

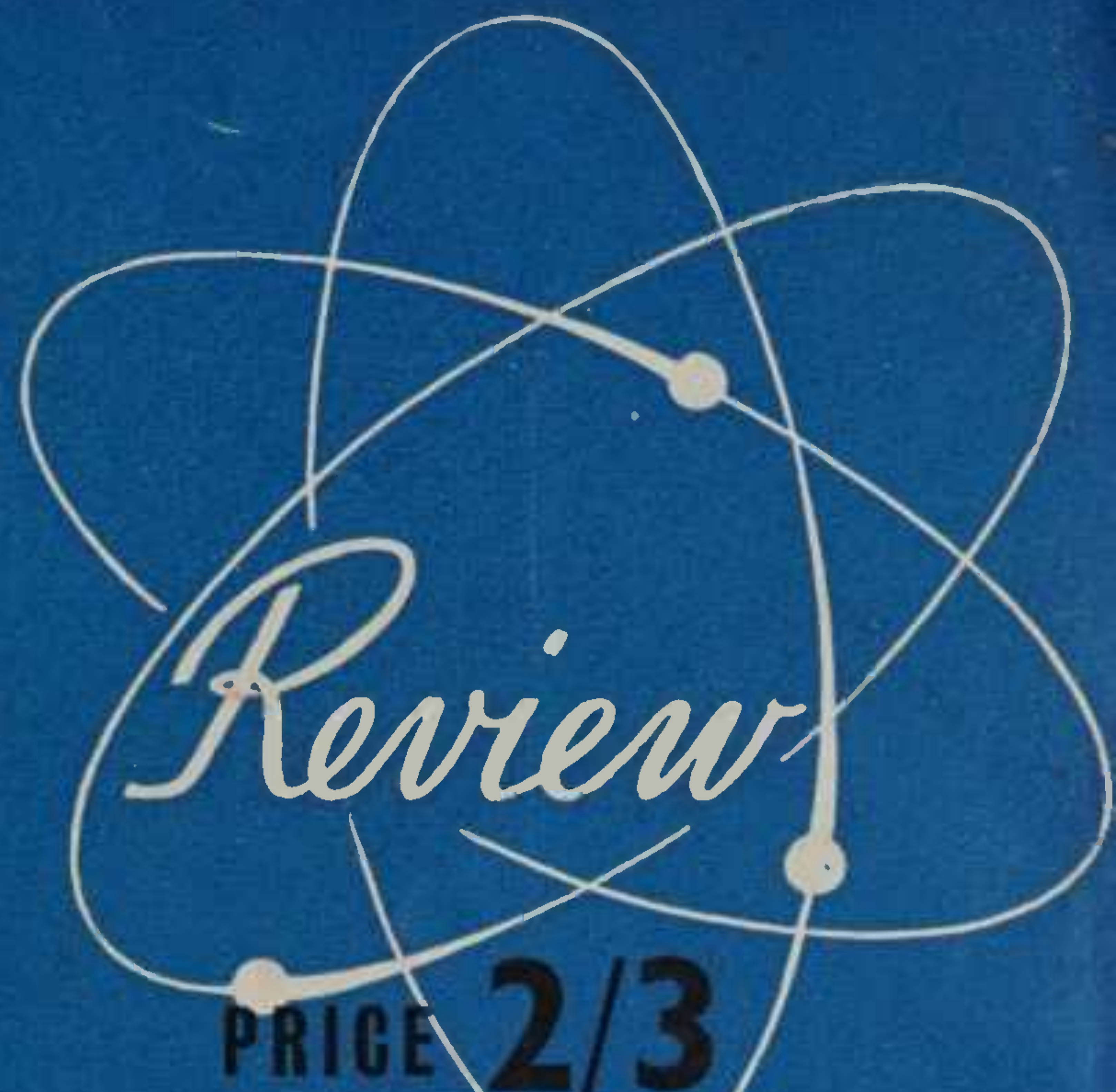
RADIO *and* ELECTRICAL

TELEVISION — COMMUNICATIONS — SERVICE — SOUND

VOL. 15, No. 10

DECEMBER, 1960

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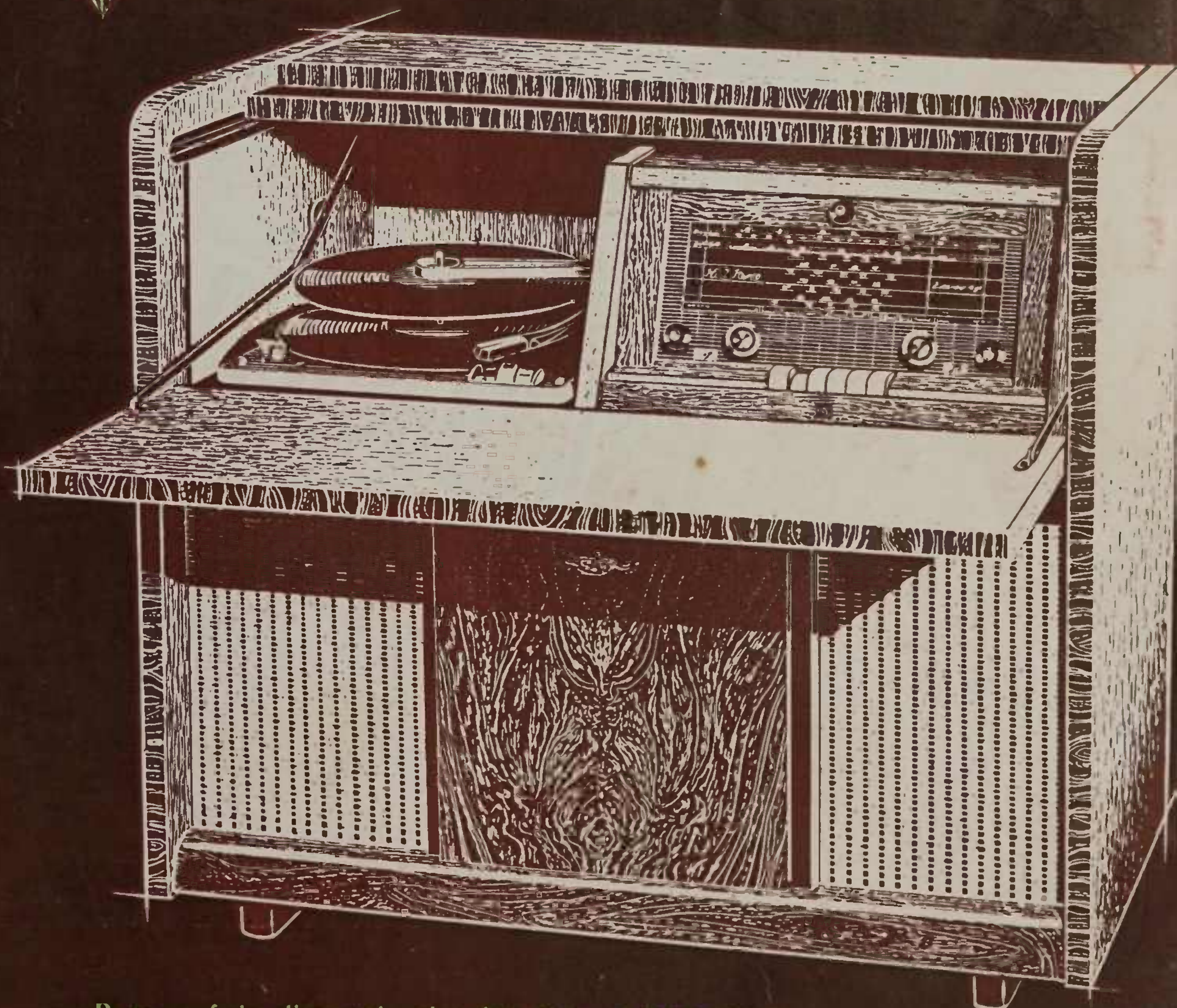
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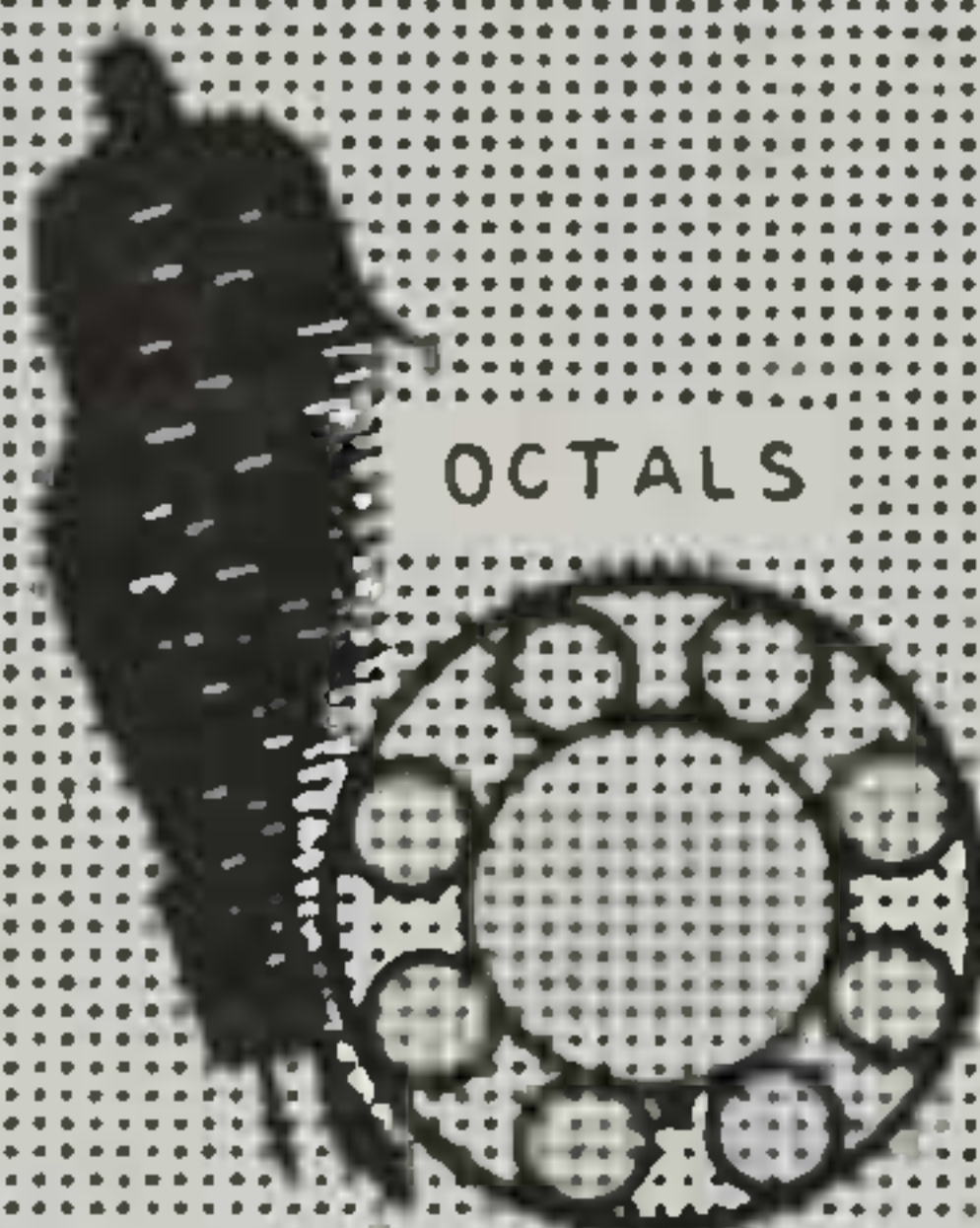
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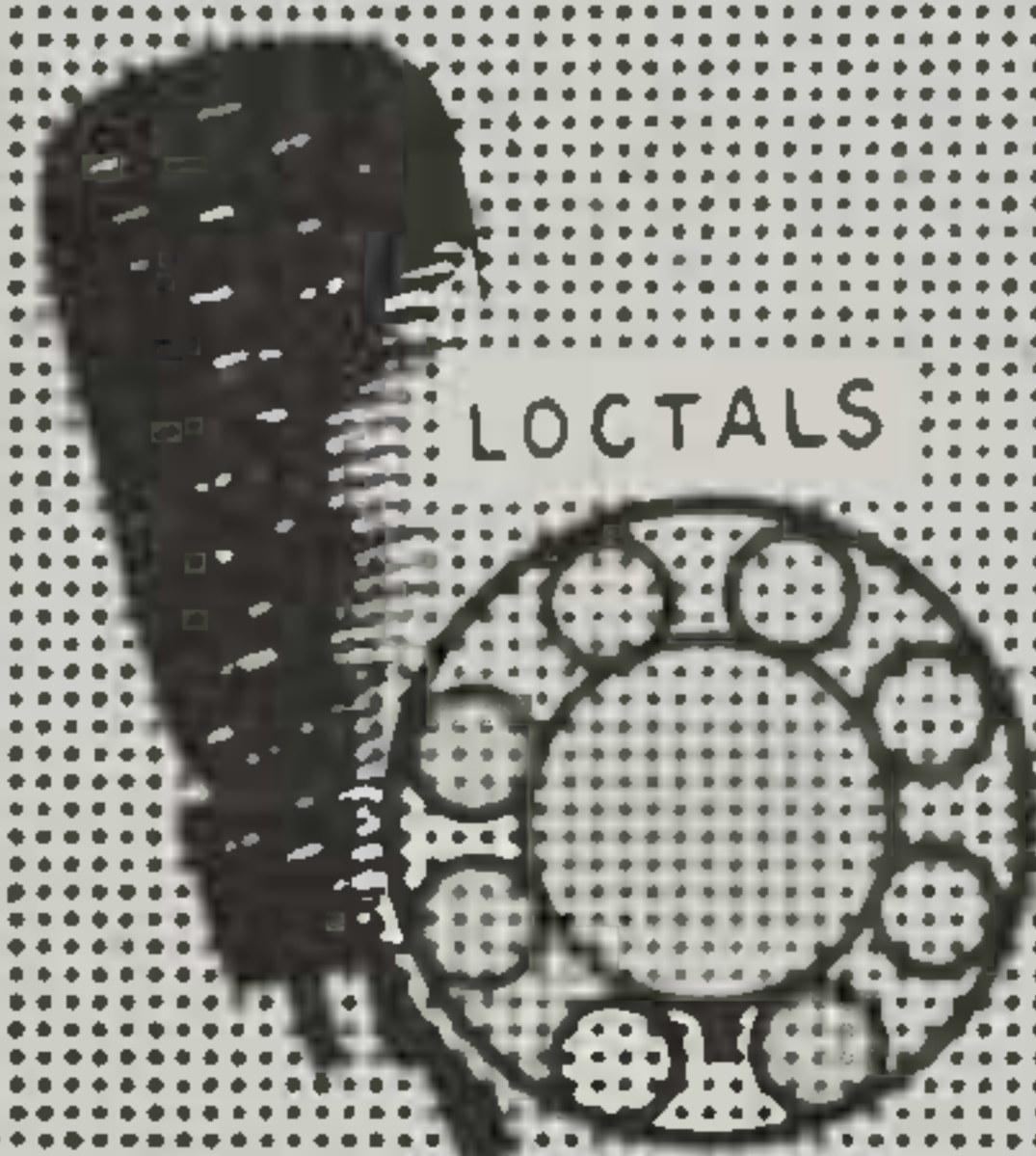
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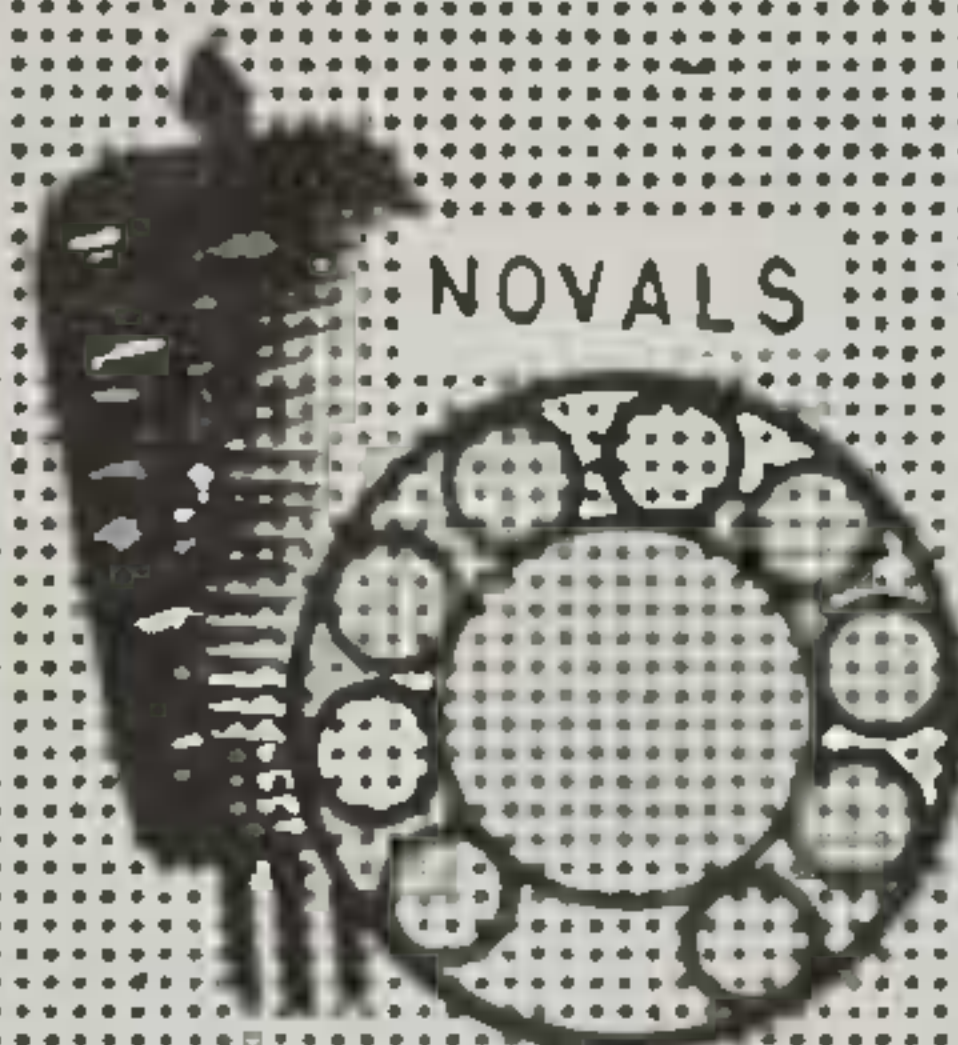
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Vol. 15, No. 10

DECEMBER, 1960

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Sole New Zealand Distributors: Gordon & Gotch (N.Z.) Ltd., Wellington.

AUDIO TRENDS IN BRITAIN AND AMERICA

In a recent issue of *Wireless and Electrical Trader*, there is an interesting appraisal of the present and probable future situation of disc and tape in the field of high-quality audio reproduction. This has been written by P. Wilson, M.A., who is well known in this country as technical editor of *The Gramophone*, and who has some shrewd observations to make on present and future trends. These should be of interest to us in New Zealand, because in these matters we tend to take our lead from what takes place in Britain.

In America, it appears, pre-recorded tape has had limited success, more especially for stereo, but has had a considerable set-back since the introduction of the stereo disc. Some time ago, R.C.A. announced with a flourish that it had a magazine-loading tape machine which was going to revolutionize the domestic tape market. This announcement unsettled the market to such an extent that people stopped buying, and waited to see what would eventuate. As things turned out, R.C.A. did not go on with their scheme, and things settled down in favour of stereo disc reproduction.

In Britain, pre-recorded tapes have not been a commercial success at all, but tape recorder business has exceeded all expectations. Mr Wilson puts this down to the fact that there, the users of tape recorders are much more interested in their own recordings than in playing pre-recorded material, while in America, the reverse appears to be the case. In America, Ampex have announced their 4-track stereo machines, which are being sold alongside 4-track, $7\frac{1}{2}$ -inches-per-second pre-recorded tapes, which even include transcriptions of the British Decca master tapes from which the Decca stereo discs are made. There are signs that there may soon be available in Britain 4-track stereo tapes similar to the Ampex ones, and this is expected to increase the demand for multi-speed, 4-track tape recorders, which are already available, especially from Continental makers.

An interesting possibility is that the B.B.C. may adopt one or other of the several multiplexing systems which enable stereo broadcasting to be done from a single station. Should this come about, it will certainly heighten the demand for stereophonic equipment of all kinds, whether disc or tape, and it will also call for completely re-designed broadcast or FM receivers, depending on the system chosen. It could also create a demand for adaptor units, which can be fitted to existing sets, should the chosen system be workable in this manner.

Mr Wilson considers that the prospects for stereo tapes in Britain are quite bright, and he says that there is a considerable body of informed opinion which believes that stereo tapes will supersede discs in the comparatively near future.

The fact remains, however, that to the consumer, who has been conditioned to their use over a very long period of years, discs are still more convenient to handle than tape, and it seems unlikely that cassette-loading tape decks will forge ahead rapidly enough to cause a significant change in what is now an ingrained preference, in a reasonably short time. At present, only Garrard have a cassette-loading deck on the market in Britain, but a reasonable number of manufacturers seem to be using it, and the system may well become popular more quickly than we think.

In Britain, it appears, there is a distinct tendency for the cheap portable stereo player to disappear from the market. Mr Wilson puts this down to the fact that distorted stereo is more painful to listen to than equally distorted single-channel sound! This is a most interesting observation, in face of the view initially held by many who should have known better, that the advantages of stereo are such as to make imperfections in a reproducing system less annoying to the listener.

From these somewhat random comments, it would appear that sound reproduction in the home has by no means come to the end of the developmental road. Those who like ourselves are interested in the technicalities as well as in the musical results have still plenty to hold their attention, and can still anticipate developments which will bring the advantages of high-quality sound to more and more of the listening public, and which cannot fail to advance the general standard of home musical reproduction.

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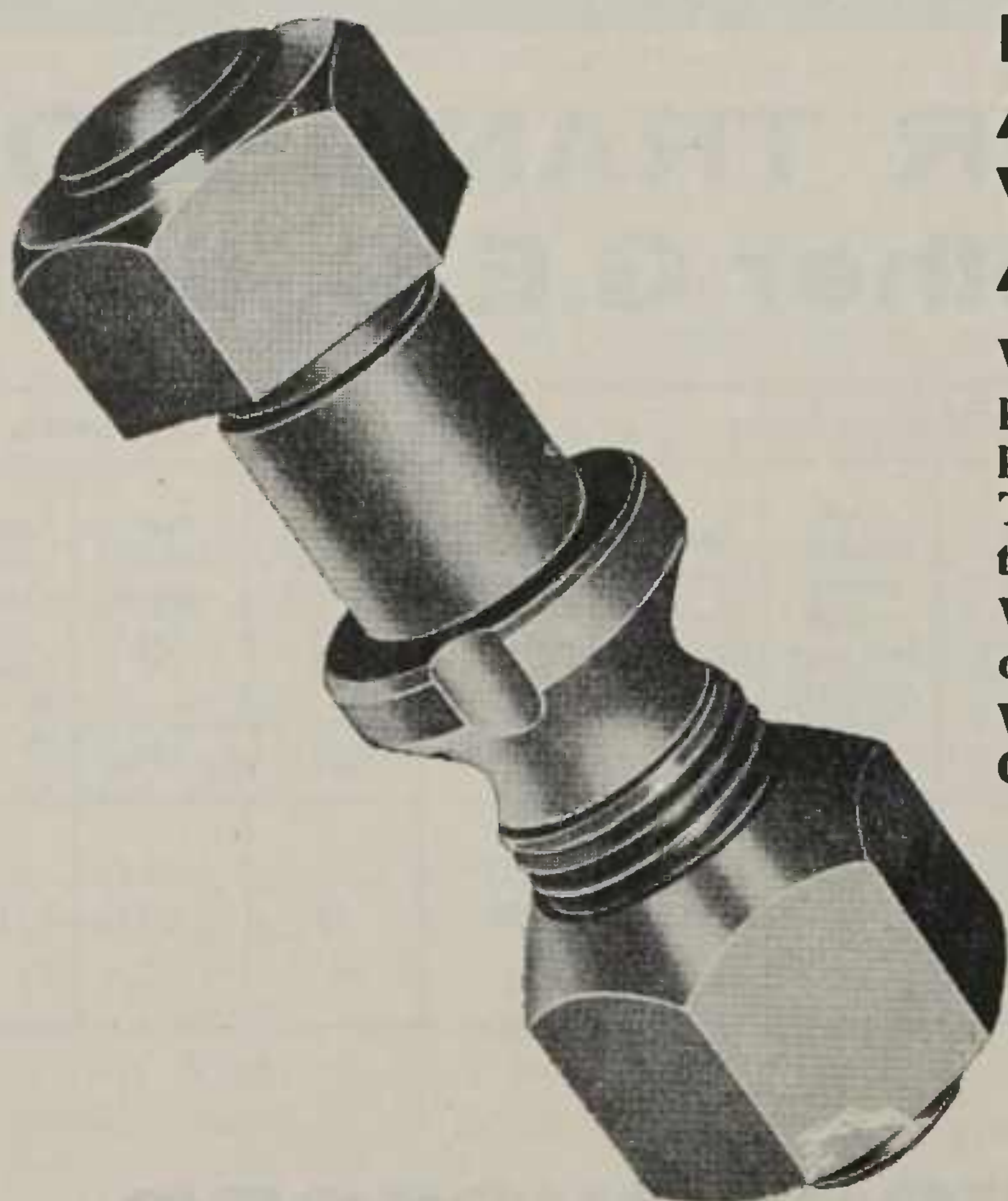
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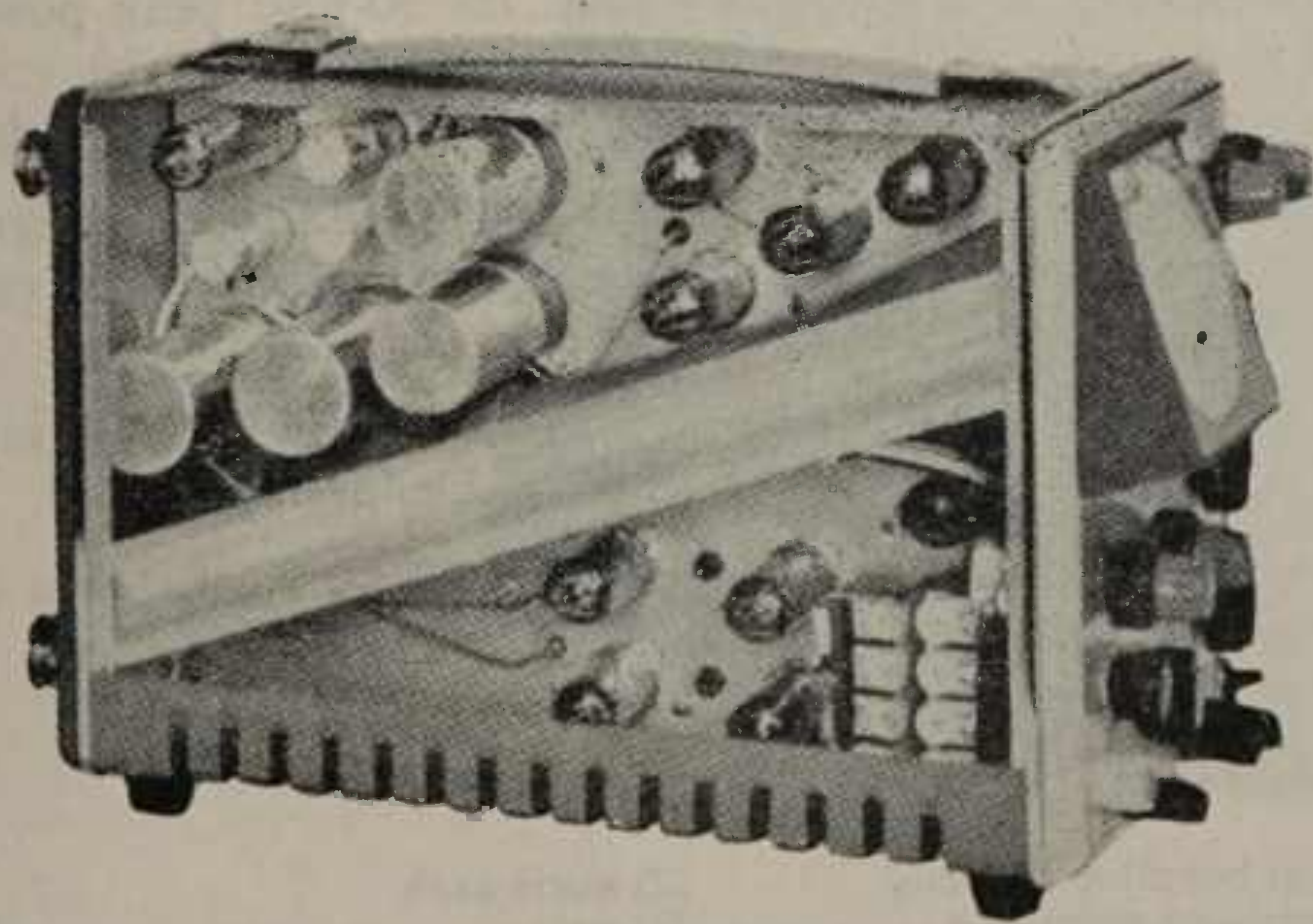
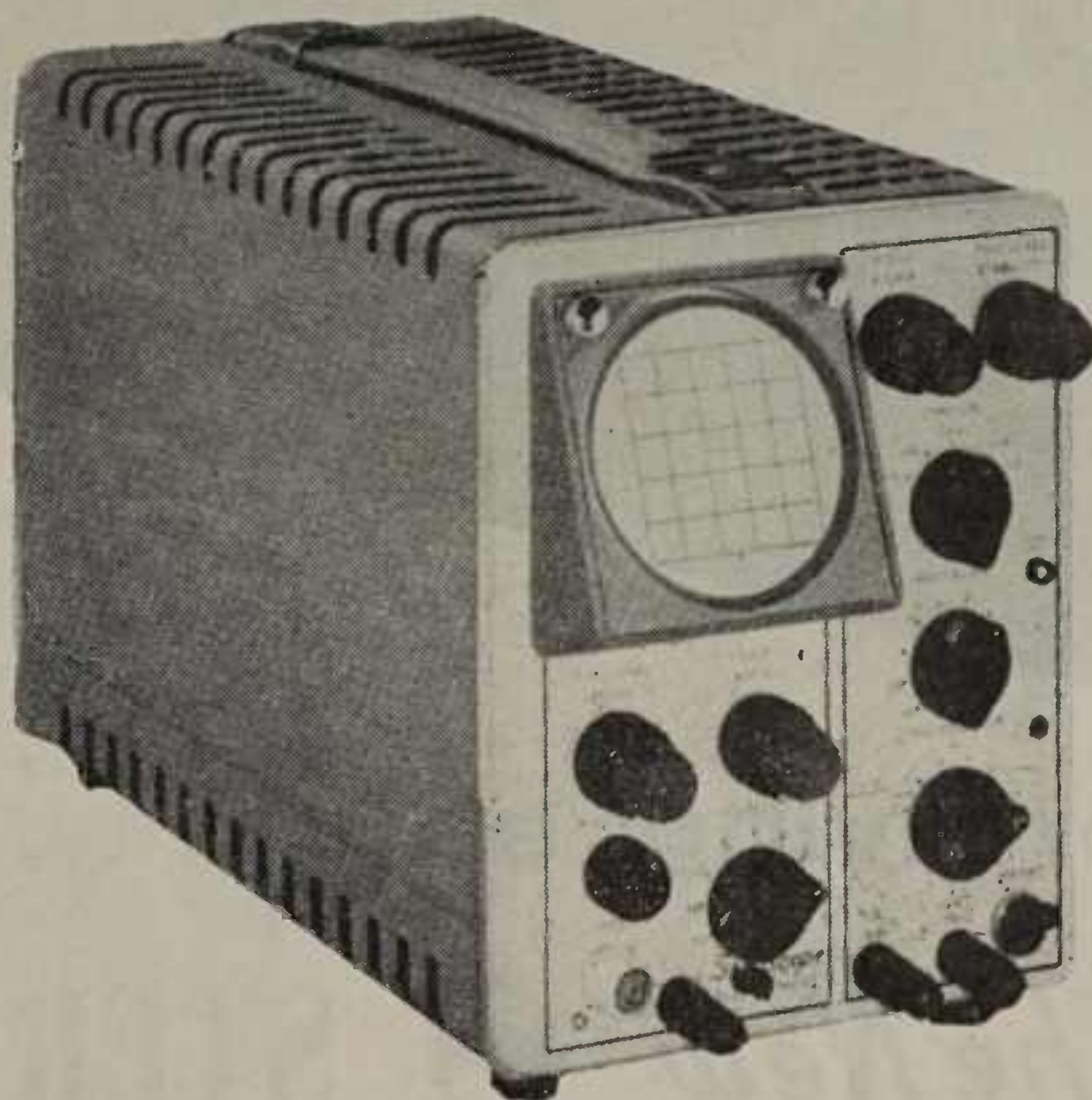
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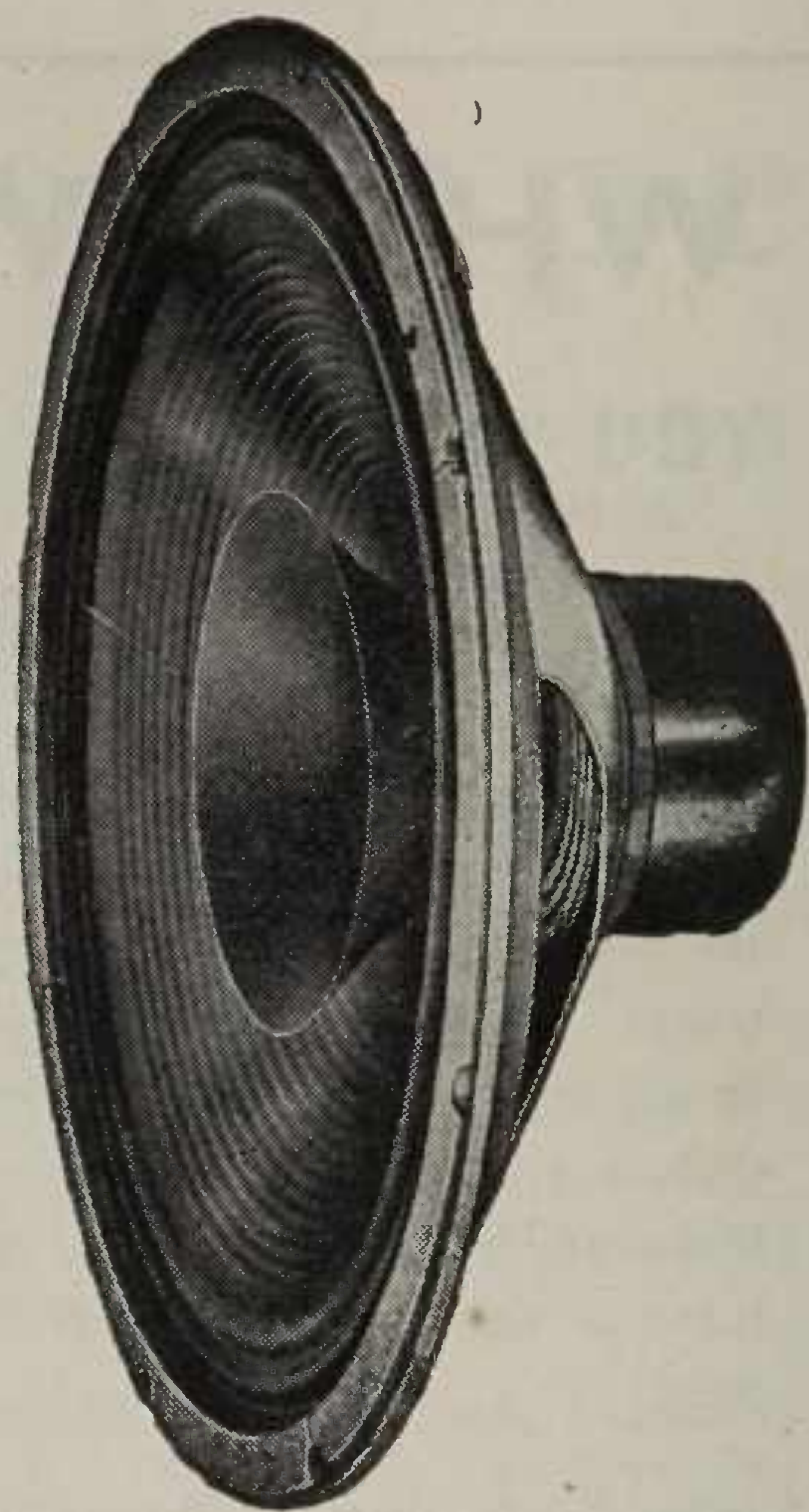
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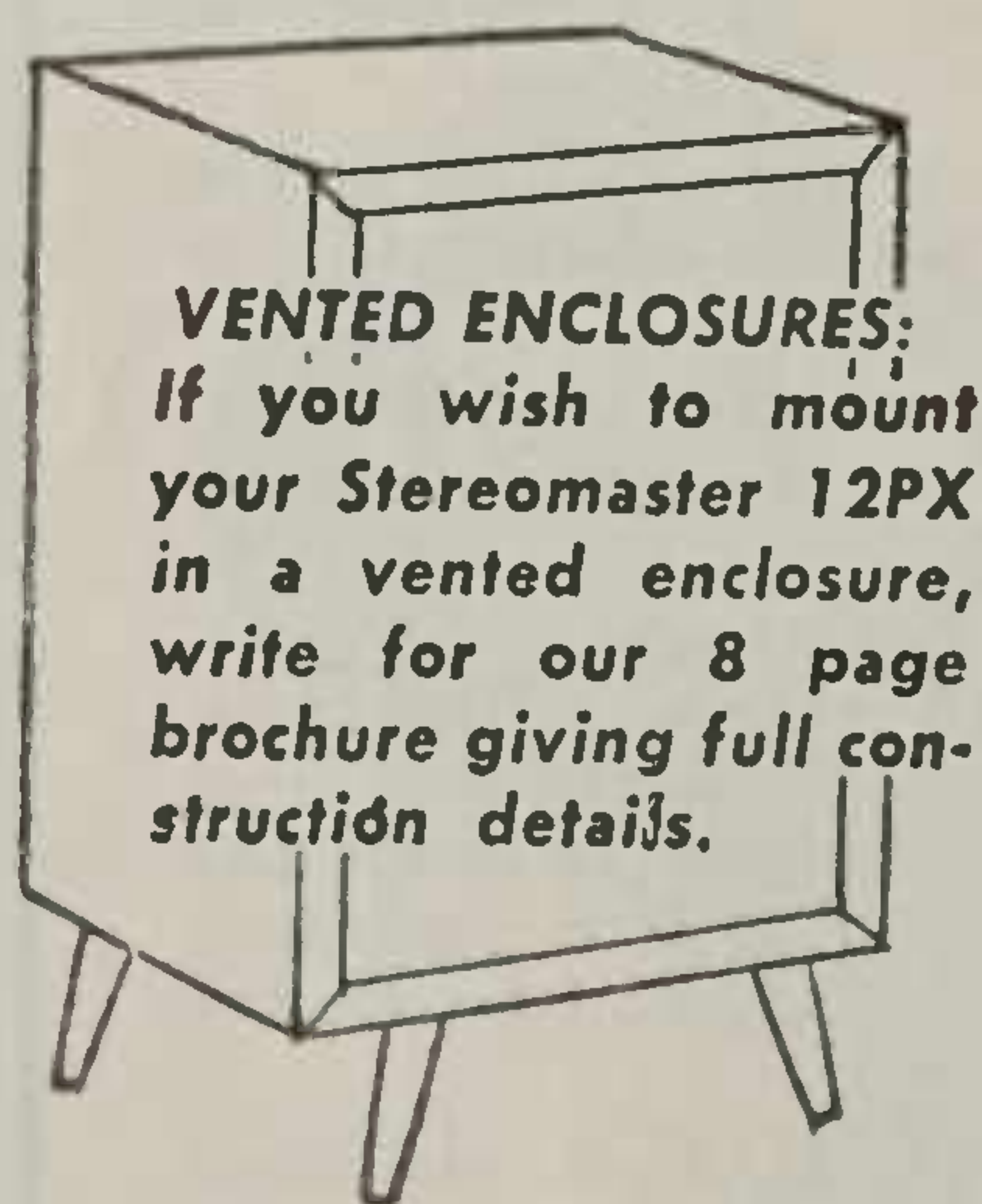
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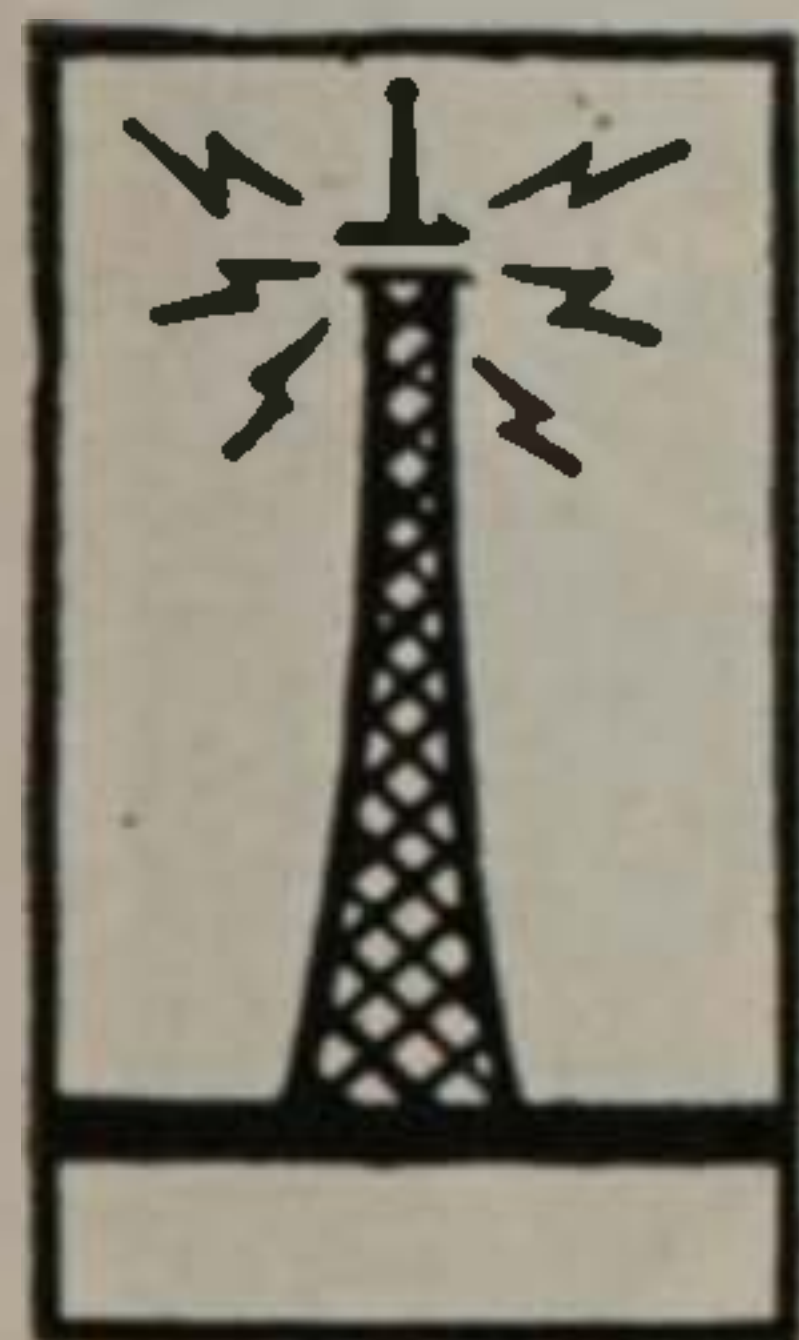
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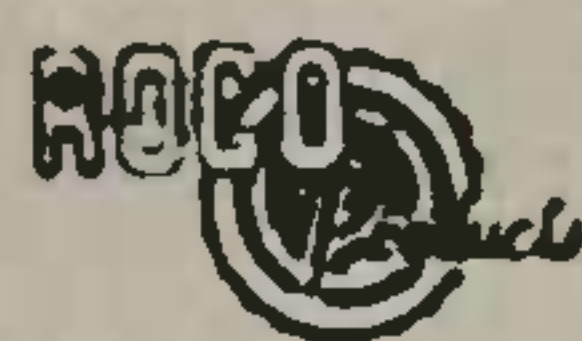
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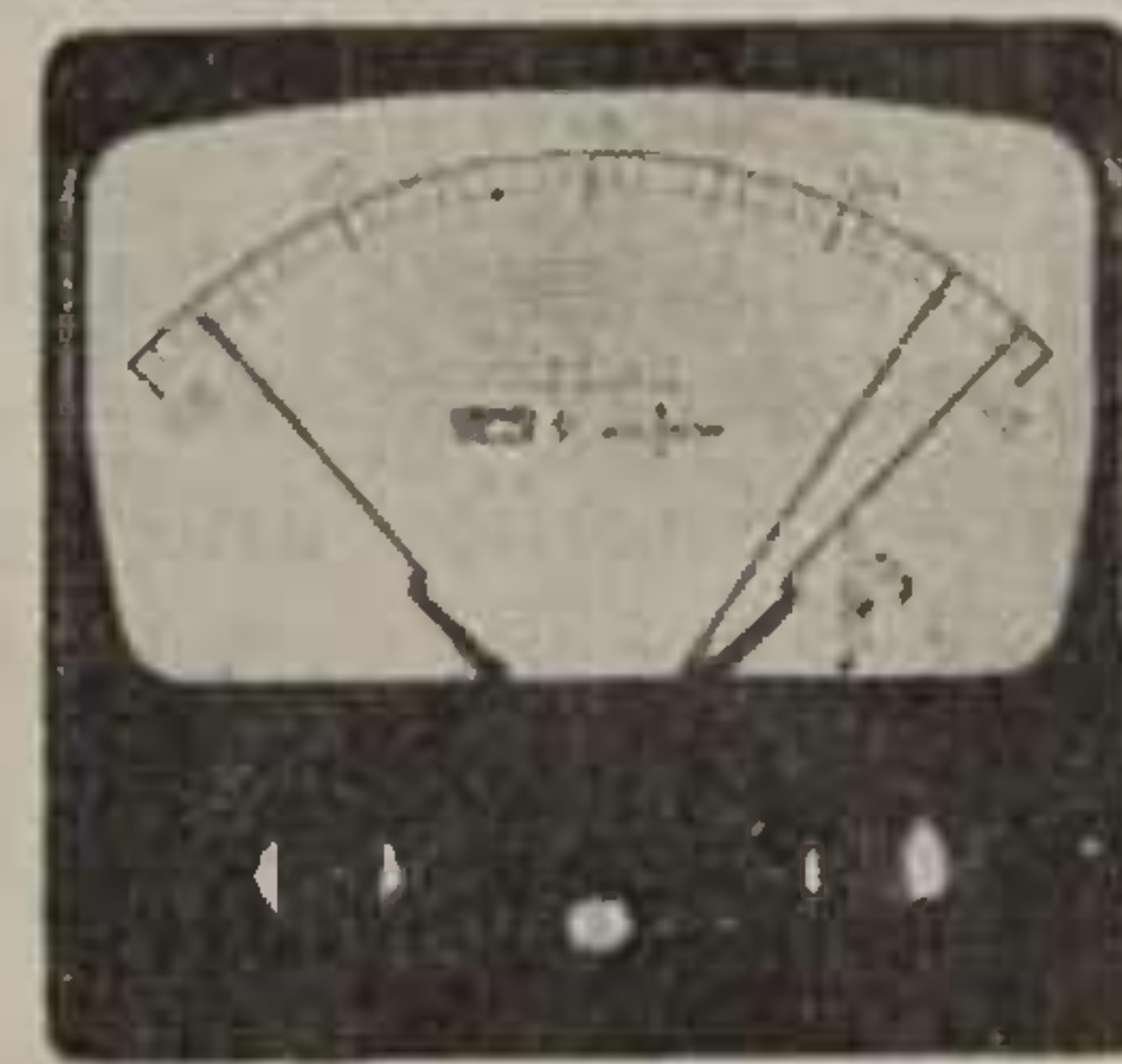
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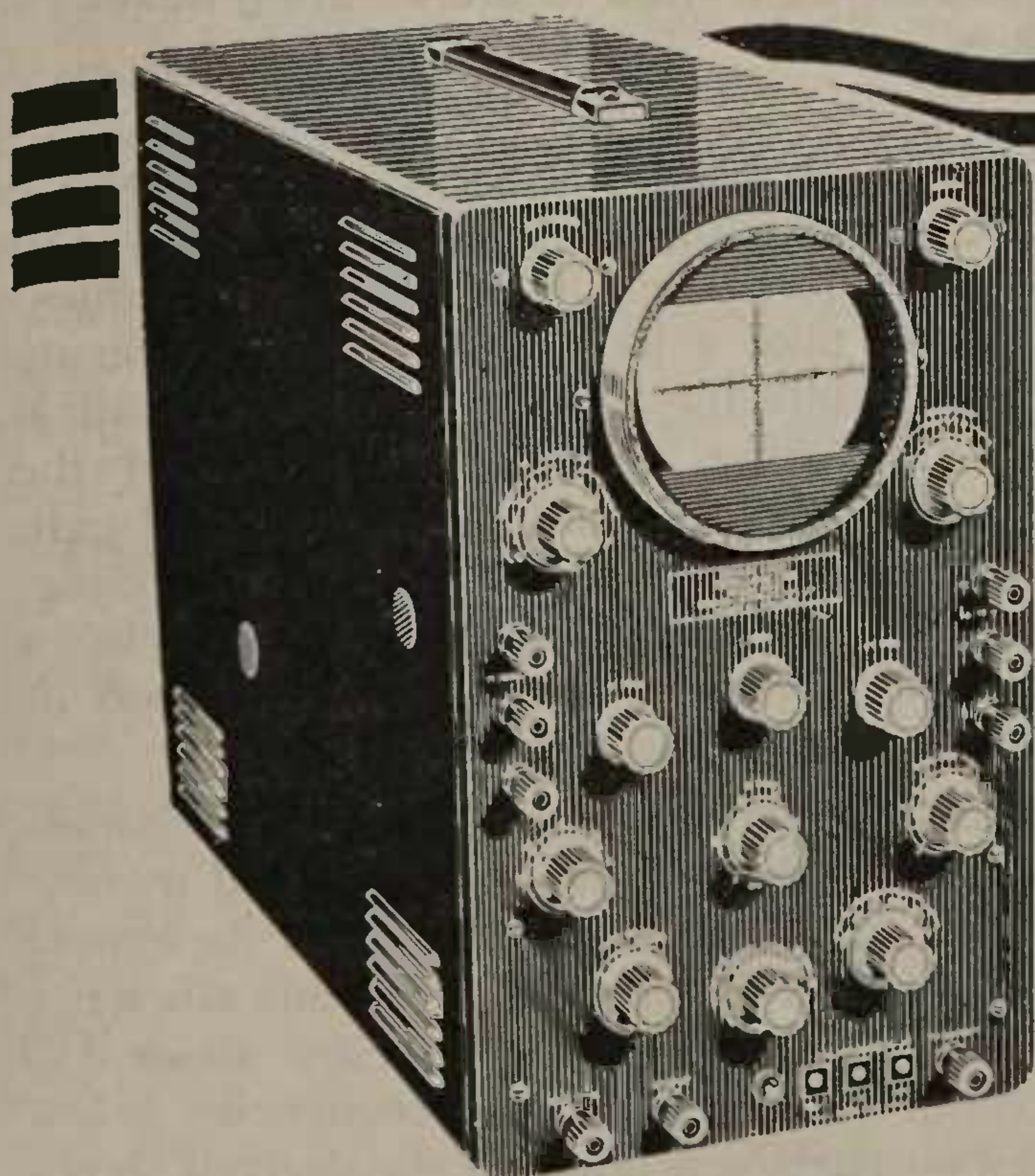
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IN.2.

MIXED-BASS STEREO

By B. J. SIMPSON

(Reprinted by courtesy of *Radiotronics*)

Stereo is not new. In fact, it is quite an old idea, as a search of the literature of the radio art will reveal. It has come upon us now, largely because improvements in technical facilities and "know-how" have made it a commercial proposition. Stereo records and the equipment with which to play them are now available in this country in ever-increasing quantity, and many of us are looking at the possibility of converting to stereo.

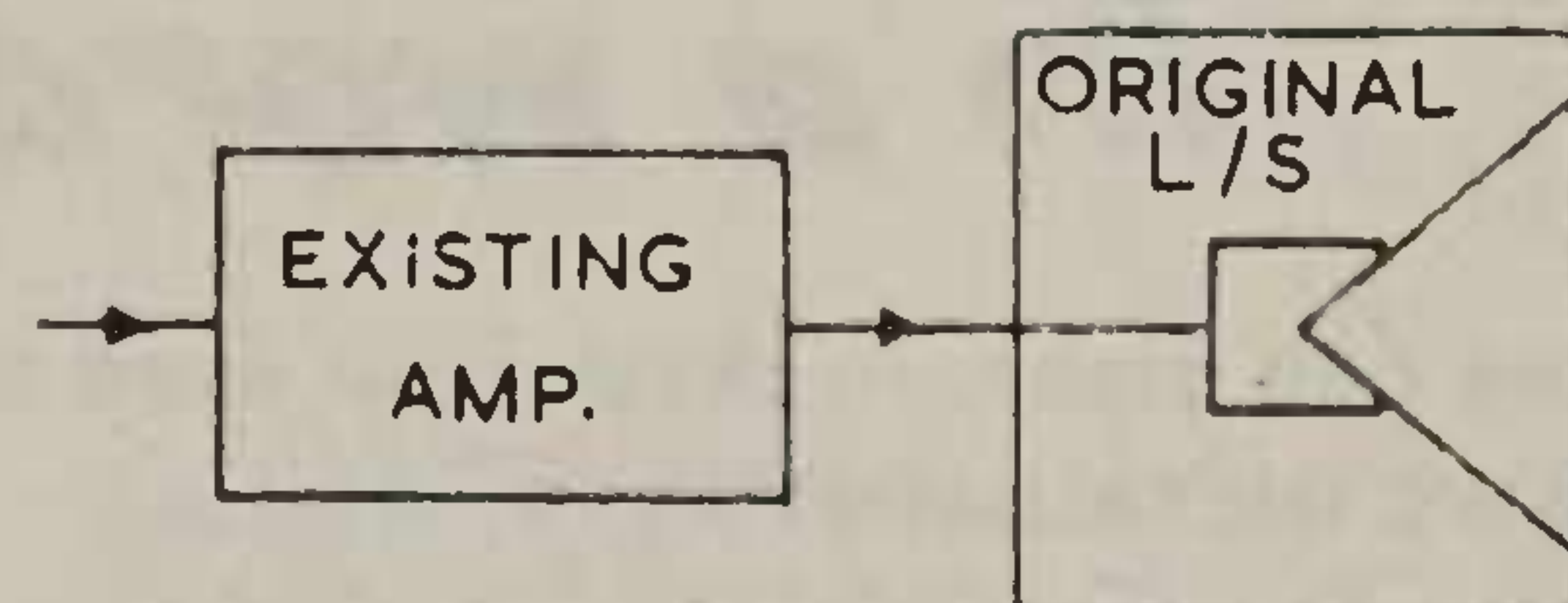
For those of us who must count the pennies, and that includes all but a fortunate few, stereo has raised many thoughts and problems. Many readers will of course already possess a single channel home music system, which has probably been built up over the years, with much trial and error, and which is dear to the owner. He has become attached to it. Frequently no specific data is at his fingertips to "prove" the quality of his set-up, and in some cases the fi is not as hi as it could be. This doesn't matter—he likes it and it gives him pleasure, which is surely why he listens to music. This of course eliminates the over-enthusiastic and unhappy few who play records to listen to the sounds rather than the music.

The point is that most listeners, even if they do convert to stereo, would also like to retain the character of their existing single channel for playing the stock of monophonic records they have collected over the years, and which they are certainly not going to discard.

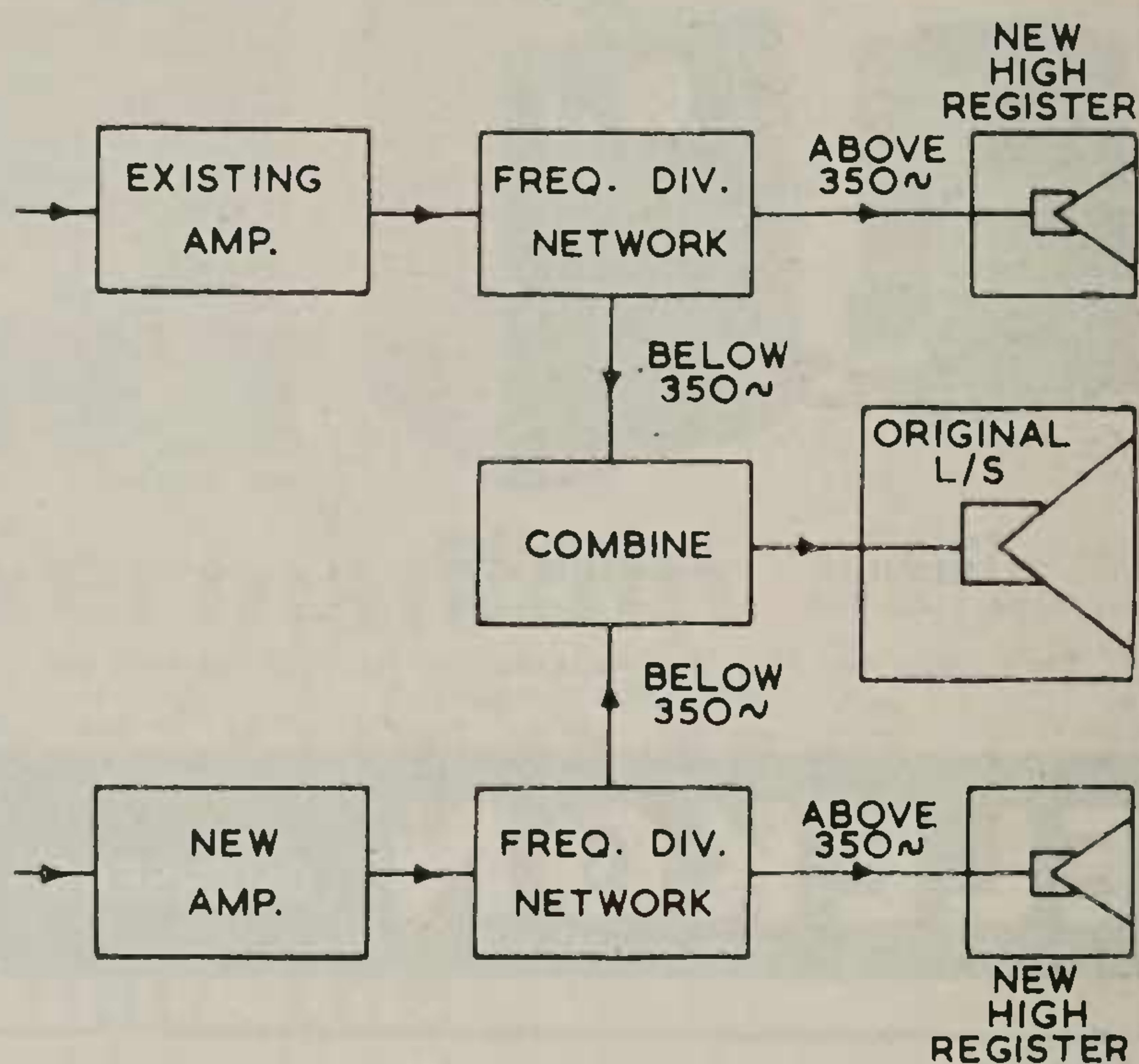
Assuming then that there is a single-channel system already in the home, the first thing we learn is that a complete second channel is required. In other words, we are now faced with building up an almost complete duplicate set of the equipment already existing, plus the provision of a stereo pick-up.

Much of this is inevitable of course if we want stereo, but there is at least one way in which we can produce acceptable stereo without complete duplication of the existing channel.

Let us look for a moment at the loudspeaker system in use. Most music systems will have either a single-unit wide-range speaker, almost certainly in an enclosure of large proportions, or they have a dual speaker system (woofer plus tweeter), probably also in a large box. The duplication of either of these two arrangements is costly, and is further complicated by the increased floor space required. This last point frequently causes distress to the distaff side of the family when the idea of a second unit is dangled in conversation, and is frequently vetoed without further discussion.



A—BEFORE CONVERSION



B—AFTER CONVERSION

Fig. 1.—System Using Single Wide-range Loudspeaker Converted to Stereo using Mixed Bass.

Granted then that a second amplifier channel and a stereo pick-up or cartridge are required, what can we do about the loudspeakers? To answer this question, we must first take a look at the human hearing system, and the interesting phenomenon of binaural perception. At this stage we are fully aware of the mechanism of hearing, different lengths of sound path to the two ears, and how the brain, by detecting, measuring, and interpreting signals generated by a different sound pattern at each ear, is able to tell us the direction from which the sound has come.

As with many things, however, there is an imperfection, and this is going to save us space and money. The efficiency of our binaural perception is dependent on frequency, and it has been shown that this efficiency falls off very sharply for frequencies below about 350 cycles per second. In other words, frequencies below this figure play no part in producing the desired stereo effect.

With international standard pitch at 440 cycles per second for A, F is approximately 349 cycles per second. The fall-off frequency quoted therefore represents the usually-accepted top range limit for the bass tuba and a bass singer. The range of the bass viol lies entirely below this figure, whilst substantial portions of the ranges of the 'cello, viola, and wood-winds lie also below 350 cycles per second.

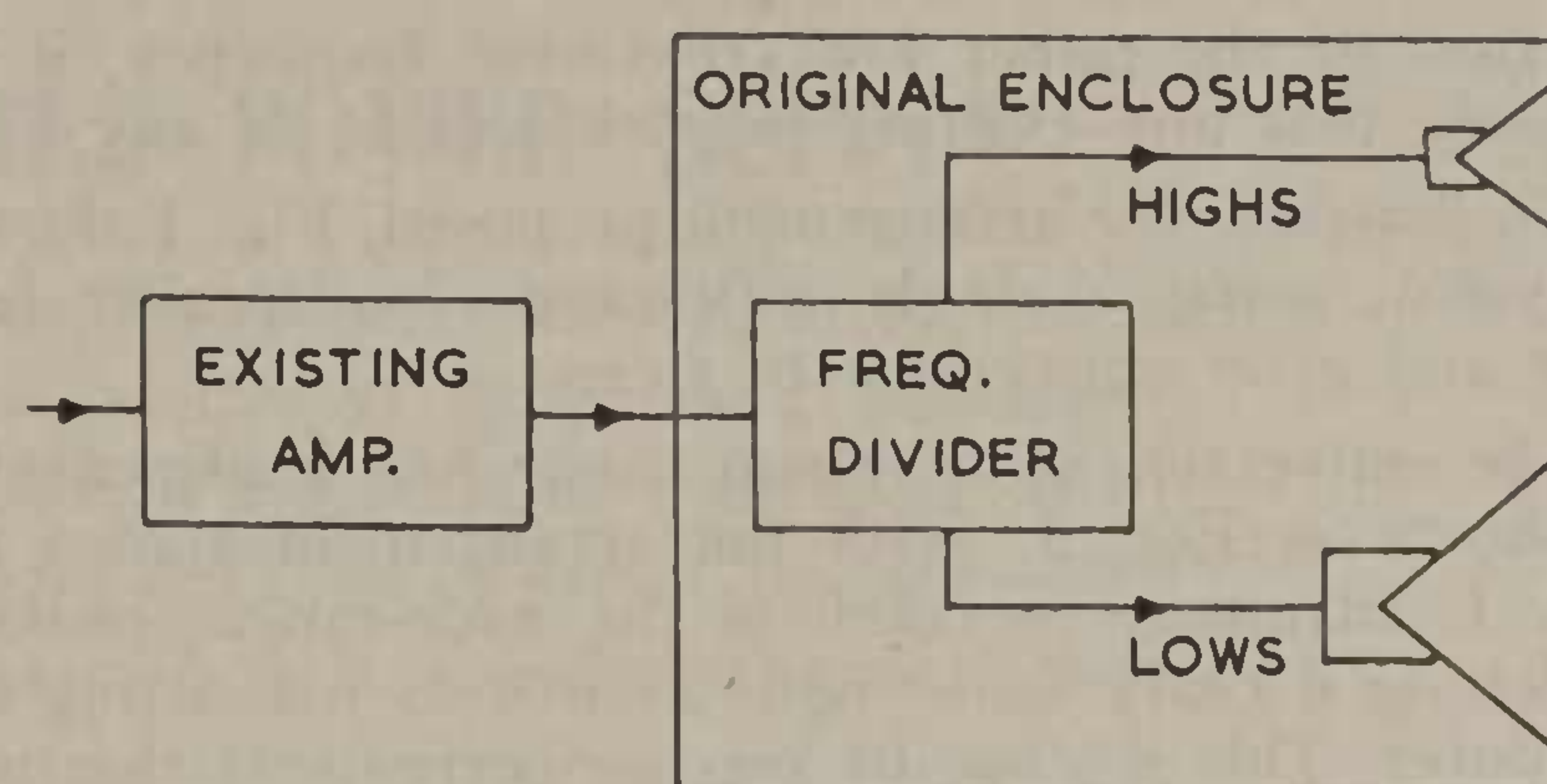
Before hundreds of letters are received from readers pointing out that they can locate the direction of a double-bass or the wood-winds in low register, this is quite so—we all can. But we derive this auditory perception, not from the fundamental frequencies being played, but from higher-frequency overtones and transients which occur at frequencies higher than 350 cycles per second.

Bearing these facts in mind it will be seen that acceptable and quite valid stereo can be reproduced if we separate the highs (above 350 cps) at the output of each channel, feeding the two sets of information to two high-register loudspeakers, whilst mixing the two bass outputs and feeding the combined bass to one low-register (woofer) loudspeaker. This conception is variously referred to as mixed-bass or blended-bass stereo, and is widely used at the moment overseas, particularly where "add-on" units are offered with the idea of converting to stereo. Some overseas manufacturers are offering special woofers for mixed-bass stereo, with two voice-coil windings, but so far as is known, no similar units are available locally. The arrangement produces a completely acceptable illusion of stereophony, giving directivity to instruments playing well below the cross-over frequency, by virtue of the harmonics and transients mentioned previously.

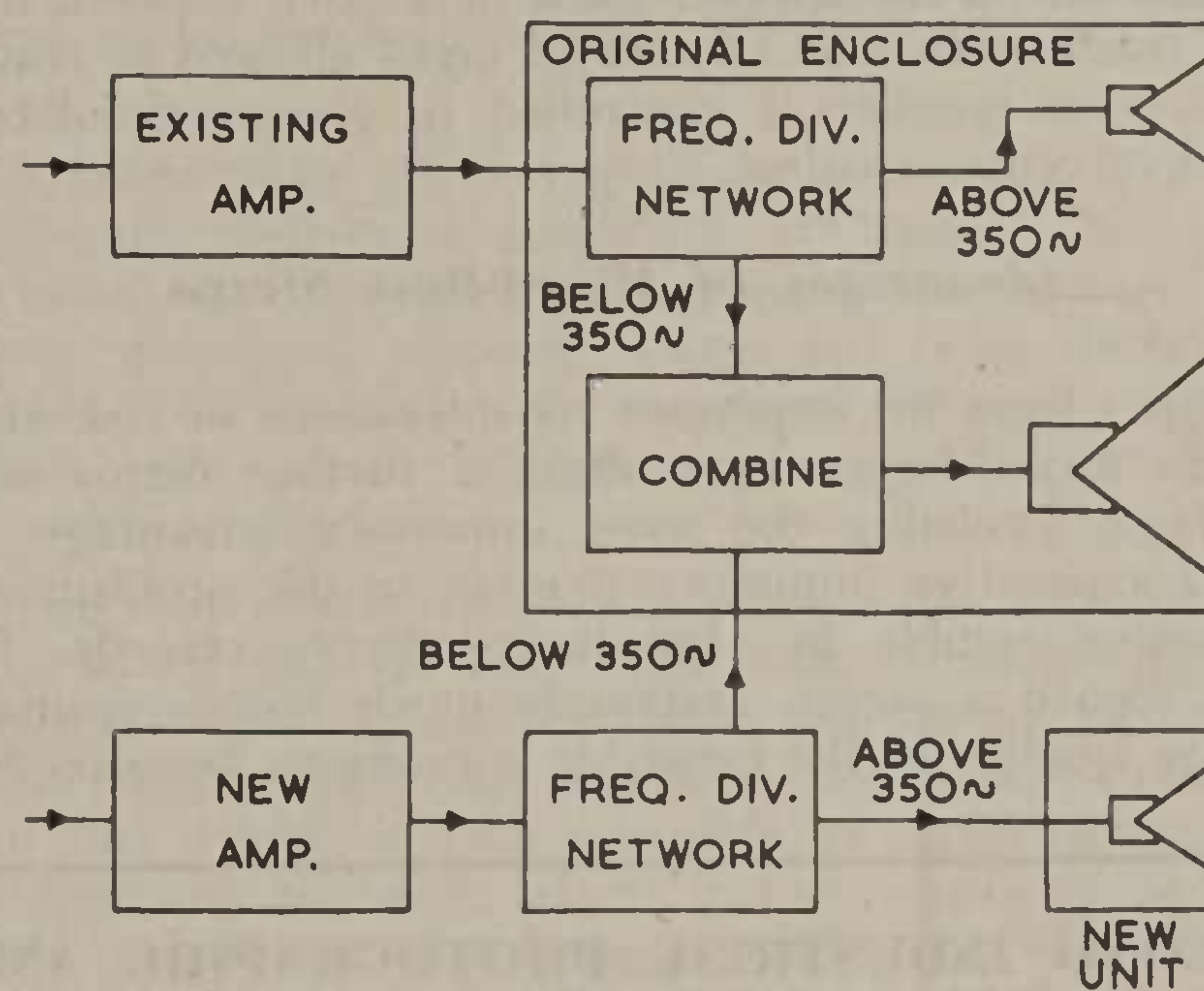
Conversion to Mixed-Bass Stereo

It now remains to be seen how this idea can be adapted to existing home music systems, and then finally to review the advantages and disadvantages of mixed-bass stereo. Reverting to what was said before, the existing music system will probably have one of two popular speaker arrangements. One is a single, large, wide-range speaker, the other a dual arrangement consisting of woofer and mid-to-high-range unit.

Taking first of all the former case, wide-range speakers are expensive, and most enclosures for them are large. In this case, one solution which suggests itself is to provide an additional two mid-to-high register loudspeakers (say, 8-inch units). These small units could be housed in quite small cabinets, as they are not required to operate below 350 cycles per second. These two units would then be given the customary stereo separation, and their size would present no trouble. Such units are often placed on bookcase shelves (the cabinet size can be arranged to suit individual room layouts), or are even fixed high on



A—BEFORE CONVERSION



B—AFTER CONVERSION

Fig. 2.—System Using High and Low-register Loudspeakers Converted to Stereo.

the wall of the room. This is a matter of individual taste and the characteristics of the room.

Meanwhile the original unit is used to reproduce bass when stereo reproduction is required, and is available as part of the original set-up when required for single-channel work. The location of the bass reproducer is relatively unimportant. It need not necessarily be located midway between the other two loudspeakers—in fact, frequently one of the newly-acquired smaller units is placed on top of the original unit.

The second case likely to be met, with two loudspeakers in one enclosure, is the simplest to deal with. All that is necessary is a second unit, preferably the same as the existing mid-to-high register loudspeaker, located in a small cabinet at an appropriate point.

One point to watch when making this type of conversion is that the two high-register loudspeakers are capable of good reproduction down to the rather low cross-over point of 350 cycles per second. The user will also need, of course, to provide suitable frequency-dividing networks in each channel to direct the different frequencies to the appropriate loudspeakers.

In view of the rather low cross-over frequency, it is unlikely that any existing nework will be of any use.

To illustrate the arrangement proposed, Fig. 1 shows a system using a single wide-range loudspeaker before and after conversion to stereo.

The conversion of a system using dual loudspeakers is shown in Fig. 2. With the arrangement shown in Fig. 1, advantage is taken of the wide-range speaker by letting it carry some highs as well as just acting as a woofer. This is done by mixing portions of the two high-register channels, and feeding the combined signal, with the mixed bass, into the wide-range speaker. In this set-up the speaker must be located between the two small units. The amount of highs allowed to reach the centre speaker is controlled to give a simulated third or centre channel.

Advantages of Mixed-Bass Stereo

Apart from the important considerations of cost and space, mixed-bass stereo offers a further major advantage. Probably the most important advantage is the comparative immunity it gives to the problem of excessive rumble in reproducing stereo records. In this regard a stereo system is much more sensitive to low quality in the turntable equipment, because the

stereo cartridge is sensitive to vertical movement at low frequencies.

This is not the case with a monophonic cartridge, which is insensitive to vertical motion, and in which rumble in the reproduction is due to only lateral movement of the stylus. On single-channel reproduction, considerable vertical disturbance of the turntable can be tolerated without affecting the quality of reproduction. In stereo recording, remember that the vertical modulations in the record groove carry the difference intelligence between the two channels. In the stereo cartridge, therefore, the system by its very nature requires good pick-up sensitivity to vertical as well as lateral movement, and unless good quality turntable equipment is used, excessive rumble may result.

Now this rumble occurs, of course, only at quite low frequencies, and when the bass sections of the two channels are mixed, cancellation of most of the excessive rumble will take place without affecting the total bass in the required signals. Mixed-bass stereo therefore allows the use of cheaper turntables to produce an acceptable standard of reproduction. The prospect of having to change the turntable equipment is not always obvious when considering a changeover to full-range stereo.

(Concluded on page 38)

SECOND INDUSTRIAL PHOTOGRAPHIC AND TELEVISION EXHIBITION

Royal Albert Hall, November 21 to 25, 1960
Marconi's Demonstrate Versatility of Closed-circuit TV

The closed-circuit television camera is without doubt the most versatile tool for industry and commerce which has been devised in recent times. Marconi's Wireless Telegraph Co. Ltd., who pioneered the technique, will be exhibiting and demonstrating a comprehensive selection from their latest equipments on Stand No. 35.

Two 21 in. monitors, two 14 in. monitors, and one 8½ in. monitor will display on the stand the "live" pictures received from three cameras located at different vantage points in or on the building, and from telecine equipment.

One camera will be sited on the roof outside the main foyer entrance and remotely controlled from the stand; visitors are invited to become do-it-yourself camera operators by taking over the simple controls which remotely operate the facilities of "pan", tilt, focus, and lens-change on the camera itself. A second camera will be installed in the north-east foyer whilst a third forms part of a visual information unit on the stand; this transmits photographs, documents, or hand-written messages as pictures to the monitors.

Telecine will also be a "live" feature of the display, and will illustrate the high picture quality obtainable from this relatively inexpensive equipment which is

currently in use in so many advertising agencies, and which will form part of the very extensive TV installations being supplied to the new liners *Oriana* and *Canberra*.

The camera channels used are Type DB871's, which have proved themselves in installations throughout the world, in such diverse situations as electricity generating stations, steel works, banks, airports, agencies, and even on the public observation platform of a Taylor Woodrow building site in Gracechurch Street, London. Such is the picture quality obtainable that there is a growing use of this camera for certain television broadcasting applications.

Another exhibit which is of unusual interest is the new Marconi-Siebe, Gorman underwater television camera. This is primarily a hand-held equipment with overall dimensions (including casing and lamps) of only 3 ft. x 2 ft. 3 in. The camera can be buoyancy-adjusted for virtual weightlessness under water; in short, it provides the maximum handiness for a diver carrying out investigations. Alternatively, the camera can readily be lowered from the surface for the periodic examination of—for instance—the accumulation of extraneous matter on the protective grilles of hydro-electric turbine intakes.

Also on show will be a selection of closed-circuit television units and accessories, including a camera Type 4339A, a pan/tilt head, a lens turret, a camera weatherproof housing and an industrial synchronizing generator.

A FIRST-CLASS REGULATED POWER SUPPLY

Fortunately, much electronic equipment does not need to be operated from a highly regulated H.T. supply, but when such an item of equipment is necessary, it is very handy to have available a suitable design which can be used as the basis of one's construction. The circuit presented here has been in use in our laboratory since 1954, and gives a remarkably good account of itself. Regulation is very much better than is usually attained, owing to special control circuitry, and the supply will be found usable in cases where the regulation requirements are very stringent indeed. Simple modifications can be made where smaller output currents are needed, but where the regulation is required to be the best possible.

Introduction

Most modern electronic equipment functions from H.T. supplies of from 200 to 250 volts, so that a general-purpose power supply whose output can be adjusted to any output voltage within this range is a very useful device. If, in addition, electronic regulation is applied, so that variations in load current and input voltage have little or no effect on the output voltage, its usefulness is greatly enhanced. For example, when experimental circuits are being built up, a conventional power supply is often a source of great annoyance, because changes in the operating conditions of valves cause changes in output voltage, as do the addition of more circuits, requiring increased H.T. current. With conventional supplies, this can be partially overcome by providing an adjustable potential divider at the output, but such things consume a deal of waste power, and at the same time are difficult to adjust. For such work, it is almost essential, if time is not to be wasted, to have a supply whose output voltage can be adjusted at the turn of a control knob, and whose voltage does not vary appreciably as the loading is increased or decreased. Similarly, if mains voltage variations are automatically taken care of electronically, so much the better.

These are by no means the only reasons for having a well-regulated power supply. Some equipment just will not function properly unless its H.T. supply has a high degree of regulation. In this class come many instruments, where a stable source of voltage is imperative if readings are not to be affected. Similarly, complex pulse circuitry such as the synchronizing generator for a television transmitter or signal generator must have a regulated supply, if for an entirely different reason. Timing circuits make up the greater part of a synchronizing generator, and these depend for the consistency of their action on the constancy of the H.T. supply. In addition, where, as in much specialized equipment, of a similar nature, steeply rising pulses are formed, these can only be adequately kept out of other parts of the circuit by having a power supply with a very low internal impedance. This is exactly the same thing as saying that the voltage regulation must be very good.

Another place where regulation is essential is when high-gain wide-band amplifiers are used. This case includes television transmitting gear, where there are many wide-band amplifier stages fed from the same supply. It also applies to amplifiers for oscilloscopes, which have similar requirements, and which must be as stable as possible.

The writer well remembers an occasion, some years ago, which was his first experience of attempting to build television signal-generating equipment. A regulated power supply was available, and it was thought that this would be quite adequate in performance for the purpose in hand, which included as well as the pulse generating gear, approximately six stages of video amplification. On the power supply then available, regulated as it was, it was found impossible to work more than three stages of video amplification without encountering low-frequency motor-boating. No amount of de-coupling in the screen-grid and anode circuits of the stages did any good at all, and finally, after a great deal of wasted time, it was reluctantly decided that the only answer would be to build a power supply with still better regulation than the one on hand—either that or else to use several power supplies, with the amplifier stages distributed between them. While the latter would have worked, it would have been most inconvenient, and expensive in parts, so the former solution was tried, and found to be the complete answer. The circuit described here was the one finally used, and can be thoroughly recommended to anyone with a regulated power supply problem.

The Circuit Described

While this circuit has much better than average performance, there is nothing at all mysterious about its success, or about the manner in which it works. It employs the now time-honoured scheme of starting off with a conventional supply of considerably higher voltages in a series-connected valve, or bank of valves in parallel. This valve is the primary regulator, since it is a triode, and can have its D.C. resistance controlled by means of varying its grid potential. A D.C. amplifier is therefore caused to compare the output voltage with that of a very stable source of voltage—

in this case, a VR tube—and to produce a signal voltage which controls the series regulator tube, according as the output voltage tends to be higher or lower than the desired output voltage. The system is, among other things, a form of negative feedback, so that the ultimate stability which is achieved depends on the gain of the whole D.C. amplifying system towards changes in the output voltage. It can never reduce the output voltage changes to zero, because for the system to work at all, there must be some change. But by making the loop gain very high, the only limitation to the degree of stability that can be attained, is the stability of the source of the reference voltage with which the output voltage is compared.

Most regulator circuits of this type use a single pentode as the amplifier for the control of signal which is applied to the grid of the series regulator tube or tubes. The present circuit, however, uses a two-stage amplifier of much higher gain, and it is here that the greatly improved performance resides.

In the circuit diagram it will be seen that the main part of the power supply is quite conventional, consisting of an 83 full-wave rectifier followed by a choke-input filter, and an additional stage of smoothing. The voltage at the output of the filter is about 500, so that the 6A3 series tubes have to drop from 250 to 300 volts, depending on the setting of the output voltage control. In this way, we ensure that the 6A3s always have from 250 to 300 voltage across them, so that they are always working on a favourable portion of their characteristic curves. Since the filaments of the paralleled 6A3s are "up in the air" to the tune of 200 to 250 volts, they must have their own winding on the heater transformer, and as the tubes are directly heated, there must be a centre-tapped resistor across the filaments so that the filament A.C. voltage is not superimposed on the D.C. output voltage.

The 6A3s are each provided with a 10 k. grid stopper to prevent parasitic oscillation, and the paralleling of the grids is done at the outer ends of the stopper resistors, and not at the grids themselves. From the unregulated supply there is a 1 Meg. resistor which acts as the plate load resistor for a 6SF5 amplifier valve, and the grids of the 6A3s are connected directly to the anode of this valve. The cathode of the 6SF5 is connected to the anode resistor of a VR75 regulator tube, which is fed via a series combination of 7.5 k. and 2.5 k. from the regulated output voltage. The VR75 provides the stable reference voltage with which the output is compared by the D.C. amplifier.

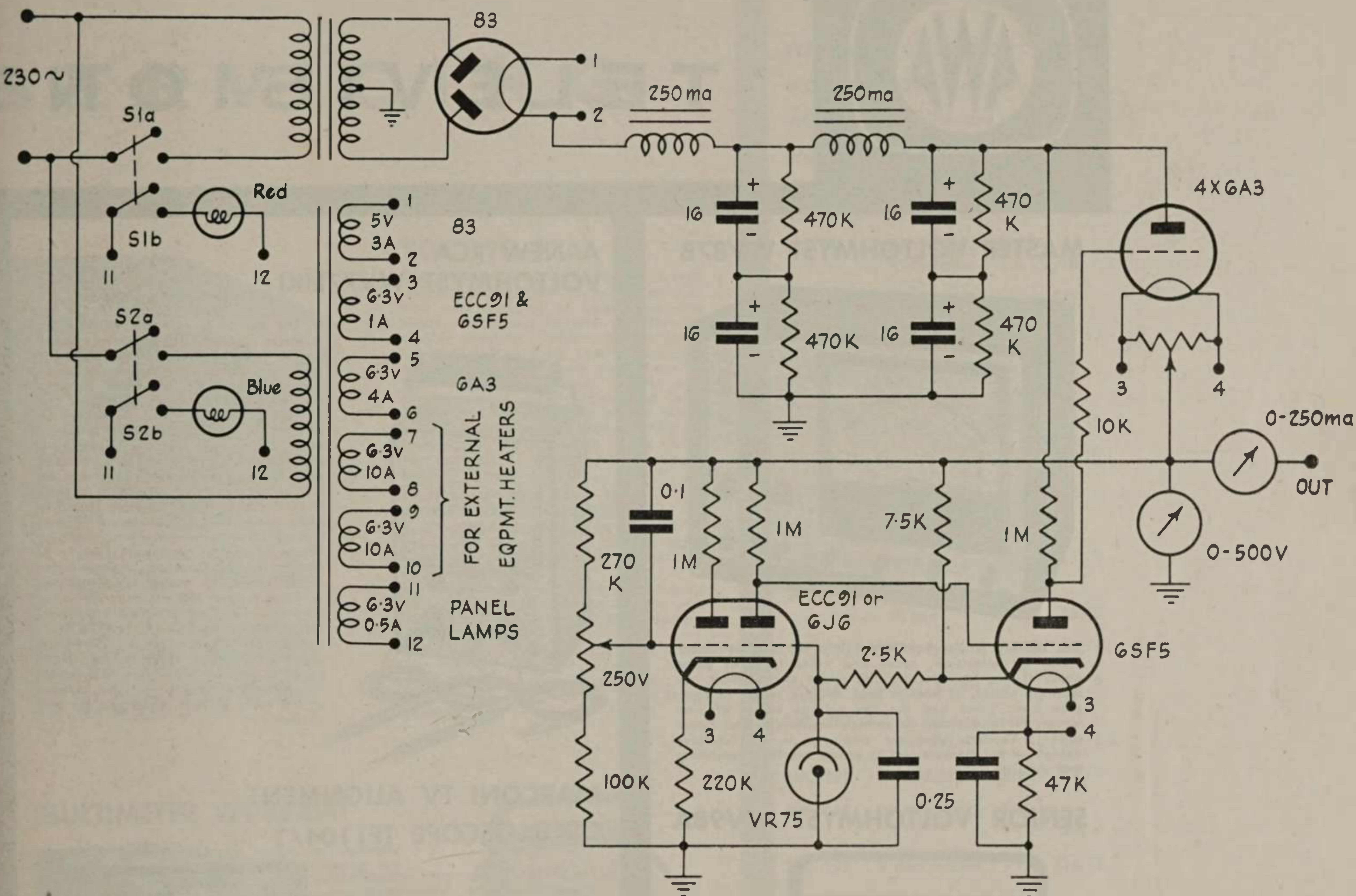
The ECC91/6J6 is connected in a cathode-coupled or long-tailed pair circuit arrangement. Its two plate-load resistors are fed from the regulated supply, while the left-hand control grid is fed with a portion of the output voltage, determined by the setting of the 200 k. potentiometer. Output is taken from the right-hand triode of the ECC91, which means that the amplified

voltage changes will be in the same polarity as those at the input grid of this stage. Thus, we have in the ECC91 and 6SF5, a two-stage D.C. amplifier of very high gain, in which there is only one phase reversal instead of two, as there would be if both stages were of the normal type. The standing plate potential of the ECC91 sections is determined partly by the fact that the "spare" grid (of the right-hand triode) is directly connected to the anode of the VR75, and partly by the setting of the control potentiometer. However, once the latter is set and left, the grid of the ECC91 will vary in potential *if for any reason at all* the supply's output voltage changes. This change is amplified by the ECC91, and is applied to the grid of the 6SF5, which amplifies it further, and applies it to the 6A3s in the correct polarity to counteract the original change. Note that even though the output voltage of the supply may change, the grid potential of the right-hand section of the ECC91, and the cathode potential of the 6SF5 change hardly at all, so that the full amplification of both tubes is obtained. The overall gain in the control channel is about ten thousand times. This gain is divided by three because only about a third of the output voltage of the supply is applied to the grid of the ECC91. The gain is thus some 3300 times, and as the full output of the control amplifier is fed back to the input of the regulator tubes, any output voltage fluctuations that would occur without the regulator in action are reduced by a factor of 3300. This gives some idea of the exceedingly good regulation possessed by the supply. Similarly, the apparent internal impedance is reduced by a like factor. Thus, if the supply had an internal impedance of 500 ohms—which is a reasonable figure for an unregulated supply—the actual internal impedance would be about 0.15 ohm. In other words, within the allowable output current range, this supply has a lower internal resistance, volt for volt, than a large accumulator, which is saying something. For one thing it explains why a shock from such a supply is just what its name implies—if not more so!

A.C. Regulation as Well

In our description of how the regulating system works, we have omitted to explain the purpose of the 0.1 μ fd. condenser which goes from the regulated output to the moving arm of the control potentiometer. This bypasses the 300 k. resistor above the potentiometer, and ensures that any alternating voltages that may appear at the output terminal of the supply are fed directly to the grid of the ECC91 without attenuation. For such voltages, the amplification is therefore about three times the D.C. amplification, so that hum and noise at the output will be effectively suppressed by the regulating action just as are the D.C. changes.

Note that the ECC91 and the 6SF5 each have their own heater windings on the filament transformer so as to avoid high voltages appearing between the heaters and cathodes of these valves.



Range of Adjustment

The minimum output voltage of the supply is approximately 200, while the maximum is about 300, or a little less. At 250 volts—for which the supply is really intended, the regulation continues until the output current reaches approximately 250 ma., at which point regulation abruptly ceases, owing to the 6A3s, going into grid current.

Construction of the Supply

Few precautions need be taken with the construction of the power supply, other than to avoid unnecessarily long leads in the D.C. amplifier section. One-watt carbon resistors can be used throughout the construction except for the 7.5 k. resistor, which should be rated at 5 watts or more, in order to keep it cool. The output voltage of the unregulated section of the supply is too high for single 450-volt electrolytics, and so two 16 μ fd. units are used in series, with 470 k. equalizing resistors across them. Make sure that all chassis grounds are firmly made. Install separate primary switches for the two transformers, as shown.

so that the heaters of the equipment can be warmed up before the H.T. is applied.

Reduced Output Currents

If a supply is needed that will never be called upon to deliver 250 ma., it would be wasteful to build this one just as shown. Considerable economy can be effected if desired, by making the H.T. transformer a 150 ma. one, and the smoothing chokes likewise. However, if there is any likelihood of the full 250 ma. being required at some stage, it is good economy to build the supply exactly as shown, because a second supply, equally well regulated, but of lower current capacity would be a much more expensive way of getting the output capacity, because of the necessity for duplicating the regulator arrangements.

The transformers originally used for this supply were donated to the Electronic Institute's Wellington Branch television project by the Transformer Company of New Zealand, who hold the original design specification, and could no doubt supply others like them to order.



TELEVISION

MASTER VOLTOHMYST WV87B



The WV-87B Master VoltOhmyst is a de luxe instrument useful for television, radar and other types of pulse work. It has facilities for the direct measurement, on separate scales, of peak-to-peak voltage values of complex wave forms and the rms voltage values of sine waves. It also reads dc voltage resistance, and direct current. Vacuum tubes are employed in all functions except current measurement to ensure excellent sensitivity and stability.

SENIOR VOLTOHMYST WV98A



The WV-98A Senior VoltOhmyst provides direct peak-to-peak measurement of complex wave shapes up to 1400 volts and is especially useful for television signal tracing and industrial servicing. Quantitative measurements of practically all of the important complex waveform voltages found in video, sync and deflection circuits can be obtained with the instrument. The WV-98A has such refinements as seven non-skip ranges on all functions, wide frequency range and extended voltage range. It is provided with Type WG-299B DC/AC Ohms Probe and shielded cable. Available as accessories are a slip-on crystal probe, WG-301A, which permits rms measurement in r.f. circuits up to 250 mc, a high voltage probe, type WG-289, and a multiplier resistor, WG-206, which extended the dc voltage range of the instrument to 50,000 volts, and multiplies all scales by 100 times.

A NEW RCA VOLTOHMYST WV77E(K)



- The easiest to assemble VTVM ever.
- Meter electronically protected against burnout-PLUS-ohms-divider network fuse-protected. Unit is burnout proof!
- Ultra-slim probes and flexible leads—easy to use in those tight spots.
- Cables can be stored in plastic holder attached to handle, for increased portability! Plenty of room for power cord too.
- Separate scales for 1½ volts rms and 4 volts peak-to-peak ensure rated accuracy on low ac readings.
- Famous RCA Volt-Ohmyst circuit means excellent stability under conditions of line voltage fluctuation—PLUS—special circuit to minimise effects of contact potential change.
- Easier, faster to read scales—meter colour coded to match range switch.
- Extra rugged 400 microampere meter movement.
- Case completely shielded for protection against r.f. fields.
- Voltage divider networks use 1% tolerance deposited carbon resistors.
- Front panel is brushed aluminium—all lettering is acid etched to last the lifetime of the unit.
- Both wired and kit unit available.

MARCONI TV ALIGNMENT OSCILLOSCOPE TF1104/1

The TF1104/1 is designed primarily for frequency response measurements on television and f.m. receivers operating in v.h.f. bands 1, 11, and 111. It comprises a frequency-swept generator for connection to the input of the r.f., i.f., or video stages of the receiver, and a c.r.o., synchronised to the sweep frequency, for viewing the receiver output. Internally generated calibration 'pips', can be superimposed on the display, enabling tuning and bandwidth adjustments. Other important applications include the adjustment of discriminators in f.m. receivers and the matching of aerials to transmission lines. Can also be used as a conventional oscilloscope.



WO-33A (K) OSCILLOSCOPE

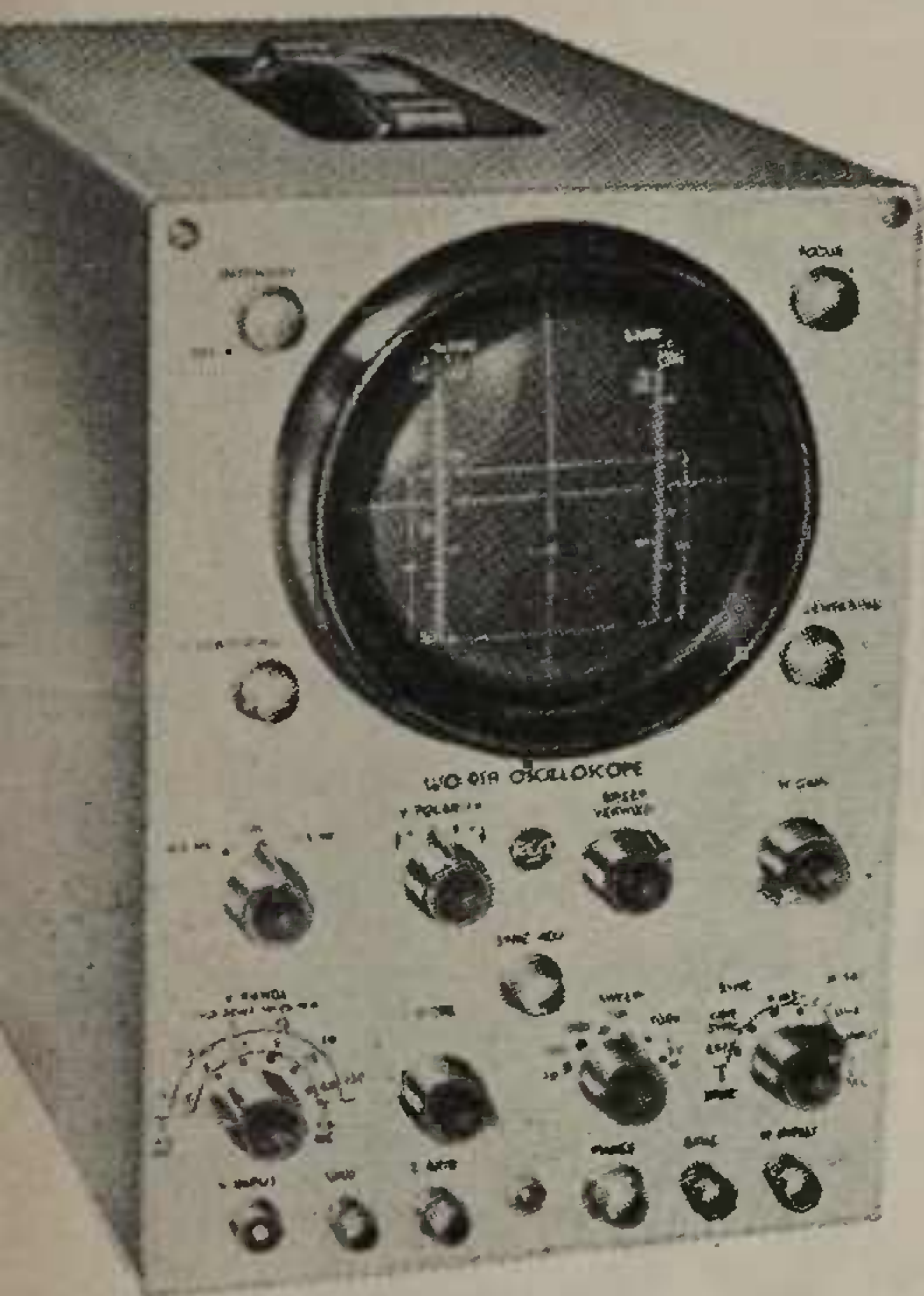
Whether you're a ham, an Electronics hobbyist, a TV Technician, or an engineer the new WO-33A (K) Oscilloscope will help you solve those tough servicing problems. Here's a 'scope that's good for PA work—so sensitive you'll get a clear trace display from the lowest level pickups, microphones, and other low level electronic equipment. It has gain comparable to an aural-visual signal tracer and is the only 'scope available that gives you high gain and excellent bandwidth at such an economical price and compact size. The WO-33A (K) can be used in PA systems servicing, radio troubleshooting general servicing and alignment work in black and white and colour TV applications.

VERTICAL AMPLIFIER: Wide band position Sensitivity—100 rms millivolts/inch
Bandwidth—within -3db, 5.5 cps to 5.5 Mc.
Narrow band position Sensitivity—3 rms millivolts/inch
Bandwidth—within -3db, 20 cps to 150 Kc.

SWEEP CIRCUIT: Sawtooth range—15 cps to 75 Kc. Sync—external + internal
Line sweep—160° adjustable phase. Sync range—to 4.5 Mc.

VERTICAL CIRCUIT INPUT IMPEDANCE:
At Lo-Cap Cable Input—10 megohms, 10 micromicrofarads (approx.)

SERVICING



RCA WO-91A

The WO-91A is a new, low-cost, 5 inch oscilloscope designed for use in production and servicing of both black and white, and colour TV sets. Essential for trouble shooting in chrominance circuits, the WO-91A can be used to observe and measure colour-burst signals and is equally useful for signal tracing and aligning wide band video amplifiers. The WO-91A is equipped with a multi-scale graph screen, scaled directly in volts for all scales, which makes direct measurement of peak-to-peak voltages as easy as with a VTVM.

CHOICE OF WIDE-BAND OR HIGH-SENSITIVITY OPERATION:

A front panel switch gives the user a choice of wide-band or narrow-band (high sensitivity) operation of the vertical amplifier.

Frequency response: (reference frequency 10 kc) Wide-band position, within ± 1 db from 10 cps to 4.5 Mc; Narrow within ± 6 db at 1.5 Mc.

Sensitivity: 0.05 peak-to-peak volt per inch (0.018 rms volt) in narrow band position; 0.15 peak-to-peak volt per inch (0.053 rms volt in wide-band position).

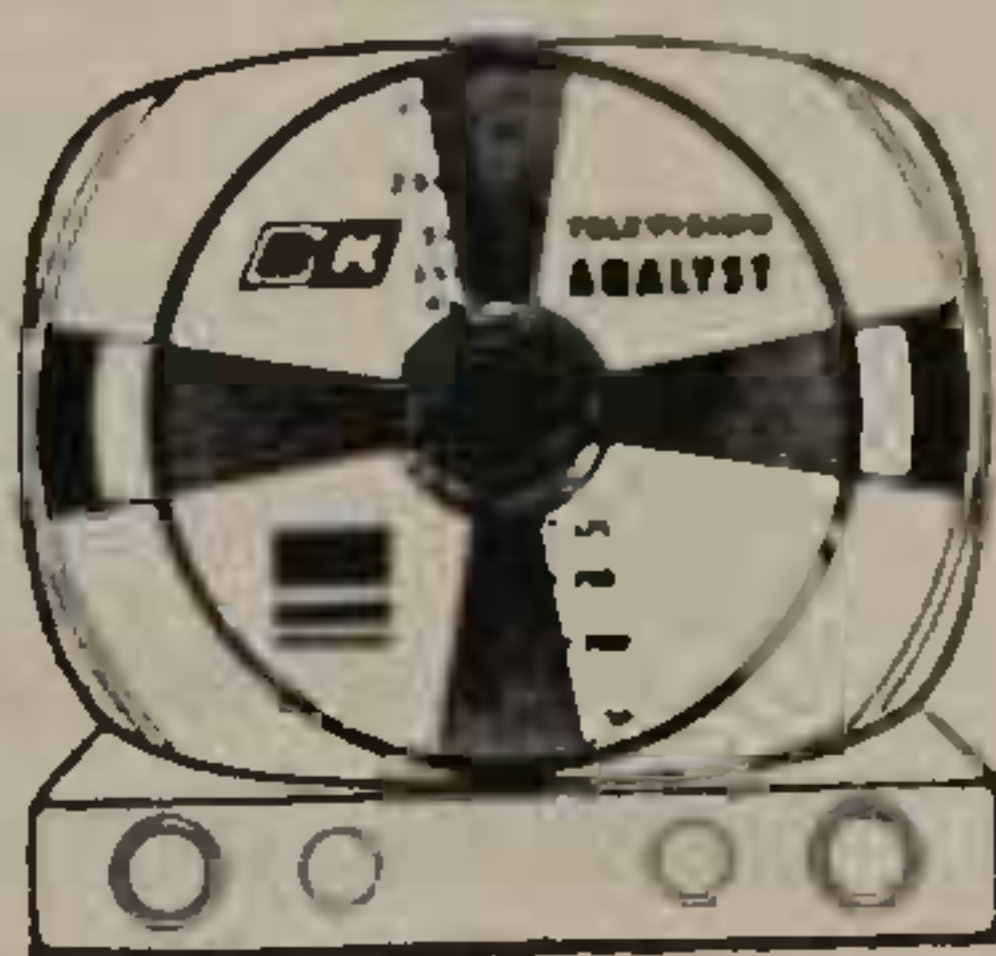
RCA MULTIMETER WV38A(K)

Volt-Ohm-Multimeter has special ranges for transistor applications. You'll do a more professional servicing job with this highly accurate, versatile and stable VOM—a world leader from the world leader in electronics. Never so many valuable features packed into a VOM. Ohms-divider, network fuse-protected. Easy-to-read scales. Extra-large $5\frac{1}{4}$ inch screen. Polarity reversal switch. Improved frequency response. Full-wave bridge rectifier. Less circuit loading. Standard ranges. PLUS—modern styling—it's an instrument you'll be proud to show off in home or shop. New handle clips accommodate probes and test leads for extra carrying convenience. Extra 1-volt and 0.25 volt (25 Omv) dc ranges for servicing transistor equipment.



B & K TV ANALYST

Tests each stage separately and you watch the results on the TV set itself. Unique, point-to-point signal-injection technique makes TV trouble shooting quick, direct, easier and more profitable. With the remarkable B & K Model 1075 TELEVISION ANALYST, you can accurately isolate any faulty stage and quickly diagnose any TV troubles. No external scope is needed. By use of the generated test pattern you can actually see the resultant condition directly on the picture tube of the television set itself. You can easily trouble shoot and signal trace any stage throughout the video, audio, r.f., i.f., sync. and sweep sections of black and white and colour television sets. Model 1075 is supplied complete with standard test pattern, white dot white line crosshatch and colour bar pattern slide transparencies and one clear acetate. Complete with cables.



PRICE LIST

TYPE No.	DESCRIPTION	PRICE
WO-33 (K)	3" Oscilloscope kit	£49
WO-33	3" Oscilloscope wired	£69
WO-91a	5" Cathode-Ray Oscilloscope	£115
B & K	Analyst	£150
TF1104/1	Marconi TV Sweep Generator	£198
WV-77e	Junior Volttohyst	£25
WV-77e(K)	Junior Volttohyst Kit	£19.15
WV-87b	Master Volttohyst	£63
WV-98a	Senior Volttohyst 230v.	£35.10
WV-38a(K)	Multimeter kit	£19.10
WV-38a	Multimeter wired	£22
R.C.A. ACCESSORIES		
WG-206	Probe	£3. 3
WG-216b	Low Capacitance Probe	£3.18
WG-220	Direct Probe & Cable	£2. 6
WG-264	Crystal Diode Probe	£4. 9
WG-289	High Voltage Probe and Resistor	£6.18.6
WG-291	Demodulator Probe	£4. 9
WG-293	Low Capacitance Probe	£4. 4
WG-295	Video Marker	£14.18
WG-299c	DC/AC ohms Probe and Cable	£4.17.9
WG-300b	Direct/Low Capacitance Probe and Cable	£7.18
WG-301a	Crystal Diode Probe	£4. 7.9
WG-302a	RF/IF/VF Signal Tracing Probe	£4.19

INSTRUMENTS:

A correct choice of instruments combines efficiency in time of operation with best receiver performance and economy in equipment cost. The correct equipment is also less demanding on the skill of the serviceman. AWA's selection of test equipment is your insurance of efficiency, reliability and economy.

Address all enquiries to
**AMALGAMATED WIRELESS
(AUSTRALASIA) LIMITED**
Auckland Wellington Christchurch
Dunedin

A "NEW KIND OF PHONE" USES INFRARED AS A VOICE-CARRIER

BOSTON, October 10.—A new communication system that uses principles of missile detection and satellite observation to send telephone-like conversations hundreds of yards without wires was introduced here today by Infrared Industries, Inc., Waltham, Mass. It will be marketed as a consumer product through specialty outlets, according to E. Douglas Reddan, president of Infrared Industries.

The Infrared "Infraphone" was demonstrated to a gathering of more than 600 of the country's top infrared scientists and military systems designers attending the fourth annual IRIS (Infrared Information Symposium) meeting sponsored by the Office of Naval Research at the Somerset Hotel in Boston, October 10-12. It uses invisible infrared radiation as the voice carrier.

In operation, the hand-held, self-powered Infraphone, about the size of a home movie camera, is "aimed" at another unit anywhere within its line-of-sight. The invisible beam carries the conversation between the two units. Both phones are identical transmitter-receiver units, and talking and listening may be simultaneous, as with a telephone. The streamlined Infraphone housing has the appearance of a dual-lens reflex camera, in which one "lens" is the infrared source and the other, the infrared receiver. A pistol grip and tubular rifle-like sight facilitate holding and aiming. The unit weighs less than 26 ounces.

"The Infraphone is powered by ordinary flashlight batteries, and can be used anywhere within line-of-sight, indoors or out, day or night," Reddan said. "Because of its optical principle, it can be used to carry on conversations through closed windows or even around corners, using mirrors," Reddan added. Range of operation is hundreds of yards, even in bright sunlight, and clarity of conversation is comparable to telephone.

Infrared Industries, Inc. intends to market the Infraphone through electronic supply houses, sporting goods stores, marine supply outlets, and hobby shops. It will be on sale in a limited number of electronic supply houses within a few weeks and should be available nationally through other retail outlets within a few months. Initially, the price will be about 20 dollars a unit.

The Infraphone has important commercial applications, in addition to its recreational aspects and use as a scientific-educational device for all age groups. Reddan foresees large demand in transportation and construction industries and by public safety workers. Infraphone provides low-cost, two-way communication between moving vehicles and can be used in some instances in place of a ship-to-shore communication sys-

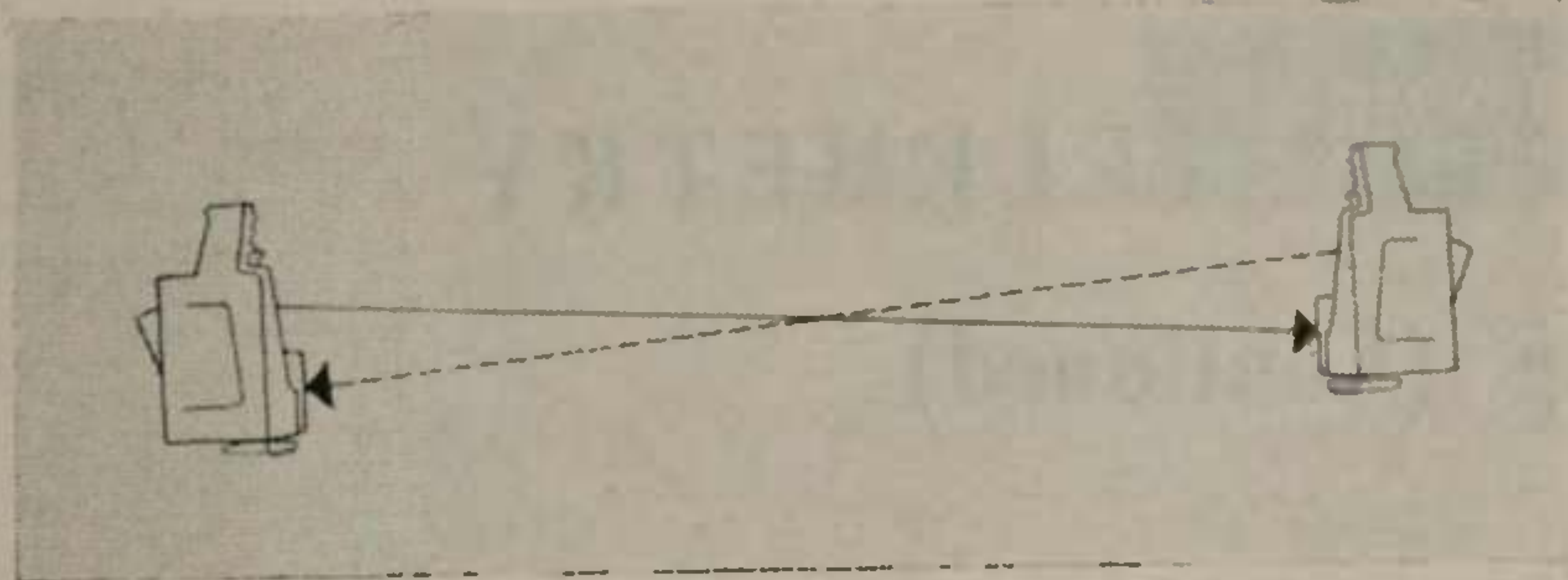


New Infrared Industries, Inc. Infraphone uses invisible infrared ray to send telephone-like conversations hundreds of yards without wires. Instrument is completely "solid state", utilizing a fully-transistorized, printed circuit amplifier and semiconductor infrared sensing element. It operates on ordinary flashlight batteries.

tem. Unlike conventional "Citizens' Band" two-way short range radio, Infraphone is not subject to FCC regulations and does not require a licence to operate. It can be used by surveyors and construction workers in areas where radio "walkie-talkie" creates an explosion hazard. It may also be used by Civil Defence, police, and firemen for traffic and crowd control and for rescue work. Communications based on the infrared principle may also be used in the exploration of outer space.

At the IRIS meeting at which Infraphone was demonstrated, the phone was used to direct questions from the floor to the speaker's platform. Infraphone provides confidential communication in crowds, regardless of noise, and has been suggested for use in securities' and other trading markets.

Infraphone is a completely "solid-state" instrument utilizing a fully-transistorized printed circuit amplifier, without internal wiring. Its "voice detector" is also a tiny semiconductor called a photoconductor, which is



Infrared Industries' Infraphone, called a "new kind of 'phone", sends voice messages hundreds of yards on a beam of invisible infrared radiation. Unit is "aimed" like a camera; operates anywhere in line-of-sight.

sensitive to the infrared radiation of the Infraphone transmitter.

Infrared radiation is the invisible energy given off by any warm or hot object. Like radio and light waves, it is everywhere in nature, and, as used in the Infraphone, it is completely harmless. Infraphone is believed to be the first consumer product to be based on this new technology, used in the Sidewinder missile and Midas and Tiros satellites, and for secret signalling by the army and navy. Infrared Industries, Inc. is the primary supplier of infrared detectors and instrumentation for the Sidewinder and Midas programmes.

"Although the new product is an outgrowth of company research programmes aimed at enlarging its commercial market," Reddan said, "the accomplishment of building a precise, scientific instrument such as the infrared Infraphone for a price anywhere within the reach of the average consumer would be impossible except for military emphasis on advanced research in solid state physics and the demand from the armed services for infrared sensitive photoconductors of military reliability in large volume."

The Infraphone unit is both a transmitter (microphone, voice-to-infrared converter, infrared source and optics) and receiver (optics, infrared-to-voice converter, amplifier and earphone). The Infraphone uses ordinary flashlight batteries for absolute safety. Its transistorized amplifier is ready for instant use without a "warm-up" period. Only the flashlight batteries and bulb ever need replacement. The Infraphone housing is unbreakable high-impact styrene plastic.

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RADIO'S SCATTER SIGNALS

The history of radio transmission is spiced every few years by some new technique of propagating radio waves from one point to another. Each such advance extends the utility and capability of radio to new applications, and broadens the technological frontiers. A relatively new technique for radio transmission is called "tropospheric forward scatter." The troposphere is the name given the airspace surrounding the earth, and reaches a height of 40-50,000 feet.

Radio waves have certain peculiarities, depending on wavelength. They are not all propagated from point to point in the same manner, but travel over entirely different distances depending on wavelength. Very-low-frequency waves with a wavelength of 1000 metres or more are propagated along the earth's surface (ground waves), for distances determined by the emitted power.

Medium-frequency waves with a wavelength of several hundred metres are the most popular broadcast waves. These medium-frequency waves are partly propagated along the earth's surface and partly reflected by the atmosphere and can be received at distances of 300 to 600 miles with, however, a poor reception zone at about 120 miles. Short waves between 80 and 15 metres are received around the entire earth even at very low transmitting powers. These waves are reflected by the upper atmospheric layers in such a manner that they span the greatest distances. These short waves can be beamed in their height and width so that it is possible to obtain a narrow angle of radiation.

As we study waves of even shorter length, we find that very-high-frequency waves between 10 and 1 metre in length behave in a similar fashion to light waves. They do not follow the curvature of the earth but can be received only within the optical range, which is determined by the height of the antenna. Beyond the horizon, vhf waves travel away from the earth straight into space. Ranges up to, say, 120 miles can be obtained, provided the height of the antennae is sufficient. On the other hand, however, it is possible to beam these waves almost like light waves and to obtain very narrow directive beams which strike only the target located in the directional and optical range, and cannot be received outside of this beam. These waves are therefore preferred for the transmission of communications over long distances—for telephony, broadcasting, and television. For these transmissions, relay stations are provided at intervals of, say, 35 to 50 miles on an average.

Where the distance between the transmitter and the receiving station is so great that they cannot be brought by any means into line of sight, and if the nature of the terrain or sea located between the transmitter and the receiving station does not permit the erection of repeater stations, it is still possible to establish a connection by employing these vhf waves in scatter propagation.

(Continued on page 30)

Technology

AN INTRODUCTION TO TELEMETRY

Part 5—Multiplexing (Continued)

Pulse-Amplitude Modulation

As was indicated in last month's installment, it is not necessary to transmit continuously the output of any one transducer, particularly when its output is varying relatively slowly. Instead, samples, or individual measurements can be made at intervals, and the results transmitted, also at intervals. This process is known as *sampling*, and was illustrated in Fig. 3-4, and in Fig. 3-5, the method was illustrated of using a rotating switch or commutator to perform the sampling.

This process, instead of giving a continuously varying voltage, which is what the transducer itself produces, gives a series of pulses, each representing the amplitude of the transducer's output at the instant at which the sample was taken. The resulting train of pulses is then equivalent in all respects to a train which has been modulated in amplitude by the output of the transducer. The scheme is referred to for brevity as pulse-amplitude modulation, or PAM.

Each train of pulses can be caused to modulate its own sub-carrier in any of the standard modulation methods—usually FM. The sub-carriers are then made to simultaneously modulate the R.F. carrier, also by any of the standard methods, but usually by FM. The complete system is then specified as PAM-FM FM.

Standardization of Nomenclature

In talking and writing about systems such as we have been describing, it is usual to employ a set of standard names and definitions, which might well be called the "language" of telemetry. Thus, when the mechanical commutator method is used, one complete revolution of the switch is called a *frame*. The total number of switch contacts determines the maximum possible number of samples per frame. The number of frames completed in one second is, of course, the same thing as the rotational speed of the switch, and is called the *frame rate*. The number of samples per second is called the *commutation rate*, and can obviously be obtained by multiplying the frame rate by the number of samples obtained per frame.

Note that in Fig. 3-5, the switch has 19 contacts, but that it handles only three transducers. Of the 19 contacts, four are not connected to the transducers at all.

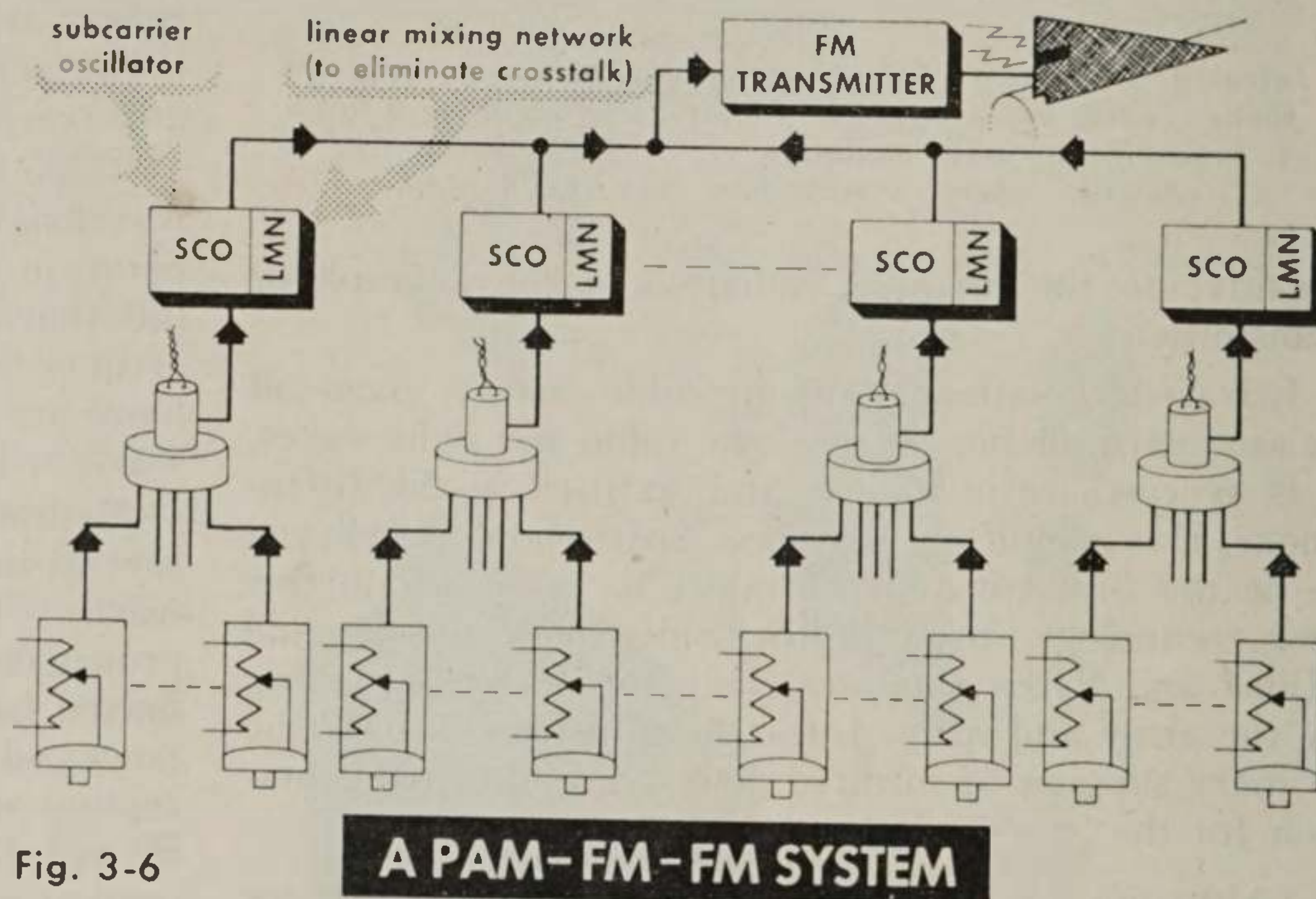


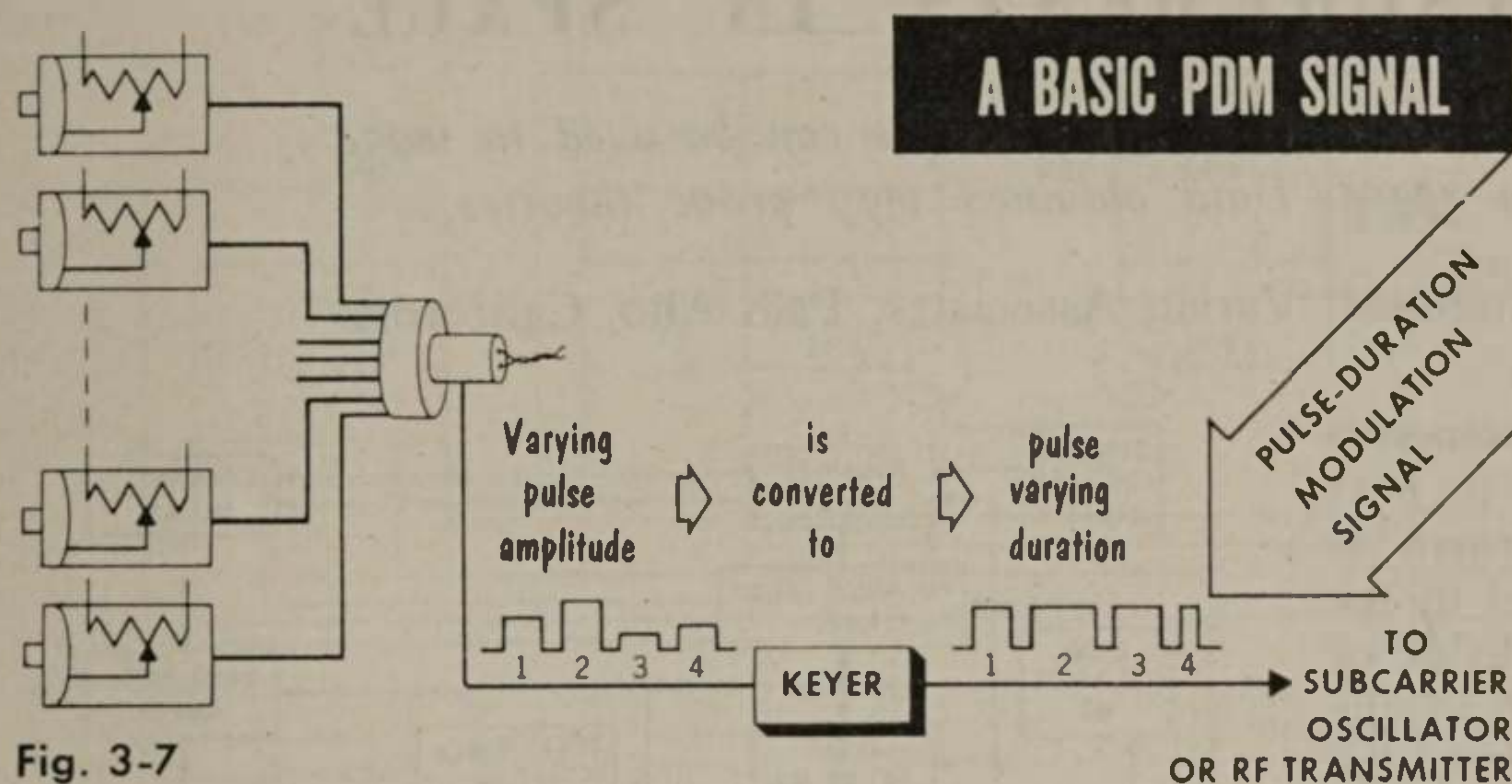
Fig. 3-6

Two are connected to fixed potentials representing the maximum and minimum amplitudes that can be produced by the transducers. These produce pulses which are used at the receiving end as calibrating pulses for the final measurement. Two more of the switch contacts are not used at all, and thus provide a gap in the complete train, which is used for synchronizing purposes at the receiving end. Of the remaining 15 contacts, five each are connected in parallel, so that each transducer is sampled five times in the course of each frame. The inter-connections are made in such a way that during the sampling period, samples are taken from the three transducers in rotation.

If all the transducers were measuring very slowly varying quantities, it would be possible to reduce the sampling rate for each one, so that in the limit, the switch illustrated in Fig. 3-5 would be able to sample fifteen transducers once per frame instead of three, five times per frame.

Pulse Duration Modulation—or PDM

Readers of this series will have noted a tendency for frequency-modulation to be used rather than amplitude-modulation in many of the telemetry processes. The reason for this is not far to seek, and has already been mentioned. When amplitude-modulation is used, signal fading is made difficult to counter in such a way as not to spoil the measurements being made. Similarly, greater care and complication is needed at the transmitting end to ensure that power-supply variations, and other unwanted disturbances do not cause spurious amplitude variations that the receiving ap-



paratus would interpret as erroneous readings. FM and PM do a great deal towards eliminating these difficulties at the source.

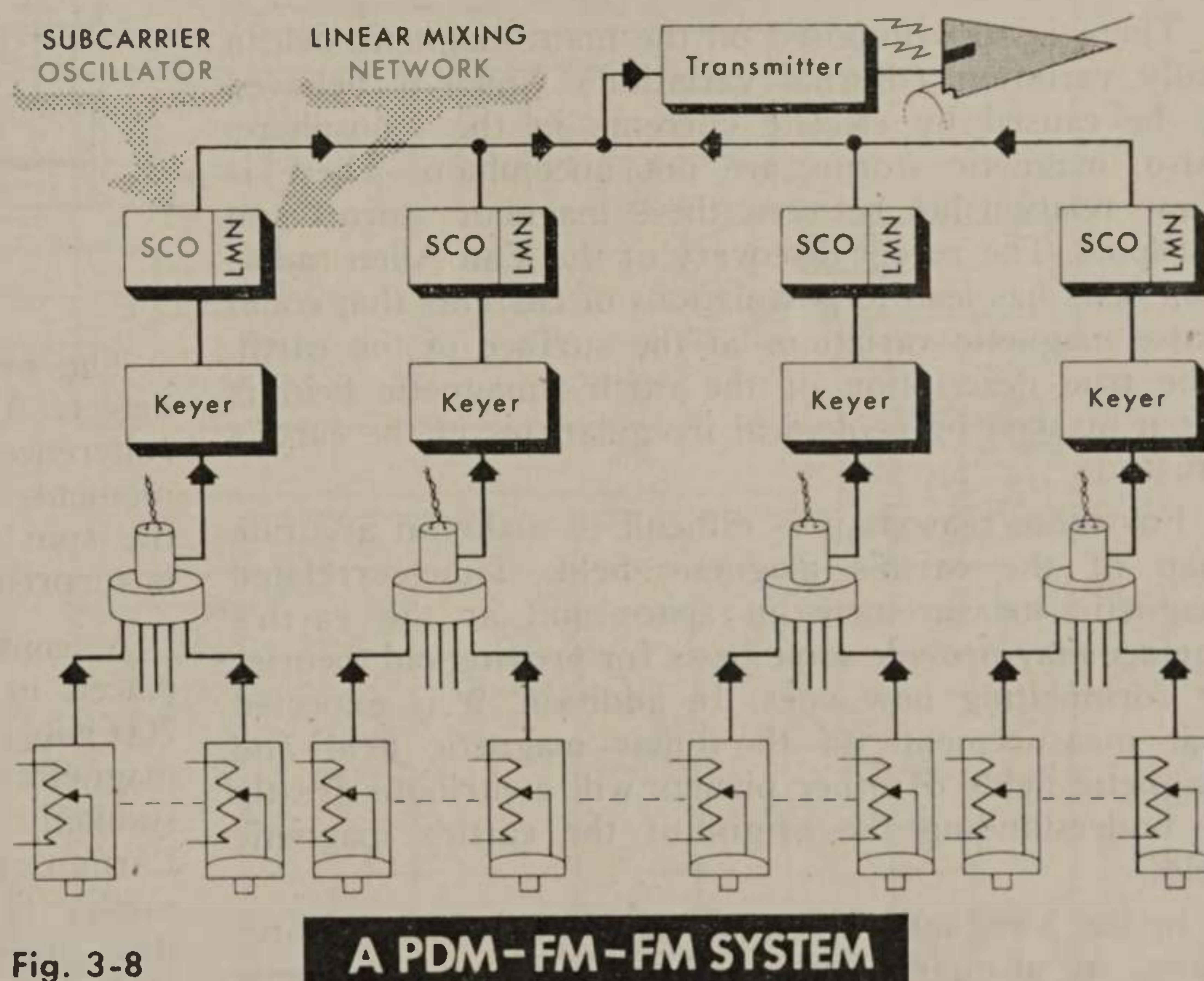
To some extent, the same considerations apply to the intermediate modulating processes, as when the sub-carriers are modulated by the transducers. Consequently, PAM is often converted into other types of pulse modulation before being made to modulate the sub-carrier oscillators. Unfortunately, the easiest method of sampling of the transducers' outputs is to produce amplitude-modulated pulses, as already described, so the first step in processing the data from the transducers is usually this one. However, once a train of amplitude-modulated pulses has been produced, it is a relatively simple matter to alter their character so as to produce trains of pulses whose amplitudes are constant, but which are modulated in some other way. One of the commonest of these is pulse-duration modulation. In this method, all pulses of a train are of the same amplitude, but their duration varies in accordance with the modulation. The change is made in what is known as a keying circuit, or *keyer*, interposed between the commutator, with its PAM signal, and the sub-carrier modulator arrangement. The combination of PDM with FM of the sub-carrier gives an arrangement that is substantially unaffected by all disturbances, such as interference or fading, which can adversely affect the answer when amplitude-modulation is used.

The production of each basic PDM signal is illustrated in Fig. 3-7, and its use in a complete PDM-FM-FM system is shown in Fig. 3-8. Fig. 3-6 shows a complete PAM-FM-FM system for comparison.

Advantages and Disadvantages of Multiplexing

Each type of multiplexing has its own advantages and disadvantages. The important thing, however, is that such a wide variety of overall systems are available, that engineers are able to choose a system for any particular problem that best suits the need of that problem, though the same system may be far from the best to use for a different set of circumstances.

Frequency-division multiplexing on its own can handle more rapidly moving signal information than time multiplexing can, because it enables continuous



monitoring of the information channels to be done. On the other hand, time-division multiplexing can handle a greater number of channels for the same bandwidth. Sometimes, hybrid systems are used, in which some of the sub-carrier channels are directly modulated by fast-changing information, while the slow-moving pieces of information are transmitted as PAM or PDM on a single sub-carrier, or even a small group of sub-carriers. As we shall see later, the engineering of telemetry transmissions in the ways that have been described enables standard receiving and recording systems to be used, regardless of the exact details of a given transmission. This is well worth doing, because telemetry receiving installations are most complex and expensive, so that if each had to be built for a specific purpose, and could not be used for others, the expense of telemetering would be far greater than it already is—which is bad enough!

(To be continued)

MAGNETIC MEASUREMENTS IN SPACE

Proton precessional and optically pumped magnetometers can be used to make magnetic measurements in space. Data obtained may prove theories.

By DOLAN MANSIR, Project Engineer, Varian Associates, Palo Alto, California.

The scientific objectives of sending magnetometers into outer space are of sufficient importance to bear repetition. It is generally agreed that the earth is comparable to a bar magnet, with poles located in the Arctic and Antarctic regions. While the knowledge of the existence of such a magnetic field is one of the oldest physical phenomena known to mankind, the origin and exact nature of the earth's field can only be postulated.

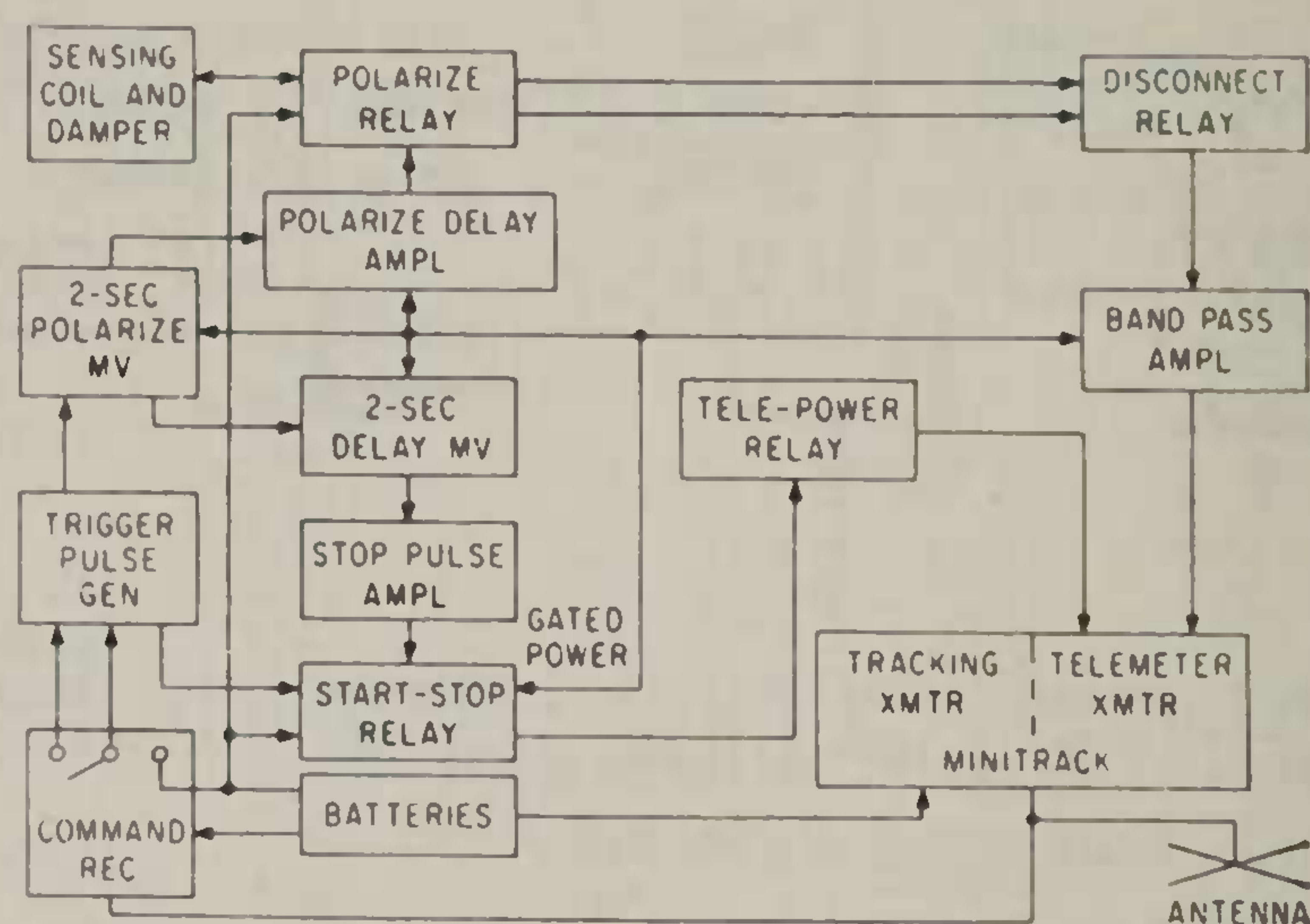
There is superimposed on the main magnetic field a daily variation (diurnal variation) which is believed to be caused by electric currents in the ionosphere. Also, magnetic storms are not uncommon. There is some relationship between these magnetic storms and sunspots. The recent discovery of the Van Allen radiation belts has lead to postulations of currents that could cause magnetic variations at the surface of the earth. The true description of the earth's magnetic field is often masked by geological irregularities in the earth's crust.

For these reasons it is difficult to make an accurate map of the earth's magnetic field. Time-correlated magnetic measurement in space and at the earth's surface may provide some basis for proving old theories or formulating new ones. In addition, it is expected that measurements of the lunar magnetic field and magnetic fields of other planets will contribute greatly to understanding the origin of the earth's magnetic field.

In the Vanguard III satellite, which made measurements at altitudes from 510 to 3,750 km., magnetic field measurements were made by a proton precession magnetometer. Later satellites will use optically pumped alkali vapour magnetometers to make these magnetic measurements.

The proton precession magnetometer was conceived by the late Russell Varian.¹ The nucleus of the hydrogen atom, a proton, is known to have a magnetic moment and spin angular momentum. These two properties determine a physical constant called a gyromagnetic ratio; the equation $w = \gamma p H$ relates frequency (w), gyromagnetic ratio (γp) and magnetic field intensity (H). This frequency is known as the Larmor, precession or nuclear resonance frequency.

The proton has often been likened to a gyroscope. If a spinning gyroscope is acted upon by an external torque it will start to precess. The proton, when acted upon by a torque $M_0 \times H$, produced by the interaction of the magnetic moment of the proton and the environmental magnetic field, will also precess at the Larmor frequency.



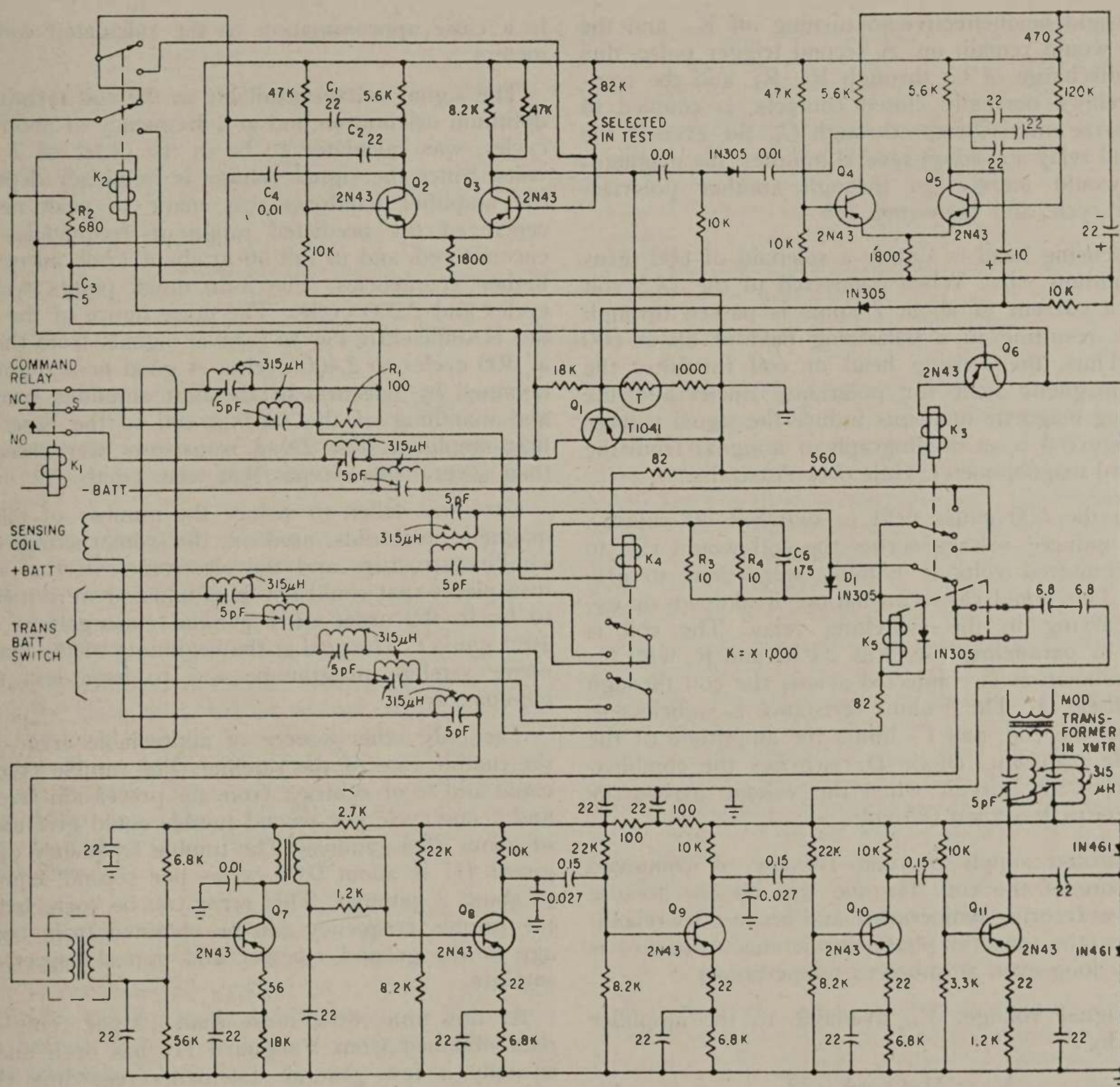
Block diagram of the complete system.

The precessing of a single proton is impossible to detect. A number of protons must precess in phase coherence to have a detectable rotating magnetic moment. The method of obtaining phase coherence in the spin systems of the Vanguard III magnetometer is surprisingly simple.

A container of liquid, abundant in hydrogen, is placed in a relatively strong magnetic field (600 or 700 gauss) that has a direction other than the earth's magnetic field. Now if the strong magnetic field is suddenly removed (in a time short compared to one Larmor period) the nuclei will precess about the earth's field at the Larmor frequency. After a short time, approximately three seconds, the phase coherence is lost and it is necessary to start with the aligning process again. If the aligning or polarizing field is normal to the earth's magnetic field a maximum amplitude signal is obtained. Any other orientation results in decreased signal amplitude, but there is no orientation dependence of the precession frequency.

Since the gyromagnetic ratio is known to an accuracy better than one part in 100,000, it is possible to measure absolute values of magnetic field to this accuracy by measuring the frequency of precession. Relative measurements can be even more accurate—accuracy being limited only by the electronics in the system. The earth's field is nominally 0.5 gauss in the United States, and precession frequencies are in the order of 2,000 cycles.

A block diagram of the magnetometer portion of Vanguard III is shown in Fig. 1. Only the command receiver and tracking transmitter were continuously powered during flight. Magnetic measurements were made when the satellite was within command range of



Circuits of the measuring device.

a Minitrack tracking station, and a simultaneous measurement was made of the magnetic field at ground level.

Turn-on and turn-off are accomplished as shown in Fig. 2. The ground command causes a momentary relay contact closure in the command receiver. This action turns the magnetometer circuits on. During the 0.1 second command relay K_1 is closed, K_2 is energized through the normally open contacts of K_1 and R_1 through to the battery. The plus battery is connected to the magnetometer ground through the contacts of K_2 allowing emitter current to flow in Q_1 holding K_2 energized.

Turn-off is accomplished after one magnetic measurement by coupling a positive pulse to the base of Q_1 , driving it to cut-off and allowing K_2 to drop out.

The second set of contacts on K_2 switch charge capacitors C_1 and C_2 into monostable multivibrator Q_2 and Q_3 (polarize multivibrator, Fig. 1). The capacitors are charged to the battery potential between commands. This stabilizes the multivibrator period. Also, the voltage across the capacitors is such that the multivibrator is forced to trigger to its unstable state immediately upon turn-on.

An additional feature of the turn-on circuit is a safeguard against a temporarily locked-on command receiver relay. From Fig. 1 it is seen that the timing functions of the magnetometer are accomplished by the 2-second polarize multivibrator and the 2-second delay multivibrator. The turn-off pulse is derived by differentiating the negative pulse from the delay multivibrator. If the command receiver relay (K_1 of Fig. 2) failed to open in less than 4 seconds, the turn-off

pulse would be ineffective in turning off K_2 , and the circuits would remain on. A second trigger pulse, due to the discharge of C_3 through R_2 , R_1 , and the command relay's normally closed contacts, is coupled to the polarize multivibrator through C_4 . So, even if the command relay stayed on several minutes, the magnetometer would merely go through another polarize-measure cycle and then turn off.

The sensing head is simply a solenoid of 600 turns of aluminium wire. When connected to the 14.5 volt battery a current of about 7 amps is passed through the coil, resulting in a polarizing field of about 600 gauss. Thus, the sensing head or coil furnishes the strong magnetic field for polarizing nuclei and the precessing magnetic moments induce the signal voltage in it. Figure 3 is an oscillograph of a signal from the Vanguard magnetometer while over Australia.

When the 600 gauss field is switched off rapidly, the self-induced voltage across the coil would rise to several hundred volts if nothing were done to prevent it. This could cause insulation breakdown or excessive arcing in the switching relay. The coil is damped by paralleling (see Fig. 2) R_3 and R_4 with C_5 . This combination is connected across the coil through silicon diode D_1 . The 5 ohms resistance is sufficient to overdamp the coil, and C_5 limits the amplitude of the half-cycle transient. Diode D_1 switches the combination out of the circuit when the voltage across the coil drops to less than 0.3 volt.

The proton supply, normal Hexane, is contained in the core of the coil. Hexane was chosen because of its slow freezing temperature and because its relaxation time (the time for phase incoherence to occur) is relatively long even at sub-zero temperatures.

The signal voltage, V_s , available to the amplifier is given by

$$V_s = M\omega Q_R n A / \sqrt{2}$$

where M is the polarization of the proton supply per unit volume; A , the average area of the coil; ω , the angular precession frequency; n , the number of turns in the receiving coil, and Q_R , the effective Q of the coil.

Since M is proportional to the polarizing field in the sensing head, and thus proportional to the polarizing coil current, it is possible to calculate an optimum coil for a given polarizing power and maximum weight-size specifications. The factor M is also proportional to a parameter, called filling factor, that accounts for the coefficient of coupling between precessing nuclei and the turns in the coil. The filling factor for a solenoid is difficult to calculate; therefore, it was assumed that the proton supply was contained in a sphere in the centre of a solenoid. Using this assumption the optimum ratio of coil radius to proton supply radius was calculated. The satellite magnetometer coil

is a close approximation to the calculated coil parameters.

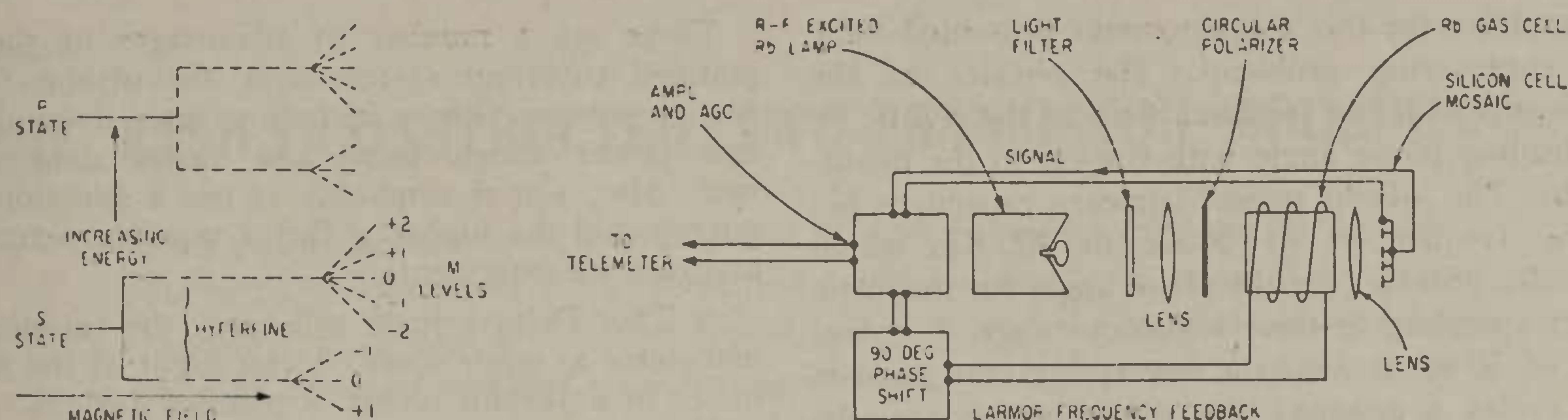
The signal voltage available at the coil terminals, at optimum orientation and at a frequency of about 2,000 cycles, was calculated to be in the order of 2 microvolts. Since the signal voltage is frequency dependent, the amplifier bandpass was made to peak near the centre of the predicted range of frequencies to be encountered, and to fall off at about 12 db an octave at higher frequencies. The 3-db down points were 600 cycles and 2,200 cycles. The noise figure of the amplifier is sufficiently low to recover signals from the noise at 300 cycles to 2,400 cycles. A good noise figure was obtained by selection of the first amplifier transistor, and matching of the sensing coil to the base of the first amplifier. The 2N43 transistors were less noisy than several other types that were tried.

Care was taken to reduce the number of pieces of magnetic materials used in the construction of the satellite structure and the electronics. Errors due to iron pieces that could not be eliminated were measured to be in the order of 1 gamma (one gamma equals 10^{-5} gauss). The goal at the beginning of the magnetometer satellite programme was to have less than 5 gammas error.

The only other source of appreciable error lies in the tumble rate of the satellite. The tumble frequency could add to or subtract from the precession frequency and a one cycle per second tumble could give an error of about 23.5 gammas. The tumble frequency of Vanguard III is about 0.09 cycles per second, equivalent to about 2 gammas. This error can be corrected since the tumble frequency can be obtained from both the agc in the ground receiver and optical aspect in the satellite.

At this time, little more than 10 per cent. of the data obtained from Vanguard III has been analyzed, so only a few general statements regarding the results can be made. In the absence of magnetic storms the fields in space are exceptionally stable. There is a possibility that a magnetometer altimeter could be useful in space vehicles. In general the magnetic storms in space are negative when they are negative at the earth's surface, indicating the main electric current producing a storm is located at some distance above the inner radiation belt. The data indicate that electric shell currents occur at different distances from the earth for different storms and that the distance may vary with time during a given storm. Measured fields range from 0.07 gauss at apogee over South America to 0.375 gauss at perigee.

Although the Vanguard III magnetometer represents a real advance in space magnetic measuring instruments, it has two disadvantages which practically preclude the possibility of eventual flight in a deep space probe. The instrument requires some 200 watt-sec. of power to make a single measurement and the signal amplitude from the device is field dependent. It would



Illustrating the principle of optical pumping.

not be practical to build an instrument to measure fields weaker than about 5,000 gammas because of increased weight and power requirements. The optically pumped alkali vapour magnetometer overcomes these limitations.

The optical pumping process was invented by A. Kastler.² In the magnetometer to be described, the method of observing the pumping process was conceived by H. G. Dehmelt³ of the University of Washington at Seattle.

Optical pumping consists of raising atoms from a low energy state to a higher energy state. Consider the energy level diagram for rubidium in Fig. 4. This shows the three lowest allowed values of the total energy of the atom. These energy levels can be further broken down into several additional energy levels (shown as dashed lines), but for the present consider only the three.

In the absence of external influences, the electrons of the rubidium atoms will be in the unexcited or ground state. To pump electrons to the P or excited state it is necessary to expend energy. Electrons can be excited to the P state by bombardment with electron or ion beams, or by irradiation with light of the correct wavelength. Electrons will not remain in the P state; they fall back immediately into lower energy states. In so doing they emit electromagnetic radiation which accounts for the energy necessary to raise them to the P state. Electrons returning to the ground or S state have equal probability of returning to either of the two Zeeman splittings. Those which end up in the higher energy level are trapped. Those which return to the lowest energy level are available to be pumped again. This is the process by which electrons are raised to a higher level.

In practice, rubidium vapour in a sealed glass cell is irradiated with light from a rubidium spectral lamp. As long as the light has enough intensity to pump faster than the electrons can be depumped by thermal agitation, the gas cell will be more transparent to the rubidium light than it would be if no pumping had taken place.

Transitions between energy levels correspond to definite spectral lines in the electromagnetic spectrum. For instance, transitions between the P states and S

states emit visible wavelength in the order of several thousand megacycles (these transitions are not dependent upon the magnetic field and are being used in atomic clock applications). When the rubidium atoms are placed in a magnetic field, the higher energy level of the S-state hyperfine splitting further splits into five levels called the m levels. Transitions between m levels are magnetic-field dependent and therefore can be used in a magnetometer system.

For Rb 87 the transition between m levels is at the rate of 699,632 cycles per second in a one-gauss field. To cause transitions between m levels the pumped gas cell is irradiated at the Larmor frequency by an electromagnetic field developed in a coil of wire wound around the cell. The transitions cause an intensity modulation of the light beam transmitted through the cell. Modulated light is detected with a mosaic of silicon solar cells and the photoelectric current is amplified. The amplifier drives the field coil at the cell to perpetuate the transition between m levels. The result is an apparatus which continuously oscillates at a frequency which is proportional to the earth's magnetic field.

The complete signal producing apparatus is shown in block diagram Fig. 5. The rubidium spectral lamp transmits light through a filter (to remove unwanted spectral lines), collecting lens, circular polarizer, gas cell and focusing lens to the silicon cell mosaic. The mosaic drives the amplifier, which drives the feedback coil and, in the rocket magnetometer, modulates the telemeter transmitter.

To develop high intensity noise-free low-power light sources it was necessary to develop new lamps. Commercially available lamps were bulky, required high power, and, worst of all, were so noisy that they were of little use.

The present lamps are electrode-less, the discharge being produced by an r-f field at 100 Mc. The tank coil of a 100-Mc oscillator is wound around the lamp bulb. The bulb contains rubidium metal and krypton. The electric field first ignites the krypton. When the temperature in the bulb reaches approximately 100 C, the discharge is through the rubidium vapour. Power consumed in the lamp package is approximately 5 watts. This includes heater power for the subminiature 5718 triodes.

The amplifier for this magnetometer presented some unusual engineering problems. The physics of the system require that the feedback field to the cell be 90 degrees leading phase angle with respect to the modulated light. The silicon mosaic appears capacitive between the frequencies of 50 Kc to 300 Kc, which automatically provides for the phase angle for magnetic fields corresponding to this frequency range. For frequencies of 50 Kc down to a few cycles (the ratio is about 7 cycles a gamma) the silicon mosaic can be made to look resistive, or at least to be resistive up to a few kilocycles and contribute a small phase angle over the rest of the band. For this frequency band it will be necessary to make the amplifier phase shift a precise function of frequency to achieve the 90-degree phase. Because of these phase shift characteristics the present models of magnetometers are being built to cover either the range of 0.5 gauss (350 Kc) to 0.07 gauss (49 Kc) or 0.07 gauss (49 Kc) to 1 gamma (7 cycles). The latter range is suitable for lunar and interplanetary probes where operation at altitudes less than one earth radius is not essential.

There are a number of advantages of the optical pumped rubidium system over the proton free precession system. These include greater dynamic range, less power consumption and faster data sampling rate. Also, signal amplitude is not a function of frequency and the higher g factor possible permits more accurate measurements.

A Thor-Delta vehicle will carry the rubidium magnetometer to outer space. A test flight of the magnetometer in a Javelin rocket is planned for this summer.

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RADIO'S SCATTER SIGNALS

(Continued from page 23)

Scatter Propagation

Scatter propagation permits reliable communication over hundreds of miles at frequencies (wavelengths) that were formerly limited to essentially line-of-sight distances. Tropospheric scatter propagation is particularly adaptable to frequencies above about 100 megacycles per second, and includes the so-called "microwave" frequencies. Its importance is evident when it is realized that station separations of 100 to 500 miles can be used instead of the more usual distances typical of the familiar radio-optical transmission techniques. In remote, uninhabited, and often inaccessible areas of the world, high capacity communications systems can now be built that formerly would have been impracticable.

World-wide radio transmission is as old as radio itself, but such transmissions were basically of small communication capacity—one telephone or one broadcast programme, or a few telegraph channels for each system. On special international circuits, certain techniques permit a number of simultaneous telephone conversations. The new long-distance tropospheric scatter method allows dozens of telephone channels and even television to be transmitted.

If a narrow beam of light is emitted by a searchlight, this beam of light is visible in clear air only

in the direction of its rays but not from the side. However, if the beam of light reaches fog, dust or clouds it will become visible because the water or dust particles refract the rays and scatter them towards all sides. Thus, a portion of the light is visible also from the side.

Electromagnetic waves of very high frequency behave in a similar manner. The scattering effect takes place in the atmosphere due to localized turbulence and variations in moisture distribution. The wave scattering from these causes is very small, but if adequate power is used in narrow beams, the scattered waves are detectable far beyond the horizon, and can be received using high-gain aeriels and receivers.

At an altitude of about 18 miles there are atmospheric layers which are strongly ionized, and it is mainly at these layers that scattering occurs. Not only is the proportion of energy which is scattered very small, but it is returned in a non-uniform manner because the refracting layers in the troposphere are constantly shifting.

One method of overcoming the disadvantage of non-uniform refraction is to employ "diversity reception". Two high-gain receiving antennae are installed at some distance from each other, and used by the same receiver. In this case one of the antennae will always pick up sufficient energy to render signals intelligible, an automatic switching arrangement being used to connect at all times to the receiver that antenna which is receiving the stronger signal.

Transistors**SOME EASILY-CONSTRUCTED TWO-TRANSISTOR BROADCAST SETS**

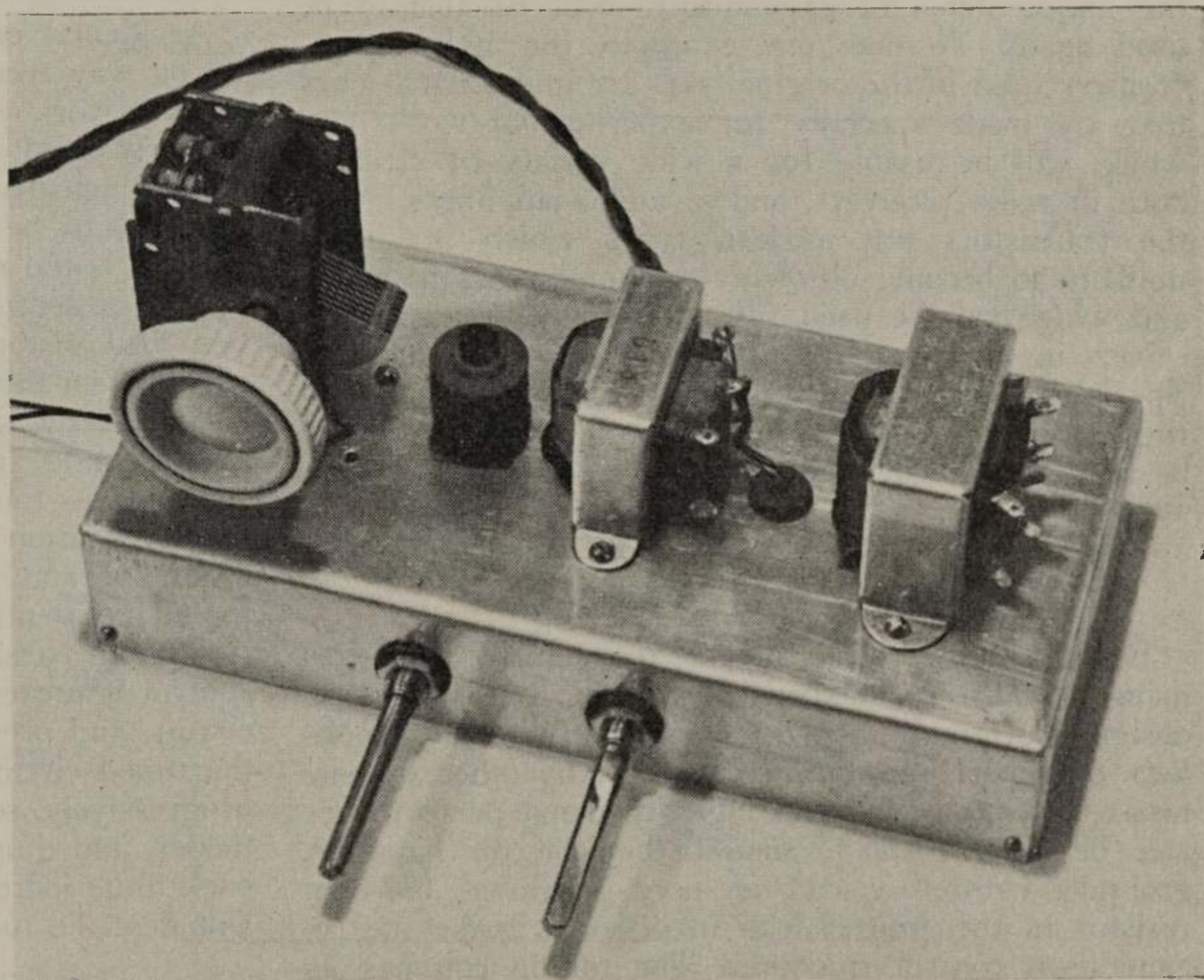
This article describes the construction of two circuits which are ideal for beginners, but whose performance makes them well worth building for permanent use around the home. Each uses a transistor regenerative detector, the second transistor being used as an audio amplifier. One arrangement has enough power output to drive a small loud-speaker, while the other, with much smaller battery consumption, is suitable for headphone listening.

Introduction

In the early days of radio, no one who was interested in building his own sets would have dreamed of starting off with anything more ambitious than a one-valve set. In the first place, parts were expensive or even unobtainable, so that many constructors had to build their own—even down to variable and fixed condensers, and carbon resistors! The former were made by cutting semicircular plates out of brass or aluminium sheet, and turning out spacers on a lathe using brass tubing as the stock. Variable condensers were even made by cutting out the ends of appropriately sized tins, and sliding one inside the other! Grid leak resistors were made by drawing lines on a block of ebonite or on a piece of ground glass with the appropriate grade of pencil lead, and many were the arguments about the correct grade to use, and the dimensions of the line required to give various resistance values! Under these conditions (and many are the stories that could be told of amateur improvisation of parts, and even batteries) when one proudly announced that he had *made* a radio set, he meant it, quite literally, in relation to most of it.

Today, hardly anybody goes in for making his own parts on this kind of scale. The parts are far too cheap to make it worth while. For one thing, and for another, even schoolboys these days seem to have plenty of money to spend on their hobbies. Of course, today's youthful experimenters will never have the thrill out of their first constructional efforts that we old fogies did, partly for reasons such as the above, and partly because radio was such a new thing in those days that the wonder of it had not yet been rubbed off by its having become a commonplace.

But this does not mean that there is not still a great deal of pleasure and good experience to be had by



building one's own radio sets, starting with the most elementary as a means of gaining confidence and manual skill before launching off into something more complex and costly. It is still a thrill, no doubt, to hear the first notes of music from one's first essay in radio construction, and to run through the house crying "It works!" and we hope that these circuits may be instrumental in providing that kind of excitement for many young radio enthusiasts.

Not Only for Beginners

However, we hope that the fact that we have billed these circuits as suitable for beginners will not prevent others from building them. They perform very well as local-station receivers, and the one which drives a speaker, in particular, would make an excellent bedroom set, with enough sensitivity and selectivity to pick up all the local stations from a short outside aerial, and with a quite pleasant-sounding output which is quite enough for the purpose.

Stock Parts Throughout

Since the sets were intended for beginners, as well as others, it was decided to use stock parts throughout, which could be bought "off the shelf" in any parts dealer's, the circuits use audio transformers and R.F. coils that are standard lines of the makers concerned, and should be readily available throughout the country for a long time to come. Furthermore, those builders who are experimentally inclined, and who will want, if possible, to use the same parts in more ambitious circuits later on, will find that the transistors chosen, and the R.F. coils and A.F. transformers—indeed all the major items of expenditure—will be able to be used again. To take one example, the audio transformers used in the original sets are multi-match ones that are made specially for experimental work, and which will be usable for a wide variety of circuits, both in radio receivers, and in audio amplifiers. Also, the transistors are modern types which are most unlikely to become obsolete for many years to come, and which can be used for almost any broadcast receiver, in appropriate positions. The coil, Inductance Specialists Type 250B, is one designed for use in transistor sets as aerial or R.F. coil, and so can also be used again if desired.

The Circuits

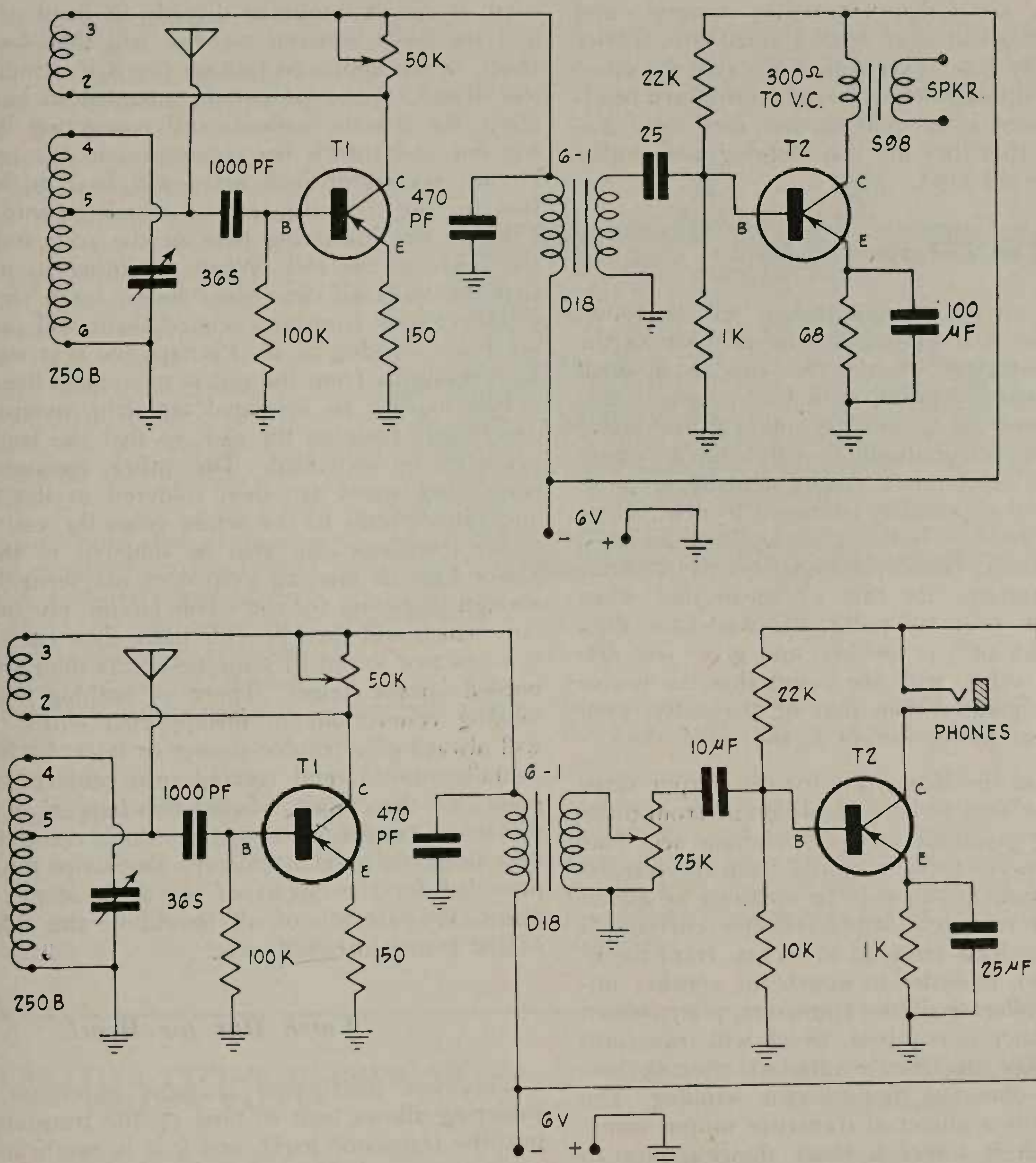
Both circuits start with a regenerative detector, using a relatively inexpensive type of R.F. transistor, designed originally for use in 455 kc/sec. I.F. amplifiers of superheterodyne receivers. Any other transistors with as good or better high-frequency performance can be used instead, should they be on hand. A grounded-emitter circuit is used, with a 150-ohm resistor in the emitter lead in order to make the regeneration control smoother. The tuning coil has its variable condenser of approximately $365 \mu\text{mfd.}$ maximum capacity connected right across it, but the input to the base electrode of the detector transistor is taken from a tap on the coil, which is lead No. 5. The blocking condenser and 100 k. resistor in the base circuit act in much the same way as the corresponding components in the grid circuit of a valve grid-leak detector. With no signal applied, the current drawn from the battery by the detector valve is only a few microamperes, but when a signal comes in, the base-emitter section of the transistor acts as a diode detector, passing current on the negative-going half-cycles of the R.F. input voltage, and being cut off by the positive half-cycles. Since the transistor is without forward bias before the signal is applied, the R.F. causes the collector current to increase, and a moderate signal will bring the current up to about 50 microamperes, which by valve standards is still minute. Connected in the collector circuit is a small winding on the coil, which gives positive feedback, or regeneration. By this we mean that the feedback winding, or tickler,

as it is usually called, feeds back to the tuned circuit some of the radio frequency energy which appears in the collector circuit of the detector. By connecting the tickler winding the right way round, the fed back voltage is given the correct polarity to enable it to add to the strength of the R.F. voltage that is picked up by the aerial. If the tickler is connected the wrong way round, the fed back R.F. opposes the original signal, and the result is a smaller signal than would be there without the feedback. This state of affairs is called *negative feedback*, or *degeneration*. For this reason, it is essential when building the set to ensure that *all* the coil connections are made as in the diagram.

Accidental connection of one of the windings the wrong way round will result in degeneration, and the set will work very poorly, if at all. If regeneration is properly used, it can and does result in greatly increased sensitivity and selectivity in the detector, but in order to be used properly, it must be controlled; if there is too much regeneration, the result is a nasty squeal, present on every station tuned in, together with very bad distortion. If the regeneration is not great enough, sensitivity and selectivity will not be great enough. Now since no two stations are likely to put in the same signal strength in the receiving aerial, some means must be provided of adjusting the degree of regeneration from time to time, as the set is tuned from one station to another. This is the purpose of the 50 k. potentiometer which is connected as a variable resistor in parallel with the tickler winding. When the control is turned fully anti-clockwise, it acts as a short circuit, and prevents any R.F. from being fed back to the tuned circuit. When turned clockwise, the control progressively reduces the degree of shunting on the tickler, and thus allows more and more R.F. to be fed back, thus increasing the amount of regeneration. We will describe its use later on.

In series with the collector of T_1 is the primary winding of an audio transformer, whose job it is to transfer the audio signal developed by the detector to the base of the audio amplifier transistor. At the same time, it steps up the current in the secondary to a suitable value for driving the audio transistor. This process is properly called impedance matching, and must be done where the greatest amplification is wanted from the transistor. The $470 \mu\text{mfd.}$ condenser connected from the transformer primary to earth is an essential component, without which the circuit will not function properly. It acts as a return path to earth for the R.F. current flowing in the tickler winding, and at the same time helps to prevent R.F. from being fed through to the audio amplifier.

The secondary of the audio transformer is connected to the base of the output transistor T_2 . This transistor is biased by the 22 k.-10 k. potential divider so that it draws a steady current from the battery of approximately 1.5 ma. This divider, together with the 1 k. emitter resistor stabilizes the collector current



For both circuits, T₁ can be 2N410 or OC45, T₂ can be 2N408 or OC72 for speaker set and 2N406 or OC71 for 'phone set.

against changes due to varying temperature conditions, and also takes care of the differing characteristics of the transistors themselves. This is shown by the fact that it is possible to insert almost any transistor in the circuit with only very minor changes in the D.C. collector current. This fact in turn means that the circuit will work properly whatever transistor is used, the only differences being changes in gain, depending on the exact characteristics of the transistor chosen. In this respect, transistor biasing circuits of this particular kind differ markedly from those used with valves, where the values of the resistors have to be changed, sometimes quite a lot, if different valve types are to be used. Most small transistors work well with collector currents of from 1 ma. to 2 ma., and give their best amplification under these conditions. Simpler biasing circuits employing only one resistor, could be

used, but if this were done different values would have to be specified for every transistor type, while the normal spread of characteristics in transistors of the same type would probably necessitate changing the value of the bias resistor if a different one were placed in circuit.

The headphones are connected directly in the collector circuit of the second transistor, which gives enough amplification to produce an uncomfortable level of sound if the volume control is fully advanced on a strong signal. Almost any type of headphone can be successfully used with this circuit. The single hearing-aid type of ear-piece is very sensitive and compact, and gives good sound quality—especially the "stethophone" type, which uses a hearing-aid driver unit, connected to two tubes, which go into the ears, and look for all the world like a doctor's stethoscope

ear-piece. These are rather expensive, however, and the same sort of driver unit, with a small soft rubber ear plug is equally good, except that it leaves the other ear free to pick up extraneous sounds. Ordinary headphones can be used with equal success, their only disadvantage being that they are considerably more bulky than the hearing-aid kind.

The Loudspeaker Set

If the second circuit is examined, it will be found identical with the first one up to the primary of the first audio transformer. T_2 in this case is a small power-type transistor, operating in Class A, and able to provide a power of about 100 milliwatts to drive the speaker. This, surprisingly to some, is enough to produce quite a loud signal, and is actually quite as much as many valve portable sets used to give before the days of transistor portable sets. In practice it turns out to be more, because a transistor has a better overload characteristic. By this we mean that when driven up to the overload point, the transistor does not seem to "pack up" so quickly, and gives less distortion than the valve, with the result that the usable power output is greater than that of the valve, even when the nominal power output is the same.

The resistors in the bias chain for the output valve in this set will be seen to be quite different from those in corresponding positions in the headphone set. This is because the power output required from the transistor driving the speaker can only be obtained by allowing it to draw a relatively heavy collector current. It is biased so as to draw from 15 to 16 ma. from the 6-volt battery. Also, in order to match the speaker impedance to the collector of the transistor, a step-down speaker transformer is required, which will transform the 3-ohm speaker impedance into an effective impedance of 300 ohms in the collector winding. The transformer used is a universal transistor output transformer, and with it comes a chart showing how to connect the six secondary terminals in order to get the right matching ratio. If a speaker of any other impedance is used, the chart will also tell the builder the right connections to make for it.

Building the Sets

Both sets are built on a small aluminium chassis, using the same building methods as are used for bigger and more complicated sets. In our own case, a fairly large tuning condenser of the right capacity was available, and so was used. This takes up considerable space above the chassis, but if one of the small modern variable condensers specially made for transistor circuits is used instead (and there is no reason why it should not be) it can be mounted on the front edge of the chassis and will be completely hidden under the chassis. If this sort of tuning condenser is

used, it can be mounted directly in front of the coil, and the leads between the two will then be nice and short, in the approved fashion for R.F. winding. Since the detector pot-type coil is intended to be mounted above the chassis, with its stiff connecting leads coming out underneath for connection to the rest of the circuit, six eighth-inch holes will have to be drilled, two for the mounting screws which go into threaded holes in the insulating base of the coil, and five for the leads to the coil. When mounting it, make sure that the leads all clear their holes, for a short-circuit to the chassis from any one of them will prevent the set from working at all. Perhaps the best way to deal with the leads from the coil is to connect them directly to the lugs of an insulated tag-strip, mounted under the chassis close to the coil, so that the leads do not need to be extended. The other components and connecting wires are then soldered to the tag strip, and not directly to the wires from the coil. The detector transistor can also be soldered to these same solder lugs. If one tag-strip does not seem to provide enough tie-points for the whole circuit, put in a second one, which will then provide more than enough. Make it a practice to put in some tie-points than are actually needed—never fewer. There is nothing worse than making connections to unsupported wires, for these will always give trouble sooner or later, by being accidentally moved, and coming into contact with other points on the circuit. Should this happen, it can have disastrous results, because it can easily cause the demise of a perfectly good transistor! Tag-strips must also be provided for the circuit of the audio stage, and here again, the last job of all should be the soldering in of the transistor itself.

Watch Out for Heat!

This last instruction is most important, because soldering allows heat to flow up the transistor's leads into the transistor itself, and if it is overheated, it can easily be ruined. Thus, it is very bad practice to solder a transistor to its tag-strip, and then continue soldering the other components to the same tags. For the same reason, the leads of the transistor should not be cut off shorter than about half an inch unless they are to be plugged into sockets, and each lead should be gripped as close to the end as possible with a pair of pliers while soldering is in progress. The pliers help to conduct heat away from the transistor's leads, and prevent it from getting inside the transistor itself.

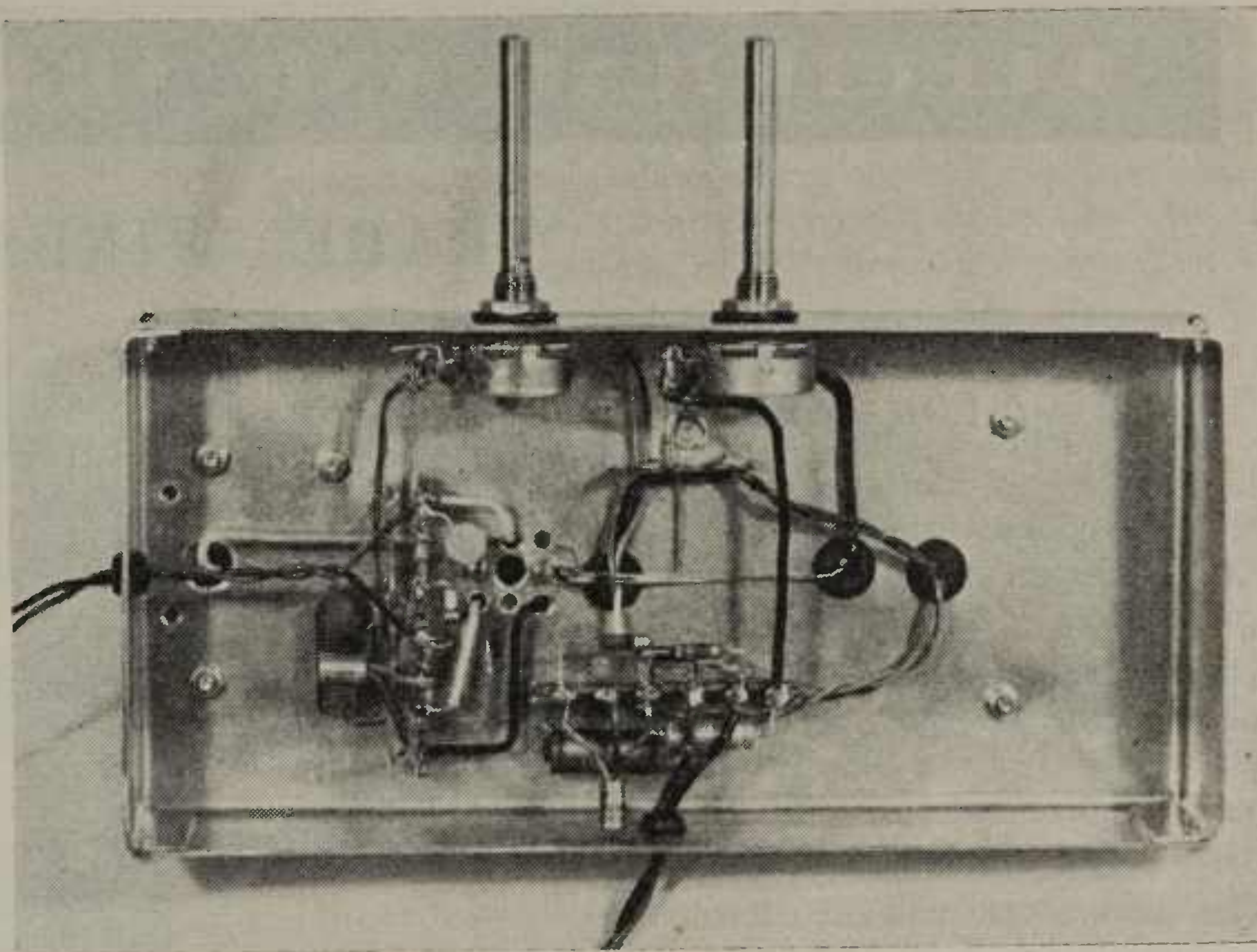
Mounting the Other Components

The inter-stage transformer can be mounted above the chassis about an inch from the R.F. coil, and holes made in the chassis on either side of it to allow the leads to be taken down under the chassis. The primary of the transformer (and this applies also to

the output transformer when it is used) is provided with fairly long leads, but the secondary windings are terminated on six solder lugs on the side of the transformer, and after the appropriate inter-connections have been made, leads must be soldered to these, and taken through the chassis holes, which should be prevented from cutting the wire by lining them with a rubber grommet. The output transformer can be mounted close to the inter-stage transformer, and the nut and bolt used for one of its mounting feet can be used underneath for holding the tag-strip referred to above.

The regeneration and volume controls are mounted on the front of the chassis, with the regeneration control close to the coil, and the volume control mid-way between the transformers. For the 'phone set, the 'phone jack can be mounted to the right of the volume control.

The circuit diagrams do not show a switch for on/off purposes, in the negative battery lead. This can be mounted in any convenient position, or, if a volume or regeneration control with a switch mounted on it can be obtained, this can be used as the on/off switch. The only difficulty here is that low-valued controls, such as 50 k. are rather difficult to find fitted



with switches, which are available readily enough on the higher-valued potentiometers.

The current drain of the 'phone set is so small that it would be quite reasonable to leave out the switch altogether, and leave the battery permanently on, especially if larger sizes in cells are used. However, the heavier drain of the speaker set makes a switch a necessity if maximum life is to be obtained from the batteries.

ALTERNATIVE TYPE-NUMBERING OF PHILIPS VALVES

(Continued from page 36)

be marked, where applicable, with dual designations, such as ECC83/12AX7 in all cases where there is direct equivalence between the Philips and American types. This is expected to be a considerable advantage for retailers, because it will relieve them of the necessity of stocking the two types, which differ only in their numbering and not in their characteristics. Since there is now quite a large number of directly equivalent European and American valve types, the saving of shelf space and duplication in ordering should be considerable, especially to those firms doing a brisk trade in replacement valves. In some cases, of course, the customer will probably have to be persuaded that the types are exact equivalents (which they are) and not just "near-enough" replacements!

E.D.A.C. HANDLING "ROBAND" POWER SUPPLIES

The Electronic Development and Application Co. Ltd. announce that they are now handling the comprehensive range of power supplies made in England by Roband Electronics Ltd. These are transistorized regulated supplies and their makers claim a number of outstanding advantages for them over their valve counterparts. Semi-conductor rectifiers and "C" core transformers result in very small temperature rise, and special protection is incorporated against voltage and current surges, and against overloads which might damage the transistors. The supplies are available fully enclosed, or as open-chassis units suitable for incorporation in built-up equipment.

EDAC informs us that illustrated catalogue sheets and full technical data are available on request.

ELECTRICAL AND TRADE SECTION

TRADE WINDS

CANADIAN GENERAL ELECTRIC GENERATORS FOR BENMORE

The National Electrical & Engineering Co. Ltd. have received an order from the New Zealand Electricity Department for two generators for the Benmore project.

These machines, each rated at 112,500 KVA, 0.8 power factor lagging 90,000 KW., 166.7 r.p.m., 16,000 volts 3-phase 50 cycles, will be built in the Peterborough, Ontario, plant of Canadian General Electric Company Ltd.

The generators will be driven by hydraulic turbines manufactured by Dominion Engineering Ltd.

The ultimate capacity of Benmore will be six equipments of the above rating. The Benmore generators are the largest, both in electrical rating and physical size, yet ordered for New Zealand. The highest rated hitherto order were the 45,000 KVA. machines for Roxburgh, and also supplied by the National Electrical and Engineering Company Ltd.

It will be recalled that National Electric were only recently awarded the contract for the three 33.333 KVA. generators for Arititia, and these too will be made by Canadian General Electric.

* * * *

B. R. HOMERSHAM LTD. INTRODUCE "LOCTITE" TO NEW ZEALAND

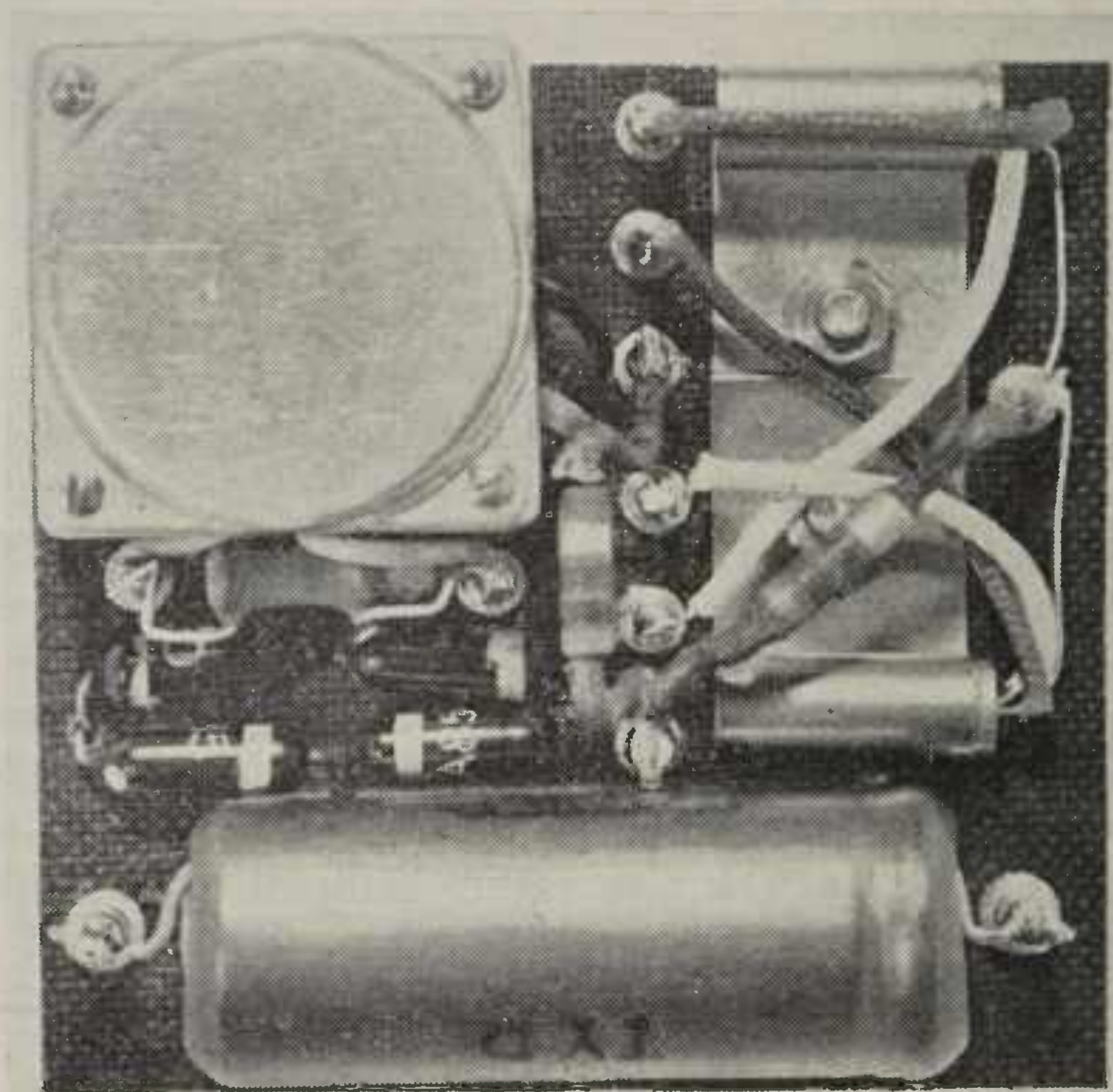
"Loctite" is an American invention, being an extremely tough plastic which polymerises in the absence of air to form a locking medium, in order to prevent relative movement between adjacent components. It is used to lock up all manner of screws, nuts, threaded joints from the largest to the smallest—from opicians' spectacle screws to crawler track bolts. It is particularly suited to vacuum or pressure sealing of pneumatic and hydraulic systems. Loctite requires no pre-mixing, has an unlimited shelf life, and comes in a ready-to-use squeeze container. Locking powers can be varied over a range of about 15:1 by correct choice of grade. If the wrong grade is used, it can be broken by heat. Loose bearings which occur in motors, automotive equipment and other engineering products are another important application.

B. R. Homersham Ltd. write that as sole New Zealand agents, they will shortly be appointing distributors in all the main trades, but in the meantime, it

is available only from their branches in Auckland, Wellington, and Christchurch. This new material is expected to find its way into most branches of engineering, and into every home as well!

* * * *

"R. & E." ELECTRONIC B BATTERY



Readers have asked us to publish a photograph of the D.C. converter described under the above title in our November issue.

The above photograph is somewhat larger than life-size, as the actual unit is approximately a quarter of an inch smaller in both width and length than the photograph shows. The largest item is the smoothing condenser, shown at the bottom of the picture, while the OC72 transistors, with their heat-sink mountings are in the top right-hand corner. Between the pot core and the smoothing condenser are the four OA85 rectifiers, only two of which are visible.

* * *

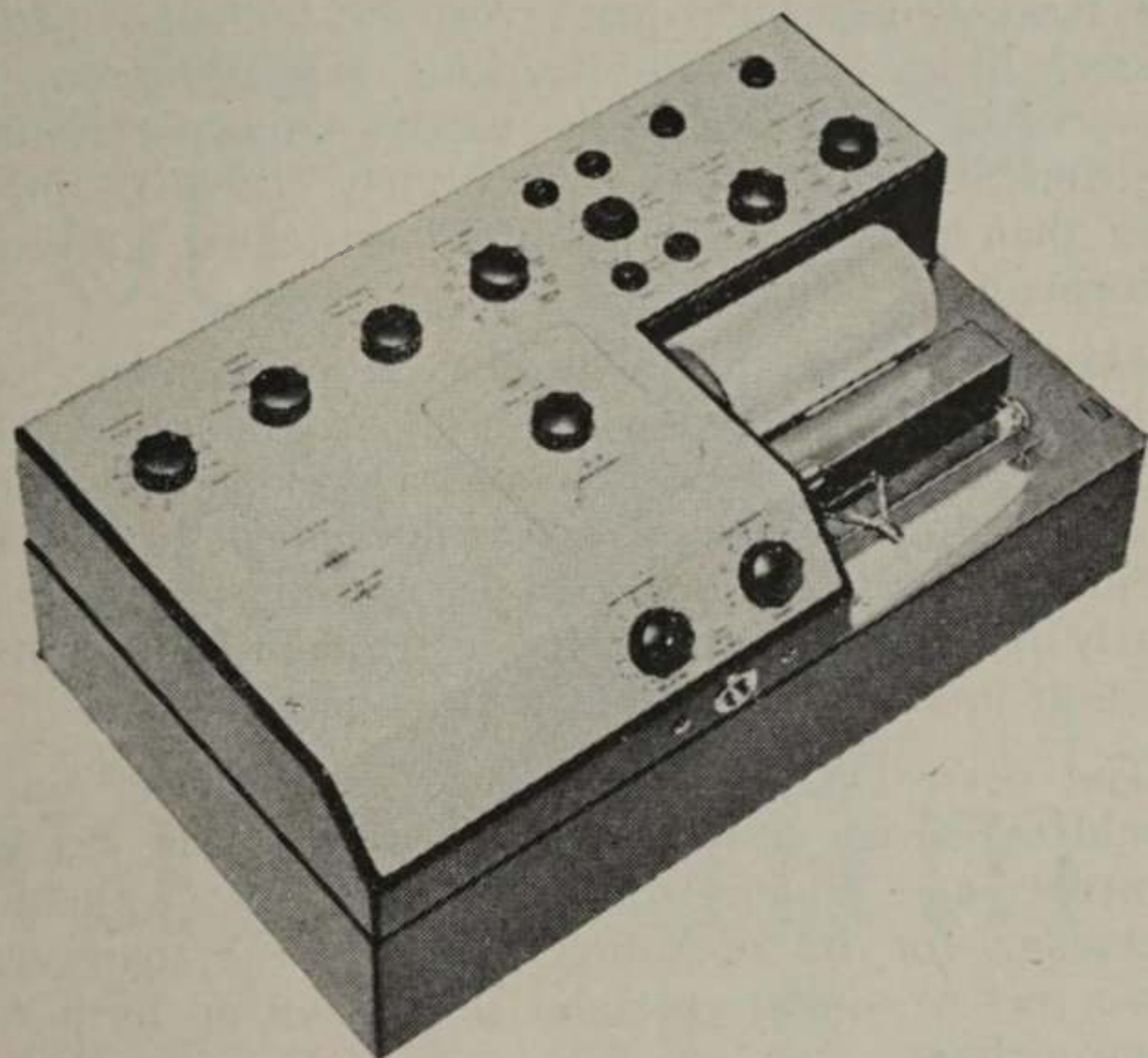
ALTERNATIVE TYPE-NUMBERING OF PHILIPS VALVES

Philips Electrical Industries of New Zealand Ltd. announce that Philips valves sold in New Zealand will

(Continued on page 35)

LATEST OVERSEAS DEVELOPMENTS

NEW HIGH-SPEED LEVEL RECORDER



Brüel & Kjaer, by the recent introduction of the Level Recorder Type 2305, have set a new standard in this field of instrumentation. Although basically designed on their Type 2304, which has been well-proven as a quality instrument over the past ten years, the new Type 2305 has had several outstanding features incorporated.

The Type 2305 covers the frequency range 10-200,000 c/s within 0.2 db as well as D.C. and will record any voltage level between 5 mV and 100 volts. A foremost innovation has been the inclusion of *three full-wave rectifier circuits enabling true R.M.S., average and peak detection of the input signal* to be obtained whereas the Type 2304 only gives half-wave peak rectification. Another new feature is the incorporation of two writing widths of 100 mm and 50 mm.

By an increase in the number of lamellae on the potentiometer from 108 to 216 a higher resolving power has also been achieved, and from the nine writing speeds of the Type 2304 the number has been enlarged to fifteen covering the two paper widths with speeds from 2 mm/sec. to 2000 mm/sec. The inclusion of a simple-to-use arrangement allows the direct recording of polar diagrams without the necessity of additional equipment.

In conjunction with the electronic, new mechanical features have also kept in step. When connected to other B. & K. instruments the motor is used to drive the tuning mechanism of the respective oscillator or analyzer, thus enabling synchronized speeds of pre-printed frequency calibrated recording paper and the tuning mechanism to be automatically obtained. A friction clutch facilitates the synchronous commencement of the paper in relation to the tuning mechanism.

When the Type 2305 is to be used for production control or in the laboratory a method has been incorporated so that a Single Chart can be run off, and where it is necessary to record several curves on the same chart, the motor can be reversed and a Single Chart run recommenced without losing synchronization.

A mechanical arrangement enables the pen to be lifted from the paper and a marking button will "event mark" the outer rim of the paper with a dip when pressed. These latter features, along with the paper drive motor clutch, can be remotely controlled. Within the Type 2305 there are two built-in switches, one to control the electro-mechanical drive of the B. & K. Spectrometer Type 2111 and the other to give successive switching of two different inputs into a single output, when this is required.

For further information the reader is invited to contact either A/S Brüel & Kjaer, Naerum, Denmark, or Electronic Navigation Ltd., Nagel House, Court House Lane, Auckland, C.1.

* * *

NEW SATELLITE TRACKING DEVICE DEVELOPED BY RAYTHEON

JUPITER, Fla., October 13.—A new top-hat shaped device that gives instantaneous and continuous data on satellite tumbling—previously unavailable tracking information—was unveiled here today by Raytheon Company.

This data is essential for design of systems to counteract tumbling, an aspect of space travel that could spell tragedy for astronauts. In manned space vehicles and capsules, for example, this violent punishment would cause blackout, sickness, and consequent loss of control.

In communications satellites, prevention of tumbling is desirable to keep antennas pointed earthward for reliable and unbroken transmission of signals.

The newly developed portable instrument was demonstrated for tracking station chiefs of the Smithsonian Astrophysical Observatory's world-wide satellite tracking network, gathered here for the first week of an annual three-week conference.

Locking on to the light reflected by Echo I, the electronic-optical unit tracks continuously and records changes in light reflection—the key to accurate measurement of tumbling.

The Raytheon device records plotting information immediately, such as course, bearing, and altitude. This instantly available data complements existing photographic methods which give high accuracy plotting about 45 minutes after satellites are photographed.

(Concluded on page 38)

MIXED-BASS STEREO

(Continued from page 16)

Disadvantages of Mixed-Bass Stereo

It is obvious that a mixed-bass stereo system cannot duplicate exactly the performance of two identical full-range reproducing systems. It is a well-known fact that doubling the effective radiating area of a low-register loudspeaker by adding a second identical unit will increase the total bass output, and can moreover extend the effective bass range by up to one-half octave.

The full advantage of this effect is not realized in stereo systems employing two full-range loudspeaker systems due to the separation of the two reproducers, but some additional bass is realized. This is not so of course in a mixed-bass system. It is left for the reader to judge whether this is really a disadvantage, but let it be pointed out that in systems using two full-range loudspeaker systems, tweeter level controls are frequently incorporated to restore balance whilst retaining the additional bass range.

There is also the largely-unexplained tendency noticed when reproducing stereo through two-woofer systems towards a further extension of bass range. This further extension, peculiar to stereo, is over and above that mentioned above. This effect also is lost when using only one bass reproducer. The listener also loses the tendency for bass delivered from two separate loudspeakers to smooth out the "peaky" response which can result from standing waves in the listening room.

Summary

Mixed-bass stereo, whilst losing some quality in reproduction, provides acceptable stereo at lower cost, not only in loudspeakers but possibly also in turntable equipment. The savings can be significant, not only in new systems, but in conversion of existing monophonic systems. The disadvantages claimed seem to be largely subjective, and are to some extent dependent on unpredictable factors, such as room acoustics, which affect all home music systems.

NEW SATELLITE TRACKING DEVICE

(Continued from page 37)

Satellite-tracking radars, unlike the new instrument, require large antennas to transmit and receive signals. Raytheon's satellite tracker has no bulky transmitter. Its receiver is a six-inch mirror. Once its detector locks on to the target, electronic impulses trigger gyro and hydraulic servo units that allow the tracking head to move freely, like a ball in a socket, recording every movement and change in light reflected by the satellite.

A further advantage of optical tracking is that light waves, because of their minute length, permit greater

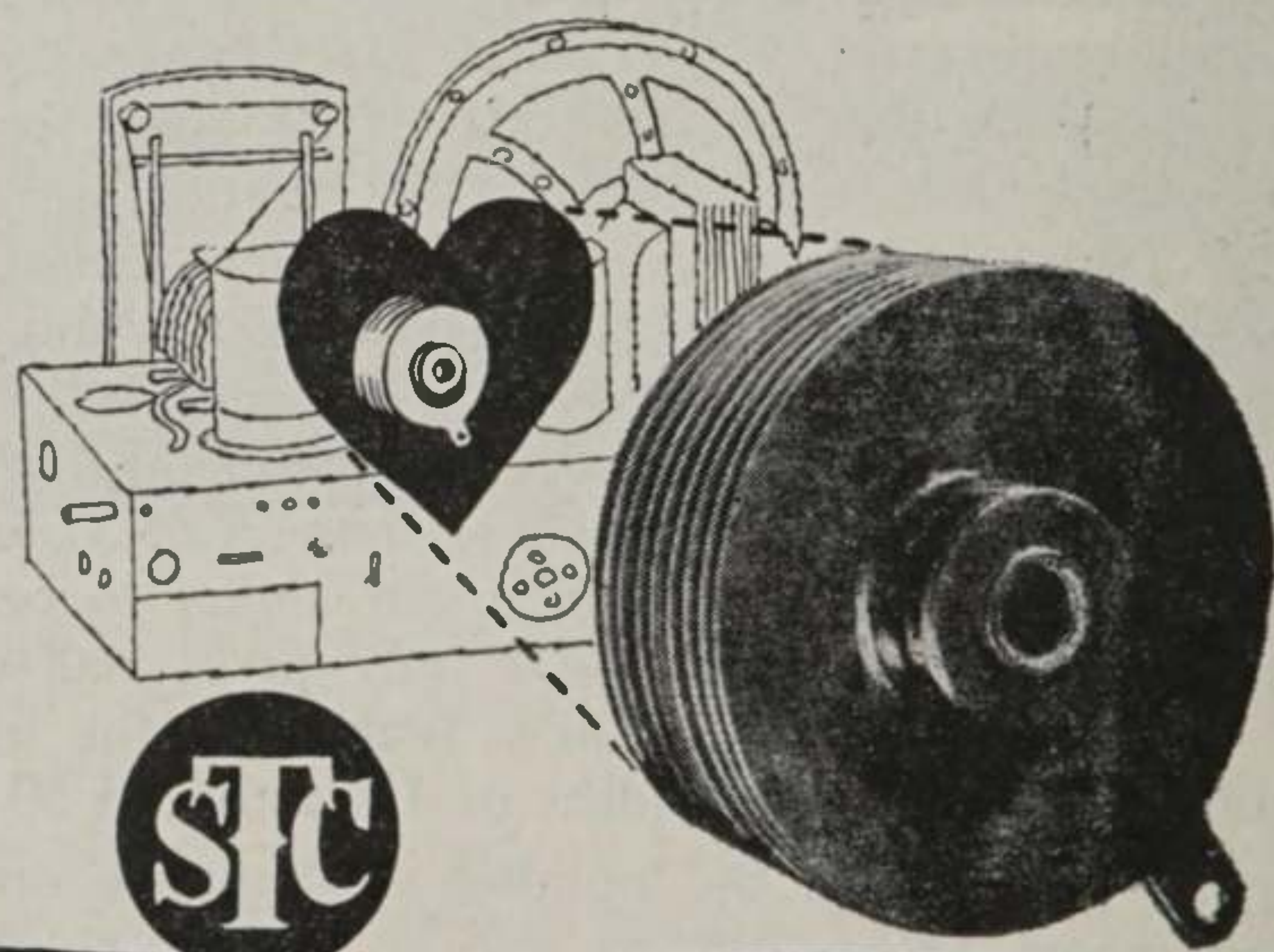
accuracy in pinpointing location than the longer radar waves.

This accuracy, according to Raytheon engineer Wesley Haywood, Jr., leader of the team that developed the tracker, may help make recovery of space probes easier. By automatically tracking capsules from the moment of re-entry into the earth's atmosphere, these instruments could more accurately predict impact area than present methods using estimated trajectory information.

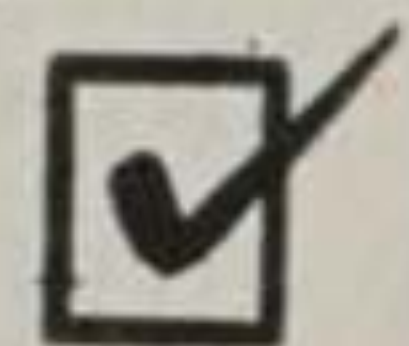
Haywood bases his estimates on performance and accuracy tests of the tracker at Raytheon's Missile Systems Division Research and Development Centre at Bedford, Mass., where it was developed. In tracking Echo I, travelling more than 18,000 miles an hour at nearly 1000 mile altitudes, the instrument has recorded location immediately within a fraction of a mile.

The device can be flown over cloud cover which would otherwise restrict optical tracking. The tracker, recorder, and all electronic and hydraulic equipment necessary for its operation take up less than eight cubic feet of space, or about that taken up by a seat in an airliner.

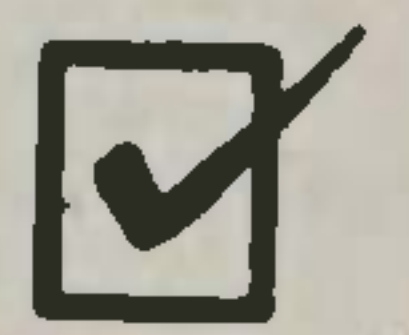
The HEART of the Portable



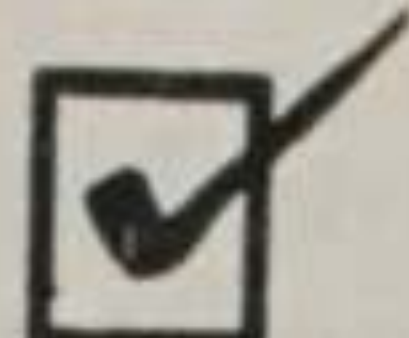
MINIATURE RADIO RECTIFIER



★ Precision-built



★ Peak performance



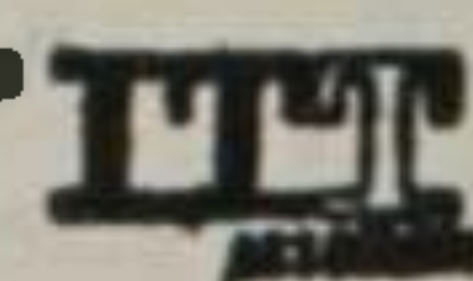
★ Practically unbreakable

Servicing Portables? Replace with STC Miniature Radio Rectifiers. The world's standard first choice among progressive servicemen.

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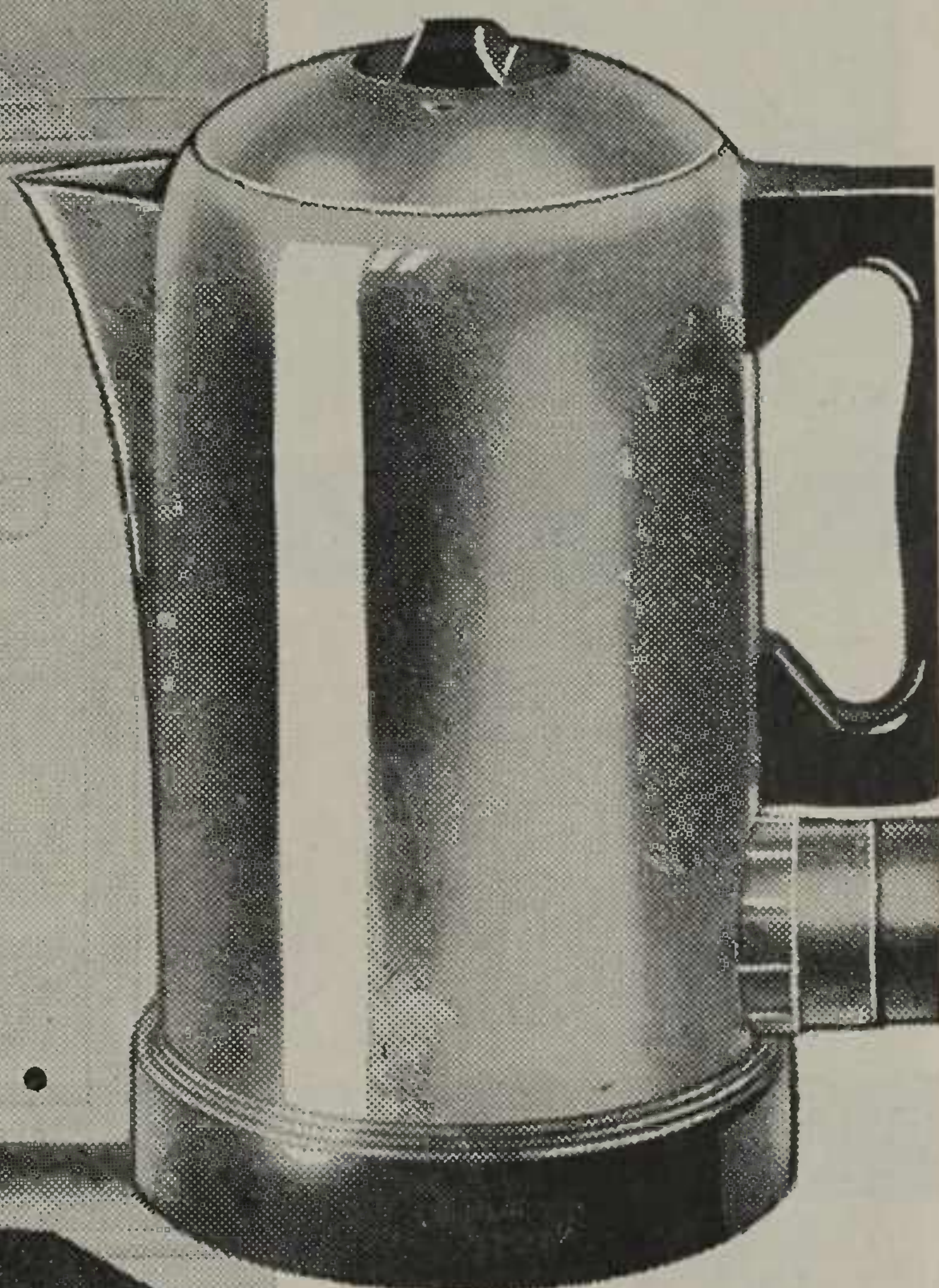
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You
can't
watch him
all the time...



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OUT**



**WON'T BURN
OUT**

SPECIAL SAFETY FITTING — exclusive fitting prevents tipping — easily fixed, gives positive protection.

SAFETY EJECTOR ELEMENT — automatically switches off if jug is dry. A simple resetting action then restores former efficiency.

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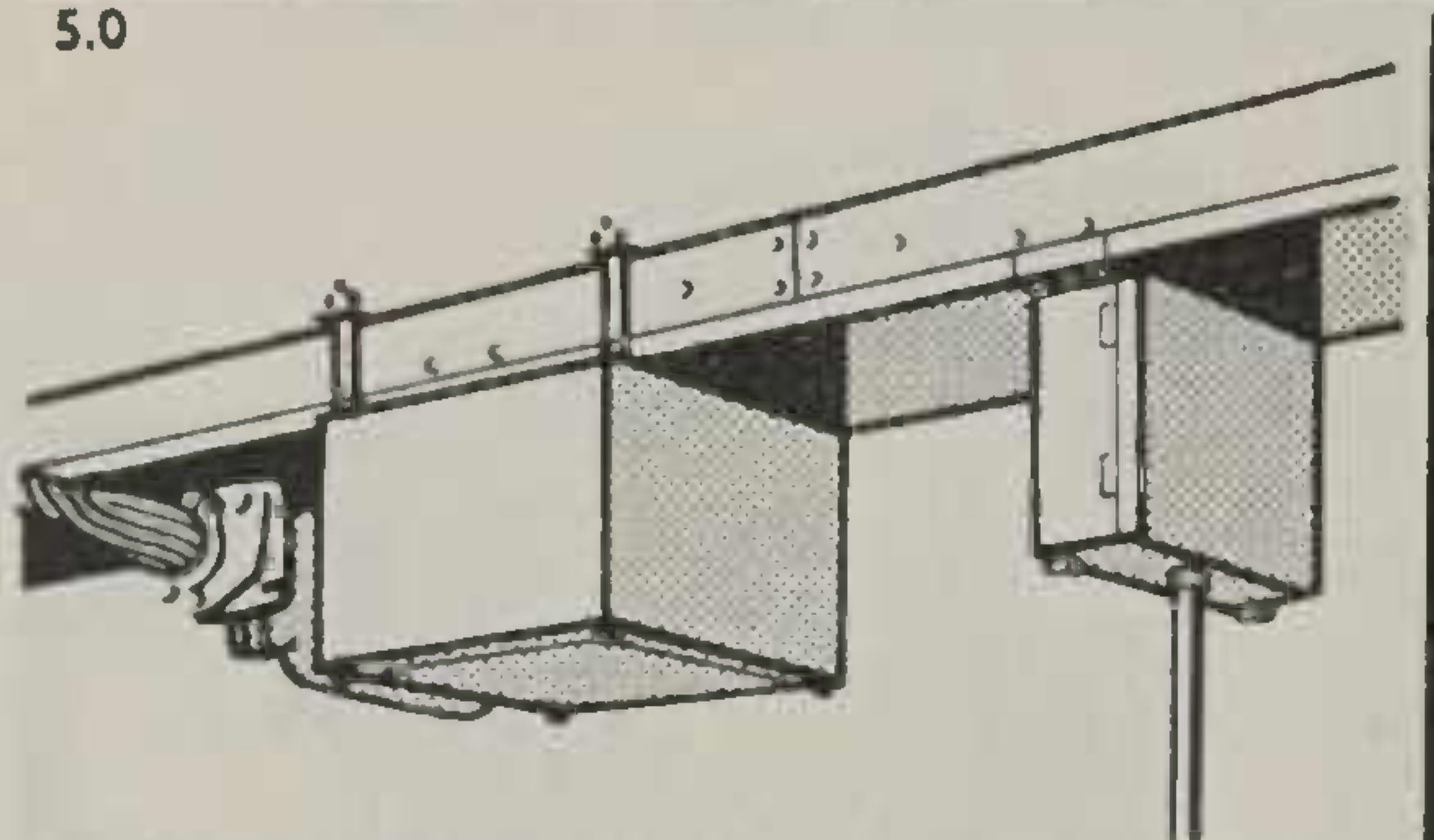


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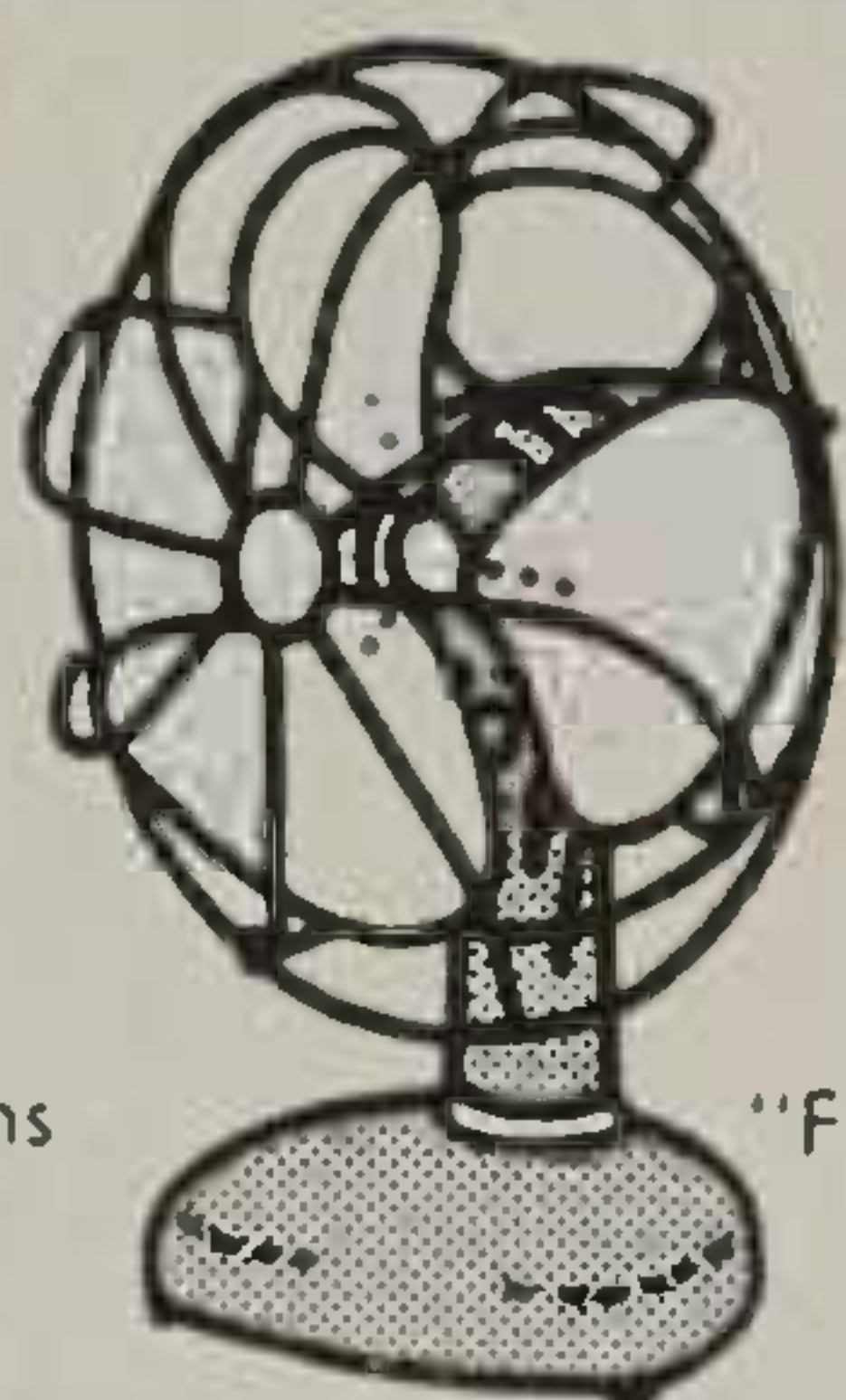
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SWITCHES TO STREETLIGHTS

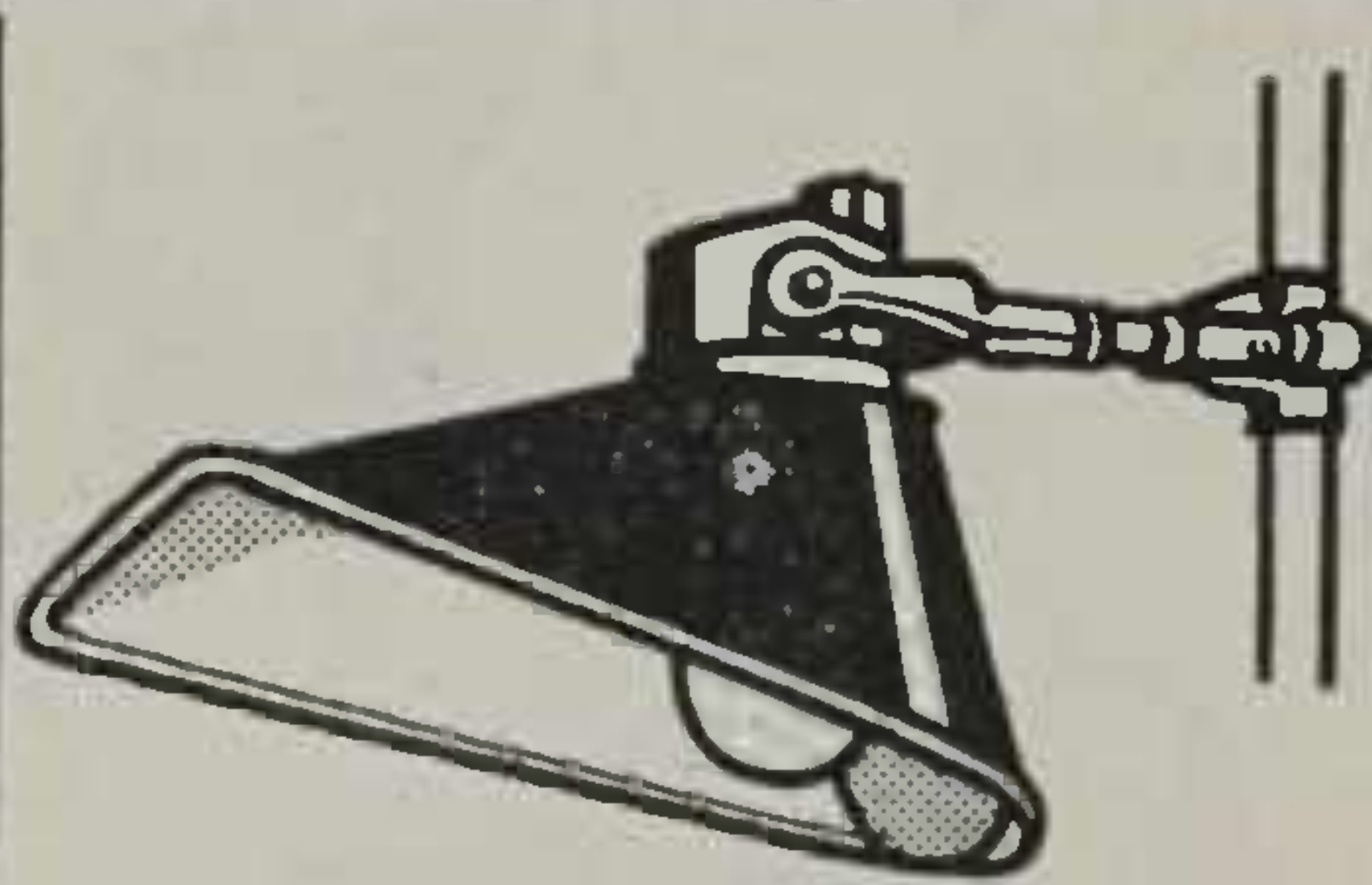
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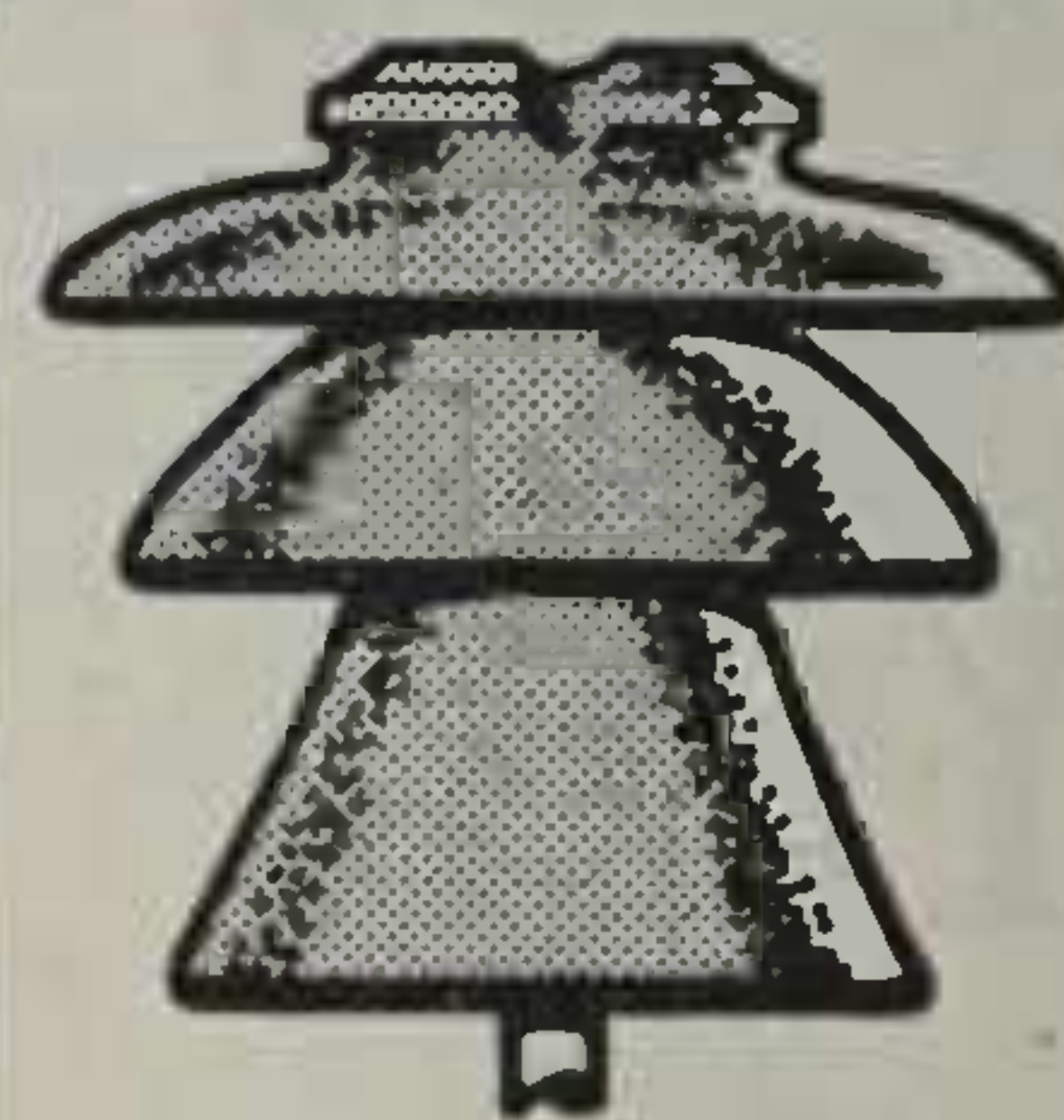
Busbar Trunking & Switchgear "OTTERMILL"



Fans "FROST"

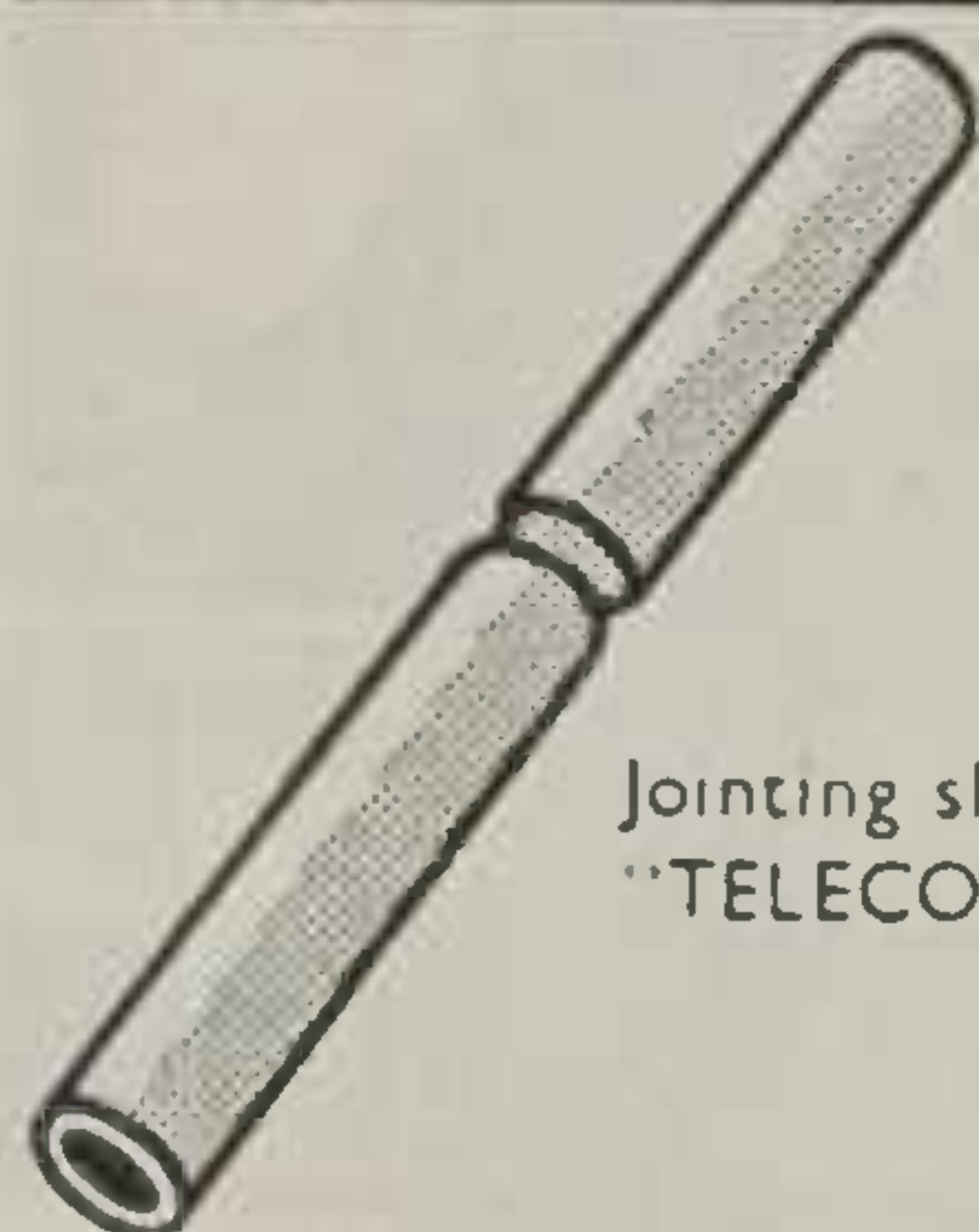


Industrial Lighting Equipment "THORLUX"

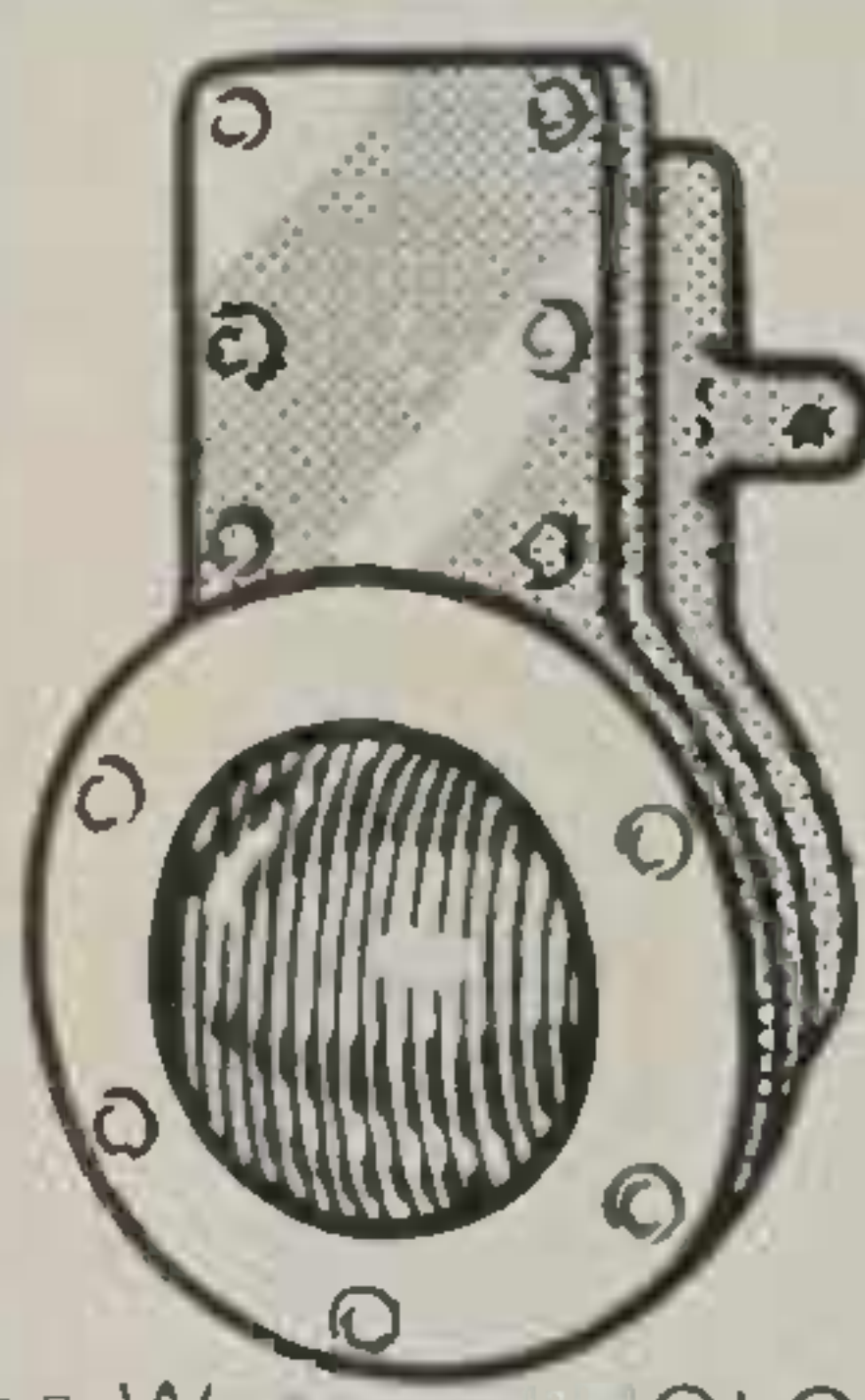


Insulators "N.G.K."

FANS TO FUSES



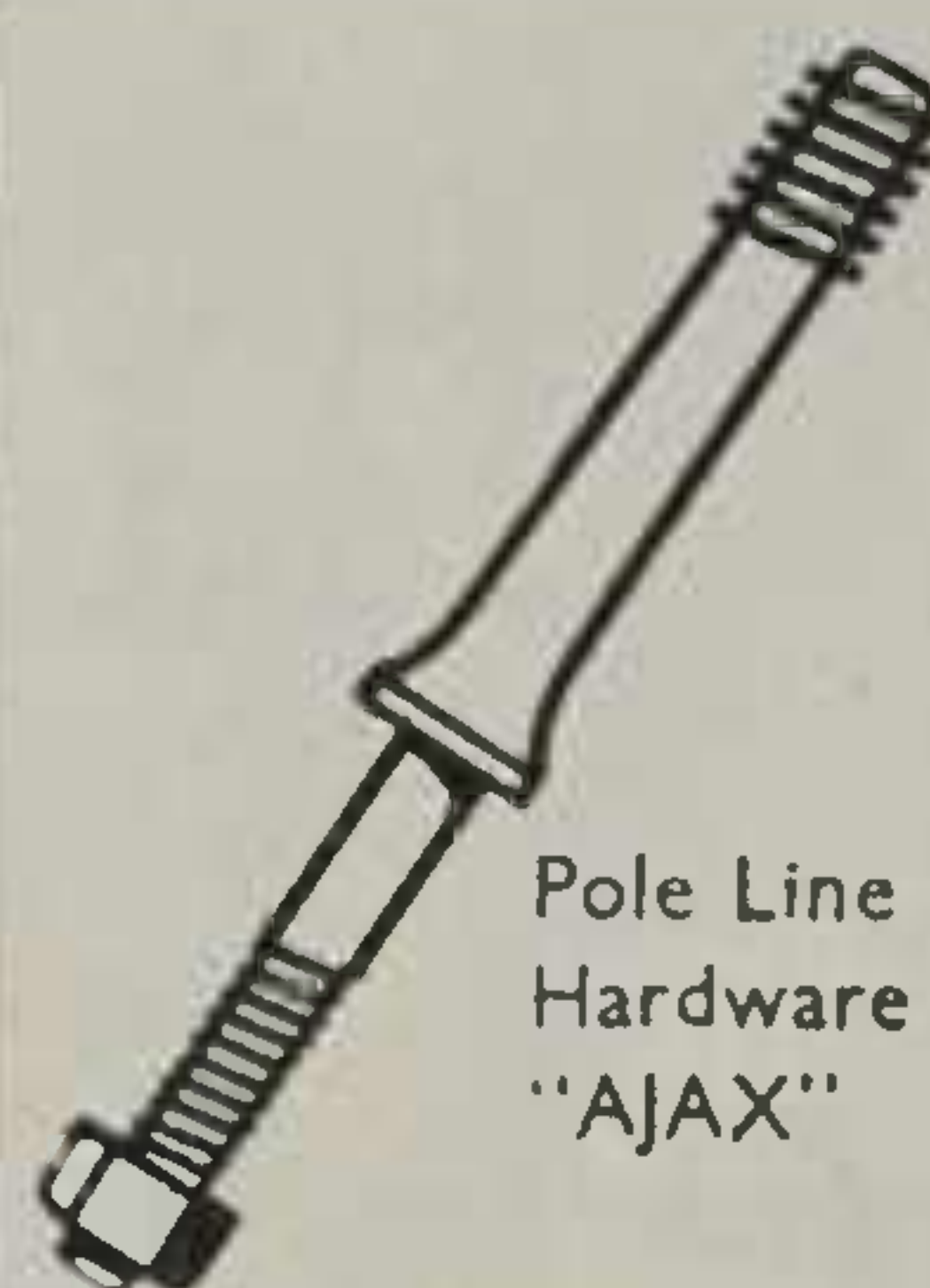
Jointing sleeves "TELECOM"



Lighting Ware "OLOPHANE"



Liquid Fuses "ESSANTEE"

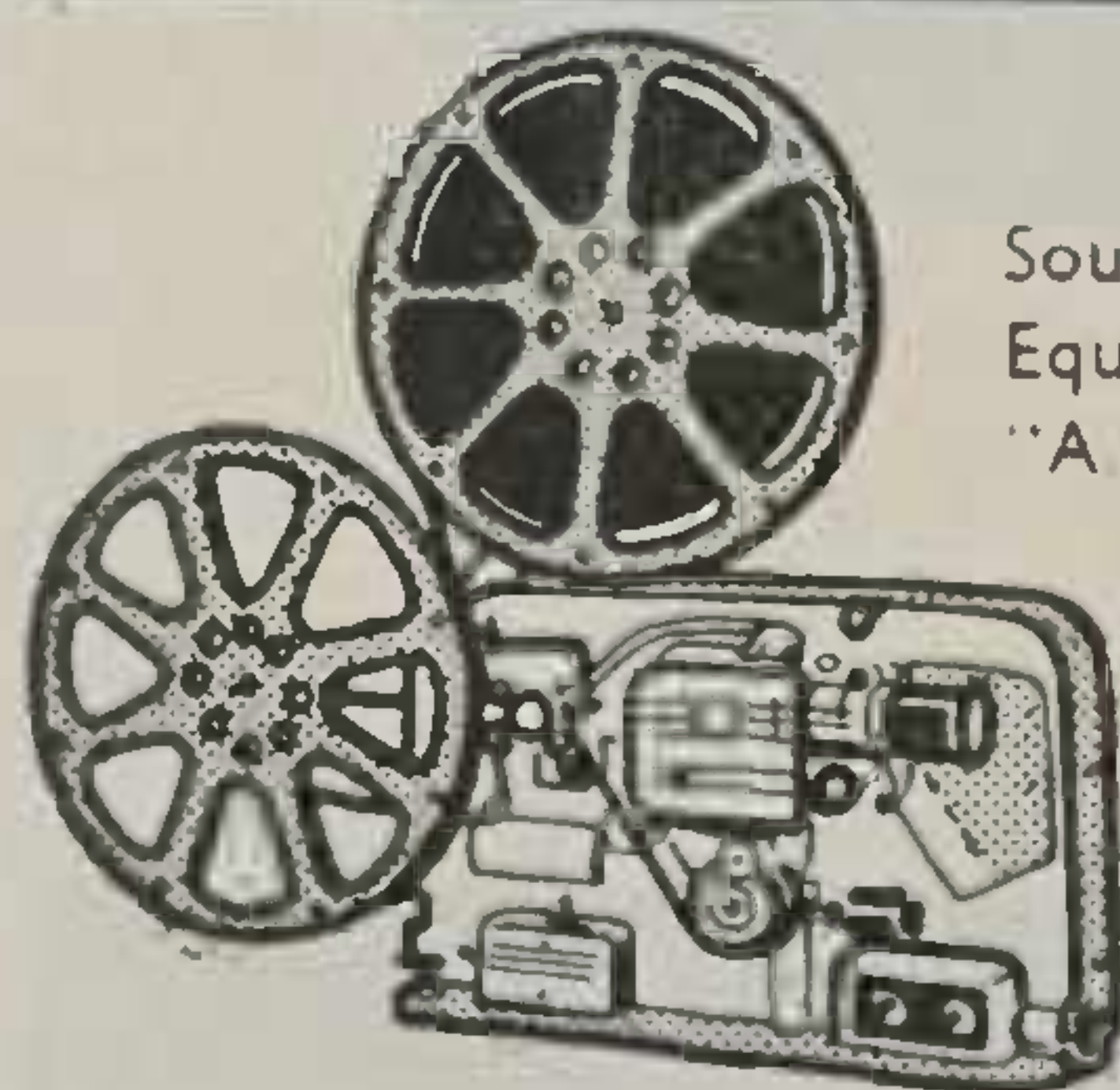


Pole Line Hardware "AJAX"

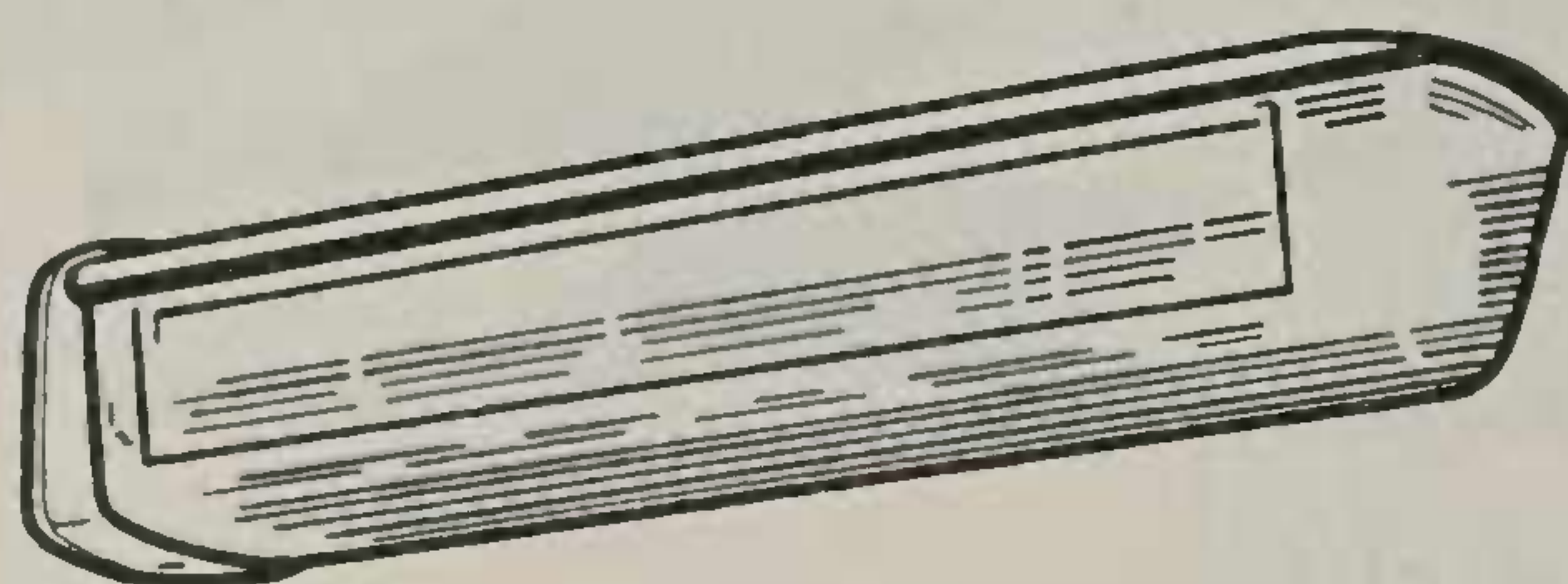


Resistance wires "CROMALOY"

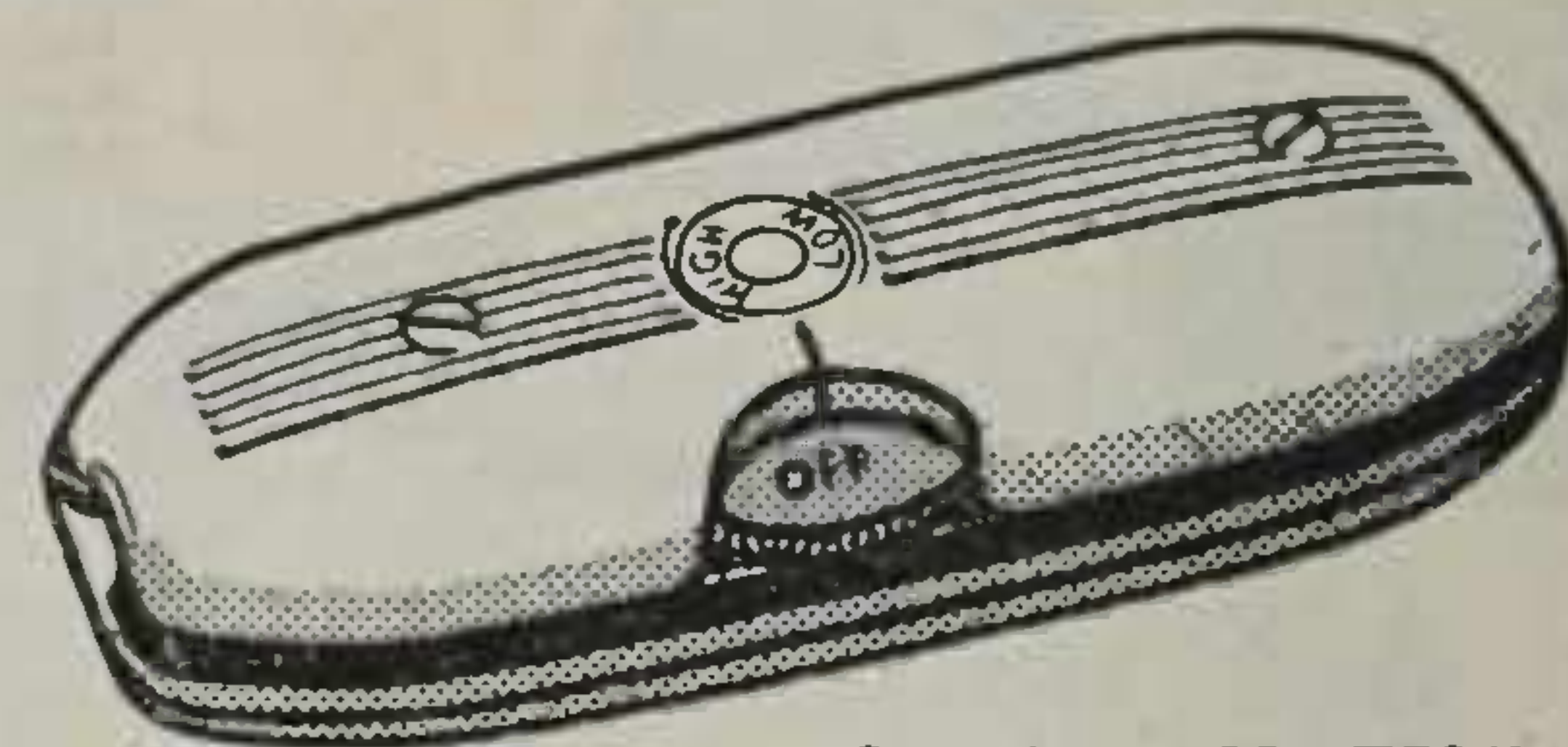
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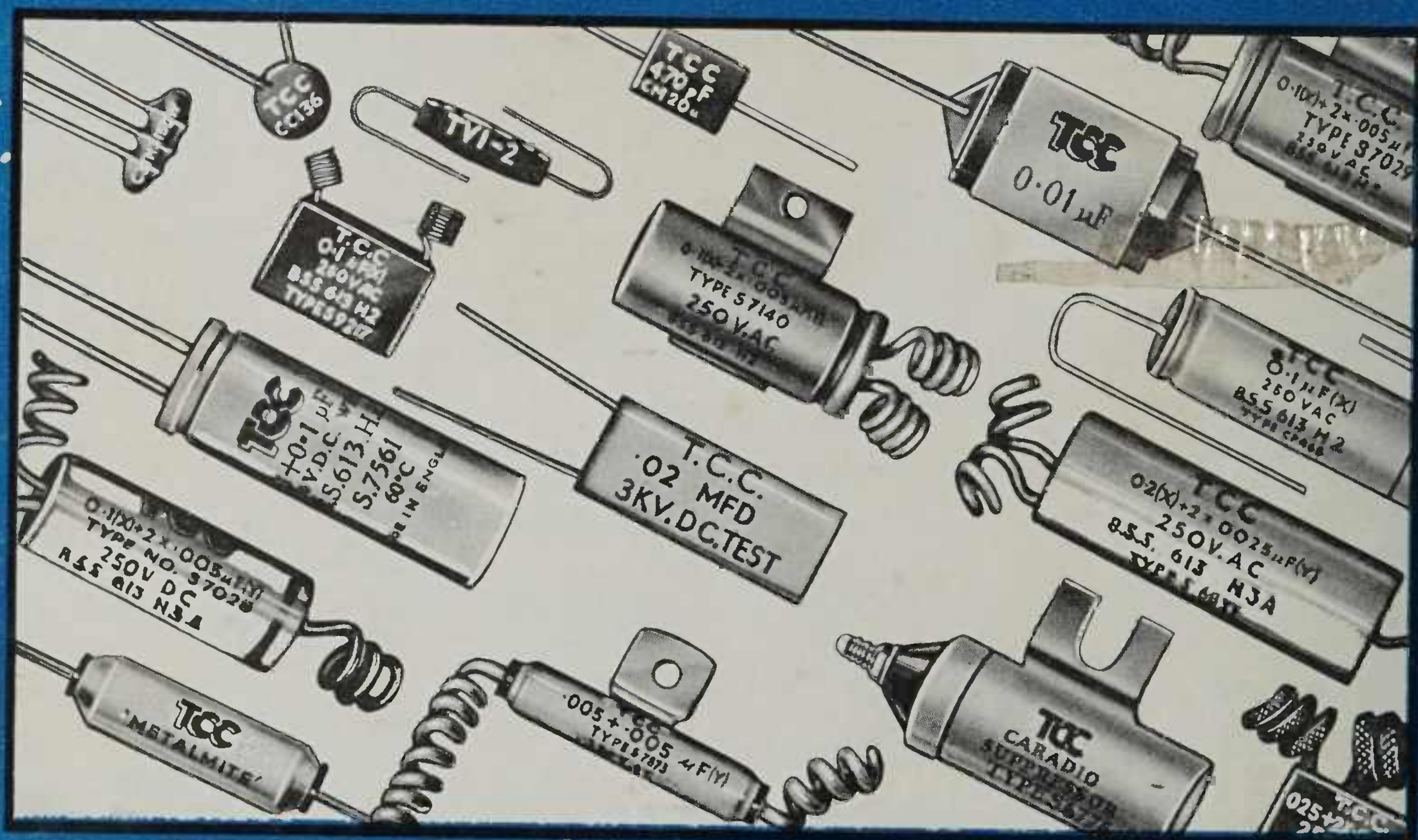
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RCA Type No.	Max. DC Plate Input (watts)	Max. DC Plate Volts	Max. Freq. at Max. Ratings (Mc)
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807	75	750	60
813	500	2250	30
829-B	120	750	200
5763	17	350	50
6146	90	750	60
7034 4X150A	500	2000	150
7094	500	1500	60

* Maximum Amateur Ratings, Class C CW
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