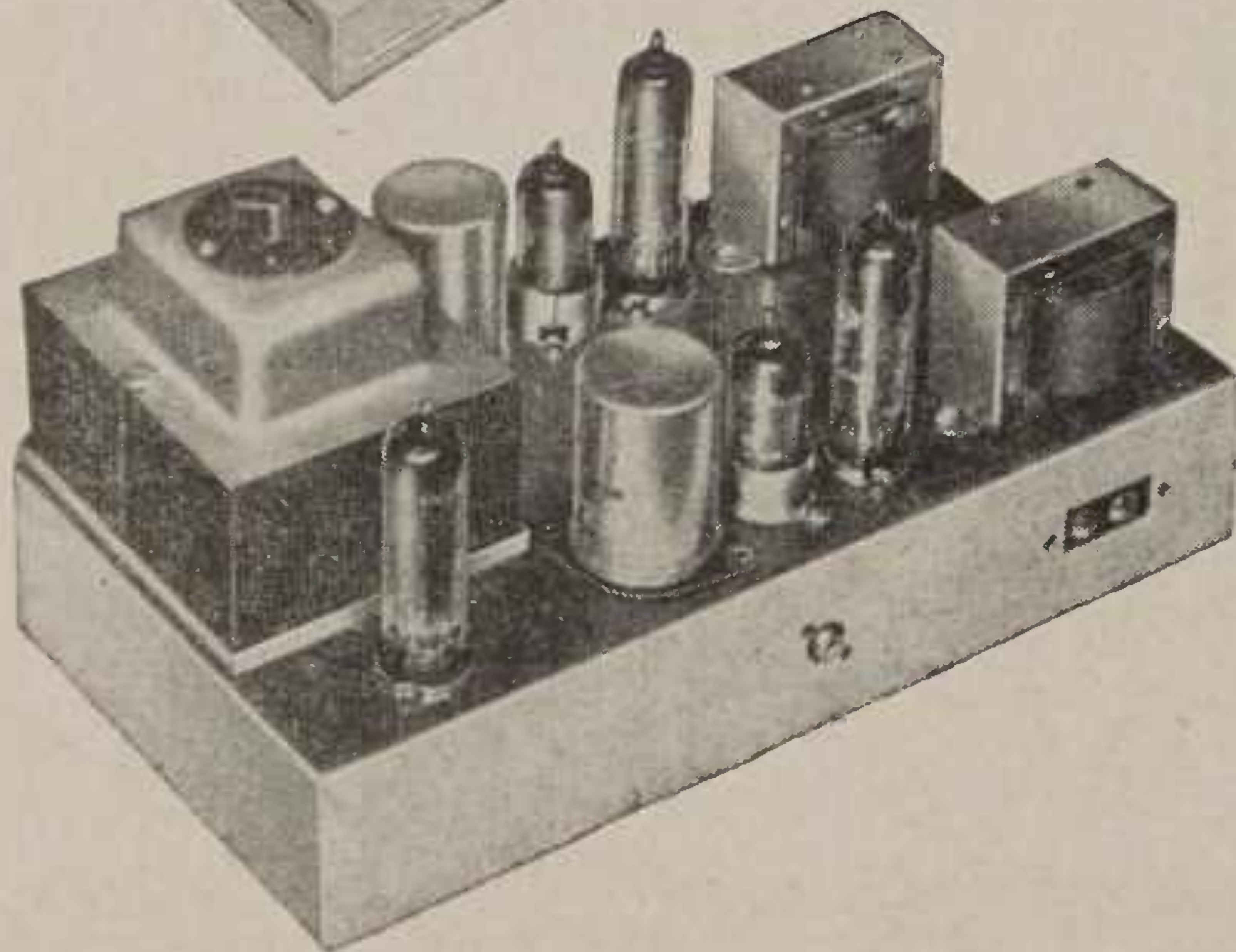
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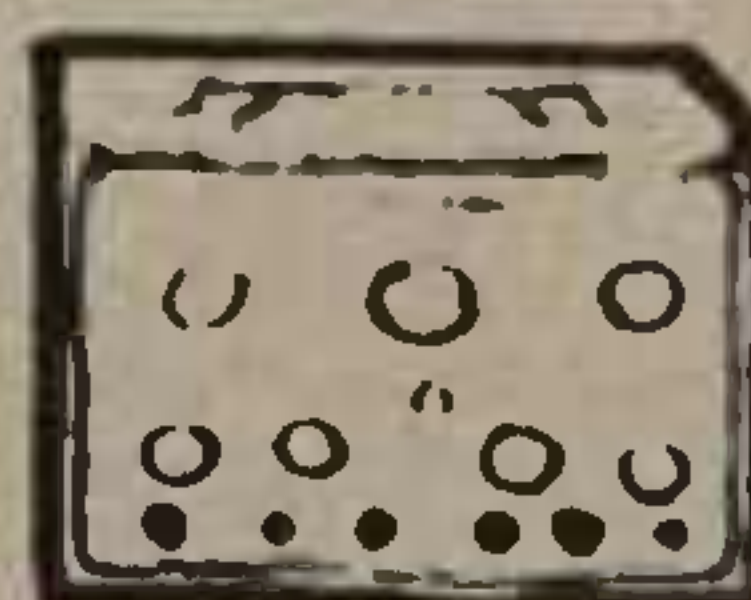
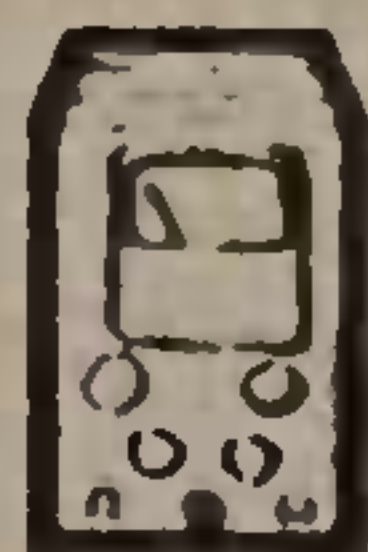
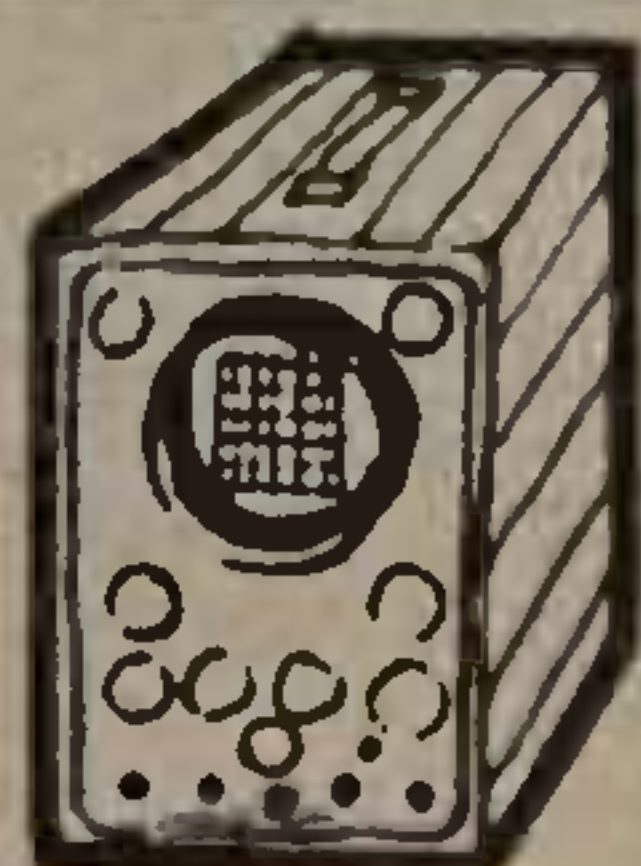
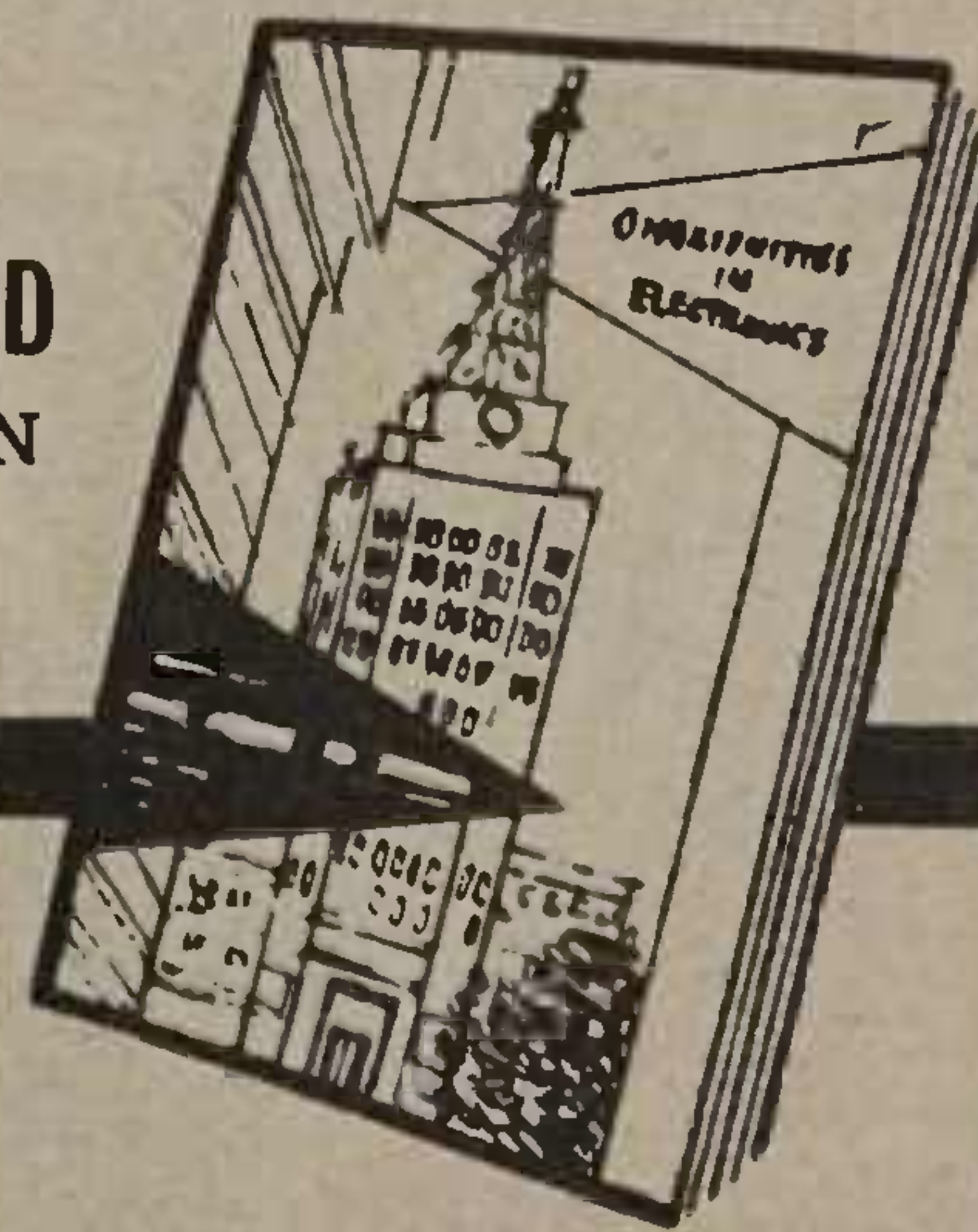
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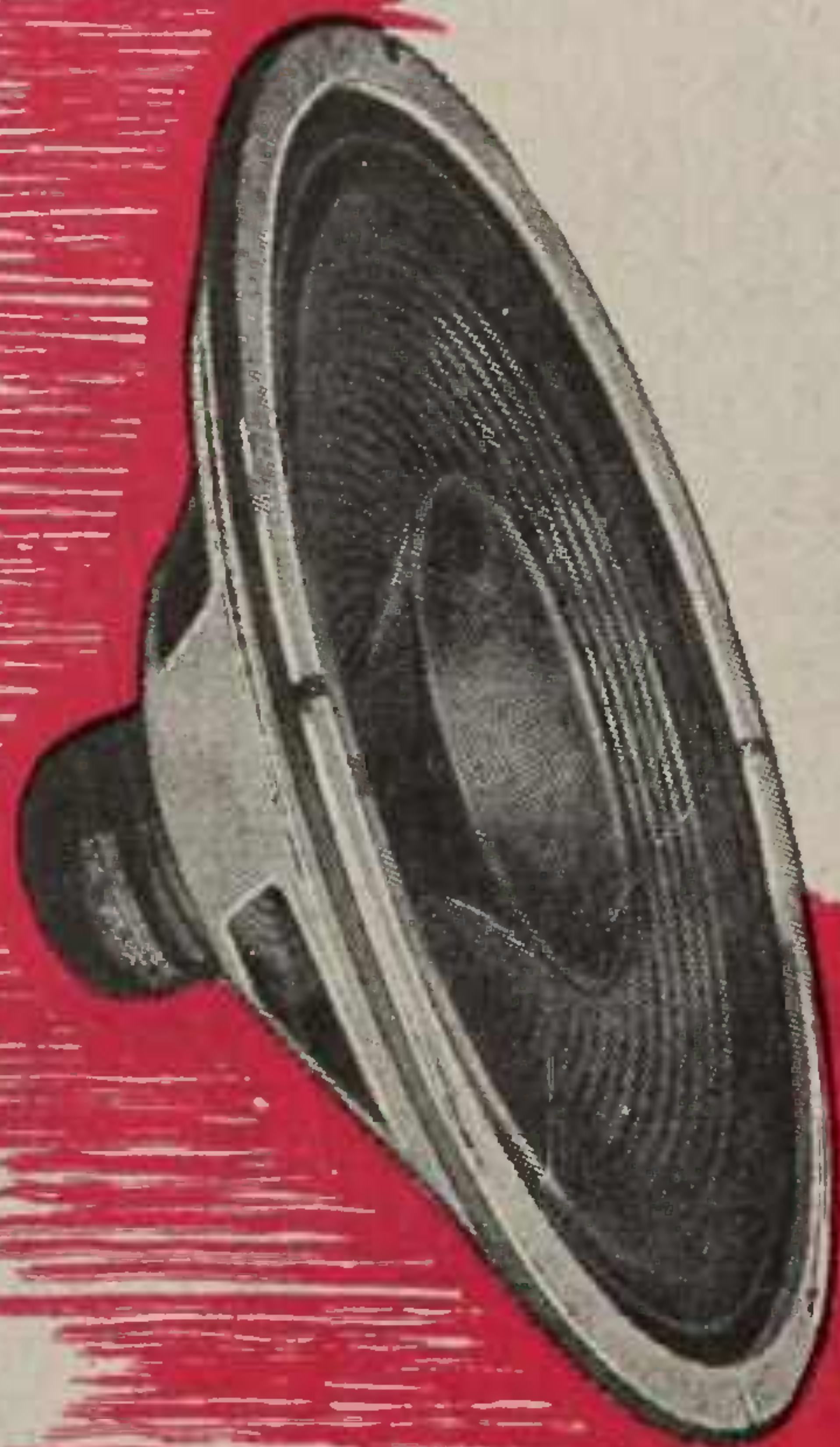


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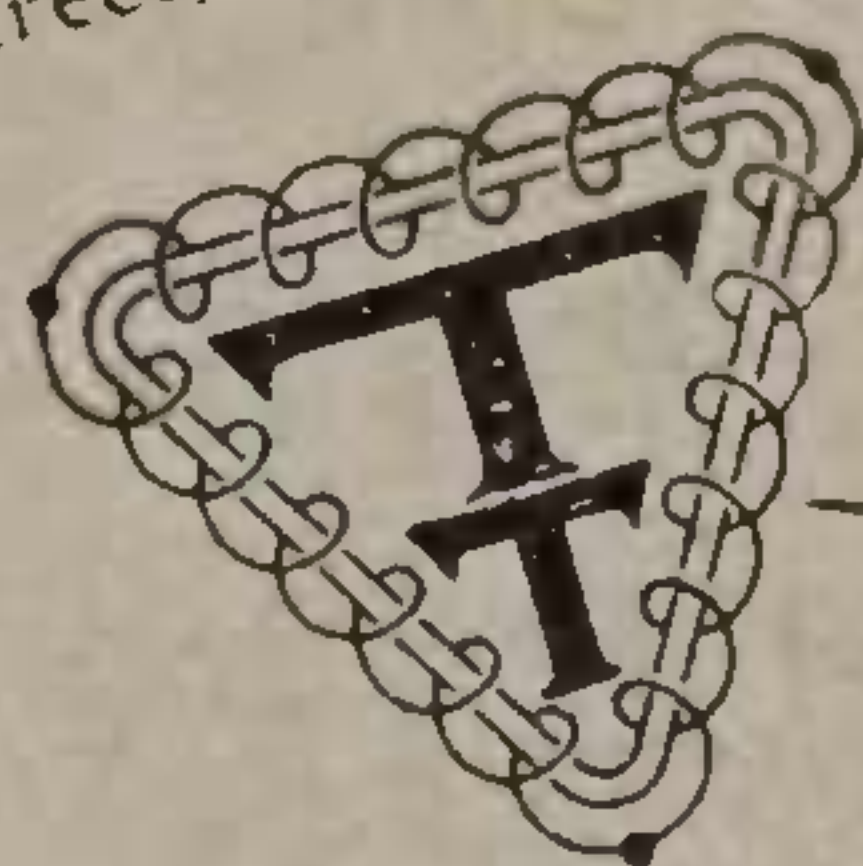
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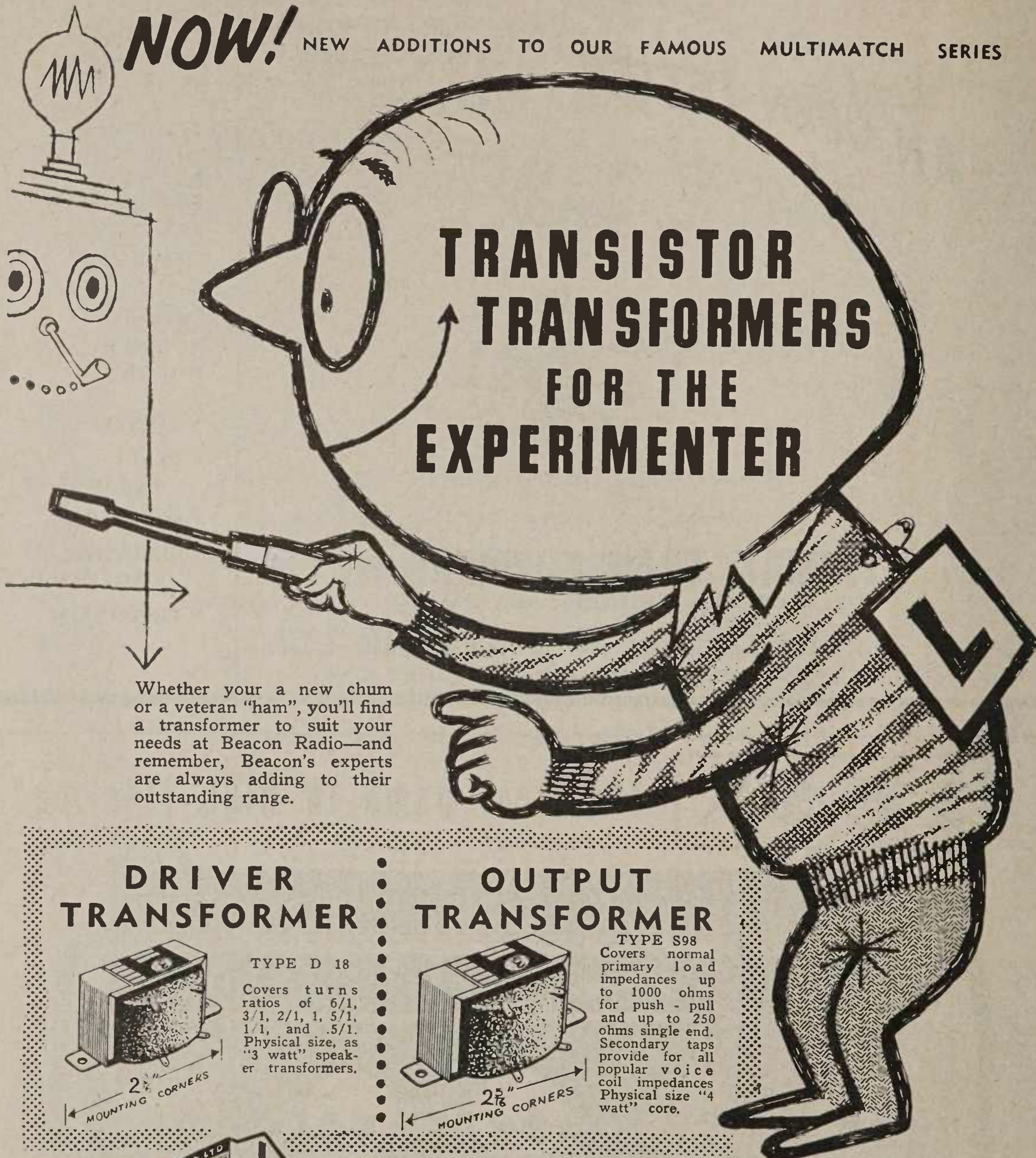
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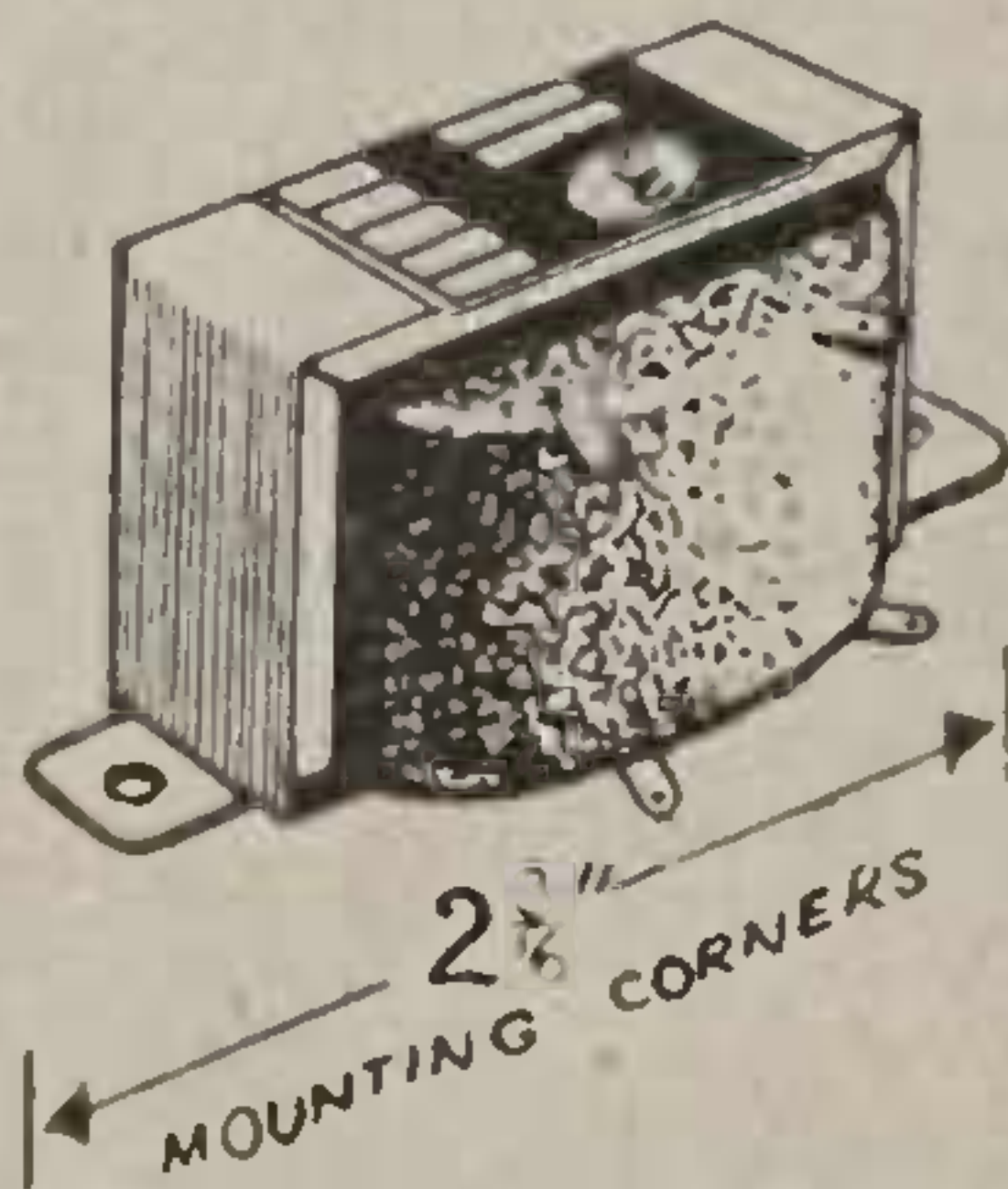
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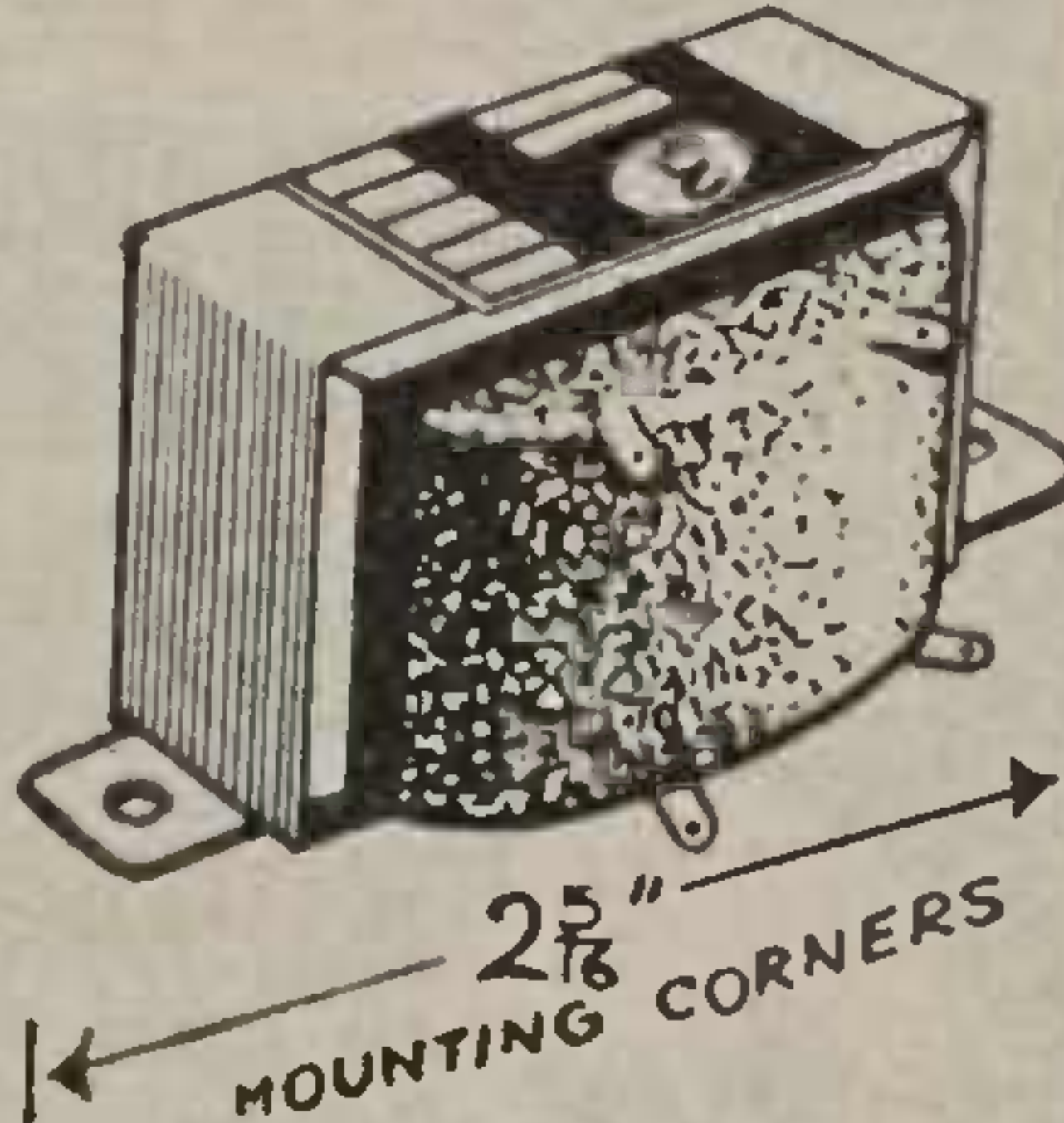
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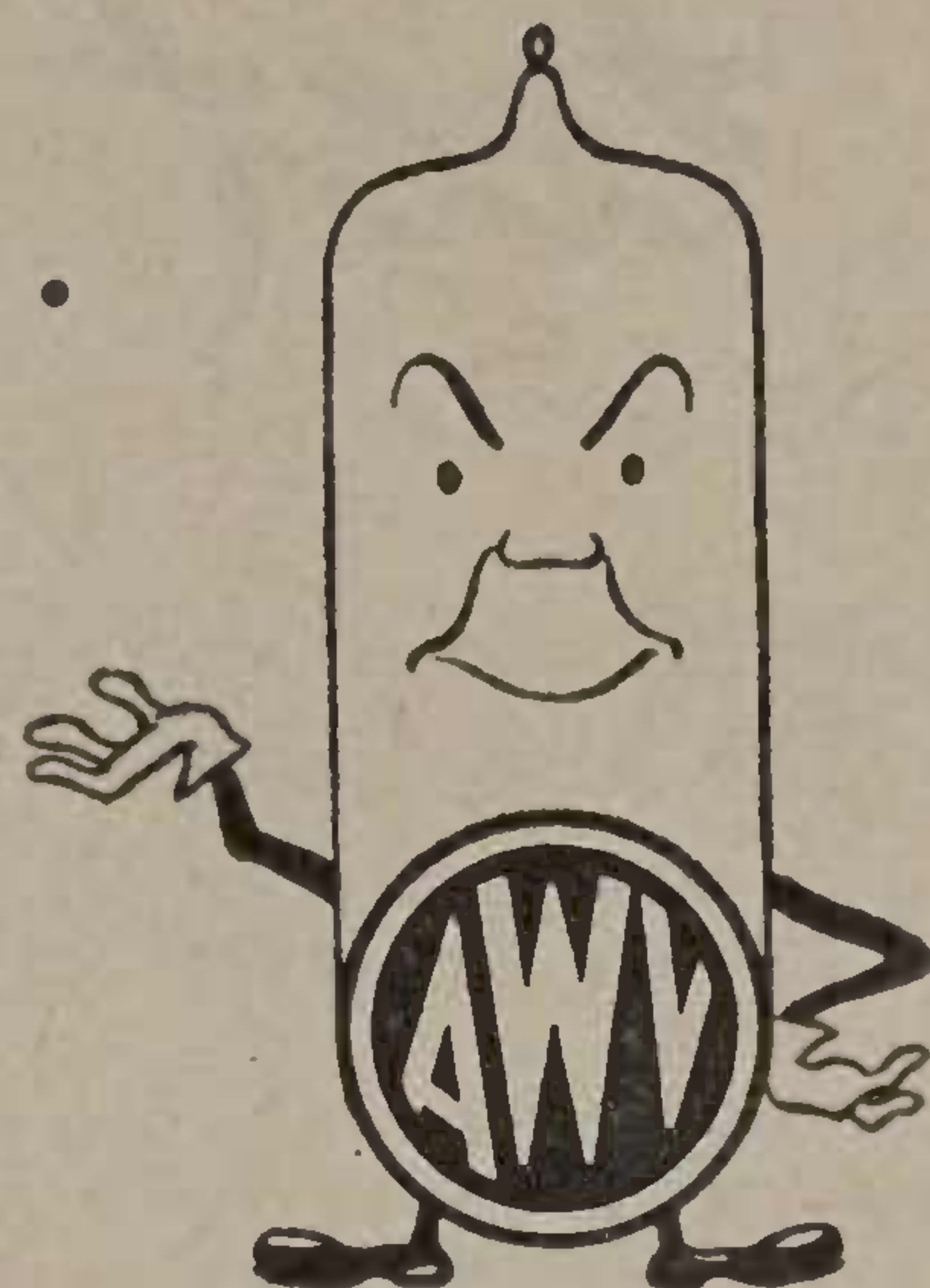


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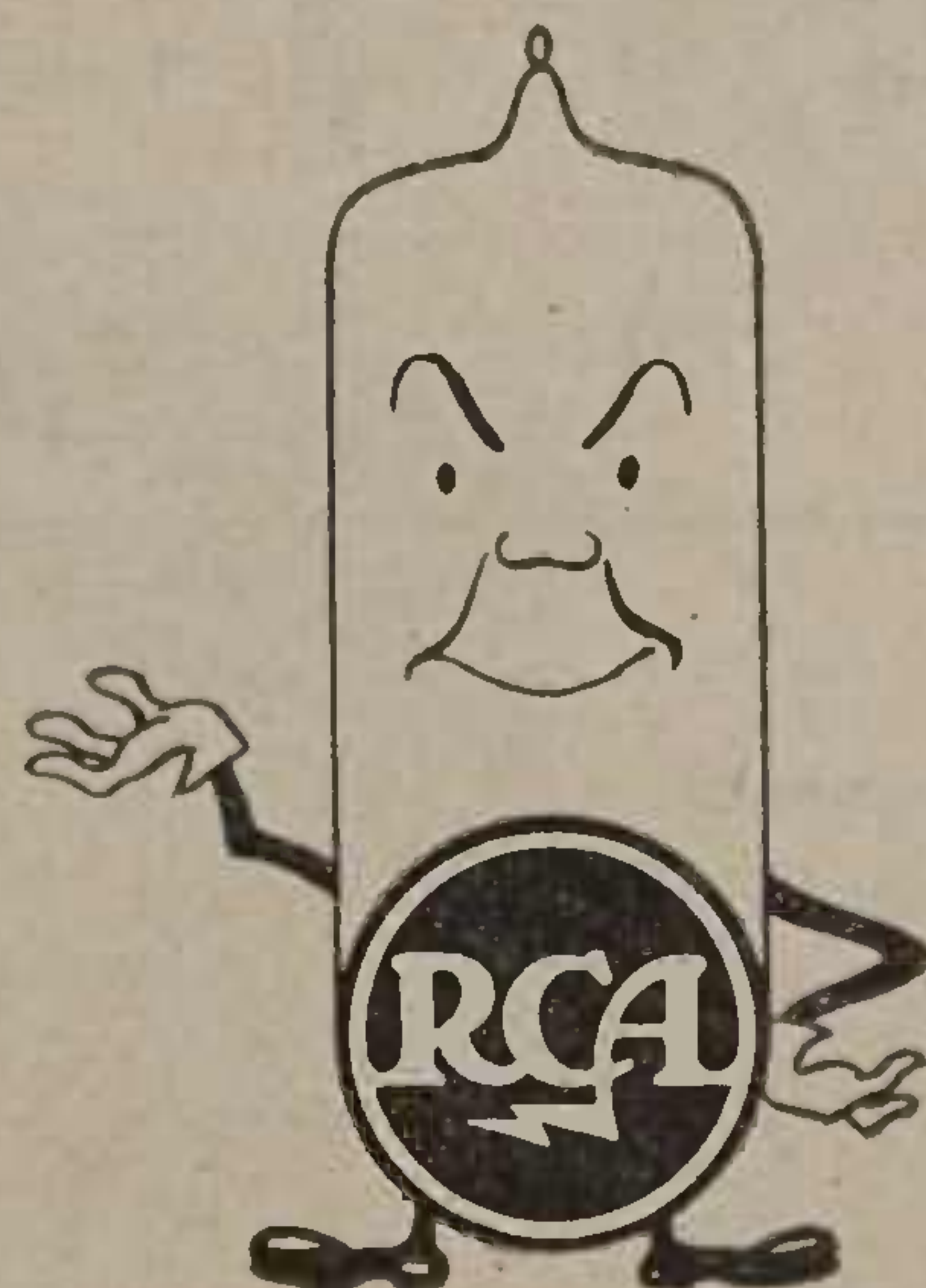
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TV

test instruments

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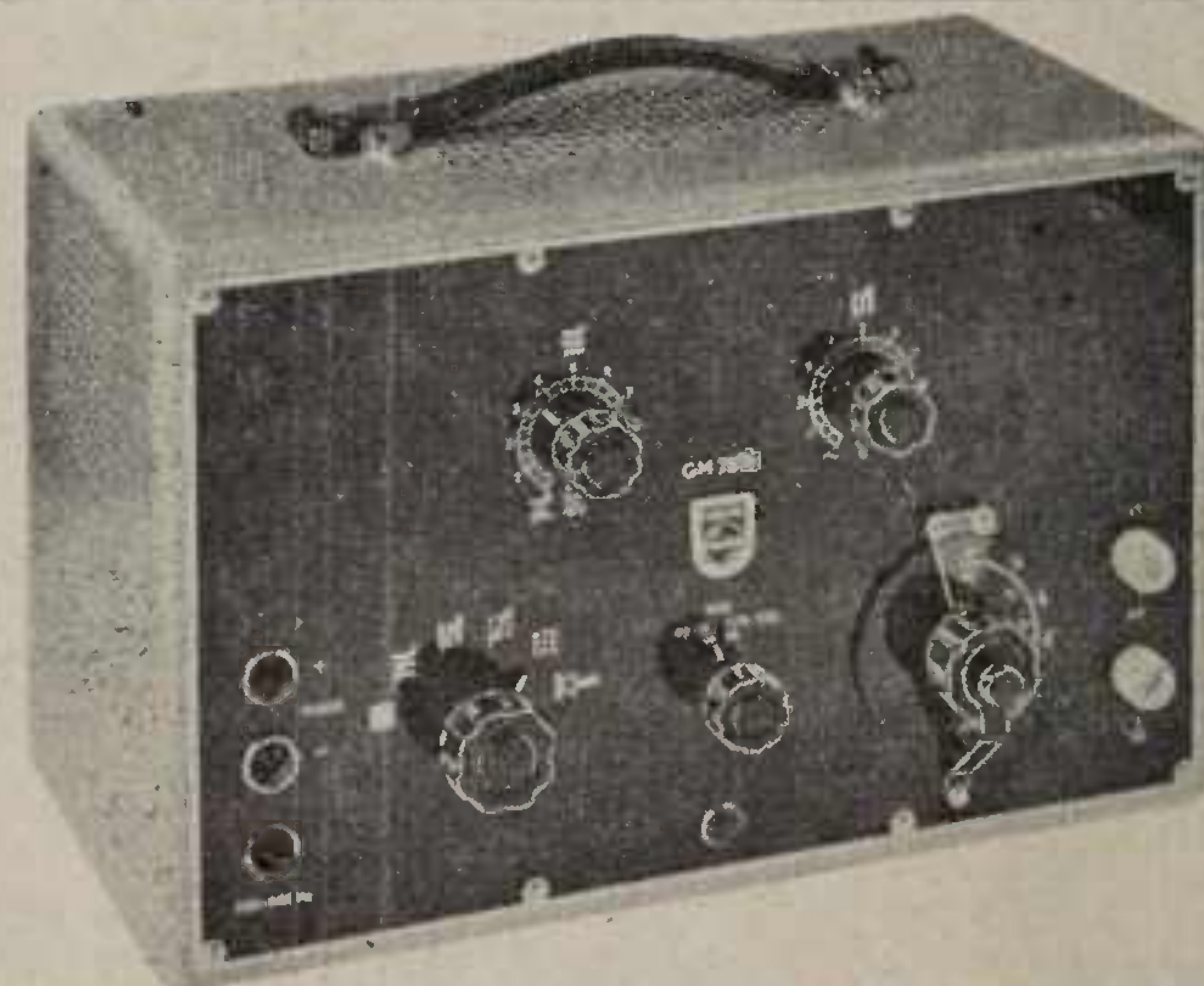
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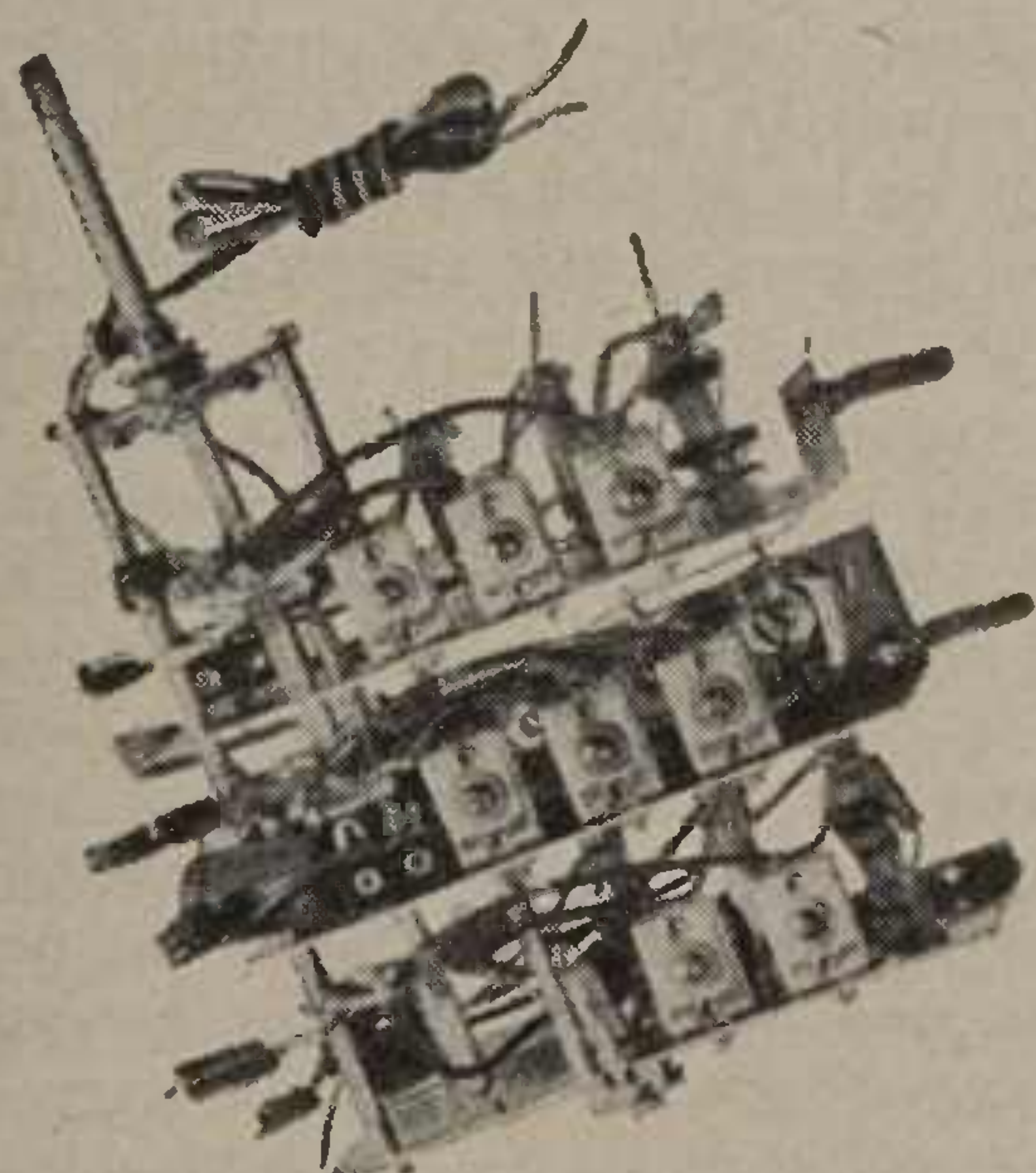


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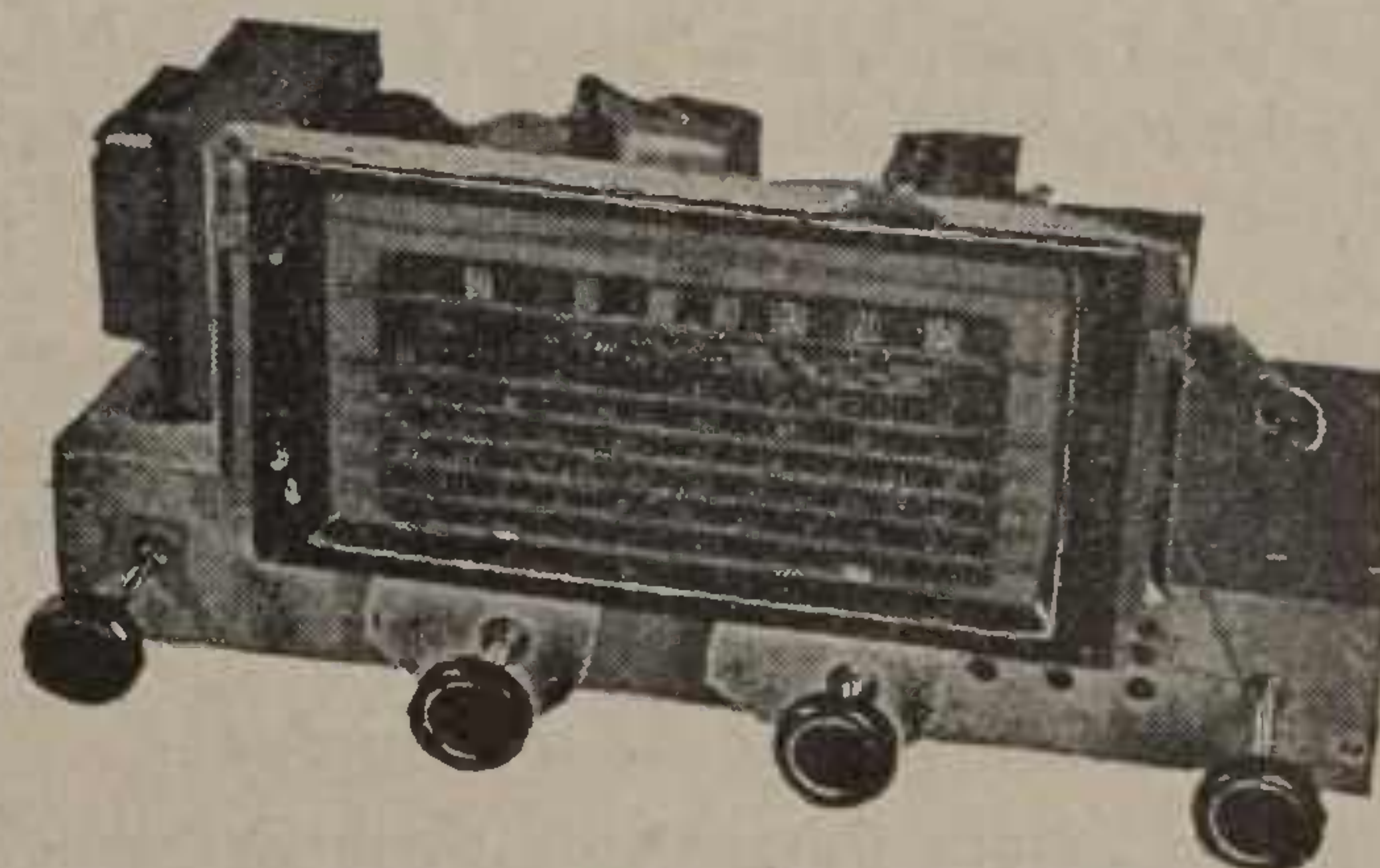


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Note II: Also available, marine unit, type 114AW, for 12-volt tubes, covers 540k/c. to 4m/c. in two bands.

Note III: Our basic kit type B/14 for 7 Transistor portable now available.

Write for particulars.

Audio

STEREO FROM THE OTHER END

A great deal is being written these days about stereophonic reproduction, but it is difficult to find much material about the making of stereo recordings. It is fairly obvious, when one listens to a variety of recordings that different companies use vastly different techniques for making them. Some are obviously "gimmicked", while others hardly seem to be stereophonic at all. Some experiences of the making of a stereo recording are related in this short article.

Introduction

There is very little material available for the serious student of recording technique to read on the subject; this has always been the case, and is a throw-back to the early days of gramophone recording, when every company had its own methods which had to be kept secret! This lack of published information makes it difficult for anyone to tackle recording without recourse to a good deal of hit-and-miss or cut-and-try, and when new problems such as stereo arise, the lack of authoritative information is even more marked. It is because of this that we have decided to publish this short article describing some experiences of our own in making stereophonic recordings.

Basic Equipment Needed

The first essential, of course, is a tape recorder that will record two tracks simultaneously. This need not be a commercial machine, but can be any ordinary recorder modified by the addition of a second record head and record amplifier. There is not even any necessity for the machine to have in-line heads, provided that the resulting tape need not be played back on any machine other than the one on which it was made. Indeed, for the experiments described here a non-standard machine was used.

Next in importance are the microphones. The whole question of making a good stereo recording boils down to the use of suitable microphones, placed in a suitable manner, and the types of microphones to be used has a very important bearing on the results obtained. It is possible to obtain results with any particular type of microphone, provided its quality is good enough, and provided that placements are organized to suit the directional properties of the microphones used.

If low-level mikes are to be used, pre-amplifiers will certainly be required, while if some mike arrangements are to be tried, special circuitry may be needed as well. However, with the recorder and microphones available, and facilities for building the small amount of special circuitry that may or may not be needed, according to circumstances, the recording enthusiast is ready to start thinking about just how he is to attack the job.

Material to be Recorded

Of course, if one just wants to make some stereophonic tapes for the sheer joy of doing so, nothing

is easier than to take a leaf out of the book of the recording companies, who used all kinds of every-day noises to produce the most life-like stereo recordings. Traffic noises, games of table tennis, trains, and so on, can all be done as well, if not better than on the demonstration records if one has a mind to it, and can obtain co-operation in suitable quarters. These are quite fun, but they do tend to pall as programme material, even though they are sometimes excellent as means of evaluating the performance of a stereo recording and reproducing system.

To our way of thinking, there is just one type of programme material that cries out for the benefits of stereophonic recording, and that is stage-work, whether operatic or straight dramatic. Here we have a type of programme material where the perception of direction and movement really means something, quite apart from the general air of realism and solidity added by stereo. There are innumerable stage groups throughout the country who would benefit greatly from having their work recorded, both to enable them to criticize their own efforts, and for the purpose of keeping permanent records of their achievements. If this sort of material is to be recorded at all, it would seem to be a pity not to give it the advantage of being done stereophonically.

In fact, what started all this off, as far as "R. & E." was concerned, was the active interest taken by the Eidtor in the Wellington Gilbert & Sullivan Society, which has just recently undertaken a very successful production of "Iolanthe". What, indeed, could make better material for the making of some experimental stereophonic tapes than a stage performance of this kind? There are music, dialogue, movement on the stage by individuals and groups of people, and at times there are upwards of sixty people on stage at once. A successful recording of such a show is quite a difficult assignment, but the conditions were very favourable, since the dress rehearsal and the first two performances were to take place in the very modern and entirely suitable Little Theatre at Lower Hutt. This theatre seats about 350 people, and has excellent acoustics. It also has the advantage of numerous ready-wired microphone circuits from the vicinity of the stage, back to the projection box! It was thus possible to set up the recorder in the projection box, and through headphones, listen to what was going on, on stage, and thus to evaluate the stereophonic effect achieved by the

particular microphone arrangement in use. Furthermore, if experimentation during the final rehearsal showed that a good result was likely to be obtained, there were two whole performances that could then be recorded, given enough tape!

Microphone Placement

Virtually the whole success or otherwise of the operation depends on this, whether circumstances are similar to those outlined, or not. Now the most obvious method, and at the same time the easiest, of attempting a stereophonic recording, is to use two non-directional microphones spaced, say, from eight to twelve feet apart. There is no doubt that successful stereo can be had in this way, but whether this is the most satisfactory arrangement for covering a large area of stage is open to question. Fortunately for us, some experiments with this simple arrangement had already been made, in the same theatre, by Mr Paul Douché, who is "R. & E.'s" laboratory assistant, and who was to do the actual recording when the time came. He had previously performed some experiments in obtaining stereo coverage of the same stage, and he had found that while it was possible to obtain reasonably good localization, there was a pronounced "hole in the middle" effect. His test consisted of setting up the recording channels, and then walking across the stage, talking all the time. When this was done, the right-left localization was obtained quite well, but there was so pronounced a drop in level between the two microphones, that the effect was as though the speaker had receded to the back of the stage at the same time as he went across, thus appearing to pursue a kind of two-sided course, from one side to a mid up-stage position, and from there down to the opposite side, up front once more. One method which has been proposed for avoiding this effect is to use a third microphone in the centre, and mixing a portion of its output with that of each of the side microphones, in order to fill out the "hole". This could be done quite easily, but would necessitate a special pre-amplifier with facilities for mixing the centre microphone in controllable proportions.

Another method of using non-directional microphones for recording stereo is to place them close together, with a sound-absorbent baffle between them. The idea of the baffle is to prevent as far as possible, one microphone from "hearing" what should predominate in the other one. It also helps to prevent cancellation taking place at frequencies which are high enough for the distance between the microphones to be approximately half a wavelength.

Use of Directional Microphones

If directional microphones are used, there are various other possibilities. The scheme which was actually used in our experiments was to mount two microphones side by side, each having a cardioid type of response, and turning them at an angle of 90 degrees to each other. In other words, each microphone "looks" outwards at an angle of 45 degrees to the frontal direction.

A cardioid, or heart-shaped pattern, has the property of giving almost even response over an arc of 180 degrees. At the back, the response gradually falls off, until directly behind, there is a complete null or zero-response point. When two such patterns are arranged at an angle of 90 degrees to each other, it is obvious that at wide angles away from the "line of shoot" of the pair, one must pick up more signal than the other, and this effect will account for some of the source localization effect that is obtained. Towards the centre, however, amplitude differences picked up by the microphones are not sufficient to account for the stereo effect obtained. Here it is more a question of phase differences between the sounds picked up by the two, and in reproduction, difference in phase between the outputs of the speakers.

There is another possibility which also uses directional microphones, but of different types. Here a single cardioid is used together with a velocity microphone which has a figure-of-eight pattern, just like that of a half-wave dipole aerial. The two are arranged so that the cardioid faces directly to the front, while the bi-directional microphone faces sideways. Now these microphones do not directly give signals representing the right- and left-hand channels, and to produce such signals, their outputs have to be combined in a special way. To obtain the channel signals, it is first necessary to obtain from the bi-directional one two equal signals in opposite phase. This done, one phase from the bi-directional is added to the cardioid output to give one channel, and the phase-reversed signal from the former is added to the latter to give the other channel. It is possible to do all this in a quite simple manner if the output transformer of the bi-directional microphone has a centre-tapped secondary, but it is also necessary to ensure that the outputs of the two microphones have the correct amplitude relationship to each other if the proper stereo effect is to be obtained. If the matrixing is done at the microphone transformers, in the manner described, there is little or no possibility of controlling the relative levels of the two, so that the whole system must be specially designed as such. It is believed that Telefunken in Germany are using a system of this kind to make stereo recordings, and that they have built the two microphones and their matrixing arrangements into a single unit which appears to be a single microphone.

When it is desired to use a similar arrangement to this with microphones that have the correct directional properties, but whose sensitivities are not necessarily properly matched, the difficulty can be overcome by using an electronic matrixing system. With this, there is no difficulty about organizing at will the relative outputs at the point where the matrixing takes place.

The above scheme had some very attractive features, and at one stage it looked as if we might have to use it for our own experiments, because of the difficulty of getting hold of two identical microphones in order to use the simpler scheme described above. Since time was a difficulty, especially when it came to making up special amplifiers with matrixing arrangements, we

were glad not to have to use the cardioid/bi-directional idea, though doing so would have been most interesting and instructive. We have since been told that Messrs E.M.I. use the twin-cardioid system in making their stereo records, and a comparison with the results obtained in these experiments, of some of the cuts on the E.M.I. demonstration record SDD1, indicates that this is in all probability true.

Some Trade Credits

Seeing that the equipment had to be arranged in very short order, and also that some of the major items, such as the microphones, would have to be borrowed, begged, or stolen for the occasion, we did some fast rushing round to find what was available. The first visit, to Mr Don Cooper at the Pye Wellington office revealed the existence of a pair of "Tannoy" high-quality cardioid microphones which he was kind enough to lend for the occasion. This settled both the microphone problem and the best arrangement to try. It was to be "cardioids at ninety degrees" from that moment. The only difficulty thus arising, was that these mikes have an extremely low output on to a 200-ohm line, of — 80db. relative to 1 volt per bar, so that even though the tape recorder had two identical channels that could normally be regarded as high-gain ones, at least one extra stage of pre-amplification was going to be needed. The low output impedance of the microphones was ideal in one respect, namely that their outputs had to be taken the length of the theatre before reaching the amplifying equipment. At the same time, the output was so low that hum and noise were going to be almost insuperable problems unless a broadcast-quality pair of line-to-grid transformers was obtained. This sent us round hot-foot to Telecommunications Ltd.'s factory. This firm, run by Mr Stan Shea, who was in the early days after the war, intimately concerned with the establishment of this journal, makes high-quality audio transformers of just the type we were wanting, and provided they had some in stock (they are all made to special order, in the ordinary course of events) we had hopes of borrowing some. Stan himself was out of town on business, but a short chat with Mr Tom Duxbury, Telecommunications' designer, produced a couple of the right sort, nominally 500 ohms to 50,000, triple-shielded in mu-metal and mounted on octal plug-in bases. There appeared to be a minor snag here, in that the nominal output impedance of the microphone transformers was 200 ohms, and not 500 (no 200-ohm transformers could be located) but some rapid thought decided that if the transformers were used without being terminated on the secondary side by the nominal 50k., any effects due to the nominal mismatch would be negligible.

We then rushed back to the laboratory, clutching microphones and transformers, and proceeded to organize the rapid assembly of a double pre-amplifier using an EF86 for each microphone, following the voltage step-up provided by the transformers. After finding that the hum level was acceptable in spite of the low signal level, but that there was more hiss than

could be tolerated, all critical resistors in the pre-amplifier were replaced with high-stability cracked carbon types, and we were ready to go.

Mounting the Microphones

The microphones were provided with their own mounting stirrups, enabling them to be tilted. The stirrups were therefore mounted on a metal bracket, and turned at approximately 90 degrees to each other, the idea being to hang the bracket from the ceiling, and then to adjust its position by means of tie-strings, which could move it backwards or forwards. No movement would be necessary from side to side, since the mikes were to cover a symmetrical area of stage. In order to take care of the fact that the mikes had to be considerably higher than the people on stage, in order not to obstruct the audience's view, it was obvious that they would have to be tilted downwards, to face approximately the centre of the stage. In this way it was hoped that the whole of the stage would be covered without any gaps, either in the centre, or from back to front.

As soon as the mike mounting had been constructed, and the pre-amplifiers pronounced satisfactory, the mikes were hung out the laboratory window, and the results listened to by means of the tape recorder it was proposed to use. Lo and behold! Stereo traffic noises, for all the world like the ones recorded in Westminster, and put on the E.M.I. demonstration disc! Then a rapid sigh of relief, and the gear packed up for the journey out to the Hutt Little Theatre, with about an hour to spare.

Arrangement in the Theatre

The proposed microphone arrangement was used, and is illustrated here. The theatre has an orchestra well, which puts the orchestra about five feet below stage level, and with their heads on about a level with the floor of the auditorium, right at the front. This was obviously going to be a help, because it was known that some of the voices were not strong ones, and that they might have difficulty in keeping above the orchestra unless it played very softly. If a good recording were to be made, it was of the greatest importance to preserve a good balance between the orchestra and the singers on stage.

Now microphones such as were being used have a directional pattern which has a minimum response directly over or below them. With the downward tilt needed to aim them at the centre of the stage, and with the orchestra almost directly below them, it should be possible, we argued, to vary the balance between orchestra and singers quite markedly, by merely swinging the mikes forward, so as to put the orchestra more and more into the area of small sensitivity, immediately on the line through the microphones. Because of this tilt, there was no possibility of putting the orchestra on a real null, and thereby "d.f.ing it out" altogether.

In practice, these ideas worked out perfectly, as things turned out. Fortunately, we were able to do all the necessary experimentation on the Thursday dress rehearsal, and on Friday and Saturday, obtain full recordings of both performances.

Results Obtained

As readers will no doubt have gathered already, the results exceeded all expectations. A suitable balance between singers and orchestra was obtained with only one shift of the microphones, after which making the recordings was only a matter of watching the levels during the performance. One of the difficulties to be expected in recording shows like this, where at times there is the large volume of sound produced by full chorus and orchestra, is that of getting enough recording level on soft solo passages.

In Gilbert & Sullivan operas, there are quite long passages where there is a continual inter-play between various solo voices, and the chorus; it was clear that during these, the operator could not possibly "ride the gain control" however perfectly he might know the score, in an attempt to bring up the solo passages. All he can do is to ensure that the loudest passages do not overload things, and hope for the best in the short solo bits. In practice, this turned out excellently, and the general success of the balance, apart from stereophonic effect, was due, we think, to the positioning of the microphones, the good acoustics of the theatre, and the use of cardioid microphones, with their very small pick-up from behind.

First and foremost, however, was the complete success in getting good stereophonic effect. Once the correct balance setting has been found during playback, the localization is well-nigh perfect. There is no question in the listener's mind as to which direction the sound comes from, and where there are several soloists on stage at once, their relative positions are accurately portrayed by the sound pattern produced. Then, of course, the air of realism and "presence" given by a good stereophonic recording is also there in full measure. In short, the experiment was as complete a success as could have been wished.

Channel Phasing

Great care was then in wiring up the recording system to ensure as far as possible that the phasing of the microphones was preserved. This could only be done by assuming that the microphones themselves, and their transformers, had been wired in identical fashion. It would have been possible to check this before the event had more time been available, but it was realized that even if the microphones were not phased the same way at the inputs to the amplifying and recording equipment, the discrepancy could always be corrected afterwards, by reversing the leads to one of the speakers. As it turned out, this is exactly what had to be done. Somewhere through the system—possibly even inside the recorder itself,—the phases had become reversed, and we did have to reverse the leads to one of the loudspeakers in order to obtain the correct effect. The audible effect of incorrect channel

phasing is most marked. The writer had read how the localization with incorrect phasing is not itself right, and how an apparently correct balance suddenly becomes quite wrong, and so on, but he would never have believed that the effects were as marked and as startling as they turn out to be. There is just no question of which phase is the correct one.

With the microphone arrangement used for our experiment, phasing is probably even more important than with other arrangements. When it was wrong, there was a very strong cancellation of all the lower frequencies, and of the lower middle ones. Indeed, the "bottom" falls out of the reproduction, and a singer placed centrally on the stage seems to recede suddenly into the middle distance. Correcting the phasing rounds out the frequency response, and brings the whole performance to life in a manner that cannot really be described. It needs to be heard to be believed. Another most noticeable effect is that with incorrect phasing, some sound seems to issue from the speakers themselves, while others seem to come from vague, indeterminate directions between the speakers. When the phasing is corrected, however, no sound can be heard coming directly from either speaker, even in the case of a singer on the extreme left of the stage, when he seems to be singing from a point just centre-wards of the left-hand speaker, but not directly out of it.

It was obvious that the microphone placement, with the downward tilt, had successfully covered the stage from back to front, there being no sign of drop-out from people being right at the back of the stage.

Results on the spoken parts were every bit as good as those on the music, and the actors could be followed round the stage as their movements take place. Even the orchestra sounds, as a theatre orchestra actually is, namely spread out across the stage; in fact the illusion is as complete as one could wish for, and thanks to the very favourable position in which microphones are placed, various people who had heard performances of the piece said that the recording enabled the words to be followed better than during the actual performance. However, this opinion was possibly due, at least in part, to the fact that the listeners referred to heard not the performance recorded, but later ones, which took place in the Wellington Town Hall Concert Chamber, which is very poor acoustically compared with the Little Theatre in which the recordings were made.

Conclusion

Altogether, we found this a most interesting experiment, and we hope that readers will have found this account interesting too. It should certainly provide some practical clues to those who may wish to follow our example, and make recordings—stereo or otherwise—of some of the wide variety of amateur shows that are put on these days all over New Zealand. Admittedly, the equipment used was not all of the amateur variety, but neither is that of many recording enthusiasts today, and there is little reason why many others should not be able to duplicate the results described above.

THE "R. & E" TAPE-RECORDING AMPLIFIER

It is now just three years since we published the design of some high-quality tape recording circuitry, suitable for those who want results that are comparable with what can be done by way of reproducing music from gramophone records. This circuitry has been exceedingly popular among readers; indeed, the first of the series of back numbers containing the original articles is now out of print, and of the rest, only a few copies remain. Since we have recently had numerous requests for these issues, we are reprinting the circuits and the information on them. To those who would ask whether there are not improvements which could be made, we must reply that the performance of these circuits is so good that we see no reason for modifying them, and we know that many who have built them would agree with us.

Introduction

It is only natural that audio enthusiasts should have taken, like the proverbial ducks to water, to tape recording as a means of obtaining added enjoyment from their hobby. There are so many things that can be done with a good tape recorder, especially if its performance is up to that of the remainder of one's equipment. But that is the rub, because even quite expensive machines of the commercial variety do not produce results that match reproduction obtained from good recordings, especially when these are played through good equipment, such as many of us now possess. This, quite apart from the delights of building one's own tape recording gear, is why so many of our readers have taken to building the circuits which we featured some three years ago. It is not blowing our own trumpets unduly to say that these circuits are capable, given a good deck, with heads of good enough quality, of results that come within the professional class.

The point here is that where one is not interested in building for sale, and therefore for a profit, it is possible to use design features which, however desirable, just do not get used in commercial equipment other than that of the professional variety that hardly anyone can afford.

Virtues of these Circuits

For those who have not met these circuits before, we should perhaps outline their virtues before going on to describe them.

(1) Standard C.C.I.R. Performance

The playback pre-amplifier gives the standard C.C.I.R. performance curve for $7\frac{1}{2}$ in./sec. tape speed, and thus gives the correct performance on pre-recorded tapes, and on tapes made on any other machine con-



View of the chassis together with the deck which was used as our lab. "guinea-pig". The combined results have been excellent.

forming with these standards. Now that tape recording techniques have been well standardized, this is an essential feature for any tape recorder that is to be used for high-quality results.

(2) Excellent High-Frequency Circuits

The oscillator-amplifier arrangement used for obtaining the erase and bias waveforms gives as good performance as can be obtained in this most important part of the "works". For making recordings with very low distortion content, this is essential, and yet is a feature often skimmed in commercial recorders.

(3) *Separate Circuits for All Functions*

The circuits for the playback pre-amplifier, the recording amplifier, and the bias-and-erase part, are completely independent of each other, using their own valves, and no switching of valves from one function to another. This makes construction and servicing very much easier, as well as enabling each portion to be designed entirely without regard for the others, and thus for maximum performance.

Various Decks

Originally, the circuits were designed to be suitable for any of three decks which were at that time available. We do not know whether Truvox or Brennell decks can still be had, but recently, there have been some Collaro ones available, and most of our recent inquiries have come from those who had that type of deck. Fortunately, the modifications to the circuit to enable it to be used with any of these decks are very few, and in the original series of articles, the general scheme was to show the set-up for use with the Collaro deck, with its own fairly complex switching, as a simple modification of the original. Indeed, no modifications at all were required for the amplifier circuits themselves, the only additions being concerned with the head circuit. We have therefore preserved the original design of the series of articles in the present re-printing, while introducing the Collaro switching circuit early in the piece to suit those who have recently acquired this deck.

The original articles have been retained, too, including the one which describes the setting-up procedure of the completed equipment.

Description of Equipment

In designing the circuits for a tape recorder, there are a few things that must be decided before the detailed work can begin. For example, is the instrument to be completely portable, or is it to be installed as part of a fixed audio system in the home? Secondly, what facilities are required for monitoring what goes on to the tape? Third, are separate heads to be used for recording, playback, and erasure? Fourth, are audio mixing facilities to be provided, so that it is possible to select more than one audio source for recording? Fifth, what audio sources are to be provided, from which recording can be accomplished? And so on.

If answers to all these questions are known, then the general scheme of the amplifying equipment can be decided, but in a case like ours, practically all of the answers are unknown, because different users want different specifications, to meet their own particular ends. Thus, all we can do is to decide on a specification that will suit a number of people, and build the gear accordingly. This does not mean that we thereby ignore those whose needs may be slightly different. In many cases, simple additions or modifications can be made which will take care of different requirements, so that only a small minority are not finally suited. This is what we hope we have achieved in the present instance.

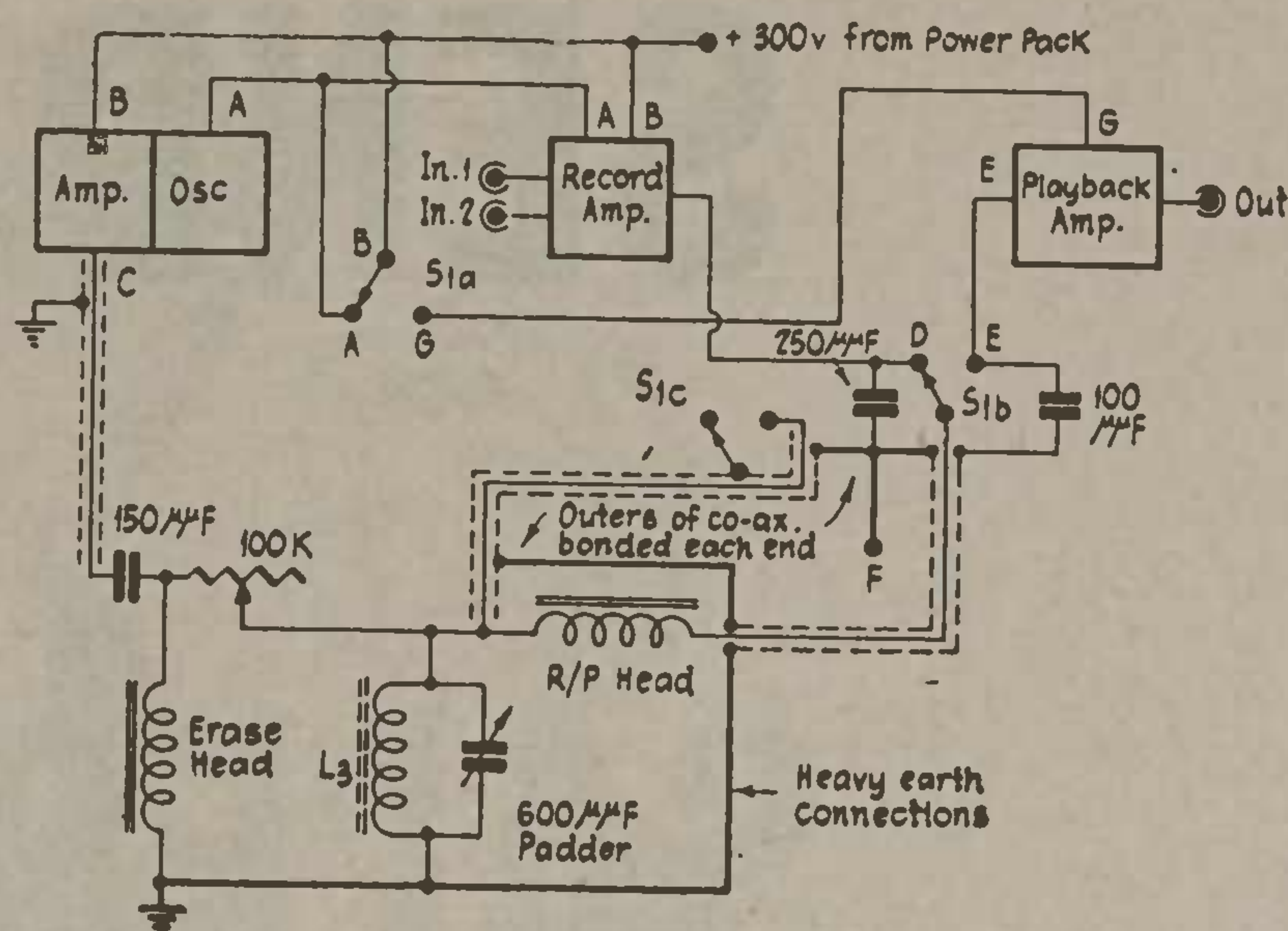


Fig. 1

The switching diagram and head circuit.

First of all, the circuit does not include a power amplifier or a loudspeaker. This decision was taken on the principle that many users of tape recorders do not want or need a completely self-contained instrument. For those who already possess an amplifier for gramophone record playing, it is usually quite unnecessary to have a built-in amplifier and speaker in the tape recording gear, because much the best quality will be obtained when the equalized output of the playback head is fed to the main amplifier. Thus, for playback purposes, the only circuit that must be provided in the tape recorder is a special equalizer and pre-amplifier. In the present equipment this accounts for two of the seven valves. The output from the playback section, as this part of the circuit can be called, is large enough to fully load any modern amplifier, and requires no special tone correction, since the response is already compensated in such a way that the signal from a standard tape emerges from it with a level frequency response, which it certainly does not have as it comes from the playback head itself. The remaining five valves are in use during the recording process. Two of them are concerned with providing the supersonic bias and erasing signal, and the remaining three perform the necessary amplification and response equalization for feeding the recording head. Of the three, two make up the recording amplifier proper, and the third is a pre-amplifier, which is needed only when a low-level microphone is used for recording.

There are two input sockets for recordings. One takes the input to the pre-amplifier valve, and is used for the microphone only. The other feeds the input to the first valve in the recording amplifier proper, and so is intended for use with signals of much greater amplitude than are obtained from a microphone, such as a gramophone pick-up or a radio-tuner. Both jacks are of the closed-circuit type, the No. 1 (Mic.) jack being arranged to earth the control grid of the pre-amplifier valve when a plug is not inserted in it. The No. 2 (Radio) jack is connected so that when no plug is inserted, the output of the pre-amplifier valve is automatically connected to the input of the recording

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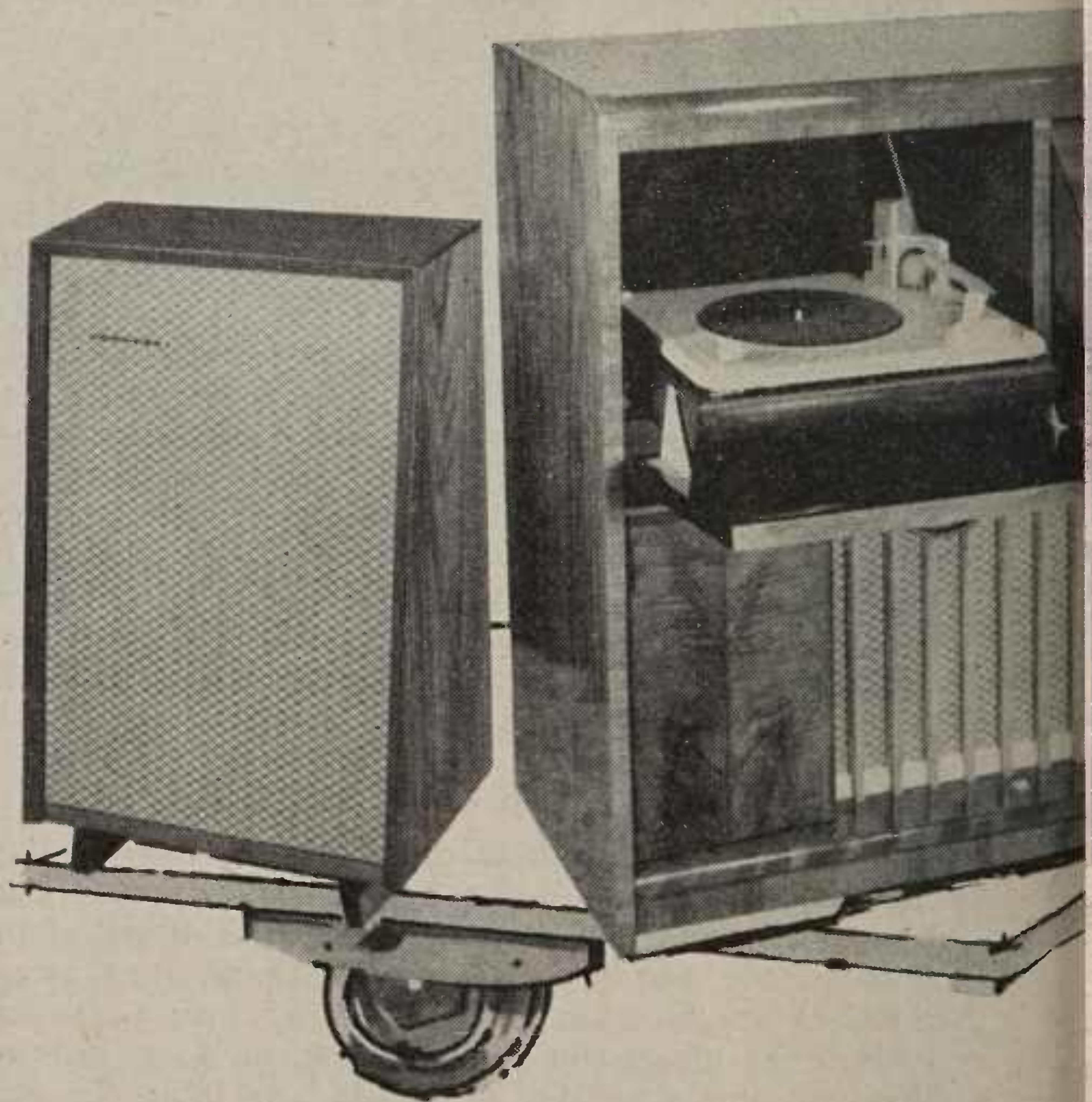
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amplifier. When a plug is inserted, this connection is broken, and the only input is from the cable connected to the plug. From this it can be seen that it is not possible to have two inputs to the recording amplifier at the same time, so that if mixing facilities are wanted, they will have to be provided separately. However, this is not difficult to do, should it be necessary in order to obtain special effects, such as recording a commentary for a film, with music playing softly in the background.

The output of the playback amplifier is brought to a third jack whence it can be taken to the input of the main amplifier, as described earlier. If the latter has a separate input socket for a tape recorder output, this connection can be made permanently, and the selector switch turned to this position when the tape recorder is in use.

The only other working control is the volume control for recording. A magic eye is used as a level indicator, and it is mounted under the chassis so that its face appears in line with the jacks and the volume control knob. There are various pre-set controls, but as these have to be adjusted only during the initial setting-up, and at rare intervals thereafter, they have been placed under the chassis. These are the controls for adjusting the erase and recording bias amplitudes, and the sensitivity of the magic-eye level indicator, and also the tuning controls for the supersonic oscillator and amplifier, and a portion of the record/playback head's circuit.

The question of how many heads are to be used is determined by the choice of tape deck, and the one used has the conventional arrangements of a separate erase head, and a combined record/playback head. About the only advantage of a three-head machine is that it becomes possible to have both the recording and playback heads, which are entirely separate, working at the same time. This enables the record to be played back only a fraction of a second after it is made, the delay being simply the time taken for the tape to travel the distance between the recording and playback heads. As this distance is seldom more than a couple of inches, the delay is only about a quarter of a second, when the tape speed is $7\frac{1}{2}$ inches per second. A system like this is often used in professional machines, because it gives almost instantaneous warning if something has gone wrong with the recorder. In an instrument intended for home use, what is being recorded can easily be monitored at the same time as the record is being made (although not from the tape) because the output of the radio tuner, for example, can be fed simultaneously to the tape recorder and the main speaker amplifier. Of course, if one wants to record something and play it back while the main amplifier is in use for some other purpose, an additional speaker or headphone amplifier is essential.

It might be thought that for recording in the home from the microphone, it would be necessary to have the whole of the recording and reproducing gear in self-contained portable form, but this is by no means necessary. Most modern microphones can be used successfully at the end of a very long piece of cable,

if desired, so that all that must be extended is the microphone lead, even if one wishes to operate at several hundred feet from the recorder.

It might be thought that a certain amount of complication would be avoided if permanent-magnet erasing were used, so that no erase head would be needed, with the electrical arrangements used for feeding it with a watt or two of supersonic erase frequency. However, it is some time since tape recorders which pretend to any sort of quality have used permanent magnet erasing. The main reason for this is that it results in a noisy tape, in the same way as does D.C. biasing during recording—a system that has disappeared altogether since H.F. biasing first gained prominence. Because of this, only very inexpensive tape decks, which are not intended for high-quality reproduction, will be found to omit an erase head, and it is standard practice to use the same supersonic frequency for both erasure and biasing, during recording. Also, since an H.F. oscillator is needed for recording bias, irrespective of what system of erasure is used, there need be no complication of the electronic circuits, merely because H.F. erasing is chosen. In the present instance, an ingenious circuit is used for feeding the erase head and the record head from the same H.F. amplifier, so that there is no need for separate amplifiers for bias and erasing. The H.F. part of the system therefore consists of an oscillator and a single power amplifier.

Circuits

Even when the individual circuits of a tape recorder are quite separate from each other, as they are here, a complete circuit diagram, drawn with the necessary switching on a single page, tends to look rather fearsome. Accordingly, the system has been split up into four separate diagrams. Three of these are the recording amplifier, the playback amplifier, and the H.F. bias and erase circuit, while the fourth is a drawing of the switching arrangements, with the separate circuits shown only as blocks. The letters on this diagram correspond to the same letters to be found on the individual circuits, so that there will be no confusion as to the exact point on the circuit that is brought to the switch in each case. Also shown on the switching diagram is the circuit of the two heads. This saves having a separate diagram with feeds going both to the switching diagram and to the H.F. section. The reason for this is that the components shown in this part of the circuit are actually situated on the deck, on a small panel specially mounted there for the purpose. This has to be done because the erase and bias frequency is approximately 60 kc/sec., so that to a considerable extent, R.F. wiring technique must be used if the proper performance is to be obtained. This is discussed further later in the article.

In practice, the three main circuits have all been built on the one chassis, but they are none the less separate entities, for all that, and they can be built and tested quite separately. In this way, the job is broken down into three separate ones, each of which is quite small, and not at all difficult. The lay-out was made in the

expectation that complete shielding of the R.F. oscillator might be needed, but it was found not to be necessary after all, and so was omitted.

Switching Arrangements

The first part that should be described is the switching diagram, together with the arrangements for feeding the heads. The former is very simple, mostly because of the complete separation of the amplifier functions, mentioned earlier. There is only one switch, comprising several single-pole two-position sections, the two positions being "Record" and "Playback". All the switches are ganged together and in practice are sections of a wave-change type of wafer switch.

One section switches the H.T. to the H.F. oscillator on "Record", and to the playback amplifier on "Playback". A second connects the record/playback head to the output of the record amplifier or to the input of the playback amplifier, according to function. It will be seen that the H.T. is left on the H.F. amplifier and on the record amplifier at all times. The purpose of this is to use the current drawn by these valves as a bleeder on the power supply. Most of the current drawn by the circuit is accounted for by the H.F. amplifier, and since it is a Class A amplifier, its plate current is constant, whether or not there is any excitation for it. Thus, if this valve were switched off on playback when it is not otherwise needed, the power supply regulation would allow the H.T. voltage to rise appreciably. There is no need for any more than 300 volts in either position of the switch, so that leaving the amplifier valve running avoids the use of a resistor of fairly high wattage as a bleeder. In this way, large thumps in the playback amplifier are avoided when the R/P switch is operated. The third section of the switch connects one end of the R/P head to earth during playback, for reasons that will be described in a moment.

The head circuit is an ingenious one, described in the Nov., 1954, issue of "Wireless World" by A. F. Fischmann. Its main advantages are that it simplifies the feeding of H.F. bias current to the R/P head during recording, and that it overcomes in a very elegant manner one of the difficulties usually associated with bias feed circuits. The difficulty, particularly with high-impedance heads, is that the impedance of the R/P head at the high bias frequency is very large indeed. This means that in order to obtain the right amount of bias current through the head's winding, a quite high bias voltage must be applied to it. Now in order to record, a relatively very small audio voltage is applied to the head at the same time, and, because of the presence of a large voltage at bias frequency, this voltage is very likely to be applied to the output terminal of the record amplifier. Some arrangements manage to prevent this from happening, but others are quite poor in this respect. In bad cases, the presence of over a hundred volts of bias frequency at the output plate of the record amplifier can actually cause the plate current in this valve to be cut off for part of each cycle of the bias frequency, and can thus upset the

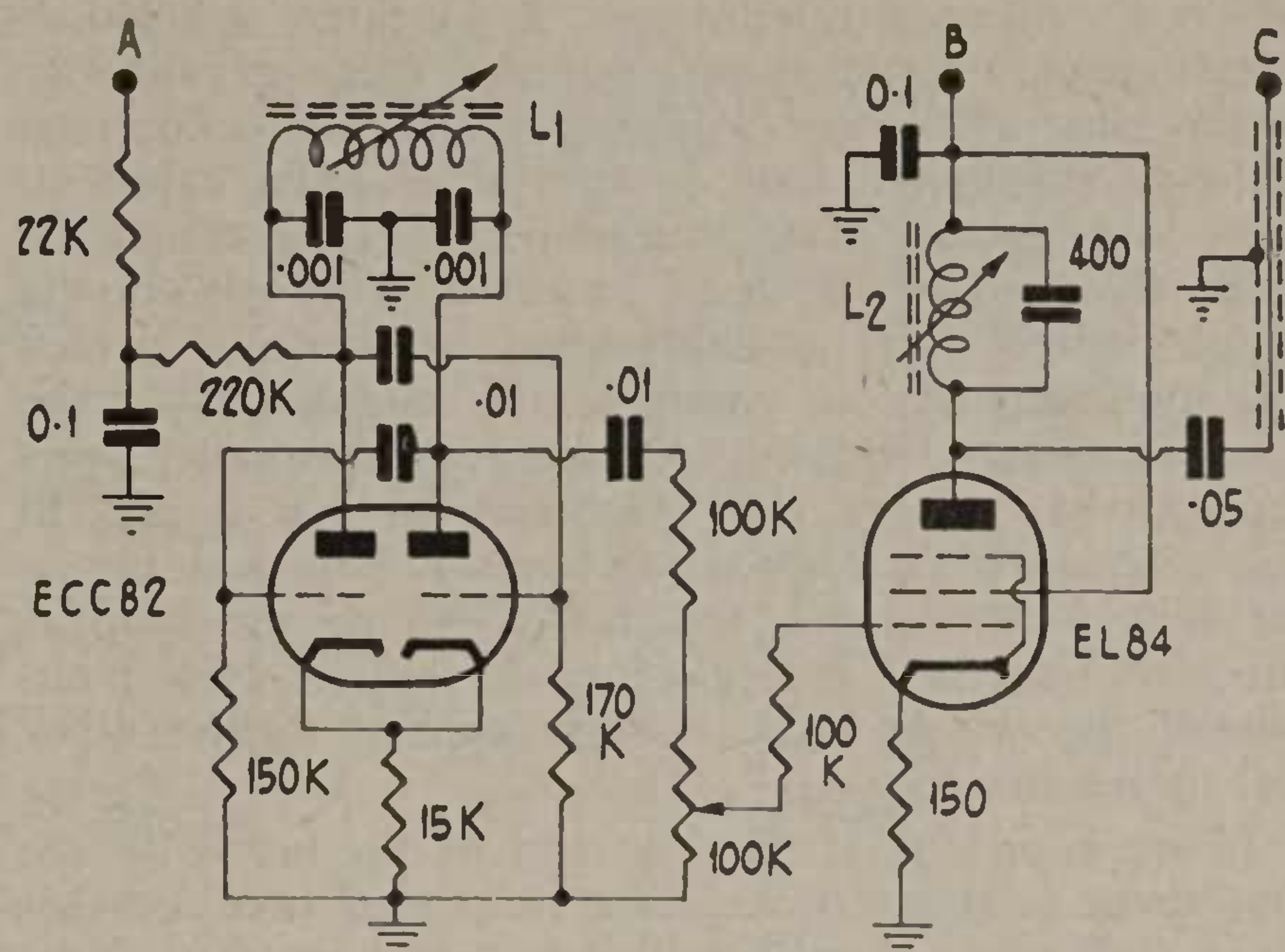


Fig. 2

The H.F. oscillator and amplifier, supplying both erase and bias currents.

D.C. operating conditions of the valve, if it does nothing worse. At the same time, it is very easy under these circumstances for the early stages of the record amplifier to pick up appreciable quantities of bias voltage on their control grids. This can lead to distortion in these stages, and the over-all result will be very poor recording quality.

In the present instance, approximately 125 volts of H.F. bias must be applied across the head during recording, and with the recording amplifier circuit used, this could mean that the whole of this 125 volts is applied directly to the plate of the final stage in the record amplifier. When it is known that at low audio frequencies, the signal voltage across the head is only of the order of 25 millivolts, it can readily be appreciated that the conditions for the production of distortion, and other undesirable effects are very favourable. The circuit used here, however, almost completely eliminates the difficulty. When the 125 volts of bias is measured across the head, only 6 volts can be measured at the plate of the last tube in the record amplifier. Under the circumstances, this is quite innocuous, and eliminates altogether the difficulties mentioned.

It can be seen that both ends of the R/P head are above ground when the switch is in the "Record" position, and that the audio signal is fed to one end, and the bias to the other. The bias is fed in from the erase head's "hot" terminal, through a series resistor, which forms a potential divider for the bias frequency, with the aid of the tuned circuit, which is peaked at this frequency. Thus, if the output of the bias and erase amplifier is first adjusted so that the correct voltage appears across the erase head, the 100 k. variable series resistor can then be adjusted to give the correct voltage across the record head. This is feasible because the erase head, when properly excited, has a larger voltage across it than is required by the record head. At what may be termed the audio end of the R/P head, the

latter is connected (through a blocking condenser which appears on the record amplifier diagram) directly to the plate of the last amplifier valve. The connection is made through a foot or two of co-axial cable, so there is a capacity of approximately $50 \mu\mu\text{fd.}$ connected from this end of the head to earth. This capacity is supplemented with a small fixed condenser, so that the total capacity to earth at the audio end of the head is about $250 \mu\mu\text{fd.}$ At the bias frequency, this capacity has a very low reactance, so that it acts to this frequency as a bypass condenser. Thus, as far as the bias is concerned, the audio end of the head is effectively earthed, and except for the six volts mentioned, the whole H.F. voltage applied to the other end of the head appears across it.

If we now look at the bias end of the head, we see that there is the tuned circuit connected between this point and earth. As the circuit is tuned to 60 kc./sec., its impedance at all audio frequencies is very low; thus, it appears to the audio signal, entering the head from the other end, as a short circuit, and the whole of the audio signal is developed across the head. From this description, it can be seen how the circuit allows both audio and bias voltages to be developed across the head, without interaction between the two feed circuits.

On playback, it would be possible to leave the bias end of the head connected to earth through the bias tuned circuit, the only change being to switch the audio end of the head from the output of the record amplifier to the input of the playback amplifier, and to turn off the H.F. oscillator during playback. Unfortunately, this simple arrangement is impracticable, for the following reason. The unshielded coil of the tuned circuit is not far from the electric motors, and picks up a few millivolts of hum because of their stray field. This hum is quite great enough almost to swamp the signal from the head, on playback, and must be eliminated. The obvious remedy is to short-circuit the coil. For some reason, one's immediate reaction to this suggestion is that the shorting switch will have to be as close to the coil as possible, but this, too, is impracticable, because we certainly do not want to have two switches to operate when changing over from record to playback, and vice-versa. The solution is to take a shielded lead back to the main switch, from the bias end of the head, and to short-circuit this end of the head to the common earth point, back at the chassis. It will be noticed that this scheme does not prevent the coil from picking up hum from the motors, but does prevent that hum from being connected in series with the head during playback. Incidentally, the amount of hum picked up is quite negligible during the recording, as both theory and practical tests indicated.

Of course, another method of overcoming the hum picked up by the coil would be to enclose the tuned circuit in a mu-metal shield. However, such shields are rather difficult to come by, and in any case are difficult to make completely effective, so that the method of shorting the tuned circuit at the far end of a piece of co-axial cable is probably the better one in any case.

Modification of the R/P Head Connections

In order to make this head circuit possible, a slight modification is necessary to the way in which the R/P head is connected in the deck itself. As originally purchased, the R/P head connection is brought out through a single piece of shielded wire. The "hot" lead is the inner wire, while the earthy end of the head winding is connected to the shielding AT THE HEAD ITSELF. In order to pick up this end of the winding, it is necessary to unscrew the cast cover plate. This enables the head assembly to be lifted up, when the two wires from the R/P head are revealed. A piece of hook-up wire is connected to the one that was previously earthed, and this is shielded with a piece of braid. The shielded lead from the "hot" end of the head is left undisturbed, so that the modification consists only in bringing out the other end through its own piece of shielded wire. This should be bonded to the HEAD END of the original shielded wire, and the common earth point on the terminal strip provided for the heads by the makers of the deck. There is a spare lug on this strip, which can be used for terminating the new lead from the head.

Oscillator and Amplifier Circuit

The oscillator uses an ECC82 in a push-pull arrangement, the chief advantage of which is its excellent waveform. It is extremely important that the output of the oscillator-amplifier combination should be as pure as possible, in order to avoid noise and distortion, so that an oscillator capable of producing a pure waveform to begin with is of considerable assistance in this respect. In order to achieve a good oscillator waveform, it is preferable to have it running at a very low level, relying on it only for driving voltage for a separate amplifier, rather than asking it to produce a watt or two of output itself. In order to make the oscillator valve operate as nearly under Class A conditions as possible, a large common cathode resistor is used. This helps to balance the two halves, and ensures that the valve gain is kept low. Both of these help to reduce distortion. H.T. is fed to the valve sections through a 220 k. resistor from the H.T. line, to one plate. The other plate gets its voltage through the low resistance of the tuning coil, so that both sections have the same H.T. voltage. This scheme of feeding in the H.T. in an unbalanced manner is permissible only because of the high value of the feed resistor. Strictly speaking, the coil should be centre-tapped, and the resistor connected to this point, but when the feed resistor is so high in value it can be connected in the manner shown without appreciably unbalancing the circuit, because its value is considerably higher than the impedance of the tuned circuit.

The output is taken from one plate of the oscillator. It is important to note that this is the opposite plate to that used to feed the H.T. to, and that the resistance connected to earth from the output plate is approximately the same in value as the feed resistor. Because

of this, the resistive loading on the two halves of the push-pull oscillator circuit is balanced, so that any unbalance arising through the unbalanced H.T. feed is counteracted by the output connection. The potentiometer feeding the grid of the EL84 power amplifier is there to enable the output of this tube to be adjusted until the correct H.F. voltage is found across the erase head. Being a pre-set control, whose setting hardly ever needs to be altered, it is placed under the chassis on a small bracket, as closely as possible to the grid of the EL84.

The EL84 is a tuned amplifier, so that in its plate circuit we find a parallel-tuned circuit, adjusted to the same frequency as the oscillator. This helps to remove traces of distortion that inevitably occur in even a good oscillator like this one, and the waveform at the plate of the amplifier is quite likely to be a little purer than that from the oscillator. A large blocking condenser removes the D.C. from the amplifier output before it is connected to the co-axial cable which feeds the H.F. power to the erase head. At the other end of the cable is a small silvered mica condenser which might at first sight appear to be unnecessary, but such is not the case. Its value has been chosen so that it acts with the inductance of the erase head as a series-tuned circuit. In this way, the inductive reactance of the head is cancelled out, and to the amplifier valve, the circuit looks like a pure resistance of some 5000 ohms. There are two ideas behind tuning the head like this, both of them beneficial to the performance of the amplifier and thus to the purity of the H.F. waveform. First, a purely resistive load is the best kind for obtaining a large output voltage of good waveform. Secondly, although the Q of the tuned head circuit is only about 1.6, this means that the voltage across the head is 1.6 times the voltage at the output end of the cable. This reduces the voltage that must be produced by the amplifier, which once more improves the quality of its output. At the same time, the head tuning provides a small amount of discrimination against harmonics which may be present in the amplifier output in spite of our precautions.

As for the R/P head, no attempt is made to tune it to the bias frequency, for there is no need to do this. Its inductance is much larger than that of the parallel-tuned circuit which forms the lower leg of the voltage divider, so that it does not prevent this circuit from having quite a relatively high Q , and thus tuning quite sharply. This circuit discriminates quite strongly against harmonics in the H.F. waveform, and provides a specially pure bias waveform for recording. Because of its high Q , this circuit needs a pre-set tuning adjustment, provided by the 600 $\mu\text{fd.}$ padder. There is no need, however, to make the tuning of the erase head

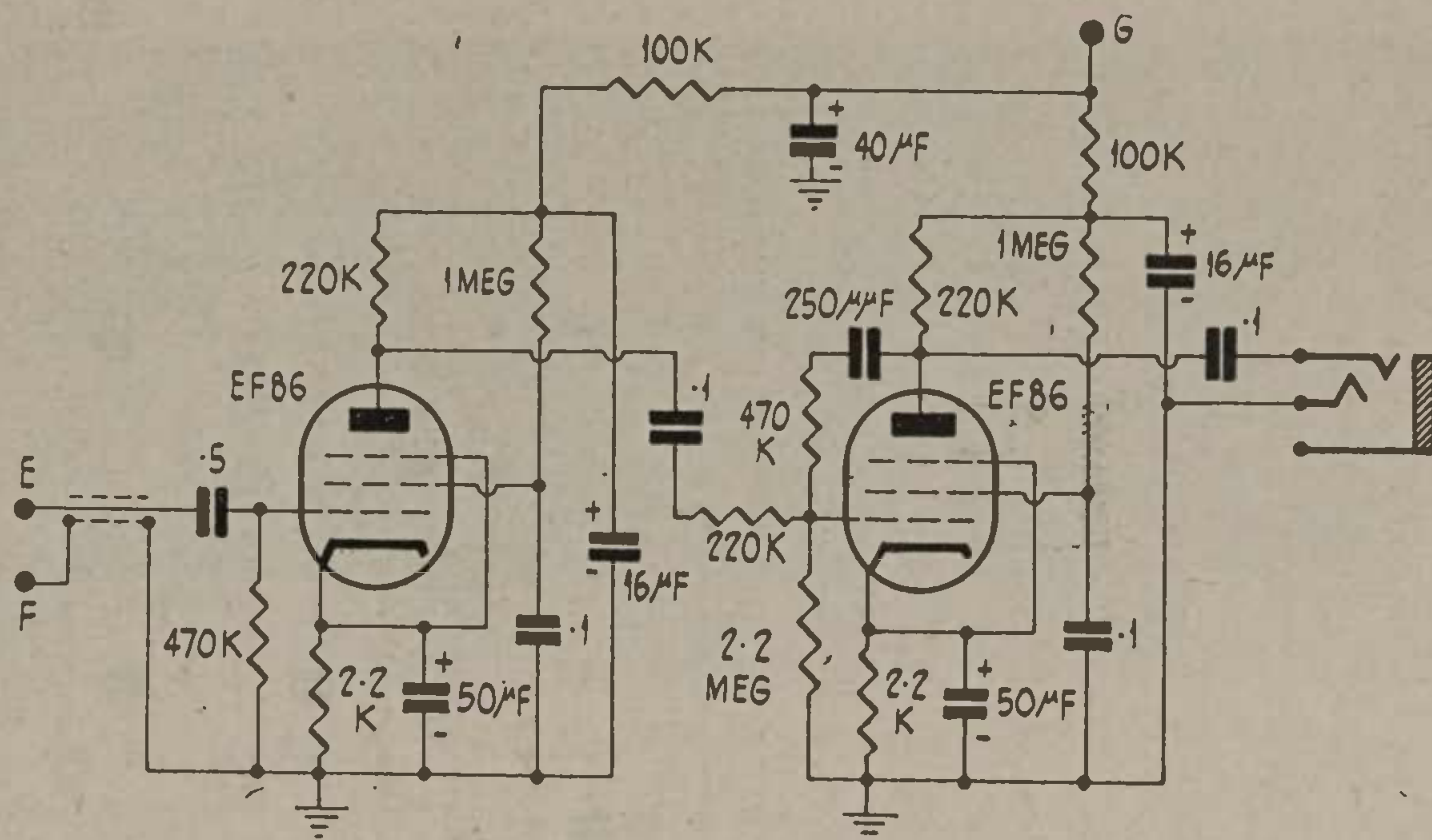


Fig. 3

The playback amplifier circuit. The output is sufficient to drive any main amplifier directly.

variable. Its very low Q makes it insensitive to large changes in the tuning capacity, so that a fixed tuning condenser is adequate.

Coils for the H.F. Circuit

The three coils used in this part of the circuit are identical, each being a winding taken from a 100 kc./sec. I.F. transformer. The oscillator and amplifier circuits are tuned with their own slugs, the capacities being fixed. The coils are made in the following way, starting with a complete 100 kc./sec. I.F. transformer.

First of all, the transformer is removed from its can, and the leads to the upper coil are carefully unsoldered. The former is then sawn in two, mid-way between the coils. For the oscillator coil, the can and the winding still attached to the base are used. The existing tuning condenser is removed, and is replaced by two 0.001 $\mu\text{fd.}$ condenser, connected in series across the winding. The centre junction of the condensers is then given a lead of bare tinned copper wire, which is taken through one of the spare holes in the transformer base. It will be noticed that at the top of the can, there is a pressed recess into which the end of the original coil former fitted. The idea of this is to make the whole assembly rigid inside the can, but since we have removed the upper half of the coil former, it is necessary to replace it with something of approximately the same diameter. This was done by whittling the end of a piece of thin dowel rod so that it was a push fit inside the coil former. The dowel was then cut to the right length to allow it to fit in place at the top of the can, just as did the original coil former.

This done, there is no base on which to mount the remaining winding, which is to be used as the plate coil for the EL84, so one has to be made. In our case it was made from a small square of polystyrene. A hole was drilled in the centre such that the former was a push fit into it. Two rivet-lugs were then mounted on

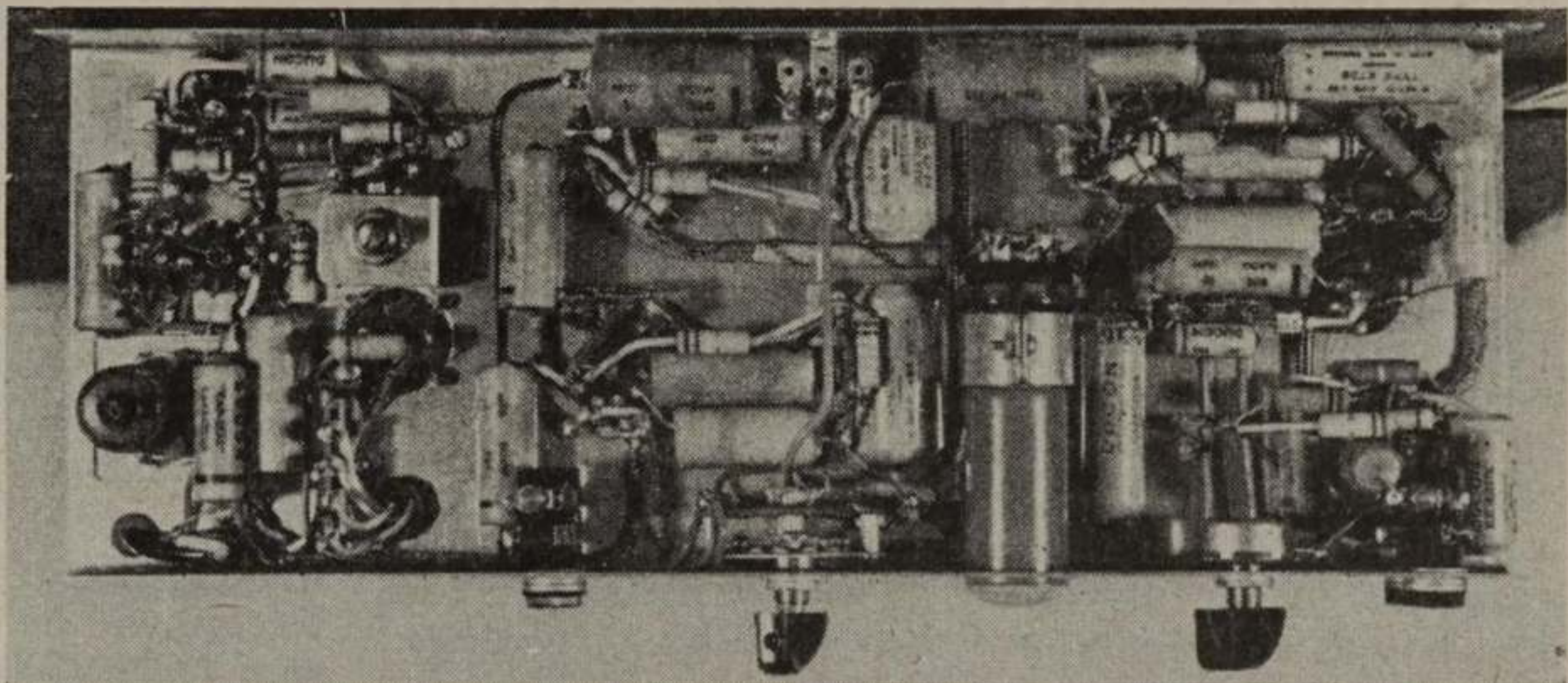
the head is also directly proportional to frequency, the current through the head is constant with frequency.

A second, more commonly used trick, is to use a normal "flat" amplifier, and to feed the head from it through a large series resistance. This resistance is made much higher in value than the highest impedance the head reaches at audio frequencies. In this way, the series of resistor swamps the impedance of the head, and that of the combination is made almost equal to the value of the resistor, irrespective of frequency. Such an arrangement will obviously give constant current through the combination of resistor and head in series, and thus in the head itself.

A third method is to build an amplifier with a flat frequency response, but with a very high internal resistance. Such an amplifier is an ordinary pentode amplifier valve, which can be capacity-coupled to the head. This scheme is fundamentally the same as the previous one, the only difference being that in the third method, the swamping resistance is built in, as it were, to the amplifier valve, instead of being connected externally, as in the second method.

The method used here is the third one. A pentode recording amplifier is not used, however, but instead a triode output valve is used in such a way that its effective output impedance is very high. The advantage of this method is that the effective output impedance can be made very much higher than that of an actual pentode valve. In addition, the amplifier is one using a high degree of negative feedback, and consequently has very low distortion. This provides a much better signal than the more common method, which is the second of those described above, and represents a *considerable improvement on the recording amplifier described in our previous series of articles on tape recording circuits.*

The system is shown in full in the circuit diagram, Fig. 4. The amplifier is a three-stage resistance-capacity-coupled one employing high- μ triodes which are ECC83s or 12AX7s. Each stage has a mid-frequency amplification of some 57 times, which in the case of the first and last stages is reduced slightly by the negative feedback caused by leaving the cathode resistor unbypassed. The overall gain without feedback would be in the region of 91,000 times, if the main feedback were disconnected. It is not actually possible to do this, because the feedback connection is made by using a common cathode resistor for the first and last stages. With the feedback connected, the overall amplification is reduced to approximately 135 times, if the load resistor is assumed to be the plate resistor of the last valve. In actual practice, the load is the head, which is



Underneath view of the circuits as they appeared in the original chassis.

connected through a blocking condenser from the plate of the output valve to earth. This has the effect of reducing the amplification considerably, and also of making it proportional to frequency; the main point about the amplifier is that the negative feedback is not voltage feedback, as is usually the case, but current feedback. This means that the *current* in the output valve is made to become a close replica of the *voltage* at the input. Current feedback has the property of increasing the apparent output impedance of the amplifier, and in this case, the effective output impedance is several megohms, so that the head must be fed in constant-current fashion.

It might be thought that a three-stage amplifier with so much feedback would be subject to instability, but such is not the case at all. No difficulty was experienced with the original, which was perfectly stable with or without the head connected, and which exhibited its constant-current properties perfectly.

The apparent complication of the circuit diagram is due mostly to drawing difficulties, because two of the triodes are contained in one envelope, as the sections of an ECC83. The third triode is one section of a further ECC83, which leaves one section to spare. This is used in the level-indicator circuit, which is also on this diagram. The level indicator consists of an EM34 magic eye tube, whose control grid is fed with rectified and smoothed audio signal, from a crystal diode. This is in turn fed from the second section of the first ECC83, which gets its signal voltage directly from the input to the main recording amplifier, through a 220 k. isolating resistor. This is the only suitable point at which the audio pick-off for the level indicator can be made, because such a pick-off must come after the volume control, but before the main amplifier, in order that the frequency response of the signal that actuates the indicator shall be flat.

The EF86 is a high-gain pre-amplifier for use with a low-level microphone. Its output is connected through the closed contacts on the high-level input jack to the volume control, so that the through connection is made automatically as long as there is no plug inserted

in the jack. When one is plugged in, however, the through connection is broken. A closed circuit jack is also used at the input to the EF86, and the closed contact of this one is arranged to short the grid of the tube to ground when nothing is in the jack, thus preventing hum pick-up at the grid.

The EF34 magic eye tube has only one of its triode plates connected, the one left without a feed resistor being that which gives the less sensitive deflection. In this way only the sensitive shadow operates, and the 500 k. level-setting control following the magic-eye amplifier valve can then be set so that the eye just closes when the maximum allowable signal for full modulation of the tape is fed to the head. Thereafter, the pre-set level control remains untouched, and the eye is used as an indication of the recorded level. Note also that the magic eye and its amplifier valve obtain their H.T. voltage from the point A, while the remaining valves in the recording amplifier get it from point B. Reference to the switching diagram will show that the H.T. line A is switched on only during recording, and feeds the H.F. oscillator as well as the circuits mentioned in the record amplifier. In this way the magic eye H.T. is removed at the same time as that of the oscillator. This allows the eye to act as a warning light, indicating that the switch is in the Record position, and therefore that the erase head is energized. This helps to avert the disastrous result of starting the tape moving with the erase circuit operating unintentionally. Pre-recorded tapes are very expensive, and tapes one has made oneself are often irreplaceable, so that any precautions that will prevent or eliminate accidental erasure are well worth while.

There is a very good reason for leaving the record amplifier working, so that the H.T. does not have to be switched off. Should the switch section which changes the head from the output of the record amplifier to the input of the playback amplifier operate a fraction of a second after one which switches the H.T. off the record amplifier it is possible for a switching thump to be applied to the head. Such a thump often takes the form of a uni-directional pulse, which can quite easily cause the head to become magnetized. If this happens, there is almost certain to be a large increase in the noise level during playback. The possibility is to all intents and purposes eliminated by leaving the H.T. on the record amplifier at all times. The output blocking condenser is then always charged to its normal voltage, and this means that the end nearest the head will be at earth potential, so that re-connecting the head when switching back to record, will not cause a D.C. pulse to be sent through the head either.

The Playback Circuit

This was printed in August, 1956 issue, and is identical with the circuit shown in the previous series of articles. The first EF86 is a pre-amplifier, with a conventional flat frequency response, whose job is to provide amplification at all frequencies prior to equalization for the non-flat response of the tape when

recorded, as it should be, with constant current at all frequencies. The output from the playback head is very small—only about 2 millivolts at 1000 c/sec. This in itself requires the playback amplifier to be extremely free from hum and noise if a good signal-to-noise ratio is to be obtained. In fact, the situation is rather more difficult than the above figure would indicate, because the output at low frequencies (i.e., below about 1000 c/sec.) is proportional to frequency, falling at a rate of 6 db. per octave. Thus, at 100 c/sec., the output will be only 0.2 millivolts, or 200 microvolts, if it is 2 millivolts at 1000 c/sec. The low-frequency response is wanted to extend to, say 40 c/sec., so that the signal voltage will be only about 100 microvolts at the maximum recording level, at 50 c/sec.; if, therefore, a signal-to-hum ratio of only 40 db. is aimed at, the equivalent hum voltage at the grid of the first tube in the playback amplifier must be no greater than 1 microvolt! Now with a low-frequency response that falls regularly, an amplifier used for tape playback must have the opposite frequency characteristic. That is to say, the response must be a maximum at the lowest useful frequency, falling thereafter in a linear manner until about 1000 c/sec. is reached, after which the response is required to flatten out, and stay flat up to high frequencies. Thus, the playback amplifier has the greatest gain at low frequencies, and this adds to the difficulty of obtaining a level overall response down to, say 40 c/sec., without at the same time running into difficulties with hum. This explains why many commercial tape recorders built for sale to the public rather than for professional or high-fidelity applications, have their response cut quite sharply at 70 c/sec. or thereabouts. Doing so avoids a great deal of the hum difficulty mentioned above.

There are several sources of hum in a tape playback amplifier. Perhaps the most important is in the tape deck itself. It contains up to three A.C. motors, and unless these are specially built for the job, they are likely to have quite strong external 50 cycle fields. The playback head is therefore situated in a hum field of measurable strength, and there is a considerable problem in preventing the head from picking up hum. One method of prevention is to enclose the head as completely as possible in a heavy magnetic screen. Sometimes this is made of thick cast iron, and sometimes it is of thin mu-metal. However, the use of a magnetic screen does not give complete protection, for several reasons. In the first place, there must be a gap in the shield to enable the tape to be threaded in front of the heads. This is sometimes tackled by backing the pressure pads with a small piece of mu-metal so that the gap is almost closed during playback. Secondly, the hum field may be so great as to saturate a thin mu-metal shield, so that its shielding effect is greatly reduced, or even completely eliminated. This seldom happens in commercial decks, but can easily do so in home-built ones. The cure in this case is to use a large, thick, shield of cast iron, with the mu-metal shield inside it. The latter is then allowed to become completely effective.

(To be continued)

QUESTIONS FROM READERS

LACK OF BASS FROM MULTIPLE-SPEAKER INSTALLATIONS

Among other things, a reader from Ohakea asks why his record-playing equipment suffers from lack of bass and middle frequencies compared with the highs he is getting. He gives details of his pick-ups and how they are used, and tells us that he has a pair of similar three-speaker systems for stereophonic reproduction, with cross-over networks at 800 and 2000 c/sec.

Part of the trouble may be due to the manner in which the pick-ups are used, but this letter brings up a point that will be of considerable interest to a large number of enthusiasts—namely the question of multiple speaker installations. We do not, of course, mean the use of two speakers or identical systems for obtaining stereo, but refer to the practice of using two or more speaker units, with the appropriate cross-over networks in place of a single speaker.

The theory behind the use of such a system is, of course, well known, and reads very convincingly. It is that by dividing the frequency spectrum up into two or more parts, and by arranging for one speaker to handle each part, rather than having a single speaker handling the whole range, distortion (particularly intermodulation) taking place in the speaker itself is minimized. Unfortunately, however, there are other disadvantages which result, and it is quite possible for these to outweigh even the one apparent advantage.

The fact is that putting the multiple-speaker idea into practice properly is by no means as easy as it might appear, even after one has constructed suitable cross-over networks. The trouble is one of matching up into a compatible system, two or more speakers of differing characteristics. A good many enthusiasts have gone to a good deal of trouble to choose the right cross-over frequencies, and make networks for them, only to be disappointed with the results obtained, or to be puzzled as to why the more complex system does not sound as well as a good single speaker.

Often, it is simply a matter of matching the sensitivities of the speakers used. Tweeters, and especially those of the horn variety, have a habit of being much more sensitive than the speakers normally used as bass drivers.

If this is the case, the overall response of the combination can be anything but flat, and in a manner that brings itself sharply to the listener's notice. Suppose, for example, that the tweeter makes twice as much sound, for a given electrical input, as does the low-frequency speaker in the upper part of its register. The over-all response will then have a pronounced step in it at about the cross-over frequency, and no juggling with the characteristics of the network will improve matters. The only thing to do is by some means to cut down the output of the tweeter *at all frequencies handled by it*. This means putting an at-

tenuator between it and the cross-over network. Often, a simple low-valued potentiometer will do the trick. Most of us have heard multiple speaker systems in which the sibilants and other consonants are far larger than life, and make speech sound as though everyone is spitting through a badly-fitting set of false teeth! In such cases, the trouble is almost always the one described above.

When one uses a three-speaker system, proper matching of their sensitivities is even more important, for the possibilities are limitless for overall responses with two sudden steps. Even worse than the steps themselves are the effects of interference between the speakers in the cross-over region. This interference is between the actual sound-waves produced by the speakers, and the effect is a raggedness in the response that often manifests itself through a nasty roughness in the sound which nothing seems to alleviate. It is for reasons such as these that the writer of these notes has come, after many years' experience, to prefer the sound of a *good* single speaker to that of many, if not most, multiple-speaker systems. But the operative word is GOOD!

PROFITABLE TV SERVICING

(Concluded from page 38)

barkhausen radiation, it is possible in apartment buildings away. But, as we saw earlier in the section on ings for sets to be separated by only two or three feet on opposite sides of a party wall.

A radio which has worked O.K. for several years suddenly develops strange whistles. One of your competitors is called in and reports that the trouble is due to interference from the television you have just installed next door. Tact is needed here if your reputation is not to suffer. First examine the TV to see that the screening is in order. Discuss whether the set can be moved to the other side of the room but do not insist. Be sure and point out that this is a constant problem with television and that his set is in no way faulty. Next, examine the radio. It goes without saying that any work done on this set must be entirely without charge. If the whistle is not exactly on the station frequency an improvement can often be affected by realigning the set, thus improving the selectivity. In most cases of this kind it will be found that the radio is working on its own internal aerial. The thing to do here is to get the owner to accept an outside aerial and fit him one free. This sort of thing happens so rarely that it is worth while losing a little money over it for the sake of prestige. If he will not accept the outdoor aerial, show him that by moving the set to the other side of the room the trouble is cleared.

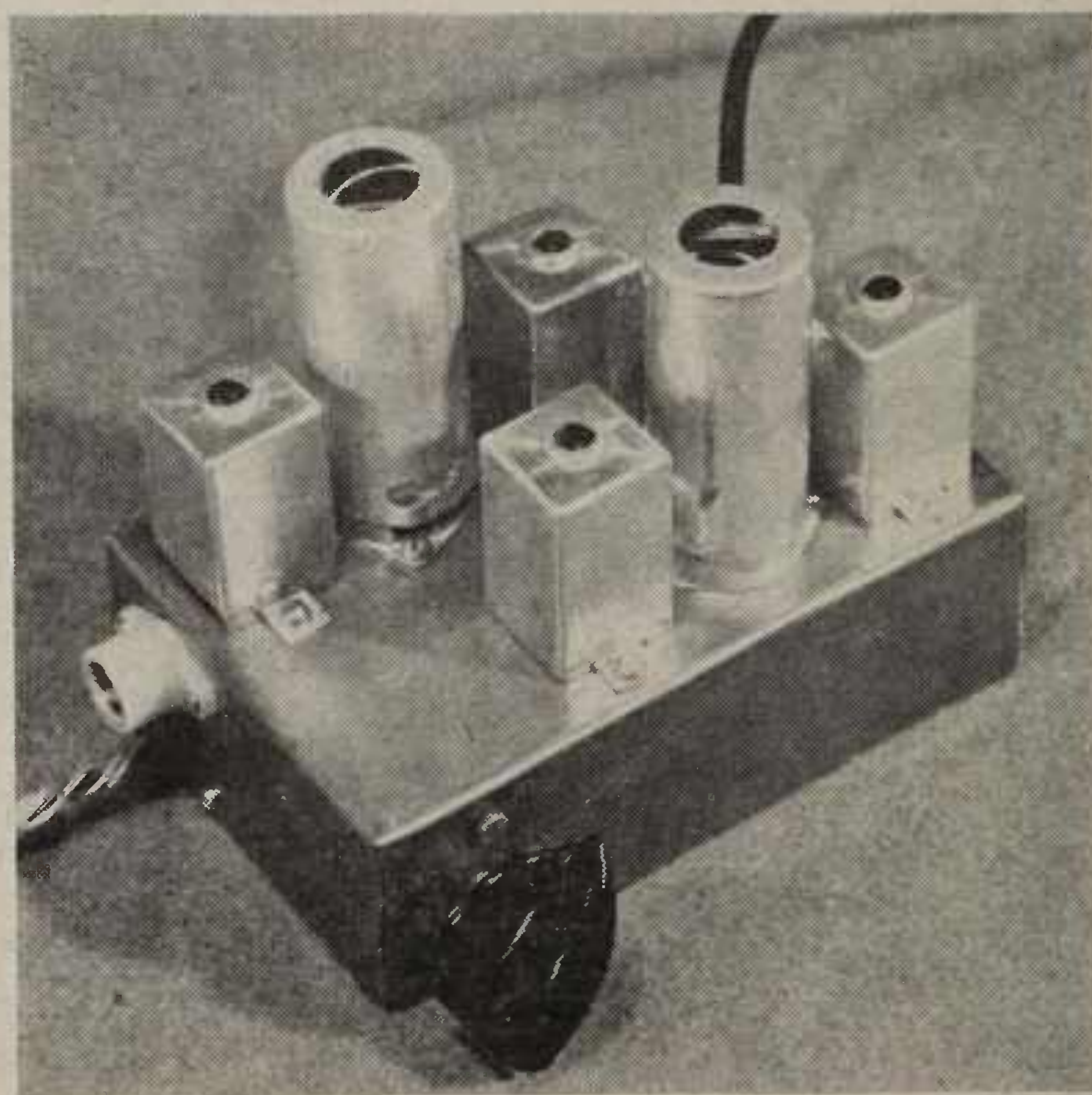
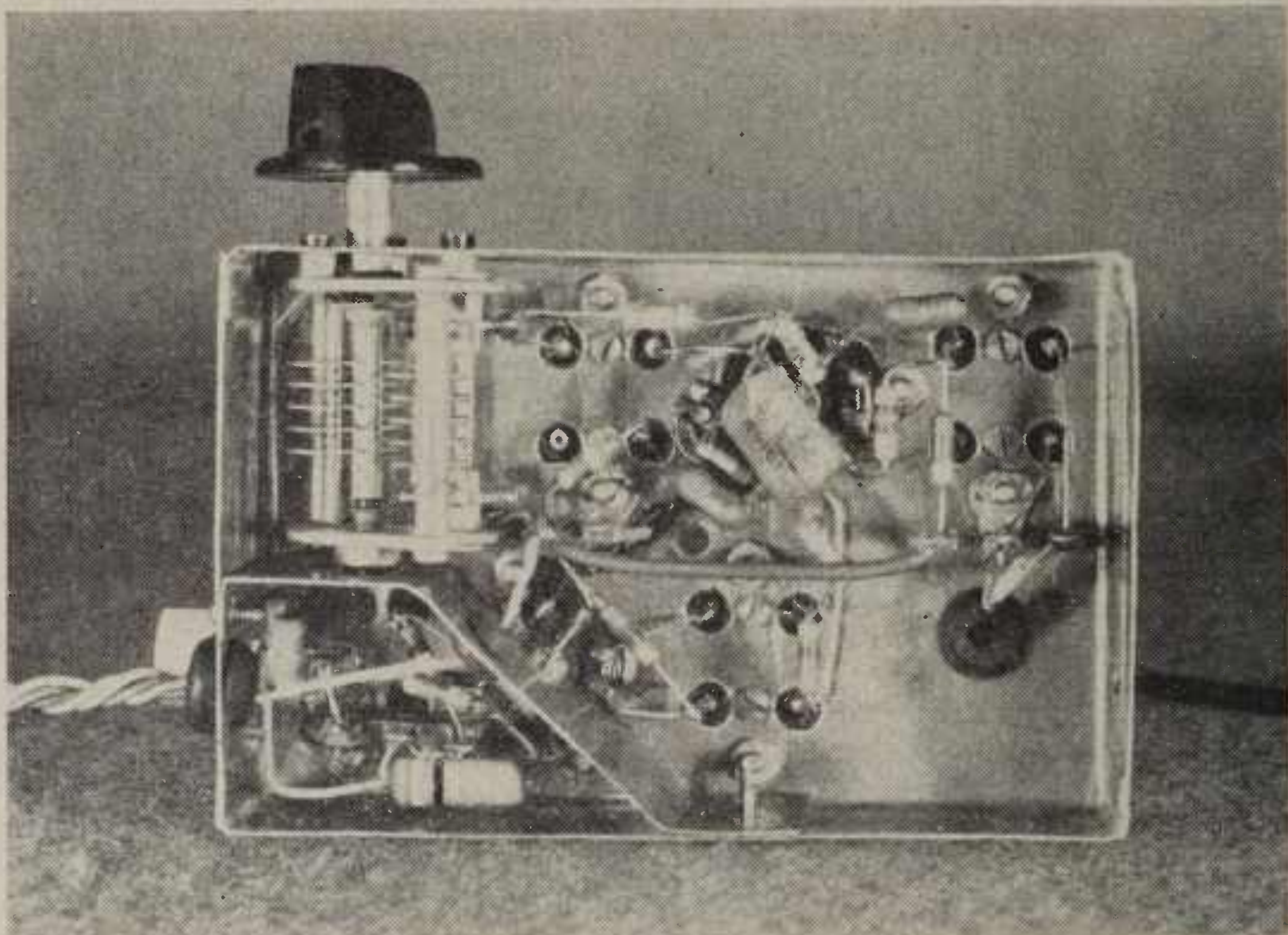
THE "R. & E." 17-INCH TELEVISION RECEIVER—PART 5

The photographs on this page are two views of the tuner, the circuit of which appeared in last month's instalment, and together with the chassis diagram printed there, should enable the builder to identify the parts successfully without lengthy description here. Next month we will be printing photographs showing the way in which the I.F. strip and the tuner chassis are mounted on the main chassis. The former is mounted vertically in the space previously allotted to it, with the valves facing towards the neck of the picture tube, and with the output end downwards. This places the audio output valve at the top, and the video detector at the bottom, only an inch or two from the video amplifier valve, so that a short unshielded lead is all that is required for this important connection.

The tuner is small enough to sit on the back of the chassis to the left of the horizontal oscillator valve, and directly behind the large shield box containing the line output valve and its associated circuit. The tuning control has been so placed that its shaft comes out at the back of the chassis. In a set like this that tunes only to one channel, it is not often necessary to re-tune, so that the tuning control does not need to be so readily accessible as when a turret is used, and having the control at the back of the set is hardly a disadvantage at all. The tuner's output is through a low-impedance link coupling, so that it is permissible to have a foot or so of miniature co-axial cable between the tuner and the I.F. strip.

Alignment

First of all, we will give a brief description of the alignment of the set when a wide-band wobulator is used. The vision I.F. output transformer is first aligned, with the scope fed from the detector output, so that the pattern is centred on 36.55mc/sec., and has a bandwidth of 4.5mc/sec. at the 3db. down level. It is not possible to give detailed instructions on how to do this, because the transformer windings are over-coupled. However, some experimental twiddling, while watching the pattern is all that is required to show the operator what should be done to achieve this end. Next, T_3 is adjusted to give a peak at 38.8mc/sec., and T_2 to give a peak at 34.3mc/sec. These circuits have quite high Q values, so a very small degree of mis-alignment causes sharp peaks to appear on the edges of the response curve. It will be noted that these circuits peak at the points where the response of the final transformer should be just 3db. down. Thus, the correct response, obtained when the signal is fed to the grid of the first EF80, is one in which there is a slight dip at the



centre frequency of 36.5mc/sec., and which is approximately symmetrical about that frequency. After alignment of the T_2 and T_3 cores to peak to their nominal frequencies, slight adjustment should be made to correct the appearance of the pattern obtained by looking at the response curve from the grid of the first I.F. amplifier to the output of the vision detector. The dip in the middle is filled in by tuning up the tuned circuits in the grid of the first I.F. valve, and the plate of the mixer, and must be done by feeding the signal (at I.F., and with the oscillator not working) to the grid of the mixer valve.

The sound I.F. channel is aligned to a centre-frequency of 5.5mc/sec., and is done with the feedback link from the grid circuit of the second sound EF80 to that of the first, disconnected. Grid current in the second EF80 is used as an indicator of the response of T_5 by taking the scope input from the junction of the two 22k. resistors, from which the feedback lead has been temporarily disconnected. The signal generator is fed to the grid of the first sound EF80, and T_5 is tuned for a maximum scope indication exactly at 5.5 mc/sec. The discriminator transformer is aligned so that the tuning of the primary gives maximum output at the centre frequency of 5.5mc/sec., while that of the secondary gives the correct S-shaped discriminator curve, crossing the zero output line at the centre frequency. Finally, the input tuned circuit is tuned to 5.5mc/sec., by connecting the signal generator to the input side of the $5\mu\text{fd.}$ input condenser, and tuning for maximum response in the grid circuit of the limiter. The feedback connection is then re-made, and the alignment is completed.

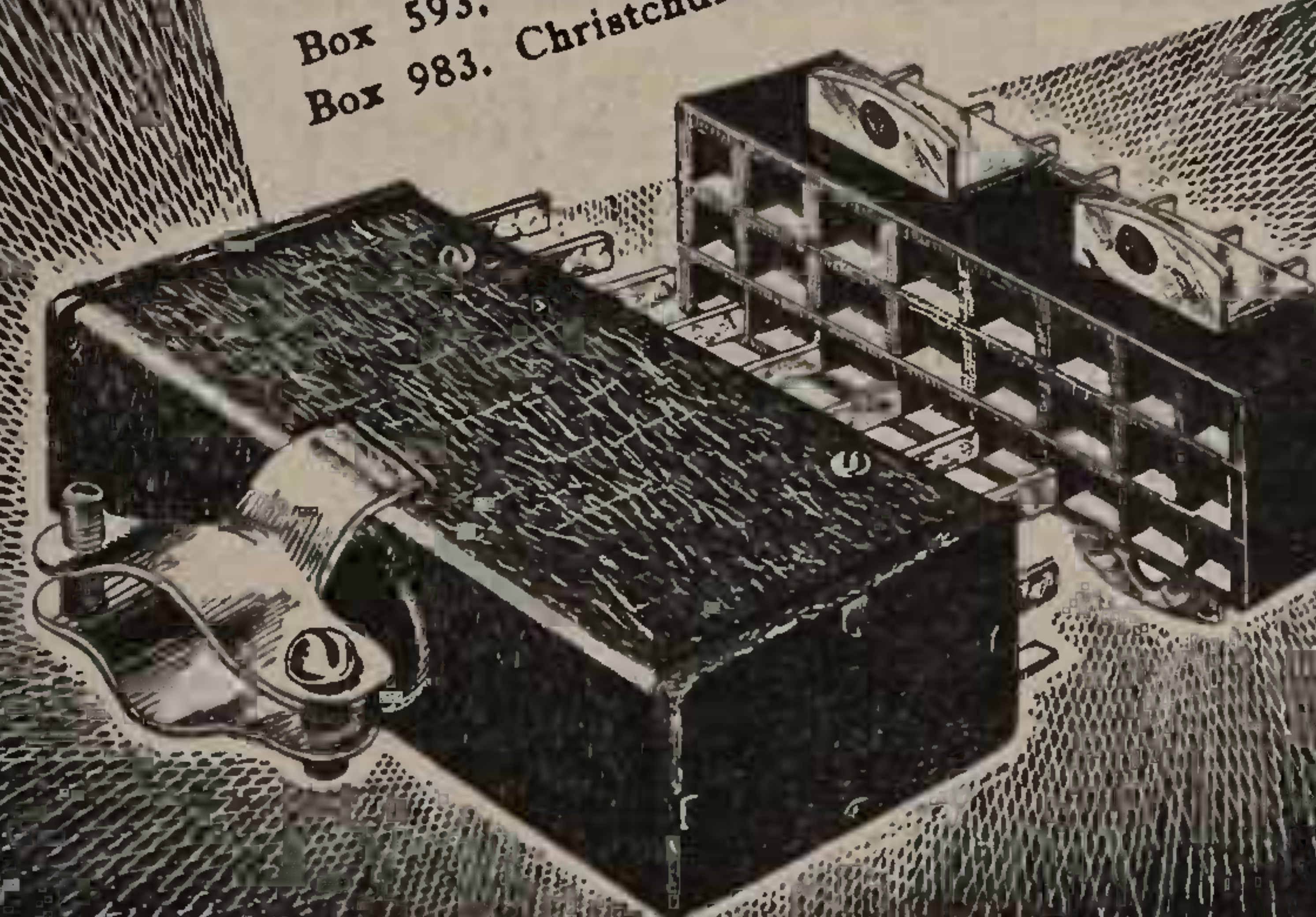
(To be continued)

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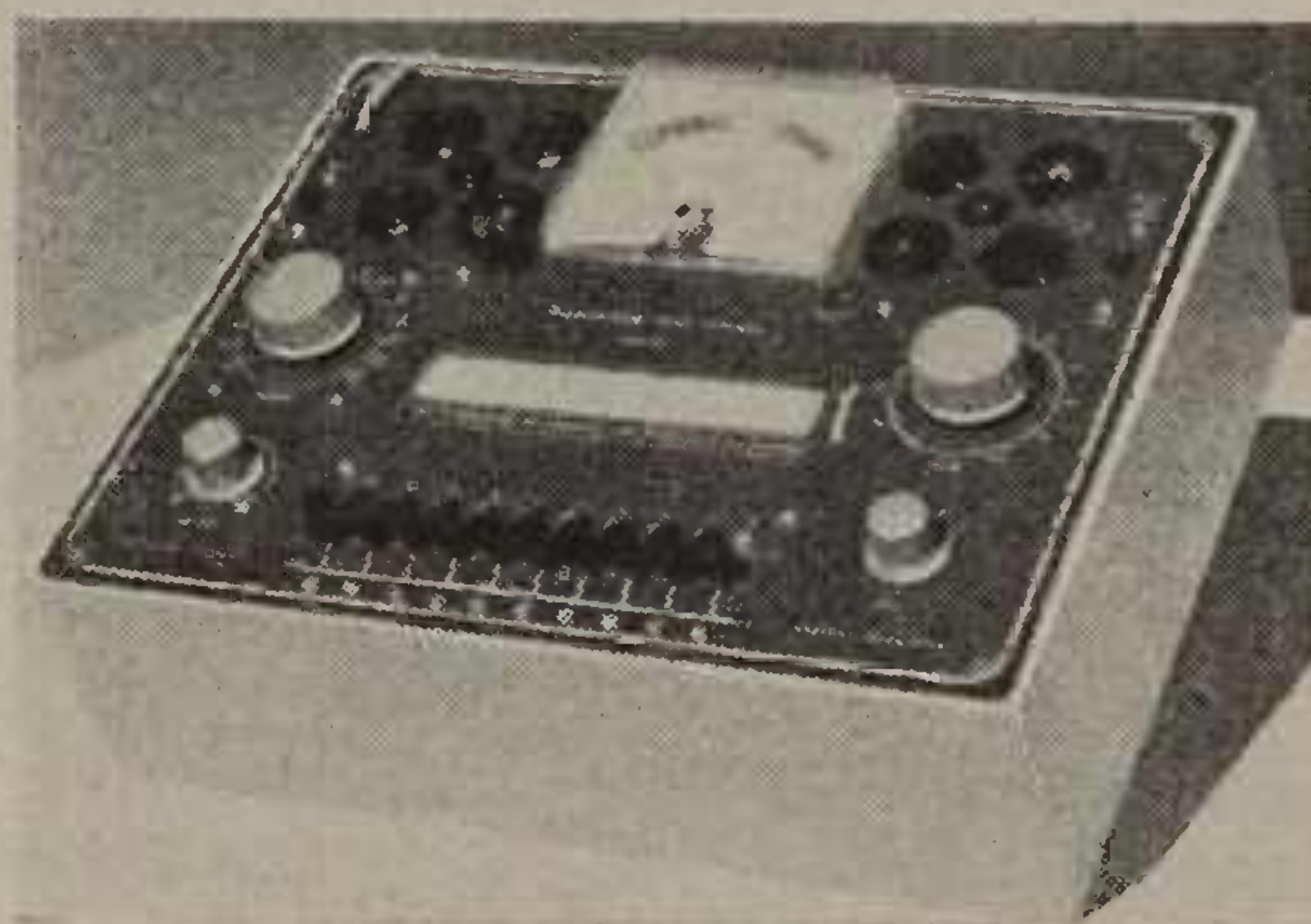
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Heathkit

TC 2 TUBE CHECKER



Now, at last, a Tube Checker at a price everyone can afford. A tube checker is essential, particularly with Television tubes, and to make it easier for servicemen we supply free during this month only a TV tube adapter with every TC 2 purchased during this month. By simply plugging this into the octal socket on the tester, and reading the chart, picture tubes may be tested in the same way as other tubes.

Made to the usual high HEATHKIT standards, this checker also has provision for an extra socket, into which we usually recommend the rimlock socket is fitted. All other tube types can be tested on this checker for open circuit shorts between all elements, leakage, heater continuity, and quality. A large 3½ in. meter shows functions. Owing to its unique design, it can never become obsolete because each element is brought out on a separate switch and new tube characteristics can easily be found by referring to valve manuals. It is, therefore, an instrument which will serve its purpose for years to come and, unlike other instruments which date and become obsolete, it is an investment.

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ELECTRICAL AND TRADE SECTION

PERSONALITY OF THE MONTH



Mr D. T. Clifton-Lewis.

There are some men you MAY meet in the Radio and Electrical trade, but one you are CERTAIN to meet is Mr David T. Clifton-Lewis, Managing Director of the well-known manufacturing company, ULTIMATE-EKCO (N.Z.) CO. LTD.

Certain to meet? Yes, for here is one who has given generously of his time and capabilities in many spheres of activity and especially within the framework of the Radio and Electrical trade. To some, leadership is an onerous task, to others, a natural outlet for skills and training. By virtue of training, capability, and a great desire to serve others, Mr Clifton-Lewis has been in demand for many years. The well-being and progress of the radio and electrical appliance manufacturing trade shows many instances of the wise guidance of this man.

Born shortly before the turn of the century, Mr Clifton-Lewis received his early schooling in Wellington and commenced work in 1910 as an office boy. Evincing an early aptitude for salesmanship, special training was undertaken and after graduating from the college with honours, a sales position was accepted.

In subsequent years, Mr Clifton-Lewis had experience of being "in business" on his own and in partnership. Early in 1926, ULTIMATE-EKCO, then known as Radio Limited, accepted Mr Clifton-Lewis as a salesman but within a year he was promoted to Assistant Manager of the Company. Guiding an expanding company through the difficult depression years, Mr Clifton-

Lewis progressed to a Directorship, full Managership, and finally to his present position as Managing-Director of the largest firm of its kind in New Zealand.

The name "ULTIMATE" is a proud one, great with tradition, performance, and promise—and it owes much to the rigid insistence on quality demanded by the Head of the Company. But not only within the Company are the qualities and experience of Mr Clifton-Lewis appreciated—on all levels, from Government to local trade organizations have come requests for this man's guidance. In nearly every instance, Mr Clifton-Lewis has served in the highest offices.

From an impressive list of civic and other public service, we learn that this man has been President of the New Zealand Radio and T.V. Manufacturers Federation (2 terms), National Federation of Radio Traders in New Zealand, the New Zealand Business Executive Institute, the Auckland Radio Traders Association, the Radio and T.V. Manufacturers Association of Auckland, and the Auckland Branch of the New Zealand Institute of Industrial Management.

The Government of the day appointed Mr Clifton-Lewis to the Manufacturers Research Committee and to the Advisory Council of the Auckland Technical Development Laboratories, both Divisions of the Department of Scientific and Industrial Research.

Commissioned war service (First World War) and local duties during the Second World War round off the service of a public spirited man who has not stinted in helping others. He also finds time to take an active part in the Masonic Order and the Rotary Organization. And finally, a happy home and family enables Mr Clifton-Lewis to carry on helping, guiding, and strengthening a growing and soundly based industry.

NEWS BRIEFS

One of the latest trade brochures to reach us is from Rola (Australia), and describes their "Twin Four" stereophonic tape recorder. This machine can make and play stereophonic tapes at either $7\frac{1}{2}$ or $3\frac{3}{4}$ inches per second, and can play four-track stereo tapes. It has an advanced specification, and includes two separate speaker enclosures, each with its own 10-watt amplifier. Price details are not mentioned.

* * *

The "R. & E." laboratory has made stereophonic tape recordings of the Wellington Gilbert and Sullivan Society's recent production of "Iolanthe". The dress rehearsal and two performances were in the Little Theatre at Lower Hutt. The first of these was used for experimenting with microphone placement, and

thus enabled the whole of both performances to be recorded. Results exceeded all expectations, and the experiment should make an interesting article for these pages. Our only regret is that the machine used had staggered heads, so that the resulting tapes cannot be played back on any other machine.

* * *

In the United States, the Ampex Corporation have been appointed by English Electric and Marconi to distribute their television products in America. The agreement includes the Marconi Mk. IV camera, using either the 3 in. or 4½ in. image orthicons made by English Electric.

* * *

From P. H. Rothschild & Co. Ltd. comes a wall-chart showing the Metro-Sound "Masterpoint" range of replacement pick-up styli. This makes a ready reference for retailers, and should be useful to all those who specialize in this type of business. Also received from the same firm is a copy of a booklet "Points on Pick-ups", which is a replacement guide to all British pick-up heads, cartridges, and styli produced over a period of years. This book should be a "must" for all dealers.

* * *

LATEST PHILIPS VALVE PRICE LIST

Philips have just issued their latest price lists for valves, transistors, and allied devices. Several new types are included which should be of considerable interest. These include the low-voltage cathode ray tubes, DC7/31 and DG7/32, the latest TV receiving types, ECC88, EF183, EF184, and ECL84, the new cadmium sulphide photoconductive cells ORP60 and ORP61, and several new high-powered semi-conductor rectifiers, together with new transistor types.

* * *

EDAC announce a new universal impedance bridge by British Laboratories, called the UB202 Mark IV. This is an instrument of advanced specification covering measurements of resistance from 0.05 ohm to 10 megohms, with an accuracy of plus or minus 1%, capacitance from 5μfd. to 1000μfd., at plus or minus 1½%, and inductance from 5 microhenries to 1000 henries, at plus or minus 2%.

* * *

Over the past ten years Autocrat Radio Limited have led the field in car radio design and in the past few years they have been first with many major modifications.

First to introduce a full range of radios with push buttons, first with transistors and now, car radios for 6-volt operation transistorized. This has been brought about by continued research by Autocrat's design engineers and they are justly proud to make this further "first".

Full technical information will be available in the next issue and Autocrat's engineers advise that this transistorized radio in 6-volt operation is suitable for Volkswagen, F.E. model Holdens, and all cars with a 6-volt system.

NEWS FROM THE DOMINION PHYSICAL LABORATORY

We are indebted to the Director of the Dominion Physical Laboratory for sending us a copy of their Project Statement for the period ending 31st May, 1959. This interesting document gives a brief account of the work in progress at the laboratory, both of a routine and a research nature; it is in three sections, Electrical, General Physics, and Mechanical Engineering.

In the radio field, there does not appear to be a great deal going on in the research line, but it is most noticeable that many items of research, though not themselves even remotely concerned with electronics, as, for example, the investigation of sheep's dental decay, do rely heavily on electronic techniques for their carrying out. The example mentioned is being carried out by means of electron microscopy.

However, in the directly electronic and radio fields, a wide variety of work is carried out. For example, Messrs Allan and Penton are responsible for running, developing, and using the New Zealand standard of frequency, and for running the Standard Frequency transmissions from ZLFS on 2.5 mc/sec., and for measuring overseas standard frequency transmissions from GBR.

Also of interest to radio workers is the maintenance of standards, by Messrs Allan and Shepherd, for the measurement of impedance, voltage, current, and power at frequencies inside the range of radio frequencies up to 1000 mc/sec. At present, the laboratory is equipped for measurements up to 300 mc/sec.

In the purely electrical field, electrical standards of voltage and resistance are maintained as primary standards, while as working standards, Wheatstone and Kelvin bridges, and calibrated sub-standard resistors are used for a wide range of resistance measurements. For volts, measurements are made using a standard-cell comparator, a precision potentiometer, and calibrated volt boxes, while calibrated shunts and a precision potentiometer are used for current measurements.

Radio Research Projects

An interesting research project is being carried out by S/Ldr. J. Mawdsley, of the Defence Science Corps, in conjunction with the Ionospheric Research Station at Canterbury University, on V.H.F. scatter propagation. At present work is in progress on the correlation of scattering levels for V.H.F. forward transmission with the day-to-day structure of the D layer of the ionosphere, as revealed by vertical incidence measurements at medium frequencies.

Messrs C. L. Henderson and F. A. McNeill are working on the measurements of ionospheric movements. The velocity and direction of the so-called ionospheric winds are deduced from the records of rapidly fading signals reflected from the ionosphere. The observations

for this project have been going on for a period of six years, and have now ceased, at least temporarily. All the results for the IGY programme have been despatched to the World Data Centre, and a paper is soon to be produced on the results and their analysis.

Research into "Whistlers"

"Whistlers" are more properly described as "very-low-frequency atmospherics". In actual fact, they are at audio frequencies, and can be received by connecting a very high-gain audio amplifier to a long aerial. This research project is being carried out in conjunction with the New Zealand Broadcasting Service, and Stanford University, U.S.A. It was part of the IGY programme, and is being continued through 1959. Whistlers are being recorded at Moore's Valley, at Dunedin, and at Scott Base. A frequency analyser is being used to study the frequency distribution in whistlers, and equipment is being developed for the automatic recording of whistler mode echoes from Station NPM in Hawaii.

Propagation Through the Auroral Zone

Mr G. McK. Allcock is responsible for continuing what started as an IGY programme for investigating radio propagation conditions within and through the southern auroral belt. Receivers are now sited at Campbell Island, Invercargill, and Lower Hutt.

Studies of the Aurora

Under Mr R. S. Unwin, who was in charge of the IGY station at Invercargill, and Mr M. Gadsen, an extensive research programme is still being carried out using all-sky cameras, spectrographs, radar, magnetic observations, and cosmic rays.

The work to date has upset many of the hitherto accepted ideas on the subject of the aurora. Several papers have already been published. Invercargill, where the work is still being carried out as an extension of the IGY programme, is now the key station for a line of auroral observation stations extending from Ellsworth, through the Pole, to New Zealand.

Mechanical Engineering

It is interesting to note that many of the projects in the mechanical engineering section at D.P.L. depend entirely upon electronics for their measuring techniques. Various investigations into the behaviour of buildings under earthquake conditions are being undertaken by means of electronic analogue computers, while a ten-storey building has been fitted with accelerometers in order to record the actual effects of earthquakes.

Conclusion

The above gives a very brief idea only of what is being carried out at the Laboratory, and often none at all of how it is being accomplished. It does serve to show, however, that there is a considerable amount of important scientific and technological work being carried out by a small but highly-trained and expert staff of scientists and technologists.

ELECTRONICS IN BRITAIN *(Concluded from page 36)*

An outstanding achievement has been the introduction of the Comet jet aircraft to regular services. The Comets are possibly the most extensively electronically-equipped aircraft in commercial operation today, and it is interesting that some future foreign users have specified identical radio systems with those used by B.O.A.C.

British radar equipment, and the associated air data processing systems which have become necessary to present intelligence quickly and simply to ground controllers, have aroused considerable home and overseas interest. Completely integrated systems were demonstrated at Farnborough. One company reports that it has received orders for well over £1,000,000-worth of a crystal-controlled type of 50 cm radar. Orders have come from Belgian, France, Germany, Switzerland, South Africa, Hong Kong, and New Zealand. The particular value of 50 cm radar is that it is virtually immune from precipitation clutter caused by conditions of rain, snow, or hail.

British radar has been chosen by many countries to overcome the dangers of increased air traffic density. The air terminal at Stockholm and the airport at Gothenburg are amongst those demanding the latest type of British long-range air surveillance facilities. Another aid for increased traffic density is airfield precision approach radar, which takes over the incoming aircraft at a distance of about 10 miles from the airport and talks it down to a landing. British equipment has been used internationally for this service for some years, but an improved version of the equipment has now appeared. This has been installed at Stockholm Airport and at Gwelo in Southern Rhodesia. It is ordered for the new airport at Arlanda (Sweden), Wellington (New Zealand), and Hong Kong, and a mobile version is in quantity production for the R.A.F.

Secondary radar has important uses both in the air and on the ground. A British firm claims to be the only one in Europe to manufacture the complete equipment. Its use in identifying civil aircraft on the radar screens has been demonstrated.

(Concluded from page 35)

includes a low-voltage output from which an indicating or warning device, such as a bell or buzzer can be operated. Self-contained also is the supply for the exciting lamp. This is provided with a lens system that together with the optical arrangements made for throwing the light on the sensitive part of the photocell, ensures that ambient external light has no effect on the device's operation. Only light coming from the proper direction, to an accuracy of plus and minus one degree, will operate the relay. Sensitivity is high, and with the low-powered light source provided, an effective range of 25 feet is obtained.

There are numerous applications for such a relay, such as counting objects passing the beam, and for indicating the presence of a person entering a shop.

Price, complete with light source, is £15 17s. 0d.

NEW PRODUCTS:

LATEST RELEASES IN ELECTRICAL AND ELECTRONIC EQUIPMENT

This section of our paper is reserved for the introduction of new products and space preference is given to our regular advertisers. For further particulars, contact Advertising Manager, "R. & E.", Box 6361, Wellington.

THE NEW PYE TRANSISTOR PORTABLE



Very neat, very tidy, very gay. And what is more important, the Pye "Parisian" fulfils all the basic requirements of a portable radio superbly well. A portable is judged by weight—the Pye "Parisian" weighs only 22 ounces; and by size—the "Parisian" measures $6\frac{1}{2}$ in. x $3\frac{5}{8}$ in. x $1\frac{3}{4}$ in.; and by battery economy—four "Penlite" torch batteries are enough to keep the Pye "Parisian" going for months.

This is, of course, an all-transistor set with the new famous Pye printed circuit. These two factors combine to give a model that performs like a mantel in a case small enough to fit in your pocket. The case itself is most attractively presented in leather available in Calypso red, forest green, or vulcan black and trimmed in gold.

Transistors still seem to have a fascination all their own. For the public there is magic in the very word, and as the Pye "Parisian" boldly proclaims "ALL TRANSISTOR" across its front it should be well on the way to a sale even before the customer hears it. For this reason alone it looks as though the "Parisian" is due for big displays in Pye dealers' windows and stores. The "personal listening" attachment displayed alongside, and a price card saying "Only £24 19s. 6d.—good selling before the salesman opens his mouth!

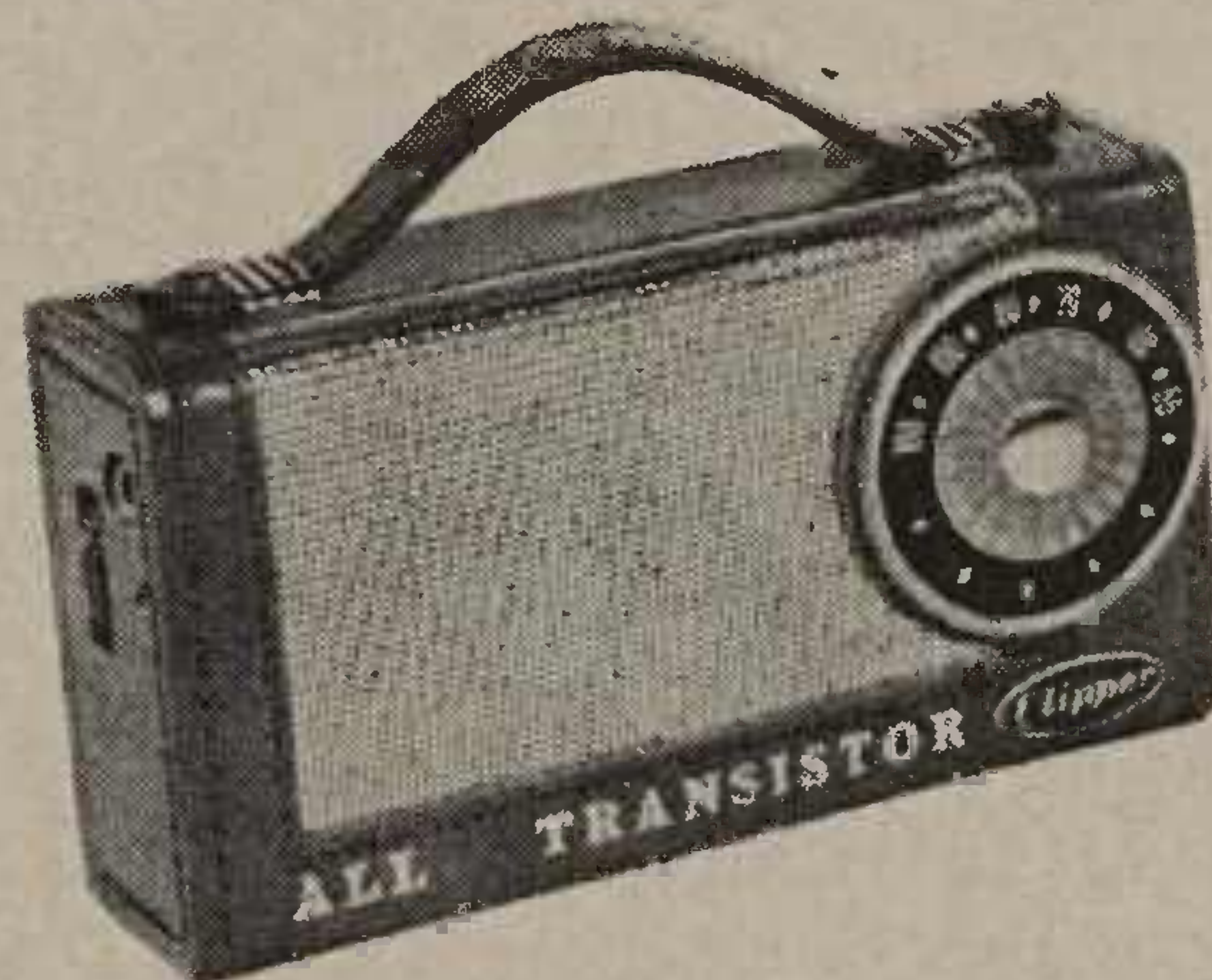
Pye Limited, P.O. Box 2839, Auckland, also at Wellington and Christchurch are sole New Zealand distributors of all Pye models.

* * *

SIX TRANSISTOR CLIPPER TALISMAN

The manufacturers have christened this new Clipper portable the "Talisman". Our dictionary gives the word as meaning "Anything that acts as a charm or by which extraordinary results are achieved". We cannot help agreeing—the Clipper "Talisman" achieves really extraordinary results.

A printed circuit is combined with six transistors to produce a radio about the size of the girl friend's evening bag that performs like a console. Perhaps this isn't too surprising in these days when people are landing things on the moon, but it certainly enhances the sales appeal of the Clipper "Talisman".



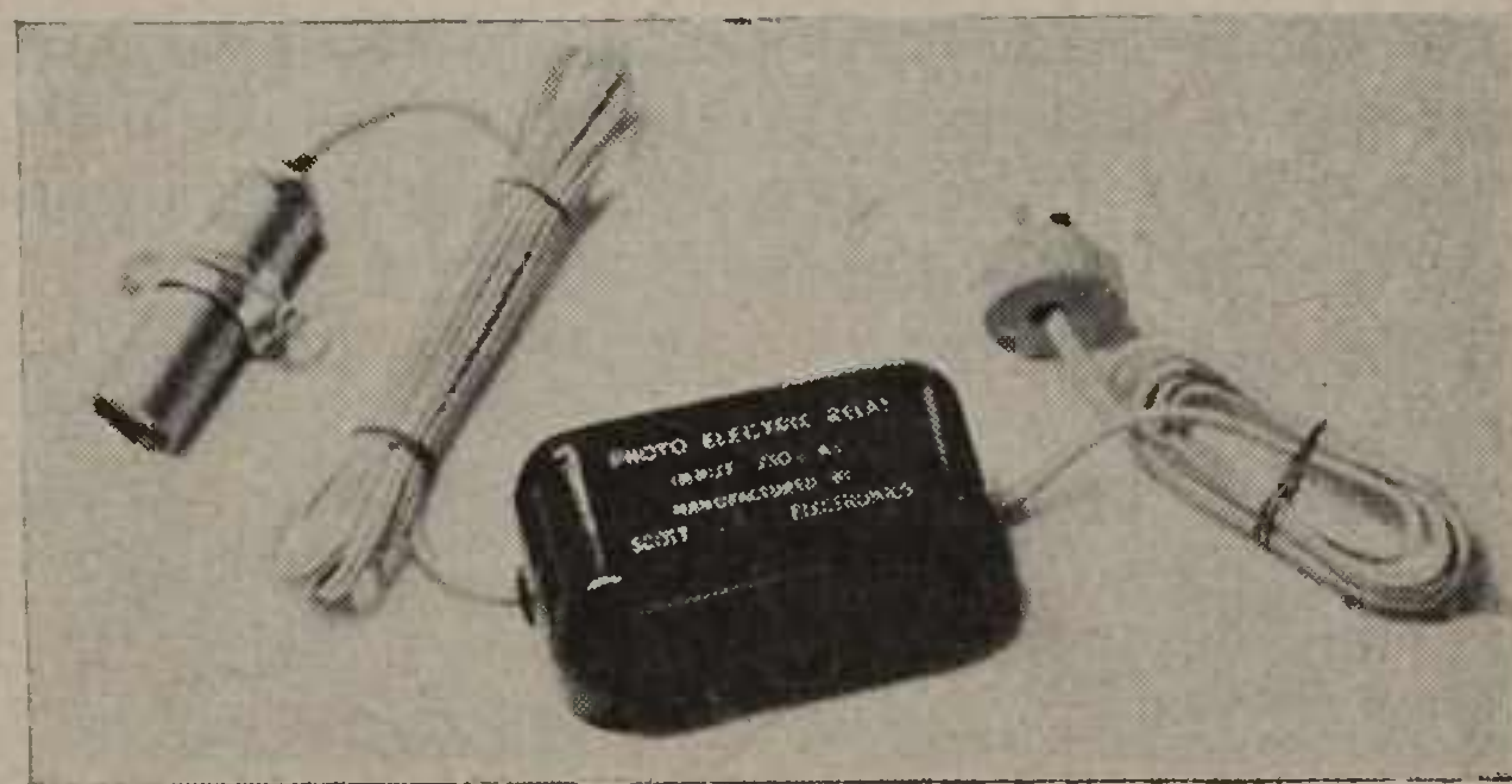
The finishing touches (which sometimes seem more important in sales getting than anything else) include a handsome genuine leather case with gold speaker surround and trim. The controls are mighty simple, as they need to be in a portable.

Included in the price (£24 19s. 6d. retail) is a personal listening attachment. Vital statistics are: weight, 1 lb 6 oz; size, $6\frac{1}{2}$ in. x $3\frac{5}{8}$ in. x $1\frac{3}{4}$ in.

The Clipper "Talisman" is available with our recommendation to all radio dealers, through G. A. Wooller & Co. Ltd., P.O. Box 2839, Auckland; also at Wellington and Christchurch.

* * *

A NEW PHOTO-ELECTRIC RELAY



From Scott Electronics Company, of 15 Great North Road, Auckland, comes news of a new photo-electric relay designed for ease of installation, reliability, and compactness.

Right up-to-the-minute in design, it uses the latest type of photo-transistor with a second transistor to operate the relay, is powered from the mains, and

(Concluded on page 34)

ELECTRONICS IN BRITAIN

The following extracts from the latest Annual Report of the British Electronic Engineering Association make interesting reading, and illustrate the extremely wide scope of the electronics industry in a predominantly industrial country, and also the extreme importance which electronic techniques have assumed since the Second World War. Those who during the war had reason and opportunity to see Britain's world leadership in electronics at that time need have no fear that that lead has not been maintained, as these extracts will show. The complete report is somewhat lengthy to reproduce in full, but the sections that we have chosen for reproduction are printed in full.

Defence

How much the industry can say about equipment produced for defence is always a problem. It is generally the case that, when information on one subject is released, an even more interesting development is under way. Some facts about the extremely successful missile guidance systems have been given during the year, and it is significant that British equipment, particularly in the field of radar, is being ordered by NATO countries.

One firm has received orders to a value of approximately £1,000,000 from the Norwegian Ministry of Defence. This order was placed as part of the NATO programme for a co-ordinated radar defence of member countries. It includes two control and reporting stations, each of high power and long range. They are completely self-contained, calling only for a power supply.

Sweden has ordered the same radar and control equipment as is used with the British "Bloodhound" guided missile.

The Federal German Ministry of Defence, following a demonstration of an equipment at Bonn, ordered a British type of medium-range radar, the sixth European country to do so.

The "Sting-ray" equipment, used to locate a distant target and "illuminate" it so that a missile can home on to the reflected radar energy, is being made available to NATO and Commonwealth countries.

An important order was won by one of the Association's member firms against strong competition from United States and European companies when the contract was signed to supply the Royal Canadian Air Force with an advanced type of airborne radar, worth £1,000,000. The equipment is the latest radar aid to submarine detection.

The Royal Danish Navy is being supplied with a British-designed and produced air warning radar for its ships, to meet a requirement for the detection of fast, high-flying aircraft. It is suitable for frigates and larger ships.

One of the more dramatic examples of the success of British missile systems was the firing of a salvo of

two rockets at a target aircraft. The first round (inert) scored a direct hit; the second made a direct hit on the largest piece of remaining wreckage immediately afterwards.

An interesting development is a portable radio beacon, designed to be dropped by parachute in forward areas to simplify subsequent troop and supply-dropping operations. It is so rugged that it can withstand an impact of 40 times the force of gravity.

Aviation

A major demonstration during the year was the work of the Blind Landing Experimental Unit of the Royal Aircraft Establishment, Bedford. These experiments have been sponsored over a period of years by the Ministry of Supply and have now resulted in many hundreds of "hands-off" landings. The equipment used, however, has mostly been developed specifically for the job by the industry. For example, a particularly accurate radio altimeter operating on frequency modulation, instead of pulse modulation, is a key instrument.

The complexity of modern high-speed flight is exemplified by the use of air data computers in aircraft which measure the basic aerodynamic quantities and from them compute the straightforward information required by the pilot (barometric height, rate of change in height, indicated air speed, Mach number, true air speed) or feed the information to an autopilot. Various flight-processing systems are now being used in which pre-set manoeuvres can be applied electronically to the controls.

Doppler navigation, which attracted much attention the previous year, has been impressively demonstrated at home and overseas. A Viking aircraft equipped with a commercial Doppler system has been used to show international airlines, aircraft industries, and government departments this remarkable aid to accurate navigation and time-saving in air operations. Installed in a Canberra aircraft, it has proved itself under difficult conditions while flying over a smooth sea surface.

(Continued on page 34)

For the Serviceman

PROFITABLE TV SERVICING—Part 4: The Line Timebases (Cont.)

By P. E. CLEMENT

Last month's article was concerned mainly with major faults in the output stage, causing complete loss of raster. Before passing on to the oscillator let us deal with several minor faults to which this circuit is prone. These are "minor" only in that they do not cause loss of picture. They can still be expensive to the customer.

Brushing, Arcing, and Corona Discharge

Very high pulse voltages are present at a great many places in the line output stage. Despite considerable advances in design of recent years, breakdowns of insulation are not uncommon. This frequently shows up as a feathery vertical bar on the picture; sometimes accompanied by a hissing noise on sound. The favourite spot for this arcing is between scan coil windings, or an internal flashing over in the E.H.T. rectifier, but it can occur at width and linearity controls, in fact anywhere that high voltages are present. Instruments are of little use in locating these breakdowns, it is best to rely on one's senses of sight, hearing, and smell. Observing the set in a darkened room will sometimes show, by that tell-tale point of blue light, where the fault is.

If there is any point or sharp edge in a high voltage circuit, an electrical discharge will take place at that point. This is often illustrated at technical schools with the following simple apparatus: a teardrop shaped metal object is fixed to one end of a metal rod at the other end of which is a spherical counterweight. The arm is balanced on a needle pivot, and the whole mounted on an insulating pillar. When this instrument is connected to a source of high voltage an electrical discharge takes place at the pointed end of the teardrop. Molecules of air adjacent to the point become ionized and are repelled away in a steady stream, driving the arm and counterweight round in a circle. This phenomenon, known as corona discharge, is a first-class nuisance in television, and considerable research has been carried out to overcome it. The modern line output transformer usually has three short polythene-encased leads (E.H.T. rectifier anode, output valve anode, and damper diode cathode) terminated in polythene "hats" over the metal top cap connectors. The E.H.T. lead to the cathode ray tube is also of moulded polythene. Prior to about 1957 E.H.T. rectifiers were of the solder-in type; connections being made by wires to three puddles of solder. Considerable care with soldering had to be exercised when replacing these if all points were to be avoided. Fortunately these pests are on the way out. All the same, care must be taken with soldering anywhere high voltage is present. Joints must be rounded and smooth, without points of solder or whiskers of wire sticking

out. Corona discharge is picked up by the "front end" as graininess (snow) and background rushing noise on sound.

It goes without saying that all metal objects in a TV set *must* be earthed to chassis, otherwise static charges will build up and periodic cracking across to earth will take place. This applies to ion trap magnets and in particular the metal foil screening with which the cabinet is lined.

As stated last month, the E.H.T. reservoir is formed by the capacity between the inner coating of the C.R.T. (at final anode potential) and the external earthed aquadag. This outer conductive coating is earthed, either by bronze or copper strips which are sprung against the tube, or a long coil spring (often a piece of ordinary curtain wire) which is stretched over the C.R.T. and anchored to chassis. The copper strips are a source of trouble. Frequently the coating is worn away at this point or the spring strips lose their tension, and contact is lost. When this happens the outer coating charges up to the E.H.T. potential and sparks across the small gap to earth.

Many manufacturers include a thin polythene disc between the flare of the scan coils and the tube. Others also wrap one or two turns of wide polythene strip round the tube neck before fitting the scan coils. When changing tube or coils care must be taken to replace these insulators. I have seen several instances of E.H.T. cracking through the glass to the scan coils thereby ruining the tube.

Barkhausen Oscillation

This often arises in new sets shortly after their installation and following line timebase repairs, resulting in annoyance to both customer and engineer.

At a particular point in the line scan a very sharp pulse of parasitic oscillation occurs in the line output valve.† If the fundamental of this oscillation or any of its harmonics fall within the channel being received a spot of interference will show on the screen. Now as this barkhausen effect always occurs at the identical point on the line scan each spot will show directly under the previous one. The result is a vertical scintillating line down the screen.

A rather curious fact arises here in that the barkhausen interference of which he complains may not originate in the customer's set but in his neighbours. This is unlikely to happen if the set is the only one in a detached house, but, in large blocks of flats it often happens that a set may be only two or three feet away from one in the next apartment. Under these conditions a set, which may or may not have a bark-

hausen line on its own screen, can cause one on the next door. If the trouble is in the set under examination and a picture is being received the line will always remain stationary: if caused by a neighbour's set it may be either still or wandering backwards and forwards across the screen, depending on whether the sets are locked to the same or different programmes. To check if a stationary line is coming from a neighbouring set just tune to another station. If the line wanders it is the neighbour's set. Sometimes when this is done no interference will be found on the other channel; in which case the neighbour's set will have to be turned off to prove the point.

To eliminate barkhausen radiation, though not necessarily the actual oscillation, several methods can be employed. Firstly, if the set is fitted with a line drive control try reducing the drive slightly. In other sets a slight increase of width does the trick. If these methods are to no avail the next step is to try one of the special anti-barkhausen magnets on the market. These are either a short powerful bar magnet fitted with springs that clip on to the line output valve, or a ring magnet that also clips on the valve. The magnet may shift the line to the left or right. By rotating the magnet round the valve, and sliding it up or down, a point can be found where the line is shifted right off the screen. Other anti-barkhausen tactics are to fit a small choke or low value resistor in the valve anode lead nearest the cap. The type of choke sometimes used as suppressors in small domestic appliances are suitable. It is not always convenient to do this if the lead is of the one piece moulded polythene type. Lastly, if these methods are all unsuccessful, change the line output valve. If several are tried usually one will be found that does not cause barkhausen. I give this method as a last resort for a very good reason. If a new valve is fitted it will clear the fault; but often after a week or two when the new valve has aged in the line will return. If, on the other hand, you eliminate it on a valve already aged in, it is more likely to stay fixed. A word about the magnets. They often have very high voltages induced in them, and if situated near the cage or other earthed object will brush across. Having eliminated the barkhausen line you now have brushing troubles on your hands. Connecting an earthing lead to the magnet will eliminate this trouble, but the resultant stress set up may crack the glass of the valve. A wiser plan is to pack the space between the magnet and cage with some good insulating material, taking care not to block the ventilation.

Poor Linearity

Most common cause—damper diode ageing—can also be caused by boost reservoir or smoothing capacitors going o/c, low H.T. volts, etc. Some sets have a correction capacitor of a few hundred pico farads across a section of the output transformer. If this goes o/c or leaks, linearity may deteriorate. In many cases

linearity correction is afforded by a permanent magnet type linearity coil control. This may lose its magnetism and become ineffective. Severe non-linearity (usually a fold over) will result from either the output stage grid leak going o/c or the oscillator—output coupling capacitor leaking.

Striations and Kinks in Horizontal Lines

If no effort were made to correct it, each horizontal scanning line would have several kinks or undulations at the left-hand side of the screen. In severe cases these kinds would together form vertical striations on the picture. This phenomena is due to an unbalanced capacitive effect between line and frame scan coils and is overcome in manufacture by shunting one half of the line coils with a balancing capacitor. Usually this is a fixed value of about 30 to 50 pf, but some designers specify a compression type trimmer that can be adjusted for minimum kink. Naturally this capacitor can fail like any other with the results just stated. It should be replaced with one of the same working voltage (about 3 to 5 KV).

Another type of striation, a form of light and dark bars, and also a peculiar effect whereby the picture is dark at one side and becomes progressively brighter towards the other is due to line voltages getting into the video or tube circuits. This can be due to failure of smoothing, especially where multiple electrolytics are shared by line and video circuits.

Overdrive Line

This is the last of our family of vertical lines. If the drive from the oscillator stage is excessive there will be some compression of the picture resulting in a bright vertical line at about centre screen. This is best observed on a blank but *synchronized* raster. If your local station transmits periods of blank raster during the testing times all well and good. If not a blank raster can be obtained by inserting a resistor of about 33 K Ω in the C.R.T. cathode lead, and decoupling the cathode to earth with about a .25 μ fd. capacitor (these values are not at all critical). The resistor is there to prevent the capacitor also decoupling the sync pulses. If a line drive control is provided, the usual method of adjusting is to advance the control until the overdrive line is just visible, then slowly reduce the drive to the point where the line vanishes. However, the maker's manual should always be consulted before adjusting a drive control.

Overdrive can result in excessive boost voltage causing early failure of the line output transformer, breakdown of boost capacitors, or even damage to the C.R. tube.

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Every television radiates a whistle at line frequency (15,625 Kc/s) and at harmonics of this frequency. By the time that the 40th or 50th harmonic is reached the signal is weak enough to be only effective up to a few

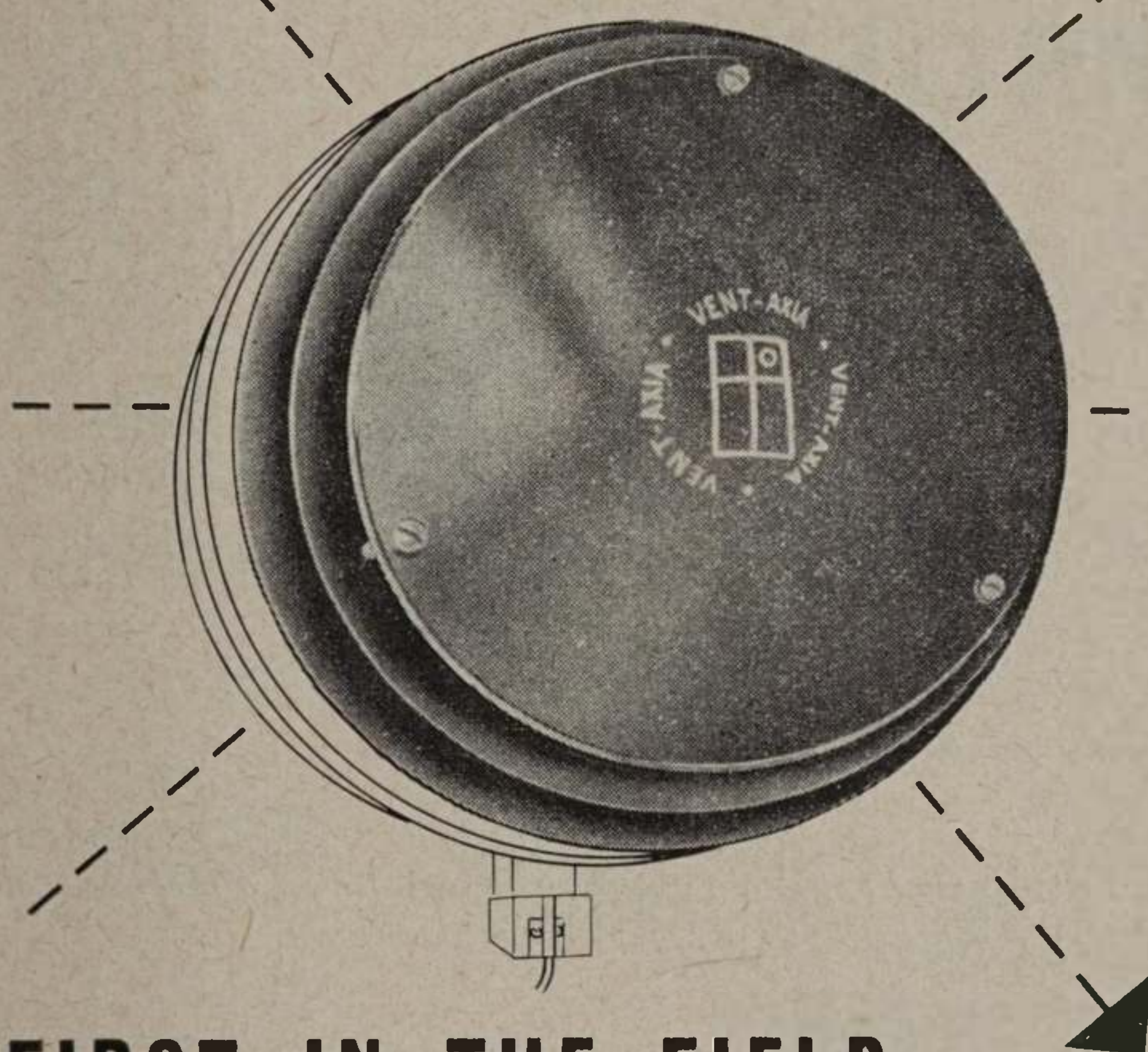
(Concluded on page 29)

†The theory of Barkhausen Oscillators is dealt with in most good text-books.

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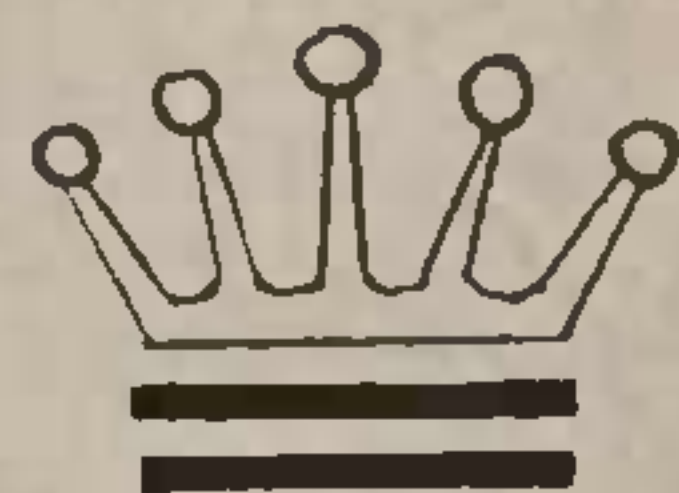
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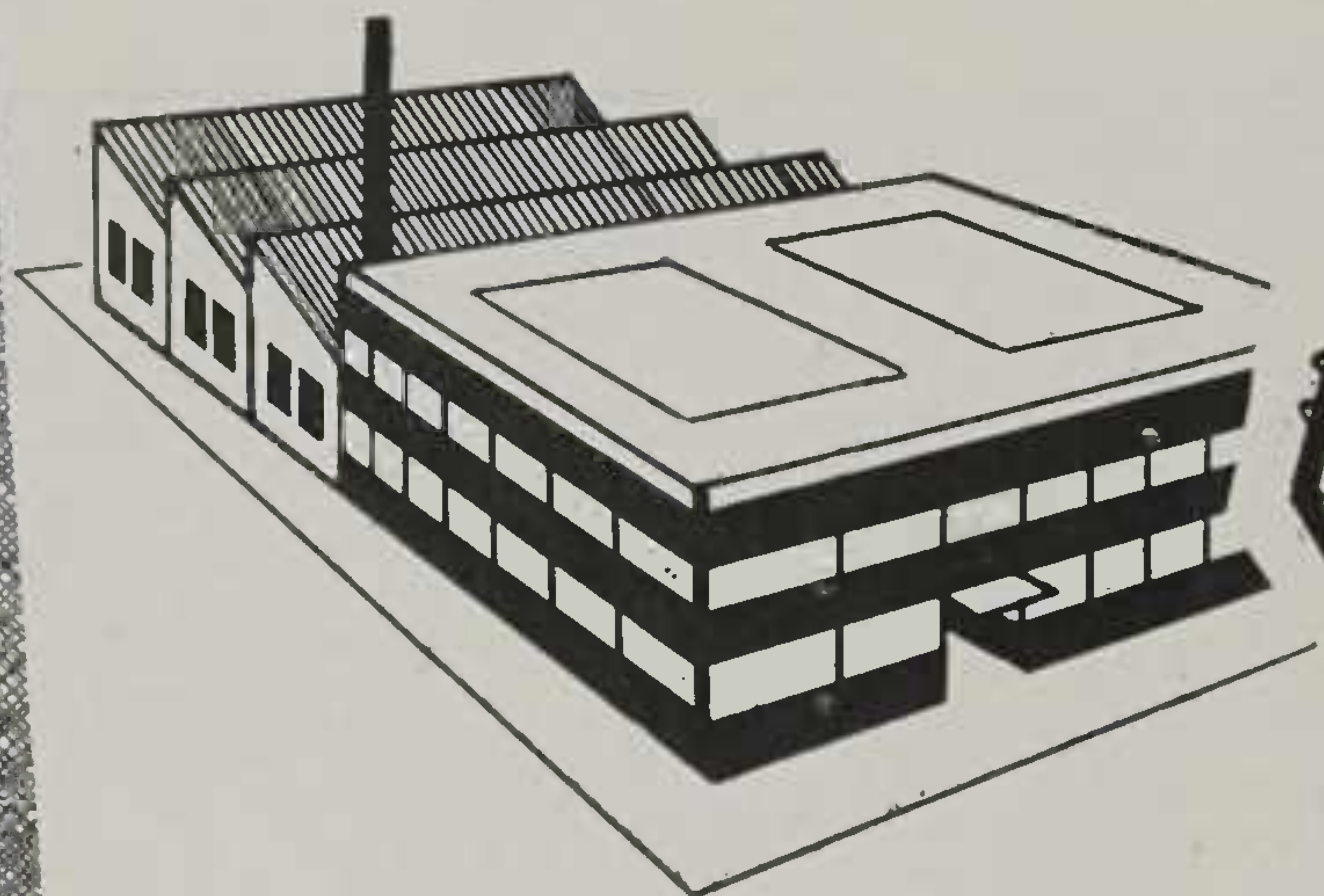


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