

instructionbook

With an EE 8 assembly kit the following eight circuits can be built:

$\frac{\mathbf{E}}{\mathbf{E}}$

With an EE 20 or the EE 8 together with add-on kit the following twenty-two fascinating circuits can be built.



Safe! No mains connections, no soldering! Easy to build, easy to rebuild!



For description of the circuits turn over to pages 2 and 3.

- two transistor radio receiver
- one transistor radio receiver
- two transistor gramophone amplifier
- automatic night light
- morse code training set
- tell-tale light
- flashing beacon
- rain and moisture indicator

- three transistor radio receiver
- two transistor radio receiver
- one transistor radio receiver
- two transistor gramophone amplifier
- electronic organ
- morse code training set
- morse code trainer with loudspeaker
- burglar alarm
- component testing equipment and: light meter
- audio amplifier
- push-pull audio amplifier
- bi-ampli amplifier
- intercom
- telephone amplifier
- tell-tale light
- flashing beacon
- acoustic relay
- pilfering alarm
- burglar alarm with power economising circuit
- automatic night light
- rain and moisture indicator
- time switch

ELECTRONICS SPAN THE WORLD

Electronics is a modern technique which increases daily in scope and which makes possible what was once regarded as a fairy-tale. Radios, gramophones and television sets are to be found in every home. Radar and radio beacons, which help ships and aircraft to find their way throught the densest fog, are in everyday use. We are no longer surprised to find rockets being shot into space, sending back information on the mysterious belts of radiation and on the magnetic fields to be found at thousands and even millions of miles away from our earth.

.... AND AT HOME

All this, communications, signalling, measuring, controlling and now even calculating is made possible by electronics. To many people these techniques are like a closed book. The EE assembly kits, in which use is made of the most modern components, will enable you to open this book and understand it. No mathematics or difficult studies are involved; just your eyes and your own common sense. And as you go along, you learn to read the drawings, to get to know the components such as transistors, and to understand how the components in the sets work.

ASSEMBLING AND EXPERIMENTING

Lots of interesting circuits can be built with the EE-assembly kits. Radio receivers, gramophone amplifiers, intercom systems are things which will give you as much pleasure in using as you had in building them. And this is also true of the less well-known circuits; the monitoring set, the flashing light, the burglar alarm, the wetness indicator etc.

All this is without any risk of fire or burnt out fuses, for these transistor sets work on batteries. You do not even need a soldering iron. So, without too much trouble and with a great deal of pleasure you can amass so much knowledge and experience of electronics that your friends, your parents and even experts will be astonished about what you know in this field.

GENERAL ASSEMBLY INSTRUCTIONS

CIRCUIT CONSTRUCTION

GENERAL THEORY

1

CONTENTS

Parts description	4
General assembly instruction	7
Fault finding	13
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General theory	41
Description of circuits (technical)	

Electro acoustics

- A 1 Simple gramophone amplifier for listening with earphone (EE8)
- A 2 Sound amplifier for microphone and gramophone reproduction. With possibility of mixing speech and music
- A 3 Push-pull sound amplifier for powerful reproduction and excellent sound quality
- A 4 Bi-Ampli amplifier for separate reproduction of high and low tones. Gives spatial spread to the sound (pseudo-stereophony)
- A 5 Electronic organ with eight keys which are tunable

Telecommunications

- B 1 Morse code training set. Offers the opportunity of practising the morse code. Sounds like radio telegraphy. Can, if required, be extended for group training (EE8)
- B 2 Morse code trainer with loudspeaker. Two-way telegraphy possible with a send-receive switch
- B 3 Intercom-loudspeaker house telephone. With speak-listen switch. Speech is reproduced by loudspeakers
- B 4 Monitoring set. Can be used to amplify weak sounds, such as birdsong in the open air. Pick-up coil

makes listening in to telephone conversations possible. Reproduction over loudspeaker or earphone

Radio

- C r Radio receiver with one transistor.
 Reproduction through earphone, reception with built-in aerial (EE8)
 Outside aerial
 Trawler band
 Directional receiver
- C 2 Sensitive, two-transistor radio receiver with earphone (EE8)
- C 3 Three-transistor receiver with builtin aerial and loudspeaker

Electronic signalling

- D 1 Tell-tale light. When light strikes the photosensitive cell a lamp flashes on and remains on until a key is depressed (EE8)
- D 2 Flashing light. A lamp flashes regularly on and off like a Belisha beacon at a pedestrian crossing (EE8)
- D 3 Acoustic relay. When the microphone receives a sound, the lamp lights up and remains on until the re-set key is depressed
- D 4 Pilfering alarm. Sounds a whistling note when light falls on a photosensitive cell, for instance when a book lying on the cell is taken away. Can

- also be mounted on the door or window as a burglar alarm
- D 4-1 Pilfering alarm with power-economising circuit
- D 5 Burglar alarm. Produces a whistling sound when intruders switch on a light or open a window. Whistling tone is continued until reset key is pressed down

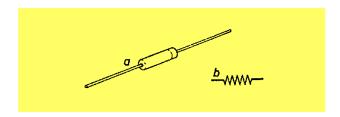
Electronic measuring and control

- E 1 Automatic night light. When the sun sets or the light in the room goes out the emergency lighting switches on automatically. When the sun rises or when the light is switched on again the night light goes out again automatically (EE8)
- E 2 Wetness indicator. A lamp lights up when the sensitive element becomes too wet. Can be used as a warning, among other things, when the bath is getting too full, when a boat is leaking or when flowers need water (EE 8)
- E 3 Time switch. A lamp is switched on and switched off again after a preset time
- E 4 Universal measuring equipment. Resistors and condensers can be tested with this.
 - Also measures intensity of light (light meter)

RESISTORS

Carbon resistors

Carbon resistors are used in the EE assembly kits. These consist of a small ceramic tube on which there is a thin spiral shaped layer of carbon. Such a layer has a far higher resistance, for instance, than a copper wire. The thickness of the layer, the length of it and the fineness of the carbon particles determine the amount of resistance. The carbon resistors are too small for the resistance value to be expressed in figures and this value can only be indicated by means of the colour code. Four coloured rings are painted on the resistors in the kit. Of these one is silver or gold. When reading the colour code the silver or gold ring must be at the right hand side.



Then the colour of the first ring (from left to right) indicates the first number, the colour of the second ring the second number and the colour of the third the number of the noughts. A gold ring indicates that the resistor is accurate to within 5%, the silver ring indicates an accuracy to within 10%.

The significance of the colours can be read from the following table:

Colour	1st and 2nd coloured ring	3rd coloured ring
black	0	-
brown	I	0
red	2	00
orange	3	000
yellow	4	0 000
green	5	00 000
blue	6	000 000
purple	7	0 000 000
grey	8	00 000 000
white	9	000 000 000

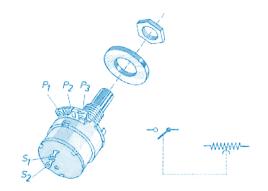
See also the chart on the inside back cover of this manual.

(The commonest tolerance value is 10% and this explains why the resistance values are such "strange" numbers. The series is, in fact, 10, 12, 15, 18, 22, 27, 33, etc. A 10 ohm (Ω) resistor can thus be a maximum of 10 ohm + 10% = 11 ohm. A 12 Ω resistor can also be 10% less: 12 ohm - 10% = 10.8 ohm. When a resistor does not have its own value, but deviates by more than 10%, it automatically comes under a different value and is naturally marked accordingly.)

Potentiometer

A potentiometer is used to regulate the volume of a radio receiver or sound amplifier. It is a resistor along which a contact can be slid and depending on the position of this contact a greater or lesser voltage is tapped off.

There is also a switch on the potentiometer in the kit for switching the battery on or off. This works off the same spindle as the sliding contact of the potentiometer. When the knob is turned as far to the left as it will go (counterclockwise), it sets the switch at off; when turned to the right it sets it at on again.



Light Dependent Resistors

There are resistors, relations of the transistor, whose resistance value is not constant. In the dark they have a very high resistance. When light falls on the striped-(sensitive) side the resistance is much lower. These photo sensitive resistors are called LDR's after the term Light Dependent Resistors.



Your L.D.R. many differ from the one shown but it can be recognised from the distinctive striped disc.



Tuning capacitor

The insulator in the tuning capacitor consists of thin layers of plastic between which two groups of metal vanes are moved as close as possible to one another by means of a spindle. The capacitance increases when the metal vanes are "turned in". The tuning capacitor is used to tune your radio receiver to a transmitting station.

CAPACITORS

Polyester capacitors

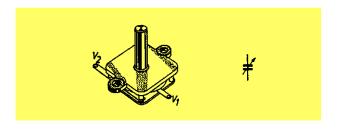
Polyester, a very suitable type of plastic for the purpose, is used in these capacitors as an insulator. A metal layer (silver) is applied to this plastic on one side. By placing two of these foils on top of one another and rolling them up tightly a capacitor is obtained. A



protecting layer prevents damp from seeping in and damaging the capacitor.

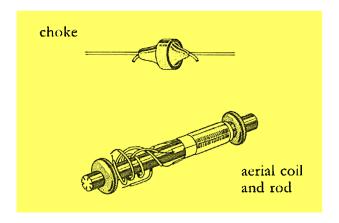
Electrolytic capacitors

In this case the insulating material is an extremely thin film of aluminium oxide. This opposes the current in one direction only, (just as a diode does) so the electrolytic capacitor must be connected in one way only. The positive pole of these capacitors is located at the grooved end of the little tube containing the capacitor.



COILS

Two different coils are used and their functions will be explained later in the circuit diagrams. There we shall also tell you what *Ferroxcube* is and what it is used for.



SEMICONDUCTORS

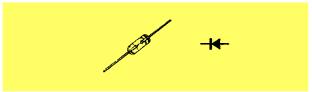
The Diode

In the figures below you will see a diode and its symbol. The arrow in the symbol represents the flow of positive holes.



EARPHONE AND LOUDSPEAKERS

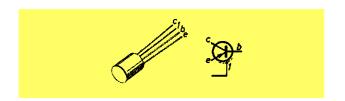
These components transform an electrical current into sound and this will be explained in the chapter on low frequency techniques.



The Transistors

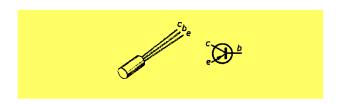
Below we have printed the figures and symbols of the two transistor types which are used in the EE kits with their corresponding symbols.





Loudspeaker (A 20 and EE 20 only)







Microphone symbol

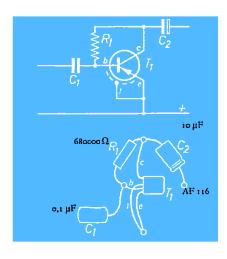


Pick up symbol

CIRCUIT AND WIRING DIAGRAMS

A number of different sets can be built and many experiments carried out with the EE assembly kits. This is possible thanks to the "assembly system". The basis of every set is the perforated mounting board, on which all components can be mounted.

In the laboratories circuit diagrams are used to show which components are used in a set and how these are connected to one another. The components are represented on the circuit diagrams by their symbol. In the diagrams we use the indications R, C, L and T. R = resistor; C = capacitor; L = coil. T = transistor.



For instance in this circuit diagram the indication R 1 represents the 680000 ohm resistor, and the indication C2 represents the 10 μ F capacitor.

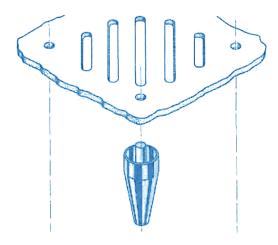
In the factories wiring diagrams are used. They show the exact place of the components and exactly how the mounting wires run.

The worst thing that can happen in your constructions is a short circuit. When, for instance, the lower wire of the above mentioned resistor of 680.000 Ω is so long that it touches one of the lower wires of the transistor, it might destroy your transistor and will exhaust your battery in less than no time.

FIXING THE PARTS

First of all the 4 feet are fixed under the mounting board.

See illustration:

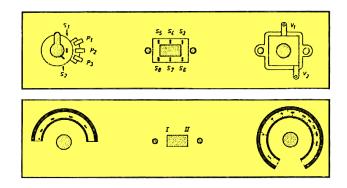


Mounting the potentiometer.

Take the rectangular strip, on which the connections of the potentiometer, the sliding switch and the tuning capacitor are drawn. This strip must be placed *under* the mounting board, so that the holes in this strip coincide with the holes present in the board and the printing on the strip is visible.

Now we can mount the potentiometer: Press the spindle of this potentiometer through the "key hole" in the paper strip and the mounting board from underneath.

Then push the potentiometer scale over the spindle of the potentiometer from the top. In the box you will find the strip with the scales among the mounting cards. Put the washer which goes along with the potentiometer on top of this and then screw the nut on the threaded bush of the potentiometer. You can now put the knob onto the spindle of the potentiometer. Do not forget to tighten the little screw in the knob. Turn the knob fully to the left so that the potentiometer is switched off. Now loosen the screw, align the pointer with the zero on the scale and tighten the screw again.



Dial and wiring card for potentiometer - switch and tuning capacitor.

Mounting the tuning capacitor. This is done with two split pins and two small rubber grommets. The split pins are pushed from above through the holes in the scale, the mounting board and the lugs of the tuning capacitor. The rubber grommets are pushed over them and then the ends of the split pins are bent outwards. Make sure you don't push the split pins into the capacitor by accident.

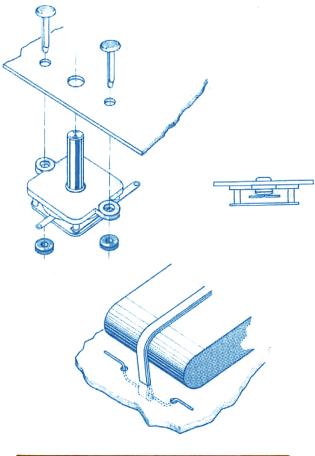
The possessors of an EE 20 or an Add-on kit are now going to mount the sliding switch. This is mounted in the centre between the potentiometer and the tuning capacitor. The sliding switch is mounted in the same way as the tuning capacitor with two split pins and two rubber grommets.

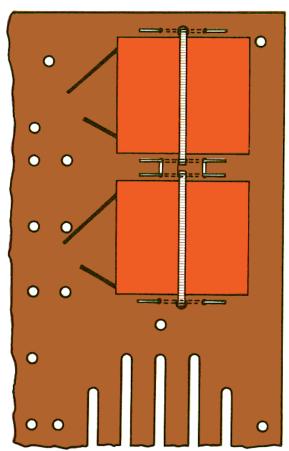
The two batteries are mounted on the right hand side of the mounting board. (See illustration). Each battery is kept in place by a rubber band. This rubber band is pushed through a hole in the board at each side of the battery and then anchored with a piece of bare mounting wire. If you use a PP 9 battery or another 9 V power pack this can be mounted in the same way; with the plus (+) nearest to the loudspeaker opening.

Batteries required are 4,5 V flat batteries.

Types: Ever Ready 1289

Exide F 40 Vidor V 5



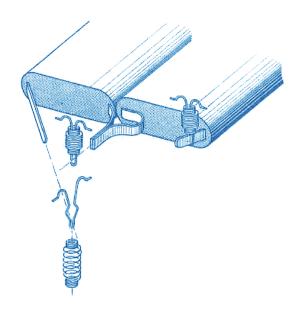


If you use flat batteries then connect the two battery strips which are next to one another. For this you bend the short strip of the upper battery and the long strip of the lower battery round so that they touch one another.

Push a large coil spring over a hairpin.

Then push the hairpin over the two battery strips.

Do not forget that you must never connect the long and the short connecting strip of the same battery together or allow them to make contact in any way. Such a short circuit results in discharging the battery in a very short time.

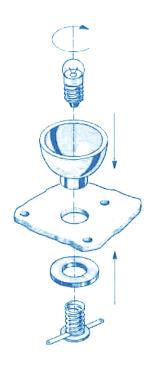


We continue with our preparatory jobs by mounting the lamp. First of all take the lamp holder and put a large rubber grommet over it. Push the lamp holder through the mounting board from below, through the round hole in the centre rear portion, that is, opposite the sliding switch. Then screw the reflector on the lamp holder and put in the lamp.



FITTING THE TUNING KNOB Screw the grub screw into the square nut

into the square nut. Insert the nut into the compartment at the back of the centre section (this should be a tight fit). The knob is then ready for the spindle.

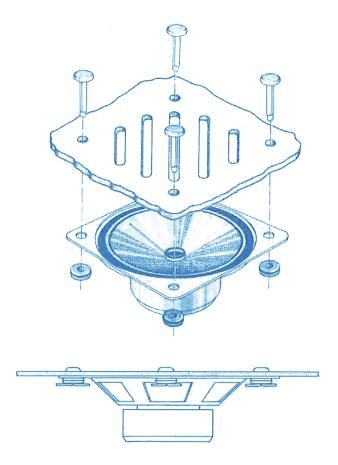


Mounting a loudspeaker. (possessors of an Add-on kit or an EE 20 only).

This is placed at the right hand side on the mounting board, under the oblong slots cut out of the board. There are 4 holes for mounting. We put a split pin through each of these 4 holes. We also push these through the four mounting holes in the metal housing of the loudspeaker. Then we put a rubber grommet over each split pin. The ends of the split pin are firmly pushed outwards. A certain amount of care in handling the loudspeaker is needed. If by accident you make a hole in the black paper cone of the loudspeaker with a split pin, a screwdriver or even your finger, you can be sure that that the loudspeaker will not perform as well as it should.

So avoid such accidents, for the loudspeaker is a very expensive component and the replacement of a ruined one will consume a lot of your pocket money.

The components we have now mounted are used in most circuits. Even if we do not require certain components, these can remain in their place, unless stated otherwise. Only the batteries must be replaced by new ones from time to time, although you will find that, if you use batteries of good quality they will last for a long time.



Now we can start building one of the many circuits which you can make with your EE assembly kit. It depends on you which one you want to start with. The various sets are divided into 5 groups: electro-acoustics, telecommunications, radio, electronic signalling, electronic control and measuring apparatus. This is a classification like the one used to distinguish between the various departments of large industries.

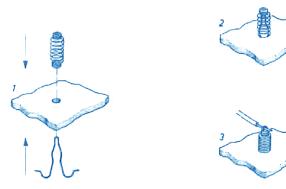
We advise you to begin with the first model in the group that happens to be most interesting to you at the time, that is with diagram A1-B1 or C1, etc. We have arranged the diagrams in each group in order of difficulty. Even the arrangement of the groups is not accidental. We have chosen to do it like this so that the explanations of the working of the various sets follow one another logically.

If you want to start with a really easy construction we would like to advise you to start with B₁ or D₂.

Whatever you do, you have made your choice and you know what you want to begin with. First of all take the required wiring diagram and put it on the mounting board in such a way that the printed numbers on it are legible from the side with the control knobs. This card must lie on the board in such a way that the holes in the wiring diagram are exactly above the holes in the mounting board. In these holes you must fit the spring terminals which are used to connect the components and wires together. These terminals consist of two parts, one known as a "hair pin" and the other a special pressure spring (large coil). The terminals are fitted to all holes punched in the card except those used for threading wires. There is a letter or a letter plus a number (for instance P2) at each threading hole or these holes are mentioned in the instructions for assembly.

You can also recognise them by the fact the wire which runs under the mounting board is marked as a dotted line.

Push the hairpin through from beneath the board and then push the coil spring firmly over the top. Do this with all the holes except the threading holes. To fit a wire, push the coil spring down. Insert the wire and then let go of the coil spring again.



You will have seen that on the wiring diagram all components are roughly drawn for easy recognition and the values or type numbers are printed beside them. If alongside a rectangle there is "10 µF", then that is, of course, an electrolytic capacitor. If there is "o.1 µF", then that is a polyester capacitor and if it says, "100,000 ohm", then that is a carbon resistor. The printed values and the shape of the drawings are sufficient to prevent mistakes. However, beside each component there is also a letter with a number, e.g. a transistor can be called T1, T2 or T3 while a resistor is marked with an R and a number. These letters are also to be found in the circuit diagrams. However, before you begin mounting the components, it is easier to fix the bare wires in place first of all. Bare wires are shown as single lines. How you recognize these components is described on pages 4-6.

When mounting an electrolytic capacitor you must be careful that you do not confuse the positive and the negative side. In the metal casing of these capacitors there is a groove or a printed "plus" at the positive side. This groove is indicated on the wiring diagram and the capacitor must now be placed in exactly the same position as printed. After you have mounted the resistors and the capacitors in their correct places, there follows the diode, if required. Pay attention to the stripe or the red mark on the diode. This is the positive side of the diode and the diode too should not be turned round. On the wiring diagram the ring is also given and therefore mount the diode precisely in the position as shown.

Alternative knob fixing

If your knob is not fitted with a grub screw then it should be assembled, using a grub screw and a nut as shown in the figure.

THE TRANSISTORS

Warning

Connect the transistors very carefully and the right way round. If you handle the transistors carelessly the leads might break. A transistor cannot be repaired! If a transistor is connected up wrongly it may become damaged internally. It is decidedly better to be careful than having to buy a new transistor. On the mounting card there are the letters c, b and e, that is to say, collector, base and emitter. On the casing of the transistor AC 126 there is a dot. The wire closest to the dot is the collector lead. If you watch carefully you cannot make a mistake. If you do make a mistake the set will not work and the transistor can be ruined. In the AC 126 transistor the wire closest to the collector is the base lead and the one farthest away from the collector is the emitter.

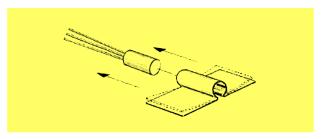
Be very careful with the connection of the transistors as these components are not as strong as, for instance, a resistor.

In the case of the transistor AF 116 the collector wire is spaced apart from the others, then follows a wire marked on the diagram as 1 for screening, after which follows the base and emitter wires. Be careful with the thin transistor wires. Do not bend them more then is necessary. Do not pull at them and, make sure that when they have been mounted they do not touch one another.

The wires should only be bent at their tips and not at the base of transistor.

Never forget to push the heat sink over the transistor or transistors when required. This is shown on the wiring diagram. Otherwise they will get too warm and you will run the risk that they will be ruined into the bargain.

When placing the *heat sink* on the AC 126 transistor, the sink must be *slightly* bent open.

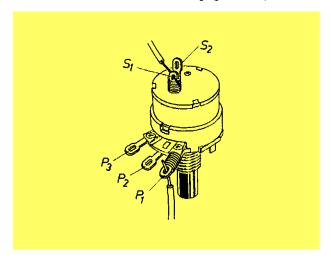


The under part of the transistor (that is the side where the wires come out) must be level with the edge of the heat sink. When the transistor is in its place, let the heat sink spring back again.

Other connections

When you have mounted these components check that you have not forgotten any connecting wires marked as black lines on the wiring diagram. Having done all this we connect the "inner area" with the "outer area", that is to say we shall connect the circuit to the batteries, the potentiometer, loudspeaker, etc. Make sure, first of all, that the switch on the potentiometer is at off (turned as far as possible in the counter-clockwise direction). The connections on the potentiometer, etc. are usually made with insulated wire (red wire). These leads are shown in the wiring diagram by double lines. Where the leads run underneath the mounting board they are marked as dotted lines.

Where the wires enter a spring terminal or the connecting tag of a component, the insulation must be removed for a length of about \(\frac{1}{4} \) inch, which you can do with a sharp pocket knife or wire strippers. Make certain that you only cut through the plastic insulation and not the metal wire. Where the wire goes through a hole you will see a letter and a number at the side which correspond to the connecting tag to which the wire must be connected. These letter-number combinations will also be found on the paper strip which



you have fixed under the mounting board. We believe that this will all be clear to you.

Sometimes two letters are shown at a hole, for instance $S_1 + P_1$. This means that this wire then goes to a contact on the switch and one on the potentiometer. In that case you must bare not $\frac{1}{4}$ inch, but $\frac{3}{4}$ inch at one end of the wire. Pushing the bared wire into a terminal will cause you very little difficulty.

To connect the wires to the potentiometer or the switch mounted on it, first of all push a small coil spring over the connecting tag. Press this spring down, push the bared end of the wire through the hole in the tag and then let the spring come back in such a way that the wire is pressed hard against the tag. The connections to the tuning capacitor, the sliding switch and the lamp are made in the same way.

We shall connect the 4.5 V batteries with hairpin springs. Push a large coil spring over a hairpin spring and next compress the coil spring so that the still free battery strip can be pushed into the hairpin.

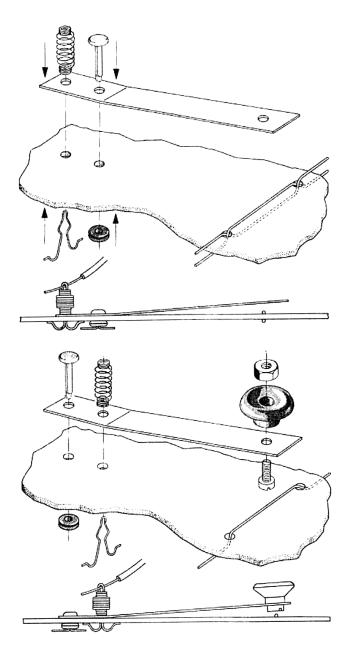
The bared end of the connection wire can be pushed in by pressing up the hairpin. If you cannot buy 4.5 V flat batteries, buy a PP 9 type or another type 9 volt battery; ask the dealer for a set of connectors too. The "button" is the positive (plus) pole, the "button" hole is the negative (minus) pole.

Take care when connecting the batteries that you don't confuse the positive and the negative. If you make a mistake the set will not work and there is a danger that certain components, such as the transistors, will be ruined.

We use split pins for the *loudspeaker* connections. There are two connecting tags on the loudspeaker. Push a split pin through each of these tags, then push the wire into the split pin. Next push a small spring over the split pin and bend the ends of the split pin outwards, in such a way that the spring is compressed well.



In the electronic organ and in some other sets, keys are used. The drawings show clearly how the keys are assembled. The best method is first of all to lay the flat spring in the correct place, then push the hair-pin through the correct hole in the mounting board and through the last hole in the flat spring. Then push the coil spring over the hairpin. Finally stick the split pin through the flat spring and the board from above, put a rubber grommet over it from underneath and then bend the legs of the split pin outwards. This is the key as used in the electronic organ. The telegraph



key, which is used in the morse-code trainer is made in a similar fashion, except for the fact that there is a little knob on the free end, which is fixed with a bolt and a nut.

Do not forget the nut at the top.

Final check

Read the instructions for assembling each set thoroughly and see whether there are any special remarks on it, such as the connection of the aerial coil, extra loudspeaker, morse key, etc.

When you have done everything stated in the general instructions and the instructions for assembling the sets, then the job is finished. First of all, check that you have not overlooked something. That is, ensure that:

- the correct components are in the correct place,
- you have not forgotten anything,
- the wires are not touching one another, where they should not be,
- all electrolytic capacitors are fitted properly with the positive end as marked.
- you have not connected any transistor wire the wrong way round.

When you have checked all this, including the assembly instructions, then you can switch on. If you have made no mistakes then your set will work well. If it doesn't, read the section on "Checking for faults".

CHECKING FOR FAULTS

If a set does not work properly switch it off immediately and start with the following points:

T. Check the wiring. Compare it with the wiring diagram on the mounting board. Make certain that you have not forgotten any connection or any component. Look and see if the wires make proper contact in the wire terminals and that they do not touch one another where they should not.

- Check that you have not confused the positive and negative poles of the battery and that the wire connection between the two batteries has not been forgotten or has worked loose.
- 3. Check whether the transistors have been connected the right way (collector, base, emitter and eventually screen).
- 4. Check whether the diode has been connected in the correct direction.
- 5. Check whether the electrolytic capacitors are connected in the right direction, that is, with the groove (+) as printed on the wiring diagram.
- Look at the colour code information given at the end of the book to make sure that you have used the correct resistors.
- 7. If necessary take a new battery to see whether the lamp is damaged.

 The circuits only work with a lamp as provided (6 volt at 0,05 Amp). Any other voltage or current rating with not function properly.
- 8. Check that your batteries are not empty. Use the lamp supplied for the purpose. N.B. Check the batteries with it one at a time, for the two batteries in series give more voltage than the lamp can take.

DISMANTLING

Start by setting the switch to "off" and for the sake of safety disconnect the batteries. The connection between the two batteries can remain. Then first of all remove the transistors. For this purpose press the coil springs down so that the transistor leads can be carefully and easily pulled out of the terminals. Pull the wires and not the transistor. When a separate loudspeaker or record player is connected, remove their connecting wires too. Then carry on removing the resistors, capacitors, the

connections on the potentiometer, etc. The wire connections of the carbon resistors, the electrolytic capacitors and the polyester capacitors were bent on being mounted. Don't straighten these again, for the models are such that you have to bend them again. The less the wires are twisted to and fro, the less is the danger of breakage. Pull the wires out of the connecting tags of the potentiometer, of the variable capacitor, etc. If you leave these dangling loose they are only a nuisance and cause you to make mistakes.

If we may give you a good piece of advice, put all components back into the box immediately. When components are lost, or when they fall on the floor and you stand on them by accident the moment will come when you are stuck and must race off to the dealer to get replacement parts. This costs money and holds up your progress. This putting away applies also to hairpins, coil springs, as well as to split pins. Be careful with them, for you cannot do without these either. After all the parts and the spring terminals have been removed you can take off the wiring diagram and replace it with the next one.

A. ELECTRO-ACOUSTICS

A_I — TWO TRANSISTOR GRAMOPHONE AMPLIFIER

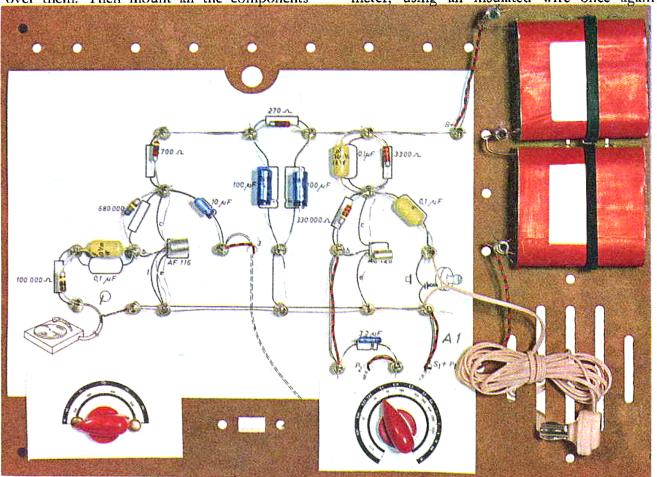
This amplifier makes it possible to reproduce gramophone records clearly and powerfully through an earphone, which means that you can play records with it without disturbing other people.

In the general instructions on page 7 and the following pages you will find the necessary instructions for assembly. Use wiring diagram A 1. Place this on the mounting board, in such a way that all the holes in the wiring diagram coincide with the holes on the mounting board.

Have you mounted the batteries and the potentiometer? If you haven't, do that first. Then place hair pins in all the holes in the wiring diagram except in those holes which are marked: S1 + P1, P2 and P3 and put springs over them. Then mount all the components

as printed on the wiring diagram. Mount the polyester and the electrolytic capacitors in their places too, taking care that the electrolytic capacitors are in the correct way round. The transistor wires must not be mixed up. If you are not sure, read the assembly instructions once more. Then connect the bare mounting wires (single lines on the wiring diagram). When you have finished with this connect the earphone to the two terminals at the right hand side on the wiring diagram where you see the drawing and the symbol. Mount the resistors.

Now connect an insulated wire to terminal P₃ of your potentiometer, thread this through the hole in the mounting board where there is no spring terminal and connect it via a wire terminal to the capacitor C₂. In the same way a wire must be led from the capacitor C₅ to the P₂ terminal of the potentiometer, using an insulated wire once again



which goes through the hole at P2. A wire from the bottom terminal of the earphone also goes through the hole marked S1 + P1, to point S1 on the switch and point P1 on the potentiometer. Then the batteries have still to be connected. From the long strip of the upper battery a wire must go to the point top right on the diagram marked B-. From the short strip of the lower battery an insulated wire must go to the switch tag S2 on the potentiometer. You must therefore thread this wire somewhere through a hole in the mounting board. Check whether the long strip of the lower battery has already been connected to the short strip of the top battery. If that is not the case do it now. If you use a PP7 or PP9 battery look at page 12.

Then connect the record player at the left hand side of the wiring diagram. The symbol and the drawing of the record player are there so that you can make no mistake. If there is no pick up socket on your gramophone you *should* consult an experienced person as to how you make the pick-up connections.

One difficulty may arise however, as most record players are provided with a stereo pick-up. The connecting cable contains two cores and one or two screening covers. Both core wires must be connected to the left terminal, the screens to the right terminal. In a non-stereo set the same applies, Core wire to the left, screening to the right.

When everything is finished and checked then put on a record, switch on the record player and the amplifier. Your amplifier is switched on and its volume can be controlled by turning the potentiometer knob; to the right for switching on and greater volume. You can now play to your heart's content. If no sound comes out of the earphone turn to page 13 which gives you instruction how to trace the faults.

A2 — AUDIO AMPLIFIER

This amplifier is the big brother of the

preceeding one. Reproduction is by means of a loudspeaker. Apart from the gramophone a microphone can also be connected. We use the little earphone as a microphone.

Instructions for assembly

We now use wiring diagram A2. It is placed correctly on the mounting board so that holes in the wiring diagram coincide with holes in the mounting board. Spring terminals are then placed in all the holes except those where you see S1 + P1, P2, P3, S3, S4 and S5. These are the lead-in holes.

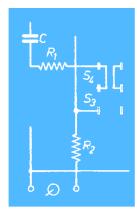
Now mount the components and the connecting wires. Take care you do not make any mistakes when connecting the AC 126 and AF 116 transistors. Under no circumstances must you forget the heat sink on the AC 126 transistor at the right hand side. Take care that none of the electrolytic capacitors are put in the wrong way round.

Connect the earphone where you see the symbol for the earphone and also the record player where the gramophone symbol is drawn. See A_1 for detailed instructions. If the connection of the record player causes trouble look at what it says about this in the section on Amplifier A_1 .

Are the transistors and the batteries correctly connected? No components forgotten? Have the electrolytic capacitors mounted the correct way round? Have you thought of the heat sink for the righthand AC 126?

Forgotten any wire connections? Everything in order? Right, switch on and play away! Slide the switch to the right for microphone reproduction; slide it to the left for gramophone reproduction.

You may hear a squeaking tone at position Microphone. Hold the little earphone you are using as a microphone further away from the loudspeaker or turn the volume control to the left, so that the volume is reduced.



Speech and music

You can connect the 100,000 Ω resistor to switch tag S4 instead of switch contact S3. In addition connect a 27000 ohm resistor (red, purple, orange) in between the C1 capacitor and switch contact S5, (mount an additional wire terminal for this purpose). This makes it possible to talk through the music.

When the switch is at position Gramophone you only get gramophone reproduction and with the switch at position Microphone the gramophone keeps playing but you can talk through the music by using the microphone.

A₃ — PUSH-PULL AUDIO AMPLIFIER

This is a gramophone amplifier which enables you to obtain greater volume and better reproduction quality than you can with the previous one. Two loudspeakers are used here. This amplifier can also be used with one loudspeaker, but then it does not play so loud.

Assembly instructions

Use diagram A₃. Mount the components and the connecting wires carefully.

Of course, you have to connect the positive pole of the lower battery to switch contact S2. The only special point to watch is the fact that now two loudspeakers have to be connected up. On the loudspeaker there is a red dot on one of the terminals. This terminal has to be connected to the contact where you see the letter B. The second loudspeaker is best mounted on a little baffle or a little box. This

second loudspeaker is connected to the same loudspeaker terminals, but you must be sure once again to connect the wire from the terminal marked B- to the connecting tag with the little red circle printed on it. If you do not do that, you will get less low notes because the loudspeakers are working against one another.

A₄ — BI-AMPLI AMPLIFIER

This is a very interesting gramophone amplifier. Two loudspeakers are used for it, one for reproducing low notes and another for high notes. This lets you hear, as it were, the violins and the trumpets separately from the cellos and the drums, which naturally makes the music sound more pleasant and more real. Some of the best wireless sets and gramophones are Bi-Ampli i.e. having two amplifiers.

Instructions for assembly

Use wiring diagram A₄ and mount the wires and components carefully. (See A₁).

Of course, you must not forget to connect the positive pole of the lower battery (short strip) to contact S₂ on the potentiometer switch. For the colour code of the various resistors see the table at the end of the book.

Connect the loudspeaker on your mounting board to the terminals beneath and above the loudspeaker symbol alongside which you see the bass symbol. The bass symbol looks like a comma with two dots after it. This loudspeaker reproduces the low notes. The high note loudspeaker is connected by means of two insulated wires.

On the wiring diagram the high note loudspeaker is indicated by the loudspeaker symbol with the treble sign as shown below.



The high-note loudspeaker wires can, for instance, be a yard in length, so that the loudspeaker can be set a fair distance from the low-note loudspeaker to underline the separate reproduction of high and low notes. The high-note loudspeaker does not need to be mounted on a baffle. As in the case of the push-pull amplifier A₃, it is important that both loudspeakers are connected in the same way, that is to say the loudspeaker terminals marked with a red dot must be connected to B—.

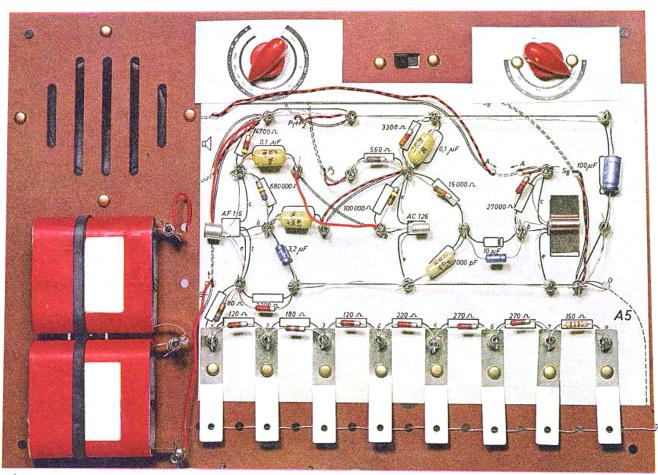
A₅ — ELECTRONIC ORGAN

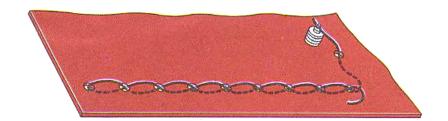
The name already tells you that this is an electronic organ on which you can play a number of simple tunes with very little practice. You can produce eight different notes with the eight keys and with the help of a potentiometer you can tune your organ to produce a musical scale. We shall tell you how to do this after the mounting instructions.

Mounting instructions

This is one of the most difficult sets in the assembly kit and we hope you do not begin with this one before you have had a fair amount of experience with other sets. First of all remove the lamp and put it away for later use.

The wiring diagram A₅ is placed altogether differently from those used for all the other sets. Put the mounting board in front of you so that the potentiometer and the tuning capacitor are now at the back and then lay the wiring diagram on the board so that all the numbers can be read from the front. Now let us begin mounting in the ordinary way. Do not forget when placing the spring terminals that these terminals do not come into the lead-in holes marked P₁ + P₂, P₃ and S₈, nor into the holes marked with a letter A and an arrow or the letter C with an arrow. Nor into the holes for the eight keys at the front of the wiring diagram.





You will of course be careful that the transistors are connected in the correct way and that the electrolytic capacitors are placed in the correct direction. For the colourcode of the various resistors see the table at the end of the book.

Now you have got to thread a wire through the front holes of the mounting board. A bare wire must be used and you can see on the drawing exactly how it must run. If you have done this you can mount the keys in the way shown on page 13. Finally, for we assume you have not forgotten anything else, the still free positive pole of the batteries (short strip) must be connected with insulated wire to the switch contact \$7.

Tuning and playing

Press a key and you should hear a note. If not take the advice given on page 13. When everything works then press in succession keys 1, 2, 3, 4, 5, 6, 7 and 8. You will then hear that the notes coming out of the loudspeaker get steadily higher, but they will probably be out of tune as yet.

Now turn the potentiometer knob until, having played the keys 1 to 8 inclusive in succession, you hear the scale in tune, i.e. doh-ray-me-fah-so-lah-te-doh.

If you do not succeed in getting a reasonable scale, interchange the capacitors C_4 (0,1 μ F) and C_5 (47.000 pF) and try again.

You can now play simple tunes.

For this purpose try to get hold of a tutor for the recorder (soprano recorder) or a school song book, doh is 1, ray is 2, etc. You will see how well you get on.

B. TELECOMUNICATIONS

BI — MORSE CODE TRAINING SET

When you depress the sending key of this set you hear a whistling tone in your earphone. Press the key down briefly and you will hear what is called a dot, press the key down for longer then you will hear what we call a dash. A long time ago certain agreements were made by which each letter of the alphabet and each figure was given a code consisting of dots and dashes. The morse code is used throughout the world and on the radio you have no doubt heard telegraphists (morse operators), working on the air. If you learn the morse code by heart (given on page 56) and practice hard you will be able to pick up such telegraphic information. You will of course notice that some operators transmit far too fast for you and that the messages which are transmitted are not always in English, but for instance in Spanish. Well there is nothing you can do about that of course but if you work together with a friend you can practice and send messages to your heart's content.

Assembly instructions

In the general assembly instructions on page 7 and following you will find the necessary instructions for assembly. Use wiring diagram B1. Place it on the mounting board in such a way that all the holes in the card coincide with the holes on the mounting board. You have of course already mounted the batteries and the potentiometer and have placed the mounting board in such a way that the potentiometer is at the front. The wiring diagram B1 must be so placed that all numbers on it can be read from the front. Now fix all the terminals in the holes marked in the wiring diagram, except those which are marked with P1 + S1, P2, P3, A and B. No terminals are to be put in the holes for the sending key. Then fix the long bare wires, that is, the wires corresponding to the continuous black lines on the wiring diagram. When this is done continue by mounting all the components, first the resistors,

the colour code of which you can find at the end of the book.

Then come the polyester capacitors and the electrolytic capacitors. Pay careful attention that the groove in the casing of the electrolytic capacitors is placed as shown on the wiring diagram. Then mount transistor AC 126 as well. The dot on the housing of the AC 126 indicates the collector wire. This dot is also to be found on the wiring diagram card, which you must not overlook.

When you have done all this, you can mount the three insulated wires drawn on the wiring diagram.

From the electrolytic capacitor C₄ a red wire goes through the hole marked P₃ under the mounting board to the contact P₃ of the potentiometer. In the same way an insulated wire runs from the electrolytic capacitor C₅ through the hole marked P₁ + S₁ under the mounting board, through to the P₁ contact of the potentiometer and S₁ of the switch on that potentiometer. Do not forget the wire to contact P₂.

Now lead a bare wire from the electrolytic capacitor C₅ above the wiring diagram to the left-hand hole A, then under the mounting board and up again at the right-hand hole A, and down again through the left-hand hole B and up through the right-hand hole B. At this point you let an end of the wire protrude, so that it cannot fall back. Then you have to fix the morse key. The drawing and the instructions written on page 13 will help you along with this.

Now connect the earphone, at the right-hand side of the wiring diagram, to the terminals just above and below the symbol for the earphone. There is an earphone drawn beside it so that you cannot mistake it.

Have you now connected one short and one long strip of the two flat batteries? If you have not, do it now and then connect the negative pole, that is to say the long strip of the topmost battery to the wire terminal marked B-, with a bare wire if you wish. Connect an insulated wire from the positive pole of the lower

battery (short strip) to the contact S2 of the potentiometer switch; you will find a hole somewhere where you can lead this wire in. If you use a PP7 or PP9 battery look at page 12. Before you switch on your morse set, first of all check everything you have done and watch out that the transistor is correctly wired.

If you are convinced that you have indeed made no mistakes, switch on by turning the potentiometer knob to the right. Press the sending key down and you should hear a whistling tone from the earphone, if not see page 13 for fault finding instructions.

Possibilities of extension

You can practise with this set just as it is.

You then hear in the earphone exactly what you are transmitting with the morse key. If you have connected a couple of long wires to your earphone then someone else can hear what you are transmitting in another room, even if you do not hear it yourself. Your friend cannot transmit back, but as you are a handy fellow it will not be difficult for you to make a second morse key which you will fasten onto a little bit of wood. Connect this second morse key in precisely the same way as the key on your own set; that is a wire to the negative side of the 10µF electrolytic capacitor and the other wire to the positive side. If you can lay your hands on a second crystal type earphone, and connect it to the same terminals as the first earphone is connected to, then you can transmit backwards and forwards. Each of you then has one morse key and one earphone at his disposal and each person hears what the other one is transmitting and also what he is sending out himself.

Morse traffic in groups

When a youth club or a group of scouts want to practice morse telegraphy, several earphones can be connected in parallel to the earphone of this set, that is in exactly the same way between the same two terminals. The instructor has the morse key in front of him and all his pupils hear the telegraphy and can write down what they have heard. It is of course of the greatest

importance to begin slowly and gradually increase the sending speed when everyone really knows the morse code inside out.

B₂ — MORSE CODE TRAINER WITH LOUDSPEAKER

The difference between this and the set previously mentioned is that the morse signalling is reproduced here through a loudspeaker.

Instructions for assembly

Use wiring diagram B2. Read through the instructions on circuit B1.

Carry out the mounting of B2 in the way described in B1.

Thus first of all mount all the components including the second AC 126 transistor, not forgetting the heat sink.

Connect the potentiometer and the switch with red insulated wires. From the positive terminal of the lower battery (short strip) an insulated wire runs to the switch contact S2. Connect the loudspeaker to the two wire terminals below and above the loudspeaker symbol at the righthand side on the wiring diagram. Before you switch on the set, check all components and connections carefully once more, and switch on the set by turning the potentiometer knob to the right. The further right it is turned the louder the tone.

Two-way switch

Two-way telegraphy is possible, as already described in B1, by connecting up two sending keys and two loudspeakers to the loudspeaker terminals. It is however more pleasant and, as far as the consumption of current is concerned, better to incorporate a two-way switch. To do this we connect switch contact S7 to the terminal below the loudspeaker symbol. The loudspeaker tag is not connected to this terminal but to the switch contact S8.

The second loudspeaker is in a separate room which also contains the second morse key and is connected to the switch terminal S6. The

other tag of each loudspeaker remains connected to the terminal marked B. When we move the knob of the switch to the right we hear what our friend is tapping elsewhere; when the switch knob is to the left our friend hears what we are tapping out. The second morse key is connected to the same terminals as the first one.

This set too is very suitable for teaching morse to groups, but in no case should more than two loudspeakers be connected up to it, because the AC 126 transistor may be damaged. For morse teaching in club premises which are not too large this set is of course outstandingly good.

B3 — INTERCOM

In factories, offices, shops and restaurants much use is made of loudspeaker house telephones. Two way contact is possible over quite a large distance and the volume is adjustable.

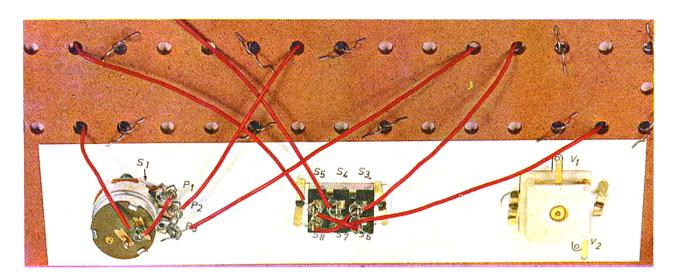
Instructions for assembly

This is a fairly complicated set and we hope that you will not begin it until you have had some experience in assembling the simpler sets. Use wiring diagram B₃. Put this one in the usual manner on the mounting board and insert terminals in all the holes except those marked $S_1 + P_1$, P_2 , P_3 , $S_3 + S_8$, $S_5 + S_6$, S_4 and S_7 . When all terminals are in place, begin mounting the resistors, the capacitors, the

transistors and the required bare connecting wires. For the colour-code of the various resistors see the table at the end of the book.

Do not forget to put the electrolytic capacitors the correct way round and avoid making any mistakes when connecting up the transistors. When you have done all this connect the central part with the outside part, for which you used insulated wires. For instance, first of all an insulated wire from the terminal containing the screening wire and emitter wire of the AF 116 transitor, across the wiring diagram, then through the hole marked S3 + S8 and down and underneath to the switch contacts S₃ and S8. Then run the wire from potentiometer contact P3 up through the hole marked P3 to the o.1 µF polyester capacitor C3 etc. From the still unconnected positive pole of the lower battery (short strip) an insulated wire runs to switch contact S2. Do not forget to connect the negative pole of the top battery (long strip) to the wire terminal next to the marking B-. At the righthand side of the wiring diagram you will see the symbol for the loudspeaker. This indicates the loudspeaker mounted in your set. Connect this in the way shown on the wiring diagram, that is to the terminal placed just above the loudspeaker symbol and to the terminal at the bottom right-hand corner of the circuit.

Connect the second loudspeaker with a pair of long wires to the terminals placed just right of the loudspeaker symbol at the bottom



left-hand part of the wiring diagram. You can easily use two-core mains flex which you can buy in any shop. This does not need to be particularly heavy flex.

One last check and then switch on by turning the potentiometer knob to the right. Now set the knob of the sliding switch to the left and speak into the loudspeaker of your set.

If everything is in order, your voice should be clearly heard through the other loudspeaker. If the reproduction is too soft turn the knob of the potentiometer further to the right. If this is in order set the knob of the sliding switch to the right. Now your friend in the other room can talk into the loudspeaker there and you can hear him.

Applications

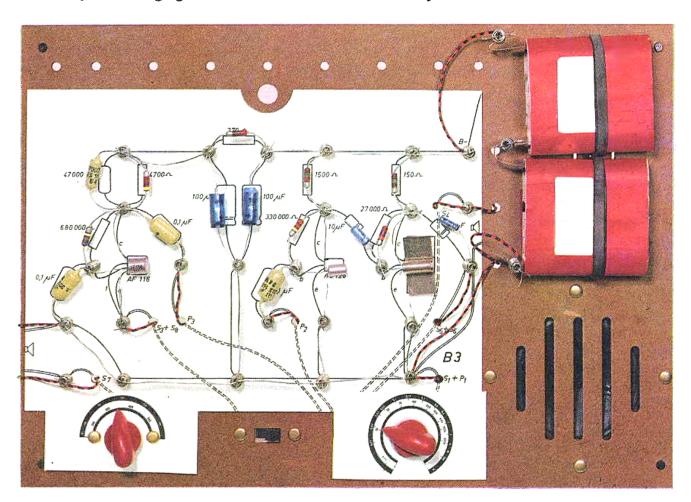
The number of applications is particularly large. This set can render excellent service as a baby-sitter. When the baby is lying in its cradle and the loudspeaker hanging above the cradle is

switched to the microphone position, then your mother in the front room or the kitchen can hear the baby crying. She can even switch over the sliding switch to say a few soothing words to the child without having to climb the stairs.

You can of course place a loudspeaker outside the front door and if anyone rings the bell your mother, from the kitchen can ask: "Who is there?" and, when she hears that it is the greengrocer she can tell him what she needs in the way of potatoes etc. Do not leave the loudspeaker out in the rain, however, as it will get spoilt.

Over

In radio telephony it is often necessary to throw over a switch when you change from talking to listening and this you announce at the end of the sentence by saying "over". When you use this circuit as a loudspeaker house telephone or as a link with the lad next



door, then it is a good habit always to say "over" when the message is finished, so that your friend is warned that it is his turn to speak. Of course, you can also use this set to put on a play which is reproduced in another room. This is a particularly attractive idea especially if you are well prepared and have made sure of all kinds of sound effects. You will be fascinated by the number of sounds you can produce with such simple means as bits of paper, sticks, glass marbles, metal plates, etc. If you start out on this on a rainy afternoon, it is very likely that you will get so much fun out of it that you will be sorry to see the sun shining again.

B4 — TELEPHONE AMPLIFIER

This is a particularly sensitive microphone amplifier with which you can capture even very slight sounds and reproduce them clearly through the loudspeaker. You can also use it to reproduce telephone conversations through a loudspeaker.

Instructions for assembly

Use circuit card B4 and first of all fix all spring terminals. Leave the holes indicated by S1 + P1, P2, P3, S4, S3 and S5 free. Mount all the wires and components in the usual way. Give your usual close attention to the correct mounting of the transistors and electrolytic capacitors and do not forget the heat sink for the right-hand AC 126. See colour-code at end of book for the resistor values.

Connect the negative pole of the battery to the wire terminal at B- and the positive pole of the lower battery to the switch contact S2. Also connect a loudspeaker. The earphone is connected to the second and fourth terminals from the left at the bottom of the wiring diagram. As this earphone is being used as a microphone the microphone symbol is shown here. Now take the choke-coil with the wax covering out of the kit and connect two insulated wires to it. Remove about half an inch of insulation on the ends of these wires and twist them onto the ends of the coil. One insulated wire to each coil wire. Connect the free ends of

these wires to the first and fourth terminal at the bottom left of the wiring diagram. Now set the sliding switch to the right.

Microphone amplifier

When you have switched on the set let someone speak gently into the microphone. His voice will be clearly audible through the loudspeaker. It is perhaps possible that before anyone says anything a squeaking tone will be heard from the loudspeaker. This is because the microphone and the loudspeaker are too close to one another. You can avoid this by placing the microphone somewhat further off or by turning the knob of the potentiometer a little to the left, thus making your loudspeaker less loud. You will notice that when you hang your microphone out of the window on a quiet evening and turn the potentiometer fully to the right, that is, to maximum sensitivity, the song of the birds outside will be heard in your room even if the birds are a long way from your home. This set can also be used to good advantage in performing radio plays.

Telephone amplifier

This is quite an astonishing experiment. Set the sliding switch to the left and place the recording coil near the telephone as shown in the illustration. Call up a friend on the telephone and begin a telephone conversation with him. What you say and what he says will then be heard through the loudspeaker. The loudspeaker can, of course, also be in another room. The telephone is also an electrical instrument and everything that you say and what your friend says generate currents which go through coils in the telphone set. These



coils generate a magnetic field which goes through your pick-up coil. These magnetic fields in turn generate little voltages in the pick-up coil, which are further amplified by the monitoring set until they reach loudspeaker volume. Find out by trial and error what the best position of the pick-up coil is. With some telephones which are shielded very efficiently, this trick might not work.

Earphone listening

It may be that you do not want any reproduction through the loudspeaker or that you have too much bother with "microphony"; the whistling tone which is produced when the microphone is too close to the loudspeaker. In that case it would be better to use the loudspeaker as a microphone. Connect the loudspeaker to the microphone terminals (second and fourth wire terminals bottom left). The earphone is connected to the wire terminal at B- and to the collector of the lefthand tran-

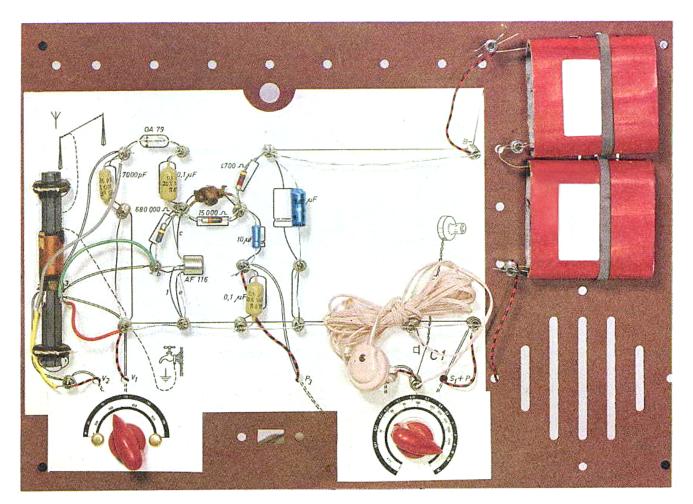
sistor AC 126 across the 3.2 μ F electrolytic capacitor C6.

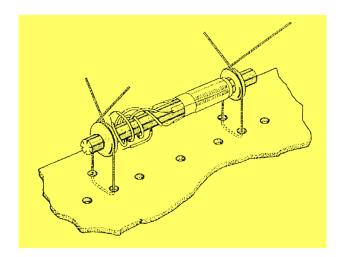
You can use the terminal at the right-hand side of the wiring diagram where you see the small letter b. The right-hand transistor T₃ and the 27,000 ohm resistor R₇ do not need to be used any more.

C. RADIO

C₁ — RADIO RECEIVER WITH ONE TRANSISTOR

This radio receiver has its own built-in aerial and can be listened to with an earphone. It is suitable for medium wave reception, that is for the wavelength on which most broadcasting transmitters broadcast. You have naturally made all the necessary preparations, the batteries have been fixed, the potentiometer and the tuning capacitor (variable capacitor), as described on page 7 etc.





Take wiring diagram C1 and put it on the mounting board in such a way that all the holes in the wiring diagram coincide with the holes on the board. Do not forget to place the wiring diagram in such a way that you can read all the numbers from the front, that is from the side of the tuning capacitor and the potentiometer.

ASSEMBLY OF THE FERROCEPTOR

Slide the aerial coil on the ferroxcube rod until it is precisely in the middle of the rod. Push a sharpened matchstick between the coil and the rod so that the coil cannot change position. Then push on the two large grommets as shown in the illustration. Now your "ferroceptor" is ready and you can mount it on the wiring diagram. Place it so that it lies roughly on the illustration on this card and is turned so that the tag with the red wire lies closest to the card.

If required move the rubber grommets a little upwards or downwards so that they are in line with the little holes. Then mount the aerial with the aid of small bits of string (never wire) running across each grommet through the holes and knot them below the mounting board. The sort of knot you want to use must, of course, be chosen by yourself. As you will later want to remove the aerial it is perhaps best if you tie the strings the way do up your shoe-laces.

Fix the spring terminals in all the holes of the

wiring diagram, except for those marked with $S_1 + P_1$, P_2 , P_3 , V_1 and V_2 . When all these terminals are in place you can start mounting the components. Take care that they are mounted exactly as drawn on the wiring diagram. Colour-code for resistors can be found at end of book.

Connect up transistor AF 116 as well. It is of the greatest importance that you do not make a mistake with the connecting wires. First of all connect the collector wire which is a little bit to one side, and then one after the other, the screening (1), the base lead (b) and the emitter lead (e). Then put the insulated and bare connecting wires in the correct place.

When you have done this work connect the red wire of the aerial coil to the terminal connected by a dotted line to the drawing of the tap. The yellow wire to the terminal connected to contact V2 of your tuning capacitor, the green wire to the point where you see the b of the base of the AF 116 and finally the grey wire to the junction point between the 47,000 pF polyester capacitor and the OA 79 diode (X1). Connect up the earphone and the batteries (connect plus terminal of battery to S2) and if everything seems to be all right switch on. Turn the tuning capacitor until you have received one or more stations. May be you will get louder reception if you turn your whole set a bit or attach an outside aerial (see following paragraph).

Outside aerial

Where reception is weak, this can be considerably improved by connecting an outside aerial (read also page 57 etc.). An outside aerial must be fixed between two high points, like two chimneys, or between a house and a garage. This is a job that can only be done by adults, and even then only with the express permission of your parents. Special aerial wire can be bought from your radio dealer and this must be fixed between insulators made of glass or porcelain, which you can also buy through the radio trade.

In the illustration you can see how the wire

must run through the insulators. The aerial lead must naturally be led into the house. You should ask your parents how this should best be done. The inlet must be insulated.

Inside the house you are recommended to use insulated wire. The mounting wire such as you find in the assembly kit is suitable for this, provided you have enough of it. When using an outside aerial a proper earth-lead is essential. The best earth connection is the water supply. With the necessary terminals which can also be bought from a wireless dealer or an electrician, you can fix the earth wire to the water supply pipe. That is so long as this pipe is not made of plastic, in which case it will be of no use. Do not forget to scratch off paint or rust if necessary from the water pipe. Now the question is, how can you connect the aerial and earth to the receiver? For this purpose place an extra spring terminal at the top left side. Take a piece of insulated wire and wind two or three turns of this wire around the ferroxcube rod as shown on the wiring

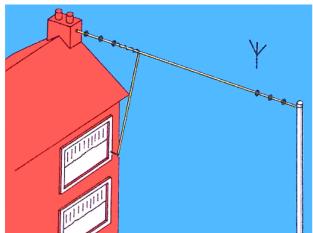
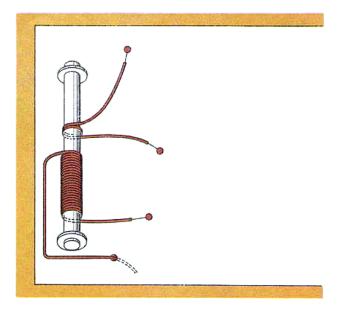


diagram (dotted lines). Connect one end of this "coil" to the new terminal and the other end to the terminal which is connected to the capacitor connection VI. Connect your outside aerial to the top terminal and the earth lead to your lowest terminal. Then you can work out by trial and error whether you get better reception with two rather than three turns round the ferroxcube rod and whether pushing your own aerial coil to and fro improves reception.

Trawler band

Broadcast transmitters work on the Medium wave, that is to say on wavelengths between roughly 190 and 600 m, but there are a number of interesting transmitters on the shorter wave lengths as well; such as on what is called the trawler band. This is between roughly 180 and 60 m. To receive these you need another coil. This one you have to make yourself out of red insulated mounting wire. First of all you must take the medium wave coil off the ferroxcube rod. Then you need to wind twenty-eight turns as closely together as you can around the rod. Connect the two ends of your home made coil to the spring terminals of the V1 and V2 contacts of your variable capacitor. Next to your trawler band coil wind two more turns of insulated wire which you join to the connection between the diode and the 47,000 pF capacitor on the one side and to the base wiring of the AF 116 transistor of the other. Should the set whistle reverse the connections of this coil. If you don't live close to the coast, an outside aerial will probably be necessary. The connection for this is made exactly as described under "outside aerial", that is two more windings, one end of the wire going to the aerial and the other end to the earth lead. Once you have done this just turn your tuning knob carefully



and if all is well and you are not too far away from the transmitter, you can hear whether the fisherman had a good catch and all sorts of interesting reports.

Directional receiver

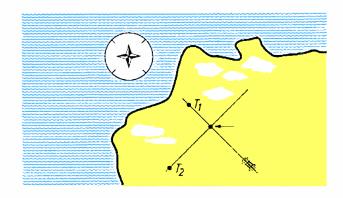
For radio direction finding you do not require any outside aerial and, in fact, this aerial should not be connected. You will find when you move the whole receiver slowly round in a circle without tilting it, that at a certain position of the receiver, the transmitter is no longer audible.

This is due to the fact that the radio waves then pass through the aerial rod in the wrong direction. This happens when the aerial rod is pointing exactly in the direction of the transmitter. If the ferroxcube rod is pointing from left to right then the transmitter is situated left or right of your receiver, exactly in a line which you could imagine running through the ferroxcube rod. This property can be used to find your position just as ships do at sea. For this purpose you need a compass just as ships require one.

How do we set about this? Let us first assume that reception of a given transmitter i.e. To disappears when the aerial rod runs exactly North-West to South-East. You fix this direction, of course, by means of your compass. Then, on your chart draw a line through the transmitter running exactly North-West to South-East. You are somewhere on that line with your receiver. Now tune to one or other transmitter T2 which is not on the same place but whose location you know, of course.

Now you will find, for instance, that the second line runs from South-West to North-East so you will draw a second bearing line through T₂ in the direction South-West to North-East.

You are also on this line with your receiver. Where are you now? You are both on the first line and on the second line and there is only one point where that is possible, namely at the point of intersection of these two lines. That is approximately where you are.



C₂ — TWO TRANSISTOR RADIO RECEIVER

This receiver is also suitable for reception with the earphone, and the use of a second transistor makes this receiver much more sensitive. The colour-code of the resistors is to be found at the end of the book.

The two-transistor receiver is more complicated than its predecessor. Without the experience gained in building the C1 receiver it might happen that the C2 doesn't work as well as you had hoped. This is because this extremely sensitive circuit must have each component accurately placed. Even the connecting wires must run exactly as shown. Therefore read carefully the assembly instructions for C1 once again. A large part of C2 is precisely the same as C1, but instead of only C15 we also use C16 which is of the same value, and an important difference is of course that a second transistor is used. Use C2 wiring diagram.

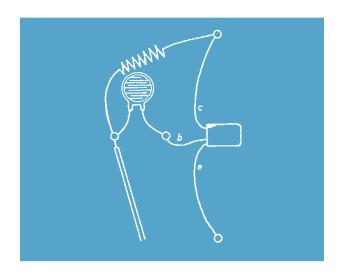
If reception is too weak, use an outside aerial if possible. This receiver can also be used as a radio direction finder (see C1 instructions).

C₃ — THREE TRANSISTOR RECEIVER WITH LOUDSPEAKER REPRODUCTION

More powerful currents are required for loudspeakers than for earphones. That is why a third transistor is used in this project. Because of the increased amplification, assembly is even more critical than in the previous case. We hope that when you did start, it was with the one transistor receiver. For the instructions for assembly go back to the instructions for the one transistor receiver C1. Set about it in the same way but now of course use wiring diagram C3. We should like to draw your attention to one thing in particular. Do not forget to place the heat sink on the right-hand AC 126 transistor. If you do not do that the receiver will work, but there is a danger that it will keep getting weaker and weaker after some time, and that your transistor may even break down.

Special Application

What would you say to an alarm which only rings when it is good weather and which is quiet when it is raining cats and dogs? Something like this can be made. Fix a second spring terminal near the terminal to which the base of the left-hand AC 126 transistor is connected. To the new terminal connect the resistor R6 and the wire which runs from the C17 capacitor. Leave the base lead of the AC 126 on the



terminal. Place the LDR between the two terminals (consult the figure). You will notice that if you have done this properly, your receiver behaves exactly as it did before. But now put the light out. Reception will then become very quiet and in fact may be completely inaudible. When the light is switched on again you have music once more. This is due to the fact that the photo sensitive resistor without light has so great a resistance that the currents to the base lead are practically unable to get through any more. You can now imagine

that you can use the wireless set as a kind of alarm clock. When the sun rises in the morning it begins to play again. If the sky is clouded and it remains dark for a long time your set will not play and you can sleep on.

D. ELECTRONIC SIGNALLING

D₁ — TELL-TALE LIGHT

This apparatus signals whether the light has been on in rooms that are normally dark. As soon as a light goes on in the room where you have set up this circuit, the signalling lamp on your tell-tale equipment lights up. Even if the lamp in the room is turned off immediately, your signal stays alight until you have depressed the secret key on the set. You can thus see if anybody has been in the room and turned on the light, even if it happened hours ago.

Take wiring diagram D1 and place it on the mounting board in such a way that the holes in the wiring diagram coincide with those on the mounting board and that the numbers on the diagram are visible from the front, that is from the side where the potentiometer is placed. Is the lamp fitting in its correct place? And the batteries and the potentiometer? (Plus terminal of battery to be connected to S2 of potentiometer).

Place spring terminals in all the holes, except where they are marked A, B, C, L and S1. As you know, these are the holes for leading in wires. Then fix all components in the terminals. The collector lead of transistor AF 116 which is a little bit apart from the other ones must be at the top. The next lead is the screening, marked 1. The collector lead of the AC 126 is marked by a red dot.

Don't forget to place the heat sink over the transistor. Pay attention to the lower bare wire which runs from left to right. At two

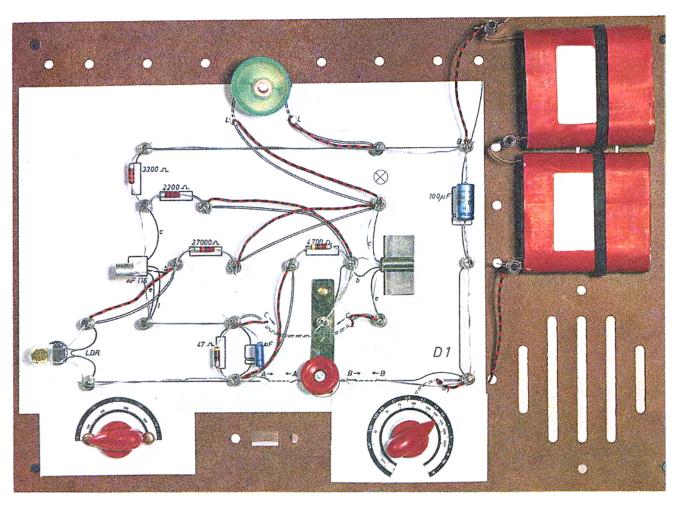
points, namely between the letters A with the arrows and the letters B with the arrows, this wire runs underneath the mounting board. Elsewhere it runs above it. Pull this wire as tight as possible so that it doesn't hang slack. How you can make the telegraph key is described in detail on page 13. Do not forget the wire of the reset key to the terminal to which the base lead of the transistor is connected. Finally you have still to mount the LDR on the two spring terminals (bottom left). Do not forget, the side with the stripes is the sensitive side. Switch on the set by turning the knob on the potentiometer to the right. The lamp on your set should immediately light up. Now put out the light in your room and press on the reset key. The signal lamp should go out again. Flash a pocket torch round in the room and you will soon see how sensitive your telltale light is.

This circuit can be made to react still faster. To do this replace the resistor R₃ by one of 100,000 ohm (brown, black, yellow) or one of 330,000 ohm (orange, orange, yellow).

The colour-code of the resistors can be found at the end of the book.

D₂ — FLASHING LIGHT

This circuit is an example of a flashing light which could be used for a variety of purposes such as Belisha beacons, police signs, trafficators and display signs. Further it is a very modern piece of equipment because everything is done electronically. We shall use wiring diagram D2 and after fitting the lamp, the batteries and the potentiometer on the mounting board, we place the diagram on it in such a way that all numbers are legible from the potentiometer side and the holes in the wiring diagram coincide with those in the board.



Then fit spring terminals in all holes except those marked with a letter L and S1. Fix the bare connecting wires and then mount the resistors (See end of book for colour-code). Next come the electrolytic capacitors C1, C2 and C3 (make sure they are in the correct position, with the groove in the casing at the end marked) and then the bare wire connections. Connect the AF 116 transistor and make sure you do not get mixed up with the various wires. Next connect the AC 126. Watch out here for the dot which indicates the collector lead and, of course, do not forget the heat sink. Screw the lamp into the fitting. Check whether the connection between the plus and the minus pole of the two batteries is still in good order and then connect the negative pole of the topmost battery (long strip) to the wire terminal at B-, and the plus pole of the lower battery (short strip) to the switch tag S2. Naturally this last named connection is done with an insulated wire. We had almost forgotten the insulated wire from the switch tag Sr to the terminal at the bottom right on the wiring diagram.

We must not forget to connect the lamp with red wires from the terminals above and below the symbol of the lamp. Then two more insulated wires, one from the base of the AC 126 to the 10 μ F capacitor and another one from the collector of the AC 126 to the 100 μ F capacitor.

When this is ready and checked, switch the set on by turning the potentiometer knob to the right.

The lamp begins to flash on and off and will keep on doing this, if necessary for hours on end, until the battery is exhausted.

D₃ — ACOUSTIC RELAY

This is an electronic switch which turns on a lamp when a sound is made in a room. The sensitivity of this equipment is adjustable. It can therefore be used as a sound alarm which is activated by very slight sounds. It is however also possible to use it as noise meter, in which case the lamp only goes on when the sound is above a certain volume, for instance when a baby burbles and "sings" the lamp will not burn, but as soon as it cries the lamp goes on and stays on until the reset key has been pressed down.

Use wiring diagram D₃. The lamp fitting, batteries and potentiometer must be fitted first of all.

Put this card correctly on the mounting board and fix the spring terminals in the holes except for those marked A, B, C, S₁ + P₁, P₂ and P₃. Then mount, in sequence, all the bare connecting wires and the components, diode and transistors. Make sure that between both letters B and both letters C the bare wire runs under the mounting board. Do not forget to connect the transistors, the diode and the electrolytic capacitor properly.

Work carefully and do not forget any wires. Now fix the insulated wires on the wiring diagram. Remember that the insulated wire from the emitter wire of the AC 126 to the resistor R8 runs partly under the mounting board.

Then mount the reset key (morse key) as shown on page 13. At the bottom left on the wiring diagram there are two terminals. You should fix to them two insulated wires, on the other end of which is connected a loudspeaker. We shall use this loudspeaker as a microphone.

Now connect the battery, negative pole, the long strip, of the topmost battery of the wire to terminal B-, and the short strip of the lower battery to the switch tag S2.

Make sure that the connection between both batteries does not make contact with other parts of the set, such as the casing of the electrolytic capacitor. When this has been done, switch on by turning the potentiometer knob to the right. If it doesn't work than you have perhaps forgotten to connect the wires on the potentiometer itself. This does not seem likely, however, for before switching on you have, of course, checked everything.

Instructions for use

Put the loudspeaker down where you want to observe the sound. Turn the potentiometer knob far to the right until the lamp begins to burn at a sound of which you consider loud enough. By pressing down the reset key the lamp will go out again. You can now, for instance, tell who has slammed the door too hard. You set the potentiometer at a given position and whoever slams the door so hard that the lamp goes on will be fined! This is of course only one application. There are hundreds of other ones.

D₄ — PILFERING ALARM

This alarm set gives a sound signal when light falls on the LDR (photo sensitive resistor) or when a window or door, which should remain closed, is opened.

Use wiring diagram D4 and on it fix the terminals as before in all the holes except those marked A, S1, S3, S4, S6 and S7. Then mount the components and the bare wires. For the colour-code have another look at the end of the book.

Do not forget to connect the transistors correctly and above all the heat sink on the AC 126. Connect up the insulated wires from the terminals on the wiring diagram to all the switch contacts indicated. Do not forget them. Also connect the batteries: negative pole of the topmost battery to the B—. terminal and the positive pole of the lower battery to the switch tag. Sz. Then connect the sliding switch with insulated wires to S3, S4, S6 and S7 and all other wires which you have not yet mounted.

As far as the loudspeaker is concerned, you can use the one on the mounting board or a separate one. You can connect this to long wires, if required in another room. One wire therefore goes from terminal B- to the loudspeaker and the other from the collector circuit of the AC 126 transistor to the loudspeaker as well. Then connect the LDR where it is marked on the wiring diagram. Now set the sliding switch to the right and switch the equipment on. If everything is in order you will now hear

a whistling tone from the loudspeaker. Then put your hands on the LDR so that it is in total darkness. The whistling tone will stop. Do not forget that the LDR is particularly sensitive and reacts to a very small amount of light.

Application

The applications of this circuit are numerous. You can, for instance, connect a couple of insulated wires to the LDR in the way shown in scheme B4 for connection to a telephone coil. With this you can put the LDR some distance away from your set, flat on a table and put a book down on top of it. As soon as someone picks up the book the whistling begins. You can put the set down somewhere where it is usually dark, for instance in the cellar, and if anyone puts the light on the whistling tone is heard from the loudspeaker.

If you have an electric train with a head lamp, you can put the LDR in a tunnel and when the train enters the tunnel the whistling tone begins, so that the level crossing at the front of the tunnel can be closed. It may be handy to put the LDR inside a cardboard cylinder so that it is in shadow until the light from the train falls up on it.

The second possibility

At the left of the wiring diagram there are still two terminals waiting to be connected up. You can let two wires run from them, for instance, to a window or a door. When these wires make contact at the other end the loudspeaker is silent but when you separate the wires you will hear the whistling tone again. Before putting this burglar alarm into service you must set the sliding switch to the left. If you now take two metal drawing pins and stick one of them in the window sill and connect one wire to it and stick the other pin into the window frame and connect it to the second wire, than the loudspeaker will be silent as long as the window is closed. When the window is opened the whistling tone will be heard again.

D_{4.1} — VARIATION ON CIRCUIT D₄

This is a variation on circuit D4, another pilfering alarm, but the advantage of this one is that this set uses hardly any current in the rest state; that is to say when the loudspeaker is not working.

Use wiring diagram. D4.1. Read the assembly

instructions of D4 through again and set to work in the manner indicated, except remembering this time that there are two AC 126 transistors to be used, each with a heat sink and remembering also that a number of other components are different. Make sure of the holes into which you may not fix terminals. We do not think we have to tell you anything more about the assembly. The LDR is now placed in a different place than in the previous set and the sliding switch works in reverse. Switched to the left the set is sensitive to light and switched to the right it signals the opening

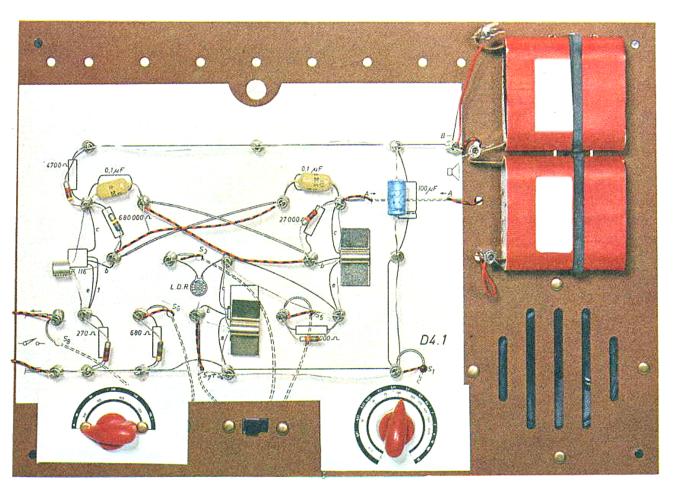
of doors or windows.

D₅ — BURGLAR ALARM

The special feature of this alarm is that, when the warning tone rings out it keeps sounding until the reset key is pressed down. It is possible to work with light signals or switch contacts here too.

After having made certain that the sliding switch, the potentiometer and the batteries are in the right places, put the D₅ wiring diagram on the mounting board. Insert the terminals in the correct holes, but not in the lead-in holes and those which take the two keys (signalling keys). Then mount all the components carefully.

After mounting all the components and the transistors (do not forget the heat sink on the AC 126's) it is best to mount the two keys as illustrated for the keys of the electronic organ A bare wire runs under these keys and you have to thread it through the holes in the mounting board so that they lie on the wiring diagram under the keys in such a way that each key



makes contact with the bare wire when it is pressed down.

Then connect the insulated wires followed by the battery and the loudspeaker (see D4 for this).

Is the LDR in its correct place?

When the sliding switch is pushed to the right you will find, if sufficient light falls on the LDR that the loudspeaker produces a tone. If the sliding switch is pushed to the left the whistling tone begins when the left-hand key is depressed. You can stop this tone by pressing down the right-hand key, provided that the cause of the tone has first been removed. That is, no light falls on the LDR or the left-hand key, the alarm key, is released.

Instead of the alarm key you can also connect two long wires to the places required (base circuit of left-hand AC 126 and emitter circuit AF 116) and connect the other ends to drawing pins. Stick one of the drawing pins into the window-sill and the other into the window frame in such a way that when the window is closed these two come into contact; the whistling tone beginning when the window is shut.

E. ELECTRONIC MEASURING AND CONTROL

E1 — AUTOMATIC NIGHT LIGHT

This is a piece of equipment that has many practical applications, for instance, automatic control of street lighting and car parking lights. It is also used in conjunction with automatic door control for lifts, shops and garages. When it gets dark in your room because somebody has switched off the light or simply because the sun has gone down, then the lamp in your apparatus begins to burn automatically.

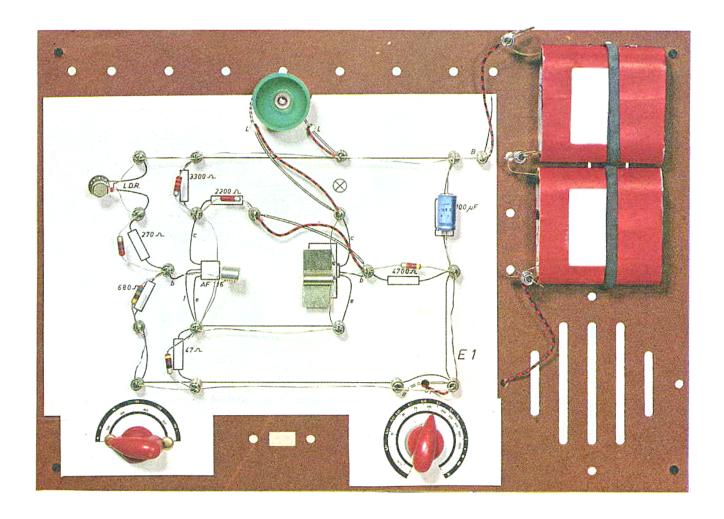
If your lamp, the batteries and the potentiometer are not yet fixed on the mounting board, fit them right away. Then take wiring diagram E1 and put it on the mounting board, so that all numbers on the wiring diagram can be read from the side where the potentiometer is fixed and all the holes in the wiring diagram coincide with holes in the mounting board. When this has been done place wire terminals in all the holes, apart from those marked S1 and the two showing the letter L, for these are lead-in holes. Now comes the mounting of the resistors, whose colour-code is to be found at the end of the book.

Then, if you haven't done it already, fit the long bare wires and the insulated wire between the resistors R₅ and R₆. Also fix C₁ in the wiring diagram. Now connect the transistors correctly.

After mounting the transistors and placing the heat sink on the AC 126 you must connect the lamp. The connecting terminals for the lamp are just above and below the lamp symbol and the wires run above the wiring diagram to the holes where you see L. Now connect the LDR to the two terminals top left.

Is the switch on the potentiometer at "off" (is it turned fully to the left)? Then connect the negative pole of the topmost battery (long strip) to the wire terminal near the B-. The positive pole of the lower battery (short strip) is connected by means of an insulated wire to the switch tag S2 on the potentiometer. Are the batteries still connected? Have you checked everything carefully? Switch on then. What happens?... Nothing. But now switch off the light in your room and the lamp goes on. You can replace the resistor R2, which is connected between the base (b) of the transistor AF 116 and the lead that goes to switch contact S1, by the potentiometer. This enables you to adjust the sensivity of your automatic night light.

For this purpose remove resistor R₂ and the terminal beneath the mark "680 Ω" on the wiring diagram. Then bring an insulated wire through the hole that now remains, from the base (b) of the transistor AF 116 to potentiometer tag P₁. A second wire runs through the same hole from the terminal bottom left on the wiring diagram, to potentiometer tag P₂.



E₂ — WETNESS INDICATOR

This equipment warns us by means of a light signal when anything gets damp. A number of interesting experiments can be carried out with it. Just read the list of applications which follows the assembly instructions and also on page 61. Then you will see that the name wetness indicator is far too modest.

Instructions for assembly

This equipment is built on wiring diagram E2. You will need the following components: the lamp fitting, the potentiometer and the batteries. The latter must be connected to one another as described before.

After fixing the spring terminals connect up the various connecting wires.

After mounting, the 100 µF electrolytic capacitor (watch out for the groove in the casing) it is the turn of the resistors and the AC 126 complete with heat sink. The lamp fitting should also be connected, of course, and finally the batteries.

The negative pole of the topmost battery (long strip) is connected to the terminal at B—. The positive pole (short strip) of the lower battery is connected with a red wire to switch contact S2. We should connect the wires with bared ends to the terminals to which the base and collector of the AF 116 are connected. Have a good look at your set again and before switching on read the "applications" which follow.

Applications

- a. Take a piece of paper (not glossy) and draw a thick line on it with a lead pencil. Press the end of one of the two wires on one end of the line and move the other wire along the line. The lamp will burn most brightly when the two bared wire ends are close together.
- b. Take a piece of newspaper and press the ends of both wires on it. Nothing will happen. Now let a couple of drops of water fall on the newspaper. Hold the bared wire ends on the damp patch on the paper. The lamp lights up. As soon as you remove the wires from the damp patch the lamp will go out again. Thus, wet paper conducts electricity. You have probably found out by now that you do too!
- c. Now take a piece of blotting paper. Thread the two wires through this paper at some distance from one another. Connect one wire to b and the other to c (see mounting card). After a few drops of water have fallen on the blotting paper the lamp will burn. Thus you have a rain alarm.
- d. Stick the wires connected to the collector and the base of the AF 116 into a flower pot, both wires being some distance away from one another. If the earth is dry the lamp will not burn, but as soon as the earth in the flower pot is sufficiently damp, the lamp will go on. Thus there will never be any withered plants thanks to this set.

e. Liquid indicator

A wire, for instance the one connected to the collector, should be connected to a metal pan or something of that sort. Put the other wire in the pan but not touching the metal. When water is put into the pan the lamp will go on as soon as the surface of the liquid has reached the wire in the pan. This applies only if the liquid is conducting, i.e. it will not work if you carry out the experiment with oil or very pure water. Oil

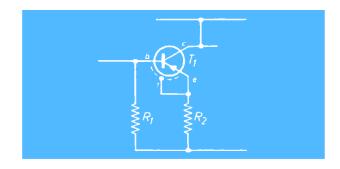


and very pure water, such as pure distilled water do not conduct electricity.

f. The rectifying effect of diodes

For this experiment first connect a 4,700 ohm resistor (yellow, purple, red) between the base of the AF 116 and the bottom of the 27,000 ohm resistor (the end which is connected to the switch S1). Now connect a diode between the collector and the base lead of the AF 116. First connect the end of the diode which is marked with a stripe to the base wire of the AF 116. The lamp will not burn. Now turn the diode around, that is, so that the stripe on the diode is connected to the collector lead of the AF 116. The lamp will now go on. That shows that the diode only lets the current through in one direction, namely when the striped end (with the P-germanium) is turned to the negative terminal of the battery.

g. After removing the extra 4,700 ohm resistor connect an LDR between the base and the collector of the AF 116. The more light that falls on the LDR, the better the lamp will burn.



Remarks

The fact that we can use this set as a wetness detector already indicates that it is very sensitive to moisture.

In the case of wet weather there is the danger that the lamp will light up due to the water which may have penetrated the mounting board. Then the lamp will start to glow before you have connected anything to the AF 116 transistor. In that case you must replace the 27,000 ohm resistor by one with a lower value, for instance, 12,000 ohm. That makes the circuit somewhat less sensitive.

Applications of the wetness indicator are many of course. If you have a boat you can use the moisture-sensitive element (piece of blotting paper with two wires stuck through it) mounted immediately above the keel. The lamp will warn you when the boat is letting in water. We have already pointed out that you can put the two wires in a flower pot to warn you when the earth is getting too dry. You can also put the piece of blotting paper in an article of laundry that you are hanging up to dry and clip it in place with a clothes peg. The lamp will go out when the article is dry. Instead of blotting paper you can also use a piece of flannel or cotton or something similar.

If you have a water pistol you can make an automatic target. Take a round disc and make a hole in it roughly 1 inch in diameter. Hang behind it a moisture-sensitive element, for instance made of a very thin piece of blotting paper. When you score a bulls-eye this conducts a small current and the lamp goes on. Before going any further you must of course make sure that your moisture-sensitive element is dry again.

E₃ — TIME SWITCH

This circuit will automatically time the period over which a lamp will stay alight. By using the potentiometer you can make that time longer or shorter as you desire. An application of this is presetting the exposure time for printing photographs and also in time regulated stair lighting. The fitting for the lamp, the batteries, the potentiometer and the sliding switch must be mounted on the mounting board. You begin again as usual by fixing all the terminals. on the E₃ wiring diagram apart from those marked with a letter or a letter and a figure. Then mount the components.

Then fix the electrolytic capacitors in position, naturally in the correct position with the groove in the casing as shown in the wiring diagram. Then all the bare connecting wires and finally the transistors. You must take good care that the collector wire, that is, the wire near the dot on the screening can of the transistor, is connected to the proper terminal. Do not forget the heat sink on the right-hand AC 126 of course. When you have done this and checked that the switch on the potentiometer is in fact off (turned fully to the left), you begin mounting the red wires. Before you connect the battery, check whether you have put the lamp properly into its fitting. Then connect the negative pole of the uppermost battery (long strip) to the terminal where it says B- and the positive pole of the lower battery (short strip) to the switch tag S2.

When you have also connected the sliding switch and have checked everything yet again, you are ready to switch on. Do this by turning the knob on the potentiometer round to the right. The sliding switch must in this case be to the left. Now set the sliding switch to the right and the lamp immediately begins to glow but goes out again after a short time. The duration of time can be adjusted with the potentiometer. If you want to produce another flash of light you must first move, the sliding switch to the left. When you move this to the right once more you again get a flash of light.

For every position of the potentiometer knob,

which you can read from the number on the scale, you can decide how many seconds the flash of light shall last. If you make a little table or a graph of this, you can then use this table or graph to set the potentiometer knob in the correct position according to the number of seconds you want your flash of light to last. After you have done all this you can switch your sliding switch to the right and you will get the flash of light lasting the precise number of seconds chosen.

E₄ — UNIVERSAL MEASURING EQUIPMENT

Let us assume you are given a present of a resistor or a capacitor on which there is no colour code and which has no value stamped on it, but you would like to know how big it is. That is the same problem as the manufacturer of components is faced with, for when he makes these components he would like to know how great the capacitance or the resistance is before he stamps the value on them. He must carry out measurements.

Another example is when you want to take a photograph.

Then the exposure time depends on the intensity of the light, but you have to be able to measure this intensity. Naturally you can buy an exposure meter in a shop, but the manufacturer of the exposure meter must also be able to measure the intensity of the light before he knows exactly what he is going to put on the little scale of the meter. The apparatus we are going to make now will help us to measure the value of resistors, the capacitance of capacitors and also to measure the intensity of light.

This universal measuring equipment is not so difficult to assemble, but you can only get real benefit and pleasure out of its use if you have a certain amount of knowledge of electronics. Such knowledge can only be acquired after you have built a number of sets with our assembly kit.

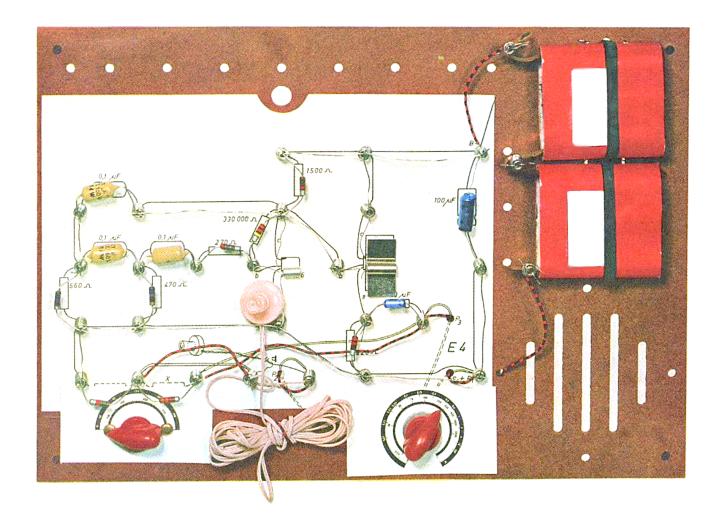
If you have this knowledge take wiring diagram E4 and put it on the mounting board in the correct way. Fix wire terminals in all the holes apart from those marked S1 + P1, P2 and P3. Make sure that the dial is properly located on the potentiometer, that is to say, when the switch is at "off" the point of the knob must be exactly above the first line on the left. This apparatus is not, of course, as accurate as the type used in factories and in laboratories, but, as you will see, it is accurate enough for our purposes.

Measuring resistances

The measuring we shall do consists in comparing the value of an unknown resistor with that of a known resistor and our apparatus shows how many times the unknown resistor is greater or smaller than the known resistor.

At the bottom left of the apparatus there are three wire terminals with the wires running towards them, but which are not connected up. Between the second and the third terminal from the left (between which there is a dotted resistor marked with an X) we now connect our standard resistor, that is to say, the resistor which we are using to compare the unknown resistor with. For this purpose we can take a 1,500 ohm resistor, for instance. Connect this one up. Then take another resistor without looking at its value and connect that to the first and second terminal from the left. Now switch the set on and put the earphone to your ear. You will hear a whistling tone. Now turn the potentiometer knob until the whistling tone disappears. Then look where the pointer is on the scale. Assume that it is above the 10, and then we know that the unknown resistor is 10 times as great as the comparison resistor. This unknown resistor is in our example thus 10 times 1,500 ohm, that is, it is 15,000 ohm. Thus our unknown resistor is not unknown any more.

It may also be that the tone disappears when the indicator on the knob shows 0.1. Then the unknown resistor is a tenth of 1,500 ohm, that is 150 ohm, etc. A resistor of 1,000 ohm is



very suitable as a standard resistor. Other suitable values are 100 and 10,000 ohm. These are not supplied in the kit but can all be obtained from dealers.

Measuring capacitors

Measuring capacitors is carried out in the same way as measuring resistors. However there is one difference, namely, the standard capacitor must now be connected between the first and the second terminal from the left.

The unknown capacitor is connected between the second and the third terminal from the left, where the X is marked. Measurement is carried out in exactly the same manner as for resistors.

Light Meter

The lumen is the unit of light intensity. If you think of yourself as 10 feet away from a lamppost in which there is a lamp of 100 Watt, then where you are the intensity of illumination is 1 lumen per square foot. That is, provided there is no other light. Should you try to read a book you will find that 1 lm/sq. ft. (lumen per square foot) is far too little, at least for comfortable reading.

For good illumination for reading and doing homework you need at least 30 lm sq.ft., for drawing at least 50. A watchmaker must illuminate his workpiece with at least 100 lm/sq.ft. A blacksmith, on the other hand, can if need be work with 15 lm./sq.ft.

For general lighting of a living-room, 15 lm/sq.ft. is sufficient, but if your mother wants to sew and she has dark material, 70 lm/sq.ft. is required.

Daylight is much more intense than artificial light and you reach far higher lumen figures. If you go in for photography a good deal and you have no exposure meter, you will be glad to know that this light meter is very useful for the purpose. You must calibrate it yourself, however, and decide for yourself what exposure time and diaphragm setting is the best for the various intensities of illumination.

Between the first and the second terminals bottom left, connect a 120 ohm resistor (brown, red, brown). The LDR is connected between the second and third terminals from the left, that is where it is marked with an X. Mount it so that the striped side of the LDR is upwards, for that is the sensitive side. Then let light fall on the LDR, for instance, by placing the whole equipment on the table under the lamp and turn the potentiometer knob until the tone coming from the earphone disappears. The position of the potentiometer knob shows the illumination. If the point of the knob, for instance, is between the 200 and the 300, then the illumination is roughly 250 lumen.

GENERAL THEORY

INTERESTING AND GOOD FUN

Engineers and technicians of our great laboratories have designed the components in this EE-assembly kit and have thought out circuits with all the skill and pleasure with which they work on radio or radar, on electronic controls or television. The field of applications of electronics is getting steadily greater and for that reason the demand for clever and enthusiastic technicians is steadily growing too. Perhaps the pleasure that you will get out of your EE-assembly kits will encourage you to think of making technology your job in life. When you are studying, but later still, when you are working, you will realise how many useful things you learned when you were experimenting in your own room. For the moment, however, we wish you many hours of pleasure.

Atoms

All bodies in nature are made up of atoms. These atoms consist of a nucleus with a number of electrons round it. This could be compared with the solar system. In our solar system the sun is the nucleus and all the planets are revolving round it.

The tiniest piece of matter still detectable as such consists of millions of atoms.

In nature substances differ the one from the other in regard to the composition of the nucleus and the number of electrons revolving around it. Hydrogen is the substance with the simplest atom; only one electron revolves round the nucleus of the hydrogen atom. Another kind of atom, that of helium, has two electrons.

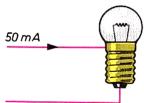
As for the copper atom, this has 29 revolving electrons, not all of which are at the same distance from the nucleus. The last of the 29 is quite a way out from the nucleus, almost free from the others. The force that holds it in its solar system is not as strong as for the other electrons. It is able to slip from one copper atom to another. It is called a free electron.

Since a tiny bit of copper contains milliards of atoms, it also contains milliards of free electrons. Electrons are all loaded with a negative electric charge. A movement of electrons is called an electric current. Electrons can move easily through copper wire, as copper is a good electrical conductor.

Big and little currents

When you turn on a tap, water comes out of it. The water runs through a water pipe. When you turn on the switch of the electric light, electrons stream through the wiring in enormous numbers. Yes, literally enormous numbers, for when you switch on a big lamp 6.3 million times a million times a million electrons flow through the lamp each second. It is very hard to work with such a number and that is why a current of 6.3 million times a million times a million times a million electrons per second is simply called a current of 1 ampere. This can be written in an even shorter form as 1A. In Electronics we are usually more sparing of electrons than in what we call the mains power supply. Here much smaller currents than 1 ampere (1A) are used, in fact 1000 or a million times smaller. In order to make it easier to talk about these little currents, the thousandth part of an ampere has been called milli-ampere, shortened to mA. The millionth part of an ampere is called a micro-ampere, shortened to μA (μ is the Greek letter mu).





Resistance

Now you know very well that water just does not run through the pipes of the water system of its own accord. It has to be pumped through because the water in its path through the pipes meets with resistance. It is just the same with electric currents. They also meet resistance. even when the electrons run through a copper supply system, through which electrons can flow easily. In both cases a long supply system offers more resistance to the current than a short one and a narrow system offers more resistance than a broad one. In the case of water pipes the sort of material of which they are made does not affect the flow. In electric wires it is a bit more complicated, because if these are not made of a good conductor like copper then the current does not flow through so easily. For instance, iron has a greater electrical resistance than copper. The unit of electrical resistance is the ohm, also written in symbol form as Ω . A copper wire 200 yards in length and 1/12 inch in thickness has a resistance of 1 Ω .

A resistance of 1000 Ω is called 1 kilo ohm, shortened to $k\Omega$ and one million ohm is called 1 megohm, shortened to $M\Omega$. A resistance of 500,000 Ω can thus be called 500,000 Ω or 500 $k\Omega$ or 0.5 $M\Omega$, whichever way is best for the purpose.

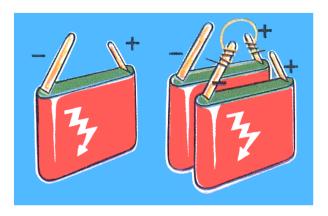
Voltage

Water will not flow through the pipes on its own, for there always has to be a force to send it through the pipes. Likewise an electric current requires a force, a force which we call voltage. Voltage can be obtained from a battery. The unit of voltage is called a volt. If you have a wire with a resistance of 1Ω and you connect it to a battery with a voltage of 1 volt, then a current of 1 ampere flows through the wire. In electronics we can have voltages far greater than one volt and also others which are much smaller.

For instance, the picture tube of a television reciever works with 18,000 volts. In that case we can also speak of 18 kilo volts (kilo = 1000), shortened to 18 kV. But in the radio receiver we also come across voltages of 1/1000 volt and 1/1,000,000 volt. These are called millivolt and microvolt, shortened to mV and μ V respectively. The batteries we use for our electronic experiments have a voltage of 4.5 volts. However, when we connect 2 of them as we say "in series", they then work together. The total voltage is then 4.5 + 4.5 = 9V. By the way, in case you are wondering, the words ampere, ohm and volt are derived from the names of famous scientists.

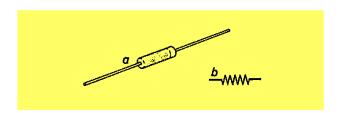
The various types of diagrams

In electronic apparatus we use components



which are connected to one another by means of copper wires. "The circuit diagram" shows us theoretically how these connections run. In the circuit diagrams the components are represented by symbols.

Thus the symbol for a resistor can be seen in the illustration and beside that, you can see what a certain type of resistor looks like in reality. Next to it is the symbol for a battery. Further on in this book we shall continually come across circuit diagrams. The wiring diagrams are to be found on separate assembly



cards. The circuit diagram is used to explain the working of a circuit, the wiring diagram to enable you to build a set. In the laboratories circuit diagrams are used and in the factories wiring diagrams are used, just as in your EE book and kit.

Plus or Minus?

On the symbol for the battery you will see a plus sign and a minus sign. These show the direction in which the current flows. But pay attention now! The agreement to do this was made before we knew of the existence of the electrons. One side of the battery was called plus and it was said that the current flows from plus to minus.

It was only later that someone discovered that the electrons actually move in the opposite direction, that is, from the — to +. We should not laugh at our grandparents and great grandparents too much over this. They just had not sufficient information at the time.

A battery is, as it were, a little box, in which there are an enormous number of electrons. The electrons flow from the minus side across the resistor along the connecting wire to the plus side of the battery.

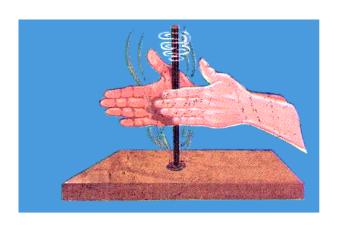
When the chemicals in the battery which generate the voltage have lost their strength the battery is discharged.



Alternating current

Until now we have only considered a current which always flows in one direction. This is always the case in the water supply. In electricity it can be different. There the electrons can flow for a time in one direction through the wire, and then for a time in the opposite direction and then once again in the first direction, and so on. Now you can say, "Fancy that!" Indeed, if the water in the pipes behaved like that, very little would come out of the tap. Electricity does not need to come out of the wiring, however, to be useful. In order to realise this let us get help from primitive man. He can make a fire by rotating a stick very quickly in a block of wood. The friction causes heat and, if the heat is enough, the stick will start to smoulder. Friction means overcoming resistance. When you rub your hands, they also get warm because one hand moves acorss the other and meets resistance.

When an electric current flows through a wire a resistance also has to be overcome. This makes the wire warm, regardless of whether the electrons move from left to right, from right to left, or to and fro. The strength of the current and the magnitude of the resistance determine how much heat is developed, irrespective of whether it is "direct current" (D.C.) or "alternating current" (A.C.) Examples of heat development by means of electric current are quite familiar to you: in the electric fire and the incandescent lamp. This alternating current does, however, have other special advantages over direct current which we shall see in a moment.



Alternating current is obtained from our mains sockets. Do not tamper with the mains as these voltages are more than enough to cause a fatal accident. The batteries we use give direct current, enough to work the sets we are going to build, but fortunately much too little to be able to cause accidents.

While we are about it, the batteries you use with these sets are 4.5 volt pocket lamp batteries. Connected in series the two batteries give 9 volts.

Frequency

We have to know a bit more about alternating current than the number of amps. We must know for instance the speed at which the current moves to and fro. Just imagine that the current moves from the top to the bottom for half a second and then for another 0.5 second from the bottom to the top. etc., that is, once up and down every second. (fig. A)

This once up and down or to and fro is called a "cycle" of the alternating current (and alternating voltage). The number of cycles per second is called the "frequency". In this example the frequency is thus I cycle per second. The voltage of the mains supply socket has a frequency of 50 cycles per second. Instead of saying cycles, per second, which is a bit of a mouthful, we can shorten it to c/s. The frequency of the mains voltage is therefore 50 c/s. In radio engineering much higher frequencies are used.

Many broadcasting stations work at frequencies of millions of c/s. For the sake of conve-

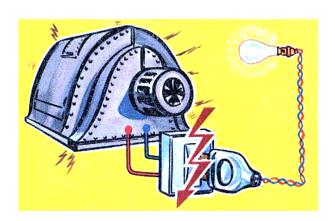
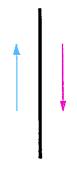


fig. A



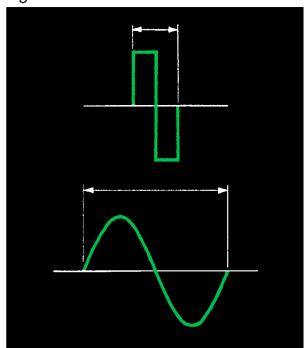
nience we speak of kilo c/s (kc/s) (1000 c/s) and mega c/s, (Mc/s), (1,000,000 c/s). In reality an alternating current usually does not work by fits and starts as shown above, but more gradually. It begins modestly in one direction, increases and then decreases gradually, changes direction, etc. (fig. B)

Coils

Alternating current goes through wires and resistors in just the same way as direct current. But when we wind a wire into a coil, we notice a difference. A coil offers more resistance to alternating current than it does to direct current. The higher the frequency the greater the difficulty the current finds in flowing through a coil.

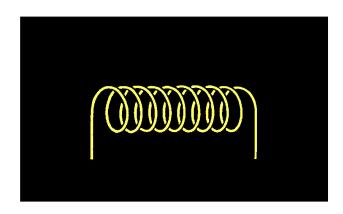
How does this come about? When a current passes through a coil a magnetic field is created

fig. B

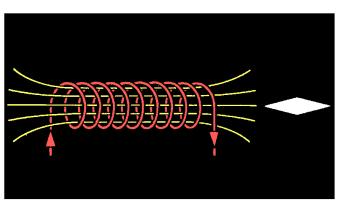


similar to that around an ordinary bar magnet. A coil like this will therefore attract iron filings and a compass needle.

The wind against the sails of a windmill turns the sails around. On the other hand when you turn the sails by means of a motor, these sails will behave like a giant fan and generate wind too. Can we try this in terms of electricity; will a magnetic field stationary about a coil also generate a current in it? The answer to this simple question is no. When a coil lies close by a bar magnet, no voltage is generated in it which can cause a current to flow, just as a stationary windmill will not generate wind. But this "no" is not final; which is just as well because otherwise wireless, television and lots of other things would be impossible.



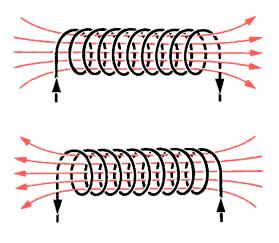
What is really important is that if we move the magnet a voltage is in fact generated in the coil. A magnetic field moving along a coil generates voltage in the coil. When a current flows through a coil a magnetic field is generated. When the current is reversed in its direction,



the magnetic field also changes direction. The magnetic field thus varies and generates a voltage in the coil.

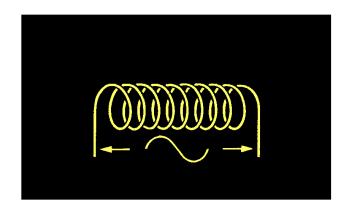
Now where does all this lead to? Let us put an alternating voltage in the coil. Then an A.C. will flow through the coil — that is clear. This A.C. will cause a magnetic field which will be an alternating one. Then, of course, the voltage which is caused in this coil by the magnetic field changing its direction all the time will again be an alternating voltage.

So far so good. But what next? Will this new voltage help the old one to send a current through the coil or oppose it? In fact, the new voltage opposes the old one — fortunately, for if it were the other way around the current would get bigger and bigger and bigger. As it is, however, the so-called induced voltage works against the applied voltage and will thus cause the current to become smaller. That is the same as when we increase the resistance. Now the higher the frequency of the alternating



current, the more rapidly does the current change its direction and the greater is the counter voltage. As a result the current becomes all the smaller i.e. the resistance of the coil becomes all the greater.

Of course, should we have applied a steady D.C. source there would be no induced voltage once the current has begun to flow. Thus the current is then only limited by the resistance of the coil wire, the important changing of voltage being missing.





Well, we have seen that direct current easily flows through such a coil and that alternating current does so with more difficulty. The higher the frequency of the alternating current, the harder it is for this current to flow through the coil. A coil can therefore be used as a barrier which will let direct current through but will almost stop alternating current.

Electric field

Magnetic fields are well enough known thanks to the compass and the horseshoe magnet.

But there is also an electric field. A magnetic field is generated when a current flows through a wire; an electric field is present around an object on which there is a voltage. You know that when you rub a glass rod or a gramophone record with a piece of dry wool or silk cloth, the rod or record can attract dust and small pieces of paper. That is due to the fact that, as a result of rubbing, these objects become electrically charged and electrons have come up to the surface.

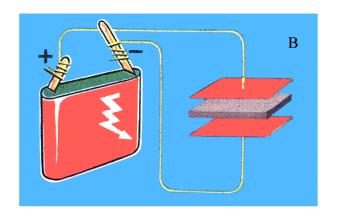
What you cannot see is that the electric field does not only attract particles of dust but also attracts and repels electrons. As far as repulsion is concerned just think what happens when two magnets are brought close together. The north pole of the one attracts the south pole of the other, but two north poles repel one another. Electrons are all negatively charged. So, just as "like" magnetic poles repel one another, so do electrons repel one another.

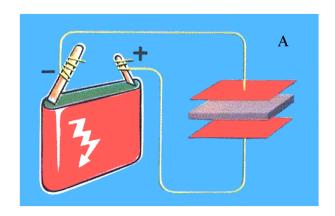
Condensers

Let us now find out what happens when two

metal plates set up as in the illustration A are connected to a battery. Electrons flow from the negative pole to the upper metal plate. They have to, because there are lots and lots of electrons in the battery all trying to repel one another. The wire connection and the plate give them the chance of pushing a few thousand million electrons out of the battery along the wire and into the plate. Once they have got there they can go no further because the air space will not let the electrons through. Air is not a conductor, it is an "insulator".

But an electric charge generates an electric field which goes through the air and reaches the other plate. There are also electrons in this plate. As a matter of fact there are always electrons present in a conductor, even when the conductor is not connected to a battery. The electrons just happen to be present in the metal. They do not flow through it so long as there is no particular reason to, but they can be moved. As we have just said, electrons are unfriendly and impolite.





Impolite people boarding a train push their way in and use their elbows. Electrons are much worse than people. They are always impolite to one another and can even push at a distance, that is even when they cannot reach each other with their elbows. The electric field that is emitted from the top plate therefore pushes electrons out of the lower plate, along the wire to the "plus" pole of the battery. The higher the voltage the more electrons can be pushed away.

What happened at the moment we connected the battery to the two metal plates? A current of electrons flowed from the minus pole of the battery to one of the plates and from the other plate to the plus pole of the battery. That is all. Once the "filling up" stops the electrons on either side of the gap reach equilibrium. They stop moving and no more current flows. Now we quickly connect the battery the other way around to the two plates, (B) that is, plus is now at the top and minus is now at the bottom. The minus pole of the battery again sees its chance to get rid of some electrons, this time to the lower plate which is, of course, "empty". Once the electrons have reached the plate they repel their brothers and sisters still present on the upper plate with such force that the latter end up in the battery, thus causing a current to flow again until the bottom plate is charged with electrons. Now compare the second drawing with the one above it.

First of all the electrons flowed in the upper wire from left to right, then the other way round. If we keep reversing the poles of the battery an alternating current will flow through the wire. It will be clear to you that if reversing the poles is done very quickly the electrons will fly backward and forward far more often than when the poles are reversed at a gentle speed. Instead of reversing the poles of the battery we can also apply an alternating voltage.

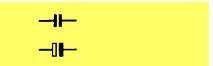
In engineering, alternating voltages are produced in many ways, some of which will be discussed later on. Two metal plates, parallel, but not touching one another are known as a "capacitor". When the frequency of the alternating current becomes greater the current flows more easily through such a "capacitor" or "condenser" as it is also called.

A capacitor is thus the exact opposite of the coil. It does not let any direct current through but permits alternating current to flow, particularly if it has a high frequency. The dimensions of the capacitor, that is to say the size of the plates and the distance between them, determine the "capacitance". The capacitance is the ability of the capacitor to hold an electric

charge. The greater the capacitance, the easier the alternating current can flow throught it. The capacitance is measured in farads, shortened to F. The farad is a very large value, therefore, we use mostly the micro farad (μ F), which is one million times smaller, and the micro micro farad (μ F), usually called pico farad (μ F) which is a million times smaller still. Sometimes use is also made of the nano farad (μ F), which is equal to one thousand pF. Thus:

 $F = 1,000,000 \mu F$ = 1,000,000,000 nF

= 1,000,000,000,000 pF or $\mu \mu F$



These are the symbols for capacitors. The low one represents an electrolytic capacitor.

SEMI CONDUCTORS

We have already spoken a couple of times about the amplification of voltages and currents. A loudspeaker needs quite a large current, which is, in fact, thousands of times higher than the currents that flow through your aerial as a result of the radio waves which it picks up. It is possible to amplify (that is: increase the strength of) alternating currents and voltages by means of electron tubes (valves) and transistors. In the building of our Philips Electronic kits we make use of modern transistors.

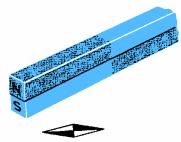
The operation of a transistor is a rather complicated matter. In fact, it is not only complicated, but rather mysterious. A transistor has the appearance of a little metal or glass tube with three or four wires coming out of one end. The tube is, however, only a protection for the actual transistor, which is contained in the tube and is made of a rare and therefore expensive material called *germanium*. This is a precious and useful element which is called a metaloid by chemists.

The metaloid Germanium has similar properties to those of metals like copper, iron, silver and gold. Most metals are good conductors of electricity, germanium, however, is not. Substances like paper, rubber and mica are such poor conductors of electricity that they are called non-conductors or insulators. Germanium is not an insulator either since it does conduct to a certain extent. It is, therefore, called a semiconductor. We might, however, also call it a semi-insulator.

Germanium can only be used for transistors in an extremely pure form. If you were to count all the grains of sugar in a four-pound bag, you would find that there were about ten million. If one grain of sand was present in the four pounds of otherwise pure sugar, the sugar would be "contaminated" to the same extent as the germanium used for transistors. This should give you some idea of how pure this material has to be.

Electrons and Holes

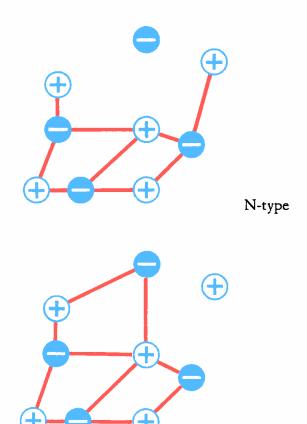
We already know that the smallest visible piece of metal contains millions of electrons. Electrons are minute particles of electricity possessing an electric charge. This charge is normally not noticeable because there are also opposing charges in the metal which cancel it out. If you put identical magnets one on top of the other with the north pole of the one on the south pole of the other, you will see that iron objects are no longer attracted as strongly as before.



The opposite magnetic charges have cancelled each other out. Like everything in nature, it all depends on balance.

Electric charges are either negative or positive -just as magnet poles are either north or south. Electrons are all negatively charged. If we take an electron (negative charge) out of the metal, there will be a "hole" left. The electric charge of this hole is the opposite of that of the electron—holes are positively charged. So the charges of the electrons together do no longer fully cancel out the opposing charges (of all the holes together) which are present.

Now what is the position in pure germanium? It is full of electrons and holes. These electrons and holes however are all firmly fixed in the material. This is why germanium is such a poor conductor. When some arsenic is introduced into the germanium, we cause a number of electrons to be a little more easily moved. If we put some indium into the germanium we find that then some of the holes can be moved a bit more easily instead. Germanium "doped" with a little bit of arsenic is called N-type Germanium because in this



the negative electrons can move. Germanium doped with indium is called P-type germanium as in this the positive charges can be moved about.

Frontier traffic

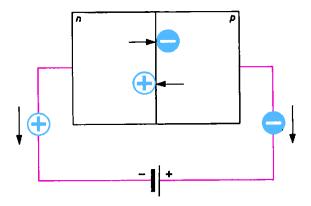
If you now place two small slices of pure germanium up against one another, then nothing happens, not even if you connect a battery across the pair of them. If, however, we put a slice of N-germanium and one of P-germanium together, we find that current flows easily through the pair of them when a battery is connected across them. The plate of P-type germanium must then be connected to the plus (positive) pole of the battery and the N-type germanium to the minus (negative) pole of the battery.

This current is in fact so high that it would damage the small germanium slabs — so don't try it, whatever you do!

This can be explained as follows:

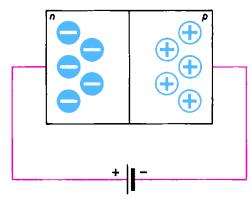
Opposite charges, like those of electrons and holes attract one another, the same as do opposite magnet poles. The electrons in the

P-type



N-germanium are attracted by the holes in the P-germanium. As the electrons can move about within their own slice of germanium, the forces of attraction will thus move them towards the junction between N- and P-germanium and some of the electrons may even cross this border. So likewise with the holes which are in the P-germanium.

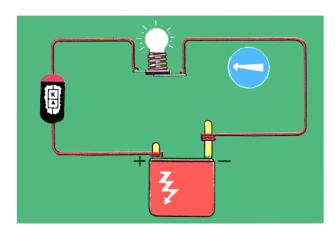
The battery has been so connected that its minus pole tries to push the electrons in the N-germanium towards the P-germanium, while the positive pole aids and abets by pulling at the electrons. Under the influence of all these forces some more electrons will cross the junction and even pass through the P-germanium. To make up for the loss, the battery supplies an equal number of electrons to the N-germanium which are again pushed and pulled towards the junction which they cross

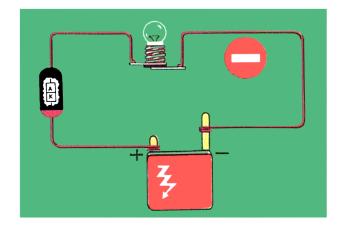


and so on. To the holes the same happens, but, of course, they move in the opposite direction. Next we connect the battery the other way round : plus pole to N-germanium, minus pole to P-germanium.

The plus pole attracts the electrons in the

N-germanium away from the junction. The minus pole does the same to the holes in the P-germanium. These forces are larger than the forces between the holes and the electrons within the P- and N-germanium respectively. Thus round the junction neither electrons nor holes are left. The battery has won, but at a price. Once the plus pole of the battery has drawn away all the electrons from near the junction, there are no more electrons to follow up and hence—no current of electrons. It is the same with the holes.





Such a combination of a slice of N- and a slice of P-germanium is called a diode — it lets the current pass in one direction only.

The Diode converts an alternating current (A.C.) into a direct current (D.C.).

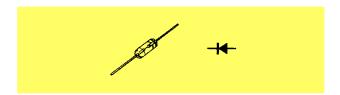
It is not difficult to discover what happens when an alternating voltage is connected to a "germanium diode" of this kind. During the half cycle when the voltage on the P-germa-

nium is positive and negative on the N-germanium, current flows. During the following half cycle, when the voltage is reversed, no current flows. The current through the diode will only flow in one direction and is, therefore, direct current, even though it flows with interruptions. The alternating voltage has been "rectified".

In our assembly kits, the diode is used in radio receivers and its function there is explained in the relevant chapter.

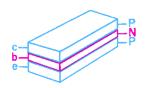
Diode rectifiers are used for example in accumulator chargers. Accumulators must be charged with direct current, but the current we get from our mains is alternating. The accumulator charger therefore contains a rectifier which turns the AC into DC. The diode used in the kits is however not suitable for this purpose (it is not strong enough).

There is no way of telling from just looking at the diode which of its two lead wires is connected to the N-type germanium and which to the P-type. The diode is, therefore, always marked on the "cathode side". The other lead wire is said to be on the "anode side". You should always pay attention to this during assembly.

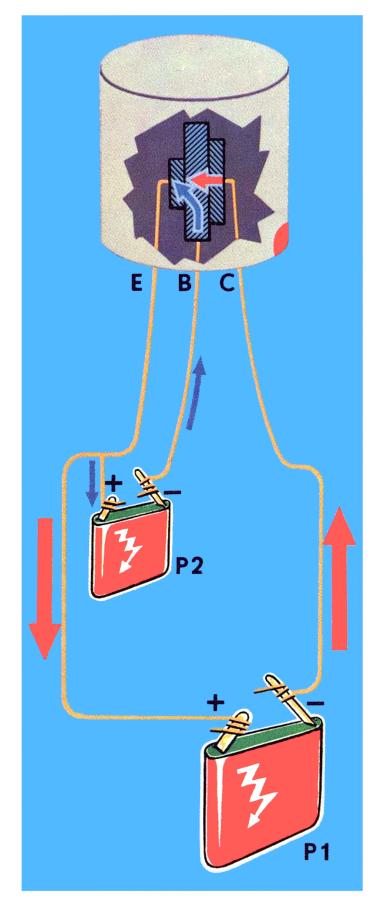


In the symbol for the diode, the arrow shows the direction in which the holes go through the diode. The electrons thus move against the arrow. The mark put at one end of the diode indicates the negative side: that is, the side connected to the N-germanium.

Transistors amplify currents and voltages The transistors used in the assembly kits

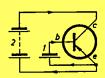






consist of three layers of germanium, namely one layer of N-type germanium with a layer of P-type on either side of it. The middle layer of germanium is called the *base* (b), one of the P-type layers is called the *emitter* (e) and the other the *collector* (c).

Now refer to the yellow figures below and let us imagine that we connect two batteries across our transistor; battery I with the minus pole attached to the base and the plus pole to the emitter; battery 2 with its plus pole again connected to the emitter, but with its minus pole connected to the collector. Currents will thus flow through the transistor: A current from battery I via the base and the emitter and also a current from battery 2 through the collector, the base and the emitter. The arrows show the direction in which the electrons flow. If we now measure these



currents we will find that the current through the collector lead (c) is considerably greater than that through the base lead (b). You may find this all rather dull, but what we are leading up to *does* concern you, because this is precisely why we use the transistor.

Let us suppose that the voltage of battery I becomes slightly higher.

The current supplied by battery I will then also become slightly higher. This is quite logical, of course. The collector current, however, is also altering. This may come as a surprise to you, but there is still another surprise to come. These changes in the collector current are much larger than those in the base current. In other words, a small change in the base current produces a large change in the collector current. For example:

Battery 1 gives ½ volt
base current 1 mA

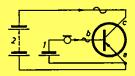
emitter current 20 mA collector current 19 mA

Battery 1 gives 1 volt

base current 2 mA emitter current 40 mA collector current 38 mA

Change of the base current 2 - 1 = 1 mAChange of the collector current 38 - 19 = 19 mA.

We thus see that whatever the voltage of battery I may be, the collector current is always 19 times as large as the base current. If we now look at the currents alone, we find that when the small base current is doubled the larger collector current is also doubled. If in a circuit the base current from the transistor is changed in one way or another, the collector current changes in proportion.



We can also connect a source of alternating current, e.g. a microphone, in series with battery 1. We will then have not only direct current, but also alternating current flowing through the base of our transistor. Such a combination of direct current and alternating current can be regarded as direct current which periodically increases and decreases in strength. We will then have a current through the collector of the transistor which also becomes periodically stronger and weaker. These changes in the collector current may likewise be regarded as an alternating current superimposed on the normal direct current through the collector. As we have just seen, this alternating current will be greater than that through the base, in our example it will be 19 times as large.

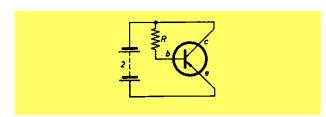
In other words, the transistor has amplified the alternating current in our example 19 times. In practice, the amplification can be considerably more, a few hundred times for instance.

Transistors are used to amplify the low voltages and currents coming from a pick-up, a microphone or an aerial so much that they can operate an earphone or a loudspeaker. If one transistor does not give enough amplification, we can use two or even three, one after the other (in "series").

Actually we use only one battery, battery 2 of our drawings, and we connect the base of the transistor to the collector via a resistor R. This is thus also connected to the minus pole of the battery, giving the base of the transistor the desired negative voltage. By giving the resistor the proper value, we can make sure that the base voltage will also have the right value. A transistor thus needs two kinds of voltages: DC voltages so that it can work at all, and alternating voltages for it to amplify.

By using capacitors, which, as we have mentioned, pass alternating current, but not direct current, we can arrange that the alternating current passes from one transistor to the next without the accompanying direct current. If we did not do this, the direct current accompanying the alternating current would upset the operation of the second transistor.

The use of *coupling* capacitors prevents this trouble.



A. ELECTRO-ACOUSTICS

Electro-acoustics is the fancy word for everything to do with picking up, amplifying and reproducing sound.

What is sound? Sound is what we call all audible vibrations of the air. When you throw

a stone into the water you see the ripples on the surface. Circular waves spread outwards from the point where the stone fell into the water. When you clap your hands similar waves are generated in the air. You cannot see these waves but they are real nevertheless. You can hear them all right, for our ears are intended for the purpose of perceiving such air waves.



The water waves go up and down. You can see that quite clearly if, near the place where you have thrown the stone into the water, there is a little piece of wood. This is moved up and down by the waves but otherwise remains stationary.

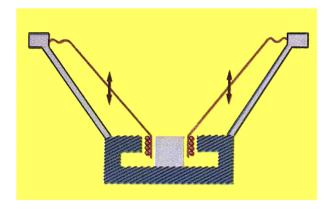
In the air, waves can travel like that too. Imagine a strip of metal locked in the jaws of a vice on a workbench. If you bend the free end of the strip and then release it, it will spring forward, going beyond its starting position, spring back again, then forward again and so on, each time passing its original position of rest. In fact the strip is vibrating.



Such vibration makes the surrounding air vibrate too. Thus waves of air move from the vibrating strip in all directions, just as in our example of the stone thrown in water. If such a wave catches your ear, you will hear a note. The more vibrations per second the strip makes, the higher the note is. The number of vibrations per second is called the frequency of the note. One vibration per second is called 1 Herz (1 Hz) or 1 cycle per second (1 c/s). Our ear can perceive notes from about 50 Hz to about 20.000 Hz. A dog can hear higher notes; think of the silent dog whistle.

The loudspeaker

All musical instruments are based on the fact that the air is made to vibrate rapidly in one way or another. When we talk or sing, for instance, the air vibrates.



The loudspeaker we use in our wireless set and gramophone amplifier is a device which causes the air to vibrate.

Just imagine you have a round disc which you move backwards and forwards a few hundred or a few thousand times a second. The vibrating disc will also cause the air to vibrate. This generates sound. The question is how do we get the disc to vibrate? To do this we fix a coil to the disc and place the coil near a magnet, for instance a horse shoe magnet with which you are familiar. Now we send an electric current through the coil. What happens next? The coil behaves just like a magnet with a north pole and south pole. When the direction of the current is such that the north pole is at the left hand side of the coil, then this north

pole will repel the north pole of the magnet and as a result the disc will move forwards. If we now reverse the current we shall change the magnetic poles of the coil so that there is now a south pole at the left hand side which is attracted to the north pole of the magnet. The disc will now be moved backwards.

What happens now if we send an alternating current through the coil? That is a current which continually keeps changing direction, for instance one thousand times a second (then we say we have an alternating current with a frequency of 1000 c/s). The coil will thus be attracted and repelled one thousand times per second by the magnet. The coil and the disc which is fixed to it will thus be vibrated one thousand times per second to and fro and we hear a clear tone. This is the principle of the loudspeaker. The real construction is somewhat different in order to ensure that a loudspeaker as powerful as possible is obtained with a magnet which is as small as possible.

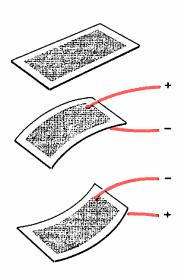
Moving coil microphone

We thus know how we can change an electric current into a sound vibration. But how can we do it the other way round? How can we turn a sound vibration into an electric current? We do it with microphones. There are several sorts of these. One sort, which is much used, works in the very same way as a loudspeaker does, but the other way round. Just imagine that there is a sound somewhere and that this sound strikes against the disc of the loudspeaker (the disc is called the loudspeaker diaphragm). This diaphragm then starts vibrating roughly the way the window panes vibrate when a heavy lorry passes. When the diaphragm starts to vibrate, the coil does likewise. A little while back we said that when a coil is in a magnetic field and the magnetic field is changed, then a voltage is generated in the coil. When the coil vibrates then its place in the magnetic field changes immediately. That is just the same for the coil as if the magnetic field were changed. In the vibrating coil of a microphone, then, some small electric voltages are generated. These little voltages

can be amplified in a way we will tell you about later, and then fed to a loudspeaker. The alternating currents now flow through the loudspeaker coil so that the loudspeaker diaphragm is made to vibrate and the original sound is heard again.

Crystal Microphones

Now there is another method of generating sound or picking it up. There are certain materials which have a very peculiar property. One such material is known as Rochelle salt. If you take a little slab of this, apply a conducting



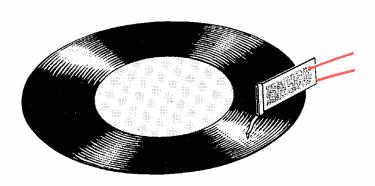
layer to each side and then connect a battery to the two conducting layers, something happens. The slab starts to bend to one side. If you then connect the battery the other way round the slab curves to the other side. You see it don't you? When you connect an alternating current to a Rochelle salt slab it bends to and fro with the alternating current. If you attach a diaphragm to this slab of Rochelle salt, the diaphragm will start to vibrate and you hear a tone. The opposite is possible too.

When sound sets the diaphragm vibrating, the Rochelle salt slab is bent backwards and forwards and a voltage is generated between the two conducting layers on the slab. Used in this way it is called a microphone.

The earphone in the EE assembly kit contains a Rochelle salt slab and can thus be used not only to change electric voltages into sound, but also as a microphone to change sound vibrations into electric voltages.

Crystal pick-up

In most pick-ups used in gramophones there are also Rochelle salt slabs. The sound vibrations come from the grooves in the gramophone record. When you examine such a groove under a magnifying glass you will see that it is not just a spiral line but that the line wriggles to and fro a little. The wavy line of the groove corresponds with the movements of the particles of air of the original sound. The gramophone needle resting in the groove is also pushed to and fro by the groove. This needle is set in a slab of Rochelle salt, which is therefore also bent to follow the movements of the needle. Again, as a result of being bent to and fro an alternating voltage is generated between the conducting surfaces on the Rochelle salt. A pick-up is thus, as it were, a microphone with a needle on it, which is not vibrated directly through the air vibrations but by means of the vibrations set up by the needle in the gramophone groove.



B. TELECOMMUNICATIONS

Telecommunications means something like "traffic at a distance". By traffic, however, you should not imagine motor cars, trains and aeroplanes, but the transmission of information. That can be telegraphy, telephony, radio-telephony, picture-telegraphy and television. What is important here is that there is always a distance to be bridged over. A loudspeaker house telephone or Intercom is just as much a piece of telecommunications equipment as the installation which will eventually be used to send messages to the first people landing on the moon, and which will be used by these people coming back to tell their wives to hurry up and get the potatoes on because they are on their way home. When you yell out of the window to your chum who lives on the other side of the street, that is hardly telecommunications. We call it telecommunications when you can transmit messages over practically any distance you wish. You cannot do that by talking or even shouting. If your friend lives a mile off then you can yell as hard as you like, but he will not hear you. It is only by electronic means that it is possible to bridge over any distance, and telecommunications is thus the electronic transmission of information. One of the oldest but still a very important method in telecommunications is telegraphy. Telegraphy is exceptionally suited for the transmission of information over long distances.

The first two circuits in this group are telegraph circuits, that is, sets with which you can send and receive morse signals. The morse code is fed from your morse key along wires to an earphone or loudspeaker and these wires can be very long. In this kit you will not get wire a mile long, and, in addition you are not allowed to fit wires over the street as you like — you have got to have the approval of the Town Council and of the Post Office authorities and we are afraid you would not get it. If your friend lives nearby and in the same block, it might be possible to fix up a connection between his and your room. These remarks

are also applicable for the loudspeaker house telephone but the monitoring set has other applications.

Morse telegraphy

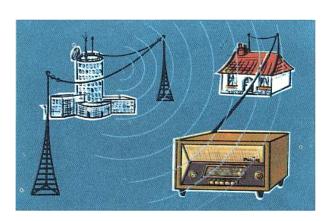
There is an international agreement that a dash should last three times as long as a dot. The rest interval between the parts of the same letter lasts as long as 1 dot, the rest interval between two words should last as long as 5 dots. In between two letters of the same word is a space lasting 3 dots. You will note that you attain the correct speed with the least effort if for the dot you say quickly "de" and for the dash you take a bit longer and say "dah". Thus the a sounds as "de dah".

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Beginning of message — —							
sos — — —							
Error							
End of message - — - — -							

C. RADIO

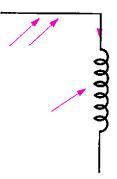
You no doubt know what radio is but probably not how it works. A radio receiver resembles a gramophone amplifier halfway, but instead of a pick-up it has a section whose working is probably totally new to you.

Do you remember how the capacitor works? An alternating current can flow through two parallel metal plates, even when they do not touch one another. We shall now replace one of these plates by the earth. This is of course not of metal but it can conduct currents well. The other plate we replace by a long metal wire stretched above the earth. This is again a kind of capacitor. If we now connect an alternating current to the metal wire — the aerial — and the earth, an alternating current can also flow through this capacitor we have made. The higher the frequency of the alternating current the greater the current which can flow through it. Now we have already said that what we call an electric field is generated between the two plates of a capacitor. That happens here too. Between the aerial wire and the earth an electric field is generated, but that is not all. You know that a magnetic field is emitted from a coil when a current flows through the coil. This is also true of a straight wire, so that a magnetic field is generated about the aerial wire and the wire leading to it. What have we now? When we connect an alternating current between aerial and earth, an electric and a magnetic field occur together and simultaneously. A combined field of this nature is called an electromagnetic field.

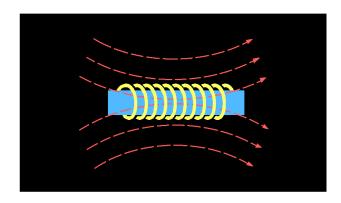


What happens now? An electromagnetic field like this propagates itself very far. It propagates itself through space, roughly in the same way as light does. In fact light is also an electromagnetic field. The radio electromagnetic fields we are dealing with behave in a somewhat different way, however. Light, as you know, does not pass the horizon. Radio waves, except in special cases, do. It is only when the radio waves are of a very high frequency that they behave in exactly the same way as light and do not pass the horizon.

We have already said that an aerial must be compared to a capacitor. So long as the aerial is not particularly big the capacitance of this capacitor is relatively small. That is why only alternating current of very high frequencies can be sent successfully through such an aerial. The frequencies can be 100,000 c/s (100 kc/s) or even higher, for instance, 1,000,000 c/s (1 Mc/s).



What happens now when the electromagnetic field strikes an aerial which is some distance away from the transmitting aerial? In that case this field generates a voltage beween the wire of the receiving aerial and the earth. If we connect a coil between the aerial and the earth, the result will be a current running through the coil. This is indeed a very small current but with the help of transistors it can be further amplified.



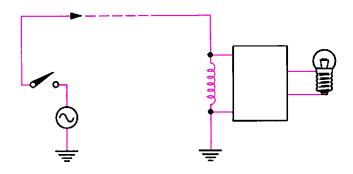
The field is, however, electromagnetic and the magnetic part of this field will flow directly through what we call the aerial coil. This magnetic part will itself generate a voltage in a coil as you may remember. We can therefore drop the aerial wire and use a coil as a receiver aerial. However, you will realize that an ordinary coil can never capture as much of the electromagnetic field as an aerial which is perhaps ten or twenty yards above the ground and may be ten or twenty yards long. A good outside aerial has a far greater receiving capacity than any little coil.

What happens now if we put an iron core in such a coil? Iron has the property of attracting and concentrating a magnetic field as it were. When a magnetic field is of a very high frequency ordinary soft iron cannot follow it any more and other materials, such as ferroxcube are used. A ferroxcube core in a coil collects so much magnetic field, that the coil behaves like a far larger coil. Without the ferroxcube core the aerial coil in your radio receiver will have to be almost a yard in section instead of just 3 inch in order to give the same results. Now when we send an alternating current with a frequency of 1 Mc/s through a transmitting aerial an alternating voltage of the same frequency will occur in a receiving aerial, even hundreds of miles away, irrespective of whether this is just a wire on the roof or what is called a ferroceptor, that is, a coil with a ferroxcube core.

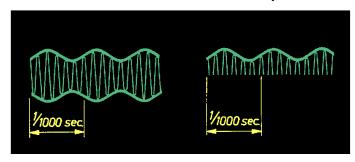
Now, a vibration of 1 Mc/s is inaudibly high. We cannot listen to this wireless wave directly.

We can, however, use it to carry our music, speech or telegraphy signals. Let us first give you an example of the last named. Just imagine you can amplify the currents flowing through your aerial coil sufficiently to light a little lamp. When the transmitter broadcasts for a very short time the lamp lights up for a short time and when the transmitter broadcasts for a somewhat longer period, for instance, a half a second, the lamp will burn for half a second. Now imagine you have a transmitting key connected in the transmitting aerial. Aerial current only flows when the transmitting key is pressed down. If you let an operator do that then dots and dashes are broadcast which, when put together, form letters, words and sentences. When a second operator looks at the lamp in the receiver he sees the dots and dashes and knows what is being tapped out hundreds of miles away.

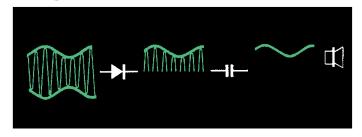
When transmitting sound things are set about in rather a different way. Just assume that you replace the morse key by a variable resistor. When the resistance is small a large amount of current goes through the transmitting aerial; when the resistance is great a small current will flow through the transmitting aerial. If somebody in the broadcasting station turns the resistor knob, the lamp in the receiver will burn either brighter or less brightly. Assuming he turns the knob back and forward three times per second then the little lamp in the receiver will also burn brighter or less brightly three times a second.



Now let us assume that he does not do this three times a second but for instance a thousand times a second. What will the transmitted wave look like now? The carrier wave becomes stronger and weaker one thousand times per second. This getting stronger and weaker is far too fast and the lamp cannot follow it. If we replace the lamp by a loudspeaker we hear. . . . nothing. The diaphragm of the loudspeaker would have to move back and forward one million times per second, a task it cannot perform as it is far too heavy. If we now take a pair of scissors and cut this figure lengthwise through the middle, all that is left are the current surges upwards, the current surges downwards having been cut off. This cutting off of such an electric vibration can be done by means



of a germanium diode. By using what is known as rectification we have turned the alternating current into direct current. In our example this is, however, no ordinary direct current, but a direct current which becomes greater and smaller a thousand times a second. This is therefore a direct current on which a 1,000 c/s alternating current is carried. If we now try to lead this current through our loudspeaker across a capacitor, what happens? The direct current is blocked by the capacitor so we can ignore it. Then we are left with an alternating current of 1,000 c/s. This is reproduced by the loudspeaker.



In all radio receivers that we shall make there is a germanium diode which acts as a rectifier. This is also called a "detector". The germanium diode detects what sort of note is being modulated on the carrier wave. In this case the carrier wave in the transmitter is being modulated one thousand times per second. It is very difficult to do this with a little knob. It is in fact impossible, but we can use a microphone as a modulator instead. Then the carrier wave is modulated to agree with the sound vibrations which have struck the microphone. If anyone sings a high note in front of the microphone then the carrier wave is modulated with a high note. If he sings a low note the carrier wave is modulated with a low note. The receiver will thus reproduce these notes exactly.

Tuning

Of course you have known for ages how to tune a wireless receiver. It is a different thing however to know precisely what takes place. We have told you that the alternating current resistance of a capacitor drops as the frequency gets higher. On the other hand the alternating current resistance of a coil increases the higher the frequency gets. What happens now if we connect a coil to a capacitor? Then at one certain frequency the alternating current resistance of the coil will be exactly equal to the alternating current resistance of the capacitor. It depends entirely on the values of coil and capacitor at what frequency this is. Now something very curious happens at this frequency. The currents which flow through coil and capacitor are, of course, identical. This is not quite so strange for, as you know, the same voltage and the same resistance means the same current.

What is odd is that as it were, they chase each other in circles. The total current seems to flow in a circle through coil and capacitor, but keeps going round and round as if it did not want to leave. This current finds it so pleasant that the alternating current resistance of capacitor and coil is the same, that the current at this particular frequency through the coil and through the capacitor becomes very great. At

all other frequencies this current is much smaller.

As it were, the coil current seems to take fright when it tries to reach the capacitor and sees that the resistance is different there. It is also true for the current throught the capacitor that, as it were, it takes fright when it has to flow through the coil and finds that the alternating current resistance of the coil is not the same as that of the capacitor.

If, by turning the tuning capacitor, we change its capacitance (that is, its value as as capacitor) this phenomenon of a specially strong current will occur at another frequency. If the capacitance of the capacitor is changed, then this phenomenon, known as resonance will occur at another frequency. All transmitters broadcast a carrier wave and the frequency of this carrier wave differs for each transmitter. At a given position of the tuning capacitor only one transmitter will bring about a powerful circular current. The circuit is therefore in resonance for that one transmitter, but not for all the others. For all these other transmitters the circular current is therefore considerably weaker and these other transmitters are therefore heard much less clearly. So softly that in most cases they are no longer audible. If we now turn the capacitor, the circuit again comes into resonance with the carrier wave of another transmitter and we thus receive it instead.

D. ELECTRONIC SIGNALLING

In the dead of night a thief wearing rubber soled shoes creeps silently up to a building. He is wearing gloves to avoid leaving any finger prints behind. With a skeleton key he opens the door which he has already oiled so that it will make no noise.

Everything is dead quiet and there is nothing to be seen, but the moment he opens the door a few inches an alarm siren begins to howl—yet there isn't a contact or anything else on the door. If the thief had tried to make entry through a window, the same thing would have happened. Invisible electronic eyes are on the look out to report the presence of intruders. Let us take another case. Somebody enters a room into which he is not supposed to come. He makes a slight noise. Somewhere else in the building a light flashes on. An invisible electronic ear has betrayed him.

Electronic signalling is not only used to trap thieves and intruders. It can also be used to warn people that a certain period of time has passed, for instance, the time required to make a photographic enlargement. It can also be used as a warning, in the form of flashing light, that danger is in the offing.

Electronic signalling is therefore extremely useful.

You too can surely imagine where you could use the various sets described above and for what purposes. You can make them with your EE assembly kit.

E. ELECTRONIC MEASURING AND CONTROL

In the technical field and in daily life a great deal has to be controlled and measured. Both in the elementary school and in the secondary school, to say nothing of technical training, pupils are still plagued with sums in which measurements are carried out. So many pints of water in so many pints of wine, or the container out of which water flows, and what happens when, etc., etc.

With the help of electronics you can measure how much petrol there is still in the tank, what the temperature of an oven is, whether the flour is not too damp and, for instance, whether a mixture of two materials is in the proper ratio. When you mix two materials with another in a machine, it may be possible not only to measure whether the mixture ratio is correct, but also to regulate the taps automatically in such a way that the correct ratio is obtained.

You can also use controls to ensure that the temperature in a room remains constant, irrespective of whether it is cold or hot outside. Just think of the refrigerator.

It is also possible to switch on a lamp after a certain period of time determined in advance. The circuits dealt with in this chapter are measuring and controlling equipment which you can not only build yourself, but also apply for your own use and benefit.

DESCRIPTIONS OF CIRCUITS

A_I — TWO-TRANSISTOR GRAMOPHONE AMPLIFIER

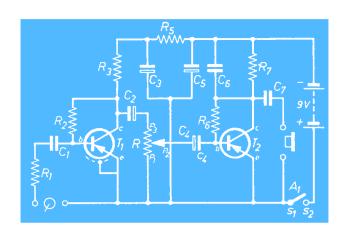
The alternating voltages, generated in the pick-up by the movements of the needle cause an alternating current to go through the base wiring of the T1 transistor. As a result an alternating current also runs through the collector wire. This current, however, as we have already read earlier on, is considerably stronger. A large part of this collector current goes through the potentiometer. From the adjustable contact, across C5 a part of this alternating current enters the base wiring of the transistor T2. The result of this is that an alternating current also flows through the collector wire of T2 which again is stronger than the base alternating current. Then it flows mainly across C7 to the earphone. The current through the earphone is hundreds of times stronger than the current supplied by the pick-up, thanks to the two transistors, and it is so strong that we can clearly hear the music through the earphone.

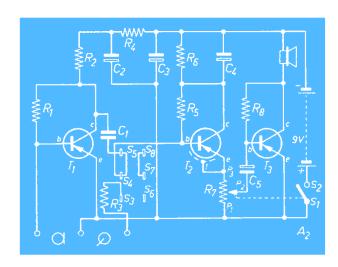
A2 — AUDIO AMPLIFIER

When the switch is at position "Gramophone" this set works in roughly the same way as amplifier A1. The main difference is that the alternating currents to the output of your amplifier no longer go through an earphone but through a loudspeaker.

When the switch is at position "Microphone" the transistor T1 comes into service. The microphone currents are much smaller than the currents given by the pick-up, for which reason an extra transistor must be used as a "preamplifier". The current in the collector wire of this preamplifier is roughly as great as the current which the pick-up itself supplies direct.

Thus when you are playing a gramophone record and suddenly switch over to Microphone, your speech will be reproduced just as loudly as the gramophone record.





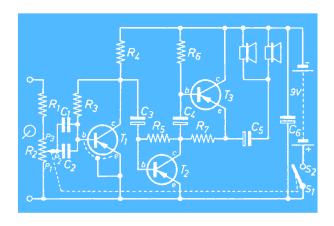
A₃ — PUSH-PULL AUDIO AMPLIFIER

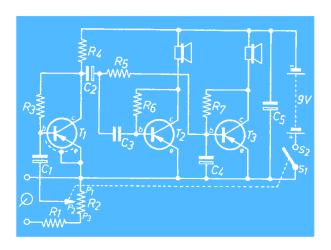
The currents from the pick-up reach the base wire of the transistor T₁ via the potentiometer. The collector currents from T₁ flow to the base of T₂. Thus alternating currents occur in the collector wire of this transistor and flow to the base of T₃, but part of this current flows directly across R₇ and C₅ through the loud-speakers. Alternating currents will now also run from the collector wiring of T₃ through the loudspeakers.

Now what are the advantages of this circuit? First of all the currents of two transistors go through the loudspeakers, thus twice as much current and therefore twice as much sound. The currents pass through the loudspeakers together and any possible excess of the one is cancelled out by a deficit of the other. That makes the sound better (less distorted).

A₄ — BI-AMPLI AMPLIFIER

The currents from the pick-up flow through the potentiometer R2 to the transistor T1. The currents are amplified by the transistors and go out in two directions, across C3 to the base of transistor T2 and across R5 to the base of transistor T₃. However, because of the presence of C3 only the high notes are amplified by T2 and then flow from the collector circuit of this transistor through the high note loudspeaker. The other current flows through R5, to the base of transistor T3. The high frequencies of this current will, however, take the path of least resistance and that is through C4. Only the low frequencies (low notes) are amplified by T3 and flow through the low note speaker. So we have an amplifier for the high notes and one for the low notes. This the engineer calls a "Bi-Ampli" Amplifier.





A₅ — ELECTRONIC ORGAN

The electric currents which are made audible, after amplification, by the loudspeaker are generated in the electronic organ itself. The notes are generated by means of two transistors; T₁ and T₂ in the same way as described on page 68 (D₄).

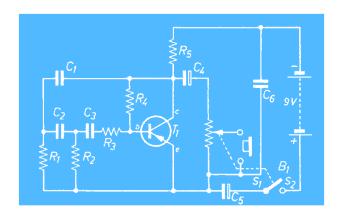
If we press one key the base alternating current of T₁ flows across C₂ through the depressed key and from there across the resistors between the keys and R₂ to the emitter of T₁.

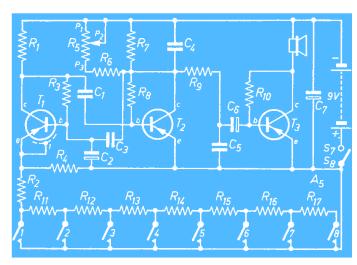
The current passes through R9 and C6 to T3, which results in a strong current going through the loudspeaker. The pitch of the tone can be modified by the 8 resistors R11 to R17.

BI — MORSE CODE TRAINING SET

In our morse set we must make the signal tones ourselves and we do this by means of transistor

When a small current flows through the base, a larger current flows through the collector wiring and lands to a large extent in the base wiring of our transistor after crossing the capacitors C1 and C2. The base current is thus increased, so that the collector current is also increased etc. so that the originally small current has increased to a considerable degree. This current surge has the effect that the transistor, as it were, takes fright and suddenly almost stops supplying current. At that moment, however, everything starts up again from the beginning. This can happen at about 1000 times per second. Part of this rapidly changing collector current runs across C4 and the potentiometer to the earphone where it creates a single note. With the potentiometer we can make the current through the earphone greater or smaller and thus the sound louder or softer.



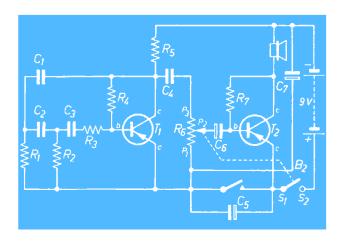


B₂ — MORSE CODE TRAINER WITH LOUDSPEAKER

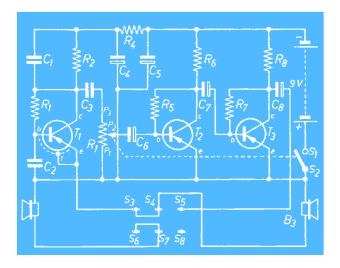
How the tones are generated can be read in the description of set B₁. A current runs from the tone generating part to the base of T₂.

As a result, a larger alternating current flows through the collector of this transistor and from the collector wiring through the loudspeaker. The loudspeaker will therefore reproduce the morse tone loud and clear. By turning the potentiometer knob we change the position of the sliding contact on the potentiometer and

From the sliding contact on the potentiometer P2 part of the current passes through C6 to the base of T2. The collector current of T2 flows to the base of T3 and this amplifies it once again. From the collector circuit of this transistor a considerable current flows across C8 to the sliding switch and from there through the second loudspeaker, where it reproduces loud and clear what was said into the first loudspeaker.



hence make the current through the loudspeaker greater or smaller and thus the sound louder or softer.



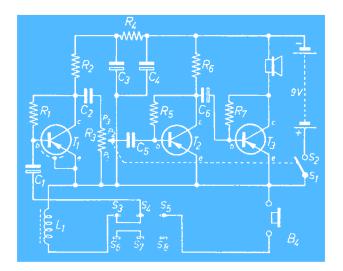
B₃ — **INTERCOM**

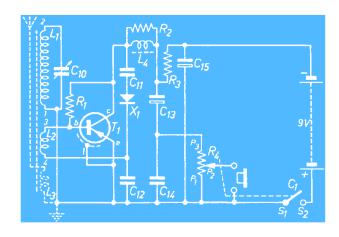
When the switch is to the left the loudspeaker in our telephone functions as a microphone, that is to say, this loudspeaker supplies little currents which correspond with what we say. These small currents flow across the sliding switch through transistor T1 and in so doing generate a stronger current through the collector circuit of this transistor. This current also flows through the potentiometer.

B4 — **TELEPHONE** AMPLIFIER

undergo this amplification.

With the switch in the right-hand position the microphone currents are fed to the base of the transistor T₁ and amplified by it. These amplified currents cross the potentiometer to the base of transistor T₂, are amplified there and then reach transistor T₃. These currents have then been amplified three times in succession and are now strong enough to pass through the loudspeaker and produce a loud sound. When the switch is in the left-hand position it is the turn of the currents from the pick-up coil to





C_I — ONE TRANSISTOR RADIO RECEIVER

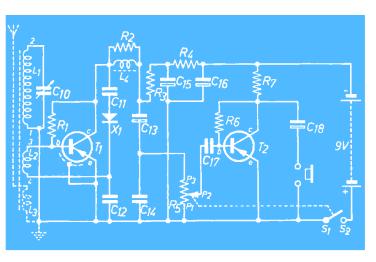
When radio waves go through the ferroxcube rod of our rod aerial, they generate voltages in the aerial coil (L1). This aerial coil is connected to the tuning capacitor and if the latter is properly tuned, powerful currents will start to flow in the aerial coil. If there is a second coil on the ferroxcube rod L2 the current through the aerial coil will also cause currents to flow through this coupling coil. These flow through the base of the transistor T1. As a result a more powerful current will flow through the collector lead of T1. This is therefore the amplified current from the aerial, that is, the modulated carrier wave. Where can this current flow to now?

A choke (L4) and the resistor R2 are connected to the collector. It is a coil with many windings and the high frequency current can hardly get through, and in fact it will also find the resistor R2 a little bit too much. The current therefore goes through C11 and the diode X1. What does this diode do now? It rectifies the current. It detects. Thus a current which conforms to the current which went from the microphone to the transmitter comes from the diode. This current flows through the coil L2 back to the base of T1. This, so-called low frequency current is dutifully amplified by this transis-

tor. That is what you call something for nothing, for T1 not only amplifies the aerial current, but also the low frequency current. In addition an amplified low-frequency current now flows through the collector lead of T1. However, this current finds that C11 has far too great an alternating current resistance, but finds it way with relative ease through the coil L4 connected with the former and from there across C13 through the potentiometer R4. From the sliding contact of the potentiometer, a part of this current flows through the earphone, where it is transformed into audible sound vibrations. The further the potentiometer is turned to the right, the greater is the part of the low-frequency current which flows through the earphone, and the louder the sound.

C₂ — TWO TRANSISTOR RADIO RECEIVER

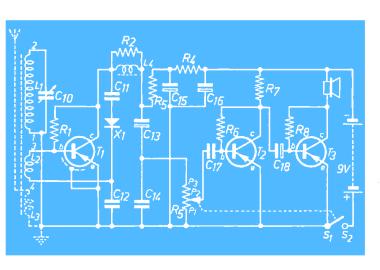
Up to and including the potentiometer the circuit diagram of this receiver is identical to the preceeding one. The currents which are taken up from the potentiometer now flow, however, through the base circuit of transistor T2. This transistor works as an amplifier for the low-frequency currents. This means that the currents flowing through the collector



circuit are much stronger than those in the base circuit. From the collector circuit these amplified currents then flow across a capacitor through your earphone.

C3 — THREE TRANSISTOR RECEIVER

The C₃ receiver is an extension of the C₂ receiver and up to and including the transistor T₂ is identical with it. The collector currents also flow from this transistor through a capacitor, but now come to the base of the transistor T₃ (with the heat sink), where these currents are once again amplified. Thus so powerful a current flows through the collector wiring that you can now use a loudspeaker instead of an earphone. You may find that if you tilt the receiver the tone of your receiver improves. It's worth trying.



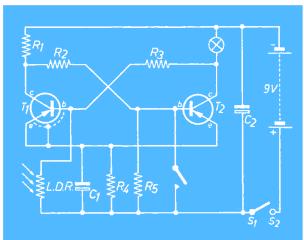
D_I — TELL-TALE LIGHT

When no light falls on the L.D.R., its resistance is high. The voltage on the base of T₁ will then be such that this transistor draws a current. If the little lamp would be placed in the collector circuit of this T₁, it would light up, but that is just the opposite of what we want. Therefore, we have added a second transistor: T₂. This transistor works the other way round to the first one: when transistor T₁ conducts, T₂ is blocked.

As soon as light falls on the L.D.R. its resistance becomes very low. This causes the current through T1 to stop flowing and as a consequence a current starts to flow through T2 and the lamp in its collector circuit. The lamp will stay on until the reset key is pressed.

D₂ — FLASHING BEACON

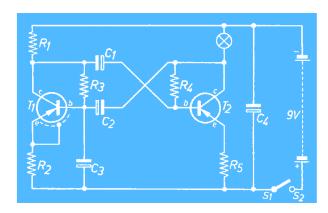
Let us assume that for one reason or another a



small current surge flows through the base circuit of T1. Then a larger current surge will flow through the collector circuit of this transistor. The greater surge of current flows across C1 to the base circuit of transistor T2. The result of this is a still greater surge of current through the collector circuit of this transistor. The current surge will for the greater part flow through our little lamp and make it light up.

A smaller part of this last current, however, crosses C2, which is thus fed another surge.

Switching on this apparatus is enough to ensure a small impulse of current through the base circuit of T1, the so-called switch-on current surge. This brings about a greater current surge through T2 which then travels to the lamp and T1, etc.



D3 — ACOUSTIC RELAY

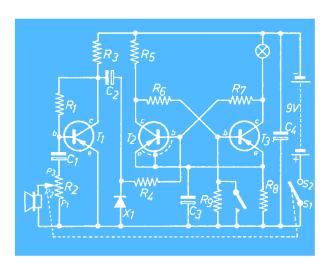
The sound which is received by the loudspeaker, causes an alternating current, amplified in the usual manner by transistor T1. This alternating current is rectified by the diode X1. These are ideas with which you are already familiar from your experience of radio receivers. This rectified current flows to the base of T2. The direction of the current is such that, when the current runs, as it were, against it, it prevents more current from flowing through the collector circuit of the T2. The rectified current is thus, as it were, against the stream. When the collector current to T2 stops, the voltage on the base of T₃ changes in such a way that T₃ begins to draw current, whereupon the lamp lights up. This lamp remains on until the reset key is pressed down again, whereby the base and the emitter of T₃ are connected with one another. The circuit therefore shows great similarity with that of set D₁, the tell-tale light.

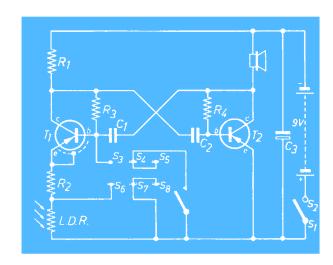
D₄ — PILFERING ALARM

When light falls on the LDR it has a very a very low resistance. A small initial current through the base of T1 is amplified and flows through the collector circuit. From there it goes through C2 to the base of T2 where it is once again amplified. This current then flows through the loudspeaker but runs in part through C1 as well, back to the base of T1. There it is amplified once more, etc. At a given moment so much current is flowing that the circuit cannot cope with it and the current stops flowing. Then everything starts from the beginning again. This rapidly repeated process creates an alternating current which operates the loudspeaker as described on page 54.

If no light falls on the LDR, however, it has a very high resistance, so that practically no current can flow through the emitter of the T1. Then the whole circuit stops operating. No whistling note comes from the loud-speaker.

With the sliding switch pushed to the left the LDR is replaced by a window or door contact switch.





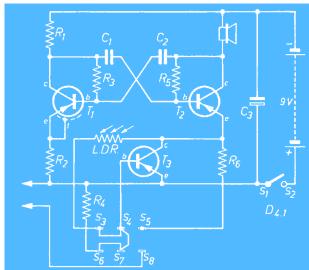
D_{4.1} — PILFERING ALARM

The circuit D₄-1 uses less current than circuit D₄.

The transistor T₁ together with the transistor T₂ ensure the generation of the alarm tone in roughly the way described in circuit D₄. When light now falls on the LDR itself, its resistance is low so that the positive voltage from the battery on the collector of transistor T₃ becomes effective. This transistor then draws current so that T₂ starts working, and in turn sends a surge of current to the T₁, which again sends a surge of current to T₂ etc.

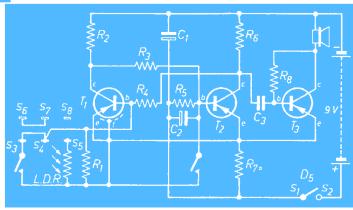
With the sliding swich pushed to the right, the LDR is replaced by a door- or window contact switch.

The transistors T₁ and T₂ together ensure the switching on and off of the tone generator. So long as no light falls on the LDR and the latter's resistance is therefore high, or the left-hand key is not pressed down, a current flows through T₁. This current also flows across R₃ to the base of T₂ and thus prevents this transistor itself drawing current. No current therefore flows through the collector wiring of T₂. If light falls on the LDR or if the left-hand key is depressed T₁ prevented from carrying current and T₂ is again able to begin sounding the tone.



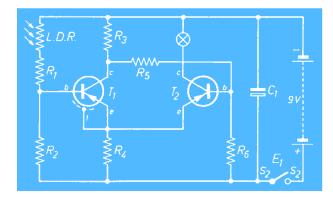
D₅ — BURGLAR ALARM

The transistors T2 and T3 together ensure the generation of the tone in roughly the same way as in diagram D4-1. The collector currents go through the loudspeaker and once they have done so are fed in part at least back to the base of transistor T2, etc.



E1 — AUTOMATIC NIGHT LIGHT

So long as light falls on the LDR its resistance is low. As a result the voltage on the base of Ti is relatively high, that is to say almost as high as on the collector. Current can therefore flow through this transistor. As a result of this current flowing the voltage on the collector is reduced. Voltage is lost in the resistor R3. The base of T2 is connected across R5 to the collector of T1. The voltage on the base of T2 will thus also be very low, too low to permit a considerable collector current at T2. If the light now goes out the resistance of the LDR increases so that the voltage on the base of Ti becomes more positive and hence the voltage between base and emitter becomes smaller. For this reason the current through the collector wiring of this transistor becomes less. This voltage also crosses R5 to the base of the T2 which can now carry a considerable current and a greater current through the collector wiring is the result of this. This current is so great that the lamp starts burning.



E₂ — RAIN AND MOISTURE INDICATOR

a. When we look at the circuit diagram and ignore the two wires leading to the mysterious little rectangle on the lefthand side of this circuit diagram, what do we see? The base of T1 is not connected and this transistor will therefore draw no current. When we now connect the base and the collector of this transistor by means of a wire, the lamp will burn. How does this come about?

The base is then connected to the same voltage as the collector and is now negative with respect to the emitter. Therefore a current can flow from the emitter to the collector. The emitter current is obliged to flow through R1. A voltage is generated across this in such a way that the top of the resistor is negative with respect to the bottom. This negative voltage passes R2 to the base of T2. The negative voltage on this base was first very small and gets bigger. For that reason T2 also begins to draw current, that is to say, a fairly big current flows through the collector of this transistor. The current flows to the negative side of the battery, but across our little lamp. This lights up. What have we shown now? We have shown that the base of a transistor must be connected to a negative voltage to enable it to carry current and that a copper wire is a conductor.

- b. Now we connect a wire to the wire terminal to which the base of T1 transistor is connected and one to the wire terminal top left on the wiring diagram, the other end of which we also make bare.
 - Let a friend hold one of the wires and you yourself hold the other wire. Nothing will happen. The lamp doesn't burn.
- c. Next get hold of the bare end of one wire in one hand and the bare end of the other wire in your other hand. The lamp will begin to burn now. This is because you are a conductor, not as good a conductor as a copper wire, but you still conduct well enough to ensure that a little negative

voltage reaches the base of T1. The current which goes through your body in this experiment is particularly small. This current is perfectly safe while the currents which you can get from the mains socket can be fatal!

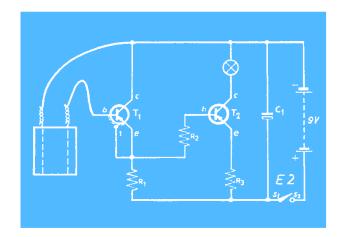
Hands off the mains socket always!!

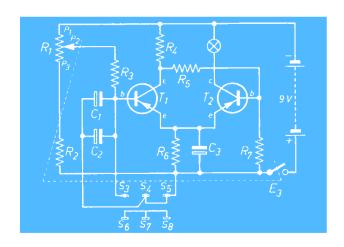
E₃ — TIME SWITCH

When the sliding switch is in the right-hand position, the capacitors C1 and C2 are connected to the poles of the battery via the potentiometer R1 and the resistor R3. Then a current flows through this circuit until the capacitors are charged. During this time the voltage between the base and the emitter of T1 will be very low and no current will flow to the emitter. As a result the voltage between the base and the emitter of T2 will be such that this transistor conducts and thus the lamp will glow. As soon as the two capacitors C1 and C2 are fully charged the left-hand transistor will start to conduct. Then the current through T2 stops flowing and the little lamp goes out. By setting the sliding-switch to the left, the capacitors are short circuited and thus discharged.

E₄ — UNIVERSAL MEASURING EQUIPMENT

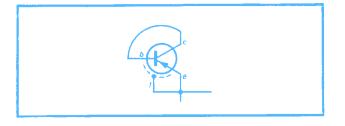
This apparatus consists actually of three parts.





The transistor T₁ ensures the generation of the tone that you hear. The transistor T₂ amplifies it. The potentiometer R₇ plus the standard resistor or capacitor together with the unknown resistor, capacitor or LDR form what is known as the measuring bridge.

As far as the generation of the tone is concerned let us assume that on the base of T₁ there is an alternating current. Then an alternating current of the same frequency will flow through the

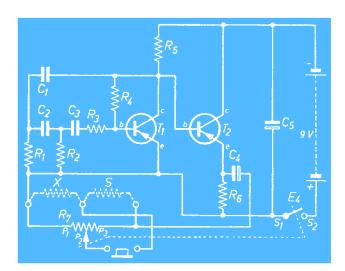


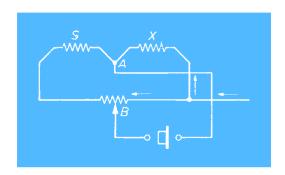
collector of this transistor. This current is to some extent fed back across C1, C2 and C3 to the base of T1 where the tone is again amplified, etc.

As a result this tone generator, as it is called, can only generate one tone, just as we want it. When switching on the equipment a small current from T1 goes to the base wiring of T2 which brings about an amplified collector current, but that collector current also flows through the emitter and from the emitter we feed a part of it across C4 through the potentiometer. Now we come to the actual measuring circuit.

We have drawn this one separately as you see. Now we see that the current from the T2 flows out from two sides; through the potentiometer and also through the unknown resistor and the standard resistor connected in series. As a result of these alternating voltages occur at points A and B.

If we now assume that the standard resistor S and the unknown resistor X are equal and that the moving contact of the potentiometer is in such a position that the resistance on its lefthand side is equal to the resistance on the right, what do we then know about the voltages on points A and B? They must also be equal. The earphone is connected between points A and B, but when the voltage upon both is the same no current can flow through the earphone. Now we shall replace the unknown resistance by one of a different value. Then the current through this resistor is a different one and so is the voltage on point A. Now there is indeed a difference in voltage between A and B and we hear a tone through the earphone. If we now turn the potentiometer knob, the voltage on point B will be changed and thus also the voltage difference between A and B. At a given moment the voltage on B will again become equal to that on A and the earphone will be silent once more. What do we learn from this? We know that the ratio between the resistor S (the standard resistor) and resistor X, which is unknown, is the same as the ratio of the resistance of the right-hand side of the potentiometer to the resistance of the left-hand part of the potentiometer. The scale on the potentiometer is subdivided in such a way that it always gives the ratios. When the knob is pointing to 2, that means that the resistance of the part to the left of the moving contact is twice as great as the resistance of the part to the right of the contact. But that means also that the unknown resistor X is twice as large as the standard resistor S.





The light meter works in a similar sort of way except that the L.D.R. now replaces the unknown resistor.

As explained before the resistance of the L.D.R. varies with the amount of light falling on its sensitive surface — the higher the intensity the lower the resistance of the L.D.R. and vice versa. In this way by comparing the resistance of the L.D.R. with a normal resistance the intensity of the light can be determined at any particular time.

colour	rst band (1st digit)	2nd band (2nd digit)	3rd band (factor)	4th band (tolerance)
black	o	0	_	gold-silver
brown	ī	I	× 10	5% 10%
red	2	2	X 100	"
orange	3	3	× 1000	,,
yellow	4	4	× 10,000	**
green	5	5	x 100,000	"
blue	6	6	x 1,000,000	,,
violet	7	7	x 10,000,000	,,
grey	8	8		10% 20%
white	9	9		white black

Colour code

10 Ohm Brown/black/black 47 Ohm yellow/purple/black 120 Ohm brown/red/brown 150 Ohm brown/green/brown 220 Ohm red/red/brown 270 Ohm red/purple/brown 560 Ohm green/blue/brown blue/grey/brown 680 Ohm 1,500 Ohm brown/green/red 2,200 Ohm red/red/red 3,300 Ohm orange/orange/red 4,700 Ohm yellow/purple/red brown/green/orange 15,000 Ohm red/purple/orange 27,000 Ohm 100,000 Ohm brown/black/yellow 330,000 Ohm orange/orange/yellow 680,000 Ohm blue/grey/yellow

