

RADIO *and* ELECTRICAL

TELEVISION — COMMUNICATIONS — SERVICE — SOUND

Vol. 15, No. 7

SEPTEMBER, 1960

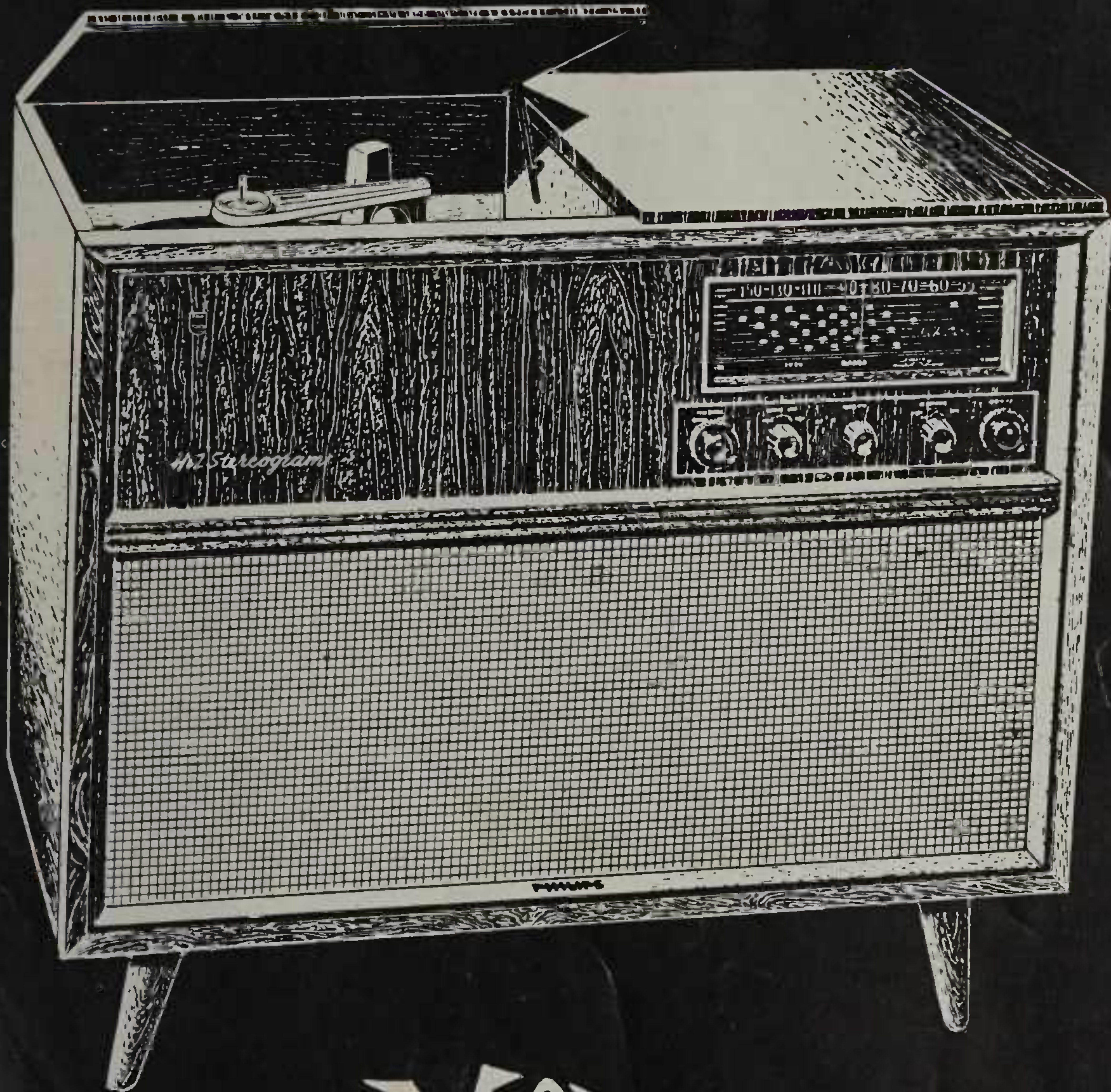
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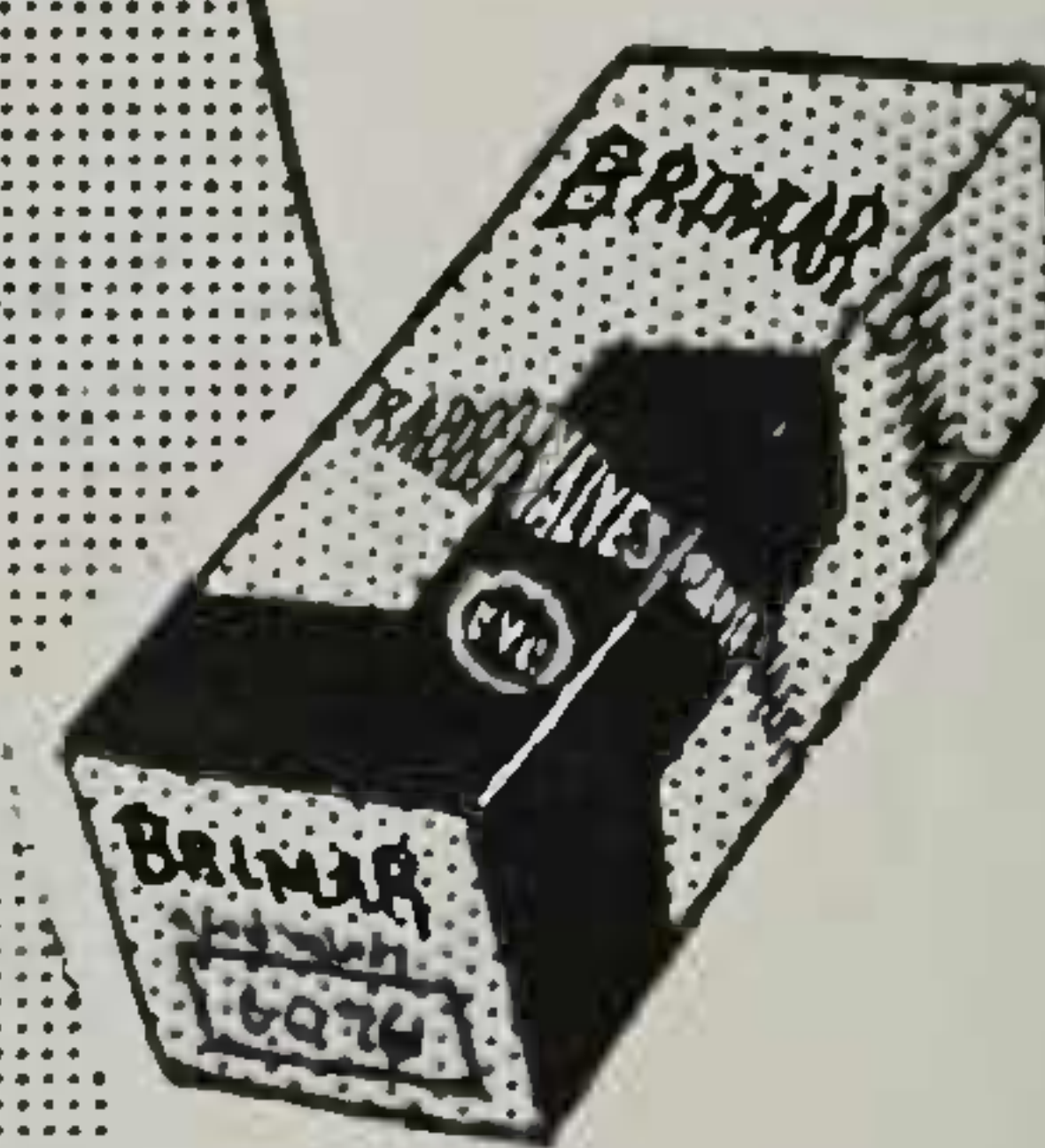
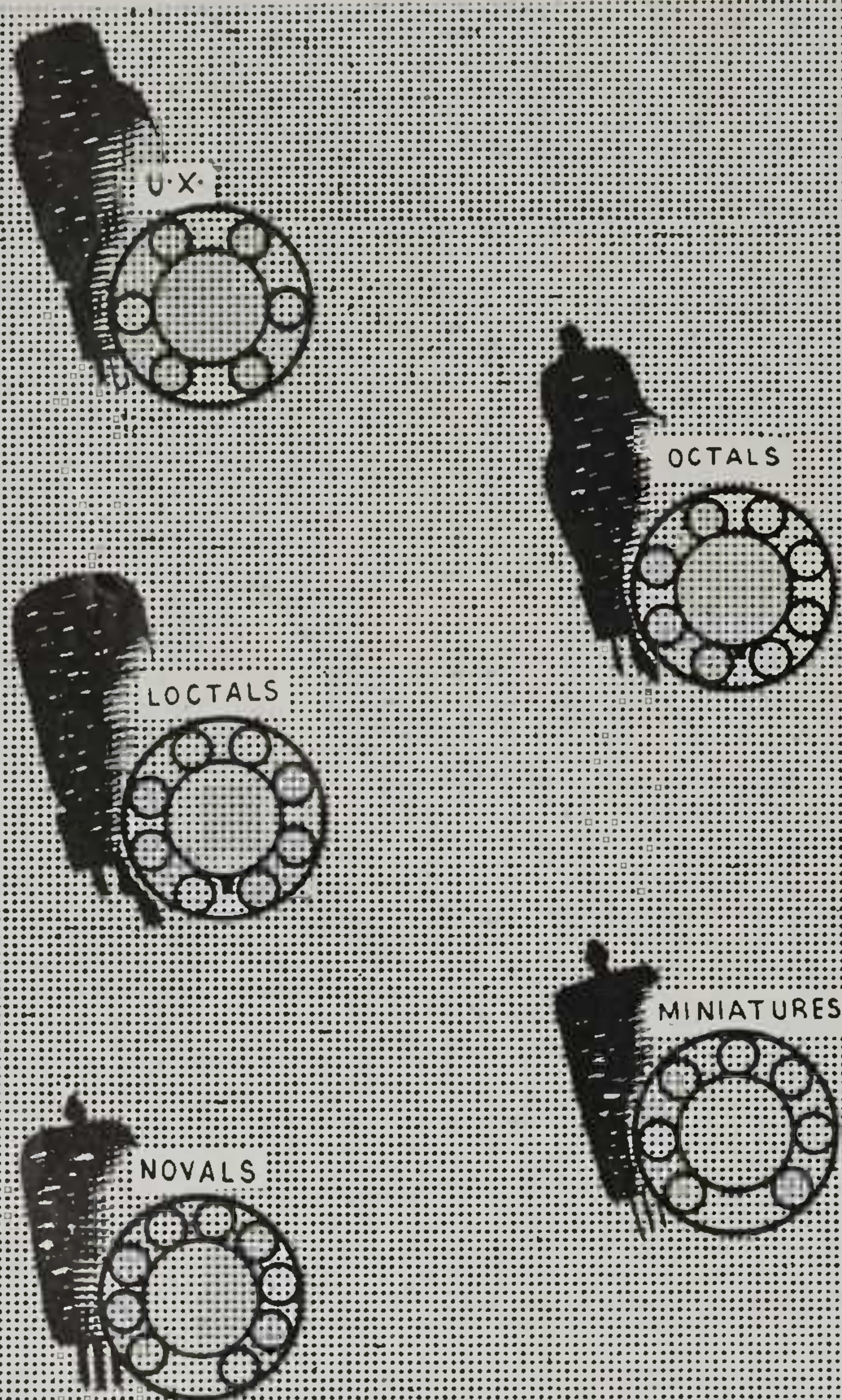


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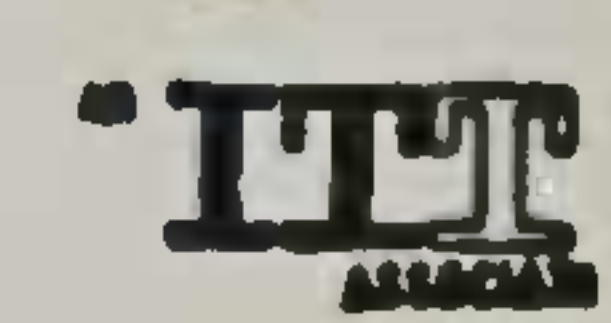
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VOL. 15, No. 7

SEPTEMBER, 1960

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Experimental TV Transmissions in Wellington

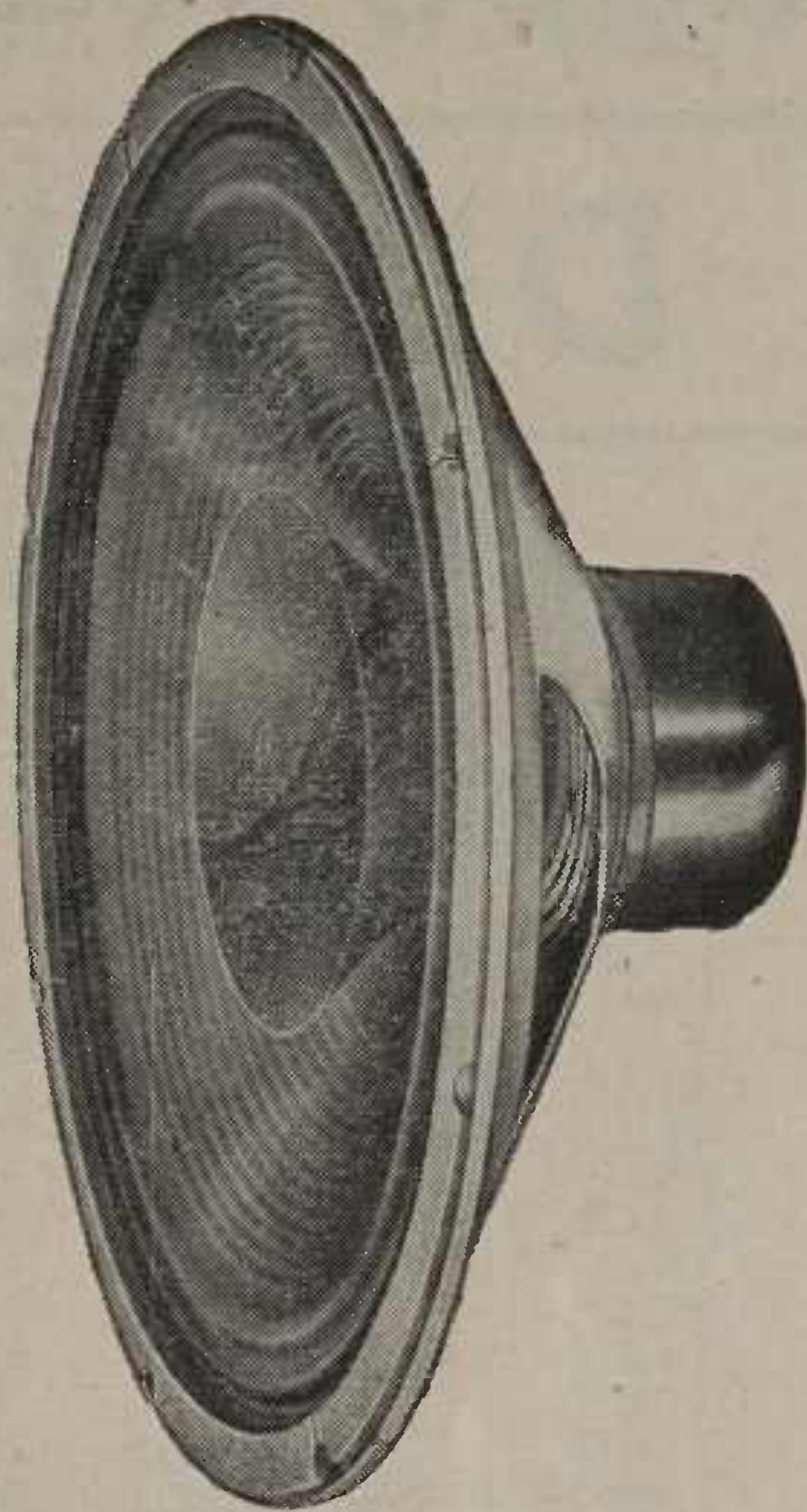
Elsewhere in this issue will be found a brief announcement to the effect that the experimental television station which has been set up by the joint efforts of the Wellington branch of the New Zealand Electronics Institute (Inc.) and the Wellington Technical College, has commenced regular experimental transmissions. For those who have been concerned with the building of the equipment, this has been a red-letter day indeed, as it represents the fruition of several years' work on the part of a few enthusiasts. There have been numerous set-backs, which we do not propose to enlarge upon here, but the initial results that have been obtained have been most encouraging, and should well repay the efforts that have been put in.

For those who may not yet be aware of the details of the transmissions, here they are. The transmission is on New Zealand Channel 6, which is from 188 to 195 mc/sec., with the vision carrier on 189.25 mc/sec., and the sound carrier on 194.75 mc/sec. Transmissions at the moment are made every Saturday morning from approximately 10.30 a.m. to 1 p.m. It is hoped soon to have the transmitter on during at least one evening a week for a short time.

The vision transmitter, which was made for the project by Collier and Beale Ltd., has an output of 50 watts peak, and feeds an aerial system comprising a two-bay turnstile array. This is installed atop a ten-foot wooden tower situated on the roof of the assembly hall at the Wellington Technical College. The only higher object than the aerial, in its immediate vicinity, is the carrilion tower, but this is far enough away not to cause appreciable shadowing effects. The aerial array will give an all-round-looking pattern, and a small amount of vertical directivity, the overall theoretical gain being about 3 db. over a half-wave dipole. Since it is estimated that about 3 db. is lost in the rather long co-axial cable run between the transmitter and the aerial, the aerial gain approximately compensates for this, so that the Equivalent Radiated Power will be 50 watts.

With this order of power output at the frequency used, reception reports have been most encouraging, and not a little surprising. Naturally, anywhere in Wellington, within line-of-sight of the transmitting aerial can be expected to obtain a very good signal, but what has surprised us is that so many reports of good reception have come from points well below the optical horizon. So far, the greatest DX has been Stokes Valley, over twenty miles away, and not remotely within line-of-sight. In this case, the mechanism would appear to be reflection into the valley from the western hills bordering the Hutt Valley. Other places to report reception have been Khandallah (not on the heights), Island Bay, Rongotai, Miramar, and Brooklyn, all of which involve propagation over one or more ranges of hills.

All of this seems to prove what we have always felt would be true, namely that the propagation of television signals in hilly areas like Wellington would turn out to be better than many people would suspect, even when making allowance for reflection and diffraction effects. There seems little doubt that when in the near future, the N.Z.B.S. starts radiating from Mount Victoria, on Channel 1, there will be few places indeed where a satisfactory signal is not received.



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Capacitance pF/ft.						17	17	17	17	17
Attenuation db/100 ft.										
10 Mc/s.						1.3	1.5	1.0	1.1	0.6
50 „						3.0	3.4	2.3	2.6	1.5
100 „						4.3	4.8	3.2	3.6	2.2
200 „						6.3	7.2	4.9	5.3	3.3
Dimensions (inches)										
Centre Conductor						1/0.022	7/0.0076	1/0.029	7/0.010	1/0.044
Over Cellular Telcothene						0.093	0.093	0.128	0.128	0.200
Over Wire Braid						0.117	0.117	0.152	0.152	0.230
Over PVC sheath						0.157	0.157	0.202	0.202	0.290

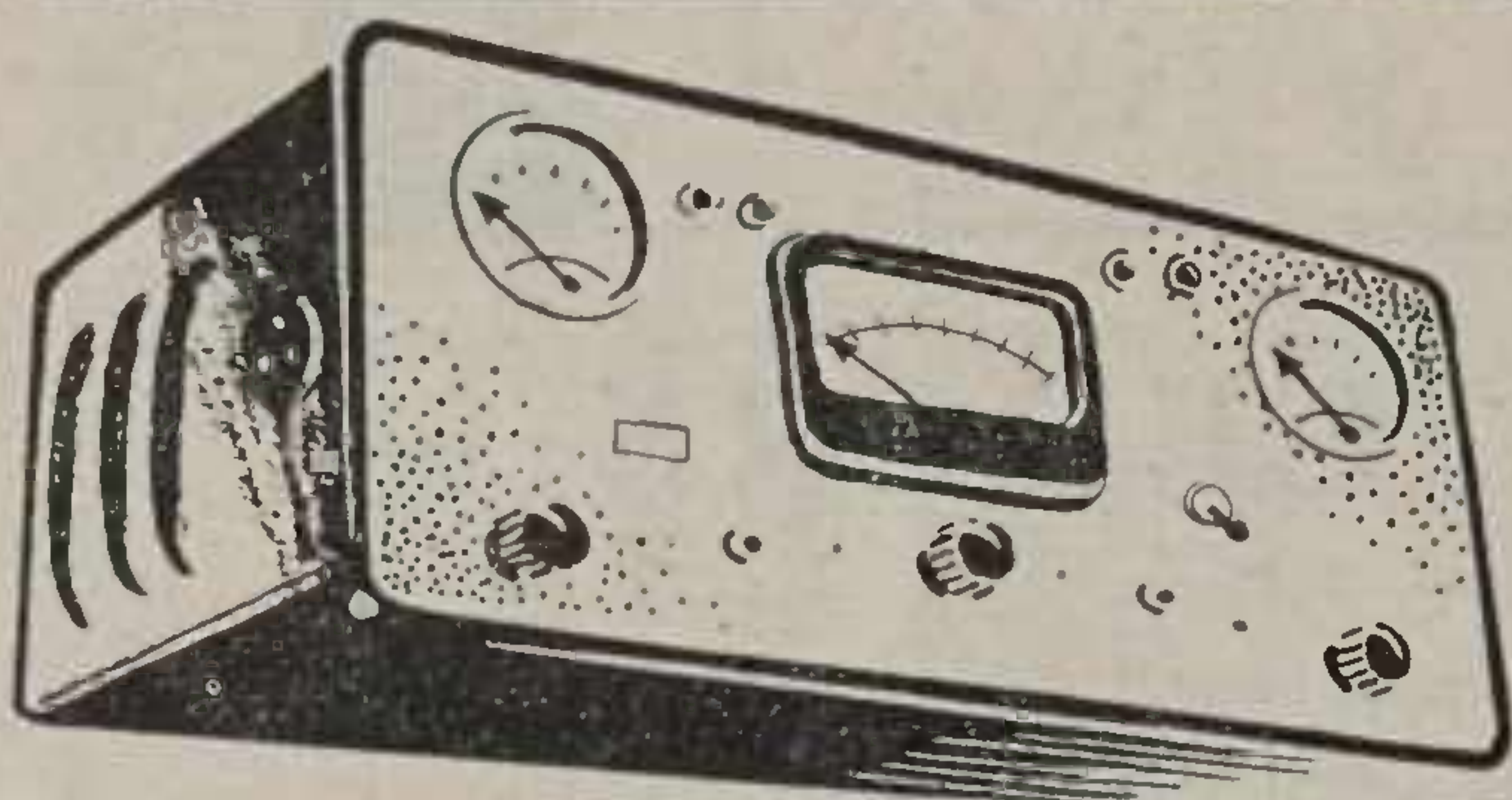
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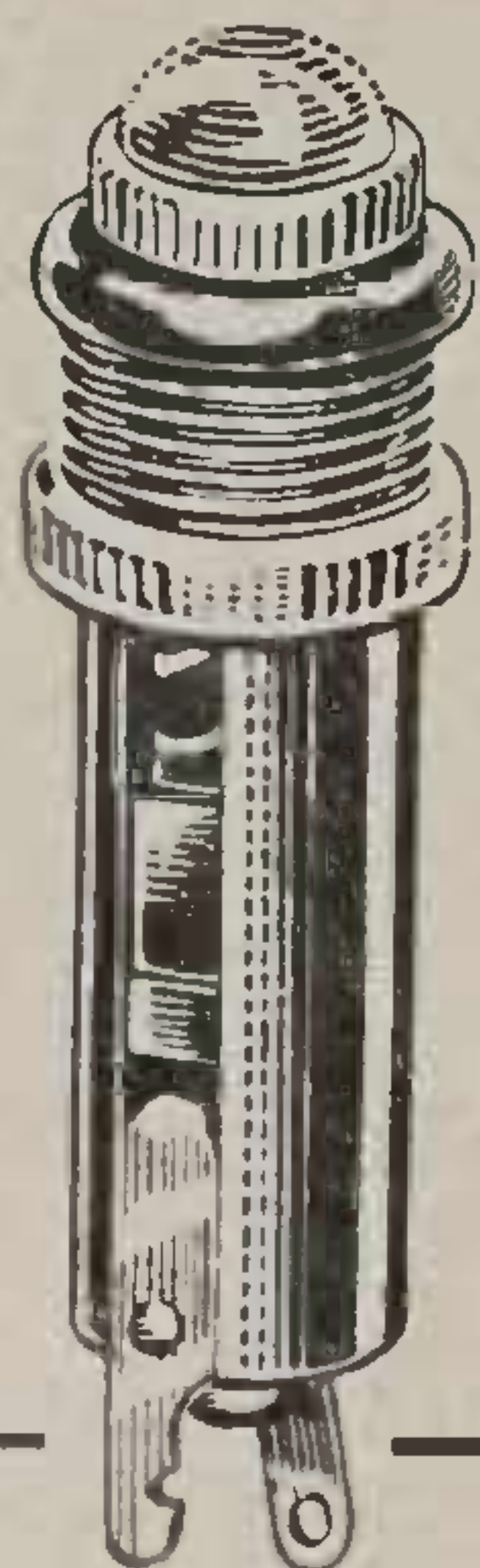
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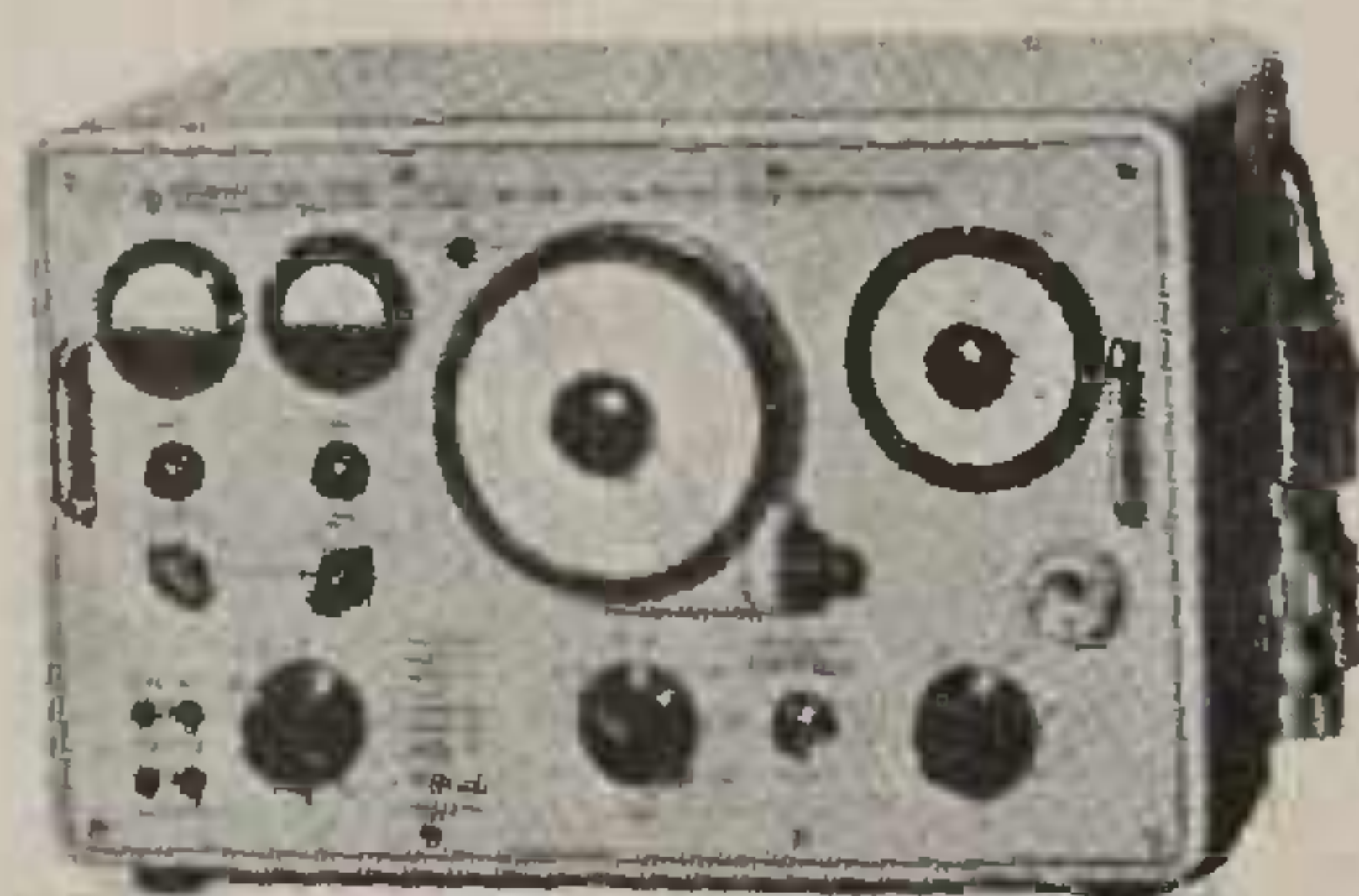
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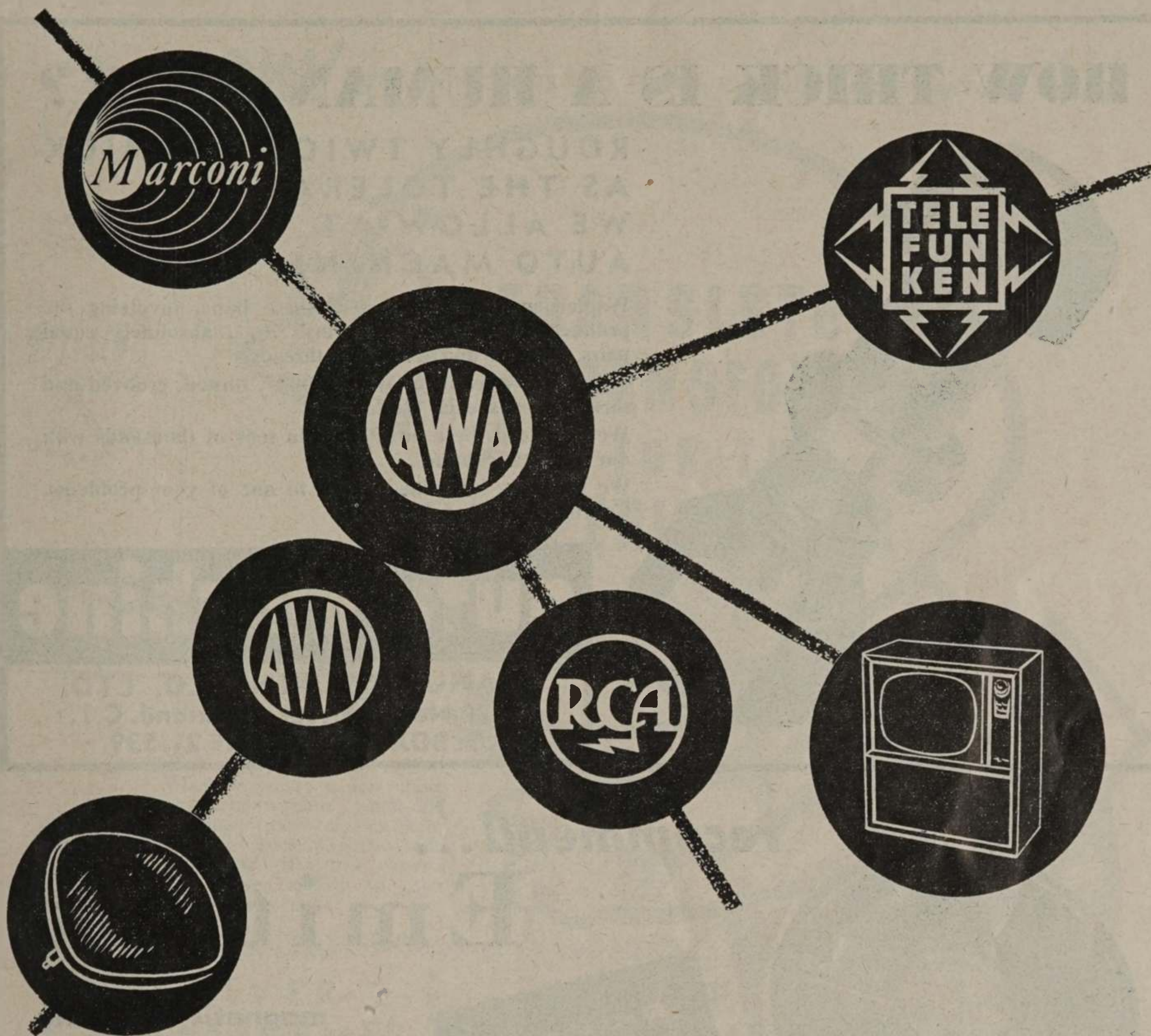


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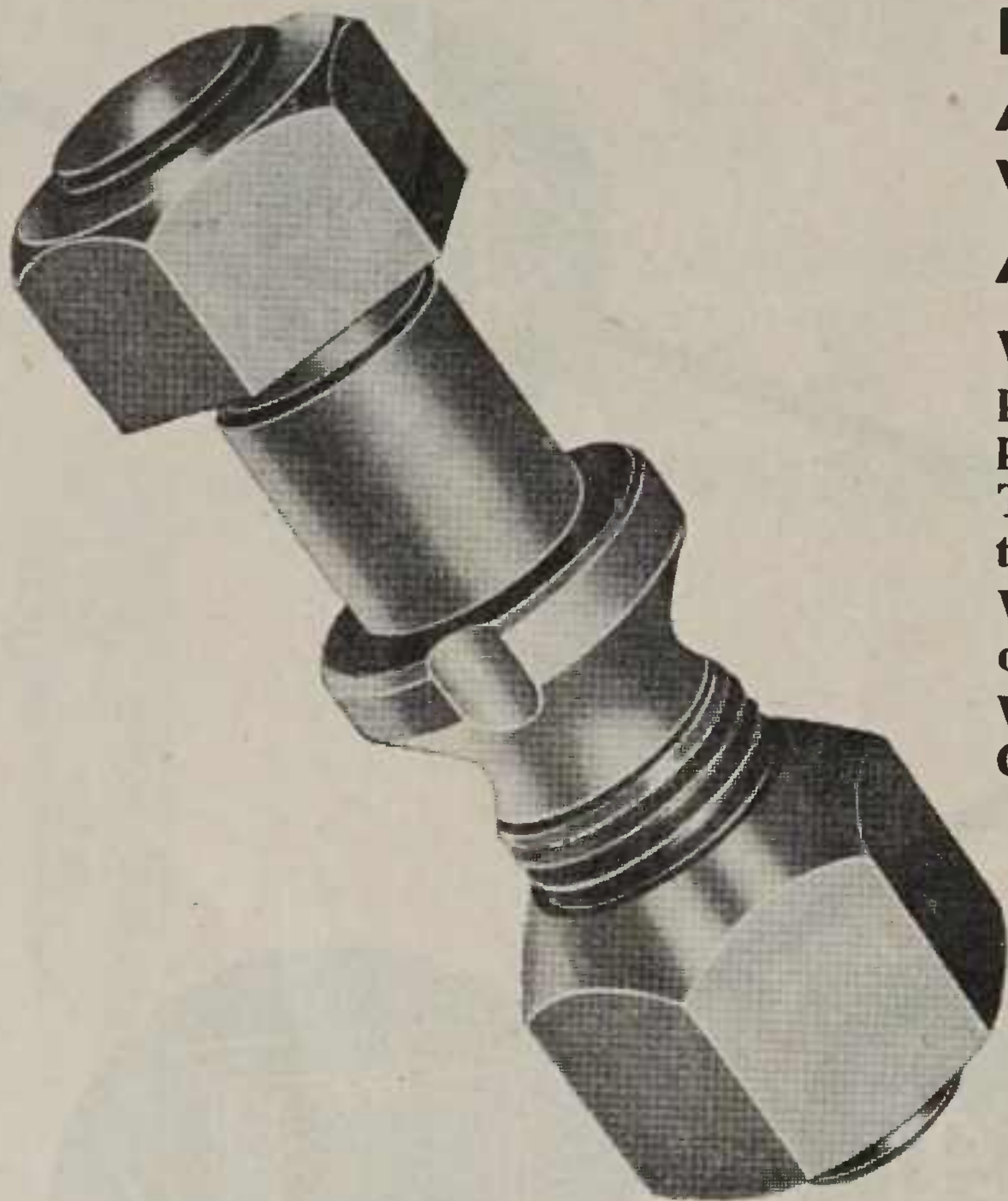
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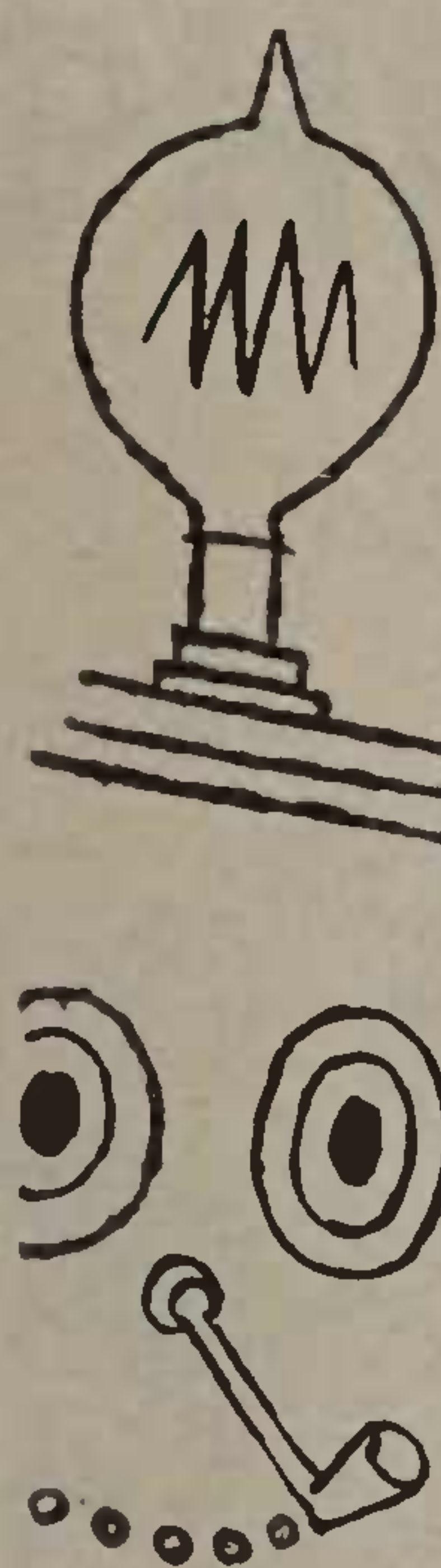
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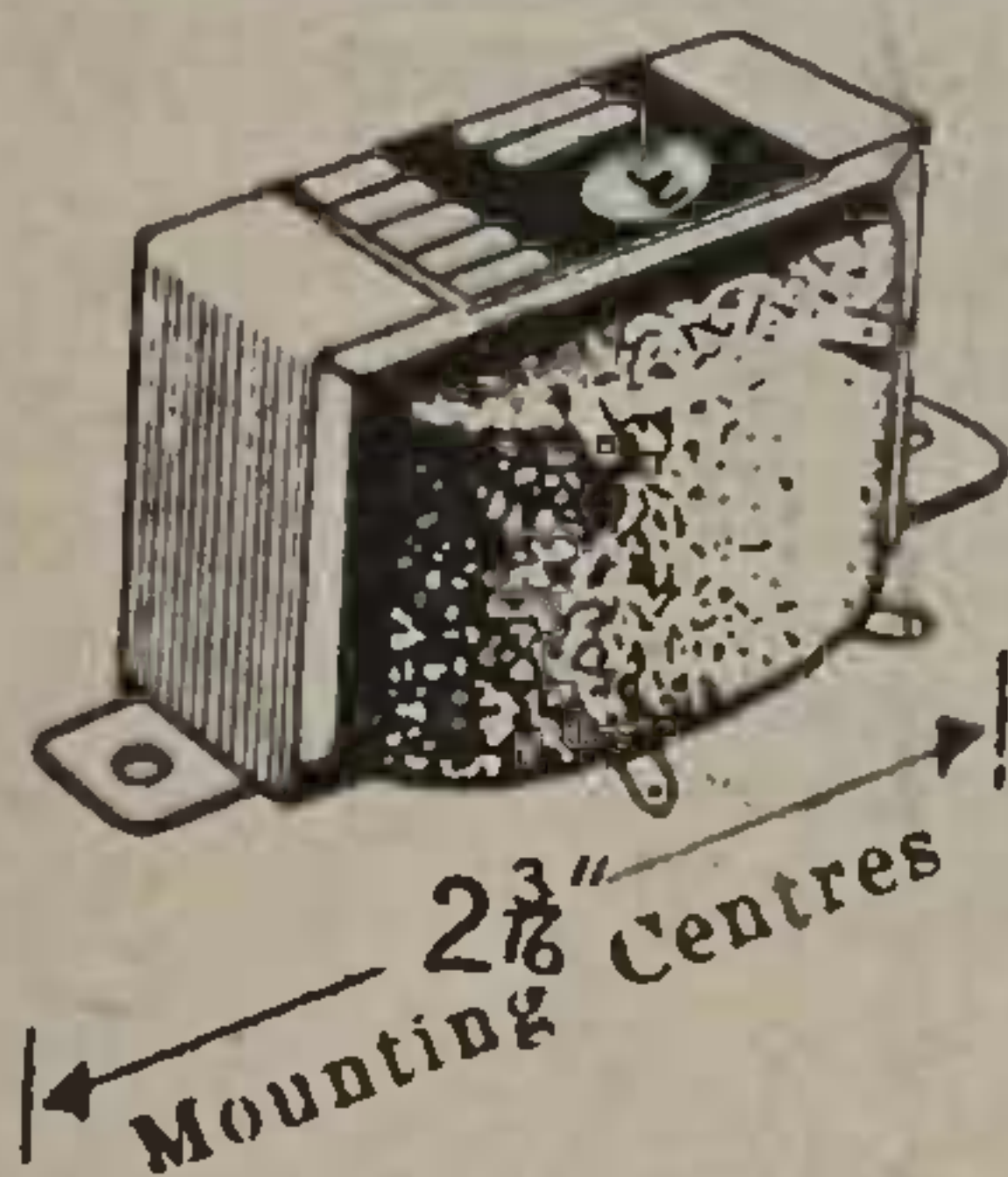
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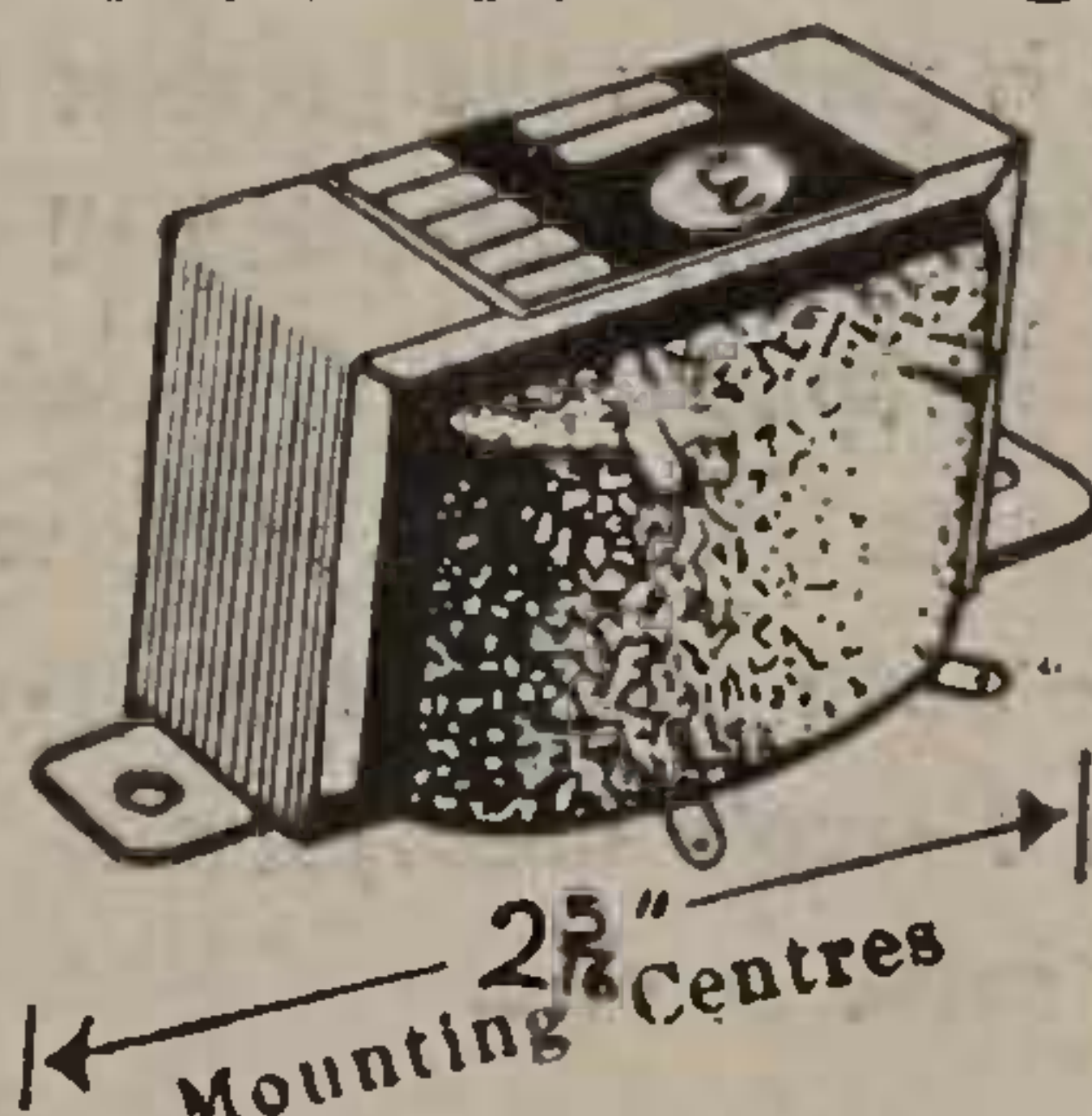
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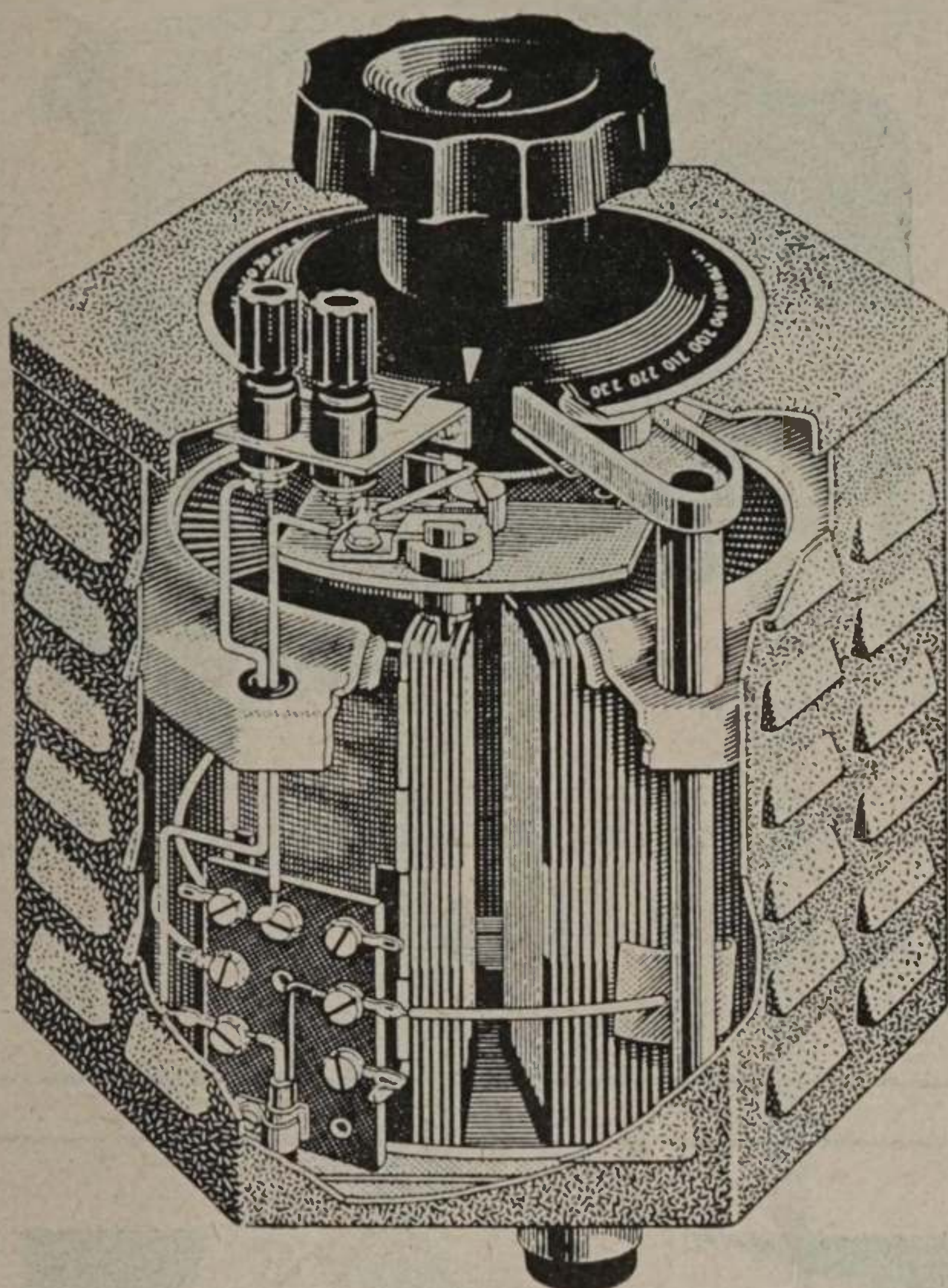
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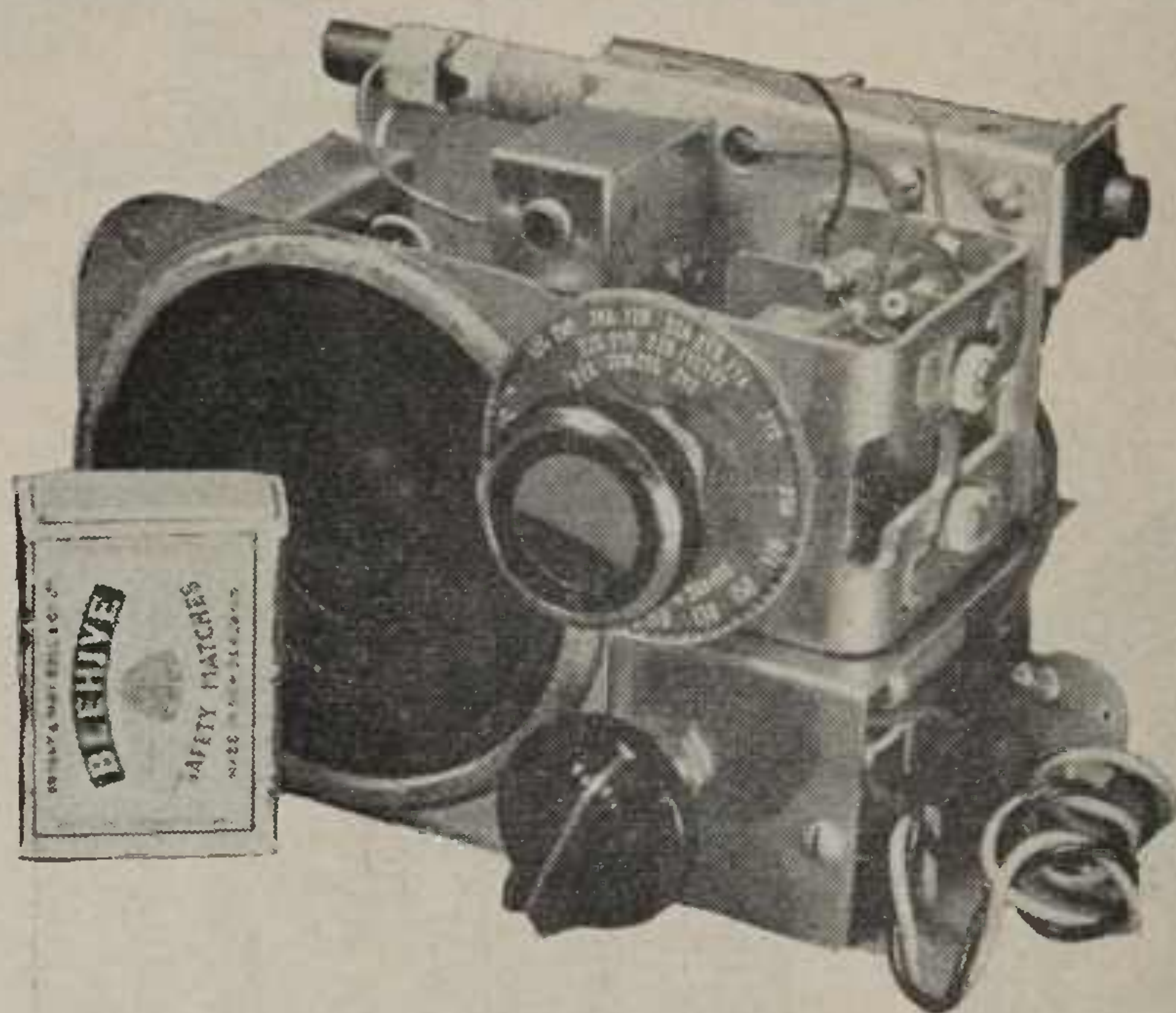
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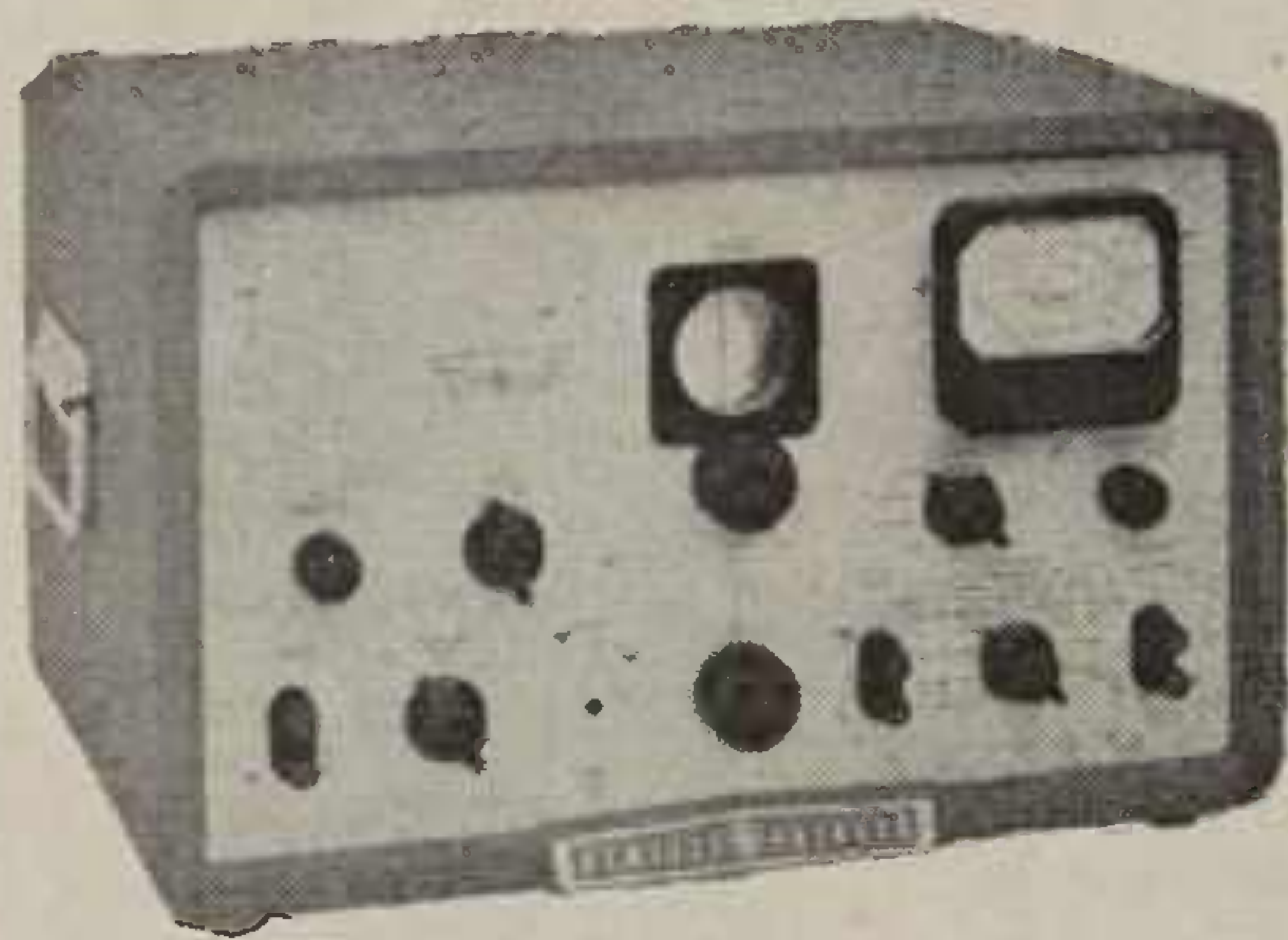
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	min.	max.			at 50°C	at 100°C
SX47	4.4	4.9	-0.04 to -0.01	13	300	150
SX51	4.9	5.3	-0.03 to 0.00	10		
SX56	5.3	5.9	-0.02 to $+0.02$	6		
SX561	4.8	6.4	-0.03 to $+0.04$	7		
SX62	5.9	6.5	0.00 to $+0.04$	4		
SX68	6.5	7.2	$+0.02$ to $+0.05$	4		
SX75	7.2	7.9	$+0.03$ to $+0.06$	5		
SX82	7.9	8.6	$+0.04$ to $+0.06$	7		
SZT1	4.8	6.4	<0.01	7		
SZT2	5.3	5.9	<0.001	6		

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SEMI-CONDUCTOR RECTIFIERS

PROTECTION AGAINST VOLTAGE SURGES

The outstanding advantages of germanium and silicon rectifiers over copper oxide, selenium, or thermionic rectifiers are well known. However, due to their comparatively high inverse resistance and low self capacitance, they are more susceptible to damage by voltage surges, and the lack of appreciation of this fact in the past has been a cause of failure in some applications.

Germanium and silicon rectifiers can be safely used at any voltage up to the maximum rated peak inverse voltage but voltage transients, however short in duration, exceeding the rated peak inverse voltage must never be applied. These transients or surges usually occur when a circuit is switched on or off and this is particularly the case where the rectifiers are supplied from a transformer.

If a means of measuring the surges which occur in a particular circuit is available, the user may be able to determine by experimental tests the most economic method of limiting them to a safe value. During the initial stages of these tests it is recommended that the input voltage be reduced considerably so that risk of damage to the rectifiers by excessive surges is removed. It should be pointed out that the input impedance of any equipment used for this measurement must be high compared with the inverse resistance of the rectifier. Unless this is so, the voltage surges may be damped by the equipment impedance, and misleading results obtained.

In the case of transformer fed rectifiers where the user is unable to measure and suppress the surges as described above, capacitor/resistor networks should be fitted in order to limit the transformer switching surges to a safe value. Capacitors are required to limit the switch off surges and damping resistors in series with the capacitors are required to limit the switch on surges. The information given below is sufficient for the user to determine values for the capacitors and resistors which will ensure protection of the rectifiers, for both single- and three-phase circuits. The diagrams show where these components should be connected into the circuit.

(a) Single-phase Circuits

(1) Switching off the Transformer Primary

The value of capacitance required to suppress the voltage surge arising at the instant of switching off

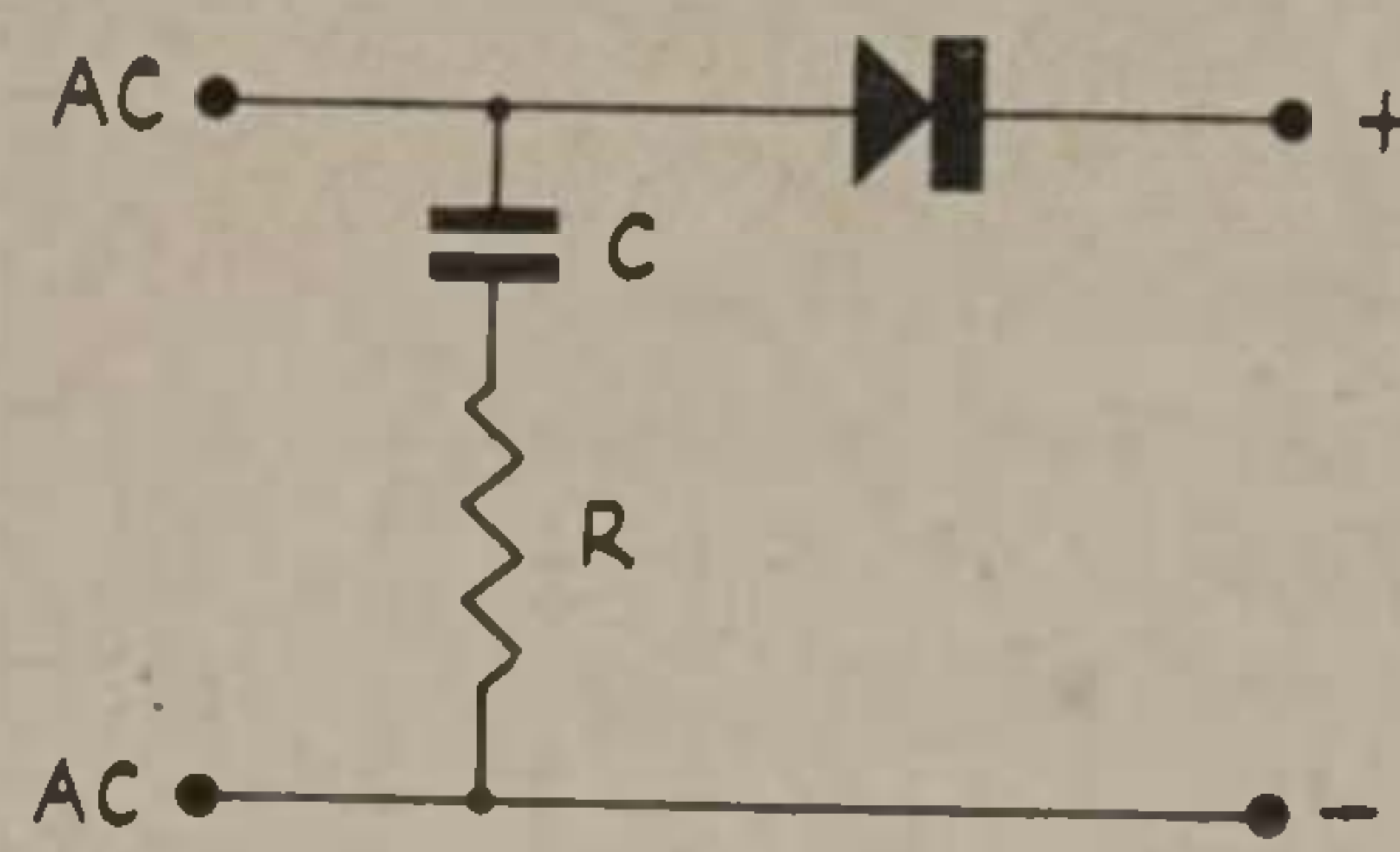


FIG. 1. HALF WAVE.

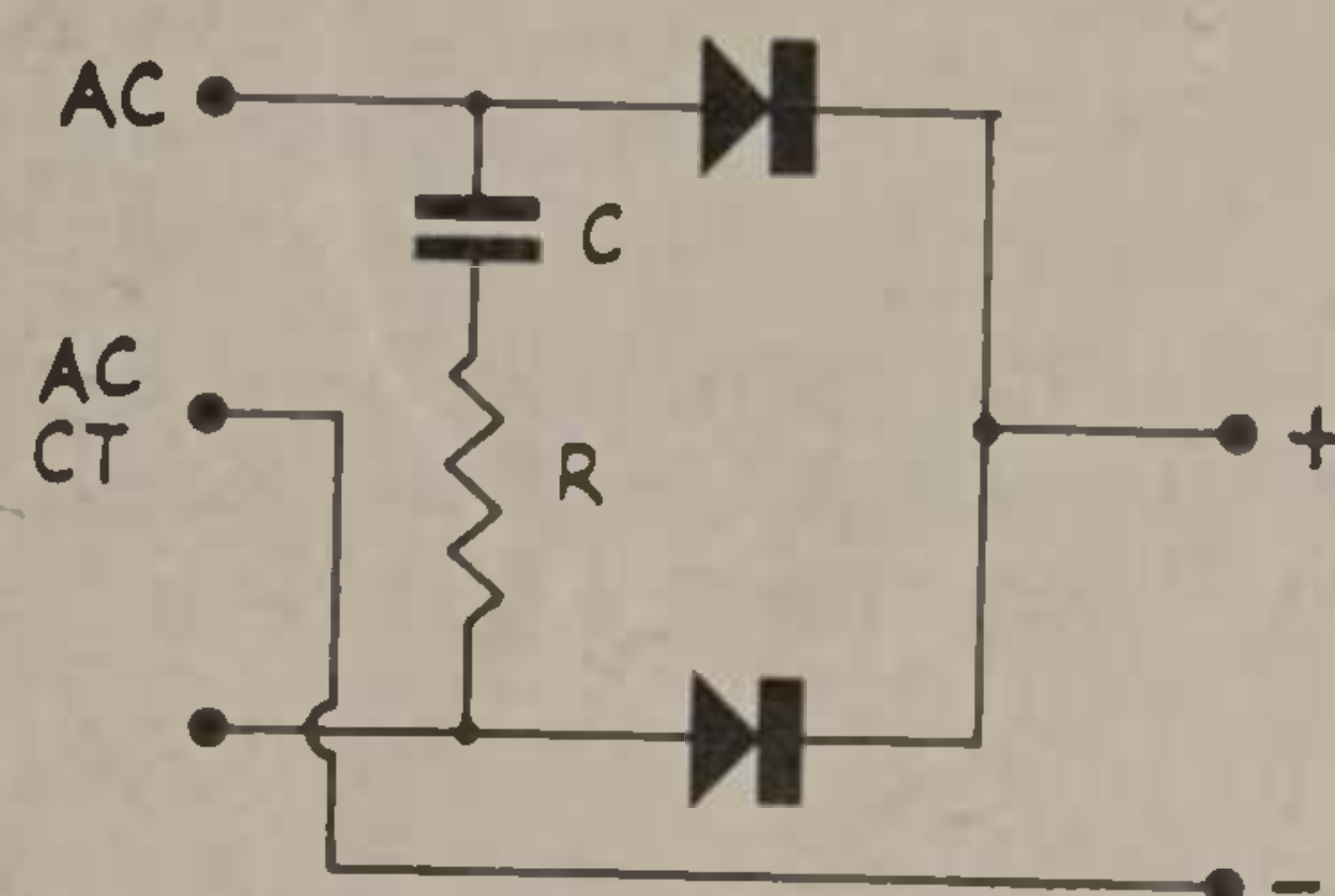


FIG. 2. FULL WAVE CENTRE TAP

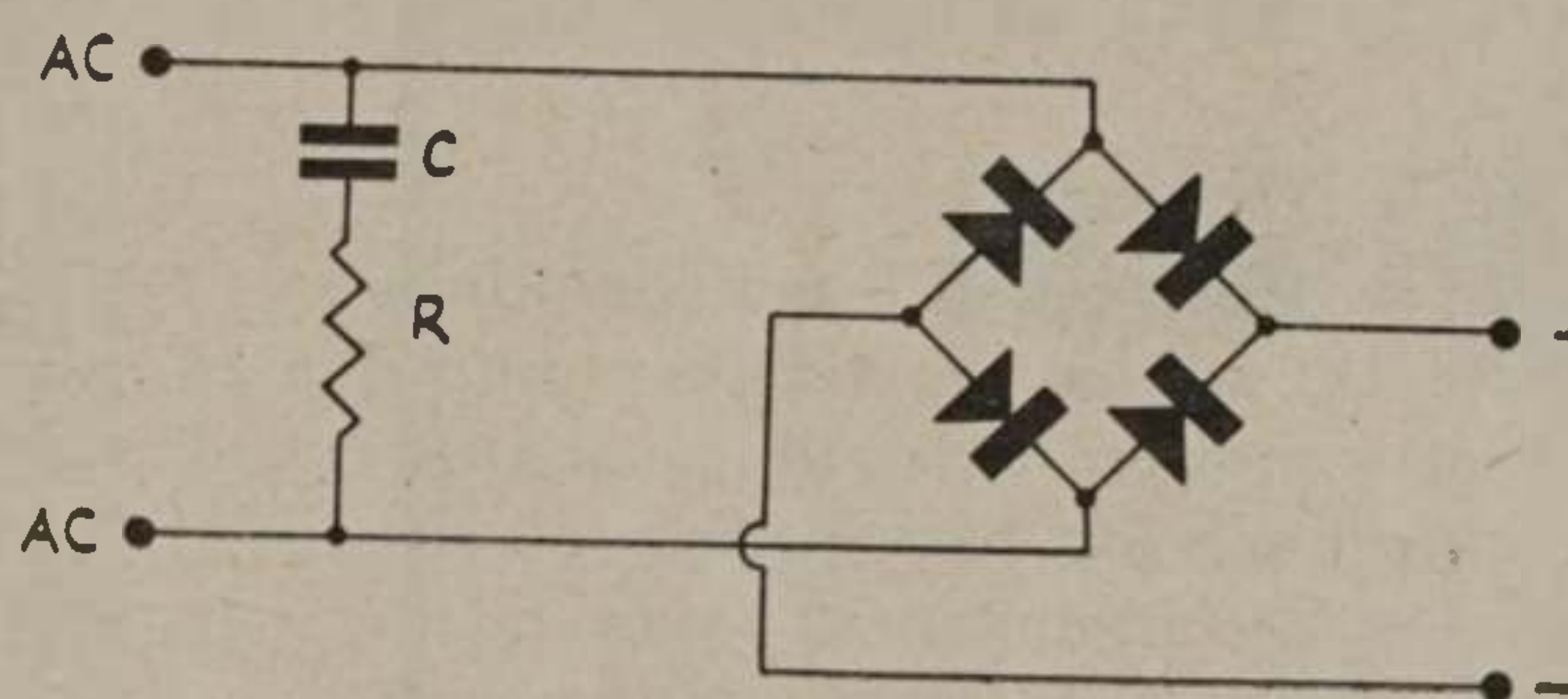


FIG. 3. FULL WAVE BRIDGE

the transformer primary depends upon the type of transformer core and on the total volt-ampere rating of the transformer. For 50 cycles per second operation it can be obtained from one or other of the following formulae:

(a) For C cores up to 200 VA total rating,

$$C = 700 \frac{\text{Total Transformer VA Rating}}{(\text{Rectifier rated PIV})^2} \mu\text{F}$$

(b) For C cores above 200 VA total rating and for all Stalloy cores up to a 5 kVA total rating,

$$C = 400 \frac{\text{Total Transformer VA Rating}}{(\text{Rectifier rated PIV})^2} \mu\text{F}$$

At frequencies of 100 cycles per second and above the value of capacitance required for any type of core up to 5 kVA total rating is given by:

$$C = \frac{1.6 \times 10^{10} \times \sqrt[3]{\text{Total Transformer VA Rating}}}{f^3 \times (\text{Rectifier rated PIV})^2} \mu\text{F}$$

where f is the supply frequency in cycles per second.

(2) Switching on the Transformer Primary

At the instant of switching on the transformer primary, voltage surges may result from the oscillation of the transformer leakage inductance with the surge suppression capacitance. These should be limited

to a safe value by connecting a damping resistor in series with the suppression capacitor. The value of this resistor is approximately given by:

$$R = 100 \sqrt{\frac{R_L}{C \times \sqrt{f}}} \text{ ohms}$$

where C is the suppression capacitance in microfarads, R_L is the load resistance in ohms, and f is the frequency in cycles per second.

The capacitor/resistor combination should be connected effectively in parallel with the rectifier. Recommended connection arrangements for various rectifier circuit configurations are shown in figures 1 to 3.

Note:

In the case where the rectifier has a large smoothing capacitor connected directly across the rectifier output terminals, switch on surges of up to twice the peak alternating voltage may occur. These may be suppressed to a safe value by connecting an inductance between the rectifier and smoothing capacitor of such a value as to make the natural frequency of the circuit less than 60% of the supply frequency. If the operation of the circuit prohibits the use of such inductance, a rectifier having a peak inverse voltage rating of twice the peak value of the supply voltage should be used. The capacitor/resistor network described above must still be fitted to take care of switch off surges.

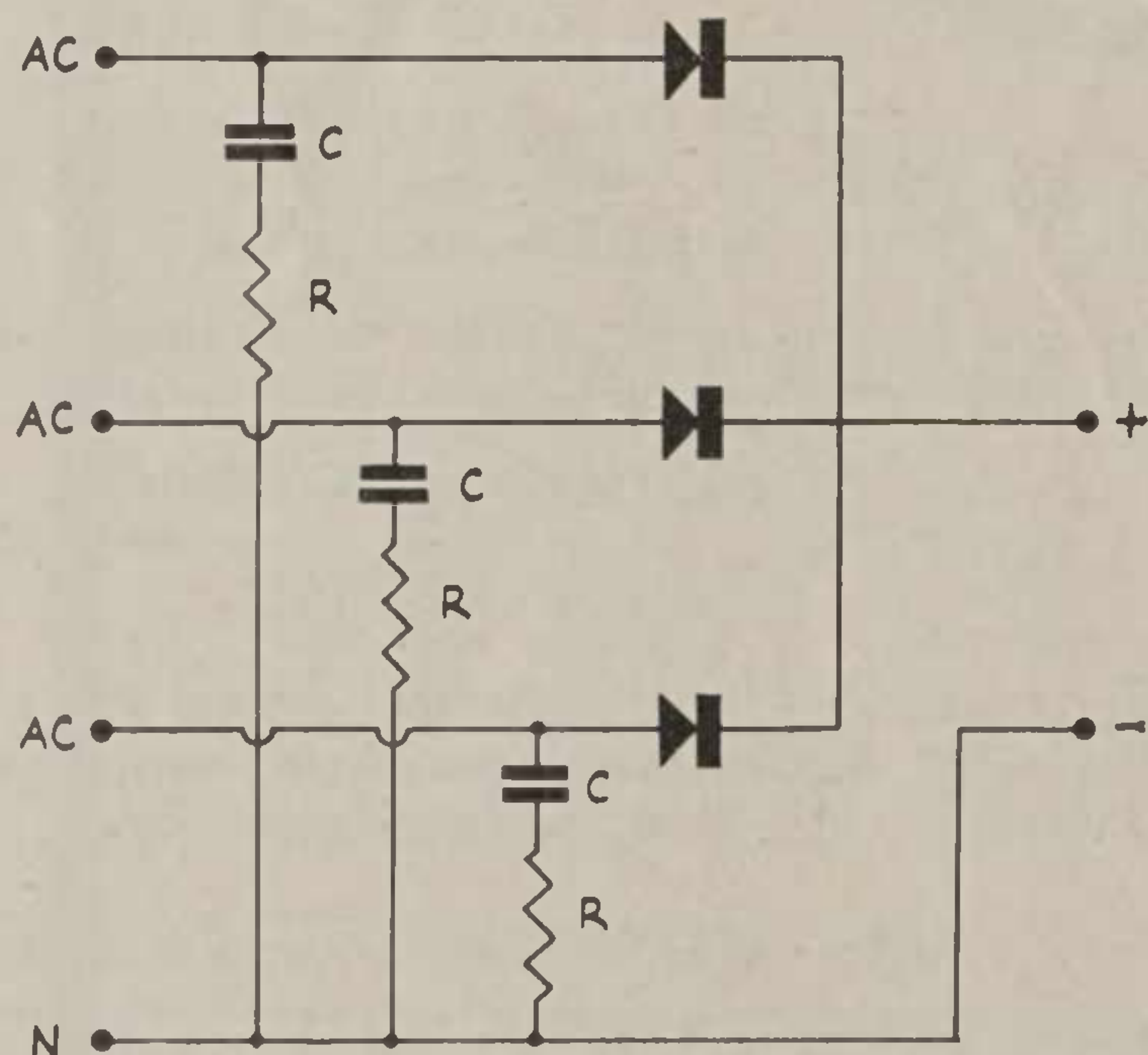


FIG. 4. HALF WAVE

(b) Three-phase Circuits

(1) Switching off the Transformer Primary

In three-phase circuits the value of the suppression capacitance required to suppress voltage surges arising at the instant of switching off the primary depends not

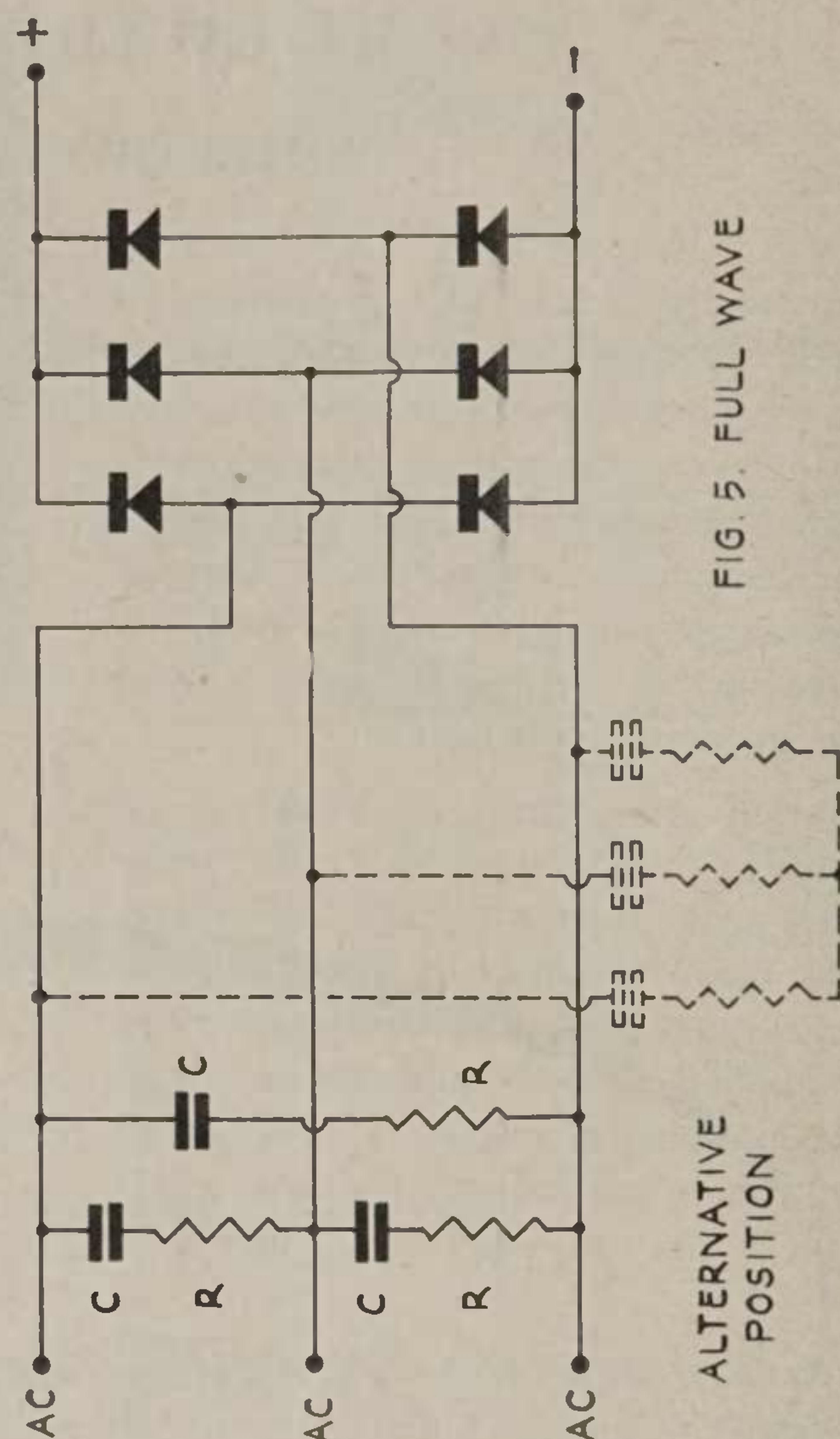


FIG. 5. FULL WAVE

only upon the total volt-ampere rating of the transformer but also upon the type of connections used.

For 50 cycles per second operation up to 5 kVA total transformer rating the value required per phase for the normal half wave or full wave bridge connection is given by:

$$C = K \frac{\text{Total Transformer VA Rating}}{(\text{Rectifier rated PIV})^2} \mu\text{F}$$

where K depends upon the transformer and capacitor connections and can be obtained from the following table.

Transformer Connection	Value of K for Delta connected Capacitors	Value of K for Star connected Capacitors
Full Wave: Star-Star. Primary Star point floating	150	450
Full Wave: Star-Delta. Primary Star point floating	300	900
Full Wave: All other connections	900	2700
Half Wave: All connections		

At frequencies of 100 cycles per second and above the value of suppression capacitance required per phase is given by

$$C = \frac{K_1 \times \sqrt[3]{\text{Total Transformer VA Rating}}}{f^3 \times (\text{Rectifier rated PIV})^2} \mu\text{F}$$

Values for K_1 can be obtained from the table below.

Transformer Connections	Value of K_1 for Delta connected Capacitors	Value of K_1 for Star connected Capacitors
Star-Star, Primary Star point floating	3×10^{10}	9×10^{10}
Star-Delta, Primary Star point floating	6×10^{10}	18×10^{10}
All other connections	18×10^{10}	54×10^{10}

(2) Switching on the Transformer Primary

As in the case of single phase circuits, surges may occur at the instant of switching on the transformer primary. These should be limited to a safe value by connecting a damping resistor in series with the suppression capacitor. The value of this resistor is approximately given by:

$$R = 100 \sqrt{\frac{R_L}{C \times \sqrt{f}}} \text{ ohms}$$

where C is the suppression capacitance in microfarads,
 R_L is the load resistance in ohms, and
 f is the frequency in cycles per second.

Recommended connection arrangements for various three-phase rectifier circuit configurations are shown in figures 4 and 5.

Note:

In the case where the rectifier has a large smoothing capacitor connected directly across the rectifier output terminals, switch on surges of up to twice the peak alternating voltage may occur. These must either be suppressed or higher voltage rectifiers used in the same manner as described in the section above on single-phase circuits.

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Technology

AN INTRODUCTION TO TELEMETRY

Part 2: TRANSDUCERS

In Part 1 of this series we showed how the purpose of telemetry is to enable us to measure things at a distance from the place at which they are occurring. So far we have considered broadly the means by which the information, once measured, is conveyed to the distant observation point. The first step, however, in any telemetry system, is to measure the quantity whose value we want to know. This is done by a device called a transducer. Perhaps the best way of defining a transducer is as "a device which is used to convert energy from one form to another". This definition holds whether we are using the trans-

ducer for measuring purposes or not, and we have numerous examples in use around us every day, though these are not usually the type that is used for measurement. Examples are microphones and loud-speakers. The former transforms vibrational energy of the air into electrical energy, whilst the loud-speaker does exactly the reverse, namely turning electrical energy into vibrational energy in the air. A gramophone pick-up is a transducer for changing vibrational mechanical energy into electrical energy, while a tape playback head converts a moving magnetic field (which is another form of energy) into electrical energy.

In telemetry, some of the items that have to be measured are control surface displacement, fuel pressure, altitude, speed, acceleration, rate of climb, air-flow, force, weight, and so on.

Some of these things represent simple mechanical movement, and so can be converted directly into electrical signals of one sort or another. Some, however, like pressure, must first be transformed into mechanical movement before they can be changed into electrical form by the transducer. Thus, a transducer may be something as simple as a potentiometer, mechanically linked to some moving part whose movement must be monitored, or it may be a combination of two devices,

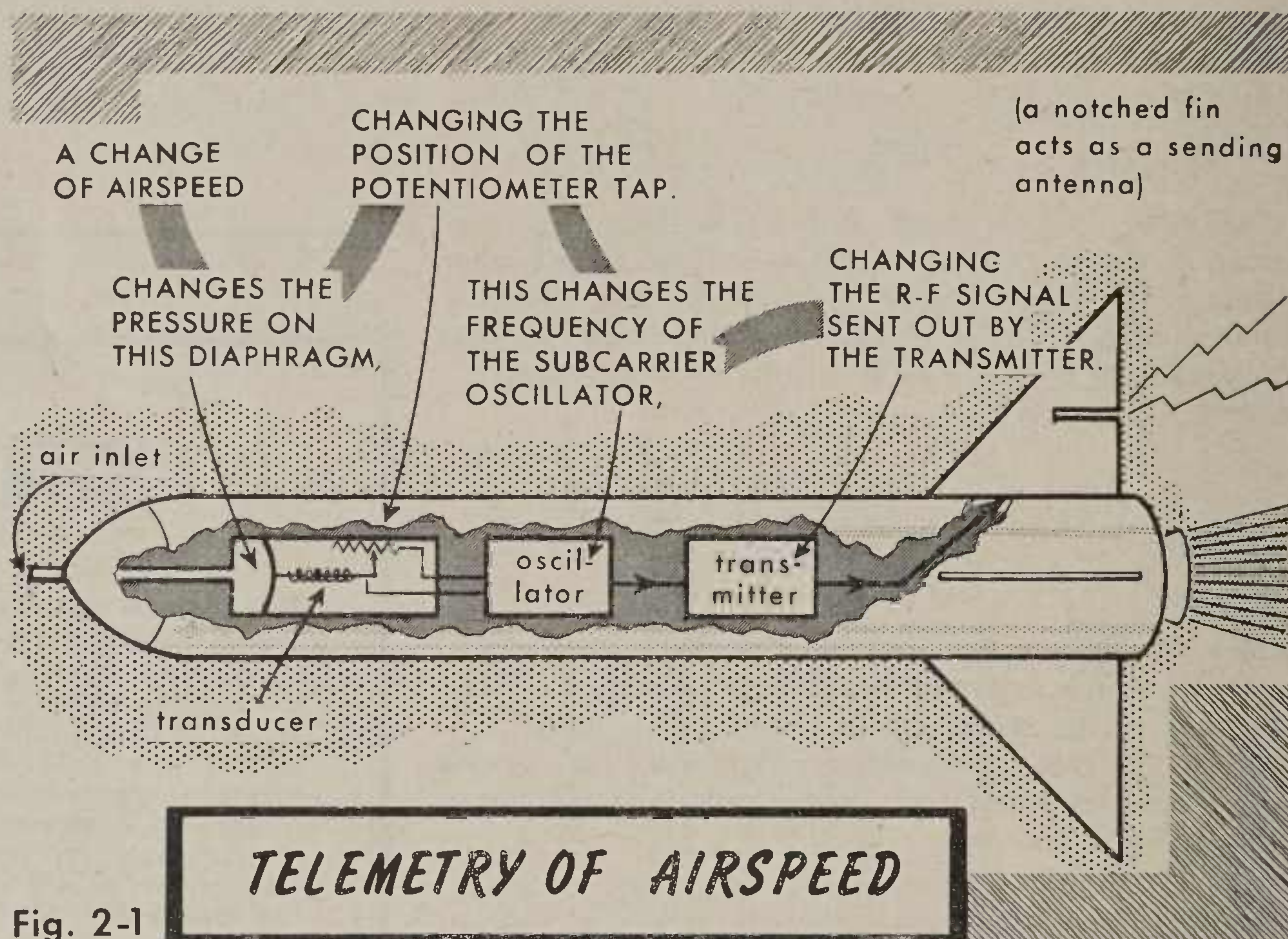


Fig. 2-1

for example one, such as a flexible bellows, converting pressure into mechanical movement which is then caused to vary the resistance of a potentiometer, or the inductance of a coil. As can be imagined, the number of different ways of making a transducer for a given job are many and various, and are limited almost solely by the ingenuity of the designer. An example of the kind of thing that is done in practice is illustrated well by Fig. 2.1. Here, the speed of the missile through the atmosphere produces a pressure which moves a diaphragm. This in turn moves the tap on a potentiometer, which is connected as a frequency-determining element in the circuit of an audio oscillator. The output of this oscillator is a sub-carrier, and variations of pressure alter or modulate its frequency. Before the missile leaves the ground, the frequency of the sub-carrier oscillator is calibrated in terms of air-speed, so that when the missile is in flight, a ground receiver detects the sub-carrier, which is amplified and applied to an audio frequency meter, thus enabling the air-speed to be continuously monitored, and if necessary, recorded at the same time.

The basic principal of transducer design is to mechanically vary either resistance, capacity, or inductance. Any of these can be used to vary the fre-

quency of a sub-carrier oscillator in the primary modulation process.

Other Types of Transducer

There are also transducers using photo-electric principles. In these, the original quantity to be measured is made to vary the amount of light falling on a photo-cell of the photo-voltaic or photo-conductive types, their current or voltage output being then made to vary the frequency or amplitude of the sub-carrier oscillator.

Transducers may also be classified according to whether they are active or passive. Active, or generating types of transducer are those which themselves generate an output voltage. They can be piezo-electric, photo-voltaic, magnetic, or thermo-electric. Passive, or non-generating types are those which are used to modulate an oscillator, such as the resistive, capacitive, and inductive types illustrated in principle by Fig. 2.2. Although some transducers are obviously more easily used for specific purposes (e.g. a photo-electric one for

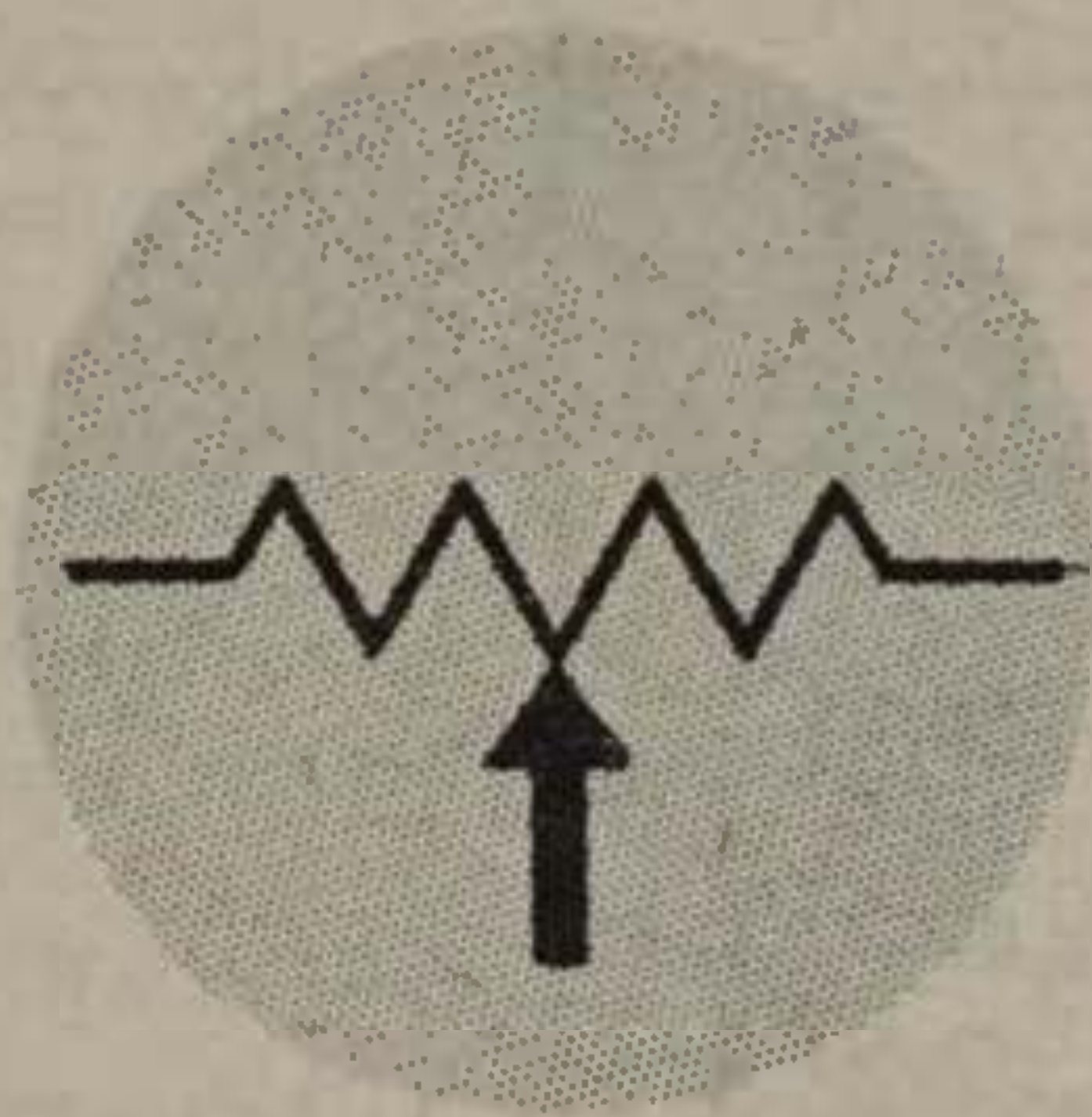
measuring illumination) THE BULK OF APPLICATIONS ARE THOSE IN WHICH THE variation of resistance, capacitance, or inductance is used. Consequently the remainder of this discussion will centre round these devices.

Requirements for Transducers

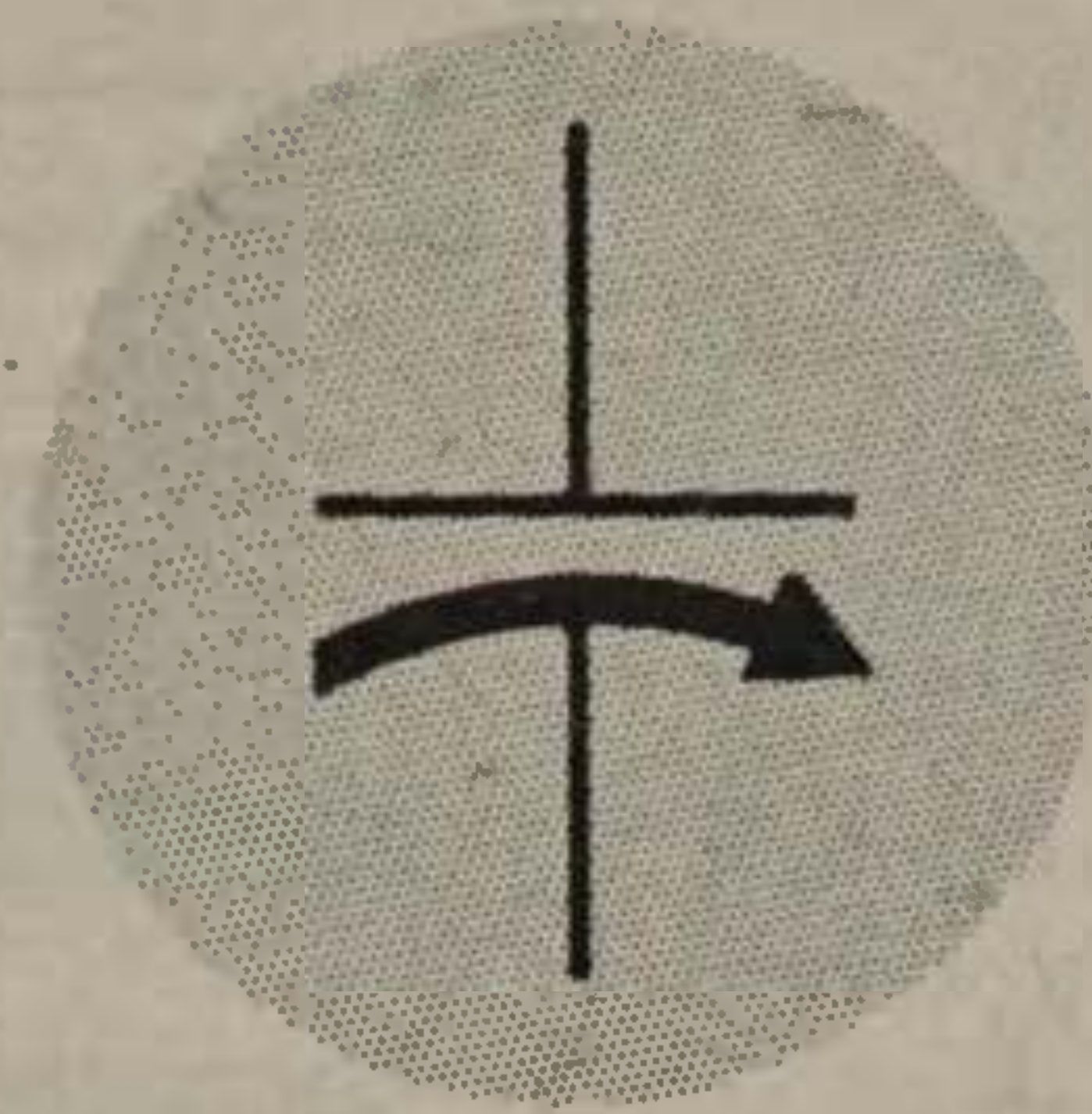
Apart from being fundamentally able to fulfill the required functions, transducers, especially for missile work, must be able to meet other, often quite unrelated specifications. For example, they must frequently be built with the smallest possible size and weight. Also, they must be able to operate in a very wide range of temperatures. Incidentally, the same problems arise even in conventional aircraft, and in telemetry concerned with the operation of atomic reactors, and not only in the field of guided missiles.

Accuracy, too, must be as high as practicable. Quantities must frequently be measured to 0.5% or even better. In addition, replacement in case of failure must be easy, and there must be a minimum of adjustments required to

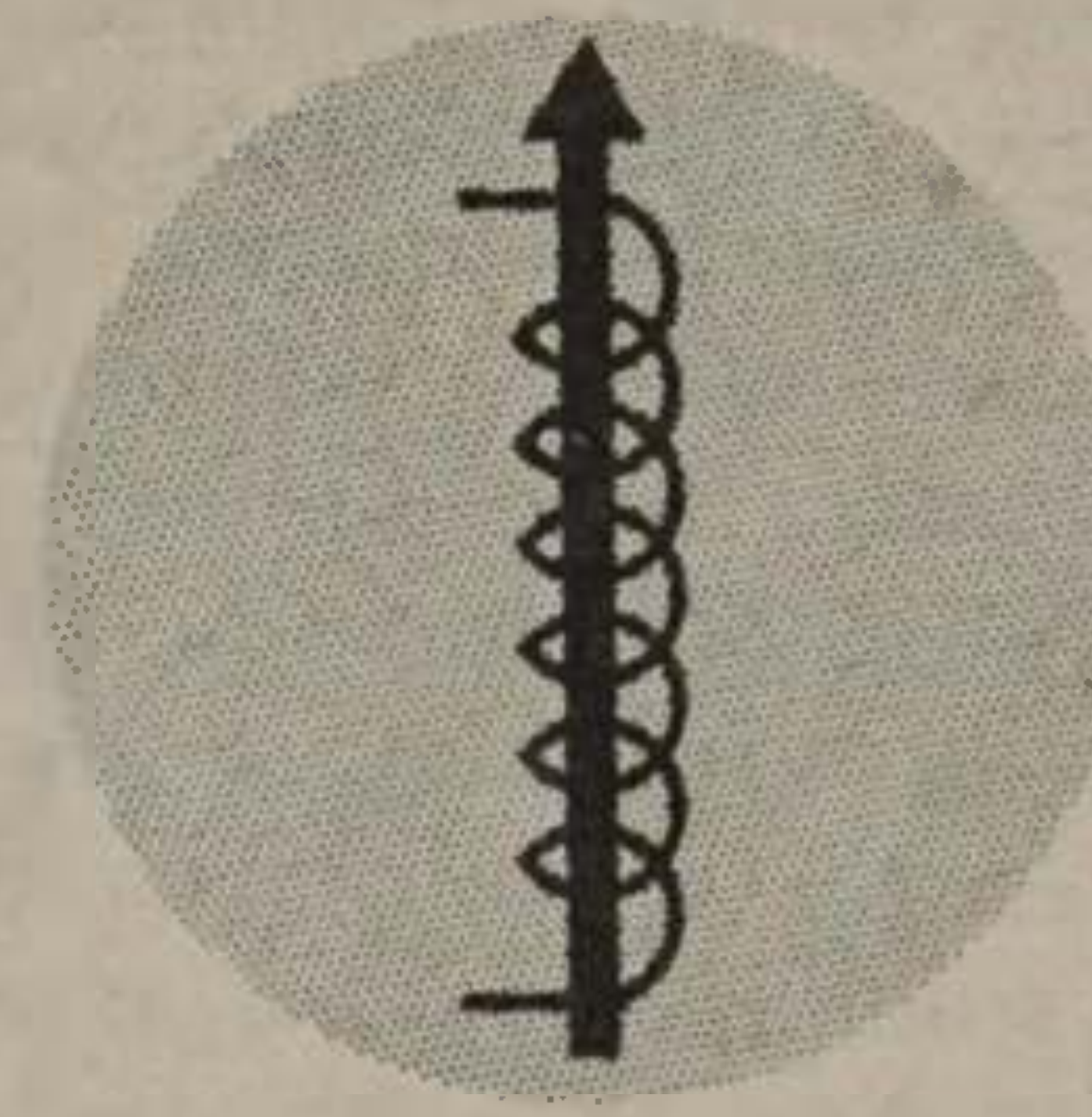
THE BASIC ELECTRICAL ELEMENTS OF MOST TRANSDUCERS ARE



**VARIABLE RESISTANCE
MOVABLE SLIDER**



**VARIABLE CAPACITANCE
MOVABLE PLATE**

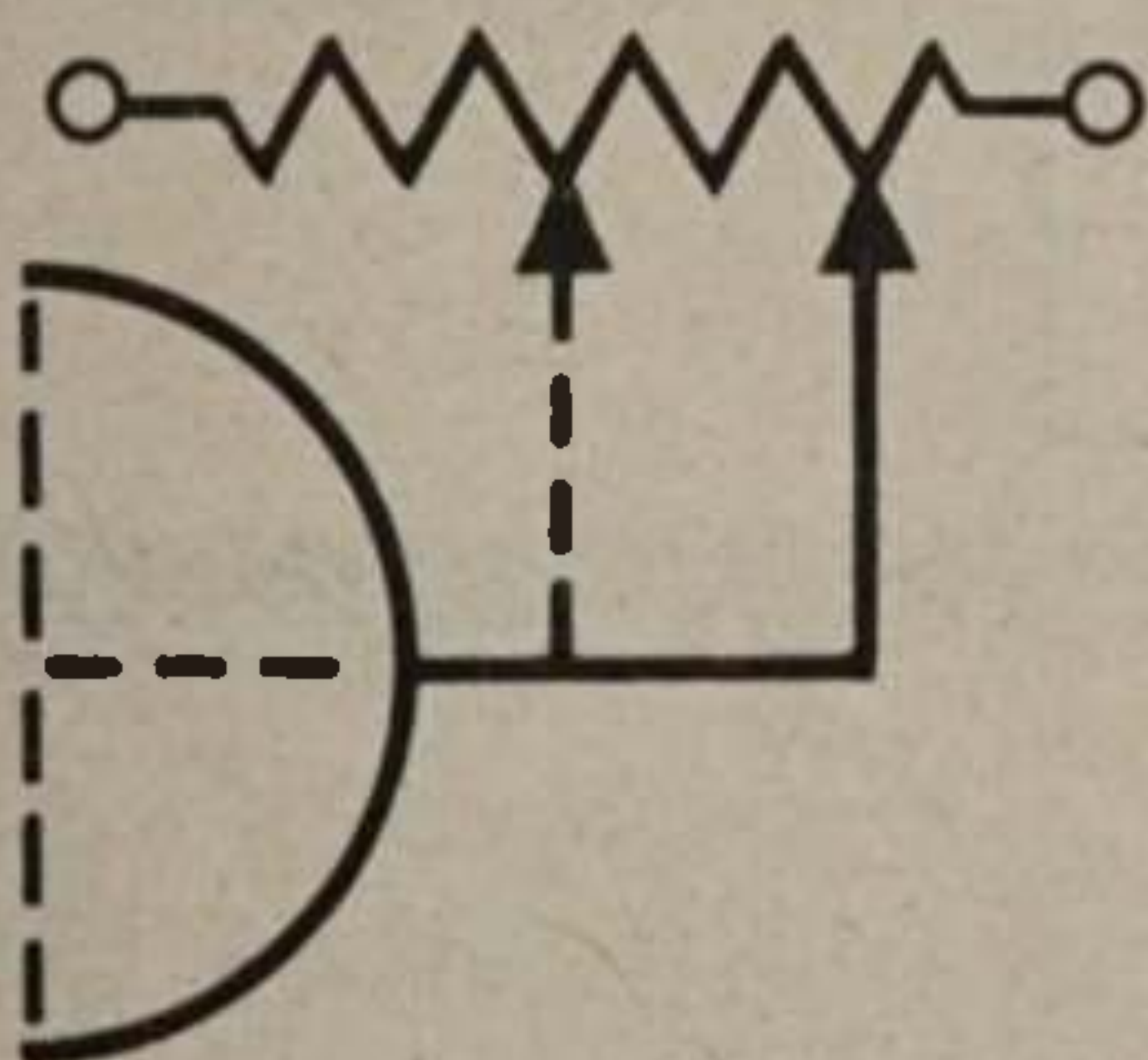


**VARIABLE INDUCTANCE
MOVABLE CORE**

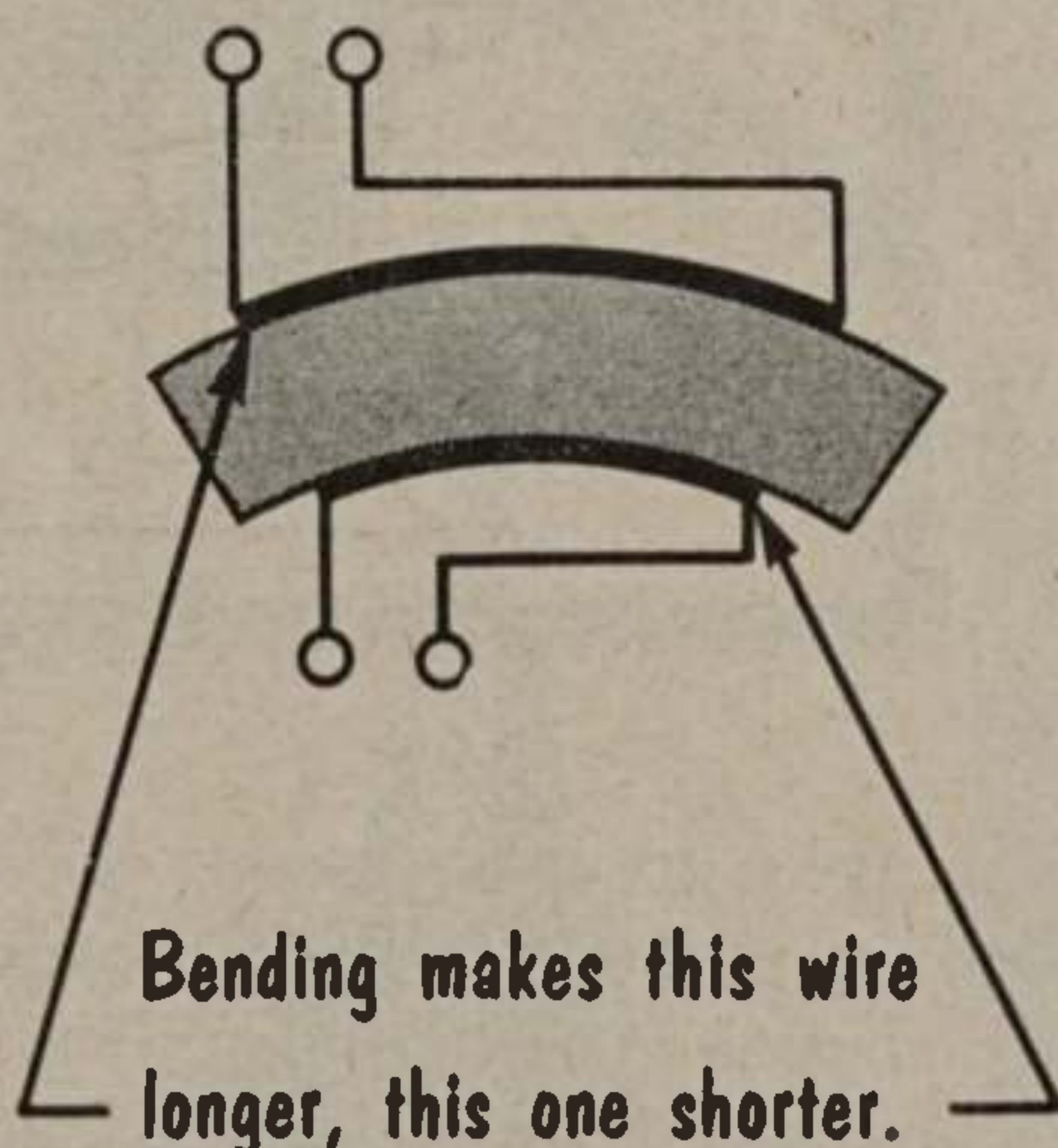
Fig. 2-2

The Resistance in a Transducer may be Varied by

moving the tap of
a potentiometer

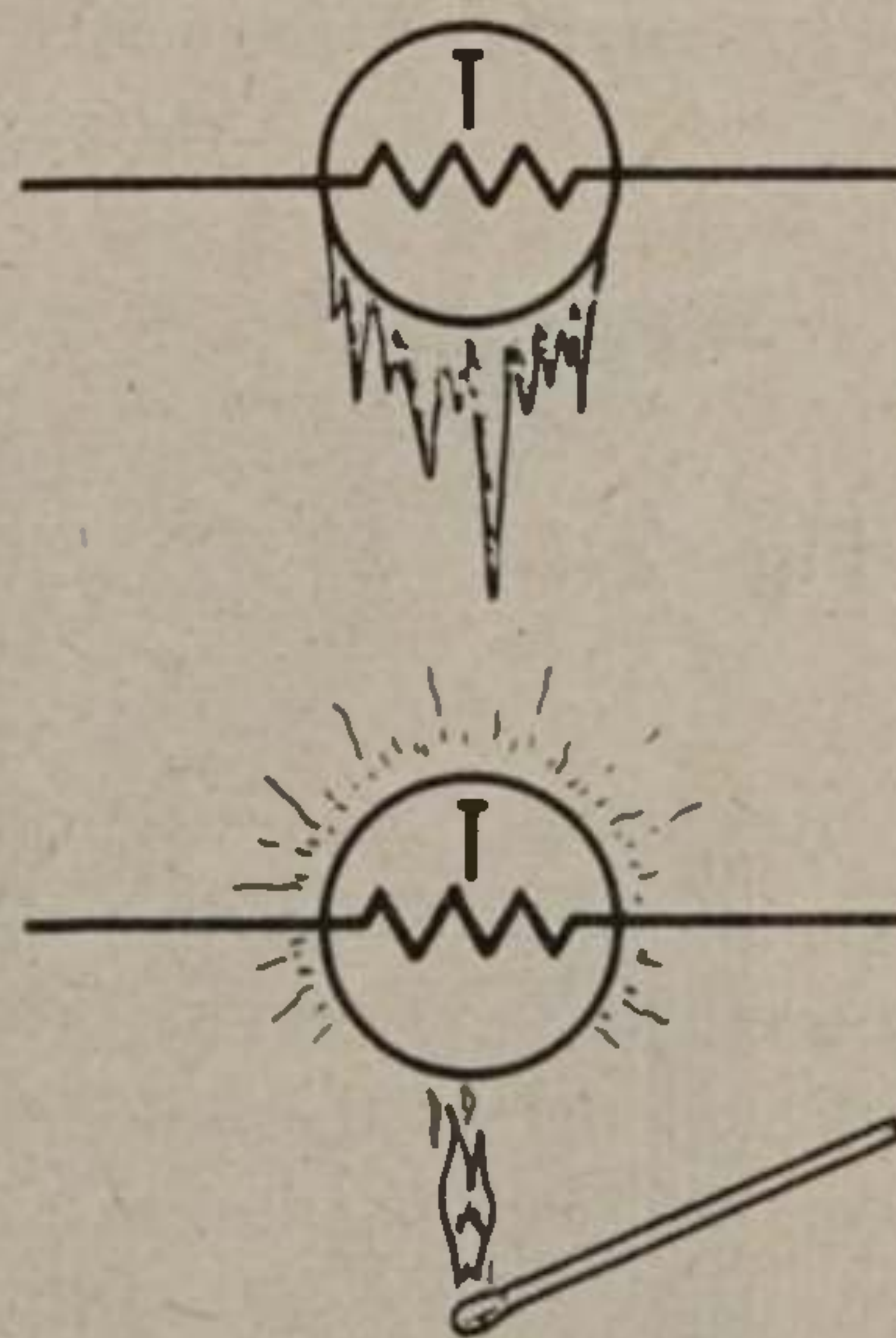


changing the length
of a resistance wire



Bending makes this wire longer, this one shorter. Resistance of the first wire is increased, that of second decreased.

changing the temperature
of a thermistor



The resistance of a cold thermistor decreases as it is heated.

Fig. 2-3

set the apparatus up, and servicing must be as easy as possible. These requirements must all be met almost regardless of cost, for missiles and complete telemetry systems are so complex, overall, that failure of components must be kept to a minimum, regardless of expense, if the system is to work at all. To give an idea of the effect of component failure on overall reliability of a complex system, we can quote the case of one defence type of guided missile. This relies on a complicated radar system for detection and plotting of targets, and on a second radar system, some of which is in the missile itself, for guidance to the target after launching has taken place. Thus, the missile itself is only one small (though essential) part of a complete system for the shooting down of aerial targets. If any part of any unit of the whole system breaks down while in use, the missile is ineffective. It has been calculated that if every sub-assembly (not even every component) in the system works for 99.9 per cent. of the time, there will still be so many equipment failures that only one missile in three will reach the target successfully. This apparently poor rate of serviceability is then overcome by firing the missiles in salvos of more than three! This indicates not only the vast complexity of the systems in use, but also the phenomenally high serviceability which each component must have in order to make the system a practicable proposition. It also explains why cost is a minor consideration compared with reliability.

Resistive Transducers

In Fig. 2.3 are illustrated three methods of using the principle of resistance variation. The first is a

A BELLOWS-TYPE PRESSURE TRANSDUCER

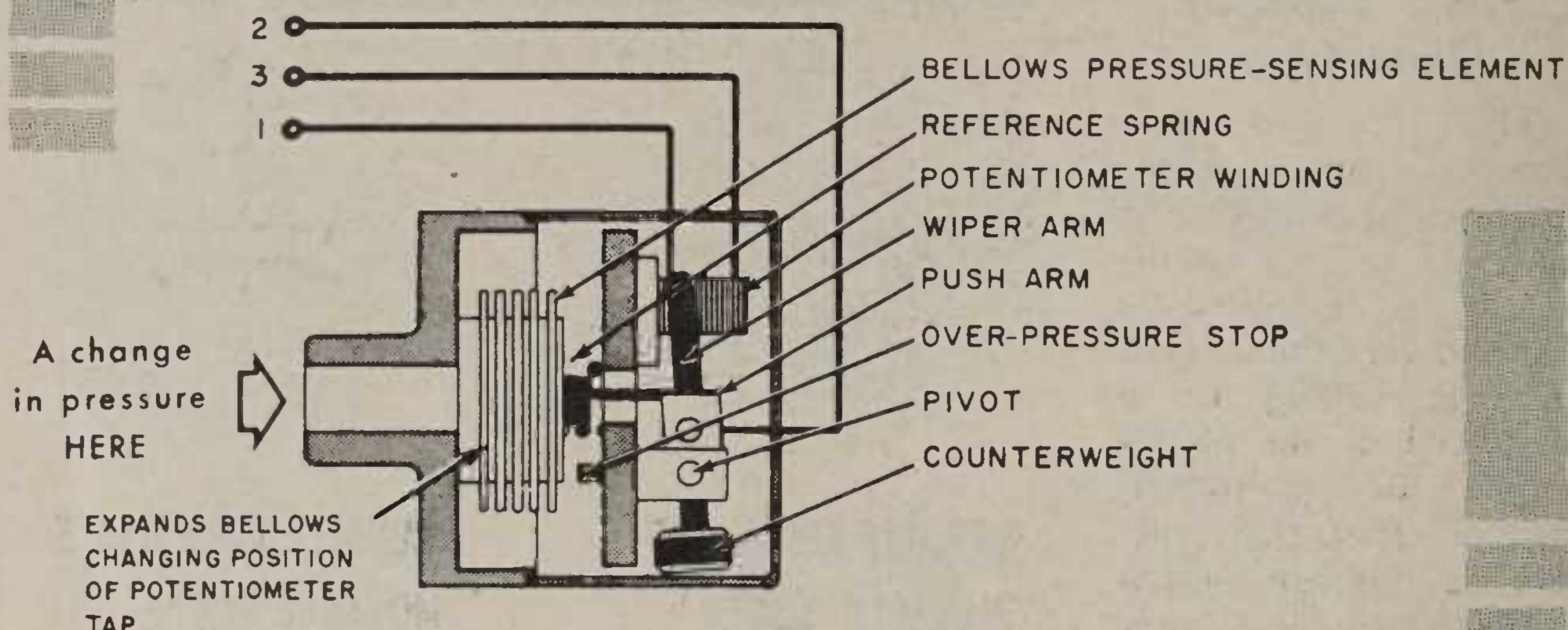


Fig. 2-4

THE BOURDON-TUBE TRANSDUCER

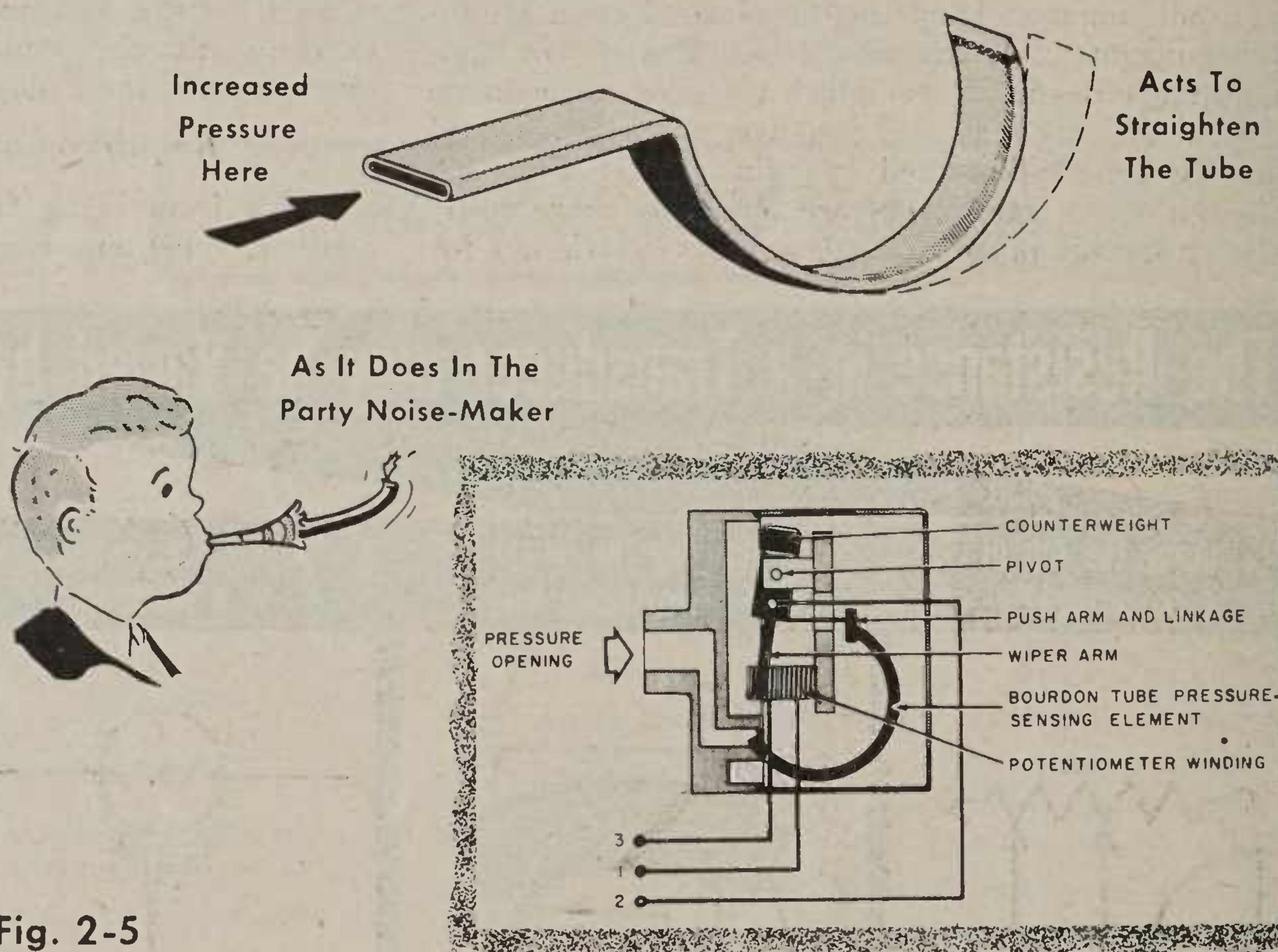


Fig. 2-5

single potentiometer, the tap on which can be varied in a wide variety of ways, of which the movement of a bellows or diaphragm is only one. Potentiometers can be made to respond to linear or rotary motion, while mechanical linkages can be used with either type to translate one type of motion into the other. The variation in resistance can be used to control the frequency of an oscillator directly, as when it is in the frequency-determining circuit of a phase-shift oscillator, or indirectly. In the latter case, a direct voltage can be

placed across the potentiometer, and the portion of it picked off at the tap is then varied by the actuating part of the device. This voltage can then be made to control the frequency of an oscillator which has been specially designed to have its frequency controlled by an applied voltage. A good example of this is the multivibrator, which can have its frequency controlled in an almost linear manner by varying the potential to which the grid leak resistors are returned.

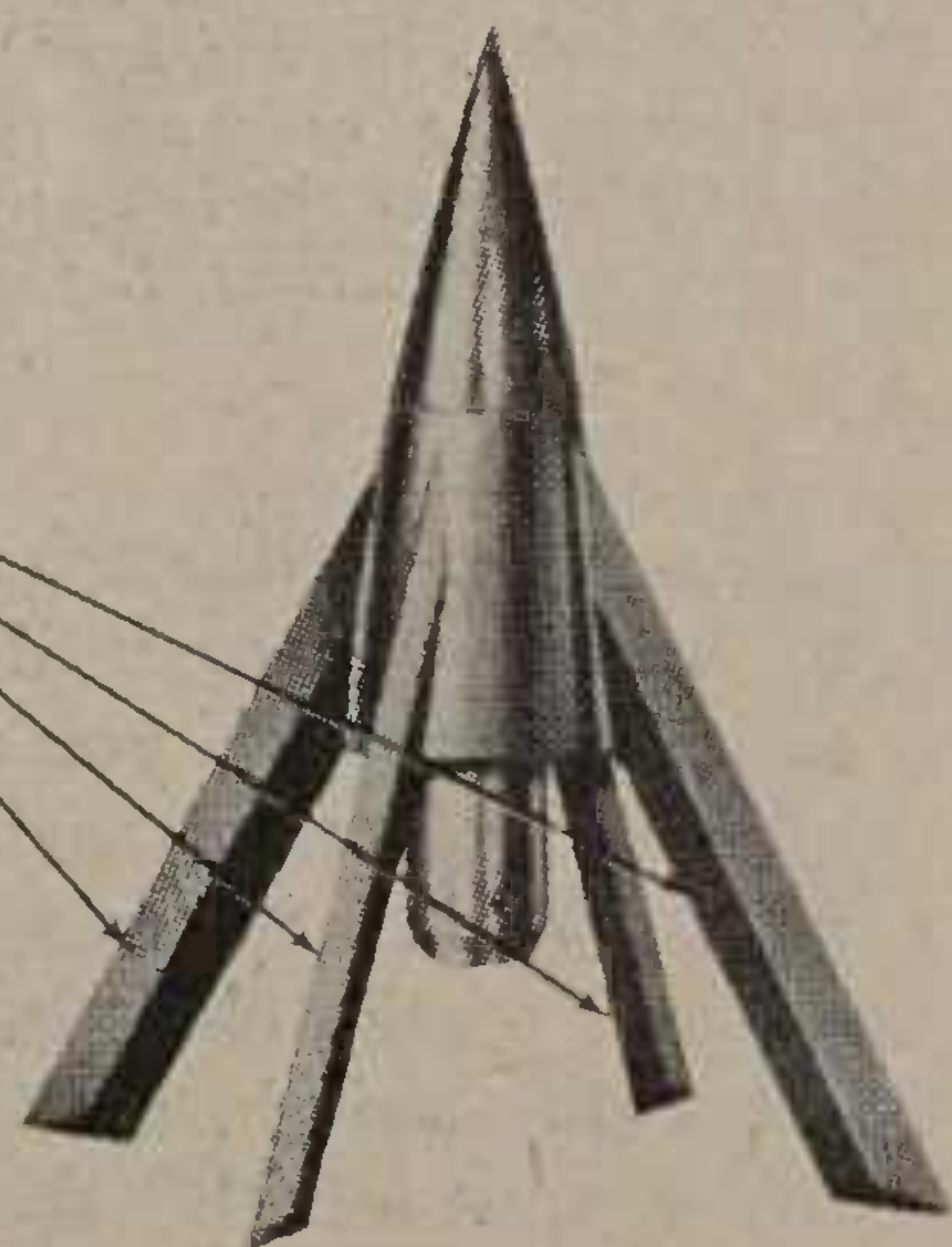
Various expedients are used to make the application of pressure produce mechanical motion, as a prerequisite to varying the setting of a potentiometer. One of these is shown on Fig 2.4, where a metal bellows is used to give (a) more travel and (b) greater accuracy than can be obtained from a simple diaphragm. In a practical instrument the moving part of the system must be counter-weighted so that it will not be sensitive to changes in acceleration, and ball bearings are used to reduce friction.

Another pressure transducer is the Bourdon tube, long used in pointer-type pressure gauges. Its principle is shown by Fig. 2.5, which also shows a schematic of a practical transducer using the principle.

A TRANSDUCER THAT INDICATES PITCH AND YAW

these vanes line up with the slip stream. When the rocket yaws or pitches the entire assembly pivots on a swivel actuating two separate potentiometers.

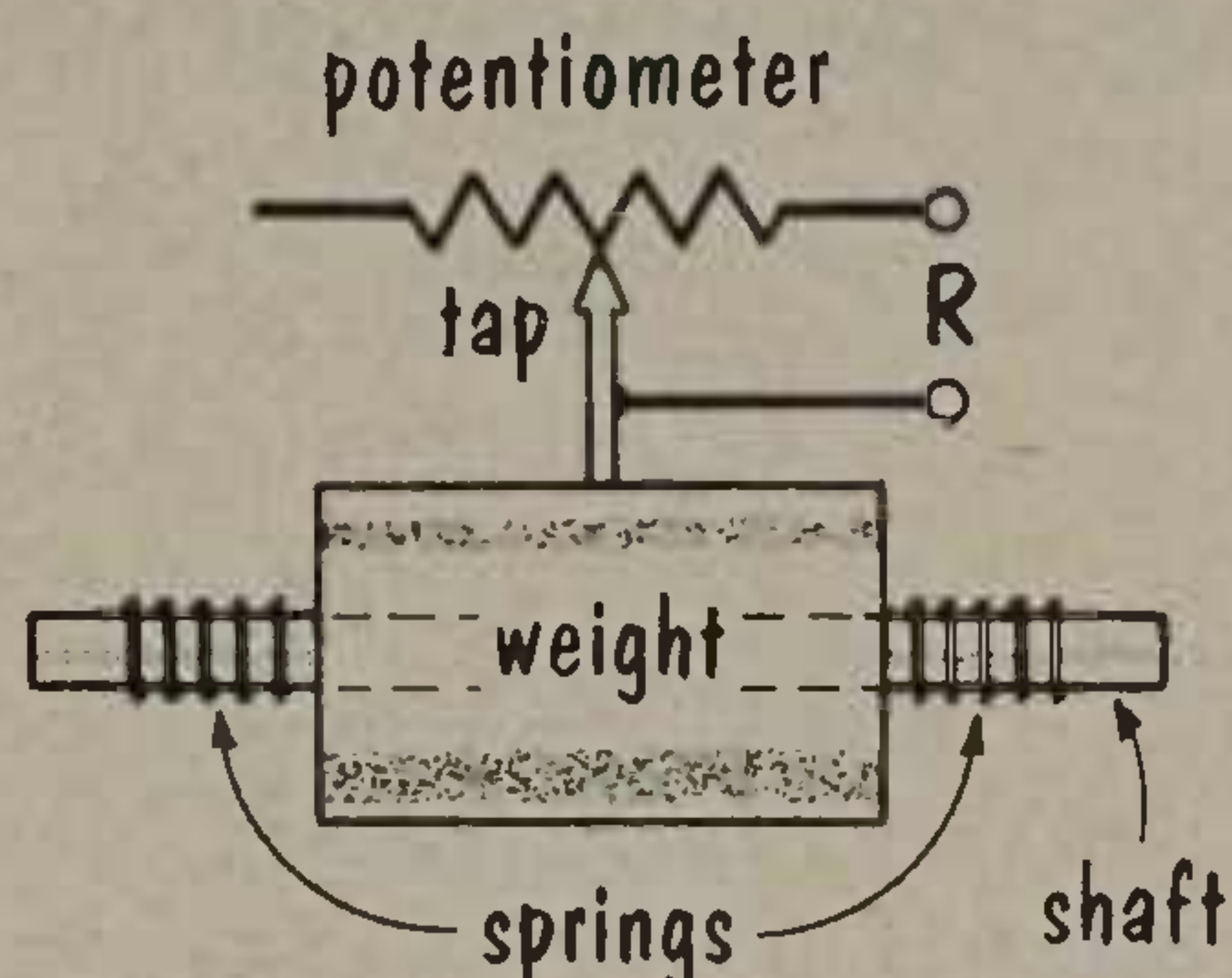
pitch yaw
this movement actuates one potentiometer and this movement actuates the other



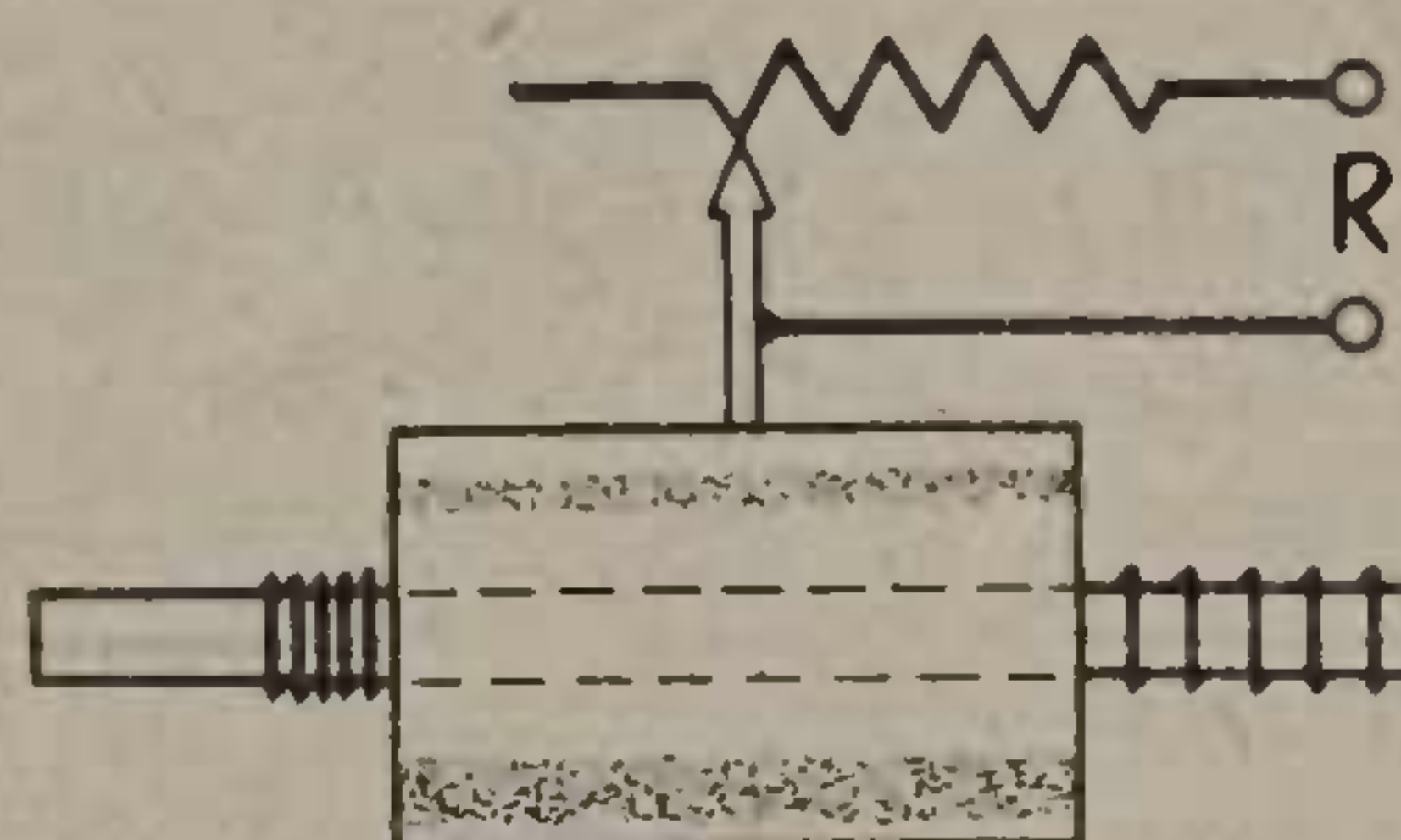
The transducer installed on a Redstone missile

Fig. 2-8

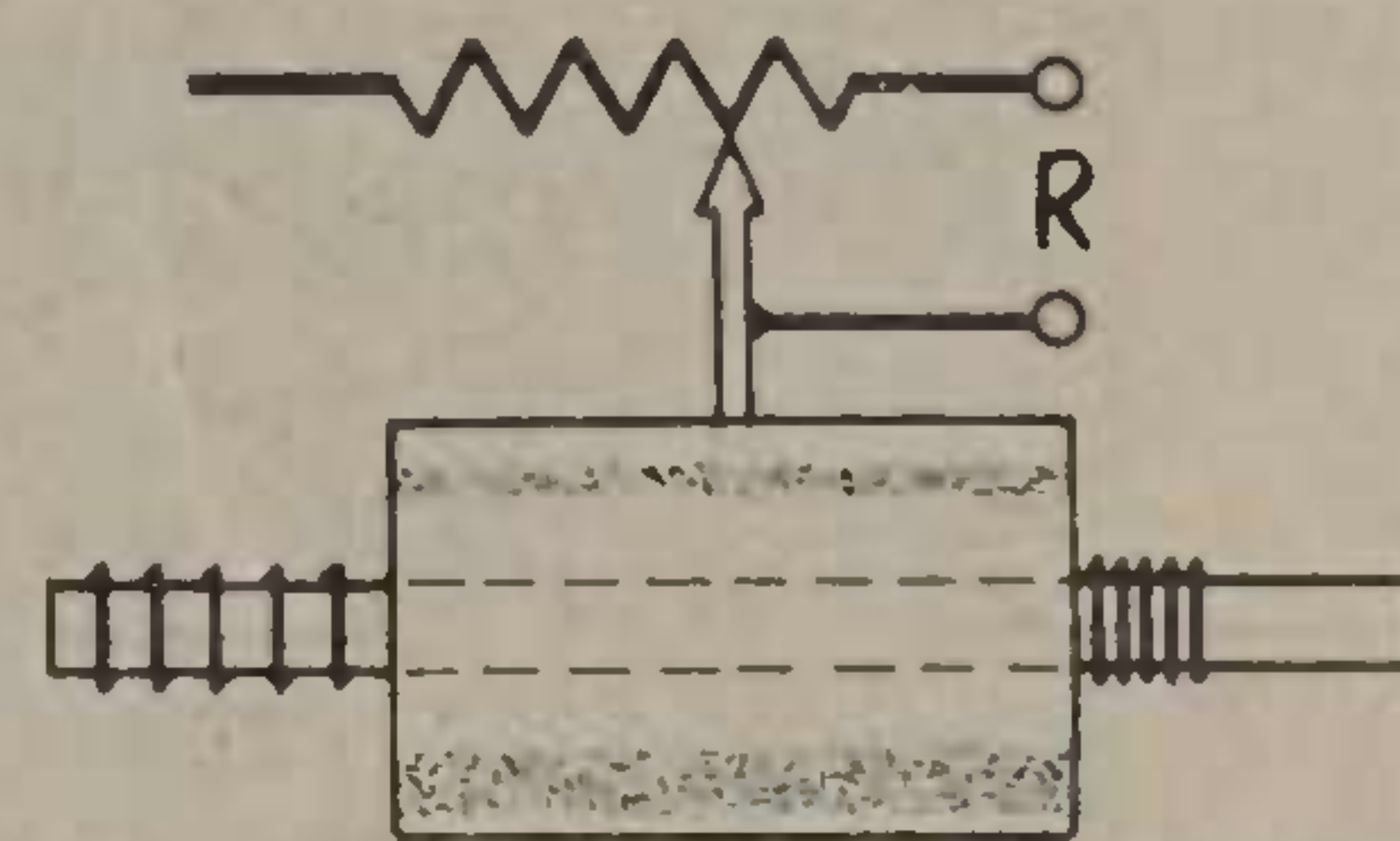
HOW AN ACCELEROMETER WORKS



when missile is standing still or moving at a constant velocity, the weight is kept at the center of the shaft by the springs. The resistance at the tap is medium.



When missile speeds up, the weight moves back on the shaft. The resistance at the tap is high.



When the missile slows down the weight moves forward on the shaft. The resistance at the tap is low.

DIRECTION OF FLIGHT

Measurement of Acceleration

Acceleration is usually measured by noting the movement of a suspended weight, held in a pre-determined position by springs. If the object in which the device is situated is moving at constant velocity, or is standing still (constant velocity of zero), there is no tendency for the weight to move against either spring, but when the missile is accelerating or decelerating, the weight tends to move relative to its mounting, and the potentiometer is thus operated.

A more complex transducer, designed to measure two quantities at once, is illustrated in Fig. 2.8. It employs two potentiometers at right-angles, one measuring pitch, and the other yaw, both being actuated by the system of vanes, which automatically aligns itself with the airstream past the missile, so that deflections of the missile from its existing straight path are detected in movement of the vane relative to its support.

A very useful type of transducer is of the strain-gauge type. This is illustrated in principle in Fig. 2.3. In one pressure transducer, a bellows pushes one end of a cantilever beam, thereby bending it. On both bending surfaces of the beam are mounted flat

(Continued on page 37)

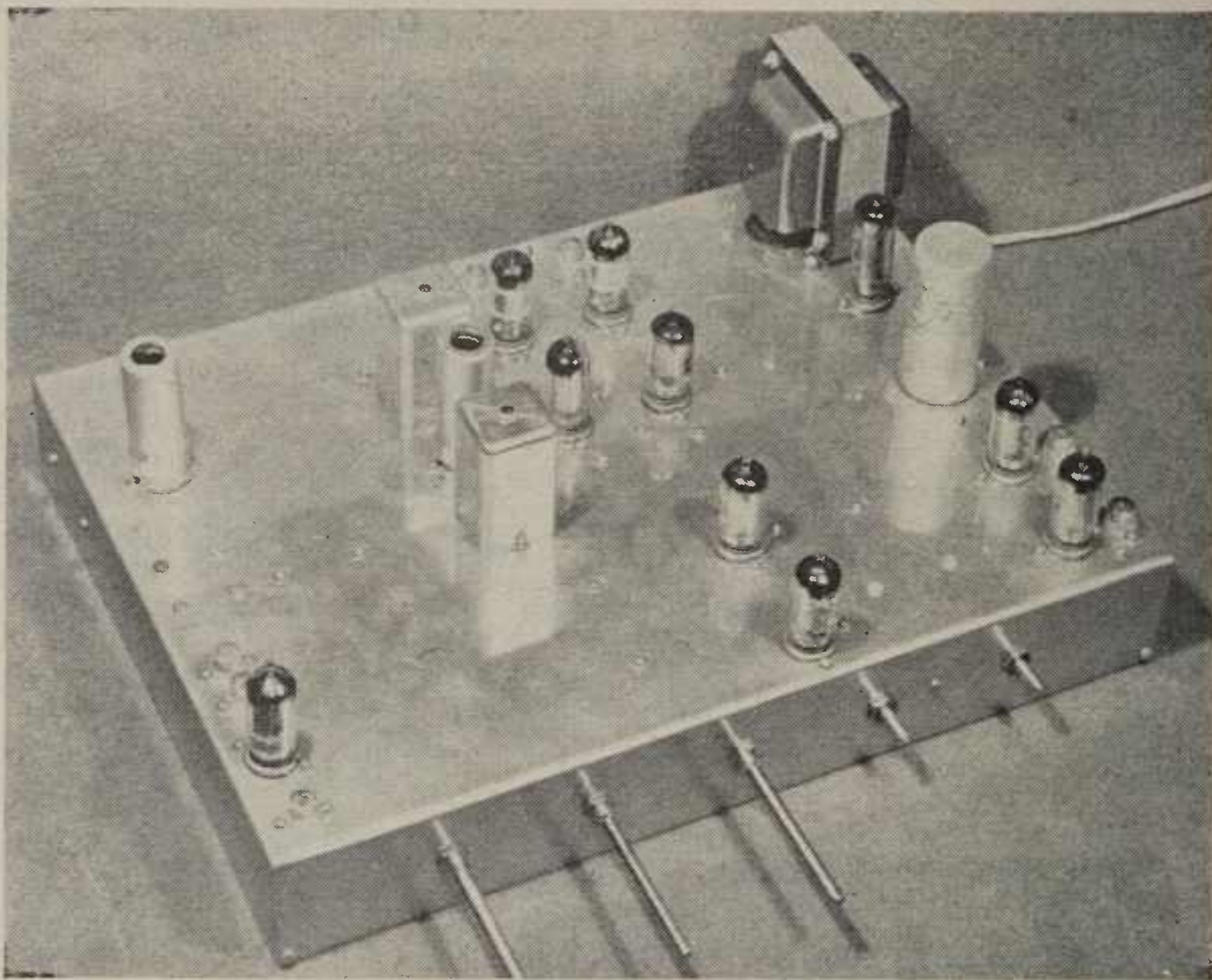
A COMPREHENSIVE AUDIO SYSTEM FOR HOME USE

Part 2: The Tuner and Pre-amplifier Section

Part 1 of this article, which appeared in last month's issue, described the system as a whole, and gave details of the power amplifier that was constructed specially for it, and which can be duplicated for stereo operation of the system. This month we present all the remaining circuits, which in our case were built on a single large chassis, with its own small power supply. Included is a broad-band local broadcast tuner of excellent performance, a dual pre-amplifier for high-quality magnetic pick-ups, and a circuit providing tone, volume, and balance controls.

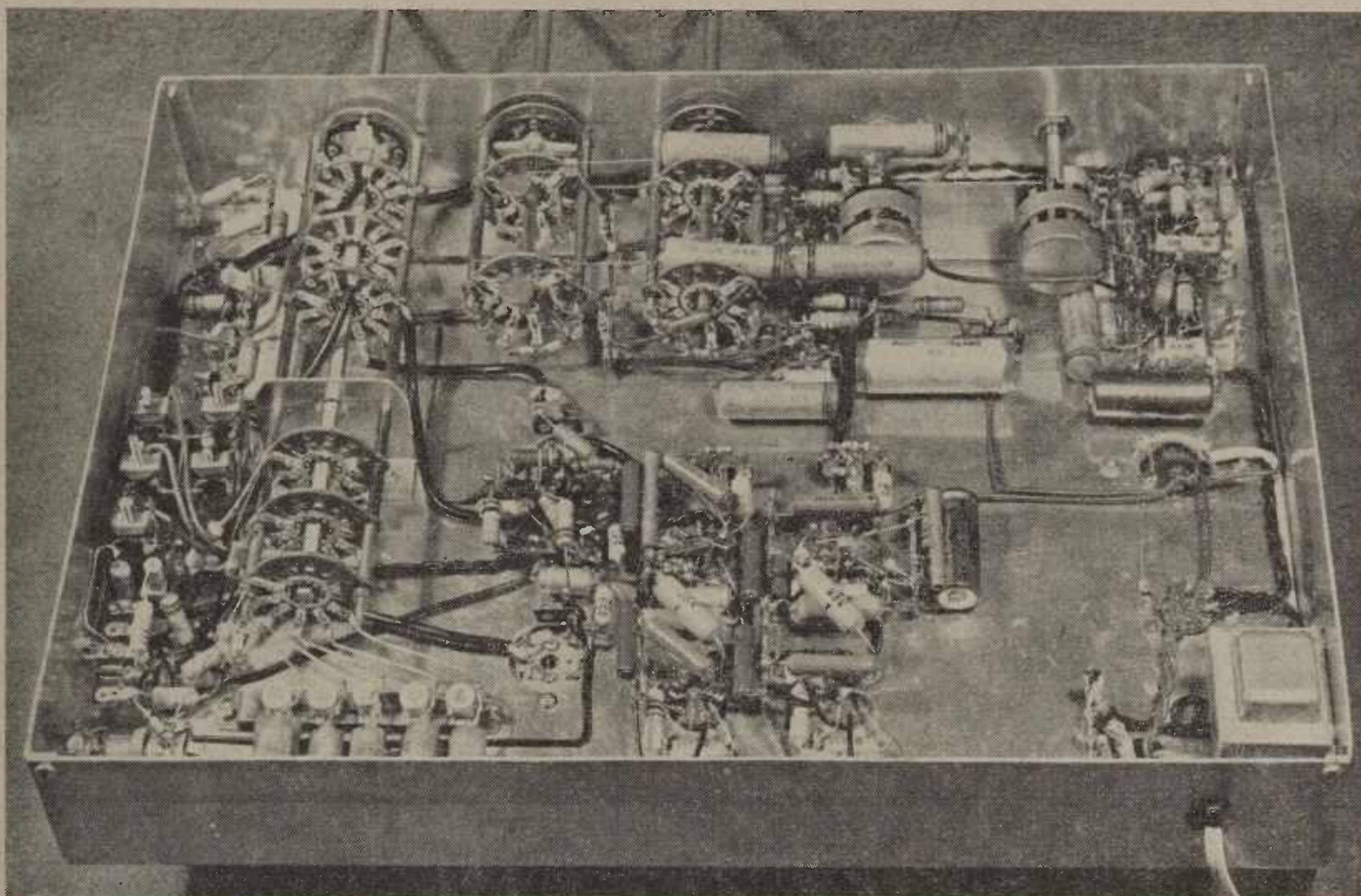
Introduction

Those wishing to build an outfit similar to this one, but not identical with it, should find little difficulty in making the necessary modifications, using what is illustrated in this instalment as a basis. Fundamental to the system is the arrangement of switching, shown in the block diagram given last month. In principle, any individual circuits that might be deemed satisfactory to the builder's purpose could be used, and any individual portions of the system could be omitted. For example, if one is not going to use a low-level magnetic pick-up, it would be quite in order to omit the four pre-amplifier valves, feeding the crystal or ceramic cartridge straight into the selector switch sections, S_{1a} and S_{1b} , and thence to the cathode followers which precede the Baxandall tone control circuit. Similarly, if one wants to make provision for building the two channels, for stereo operation, but wants to get the thing going as a purely monaural device first, it would be a simple matter to omit the bulk of the wiring associated with the second channel, but to install all the valve sockets, and wire up their heater pins so as not to make this operation too difficult at a later date. However, if it is proposed to build only a portion of the pre-amplifier, in this way, be sure to plan carefully just how the modifications are to be made, so that completion will be easily done later on. In particular, purchase the switch just as it will be needed for the full circuit, and wire it up accordingly, because once it is installed, it may be difficult to complete the wiring to it, which is much more easily done before it is put in position in the chassis.



Top view of the chassis. The control shafts, reading from left to right are, Main Selector Switch, Bass, Treble, Balance, and Volume. The tone and volume control circuits are spread along the front of the chassis, with the ECC82 at the extreme left. Next come the EF86s in the Baxandall circuit, and at the extreme right are those in the anode-follower output stages. The four EF86s in square formation at the rear are the two pick-up pre-amplifiers. The ECH81 is at the left at the back, and the EBF80 is between the two I.F. cans, the back one being the first transformer in the circuit.

Another modification that many builders may want to make is to omit the broad-band tuner, which will not be required if you already have a high-quality tuner which can satisfactorily be used. To make this omission, all that is necessary is to cut off the left-hand portion of the chassis, finishing this just to the left of the main switch, and install an input socket to which the output of the separate tuner can be taken.



Underneath view of the completed chassis. The cluster of oscillator coils can be seen to the left of the main switch and the row of aerial trimmers, in front of it.

Details of the Circuit

The circuit has been printed in three sections, each of which can be related to the block diagram which appeared in Part 1 of this article. Working backwards from the output terminals, we have first of all the circuits of the output anode-follower buffer stages. These are preceded by the volume and stereo balance controls, and then by the Baxandall tone control circuits. On the diagram, we have drawn only one of the two channels, to avoid unnecessary duplication. The power supply for the whole unit also appears on this drawing, and we have drawn in full the circuit of the ECC82 whose halves are used as the input cathode followers. This has been done because there is a slight difference between the two halves. On the upper one, channel A, a tapping has been made on the load resistor of the cathode follower as a pick-off point for feeding a tape recorder's record amplifier. This tapping has been omitted on the lower half, which is channel B. However, if you have a stereo tape recorder, and want to use it for tapping the channels from a stereo disc, Channel B can be made identical with Channel A at this point.

The overall gain of the circuit from the input of the cathode followers to the output terminals is a little less than unity, because of slight losses in the balance control circuit, and in the anode follower buffers,

which themselves have a gain of less than unity when the volume control is in its maximum position.

It is not intended to give a full description of the tone control circuit, because this is a quite well-known arrangement. The unusual feature is the use of seven-position switches rather than continuously variable potentiometers. This was discussed in Part 1 of this article, and since then has been found eminently satisfactory in actual use.

Reference to the chassis diagram will show that this part of the circuit has been well spread out. There is a good reason for this, even though it does make the chassis rather longer than most. It enables the control knobs to be well spaced—at $2\frac{5}{8}$ in. centres, to be precise—which is quite a convenience in operating. It also makes plenty of space available for the wiring, which still gets done without unduly long leads anywhere. It is not easy to make the circuit very much more compact, because of the switches, but those who want a shorter chassis could easily space the knobs closer together if they so desire, the minimum spacing being governed by the proximity of the tone control switches and the main function switch.

The power supply is straight-forward and simple. In spite of the relatively large number of tubes used, the heater requirements are fairly light and come within the rating of the transformer used, so that there is

no need to add a separate filament transformer. A word of warning here, however. If you want to compress the chassis a bit, be careful of the proximity of the power transformer to the valves of the gramophone pre-amplifier. As originally built, there is just over three inches of space between the nearest pre-amplifier valves and the power transformer, and to our horror, this pre-amplifier channel suffered from noticeable hum, while the other was as quiet as we have come to expect from these EF86 circuits. The reason was found in the proximity and orientation of the power transformer, which had been mounted with the laminations running from left to right. Turning the transformer through 90 degrees, to the position illustrated in the photograph completely cured the trouble.

The Main Function Switch

Before going on to describe the rest of the circuit, it would be best to say something about this component. It has six wafers, which have been labelled S_{1a} to S_{1f} respectively. Wafers a and b switch the audio inputs to the two channels, and in addition, perform the necessary function of parallelling the channels, at the inputs of the cathode followers, for obtaining a monaural output from stereo records or tapes. On radio, the block diagram shows that the tuner output is simply fed to both channels simultaneously, but where we have a source, such as a stereo pick-up, which has two-channel output, special arrangements have to be made where we want to parallel the channels, in order to use the pick-up on monaural discs. These arrangements are a little difficult to draw on a circuit diagram, although they are very simple to put into practice, so a brief description is in order. On the block diagram, we have shown two wipers, separately from the main diagram, and have labelled them S_{1a} (back) and S_{1b} (back). These additional wipers are wired together, as shown.

Now, on most positions of the switch, there are no fixed contacts for these wipers to touch, so that in these positions, the wipers, and their connection together, do absolutely nothing. But in positions 6 and 8 on the switch, there are fixed contacts present, which are electrically connected (by being held in the same rivet) to the corresponding contacts on the front of the wafer. Thus, when the switch is in either position 6 or position 8 (but not otherwise) the interconnection between the back wipers joins together the separate outputs that are fed to contacts 6 and 7, and to contacts 8 and 9. In the case of the gram. pre-amplifiers, their outputs are connected to contacts 6 and 7, which are paralleled at the switch. In position 6, therefore, the back contact arrangement parallels the pre-amplifier outputs, but on position 7, there are no fixed contacts on the backs of the wafers, and the pre-amplifier channels remain separated. Thus, position 6 is "Mono. Gram", and 7 is "Stereo Gram". Exactly similar arrangements are made in relation to contacts

8 and 9, so that the outputs of stereo tape pre-amplifiers can be treated in the same way if desired.

Apart from these two wafers, the switch is quite conventional. There are three wafers concerned with the tuner, while the remaining one is an H.T. switch for the tuner valve, all the others remaining on at all times.

The Gramophone Pre-amplifier

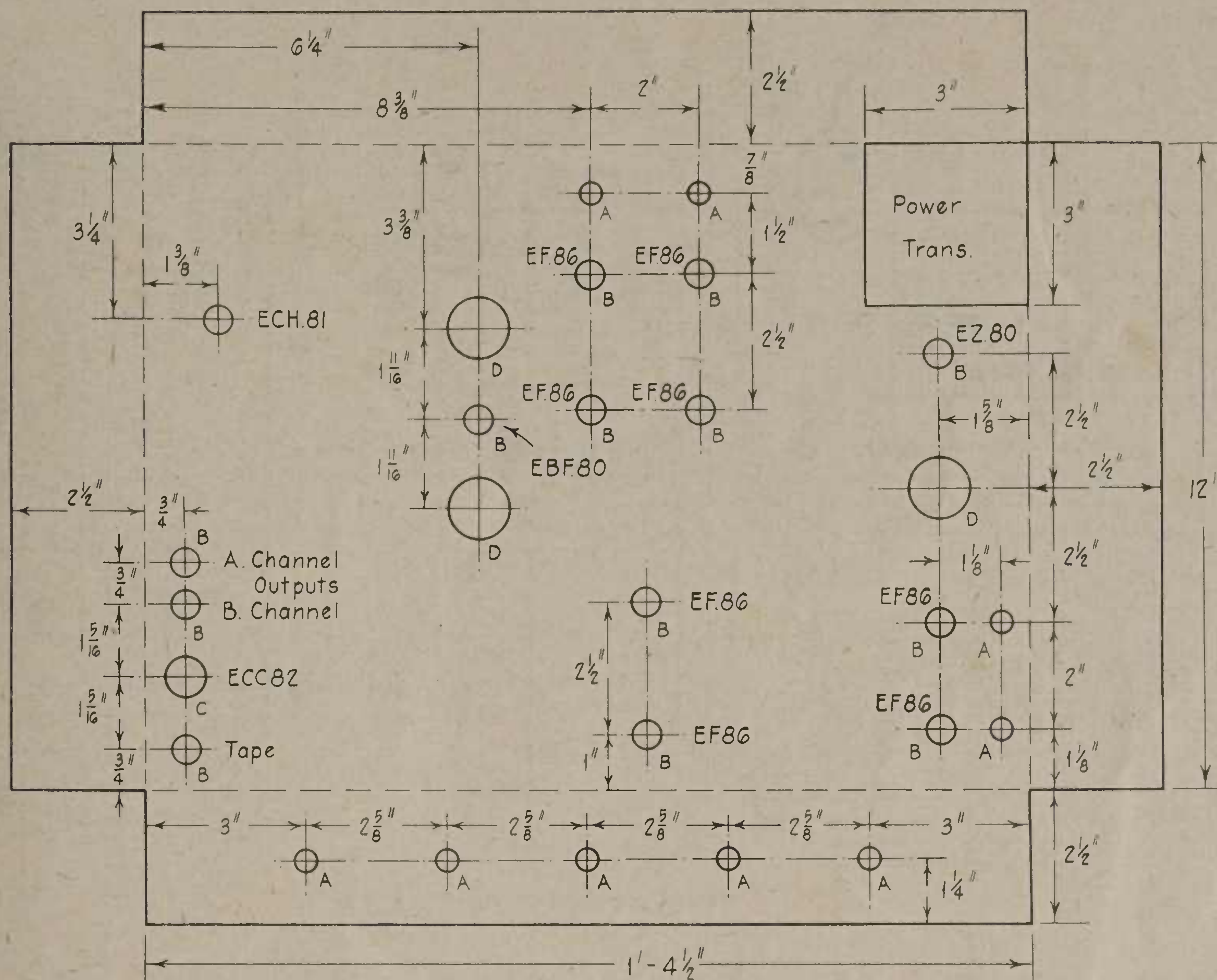
The circuit used here is almost identical with one published earlier in these pages when the first low-level magnetic stereo cartridges became available in this country. The first stage is a straight amplifier with a stage gain of about 200 times. This feeds the equalizing stage, whose gain is slightly less than unity at mid frequencies, and whose response has the necessary rising characteristic below that frequency, and falls above it, to give almost perfect compensation for the standard recording characteristic. Note that a single decoupler is used for both pre-amplifier circuits, and that only half the output is actually used.

The Radio Tuner

This tuner is a modernized version of one which we originally designed several years ago, and which will no doubt be new to many present-day readers. It is designed primarily for a wide pass-band, with correspondingly good frequency response from our radio stations. At the same time it is easy to construct and align, and so has much to recommend it to the constructor who wants first-class reception from his local stations but who does not feel up to the rather more advanced technique needed by the synchrodyne, which is undoubtedly the best performer in the field but which does present difficulties in some localities.

The tuner is a straight-forward superhet in construction, but with an intermediate frequency of 2 mc/sec. Because of this feature, it is not practicable, with standard components, to track the oscillator and aerial circuits in the ordinary way, and so recourse is had to pre-tuning, with the stations selected by the main function switch. The first five positions on the latter are for up to five local stations, as are found in some of the main centres.

A major difficulty with pre-tuned circuits is to keep them satisfactorily in alignment over long periods. This has been achieved in the present circuit by using a separate oscillator coil for each station. This tends to be more expensive than using trimming condensers, but is very much more satisfactory. The coils are slug-tuned, and keep their settings far better than do trimmers. It is not necessary to use the same device for the tuned aerial circuit, so that here, only one coil is used, and is tuned by combinations of fixed condensers, with small trimmers in parallel. In order that the Q of the aerial coil shall not determine the overall response curve of the tuner, it is damped with a resistor of only 12 k. It might thus be thought that the



DRILLINGS : A = $\frac{3}{8}$ " DIA. B = $\frac{1}{2}$ " DIA. C = $\frac{3}{4}$ " DIA. D = $1\frac{1}{8}$ " DIA.

tuning of the aerial coil would be so broad as to be useless, but this is not so at all. The main reason for tuning the aerial circuit at all is to eliminate as far as possible cross-modulation between strong local signals, through non-linearity in the mixer circuit. For this purpose, a useful degree of selectivity is obtained by the arrangement shown, while the aerial circuit is still far too broad to adversely affect the broad-banding of the tuner as a whole.

Another slightly unusual feature is the use of a crystal diode as the A.V.C. rectifier, together with the application of A.V.C. voltage to the mixer only, and not to the I.F. amplifier. The use of the crystal diode is to enable a higher delay voltage than usual to be applied to the A.V.C. circuit. The delay network consists of a potential divider, comprising a 220 k. resistor and a 3.9 k. resistor in series across the H.T. voltage, the cathode of the A.V.C. diode being connected to the junction. This provides about 4 volts of delay to the diode, so that the latter tends to stabilize the A.F. output of the detector diode at approximately 4 volts peak. In fact, the output is rather less than this because the A.V.C. diode is fed from the primary of the I.F. transformer while the detector is fed from the

secondary, where the I.F. voltage is somewhat smaller. Approximately one-sixth of the total audio output of the detector is tapped off from the detector diode load, and fed to the tone control circuits. This ensures that the output level obtained when switching from "Radio" to "Gram." is similar for both, so that there will not have to be vast changes of volume control setting.

I.F. Transformers

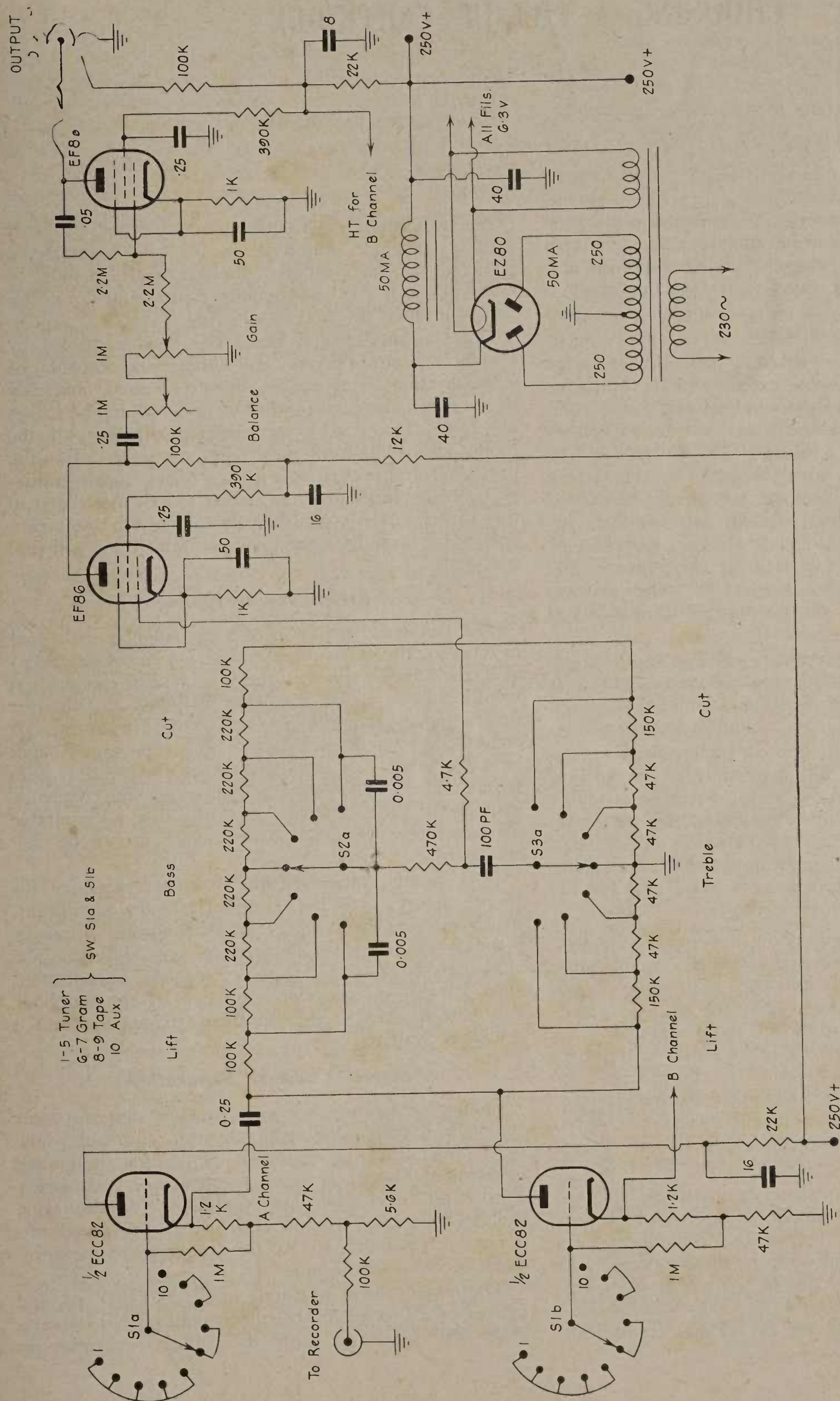
The I.F. transformers used were standard 2.0 mc/sec. ones, slug-tuned. These were found to be slightly over-coupled, so that a very good pass-band was obtained when they were properly in alignment, but the over-coupling did mean that a special alignment technique had to be used. Actually, the detector and A.V.C. rectifier load the second transformer enough to prevent the circuits of this transformer from being over-coupled, so that ordinary alignment procedure applies to this transformer. The first one, however, is definitely over-coupled, and the procedure laid down above should be followed. Paradoxically, if an over-coupled transformer is aligned in the ordinary way, the result is a much sharper resonance peak than would

Next, clip the 27 k. resistor across the primary of the first I.F. transformer (i.e. the winding connected in the mixer plate circuit) and transfer the signal generator to the grid of the mixer stage. Turn down the signal generator output so that the signal is not strong enough to operate the A.V.C., and peak the secondary of the first transformer for maximum indication.

Finally, remove the shunt resistor from the primary of the first transformer, and connect it across the secondary. Then tune the primary for maximum reading on the meter, and the job is completed.

This scheme works because, with one winding of the transformer fairly heavily shunted, the coupling is reduced below the critical value, thereby giving the transformer a single-peaked type of response. Thus, when the peaking is done in the way suggested, the windings are individually tuned to the correct frequency. Then, when the shunt is finally removed, the over-

(Concluded on page 37)



CHOOSING A PICK-UP CARTRIDGE

B. J. SIMPSON

Mr Bernard J. Simpson is the Editor of our contemporary, "Radiotronics", from which this article is reprinted, by kind permission of Mr Simpson and the Amalgamated Wireless Valve Co. Pty. Ltd.

Whether we are buying a replacement pick-up cartridge, perhaps converting to stereo, or buying a complete pick-up with integral cartridge, performance and price are the factors we find it most important to consider. The price is a personal matter, but performance we can freely discuss.

Let us say at the outset that any pickup or cartridge will "colour" sound to some extent, and therefore the buyer and the buyer only should decide which component is the most suitable for his own use. Furthermore, the colouration of sound also extends to the buyer's amplifiers and loud-speakers, so that to be really worth while, his listening tests should be carried out using a music system as close as possible to his own. The ideal thing would be to take a selection of components home and try them there. This is not usually possible, however, and we must compromise. Always carry out listening tests on recordings with which you are familiar.

The relative merits of replaceable and interchangeable cartridges used with a "universal" type of tone arm, and an integrated design of complete pick-up, largely depend on the facilities required and the money available. For those with limited funds available, the choice of an integrated design possibly offers the best solution. This includes those units where the cartridge is detachable but is not intended to be interchangeable with other makes of cartridge. On the other hand, those who like to try out new things that come along would be more likely to choose a good quality arm and then shop around for cartridges.

Most integrated designs show a better compliance (discussed later) than arm and cartridge combinations, although the integrated designs used with autochangers often have low compliance to give the stiffness necessary to track well and trip the change mechanism. This is one of the factors which make many enthusiasts dislike autochangers. By the way, if you are converting to stereo, don't be surprised if your turntable equipment suddenly proves inadequate, because the stereo pick-up is required to have both lateral and vertical compliance.

When looking for a pick-up or cartridge we find ourselves immersed in a jumble of figures which purport to show how good the various components are. How are we to judge and compare these figures? Just what do they mean. Like many figures used in specifications, they must be used carefully. They will be taken under certain conditions or at certain frequencies.

Other conditions or frequencies may (and probably would) produce different results. The properties specified may have inherent limitations which must be borne in mind. The best-sounding figures may not necessarily produce the best results for YOU.

Don't misunderstand this. The figures quoted by reputable manufacturers are honest and capable of substantiation. The maker, however, must obviously have certain standard conditions under which he makes his test. He cannot cater individually for all the thousands of different music systems in use. For the purchaser and user, it is a matter of intelligent evaluation and application of the maker's data. As a step in this direction, let's consider the more important properties of cartridges and pick-ups which we will find specified.

Frequency Response

The frequency response of a cartridge is expressed in terms of the variation of output (or sound intensity) over a specified frequency range. A typical specification would indicate a flat frequency response ± 2 db over the frequency range 20 to 20,000 cps. This means, of course, that the total variation over this range could be 4 db, which is a voltage ratio of about 1.6:1. Different makers make varying claims for the frequency response of their cartridges, and of course no reputable manufacturer will make claims which cannot be substantiated.

It is a fact, however, that relative frequency response figures are not necessarily very significant, whilst varying methods of measuring the frequency response make direct comparison very difficult. The final analysis as far as frequency response is concerned must depend on the characteristics of the amplifier and loud-speaker used with the cartridge to form a complete system.

Stereo Channel Separation

Channel separation is always worth a long argument among hi-fi enthusiasts, generally centred around how much separation is desirable. Separation is quoted in terms of db at a specified frequency or frequencies. Whilst an ideal cartridge would provide the same channel separation over its entire frequency range, this is not so in practice, so that the frequency of measurement becomes significant.

The measurement is usually made at 1,000 cps, and figures of 20 to 30 db are customarily quoted. A cartridge will generally show the widest separation at

1,000 cps, so that this figure does not indicate just how the cartridge will perform over the entire audio spectrum. For this reason some makers supplement the figure taken at 1,000 cps with a further figure indicating the minimum separation over a specified frequency range, or a separation figure taken at a higher frequency.

A cartridge with 25 db separation at 1,000 cps may exhibit only 8 db separation (say) at 10,000 cps. This figure is far more significant than the one taken at 1,000 cps, and for practical purposes could be regarded as the operative figure. Most enthusiasts argue for a minimum separation of 12 db, although a figure of 6 db minimum has some supporters. Like frequency response the final judgment of effect depends to some extent on other factors in the complete system.

Output

The cartridge output should be expressed as a voltage measured at a specified recorded velocity, measured in centimetres per second. Without the qualification of recorded velocity, an output voltage figure is meaningless. It is like saying a generator has an output of 1,000 volts without saying how much energy is required to turn it and how fast it should be turned.

Recorded velocity is expressed in centimetres per second. The velocity referred to here is the rms transverse velocity of the pick-up stylus as it conforms to the modulated grooves on a recording. The velocity is therefore dependent on two factors, frequency and peak amplitude of the recording. The figure quoted as recorded velocity in specifying cartridge output takes care of these two factors. Recording levels vary with different makes and types of record. An average level would probably be of the order of 5 centimetres per second, with instantaneous peaks around 20 centimetres per second.

Load Impedance

Still thinking of a pick-up as a generator, and remembering that the impedances of generator and load must be equal for maximum transfer of energy (maximum efficiency), we need to know the load impedance of the pick-up. This allows us to arrange that the input impedance of the amplifier has a value suitable for the pick-up. In the case of low impedance pick-ups working into valve amplifiers, this may involve the use of a transformer.

Where high-impedance units are concerned, however, it is easy to meet this requirement by choosing the appropriate value of load resistor for the pick-up. Some departure from the recommended value is permissible, but adherence to the optimum value within $\pm 10\%$ seems a reasonable rule to follow.

Don't forget that some pick-ups require a fairly elaborate equalizing network which must present the required load to the pick-up. Always follow the pick-up or cartridge manufacturer's recommendations on these points.

Tracking Pressure

Tracking pressure, expressed in grammes, is the weight required to keep the stylus in contact with the groove walls in the recording. It is important to realize just what importance this value can have. First of all we have two extremes, one where the weight is too high and excessive record wear results, and one where the weight is too low, resulting in poor tracking, distortion, and extra wear. Note that both conditions result in extra wear. This is easy to understand where heavy tracking weights are used but not so obvious in the case of too-light weights.

A stylus which is loaded too lightly will not track correctly; it will tend to ride out of the groove and bounce against the walls rather than following them accurately. When a stylus bounces in this way, the pressures exerted against the walls of the grooves is far beyond any normal tracking pressures. Complete breakdown of the wall can result, producing "jumping" and "skipping" of passages.

It follows, of course, that somewhere between the two extremes is an optimum value, and this is the figure quoted in the specification. Direct comparison of tracking weights is not possible. One cannot say, for example, that a cartridge with a tracking pressure of 2 grammes is necessarily better than one with a pressure of 7 grammes, nor will the lighter pressure necessarily produce less record wear. The important thing is to follow the makers' recommendations on tracking pressure. Most pick-up arms for use with detachable cartridges have provision for adjustment of tracking pressure.

Compliance

This property is expressed in the cartridge specification as a number multiplied by 10^{-6} centimetres per dyne, for example, 5×10^{-6} cm/dyne. By definition, compliance is the ratio of the displacement of a body to the applied force, or in simpler terms, how much the cartridge moves when a specified push is applied. Where a cartridge is concerned it relates the sideways movement to force applied by modulations on the record grooves. Compliance is the opposite of "stiffness".

It follows that compliance (related to a cartridge) is the ability of the cartridge to follow the groove modulations. A stereo cartridge must respond to both vertical and lateral movement, and a stereo component therefore has specified for it both vertical and lateral compliance. It will readily be seen that, among other things, compliance (or the lack of it) will affect record wear.

In specifying compliance, the force applied is expressed in dynes. A dyne is the force which, acting on one gramme of mass, produces an acceleration of one centimetre per second. The higher the compliance figure quoted, the "better" the pick-up, with reservations. For example, the compliance figure does not

(Continued on page 37)

AN EXPERIMENTER'S TELEVISION RECEIVER

Part 5: The Sound I.F. Channel

First of all, we must apologize to those who have been following this series of articles for having missed out this instalment from our last issue. This had to be done, through circumstances outside our control, and we hope that it did not cause builders too much inconvenience.

The sound I.F. amplifier consists of two EF80 stages, quite similar to those in the vision I.F. amplifier, and these are followed by an EQ80 nonode discriminator. This has been used because it is easy to align, and gives a large audio output, having considerable audio gain built into it, and thus reducing the requirement for gain in the audio amplifier proper. The input to the audio section of the I.F. strip is taken from a trap circuit connected to the plate of the second vision I.F. amplifier stage. This trap gives some rejection of sound signal in the vision channel, as well as picking off the sound signal for the sound I.F. amplifier, which is tuned to the sound I.F. of 33.4 mc/sec. The transformer between the first and second stages is the usual bifilar-wound single-tuned circuit, tuned with its slug, while the discriminator transformer is different in having a bifilar primary, and a secondary winding as well. This transformer is not, as all the others are, tuned merely by the stray circuit capacities, but is given a much lower L/C ratio in order to swamp certain effects in the nonode detector tube, which needs a relatively high circuit capacity to be used if it is to function properly. The bifilar primary is used for the same reasons as before, and in order to avoid the use of a blocking condenser and grid leak, which would have to be inserted otherwise. The secondary is over-coupled by a pre-determined amount—actually, the coupling is about twice critical—and care should be taken to accurately space the secondary from the primary by the specified amount, and to use the ends of the windings in the manner described. This is because a slight change in the distance between windings makes a large difference in the coupling factor, and also because reversal of the connection of one or both windings has an effect on the capacity-coupling between windings, which is not negligible.

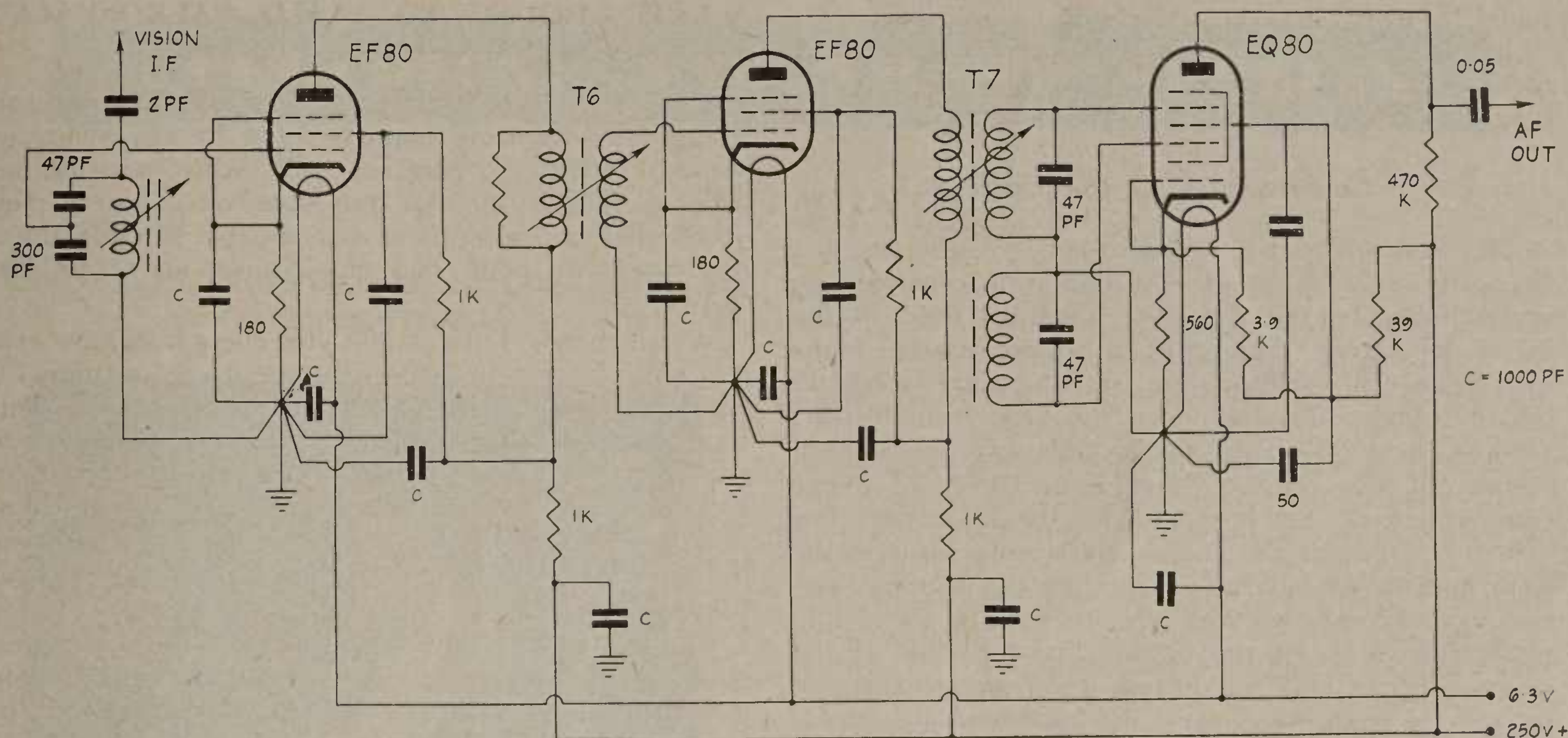
Functioning of the Nonode Discriminator

This kind of valve is known in America (where there is an exact equivalent of the EQ80, known as the 6BE7) as a "gated-beam tube", and this accurately describes its functioning. There are in all, seven grids and the usual cathode and anode, making up the nine electrodes that the name suggests. Of these, one is a suppressor, similar to that of a pentode, three are screen-grids, and are connected together inside the envelope, and another is a space-charge grid. The re-

maining two are signal grids. The space-charge grid is connected, at the socket pins, to the cathode, so that although the valve at first may seem rather complex, its application really is not. The screen and cathode are merely connected to a potential divider from the H.T. line, much as is done with many multi-grid mixer valves, while the two signal grids are connected to the last I.F. transformer, one being fed from the bifilar primary, and the other from the secondary. As drawn in the circuit diagram, one of the parts of the screen-grid— G_4 , between the upper control-grid, G_3 , and the suppressor, G_7 —has been omitted from the drawing of the valve to make it easier to draw, without affecting the principle or the builder!

The space-charge grid, connected to cathode, attracts a liberal supply of electrons from the latter, and the majority of them pass through the spaces in the grid, and are therefore made available for use. The screen-grid fulfills the usual function of shielding the control grids from each other and from the anode, and in addition accelerates the electrons towards the anode. It will be noticed that both control grids, G_3 and G_5 , have a section of the screen-grid on either side of them, thus providing effective shielding of the kind already mentioned.

An essential part of the detection system is the final I.F. transformer. In principle, this is no different from any double-wound I.F. transformer, but the system does require the windings to be slightly over-coupled, as was mentioned earlier, in order that the sensitivity shall not be too low, and so that it may be as distortion-free as possible. Now in any double-wound transformer, the voltage at the secondary is ninety degrees out of phase with that across the primary, and as this is a necessary condition for operation of the detector circuit, the transformer fulfills it automatically. The next point to note is that for proper operation, the input signals to the control grids must be great enough to cause the grids to be cut off during a substantial portion of each I.F. cycle. Since there is a small amount of negative bias on each, each is cut off for slightly less than a half-cycle. In other words, each grid can conduct only during the positive half-cycles of the input voltage. Now the construction of the valve is such that when *either or both* control grids are negative, the anode current is cut off. Thus, for anode current to flow, *both* grids must be conducting simultaneously. With this much information, we have the complete key to the behaviour of the valve with a frequency-modulated input. At the centre-frequency, to which the transformer is accurately tuned, the phase difference between the G_3 and G_5 inputs is exactly 90 degrees. At all other frequencies, the phase difference



is either greater or less than this. Thus, the first job done by the circuit is for the last transformer to produce phase modulation from the frequency-modulated input.

The next thing that happens is that as the phase of the G_3 and G_5 inputs varies relative to each other, so does the period of time, in each cycle, during which plate current is able to flow. A simple way of looking at it is that G_3 and G_5 are supplied with a series of positive pulses, which, owing to the phase differences between them overlap more or less according to how the original modulation varies the sound carrier frequency. In this way the plate current is caused to flow in pulses (at the rate per second representing the frequency of the signal) which become broader than usual when the frequency of the input shifts in one direction, and narrower than usual when it shifts in the other direction. This broadening and narrowing of the plate current pulses occurs in sympathy with the modulating frequency. This amounts to a cyclic variation in the anode current of the EQ80, at the modulation frequency, which is the same thing as saying that the modulation frequency is reproduced in the anode circuit, and the aim and object of the circuit is fulfilled.

It can be seen also, from this description of the valve's mechanism, that the arrangement is relatively insensitive to variations in amplitude of the R.F. input, and so the circuit discriminates quite well against amplitude-modulation, and against interference which results in varying the amplitude of the input signal. In practice, the amplitude-limiting effect is not fully apparent until the input voltage reaches about six volts peak. Increases above this level have no effect at all on the detection of the FM signal, and very good amplitude limiting is produced.

Alignment of the Discriminator

Because the discriminator transformer is over-coupled, a special alignment procedure is necessary, and a wobulator is very helpful, but non-essential. The job can be done quite well with the aid of a V.T.V.M. and a signal generator, provided that the following procedure is adopted.

- (1) A 5 k. resistor is connected across the secondary of the last I.F. transformer.
- (2) A V.T.V.M. is connected across the primary of this transformer.
- (3) A signal at 33.4 mc/sec. is fed to the grid of the first sound I.F. stage from the signal generator. The signal should be unmodulated.
- (4) The primary is adjusted for *maximum* response in the V.T.V.M.
- (5) The 5 k. resistor is removed from the secondary, and without shifting the signal generator or the meter, the secondary is tuned for *minimum* response in the meter.
- (6) The voltmeter is removed from the primary and connected across the secondary.
- (7) The primary is re-tuned to give *maximum* response in the meter.

This procedure ensures that in spite of the over-coupling of the windings, both are accurately aligned to the centre frequency of 33.4 mc/sec., and at the same time prevents the input capacity of the voltmeter from spoiling the result, since the circuits are finally adjusted without the meter connected across them. The placing of the meter across the secondary, for example, has no effect on the tuning of the primary, and vice-versa. The secondary, it will be noticed is

tuned by using it as an absorption circuit. This indication is quite sensitive when, as here, the coupling between windings is tight, and does not give an ambiguous answer.

Construction of the Coils

The first sound I.F. transformer—i.e. the one between the two I.F. stages—is similar in construction, and number of turns, to the windings used in the vision I.F. strip. That is to say, it has twelve turns of 30 gauge in each winding, and these are wound in bifilar fashion. The second sound I.F. transformer, feeding the EQ80 has 7 turns, bifilar wound, as each section of the primary, and 7 turns of 22 gauge enamelled wire, double-spaced, for the secondary. The primary is put at the end of the former nearest the base, and the secondary is $\frac{3}{8}$ in. from the primary. The two bottom ends of the primary go to the EF80 plate, and to G₅ of the EQ80. The top ends of the primary go to H.T. in the one case, and to earth in the other. On the secondary, the lower end goes to G₃ of the EQ80 and the upper end to earth. The 47 μ fd. condensers tuning the windings are inside the can.

In making the discriminator transformer, as per the above description, use is made of all six terminating eyelets on the base. And stiff bare wires are first soldered to these. They go through the holes in the eyelets, and on the outside of the can are clipped off to a length of half an inch or so. When the transformer is wired into the circuit, these leads are used as tie-points for the finer connecting wires, which can be bent round them and then soldered. Inside the can, the wires are taken up parallel with the coil former. They are stiff enough to act, without further support, as terminations for the coils and the two small 47 μ fd. condensers.

Since printing the diagram on page 29 of the July issue, we have decided on a modification to the pick-off trap shown there. The modification consists in making a capacitive potential divider out of the tuning condenser, and connecting the grid of the first EF80 to the tapping point. This destroys the D.C. connection to earth for this grid, so a 1 Meg. grid leak is added too. The 300 μ fd. in series with the 47 μ fd. originally there, somewhat reduces the total circuit capacity, so that the circuit has to be re-tuned, and it may possibly be found that it is necessary to add a turn to the coil. However, in our own case, this was found not to be necessary, though the circuit tuned to frequency quite close to the adjustment for maximum inductance.

(To be continued)

WESTINGHOUSE TO BUILD "AEROSPACE" ENERGY STORAGE SYSTEM

EAST PITTSBURGH, U.S.A.—An energy storage system being manufactured by the Westinghouse Electric Corporation will make possible an investigation of thermal and aerodynamic properties of missiles and aircraft at velocities of 9 to 24 times the speed of sound and at altitudes above 100,000 feet.

Westinghouse reports that the energy storage system will power a hypervelocity impulse wind tunnel—which is known in the aerospace industry as a "hot-shot" type of wind tunnel. Four basic sections—an expansion cone/test section, a vacuum reservoir, an arc chamber, and an energy storage system—comprise the entire facility. Westinghouse is building the energy storage unit for the McDonnell Aircraft Company.

The system has the capacity to deliver electrical power at the average rate of two and one-third million kilowatts—more than six times the rating of the largest turbine-generator ever ordered, according to Westinghouse. Few if any electrical units have the capability to supply this requirement, the Company reports.

The arc chamber is separated from the tunnel-tank by a thin diaphragm. Prior to test, the arc chamber is filled with highly compressed air and the tunnel-tank is evacuated to an extremely low pressure.

Then electric power from the energy storage system is delivered to the arc chamber, thus increasing the pressure and temperature of the air in the chamber to pressures up to 100,000 pounds per square inch and approximately 14,000 degrees Fahrenheit.

The diaphragm separating the arc chamber from the tunnel-tank is vaporized by the high temperature, and high-pressure air expands through a tungsten throat producing hypersonic velocities in the test section of the wind tunnel.

* * *

EXPERIMENTAL TV TRANSMISSIONS IN WELLINGTON

During the last few weeks the experimental television transmitter built by the Wellington branch of the New Zealand Electronics Institute (Inc.) has been radiating patterns on Saturday mornings between the hours of approximately 10.30 a.m. and 1 p.m. So far, simple non-interlaced bar patterns have constituted most of the programme material. While this can hardly be described as exciting to view, the results to date have been very encouraging to those responsible for the project. A fuller account will be found in the Editorial page of this issue. Anyone wishing to know further details of the transmissions are invited to contact Mr W. D. Foster, the Editor of *Radio and Electrical Review*, P.O. Box 6361, Wellington, or telephone 52-343.

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ELECTRICAL AND TRADE SECTION

TRADE WINDS

PLESSEY INTERNATIONAL HOLDS AGENTS' CONVENTION



The Chairman and Managing Director of The Plessey Company Limited, Mr Allen G. Clark and Mr T. White Wilson, Director of Plessey International Limited, welcoming the New Zealand Agent, Mr W. J. Blackwell of Auckland, on arrival at the main Convention dinner at Grosvenor House on 24th June.

On 20th June of this year, Plessey International Limited held a convention in England which was attended by fifty delegates from twenty-three countries in which Plessey has permanent representatives. The gathering, which represented all five continents, was arranged as a general get-together to exchange ideas, share problems, and allow the company to give them a broad picture of the immense resources of the Plessey group of companies, and its diverse research, development, and manufacturing programmes. Perhaps the most valuable aspect of such a convention is the opportunity for agents who are normally separated by thousands of miles from each other and the company to exchange views in a comfortable and relaxed manner, but at the same time to be stimulated by closer acquaintance with products and processes at the various Plessey factories which they were able to visit, the manufacturing processes which they inspected, and the peeps into the future that were provided by the laboratories.

There was much ground to be covered. The Plessey establishments visited are situated in the southern half of England, and the delegates walked literally miles of factory and laboratory floors, for in terms of physical

capacity there are eighteen separate major Plessey establishments, totalling together about three million square feet—housing more than 17,000 people.

And yet despite its size and the ubiquity of its products, the fundamental Plessey policy on which the Company was founded is still maintained. Plessey offers a design and manufacturing service to Industry—and, of course, to Governments—but never competes in identical fields.

Bill Blackwell, who represents the Plessey interests here so ably and is so very well known to us all, tells us that he was most impressed by the tremendous growth of the Plessey Organizations since he was last in England. Vast sums are being allocated to diverse types of research and development and the Company is attracting to it Britain's top-ranking physicists, electronic engineers, and scientists. Bill Blackwell tells us to expect many new and even sensational developments in the future from Plessey.

* * *

LARGE ORDER FOR NEW ZEALAND TV

The New Zealand Broadcasting Service has placed an order with Marconi's Wireless Telegraph Company Ltd. through Amalgamated Wireless (Australasia) Ltd. for the supply of three vision and three sound transmitters, together with studio equipment, for new TV stations at Christchurch, Wellington, and Dunedin.

The value of the order is over £100,000 and delivery is expected to be completed by October this year.

The vision transmitters, all 5 kW, consist of two Type BD 352 and one Type BD 372. The associated sound transmitters will consist of two Type BD 309B equipments (each 1 kW FM) and one Type BD 324 (1 kW FM). The stations will operate in Band I to CCIR-type standards.

This new order means that all four of the New Zealand television stations will have been equipped with Marconi transmitters—the other station, at Auckland, which has been carrying out experimental operations, has a Marconi 500 W transmitter.

For the three new stations, which will be engaged in pilot television services, New Zealand Broadcasting Service are supplying their own aerials.

* * *

NILSEN OPEN OFFICE IN AUCKLAND

As part of a plan to improve their service to the electrical trade, the Nilsen Industrial Group of Melbourne, manufacturers of low-tension industrial switch

and motor control gear, has this month established its own Sales Office in Auckland.

For over twelve years, the Nilsen Companies have been closely associated with Mr John Carrel and his Company, Carrel & Carrel Ltd., who were responsible for the introduction of Nilsen equipment to New Zealand. Mr Carrel has now been appointed to manage their interests in New Zealand.

The New Zealand headquarters of the Nilsen organization is now operating from the premises of Carrel & Carrel Ltd., known to so many of the trade in Auckland, who have in the past supported the Nilsen brand.

A Wellington Branch, which was opened two years ago by Mr Gordon Huckin will continue under his management.

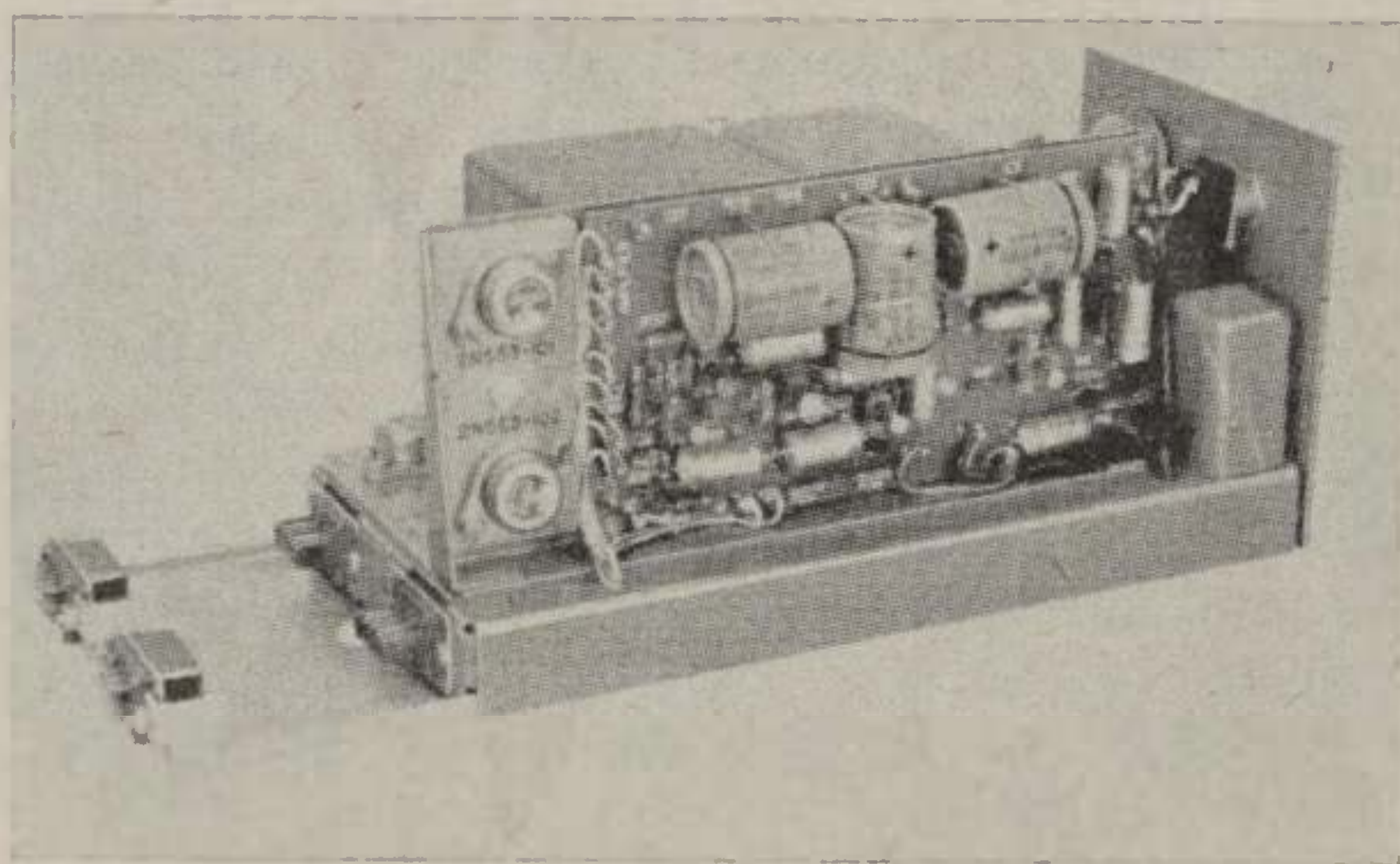
The remaining interests of Carrel & Carrel Ltd. will be carried on in close association with Nilsens in New Zealand.

The addresses of the two Sales Offices are as follows:

Nilsen Electrical Sales (Aust.) Pty Ltd.: New Zealand Head Office, 41 Shortland Street, Auckland. P.O. Box 2102. Telephones, 24-650, 42-674; Telegrams, "Nilseno", Auckland. Wellington Branch: 122 Wakefield Street, Wellington. P.O. Box 2794. Telephone, 46-248; Telegrams, "Nilseno", Wellington.

* * *

NEW TRANSISTOR AMPLIFIER BY R.C.A.



The all transistor BA-34A Monitor Amplifier is easy to service and it features plug-in construction. The output transistors are mounted on circuit boards at the rear of the chassis.

R.C.A. have recently exploded the myth that high-quality power amplifiers cannot be built using transistors. An announcement in the March, 1960 issue of *Broadcast News* gives a certain amount of information on the performance of a new transistor designed for monitoring in broadcast studios.

The power output is 10 watts, and the distortion at this level is less than one per cent. The gain is such that the amplifier can be operated directly from low-

level microphones. Hum and noise are stated to be at the phenomenally low figure of — 120 db. below the input level for maximum output. Frequency response is within 1½ db. from 30 cycles to 15,000 cycles per second.

An outstanding feature is the low power consumption of the amplifier, which draws only 25 watts from the mains as compared with 60 by the equivalent valve amplifier. In addition, it occupies only half as much space.

* * *

ADVANCES IN POWER GENERATION

PITTSBURGH, U.S.A.—Scientists of the Westinghouse Electric Corporation have unveiled a major step in the continuing search for new, more direct methods of generating electric power.

At a recent Press briefing for technical publication editors on new methods of power generation held at the Westinghouse research laboratories, they demonstrated the first magnetohydrodynamic (MHD) generator of appreciable size to steadily produce electric power from the combustion of a conventional fuel.

The new MHD generator produces electric power by passing a super-hot, electrically conducting gas, called a plasma, between the poles of a powerful magnet. This ionized gas which substitutes for the copper wires in the rotating coils of a standard electric generator, passes down a ceramic-lined tube at 1800 miles an hour, cuts across the magnetic field of the magnets and gives an electric voltage and current.

Operating at about one-fourth its full power rating, the new generator has produced 2½ kilowatts of power and has run continuously for four minutes. Previously reported MHD generators have had operating cycles about 5 seconds.

Heretofore, experimental MHD generators have obtained their white-hot operating plasma from the heat of an electric arc, thus simply changing one form of electrical energy into another. The Westinghouse generator, however, burns furnace oil with oxygen at a temperature of about 5000 degrees Fahrenheit. Thus, it accomplishes the kind of natural fuel-to-electricity conversion that is of prime concern for future development of the MHD generator as a large-scale source of electric power.

Demonstration of the MHD generator was part of a Press meeting that saw Westinghouse scientists present state-of-the-art reports and practical demonstrations of three other methods of direct electric power generation, including:

A high-temperature experimental fuel cell operating at temperatures above 1500 degrees Fahrenheit and capable of converting a carbon fuel directly into electrochemical action;

A 100-watt thermoelectric generator capable of changing the heat of a gas flame directly into enough electric power to drive an electric bench grinder and a pair of headlights;

A small thermionic generator capable of operating a small electric motor and two small light bulbs.

Also announced was the development of small, efficient "solid-state" devices for converting the direct current electricity produced by these new generating systems into alternating current, the kind almost universally used in home and industry.

New Kinds of Power Generation Forecast

The Press briefing on new methods of power generation was a repeat of a recent state-of-the-art presentation by Westinghouse management to some 200 of the nation's top utility executives. The sessions discussed the present status and future prospects of four new methods of power generation—MHD, fuel cells, thermoelectricity, and thermionic conversion.

Power generation other than that for electric utility systems best exploits the unique characteristics of these new power generation methods and will be the first use to which they are put, Dr. Hutcheson, vice-president, engineering for Westinghouse, said. Among these characteristics he cited absence of moving parts, inherent high efficiency, long life, and high reliability. Small, long-lived, self-contained electric power generators for space vehicles, remote locations on earth, and underwater craft are ideal applications for such power plants, he pointed out.

New Materials Needed

The Westinghouse scientists cited the lack of suitable high-temperature materials as the major technical obstacle to be overcome in making the new methods of power generation practical. A "major breakthrough" in materials is needed, they emphasized, in order to make them competitive for the generation of the large blocks of power now produced by steam power plants fired by conventional and nuclear fuels and employing standard turbine-generator units. However, even without such a breakthrough, these new techniques of energy conversion will find useful and immediate uses "particularly for those applications which cannot be served with power quite so effectively by any other means, and particularly for applications of military interest."

Two reasons for the increasing interest in the new method of power generation, the Westinghouse scientists pointed, are the growing concern about the diminishing supply of natural fuel sources and the vital need for adequate power for man in space.

As Dr. S. W. Herwald, vice-president, research, expressed it: "Without it, he is helpless; with it, he can exist under almost any conditions."

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IN USE IN NEW ZEALAND**

FIRST IN THE FIELD WITH PUSH-BUTTON SWITCH

A British company has now produced the prototype of a precision push-button switch for mass production. This type of switch has been the subject of American research and will be a unique addition to the range of multi-channel equipment now in use in a wide variety of industries.

The switch was designed and will be produced by Seton Creaghe Ltd., at their Park Royal, London, works. It is especially suited to high-frequency applications and is designed to reduce maintenance and the likelihood of mechanical breakdown.

The prototype is being tested to a life of one million operations. The cost is at present estimated at between £2 and £2 15s. per button.

The switch can be made with any number of buttons up to 16, and the buttons can be illuminated if required. Each button has a standard contact arrangement of two double-pole changeovers. Only one push-button can be operated at one time and the contacts of the operated button are cleared before a new contact is made. This arrangement can be altered to give "make or break", and electro-mechanical interlocking facilities are available. The switch can be banked horizontally or vertically.

Tests have been made for a contact rating of 50 volts, 250 mA d.c. non-inductive, and contact resistance is less than 20 mOhms throughout life. Capacitance between contacts is less than 2 pF between springs and less than 1 pF between sets.

The manufacturers claim that this precision push-button switch will be the only one of its type mass-produced in Britain. It has already aroused interest from leading firms in the electronics industry.

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AN INTRODUCTION TO TELEMETRY

(Continued from page 21)

coiled resistors, so that as the beam bends, one set is compressed and the other stretched. The four coils are connected in a bridge circuit in such a way that the bending of the beam unbalances the bridge, and an output voltage is obtained that is exactly proportional to the original pressure. Such a transducer can be accurately calibrated, and can indicate either rise or fall of pressure from a pre-arranged datum.

(To be continued)

A COMPREHENSIVE AUDIO SYSTEM

(Continued from page 27)

coupling of the windings comes into play once more, and the desired flat-topped response curve is obtained.

Tuning up the Stations

In the circuit diagram, we have shown a variable condenser connected to each point of the switch on the aerial-tuning section. This has been done to simplify the diagram, but in practice, each of the condensers so shown actually consists of one or more fixed condensers in parallel with a small trimmer of 30 or 40 $\mu\text{mfd.}$ maximum capacity. Since everyone's requirements will be different, according to the frequencies of their local stations, we have not specified these condensers, and they will have to be found by trial and error. However, this is not a difficult process, and all that it requires is a few small-valued silvered mica condensers, and some patience.

Tuning the oscillator coils is easy. One of the incidental advantages of using individual coils for each station is that a single tuning condenser (fixed) is connected across the common contact of the switch, and this brings the frequency range of all the oscillator coils within the band 2500 to 3500 kc/sec., and so enables any of them to tune in any frequency on the broadcast band, simply by adjusting the slug.

The best way to finally adjust the station tuning is to temporarily connect a 350 $\mu\text{mfd.}$ variable condenser (one section of an ordinary gang condenser will do) to the aerial circuit, on each switch point in turn, and estimate from the setting that is obtained for each station, how much fixed capacity is needed. This is best done with the weak signal obtained when about two feet of wire is used for an aerial. First of all, of course, the station is brought in by tuning the oscillator slug, and the signal is then maximized by tuning the aerial circuit.

(To be concluded)

CHOOSING A PICK-UP CARTRIDGE

(Continued from page 29)

take into account the total permissible or available deflection of the cartridge. It would be possible, for example, for a high-compliance cartridge to have a

very small total deflection, and thus be unable to deflect sufficiently to track and play the more heavily-modulated grooves. This state of affairs is of course not likely to occur with a reputable maker, but serves to put the compliance figure into perspective.

Dynamic Mass

Having mentioned compliance and the force necessary to move a certain mass, the next item of data concerns a rarely-quoted property, the dynamic mass. When the cartridge responds to the modulated record grooves, not all the cartridge follows the intricate variations, but only the stylus and certain portions of the cartridge, depending on its type. The portion of the cartridge which does follow the modulations is referred to as the dynamic mass. The property is expressed as a weight, usually in grammes or fractions thereof.

It will readily be seen that the lower the dynamic mass, the less inertial resistance will be offered to changes in motion imposed by modulations on the record grooves. A cartridge with lower dynamic mass may therefore be expected, other things being equal, to follow the modulated grooves easier and more faithfully. Unfortunately this interesting property is rarely quoted, and if a figure is given, it is not always as useful as it could be due to a wide divergence of views on methods of arriving at the quoted figure. It is not a case of simply weighing the moving parts of the cartridge, because the stylus tip is the point under consideration, this being where the deflecting force is applied. The property will also be affected by the method of suspending the moving parts in the cartridge. One definition of dynamic mass is that mass which, if concentrated at the stylus point, would possess the same inertia as that of the moving system.

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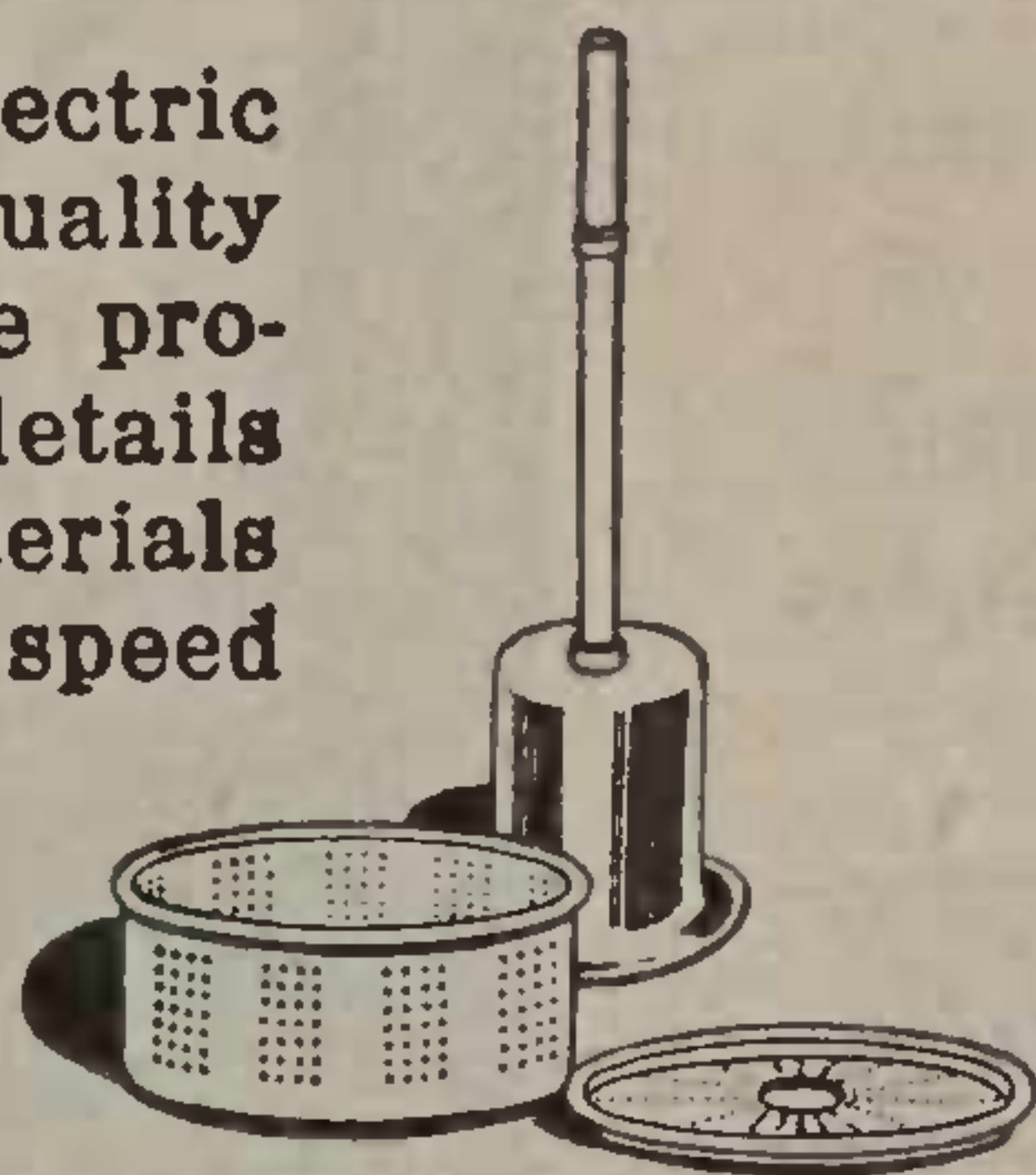
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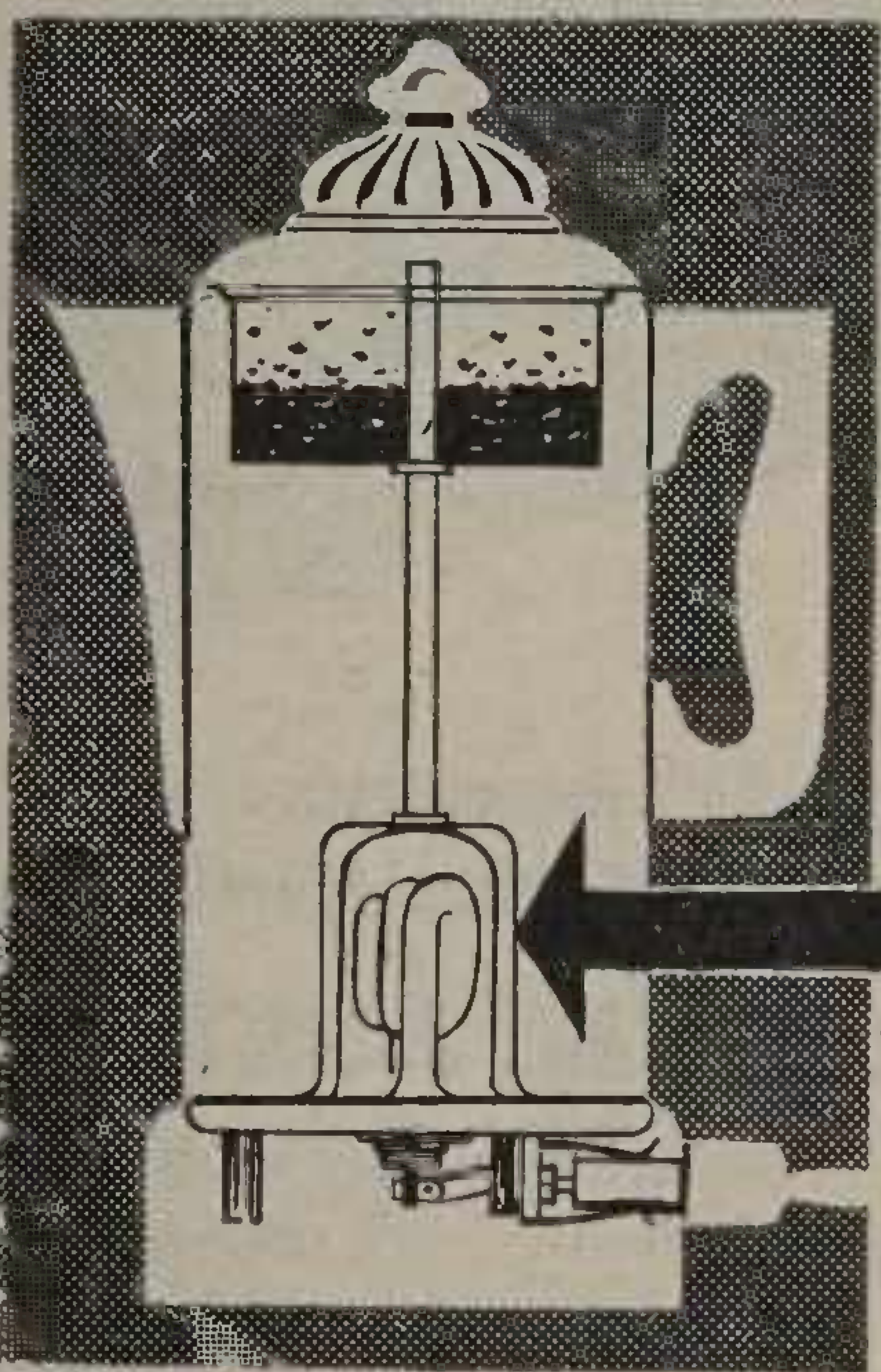
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IN536	50	35	50	750	500	250	15	-65 to +165	-65 to +175	1.1 at 500 ma	5	400
IN537	100	70	100	750	500	250	15	-65 to +165	-65 to +175	1.1 at 500 ma	5	400
IN538	200	140	200	750	500	250	15	-65 to +165	-65 to +175	1.1 at 500 ma	5	300
IN539	300	210	300	750	500	250	15	-65 to +165	-65 to +175	1.1 at 500 ma	5	300
IN540	400	280	400	750	500	250	15	-65 to +165	-65 to +175	1.1 at 500 ma	5	300
IN1095	500	350	500	750	500	250	15	-65 to +165	-65 to +175	1.2 at 500 ma	5	300
IN547	600	420	600	750	500	250	15	-65 to +165	-65 to +175	1.2 at 500 ma	5	350

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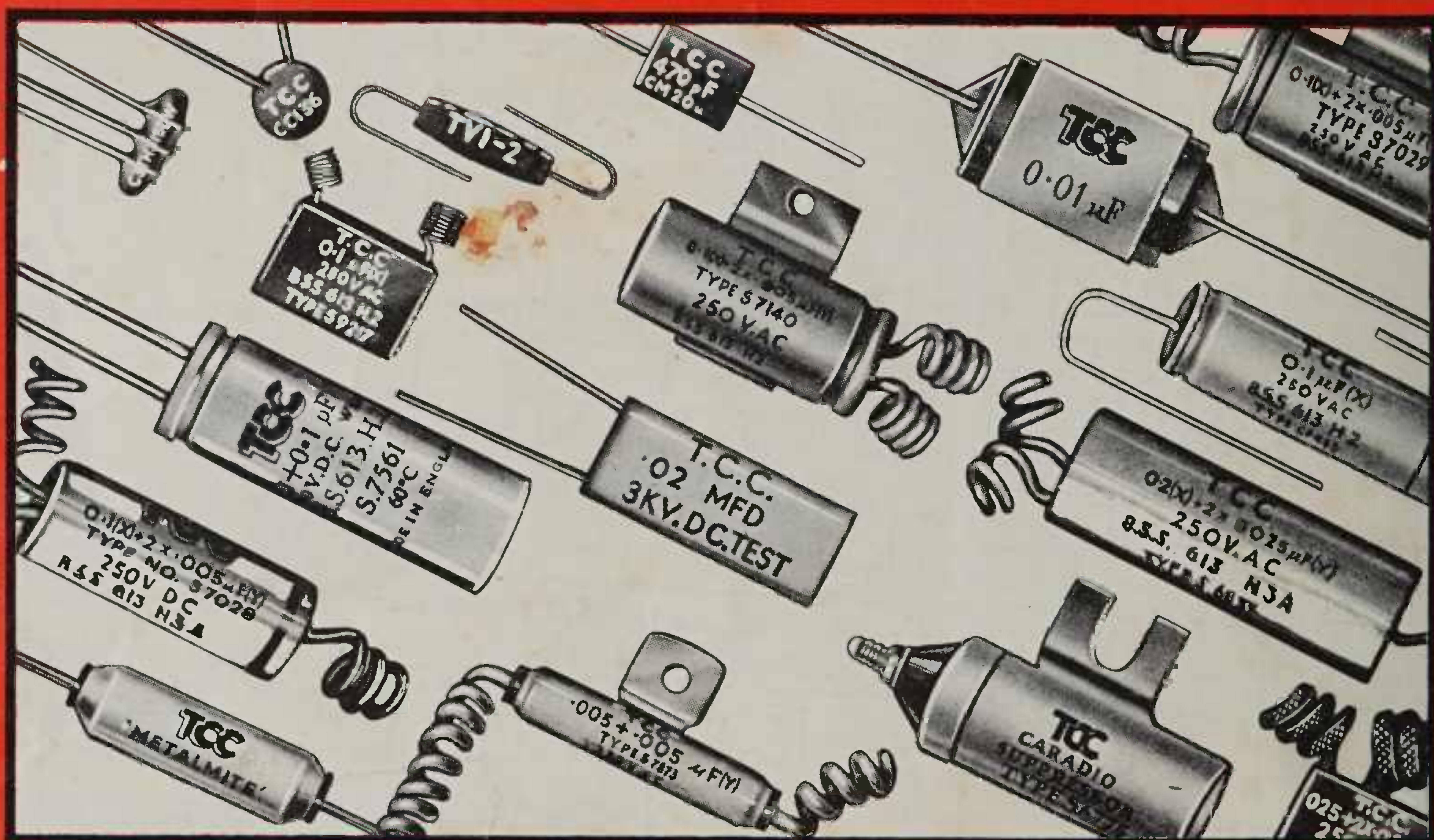
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