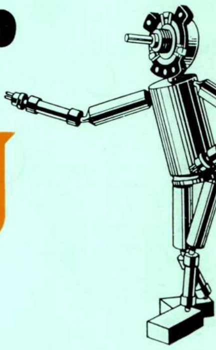
PHILIPS electronics for YOU



ELECTRONIC COMPONENTS AND MATERIALS DIVISION

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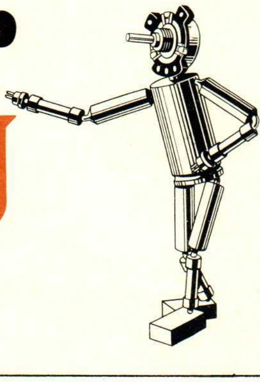


Dear Experimenter,

There is no doubt about it: the good old thermometer is an extremely useful instrument! To give it full credit: it is an indispensable aid in industry and science, in the hospital and in our home. It has, however, one serious drawback: it is so silent! It has no means of calling or warning us and in many instances that is just what we should like it to do.

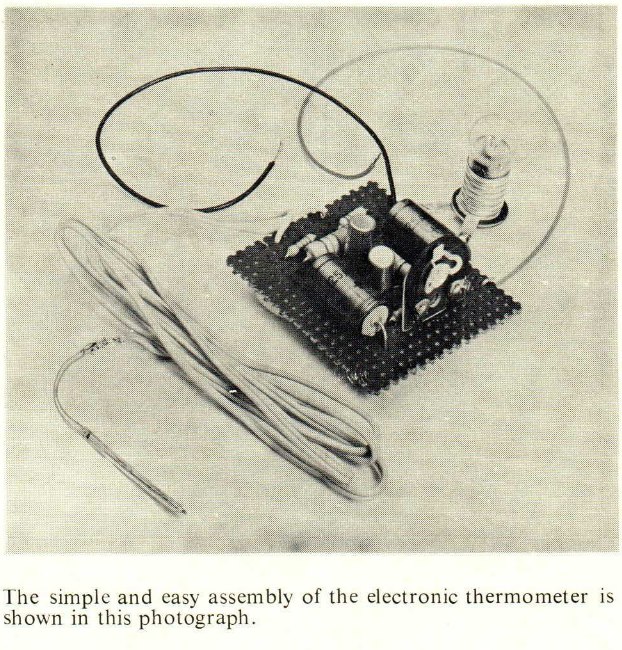
An electronic thermometer does not show this disadvantage. Connected to a signal lamp it can give you a warning that it is becoming too hot in the room, the water in your bath is warm enough, the temperature outside has dropped below zero, spring has set in, your newly hatched birdies are in danger because it is too warm or too cold for them, your hothouse is too hot. Conversely, the very simple electronic circuit in combination with a relay can be used to keep the temperature constant, whether in the dishes and basins you are using in your dark room, or in the tank which is the home of your tropical fish.

You need only a few components to build the electronic warning system and when you have finished it you will be surprised at the large number of additional uses. Mind you, it is not even necessary to go to another room or out of the house to have a look at the thermometer when you install the signal lamp close to your armchair.

Your attention, please, for the basic principle: a negative temperature coefficient resistor has been employed. Some of our future experimenter's circuits will be based on the same principle.

We wish you much pleasure in experimenting and, don't forget:

OPTIMAL RESULTS WITH PHILIPS COMPONENTS ONLY



The simple and easy assembly of the electronic thermometer is shown in this photograph.

ELECTRONIC THERMOMETER

Possible uses

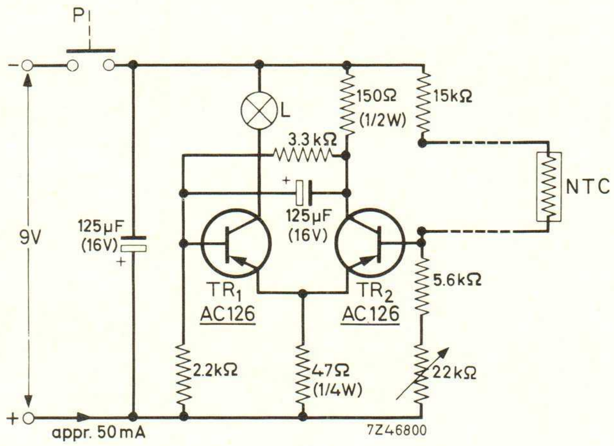
Signalling unit at preset temperatures between −10 and +75 °C

In this case a signal lamp or buzzer is connected to the device to give a warning when the preset "critical" temperature is approached (intermittent signal), or has been exceeded (continuous signal). The "critical" temperature is either a maximum or a minimum.

Typical examples
– *maximum temperature not to be surpassed:*
of the air in cold stores, cooling rooms, glasshouses, etc.
of water in bath-tub;
– *minimum temperature not to be underpassed:*
of the air in cellars, garages and glasshouses;
of photographic baths (which also must be made sure to have the *same* temperature, especially for colour photographs).

Thermostat

A relay is connected instead of the signal lamp or buzzer; its function is to switch a heating or cooling system on or off. This electronic thermostat may be used for any of the applications mentioned above, either as a new control device, or to replace an existing thermostat when this is out of order, for instance, in a refrigerator or a central heating system.



Circuit diagram of the electronic thermometer equipped with an NTC thermistor.

Parts list

		Catalogue number
NTC thermistor	: 4.7 kΩ	2322 627 11472
Potentiometer	: 22 kΩ	2322 411 02208
Capacitors	: 125 μF/16 V electrolytic (2×)	2222 001 15131
Transistors	: AC 126 (2 ×)	
Signal lamp	: 6 V/50 mA, Philips type 7121 D	One of these two
Relay	: 200 Ω, operating current abt. 40 mA	One of these two
Resistors	: 1/8 W unless indicated otherwise in the diagram. Use Philips vaporized carbon resistors.	

Note:

When the relay is connected into the circuit the electrolytic capacitor of 125 μF (shunted across the resistor of 3.3 kΩ) must be removed because otherwise the relay will operate intermittently when the "critical" temperature is approached. Shunted across the relay, connect a Philips type OA202 diode with the cathode (indicated by the white band) linked to the transistor.

Principle of operation

See the circuit diagram.
A Philips NTC thermistor, catalogue number 2322 627 11472 is the sensor. It is part of a voltage-divider circuit that determines the voltage for the base of TR2. The 22 kΩ potentiometer can be so adjusted that variations in the resistance of the NTC thermistor have the desired effect on the rest of the circuit. If, for instance, the device is to operate as a frost indicator the setting of this potentiometer must be such that resistance variations of the NTC thermistor, caused by the temperature decreasing from room temperature down to the freezing point, make the circuit behave as a flip-flop (TR1 and TR2 alternatively driven into the conductive state). Signal lamp L will then flash intermittently. With the temperature continuing to decrease to zero the resistance of the NTC element will increase from 4.7 kΩ to 15 kΩ. TR2 can then no longer become conductive since the base has attained too high a positive voltage with respect to the emitter. The circuit has been so dimensioned that TR1 receives sufficient negative voltage on its base to be driven into the conductive state. As a result the signal lamp will burn continuously. Any further decrease in temperature, although causing the resistance of the NTC element to rise accordingly, will have no important effects on the current flowing through signal lamp L.

Adjusting the circuit

The moment at which the circuit starts to give the intermittent signal as a warning that the "critical" temperature has been reached must be preset. This is done as follows *for a frost indicator:*

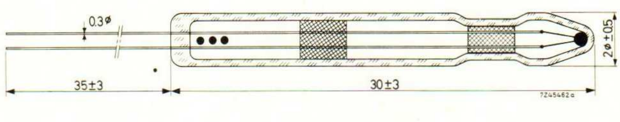
1. Place the NTC element in a container with melting ice and check with a thermometer whether the temperature is actually zero degrees centigrade.
2. Leave the NTC element in the container for some time to allow it to assume the temperature of the melting ice.
3. Depress button P and adjust the 22 kΩ potentiometer in such a way that signal lamp L is about to start flashing but just keeps burning continuously.

To adjust the device for any other temperature-indication purpose, place the NTC element in water which has been brought to the "critical" temperature.

It is obvious that the circuit can also be used the other way round. For instance, in the case described above lamp L will burn continuously when the temperature is below the freezing point, then start flashing when the temperature reaches the freezing point, and go out when it rises above freezing point.

Summarizing, the device can be used to give a warning when a minimum temperature is underpassed:
- Signal lamp off = no change in condition;
- Signal lamp flashes = approaching "critical" temperature – find out why;
- Signal lamp on = "critical" temperature underpassed – take measures.

Or, it can be used to signal when a maximum temperature is surpassed:
- Signal lamp on = no change in condition;
- Signal lamp flashes = approaching "critical" temperature – find out why;
- Signal lamp off = "critical" temperature surpassed – take measures.

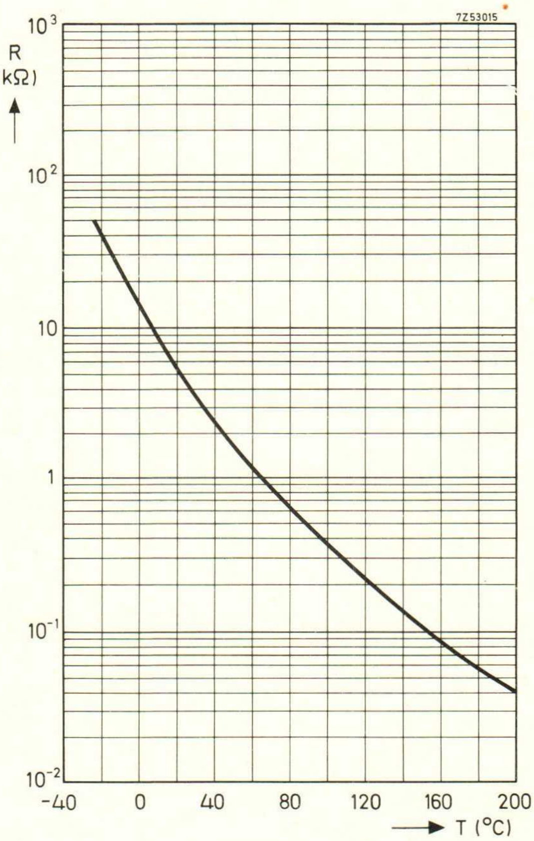


Dimensions in mm of Philips NTC thermistor 2322 627 11472.

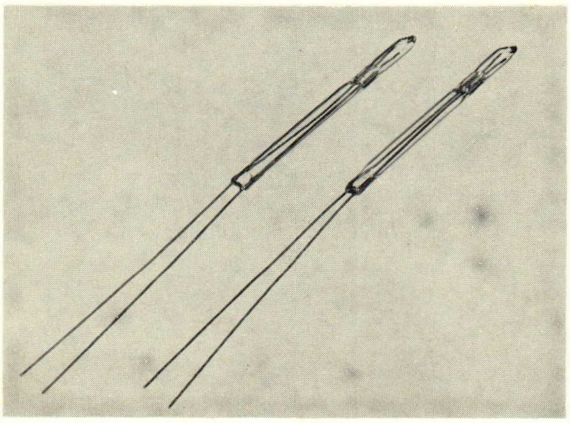
Some particulars of NTC thermistors

N(egative) T(emperature) C(oefficient) thermistors are resistors with a large negative temperature coefficient of resistivity, and made from semiconducting oxides. The resistance of these oxides decreases rapidly when the temperaure rises (around 25 °C this decrease is between 3 and 5% for a rise in temperature of 1 °C). Miniature NTC thermistors are made by applying a drop of oxide paste between two parallel platinum alloy wires, followed by drying and sintering. For most applications the miniature NTC elements are mounted in glass for protection against agressive gases and fluids. Others are mounted insulated in a metal housing to ensure good thermal contact with the chassis.

The relation between resistance and temperature is illustrated by the adjoining graph. As "nominal" resistance is taken the value at 25 °C, with a spread of ± 20%. The curve shows that the resistance of the 4.7 kΩ NTC thermistor, varies between 50 000 Ω at −25 °C and 40 Ω at 200 °C (with 4700 Ω at 25 °C).



Resistance variation as a function of the temperature of Philips NTC thermistor 2322 627 11472.



Philips NTC thermistor 2322 627 11472.

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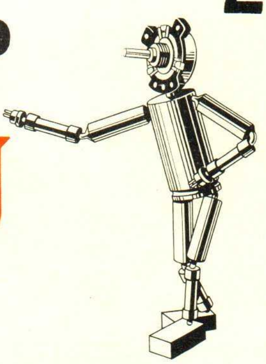


Dear Experimenter,

This issue of "Electronics for You" aims at helping you to build an intercommunication system. The system is a special one in that the units – master unit and remote unit – are extremely mobile and not, as is normal, tied to a certain place because of the fixed cable connecting them.

As most "intercoms" are mains-operated it is natural that people have been looking for a possibility of using the mains also for transporting the signals. It would then become feasible to plug the units into any wall socket connected to the signal-carrying phases.* In the system to be described here a 80 kHz modulated carrier is injected into and taken from the mains leads by means of small separating capacitors. The method does not allow long distances to be covered because of the low resistance and high capacitance of the mains: the carrier is strongly attenuated. In practice, however, one will find that inside the house the signal strength is sufficient; also, that almost no signal gets past the electricity meter.

What about interference? Naturally the electric appliances you have in the house will cause some "background" noise or hum but this will generally not become strong enough to be a nuisance. However, we cannot advise you to use the intercom in offices or factories since there the level of the interfering noise will be too high.

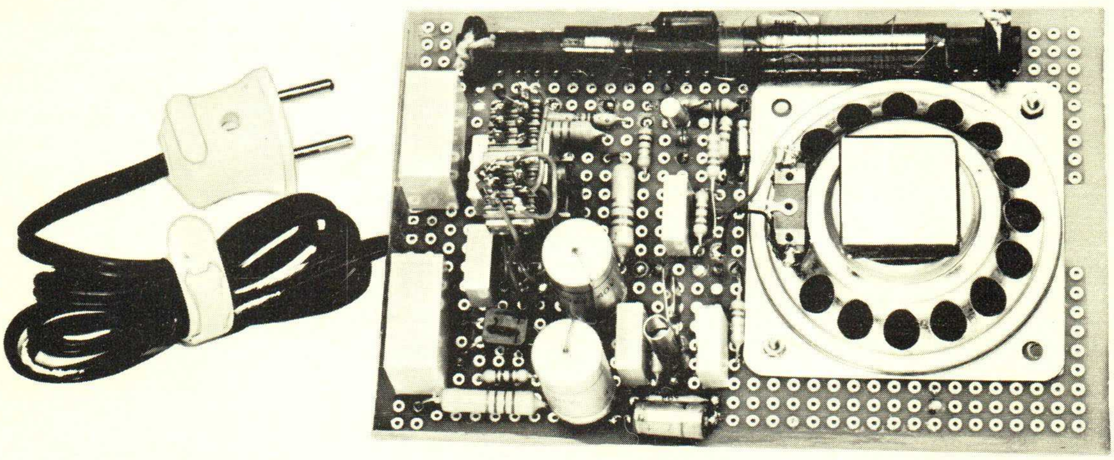
What about safety?

The circuit being connected direct to the mains it is necessary to insulate it properly to avoid electric shocks. Therefore a wooden or plastic housing should be used, lined with a sound-absorbing material because otherwise acoustic resonance may occur.

We wish you much pleasure in experimenting and, don't forget:

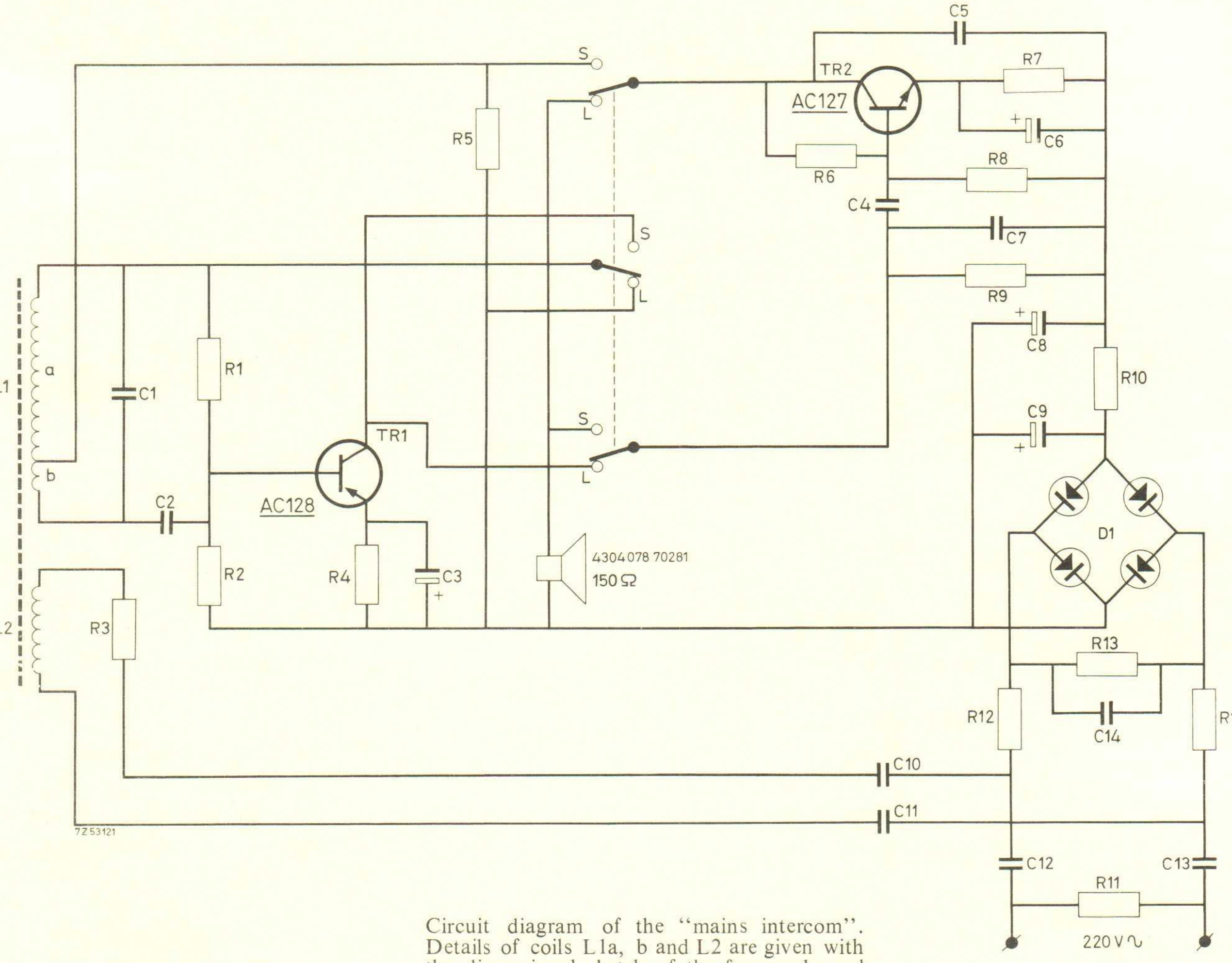
* Make sure that the wall sockets are connected to the proper phase. If two or three phases are used in the mains circuit of the house some of the wall sockets will not be interconnected.

OPTIMUM RESULTS WITH PHILIPS COMPONENTS ONLY



The simple and easy assembly of the "mains intercom" is shown in this photograph.

INTERCOMMUNICATION VIA THE ELECTRIC MAINS



Circuit diagram of the "mains intercom". Details of coils L1a, b and L2 are given with the dimensional sketch of the ferroxcube rod on page 3.

Parts list

				Catalogue number
C1	15	kpF	(ceramic capacitor)	2222 552 03153
C2	3.9	kpF	(ceramic capacitor)	2222 563 02392
C3	10	μF/16V	(electrolytic capacitor)	2222 001 15109
C4	0.47	μF/100V	(polyester capacitor)	2222 344 21474
C5	0.1	μF/100V	(polyester capacitor)	2222 344 21104
C6	10	μF/16 V	(electrolytic capacitor)	2222 001 15109
C7	0.1	μF/100 V	(polyester capacitor)	2222 344 21104
C8	250	μF/40 V	(electrolytic capacitor)	2222 023 17251
C9	250	μF/40 V	(electrolytic capacitor)	2222 023 17251
C10	0.1	μF/400 V	(polyester capacitor)	2222 344 51104
C11	0.1	μF/400 V	(polyester capacitor)	2222 344 51104
C12	1	μF/400 V	(polyester capacitor)	2222 344 51103
C13	1	μF/400 V	(polyester capacitor)	2222 344 51103
C14	0.1	μF/100 V	(polyester capacitor)	2222 344 21104
R1	47	kΩ		2322 101 33473
R2	10	kΩ		2322 101 33103
R3	10	Ω		2322 101 33109
R4	470	Ω		2322 101 33471
R5	1	kΩ		2322 101 33102
R6	33	kΩ		2322 101 33333
R7	39	Ω		2322 101 33399
R8	4.7	kΩ		2322 101 33472
R9	2.2	kΩ		2322 101 33222
R10	100	Ω		2322 101 33101

(R1 up to R10 are carbon resistors of the 1/8 W type)

				Catalogue number
R11	0.1	MΩ		2322 101 63104
R12	220	Ω		2322 101 63221
R13	1	kΩ		2322 101 63102
R14	220	Ω		2322 101 63221

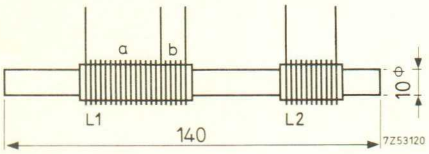
(R11 up to R14 are carbon resistors of the 1 W type)

TR1	AC128	(p-n-p transistor)	
TR2	AC127	(n-p-n transistor; this should be used here with a cooling fin type 56200)	
D1	BY122	(full-wave bridge rectifier assembly)	
Ferroxcube aerial rod	(diameter	10 mm; length 140 mm)	3122 104 91242
Loudspeaker		Impedance at 1000 Hz: 150 Ω	4304 078 70281
S/L		three-pole, two-position switch; push-button type (any switch which meets requirements can be used for this purpose)	

Principle of operation

See the circuit diagram.

Either unit is equipped with a three-pole two-position switch, one position being used for talking, the other for listening. When not manipulated this switch always retruns to the "listen" position under spring pressure. The first transistor, a type AC128 p-n-p element, is then connected as a detector, the second one, a type AC127 n-p-n transistor, serves as a power amplifier. The former is non-conductive as its base is connected via resistor R2 to the positive terminal of the bridge rectifier in the supply circuit. Except for a single very strong pulse no interfering signals can then reach the loudspeaker. An incoming modulated carrier is, on the other hand, detected by the base-emitter diode of TR1; the resulting base current makes TR1 conductive so that it can pass on the speech signal to TR2. With the switch in the "listen" position the total current drawn by the circuit is 10 mA at a supply voltage of 12 V. The input circuit for the modulate carrier comprises capacitors C10 and C11, resistor R3 and coupling coil L2, and circuit L1-C1 which is tuned to 80 kHz. Coils L1 and L2 can be shifted along the ferroxcube rod to give maximum sensitivity.



Dimensional sketch of ferroxcube rod (catalogue mumber 3122 104 91242).

Coils L1 and L2 can easily be wound by the experimenter himself. The coil formers may be of cardboard or any other suitable material; the minimum lengths should be 25 mm for L1 and 15 mm for L2. The inside diameter should be slightly over 10 mm, so that they fit nicely on the ferroxcube rod; the thickness of the former material is not critical. The wire is enamelled 0.4 mm copper wire. Numbers of turns are as follows:

L1 - 49 turns (a = 40 turns, b = 9 turns); L2 - 22 turns.

With the switch in the "speak" position the first transistor is connected as an oscillator and the second as a microphone amplifier (the loudspeaker is now used as a microphone). The two transistors are arranged in series so that any variation in the current through TR2 causes a corresponding variation in the amplitude of the carrier. This provides for modulation of the carrier by the microphone signal. The modulated carrier is then coupled into L2 and, through R3, C10-C11 and C12-C13, it is injected into the mains. Resistors R12 and R14 block the path for the carrier wave to the bridge rectifier. The total current with the switch in the "speak" position is about 8 mA at a voltage of 15 V.

The supply circuit, which is fully mains-powered, comprises:

- a voltage divider consisting of C12 - C13 - R12 - R13 - R14 and reducing the mains voltage to 15 V a.c. (under load conditions); capacitors C12 and C13 bring the voltage down without heat being evolved, that is, without losses;
- the type BY122 full-wave bridge rectifier and smoothing capacitors C8 and C9 which provide the necessary direct voltage.

Remarks on some components

The following remarks may be made about some of the components.

Aerial rod. The various units that are part of the system – there may be two or more – should all be equipped with the same aerial rod; preferably rods made of the material grade 4B1 should be taken.

Loudspeaker 4304 078 70281. Impedance 150 Ω, so a loudspeaker transformer is not needed. Coupling to microphone amplifier is effected through a relatively small capacitor (0.47 μF) which attenuates low frequencies thus improving clarity of speech signals; for same reason decoupling capacitor is also relatively small (10 μF).

C5 and C7. Prevent any 80 kHz signal from reaching the a.f. circuit.

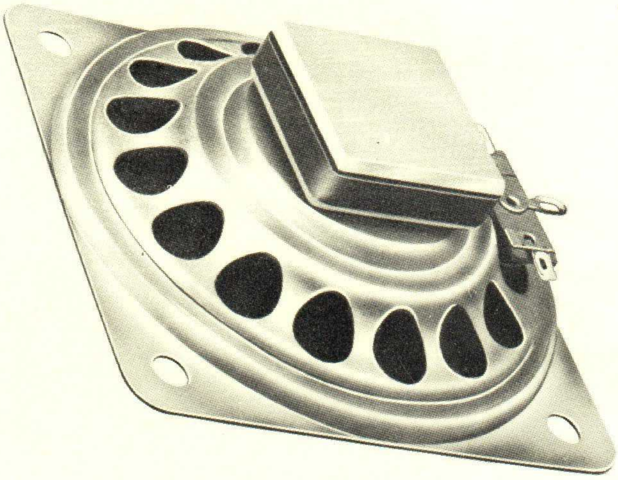
C14. Serves to suppress modulation hum.

R3. Damps the resonant circuit with L2 and the associated capacitances and thus prevents the oscillator from generating other frequencies.

R4 and R7. Provide required temperature stabilization.

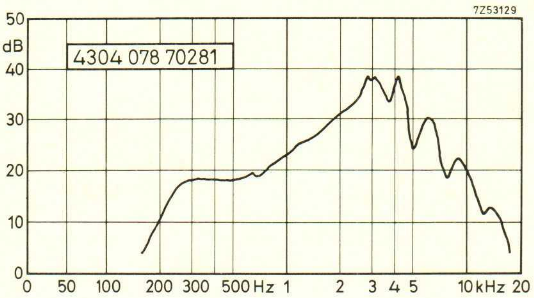
R11. Provides a path for the residual charge of capacitors C12 and C13 to leak away after the mains voltage has been removed.

MIDGET LOUDSPEAKER



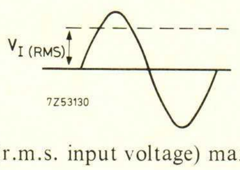
The 3″/1 W loudspeaker, catalogue number 4304 078 70281, used in the intercom system, has a cone diameter of about 3 inch (75 mm).

Both as loudspeaker and as microphone its performance at speech frequencies is very good, thanks to the special construction of the coil and the very small air gap. See the peak at 3000 Hz in the diagram below. Because of its high-ohmic coil (150 Ω) it can be connected direct (without loudspeaker transformer) into the collector lead of the base circuit of a transistor.

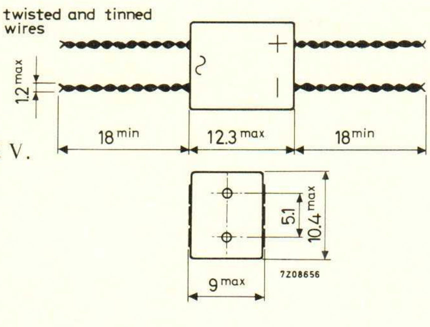


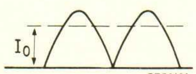
BRIDGE RECTIFIER ASSEMBLY BY122

The BY122 is a bridge rectifier assembly in a plastic encapsulation equipped with four silicon diodes. It is used for transistorized equipment drawing its power from the mains. The maximum a.c. input voltage is 42 V r.m.s. The maximum direct output current is 0.8 A, average value.

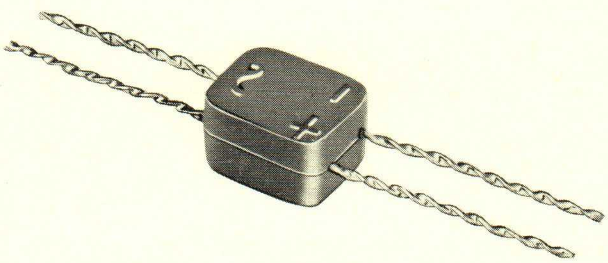


$V_{I\,(RMS)}$ (r.m.s. input voltage) max. 42 V.





I_0 (average output current) max. 0.8 A.



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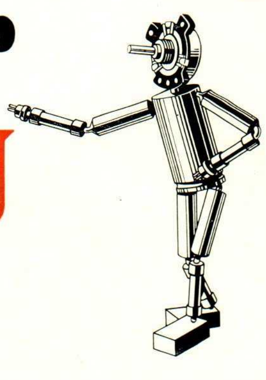


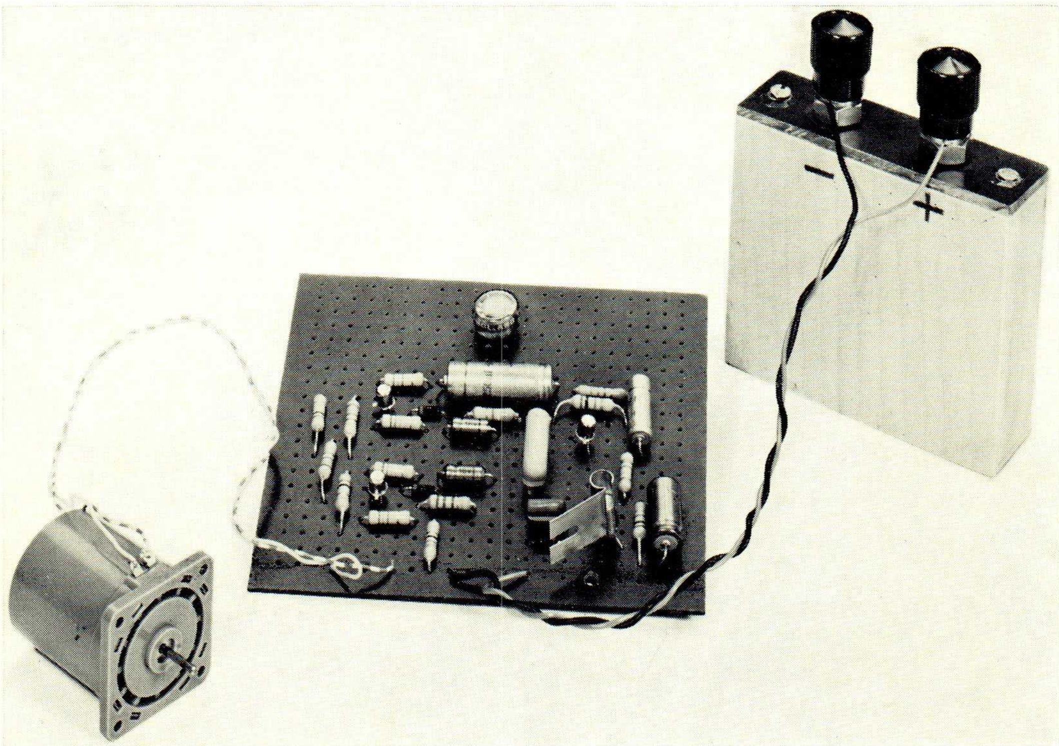
Dear Experimenter,
Have you ever tried using a beam of light as a means for starting a toy train or racing car, for switching on a lamp in a room, or the illumination of your shop windows? It's quite fun to show a customer who is *outside* your shop how he can "manipulate" the shop-window lights, or a scale model which you have *inside*. On the same lines you can also make a "light gun" for your son, or a device which ensures that a number of photographic flashlights ignite at the same moment.

The component which forms the heart of the control system in all these cases is the Philips L(ight) D(ependent) R(esistor). The accompanying universal circuit diagram will enable you to try out the interesting possibilities of the LDR. In some instances you will need one of our miniature electric motors, viz. the 9904 120 07401 (manufactured by Polymotor S.A.). We are convinced that you will be surprised to find so many applications for the LDR (and/or the motor). The method is simple and . . . you do not need licences or permits of any kind!

Now you may have noticed for yourself that despite the good points mentioned above the method of remote control by means of light flashes is not being used on a large scale. To explain this we must draw your attention to a few disadvantages. First, the object to be controlled must be "visible" by the source of the light pulses, in most cases a sharp, thin beam of light must be employed which makes it even more difficult to meet this requirement. Second, the intensity of the light sent out by our light source must be above that of the environment.

We wish you much pleasure in experimenting and, don't forget:

OPTIMUM RESULTS WITH PHILIPS COMPONENTS ONLY



REMOTE CONTROL BY LIGHT

Two circuits will be dealt with below:

a) a basic circuit; a light flash is used to make a small lamp come on;

b) a more complicated circuit which, when actuated by a light flash, operates a lamp, a motor or a relay.

Possible uses

The main applications of the remote control systems are found in the world of toys; to give some examples:

— in a mock rifle range, the rifle being a "light gun" producing a pencil beam of light concentrated by means of a lens; the beam can be very accurately directed at the "target" which carries an LDR;

— for starting and stopping an electric motor built into a toy train or car; the light produced by any electric torch is suitable for this purpose since pencil-beaming is not necessary; on the other hand, only the circuit mentioned under b) is applicable.

Some applications in the adult's world are:

— opening a garage door which involves including an additional relay in circuit b); the relay should be capable of switching on an electric motor big enough to operate the door mechanism, and the LDR should be positioned in such a way that only the light from the car's headlamps can reach it;

— igniting a battery of photographic flashlights at the same moment; one flashlight is ignited in the usual way by the camera contact and when its light falls on the LDR the remaining flashlights are all ignited via a separate circuit; this method does away with the necessity to connect each separate flashlight to the camera contact, and prevents the camera contact from being damaged by the heavier current.

We hope that you will be able to think of other useful applications. Please, do not hesitate to write us if you should like to consult — or tell — us about your ideas.

Parts list

				Catalogue number
(Fig. 1)	LDR	Light Dependent Resistor		2322 600 95001
	R1	Linear potentiometer (470 Ω)		2322 411 02203
	TR1	Transistor		AC126
	L	Lamp (6 V/50 mA)		7121D
(Fig. 2)	LDR	Light Dependent Resistor		2322 600 95001
	R1	Carbon resistor (¼ W)	82 Ω	2322 101 33829
	R2	Carbon resistor (¼ W)	2.2 kΩ	2322 101 33222
	R3	Carbon resistor (¼ W)	39 kΩ	2322 101 33393
	R4	Carbon resistor (¼ W)	10 kΩ	2322 101 33103
	R5	Carbon resistor (¼ W)	3.9 kΩ	2322 101 33392
	R6	Carbon resistor (¼ W)	1 kΩ	2322 101 33102
	R7	Carbon resistor (¼ W)	12 kΩ	2322 101 33123
	R8	Carbon resistor (¼ W)	680 kΩ	2322 101 33681
	R9	Carbon resistor (¼ W)	6.8 kΩ	2322 101 33682
	R10	Carbon resistor (¼ W)	10 kΩ	2322 101 33103
	R11	Carbon resistor (¼ W)	10 kΩ	2322 101 33103
	R12	Carbon resistor (¼ W)	150 Ω	2322 101 33151
	R13	Carbon resistor (¼ W)	12 kΩ	2322 101 33123
	R14	Carbon resistor (¼ W)	6.8 kΩ	2322 101 33682
	R15	Carbon resistor (¼ W)	680 Ω	2322 101 33681
	C1	Electrolytic capacitor	200 μF/10 V	2222 001 14201
	C2	Electrolytic capacitor	64 μF/10 V	2222 001 14649
	C3	Electrolytic capacitor	10 μF/10 V	2222 001 14169
	C4	Electrolytic capacitor	10 μF/10 V	2222 001 14169
	C5	Polyester capacitor	470 nF	2222 344 21474
	C6	Electrolytic capacitor	200 μF/6.4 V	2222 001 13201
	C7	Polyester capacitor	100 nF	2222 344 21104
	D1, D2, D3	Diodes		OA202
	TR1, TR2, TR3	Silicon p-n-p transistors		BC178
	TR4	Germanium p-n-p transistor		AC128
	M	D.C. motor (4.5 V/0.1 to 0.3 A)		Polymotor S.A.
(Fig. 3)	R1	Carbon resistor (¼ W, 10 Ω)		2322 101 33109
	C1	Electrolytic capacitor (2 mF/10 V)		2222 060 14202
	L	Lamp (2.7 V/0.15 A)		PR9 (Philips)

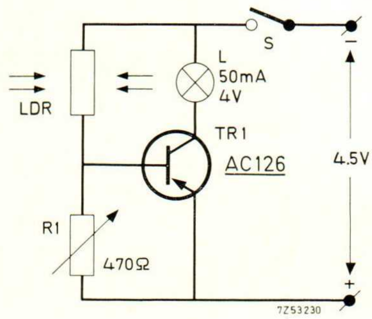
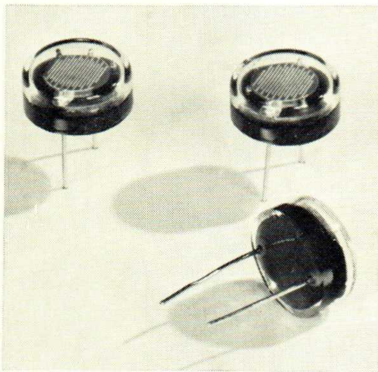


Fig. 1.



Philips LDRs (2322 600 95001).

Circuit description

Fig. 1 shows the simple circuit. When light falls on the LDR its resistance drops so that a negative-going pulse is applied to the base of transistor TR1. The resulting increase in the collector current makes lamp L light up. Make sure that L is positioned so that its light can reach the LDR. The resistance of the latter will then remain low enough for the lamp to be kept burning. To make it go out you will have to open switch S for a short moment.

The sensitivity of this circuit is governed by the transistor setting and the ambient light. R1 can be adjusted for maximum sensitivity.

The operation of the circuit given in Fig. 2 is completely different: it reacts only to short light flashes. For this reason it is less sensitive to the level of the ambient light. Light flashes reaching the LDR result in a negative-going voltage pulse at the TR1 base, and consequently a positive-going voltage pulse at the TR1 collector. Only the positive-going pulse can reach the bases of TR2 and TR3, due to the presence of diodes D1 and D2. TR2 and TR3 together form a bistable multivibrator, that is: one of them is conductive and the other non-conductive, or vice versa. A positive pulse on its base will make the conductive transistor non-conductive; consequently the collector voltage will increase rapidly and the resulting negative voltage pulse in the collector circuit will drive the other transistor into cut-off. Any subsequent light flash will in a similar way cause the multivibrator to change over.

TR3 is followed by a switching transistor TR4. As long as TR3 is conductive the base of TR4 will be so strongly negative that TR4 is wide open, connecting motor M with + 4.5 V. Remember that TR4 can carry a current not exceeding 0.1 A when not mounted on a heat sink; with heat sink the current limit is 0.3 A. If the motor current exceeds these values you will have to use a relay with preferably a coil resistance of about 50 Ω.

Capacitor C7 and diode D3 prevent interference

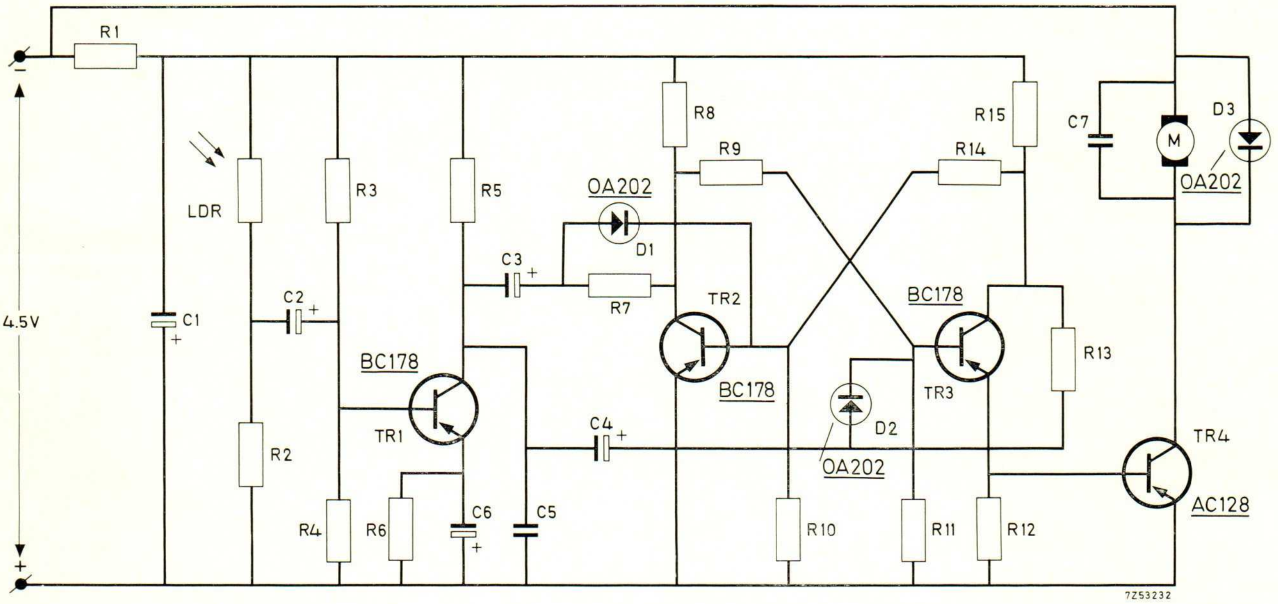


Fig. 2.

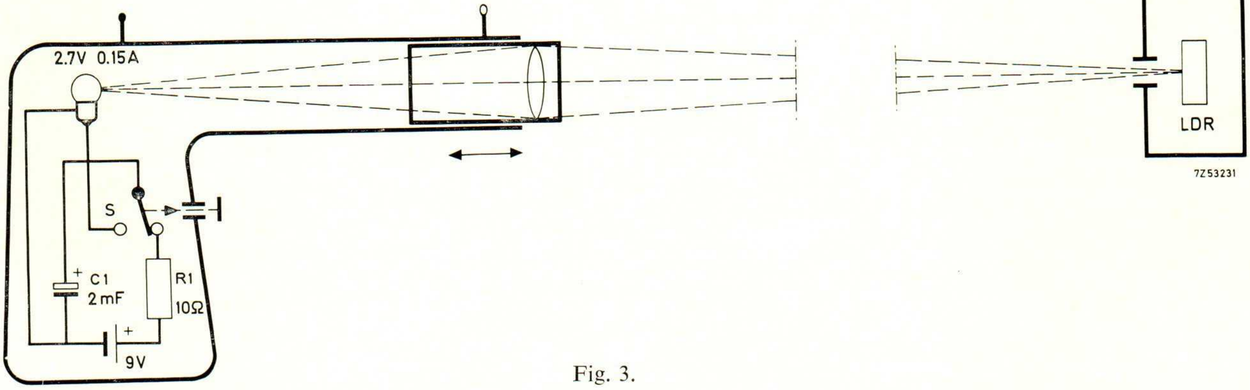


Fig. 3.

signals produced by the motor from reaching the sensitive part of the circuit, thereby having unwanted effects.

The "light gun"

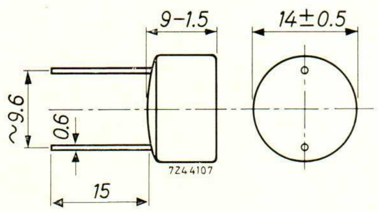
Fig. 3 is a schematic representation of a "light gun" with the trigger, S, not pulled. Electrolytic capacitor C1 is then charged via resistor R1 by the 9 volt battery. When the trigger is pulled it closes the circuit for the capacitor to discharge through the lamp. This then lights up for an instant, at an overvoltage; this method of operation does reduce the lifetime of the lamp considerably but even so a large number of "shots" can be "fired" before a new lamp is needed.

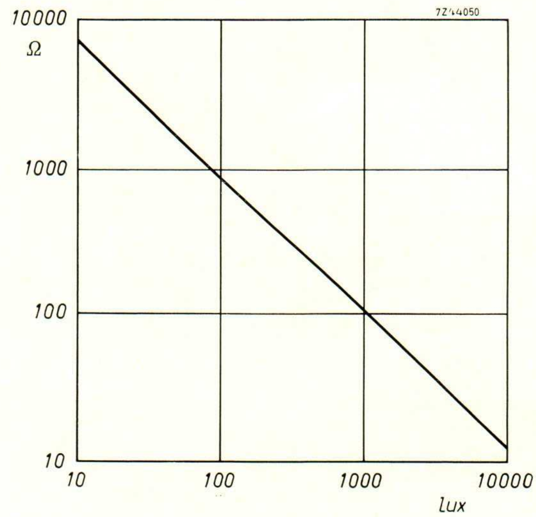
Although any incandescent lamp of about 3 V and 0.15 A may be employed the Philips PR9 is recommended since its base is provided with a centring flange. When this lamp is inserted in the holder the filament will always be in the position for maximum beaming.

The lens holder should preferably be adjustable. It is essential that the beam is accurately focussed on the "target" with the LDR, irrespective of the distance between gun and target. We recommend the use of a biconvex lens with a diameter of about 2.5 cm and a focal distance between 5 and 10 cm. To check the focal distance, hold the lens between a sheet of paper and a strong light source (the sun, or a lamp at a considerable distance) and shift it until the light spot on the paper has its smallest size. Measure the distance between lens and paper which is the focal distance.

LIGHT DEPENDENT RESISTORS

L(ight) D(ependent) R(esistor)s are made of cadmium sulphide, a material which, when prepared properly, contains no or very few free electrons when kept in complete darkness. Its resistance is then quite high. When it absorbs light, electrons are liberated and thus the material becomes more conducting. Cadmium sulphide is therefore called a photoconductor. The electrons are free for a limited time only, and when the light is switched off, they are captured by the "holes". Thus the conductor again becomes an insulator. The resistance-to-luminous flux graph of the LDR is given here. The resistance in total darkness is minimum 10 MΩ.
The resistance measured at 1000 lux is 75 to 300 Ω.



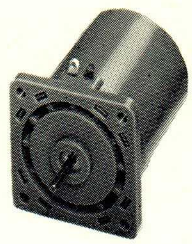


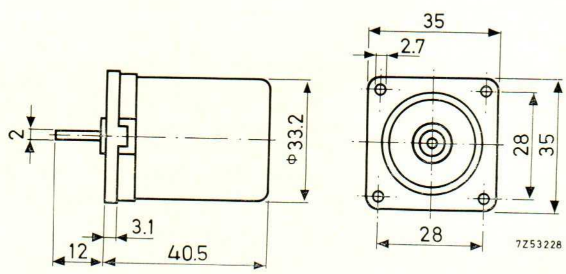
SMALL D.C. MOTORS
MANUFACTURER: S.A. POLYMOTOR

Series 9904 120 07 . . .

This small d.c. motor has a plastic moulded housing. The special flat commutator guarantees a long life. The motor can be delivered with and without a built-in spark suppression system. The standard motor is a 6 V version, but versions for other voltages (and speeds) can also be supplied. The efficiency is extremely high for such a small motor: 55 %. The motor can be used in industrial devices, small household appliances, all kinds of motor driven toys, etc. Below we give some characteristics.

Voltage	6 V
Current at nominal load	390 mA
Current at no load	95 mA
Number of revolutions/min. at no load	4800
Number of revolutions/min. at nominal load	4000





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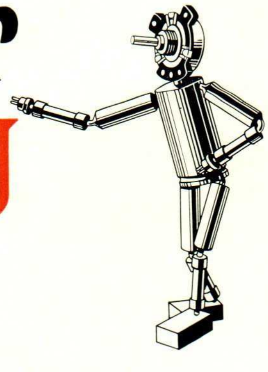


AN ELECTRONIC EXPOSURE METER

Dear Experimenter,

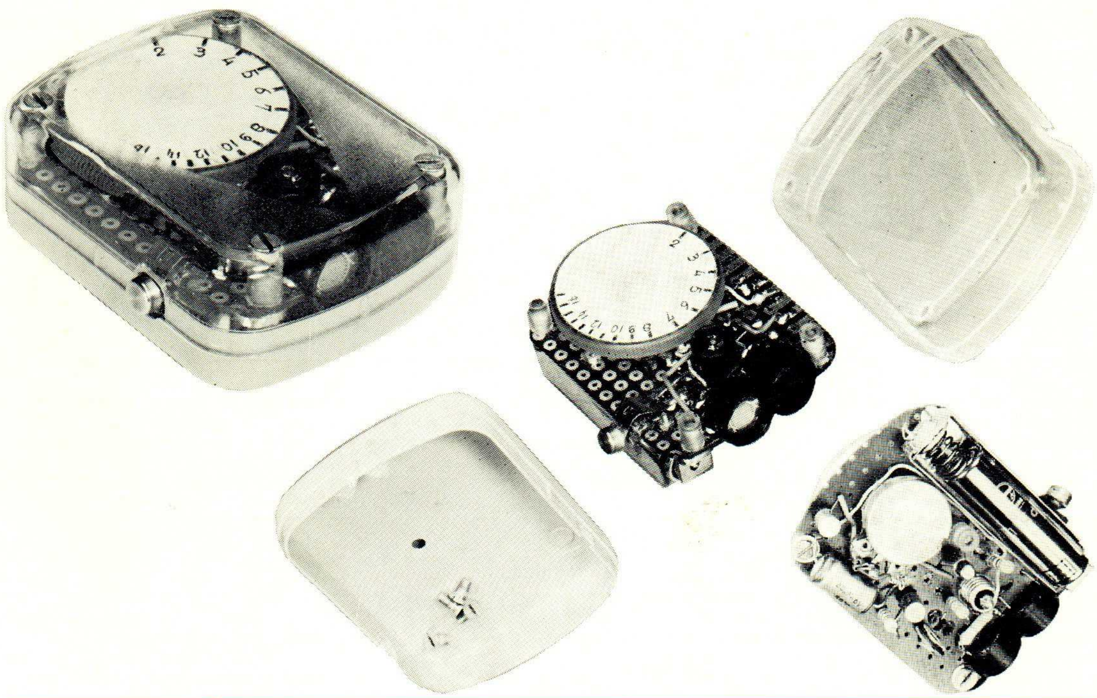
Are you an amateur photographer? If so, you are probably the proud owner of many photographs of your favourite subjects: members of your family, or friends and relatives, during holidays or on festive occasions; the moon and stars; birds and insects, etc. These you have taken not so much to win prizes as to possess a record of memorable persons, things or events.

Have you often felt the need for a good exposure meter, when the light was tricky, or when you were not sure that the sensitivity margin of your film was wide enough? And have you noticed that the commercially available exposure meters are rather expensive if you want them convenient to read over a wide range, as well as sensitive, small, light and reliable? Or, if they are conveniently priced (for instance, the types with a selenium cell and a d.c. meter), that they are not sensitive enough and yet easily damaged?

The electronic exposure meter which you will find described here goes a long way towards fulfilling your wishes. It is battery-operated, so you will have to replace the battery now and then, because otherwise the readings may become unreliable. But even so, it's not the meter that is to blame but the battery which drains itself while not in use. The instrument provides clear readings for light values between 2 and 17 (the less expensive commercial exposure meters cannot be read properly at light values below 5). Its heart? A couple of LDRs.

Now, just to make sure that we all mean the same thing by "light value", some theoretical considerations on the subject are included on page 3.

You may skip this part if you are "in the picture".



CIRCUIT DIAGRAM
OF THE ELECTRONIC EXPOSURE METER

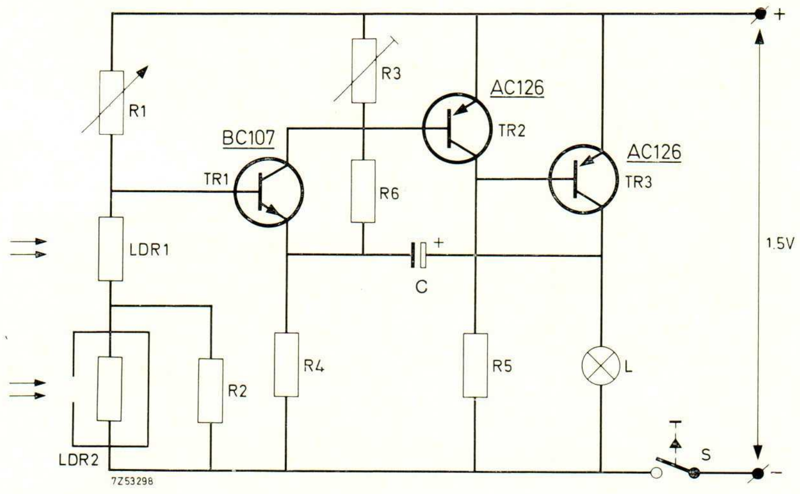


Fig. 1.

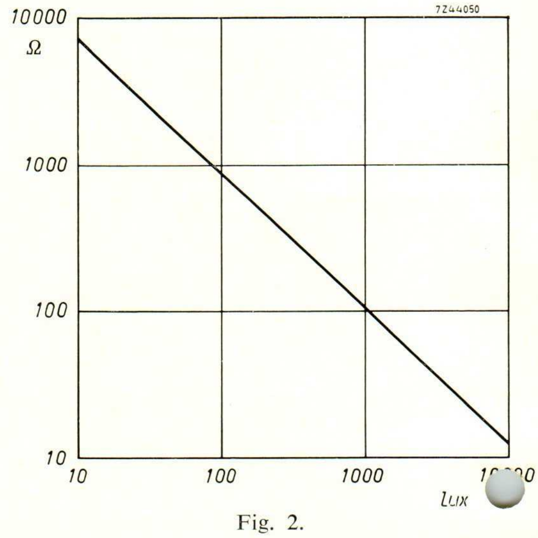
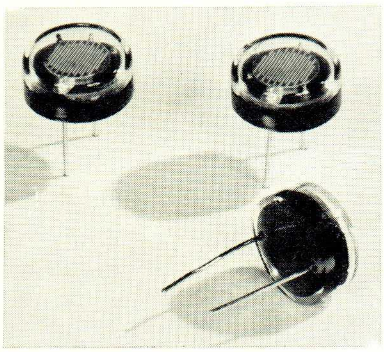


Fig. 2.

Parts list

	Catalogue number
LDR1, LDR2	2322 600 95001
R1 (carbon potentiometer, 1 M Ω, log)	2322 350 70634
R2 (carbon resistor, 100 kΩ, ¼ W)	2322 101 33104
R3 (potentiometer with screwdriver adjustment, 1 kΩ)	2322 410 05004
R4 (carbon resistor, 100 Ω, ¼ W)	2322 101 33101
R5 (carbon resistor, 150 Ω, ¼ W)	2322 101 33151
R6 (carbon resistor, 330 Ω, ¼ W)	2322 101 33331
C (electrolytic capacitor, 64 μF/10 V)	2222 001 14649
L (Philips lamp, 1.2 V/0.22 A)	type 112
TR1 (transistor)	BC107
TR2 (transistor)	AC126
TR3 (transistor)	AC126
S (pushbutton switch)	any type



Philips LDRs (2322 600 95001).

Table 1 - Exposure in seconds (21/10 DIN films)

Light value →	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Lens stop ↓	Exposure in seconds															
2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000			
2.8	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000		
4	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000	
5.6	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000	1/4000
8	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000	1/2000
11	30	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500	1/1000
16		30	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250	1/500
22			30	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125	1/250
32				30	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60	1/125
45					30	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30	1/60
64						30	15	8	4	2	1	1/2	1/4	1/8	1/15	1/30
90							30	15	8	4	2	1	1/2	1/4	1/8	1/15

Principle of Operation

See the circuit diagram (Fig. 1). LDR1 and LDR2 are the instrument's "eyes". Their resistance increases as the amount of light reaching them decreases, and vice versa; see the resistance/illumination characteristic of Fig. 2. This linear relationship is maintained at the extremes of the range; this is why LDRs are suitable for measuring illumination intensities under many different conditions, ranging from broad daylight to relative darkness. For our purpose we take the LDR type 2322 600 95001, which is not expensive. Together with R1 the LDRs form a voltage divider connected across the input of a d.c. amplifier with transistors TR1, TR2 and TR3.

It will be clear that the input voltage of the amplifier depends on the ratio between the resistance of potentiometer R1 on the one hand, and the total resistance of the two LDRs on the other. Suppose that this voltage is high enough to make TR1 conductive; the collector current of TR1 then makes TR2 also conductive; the collector voltage of TR2 falls off and with it the base voltage of TR3; TR3 is thus driven into the off-state. Under these circumstances lamp L cannot burn when pushbutton S is pressed. Now suppose that the total resistance of the LDRs decreases (more light reaches them). The input voltage on the base of TR1 falls off which results in this transistor becoming non-conductive; TR2 becomes non-conductive, TR3 conductive. Lamp L can now light up when S is closed.

It is, of course, possible to adjust R1 in such a way that for any value of the total resistance of the two LDRs, TR1 is just driven into conduction (lamp L is just on). The position of the knob on R1 will then be a measure of the illumination of the two LDRs.

With the circuit under description accurate adjustment of R1 is made possible by positive feedback from the amplifier output, through capacitor C, to the input (emitter of TR1). Due to the high gain occurring when TR1 just becomes conductive oscillations are set up; the frequency, determined mainly by C and R4, is kept at a few cycles per second.

The battery is a 1.5 V penlight battery. It should be noted that small variations in the battery voltage, as well as the effects of aging* of the LDRs, give rise to changes in the readings of the instrument. R3 has been provided to re-calibrate the instrument when such changes occur. Lamp L is a miniature type with lens. The series connection of two LDRs, one of which is shunted by a resistor, deserves some explanation. As we have seen, one LDR can have a resistance ranging from some hundreds of thousands of ohms at relative darkness to a few ohms in broad daylight. When we want to cover the full range of light values with a simple potentiometer control we have to fix the lower resistance limit at about 500 ohms and the upper limit at, say, 1000 kiloohms. In our design we achieve this by covering LDR2 by a metal cap with a hole of about 1 mm drilled in the centre. Even under a very bright light, when the resistance of the uncovered LDR1 is practically negligible, LDR2 will have a minimum value of about 500 ohms. If, on the other hand, the intensity of illumination is very low, then the resistance of LDR2 alone will be maximum but that of the combination LDR2 plus its shunt resistor R2 will be below 100 kiloohms. In other words: at high light intensities LDR1 does the job of measuring the light, whereas at low light intensities this task is taken over by LDR2. Using this arrangement with the logarithmic potentiometer R1 we get one practically linear scale of light values from 2 to 17 and avoid having subranges.

Light Values

The scale of our exposure meter is marked off in light values. These enable us to determine the lens stop and the shutter speed for 21/10 DIN (100 ASA) standard films under different lighting conditions. The relationship between light value, lens stop and shutter speed is expressed by the formula:

light value $L = {}^2\log (f/d)^2/t$

where f/d = lens stop;

t = exposure in seconds.

It can be seen that a lens stop 2 and an exposure of 1 second gives a light value two. Lowering the lens stop to 2.8 ($2.8^2 \approx 8 = 2^3$) and the exposure to 1/32th of a second ($32 = 2^5$), we get a light value of $3+5=8$.

To explain this in words we may say that the light

Table 2 - Exposure-conversion factors

ASA	DIN	Factor
12	12/10	8 x
25	15/10	4 x
50	18/10	2 x
100	21/10	1 x
200	24/10	1/2 x
400	27/10	1/4 x
800	30/10	1/8 x
1600	33/10	1/16 x
3200	36/10	1/32 x

* A light-sensitive device with negligible aging effects will become available in the near future. This type RPY33 is smaller than the LDR mentioned here, but a bit more expensive.

reaching the lens from an object having the light value 8 must be weakened by the camera by a factor of 2^8 to get a proper negative with the 21/10 DIN standard film.

Table 1 gives the exposure times for various lens stops and light values. Table 2 shows the conversion factors with which the exposure found in Table 1 has to be multiplied when using films of a different sensitivity than 21/10 DIN.

Building the Instrument

- Use a plate made of insulating material ("Pertinax" or the like) to mount the components on; the size is about 5 x 7.5 cm, the exact dimensions depending on the plastic container.
- Place a thumbwheel to which the light-value scale (divisions 2-17) can be attached on the shaft of potentiometer R1; a diameter of about 5 cm is very convenient.
- Make sure that switch S has silver contacts because otherwise contact resistances may occur which make the readings less accurate.
- Put small black cylinders around the lamp and the LDRs, thus preventing light other than that coming from the direction of the object from reaching the LDRs. The best results are obtained with cylinders as sketched in Fig. 3. Make sure that the rear of the LDRs is painted black.
- Make sure to mount R3 in such a position that

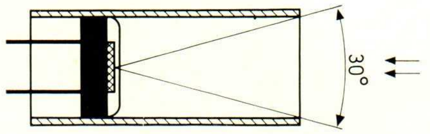


Fig. 3.

you can easily adjust it with a screwdriver without opening the plastic container.

Calibrating the Instrument

Direct the instrument at various objects that are under different conditions of lighting. Adjust the thumbwheel carefully until the lamp lights intermittently. Direct a good commercially available exposure meter at the same object and note the light value. Put this light value against a mark on the scale of the thumbwheel; make sure that both the mark and the light value coincide with an arrow drawn on the housing. Repeat this procedure to get other light values. In this way mark the divisions 2 to 17 on the scale.

Some Notes on Using the Instrument

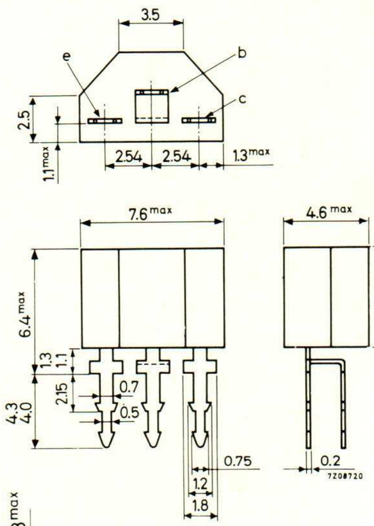
When taking photographs with artificial light, use the exposure meter at a distance of about 30 cm from the object. Decide first which part of the object is most important and direct the meter at that part; you will find that it is rather direction-sensitive. Apart from knowing and applying the general rules as to exposure (colour film: slight under-exposure to be preferred to over-exposure; black-and-white photos: slight over-exposure to be preferred), you must be prepared to practice "translating" the light value indicated by the instrument into shutter speed and diaphragm.

BC107 (BC147)

The BC107 is eminently suited for use in the first stage of the amplifier in our electronic exposure meter because of its low leakage current. We have seen that at low light values the resistance of the input circuit for this transistor (TR1) is between 0.1 and 1 megohm. An appreciable leakage current would make the instrument readings rather inaccurate.

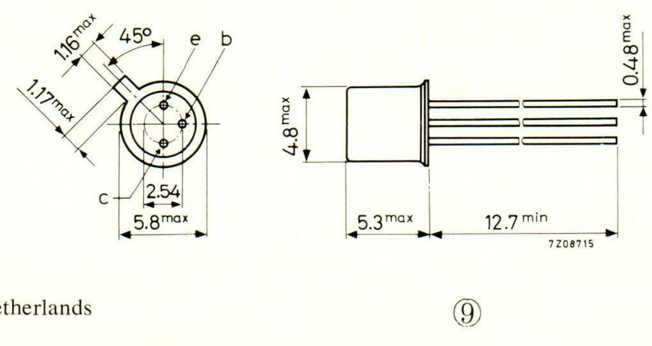
The BC107 is an n.p.n. silicon transistor with a high gain. It is often used in circuits where weak low-frequency signals have to be amplified (microphone and pick-up amplifiers) and for amplifying small direct voltages. Its temperature range is so wide that you will encounter no difficulties at all when employing it in the electronic exposure meter.

The BC107 has a metal encapsulation. It is also available in a plastic encapsulation. The plastic version has the type number BC147. Dimensional sketches of both types are depicted here.



BC147

BC107



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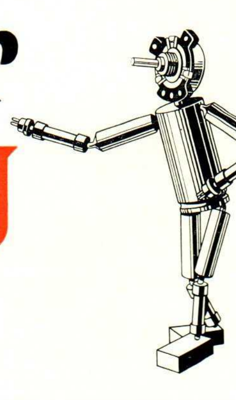


"MAGNETIC" REMOTE CONTROL SYSTEM

Dear Experimenter,

You have perhaps seen some fellow-hobbyist demonstrating how simple it is to control something from a remote position. When distances from some hundreds of metres to some kilometres have to be bridged the hobby becomes an expensive one since a transmitter and a receiver are needed suitable for operation in the so-called "citizen's band". This is the 27 MHz band which is reserved for radio control. It may also be considered a disadvantage that the transmitter should be approved by the postal authorities.

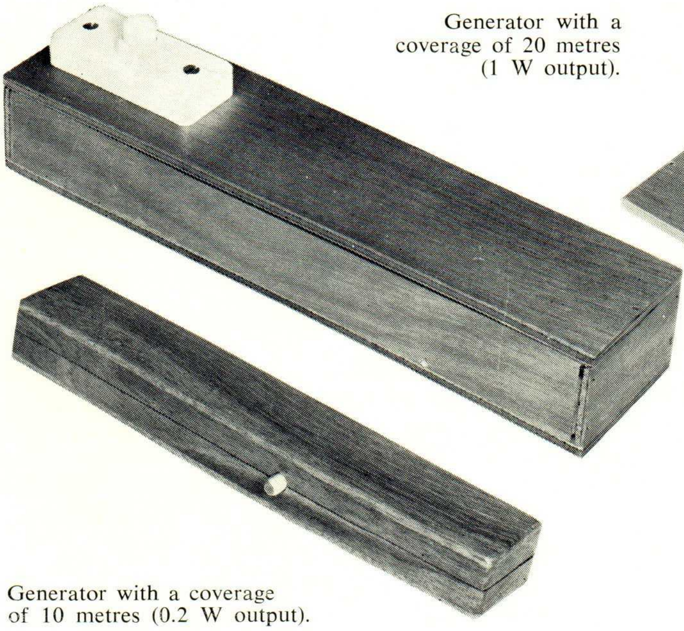
Some applications involve only very short distances to be covered, about 10 to 20 metres. It is for this category that we describe two simple circuits in this issue. You will "operate" on a frequency as low as 10 kHz with units anyone can afford; don't bother about an operator's licence. You may refresh your knowledge of electricity and magnetism while building the *generator* and *receptor*. And you will marvel at the penetrating power of the tiny amounts of energy produced at the pressing of a button. True enough, the magnetic field does not spread easily as radio waves do; instead, the fieldstrength varies inversely with the cube of the distance from the generator. That is why the coverage is so limited.

Typical applications are:

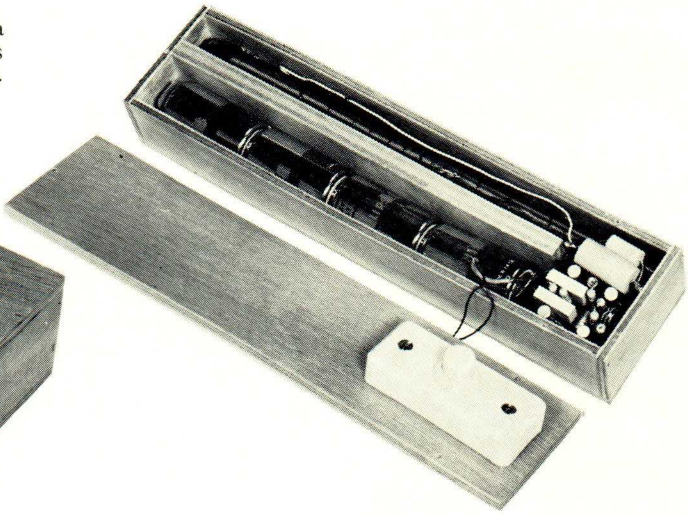
— Sending out distress signals.
  Aged or invalid people, or those who live alone, can carry the generator with them and use it to call the neighbours for help when this is needed.
— Remotely controlling various household appliances or gadgets, for instance, switching a radio or TV set on and off; operating an electric bell between two rooms; opening and closing doors (here the hobbyist will think of garage doors); changing the slides in a projector, etc.
— Performing magic tricks.
— Communicating under water (divers).

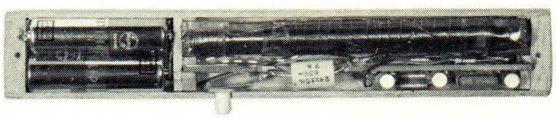
As always we leave it to your own imagination to think of other applications, some of which may be quite outside our "field of vision" — so why not tell us about them?

Generator with a coverage of 20 metres (1 W output).



Generator with a coverage of 10 metres (0.2 W output).





CIRCUIT DIAGRAM OF THE 1 W GENERATOR

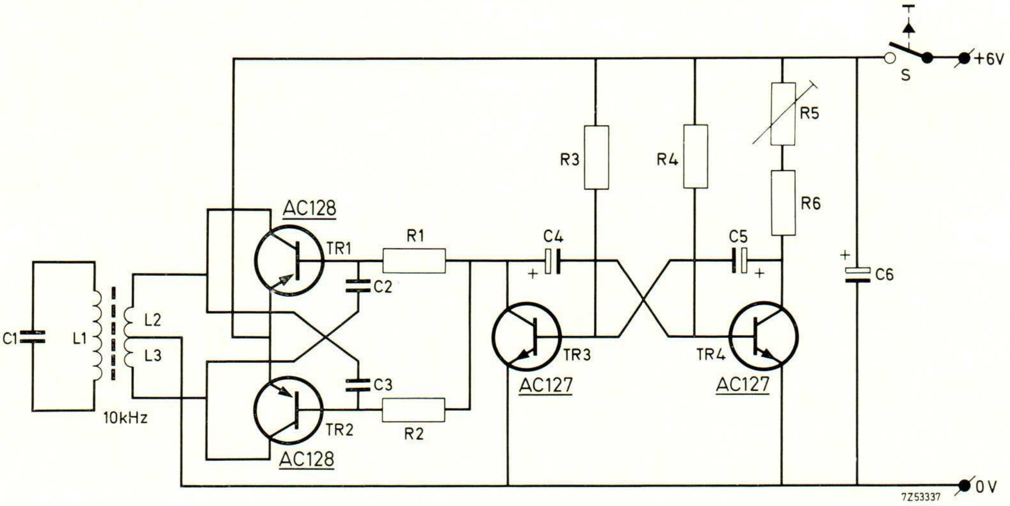


Fig. 1a.

CIRCUIT DIAGRAM OF THE 0.2 W GENERATOR

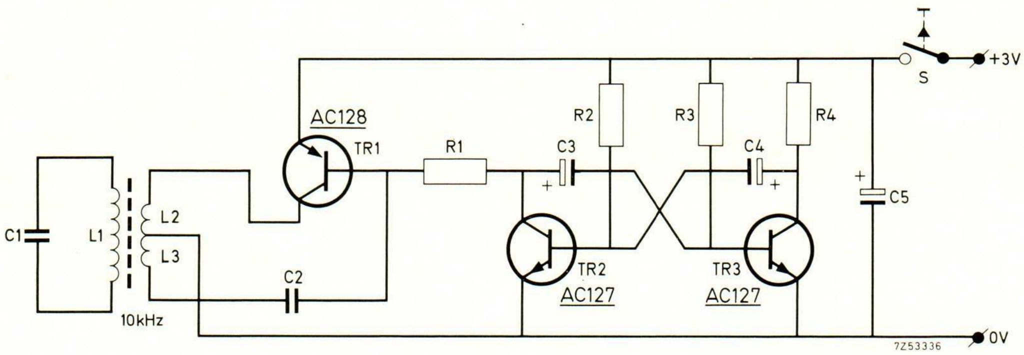


Fig. 1b.

Parts List for 1 W Generator

		Catalogue number
Ferroxcube rod 10 mm ø x 240 mm (grade 4A3)		3122 104 43442
L1 = 480 turns of 0.4 mm enamelled copper wire (1 winding)		
L2 = 8 turns of 0.8 mm enamelled copper wire		
L3 = 8 turns of 0.8 mm enamelled copper wire		
TR1, TR2 (p.n.p. transistor)		AC128
TR3, TR4 (n.p.n. transistor)		AC127
C1 (Polystyrene capacitor	15 nF/500 V)	2222 438 11503
C2 (Polyester capacitor	0.1 μF/250 V)	2222 342 45104
C3 (Polyester capacitor	0.1 μF/250 V)	2222 342 45104
C4 (Electrolytic capacitor	4 μF/ 40 V)	2222 001 17408
C5 (Electrolytic capacitor	4 μF/ 40 V)	2222 001 17408
C6 (Electrolytic capacitor	200 μF/ 10 V)	2222 001 14201
R1 (Carbon resistor	470 Ω/¼ W)	2322 101 43471
R2 (Carbon resistor	470 Ω/¼ W)	2322 101 43471
R3 (Carbon resistor	10 kΩ/¼ W)	2322 101 43103
R4 (Carbon resistor	10 kΩ/¼ W)	2322 101 43103
R5 (Miniature potentiometer with screwdriver adjustment	1 kΩ)	2322 410 05004
R6 (Carbon resistor	390 Ω/¼ W)	2322 101 43391
S (Pushbutton switch)		any type

Parts List for 0.2 W Generator

		Catalogue number
Ferroxcube rod 10 mm ø x 130 mm (grade 4A3)		4311 020 52782
L1 = 480 turns of 0.4 mm enamelled copper wire (2 windings)		
L2 = 8 turns of 0.4 mm enamelled copper wire		
L3 = 8 turns of 0.4 mm enamelled copper wire		
TR1 (p.n.p. transistor)		AC128
TR2, TR3 (n.p.n. transistor)		AC127
C1 (Polystyrene capacitor	24 nF/ 63 V)	2222 435 12403
C2 (Polyester capacitor	0.1 μF/250 V)	2222 342 45104
C3 (Electrolytic capacitor	4 μF/ 40 V)	2222 001 17408
C4 (Electrolytic capacitor	4 μF/ 40 V)	2222 001 17408
C5 (Electrolytic capacitor	200 μF/ 10 V)	2222 001 14201
R1 (Carbon resistor	1 kΩ/¼ W)	2322 101 43102
R2 (Carbon resistor	5.6 kΩ/¼ W)	2322 101 43562
R3 (Carbon resistor	5.6 kΩ/¼ W)	2322 101 43562
R4 (Carbon resistor	1 kΩ/¼ W)	2322 101 43102
S (Pushbutton switch)		any type

Generator with a Coverage of 20 metres

Fig. 1a gives the circuit diagram of the generator with the greater coverage of the two that we are dealing with. Its output is about 1 W, the operating frequency 10 kHz. The "wavelength" of the magnetic waves is so long (30 000 m) that thick walls, even of re-inforced concrete, form no obstacles.

The two push-pull connected transistors TR1 and TR2 constitute, together with the ferroxcube rod, a generator of 10 kHz oscillations. The input power supplied by the batteries is about 2 W (0.35 A at 6 V) for continuous operation. However, the oscillator in this case is pulsed for three reasons:

— to halve the average drain on the batteries;
— to minimize the heating up of the transistors;
— to prevent the receiver from responding to interfering signals with a frequency around 10 kHz (as may be produced by electric motors or the line time base of TV sets).

The pulses are produced by an a-stable multivibrator at a pulse-repetition frequency of 20 Hz, and they are fed to the bases of TR1 and TR2 via resistors R1 and R2. The output signal of the unit is represented in Fig. 2. Potentiometer R5 serves for varying the pulse width.

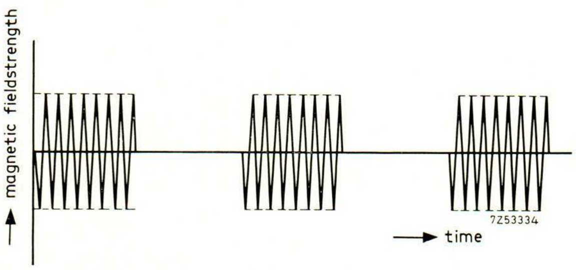


Fig. 2 - Representation of the pulsed, changing magnetic field produced by the generators.

Building the Generator

It will be clear that the magnetic field built up around the ferroxcube rod (see Fig. 3) must be as strong as possible. For this reason the longest available rod should be employed, and the diameter should be about one-tenth of this length. The suitable ferroxcube rods available in our line are 24 cm long and have a diameter of 10 mm. So we take two of these alongside each other (see Fig. 4), apply a coil former of insulating material and proceed to wind coil L1 around them (480 turns of 0.4 mm diameter enamelled copper wire, occupying about nine-tenths of the length of the rods). Next apply a layer of insulating material, and

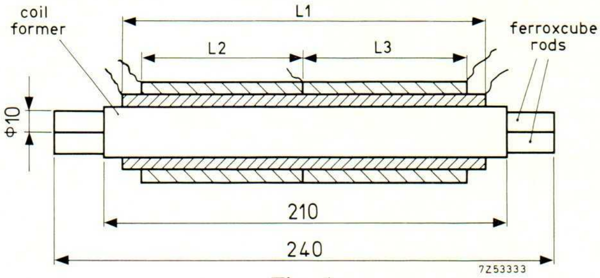
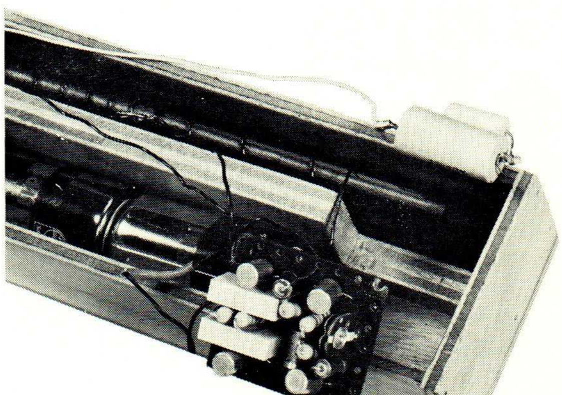


Fig. 4.

then wind coils L2/L3: 16 turns of 0.8 mm enamelled copper wire (so widely spaced that about the same length of rod is covered as with L1), with a centre tap. The ends of the 16 turns are to be connected with transistors TR1 and TR2, the centre tap to minus battery. Across L1 connect a 15 nF/500 V polystyrene capacitor with a low loss factor thus obtaining a circuit with a resonant frequency of 10 kHz. The ferroxcube rods give this circuit a very high Q so that it can produce voltages of some hundreds of volts, a strong current through the coils, and hence a strong magnetic field.

Next mount the discrete components on a small



piece of a p.w. board, connect the coils, the four 1.5 V batteries (see Fig. 5), and insert the various parts into the box made for the purpose. Press the pushbutton: the pulsed 10 kHz signal should be faintly audible. This is caused by vibration of the ferroxcube rods.

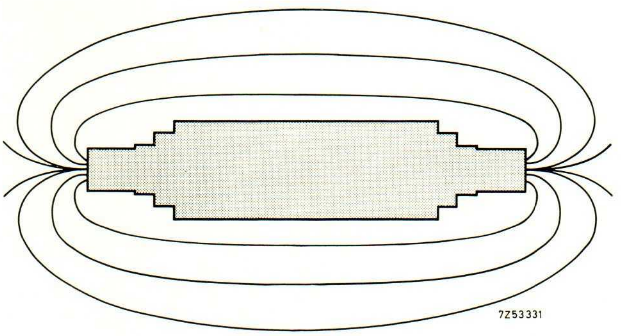


Fig. 3 - Representation of the magnetic field around the ferroxcube rod.

Generator with a Coverage of 10 metres

This is meant to be built into a box small enough to

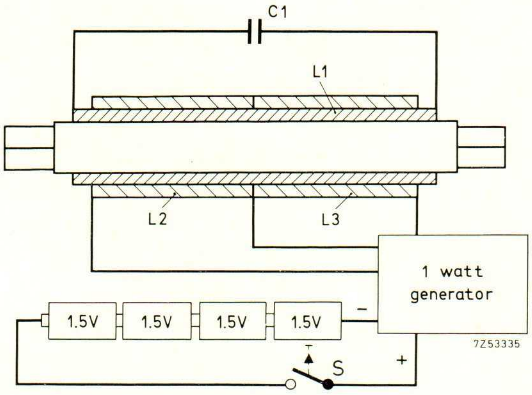


Fig. 5.

be carried conveniently. The coverage is proportionally smaller but the maximum distance of 10 metres will be sufficient for many purposes.

Fig. 1b shows the circuit diagram; we see a single transistor forming the oscillator which is again pulsed by an a-stable multivibrator. The ferroxcube rod in this case is 13 cm long and has a diameter of 10 mm. L1 is a coil with two windings each of 240 turns of 0.4 mm enamelled copper wire; L2/L3 for which the same wire is used, consists of 8 turns each, widely spaced, again with a centre tap. See Fig. 6. Two 1.5 V

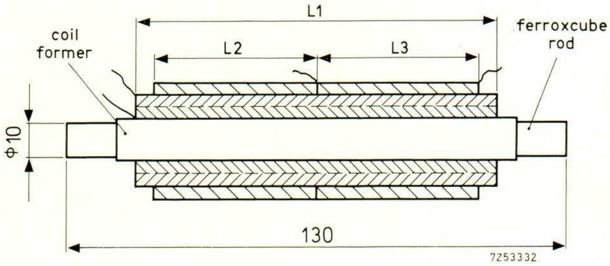
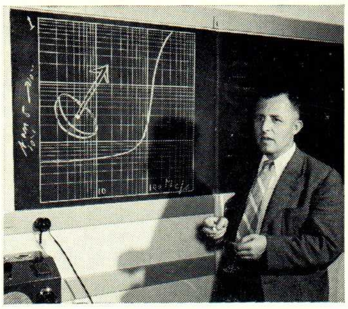


Fig. 6.

penlight batteries are employed to give the supply voltage of 3 V. The lay-out of the various parts of the circuit is similar to that described for the 1 W generator.

FERROXCUBE



J. L. Snoek (1902-1950).

The discovery of the magnetic properties of ferrites was among the most important made this century, and *ferroxcube* is still ranking high among ferrites (= mixtures of iron oxide with other metal oxides). It is a soft magnetic material with a very high resistivity, a property enabling it to follow rapid changes in a magnetic field in which it is placed, without appreciable losses.

As long ago as 1909 a research worker of the name of HILBERT managed to prepare *magnetic* iron oxide and ferrites. They showed a low conductivity for electric currents (the reason why they are called non-metallic materials) but their magnetic properties were not very pronounced, and the magnetic permeability in particular needed improving. In 1933 SNOEK, of the Philips Research Laboratories, prepared a manganese zinc ferrite and a nickel zinc ferrite of much better quality, but it was during the second World War that he succeeded in developing types of ferroxcube with not only very small eddy currents but also a high magnetic premeability and saturation flux density. In addition, the price was commercially attractive. The first publication on the new material appeared in December 1946.

The currently available types of ferroxcube can be used at frequencies of up to 100 MHz and three main groups of types can be distinguished:

Ferroxcube 3 — manganese zinc ferrite, with a rather high initial permeability and saturation flux density, but suffering from higher eddy current losses than ferroxcube 4, and therefore suitable for low frequencies (1 kHz to 1 MHz).

Ferroxcube 4 — nickel zinc ferrite, with lower initial permeability and saturation flux density but also very low eddy current losses, and therefore suitable for high frequencies (500 kHz to 100 MHz).

Ferroxcube 6 — magnesium manganese ferrite, with a square hysteresis loop making it eminently suitable for core stores in electronic computers.

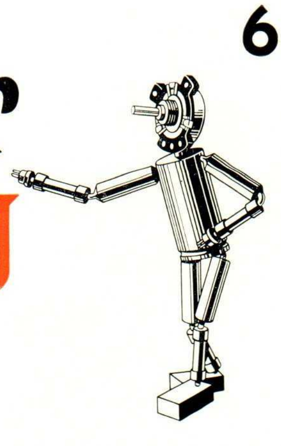
The main groups are subdivided into the grades 3A 3B, 3C and 4A, 4B, 4C, etc. Details of all available types of ferroxcube can be supplied upon request.

PHILIPS

ELECTRONIC COMPONENTS
AND MATERIALS DIVISION

electronics for YOU

6



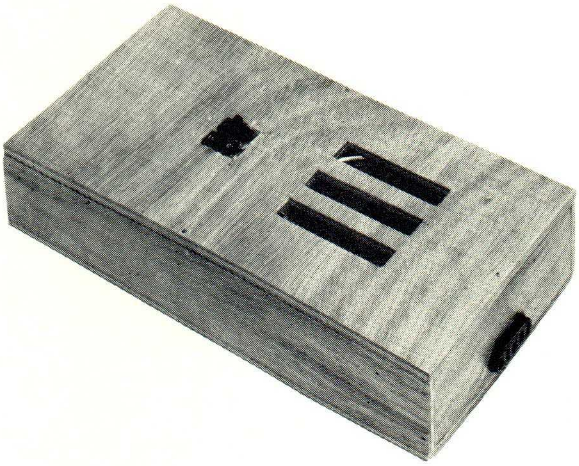
"MAGNETIC" REMOTE CONTROL SYSTEM

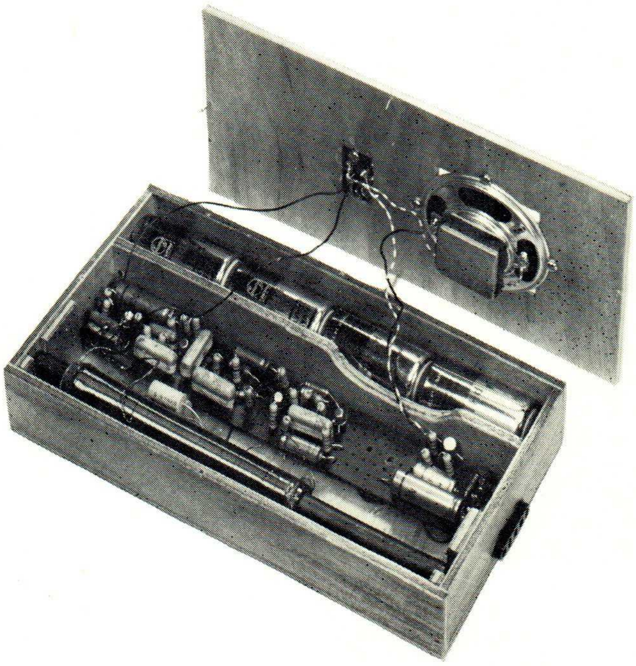
Dear Experimenter,

In No. 5 of "Electronics for You" we gave only the description of a low-frequency magnetic field generator with which you could start building a remote control system. In this issue you will find the necessary information for constructing the corresponding receptor. But first we should like to give you some good advice of a general nature.

1. The ferroxcube rod which is an essential element in both the generator and the receptor is fragile, so make sure to mount it in such a way that it is not easily broken. But don't use metal supports.
2. The housing for the generator or the receptor should not be made of metal; use wood or plastics instead.
3. The minimum distance between some of the components is critical. Be sure to read the instructions for building the units well, otherwise the performance may be affected.
4. The operation of the units is strongly affected by moisture, so you must make the housings watertight if you want to use the system while diving, or in a wet climate.

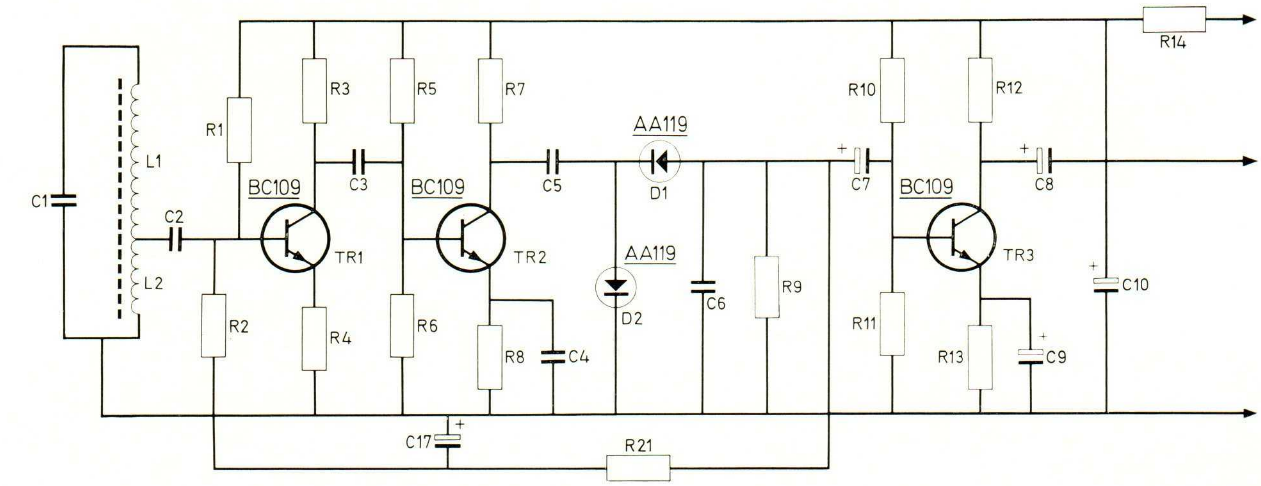
The Remote Control System can be used over distances determined by the coverage of the generator and the sensitivity of the receptor. For practical reasons the latter is limited: we didn't want you to be bothered by interfering signals which are quite numerous at 10 kHz (atmospherics, opening and closing of switches and relays, sparking of electric motors). Remember that, when using the generator and the receptor over distances close to the maximum coverage, you may have to position the units for maximum sensitivity; the coupling between the ferroxcube rods is strongest when they are in line, weakest when they are perpendicular to one another.





The "low-frequency magnetic field" receptor closed and opened. Two switches have been provided on this device, one to switch the receptor off and the other to connect the output of the receptor either to the built-in loudspeaker or to the output connector.

Circuit diagram of the "low-frequency magnetic field" receptor



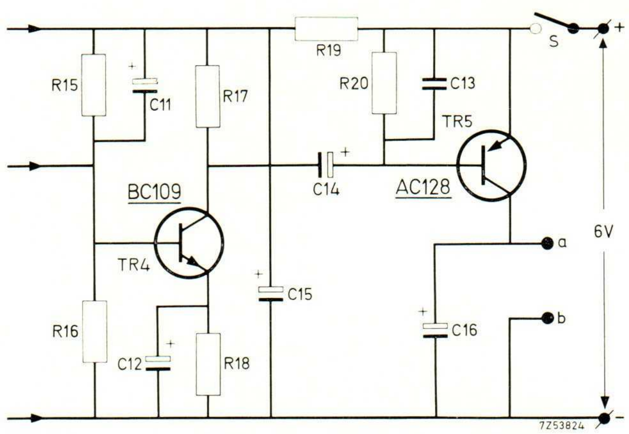


Fig. 1.

Parts List

			Catalogue number
C1	(polysterene capacitor	12 nF/125 V)	2222 436 21203
C2	(polyester capacitor	0.1 μF/250 V)	2222 342 45104
C3	(polyester capacitor	0.1 μF/250 V)	2222 342 45104
C4	(polyester capacitor	0.47 μF/250 V)	2222 342 45474
C5	(polyester capacitor	0.47 μF/250 V)	2222 342 45474
C6	(electrolytic capacitor	1 μF/ 40 V)	2222 002 17108
C7	(electrolytic capacitor	6.4 μF/ 25 V)	2222 001 16648
C8	(electrolytic capacitor	20 μF/ 16 V)	2222 001 15209
C9	(electrolytic capacitor	100 μF/ 6.4 V)	2222 001 13101
C10	(electrolytic capacitor	200 μF/ 10 V)	2222 001 14201
C11	(electrolytic capacitor	1 μF/ 16 V)	2222 002 17108
C12	(electrolytic capacitor	500 μF/ 2.5 V)	2222 001 11501
C13	(polyester capacitor	0.47 μF/250 V)	2222 342 45474
C14	(electrolytic capacitor	320 μF/ 6.4 V)	2222 001 13321
C15	(electrolytic capacitor	200 μF/ 10 V)	2222 001 14201
C16	(electrolytic capacitor	1 μF/ 40 V)	2222 002 17108
C17	(electrolytic capacitor	4 μF/ 40 V)	2222 001 17408
C18	(electrolytic capacitor	10 μF/ 16 V)	2222 001 15109
C19	(electrolytic capacitor	200 μF/ 10 V)	2222 001 14201
C20	(electrolytic capacitor	10 μF/ 16 V)	2222 001 15109
C21	(polyester capacitor	0.1 μF/250 V)	2222 324 45104
C22	(electrolytic capacitor	200 μF/ 10 V)	2222 001 14201
R1	(0.47 MΩ)		2322 101 43474
R2	(100 kΩ)		2322 101 43104
R3	(10 kΩ)		2322 101 43103
R4	(1 kΩ)		2322 101 43102
R5	(47 kΩ)		2322 101 43473
R6	(22 kΩ)		2322 101 43223
R7	(2.2 kΩ)		2322 101 43222
R8	(1 kΩ)		2322 101 43102
R9	(10 kΩ)		2322 101 43103
R10	(68 kΩ)		2322 101 43683
R11	(22 kΩ)		2322 101 43223
R12	(5.6 kΩ)		2322 101 43562
R13	(1.5 kΩ)		2322 101 43152
R14	(100 Ω)		2322 101 43101

R15 (22 kΩ)	2322 101 43223
R16 (4.7 kΩ)	2322 101 43472
R17 (470 Ω)	2322 101 43471
R18 (150 Ω)	2322 101 43151
R19 (100 Ω)	2322 101 43101
R20 (4.7 kΩ)	2322 101 43472
R21 (100 kΩ)	2322 101 43104
(R1 to R21 are carbon resistors of the ¼ W type.)	
D1 (germanium diode)	AA119
D2 (germanium diode)	AA119
Ferroxcube rod of 10 mm diameter and 200 mm length; grade 4A3	3122 104 93422
L1 (450 turns of 0.4 mm enamelled copper wire)	
L2 (150 turns of 0.4 mm enamelled copper wire)	
TR1, TR2, TR3, TR4 (n.p.n. silicon transistor)	BC109
TR5 (p.n.p. germanium transistor)	AC128
Relay (100 to 200 Ω d.c. resistance)	any type
LS1 (loudspeaker, 25 Ω impedance at 1000 Hz)	2422 257 23503
LS2 (loudspeaker, 4 Ω impedance at 1000 Hz)	2422 257 34101
S (switch)	any type

Principles of Operation

See Fig. 1.

The aerial of the receptor is also a ferroxcube rod; it should be taken as long as possible since the receiving capability increases about proportionally with the length. A grade 4A3 rod, 20 cm long, such as used in many conventional radio receivers, will serve the purpose (cat. no. 3122 104 93422).

The circuit, which must be capable of separating the desired 10 kHz signal from the many interfering signals, comprises coils L1 and L2 wound around the rod, and the polysterene capacitor C1.

The junction of L1 and L2 represents a low-ohmic tap and is connected to the first transistor; in this way the resonant circuit is damped as little as possible. For the same reason the emitter lead of TR1 is not decoupled. TR1 and TR2 together form a two-stage amplifier.

Next follow germanium diodes D1 and D2, forming a detector and voltage doubling circuit with capacitor C6 and resistor R9. The negative pulses that are left after detection (and voltage doubling) are passed on to transistors TR3 and TR4, but this pulsed signal is smoothed and fed back to the base of TR1 via R21 and R2. This automatic gain control arrangement ensures that the gain of TR1 decreases as the strength of the incoming signal increases.

TR3 and TR4 are amplifiers; capacitors C11, C13 and C16 remove all traces of the 10 kHz signal, thus preventing it from being induced to the resonant circuit. The amplified pulses are rectified by the base-emitter diode of TR5; the final result is a square wave collector current produced by TR5 which can be used to energize a loudspeaker or a relay.

When not in operation the receptor draws a current of about 3 mA.

Building the Receptor

Ferroxcube rod and coils: Take a 4A3 grade ferroxcube rod, 20 cm long, and a "pertinax" cylinder, about 12 cm long and having a diameter slightly larger than that of the rod. On this pertinax former apply three windings of 200 turns each of 0.4 mm enamelled copper wire. Make a tap after the first 50 turns of the top winding. See Fig. 2. Place the former around the rod.

Remaining circuitry: Build the remaining parts of the circuit and connect the resonant circuit to it. Make sure that the ferroxcube rod is at least 3 cm from any other component; by doing so you enhance both the sensitivity and the selectivity of the receptor.

When trying out the receptor for the first time, shift the coil former on the rod for maximum sensitivity.

It is possible that the tuning range is not sufficient. In that case capacitor C1 has to be replaced by another one: a 10 nF type (cat. no. 2222 436 21003) or a 15 nF type (cat. no. 2222 436 21503).

Some Notes on Using the Receptor

See Figs. 3 to 6.

Giving alarm: The simplest method is to connect a 25 Ω loudspeaker (e.g. type 2422 257 23503, cone diameter 64 mm) which will act as a kind of buzzer (Fig. 3). A louder warning can be obtained with the aid of a relay connected across terminals *a* and *b*. Fig. 4 illustrates a low-ohmic loudspeaker (e.g. the 4 Ω type 2422 257 34101) connected to the relay RL, Fig. 5 an a.c. door bell.

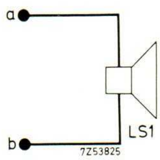


Fig. 3.

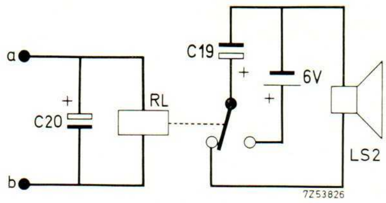


Fig. 4.

Switching a motor: This may either serve a serious purpose, such as opening a garage door, or a more frivolous one (performing magic tricks). For the connections, see Fig. 6. Notice that a large capacitor (200 μF) should be shunted across the relay coil to prevent the relay from responding to the individual pulses.

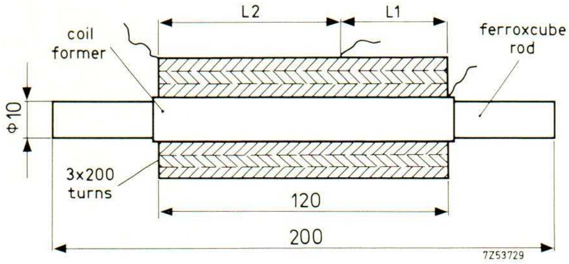


Fig. 2.

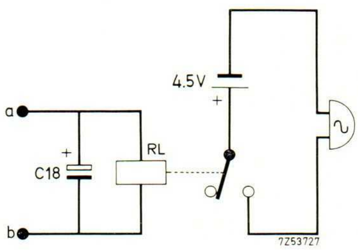


Fig. 5.

Warning: Make sure to position the relay and the motor at least half a metre from the receptor aerial, otherwise interference from the relay or the motor might cause unwanted oscillations in the receptor. When this occurs the relay will continue to attract in the absence of a signal sent out by the generator. We also strongly advise you to use separate supply units for any devices which are to be switched by the relay, to prevent the strong current pulses taken by the motor interfering with the circuit.

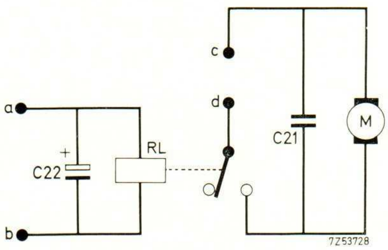
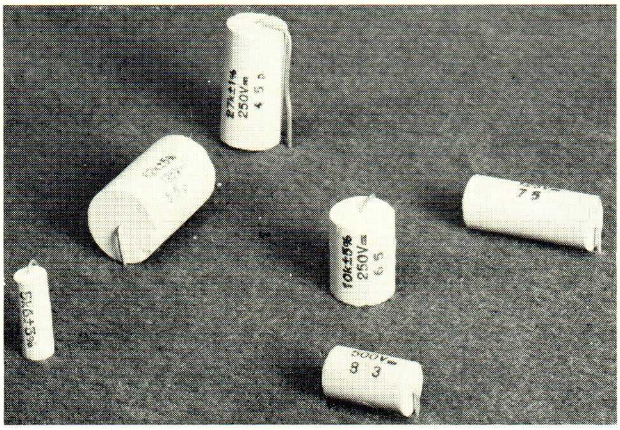


Fig. 6.

Example of mounting the a.c. door bell, the necessary relay and its own 4.5 V supply battery.

POLYSTERENE CAPACITORS

We recommend the use of polysterene capacitors in the resonant circuits of the generator and receptor because of the good properties this class of components has for tuned circuits and filters, properties that show only little spread and variation. The capacitance stability is high and the dielectric losses small (small tan δ).



Philips polysterene capacitors

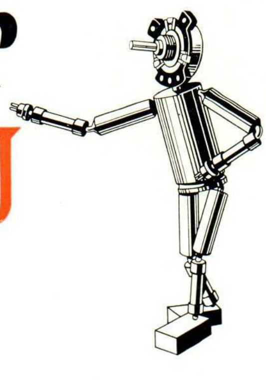
Their fairly small negative temperature coefficient makes them well suited for operation at temperatures between -40 and $+85$ °C, in combination with a ferroxcube rod which usually has a small positive temperature coefficient.

The polysterene capacitors are made in the following four voltage ranges (only the highest and the lowest capacitance values are given):

Working voltage (V)	Minimum capacitance (nF)	Maximum capacitance (nF)
63	3.6	160
125	1.5	82
250	1.3	47
500	0.68	27

The next table gives some important data of the polysterene capacitors in comparison with other types of capacitors.

	Tg δ at 1 kHz	Capacitance variation when temp. changes from -20 to +85 °C	Cap. drift during life
Polysterene cap.	2 10^{-4}	(100 ± 50) 10^{-6}/°C	1%
Polyester cap.	60 10^{-4}	+330 to +580 10^{-6}/°C	3%
Polycarbonate cap.	30 10^{-4}	+ 50 to +200 10^{-6}/°C	3%
Ceramic cap.	350 10^{-4}	+100 to +400 10^{-6}/°C	2 to 10%



STABILIZED POWER SUPPLY UNIT

FOR 0.1 TO 1.0 A AND 0 TO 15 V

Dear Experimenter,

Perhaps you have never realized that a tragedy was enacted right under your nose. Yet it is true that the large-scale electrification taking place in the years following World War II threatened to "kill" our old friend, the dry cell or battery.

It was saved by the increasing demand for cordless sets. The advent of the semiconductor made its future look bright indeed. Philips are marketing two different series at the moment:

— a *blue* series, for lighting and not too complicated sets;

— a *golden* series, for electric motors and more sophisticated equipment.

A lot of research has been put into the prevention of the electrolyte leaking away.

All good and well, you may say, but what about a versatile, simple stabilized PSU? In view of the circuits we have described in the "Electronics for You" leaflets we have assumed that you may need a low-voltage source which

— can supply any voltage between 0 and 15 V, and any current between 0.1 and 1 A;

— produces a constant voltage between the output terminals if a certain value is adjusted;

— is not ruined when a short-circuit occurs;

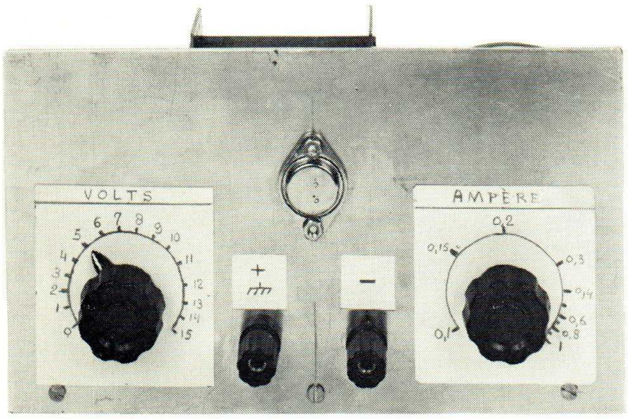
— produces no hum voltage;

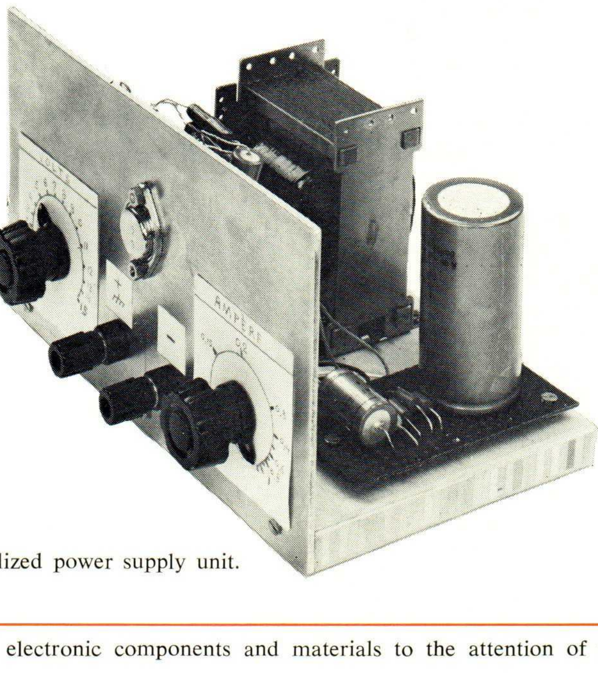
— has only a slight internal resistance;

— is protected against overheating.

We have designed a unit which you may connect to any new transistor circuit you have just built, as it can be set for minimum voltage and current output. No fear that your transistor will be damaged by an excessive current, even if there is something the matter with your circuit. The PSU also protects itself against overloading as a result of a prolonged short-circuit at maximum output current.

So, here is the unit that meets all your demands.





Views of prototype of stabilized power supply unit.

Circuit Diagram of the Stabilized Power Supply Unit

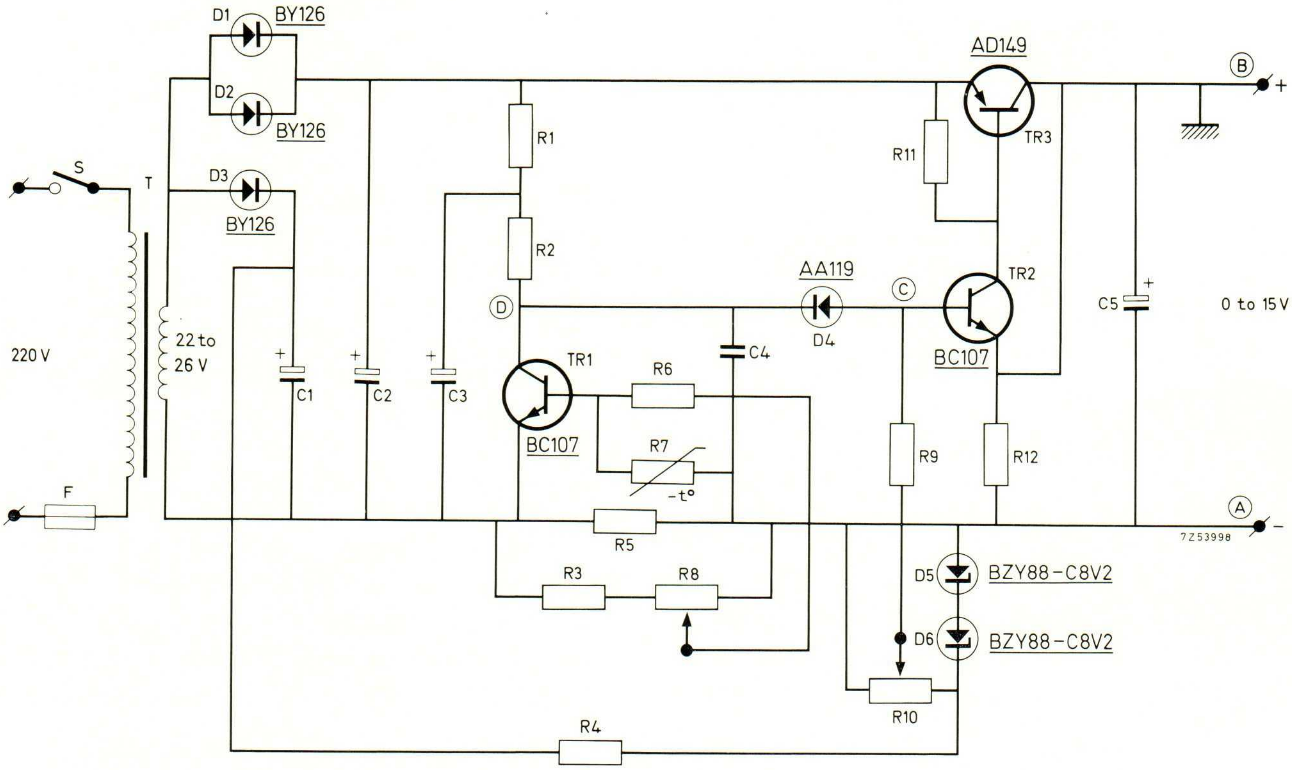


Fig. 1.

Parts List

			Catalogue number
R1	(carbon resistor	1 kΩ/ 0.5 W)	2322 101 63102
R2	(carbon resistor	2.2 kΩ/ 0.5 W)	2322 101 63222
R3	(carbon resistor	15 Ω/ 0.5 W)	2322 101 63159
R4	(carbon resistor	1.5 kΩ/ 1 W)	2322 101 73152
R5	(two wire-wound resistors connected in parallel each of	10 Ω/ 5.5 W)	2322 320 31109
R6	(carbon resistor	270 Ω/ 0.5 W)	2322 101 63271
R7	(NTC thermistor	4.7 kΩ)	2322 642 21472
R8	(linear carbon potentiometer	300 Ω)	2322 350 70719
R9	(carbon resistor	1 kΩ/ 0.5 W)	2322 101 63103
R10	(linear carbon potentiometer	4.7 kΩ)	2322 350 70706
R11	(carbon resistor	150 Ω/ 0.5 W)	2322 101 63151
R12	(two carbon resistors connected in parallel each of	220 Ω/ 1 W)	2322 101 83221
C1	(electrolytic capacitor	680 μF/ 40 V)	2222 026 17681
C2	(electrolytic capacitor	4000 μF/ 40 V)	2222 060 17402
C3	(electrolytic capacitor	220 μF/ 40 V)	2222 026 17271
C4	(ceramic capacitor	1 nF/500 V)	2222 563 02102
C5	(electrolytic capacitor	680 μF/ 40 V)	2222 026 17681

T	(40 W mains transformer, 220 V primary/22 to 26 V secondary)	any type
D1, D2, D3	(silicon diodes)	BY126
D4	(germanium diode)	AA119
D5, D6	(Zener diodes)	BZY88-C8V2
TR1, TR2	(n.p.n. transistors)	BC107
TR3	(p.n.p. transistor)	AD149
S	(mains switch)	any type
F	(fuse 0.5 A/250 V)	any type

Circuit Description

See Fig. 1.

The mains transformer T is a simple one with a 220 V primary, and a 22 to 26 V/2 A secondary. Diodes D1 and D2 provide half-wave rectification; these two parallel-connected diodes can be replaced by *one* BY118. D3 handles the reference voltage which is stabilized at 15 V by the two Zener diodes D5 and D6 connected in series. With potentiometer R10 the output voltage can be set to any value between 0 and 15 V.

The output voltage at point *B* also appears at the emitter of TR2, the reference voltage at point *C* being fed to the base of the same transistor. When the base of TR2 is negative with respect to the emitter, then there will be no base current nor any collector current. As the collector of TR2 is connected with the base of TR3 the latter will be non-conductive; its high resistance will cause the voltage at point *B* to decrease. But when the base of TR2 becomes positive relative to the emitter, transistors TR2 and TR3 will both start conducting and the voltage at *B* will increase. Equilibrium is obtained with the difference between reference voltage and output voltage varying from 0.5 to 0.8 V (voltage limits representing TR2 being fully "on" or fully "off") with zero current and 1 A current drain, respectively. Hence the internal resistance of the circuit may be put at 0.3 Ω.

The circuit is capable of minimizing rapid voltage fluctuations, and therefore almost eliminates the hum resulting from the half-wave rectification. Experiments showed that the hum voltage does not exceed 0.02 V with the most unfavourable load.

Limiting the Current

The essential components incorporated to keep the output current within safe limits are R5 and TR1. Resistor R5 is a 5 Ω/10 W resistor inserted in the negative lead; the voltage across it depends on the output current. A fraction of this voltage, depending on the setting of R8, is fed to the base of TR1. The moment its base voltage exceeds 0.5 V, TR1 becomes conductive; the resulting collector current will cause the voltage at point *D* to decrease. When this voltage becomes lower than that at point *C* a current starts flowing through R10, R9, D4 and TR1 and the negative lead. As a consequence the voltage at point *C* drops and with it the output voltage at *B*. In other words: the output voltage is lowered when the output current exceeds a certain value set by means of R8. In Fig. 2 the output voltage is plotted against output current values of 0.1, 0.2, 0.5 and 1 A, as set with the aid of R8.

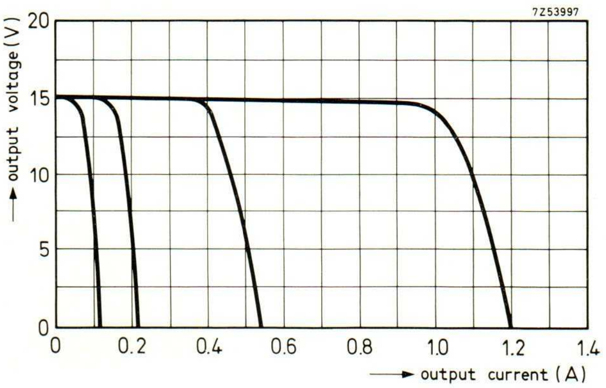
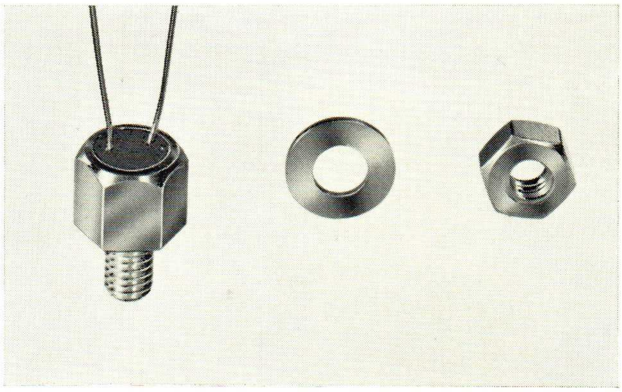


Fig. 2 - Voltage/current characteristics of the PSU.

Protecting TR3

At a load of 1 A/1 V, or when a prolonged short-circuit occurs, transistor TR3 may become overheated by the excess power it dissipates. To protect it NTC thermistor R7 is connected to its "control circuit". When the transistor becomes too hot, R7 will cause TR1 to become conductive earlier than is set by means of R8. Consequently the amount of power to be dissipated by TR3 decreases to a safe limit.

Electrolytic capacitor C3 eliminates hum from the "control circuit"; capacitor C4 prevents r.f. oscillations being set up.



Special NTC thermistor for mounting on heat sink.

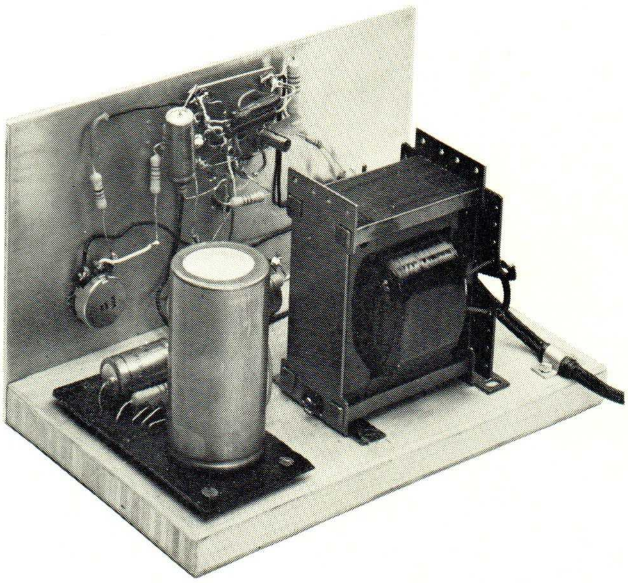
Building the PSU

Special care must be given to the cooling of power transistor TR3. A heat sink of at least 10 x 10 cm^2 and 2 mm thick should be used. In our prototype the front plate was the heat sink, which gave the advantage that the transistor temperature could be checked roughly by just touching the front plate. In this way the front plate is made to carry the positive output voltage, which is the reason why the positive terminal of the PSU is shown earthed in Fig. 1.

Transistor TR2 also needs a heat sink since it will be dissipating power quite close to the rated value when a short-circuit occurs (see photograph below).

NTC resistor R7 is provided with a threaded end and when this is inserted in a hole in the front plate as near as possible to TR3 the heat transfer from transistor TR3 to the NTC thermistor will be very good.

The bottom plate of the unit's casing must be made of wood and be sufficiently strong to carry the rather heavy weight of the mains transformer.



POWER TRANSISTOR AD149

This is a p.n.p. germanium power transistor with the collector connected to the mounting base. It is primarily intended for use in a matched pair, 2 x AD149, in class B push-pull output stages with an output power of 20 W, but it also is often used in stabilized power supplies. The data are as follows:

Collector-base voltage (open emitter)	$-V_{CBO}$	max.	50 V
Collector-emitter voltage (open base)	$-V_{CEO}$	max.	30 V
Collector current (d.c.)	$-I_C$	max.	3.5 A
Total power dissipation up to $T_{mb} = 45$ °C	P_{tot}	max.	32.5 W
Junction temperature (for short periods)	T_j	max.	110 °C
D.C. current gain at $T_j = 25$ °C; $-I_C = 1$ A; $V_{CB} = 0$ V	h_{FE}		30 to 100
Cut-off frequency $-I_C = 0.5$ A; $-V_{CE} = 2$ V	f_{hfe}	typ.	10 kHz

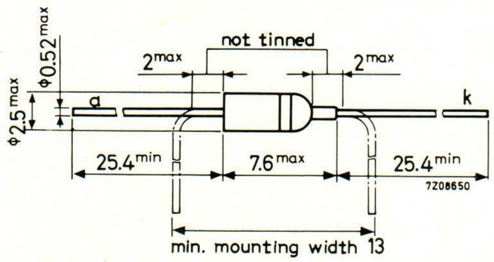
ZENER DIODES, BZY88-SERIES

The BZY88 Zener diodes are silicon diodes in subminiature all-glass DO-7 encapsulation for use as low-current voltage stabilizers or voltage reference elements.

The series consists of 24 types with nominal Zener voltages ranging from 3.3 to 30 V with a tolerance of ± 5%. The types widely used by experimenters are given in the table below.

Quick Reference Data

Repetitive current	I_{ZRM}	max.	250 mA
Total power dissipation up to $T_{amb} = 50$ °C	P_{tot}	max.	400 mW
Junction temperature	T_j	max.	175 °C



Dimensions in mm of the BZY88-series Zener diodes.

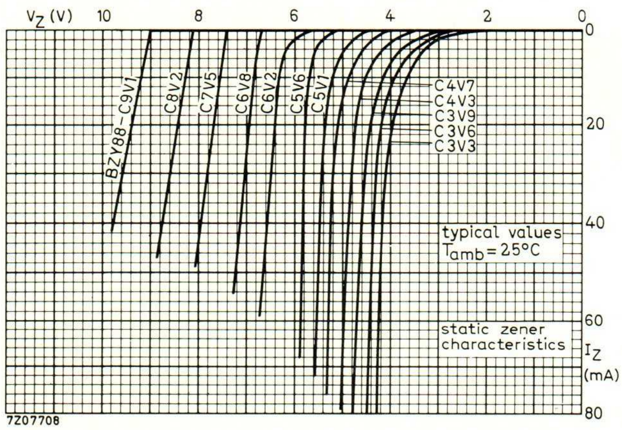
BZY88-....	Zener voltage V_Z (V) at $I_Z = 5$ mA		
	min.	nom.	max.
C3V3	3.1	3.3	3.5
C3V6	3.4	3.6	3.8
C3V9	3.7	3.9	4.1
C4V3	4.0	4.3	4.5
C4V7	4.4	4.7	5.0
C5V1	4.8	5.1	5.4
C5V6	5.3	5.6	6.0
C6V2	5.8	6.2	6.6
C6V8	6.4	6.8	7.2
C7V5	7.1	7.5	7.9
C8V2	7.8	8.2	8.7
C9V1	8.6	9.1	9.6

Voltage regulator or Zener diodes as sources of stable reference voltages have several advantages over the old gas-filled stabilizer and reference tubes. The most important of these is the wide range of obtainable reference voltages: from less than 4 V to more than 70 V (the gasfilled stabilizer tube has a lowest limit of about 70 V). These silicon semiconductor devices have a normal diode characteristic in the forward direction and a constant voltage property in the reverse direction. In other words, when forward-biased, they behave like normal diodes; when the bias voltage is reversed, a leakage current of only a few microamps flows through them. This current is independent of the applied voltage over a quite wide range, but eventually increases suddenly to a large value (tens of milliamps or even several amps). The voltage at which this occurs is known as the *breakdown voltage*. The voltage across the diode after breakdown is known as the *reference voltage;* this cannot greatly exceed the breakdown voltage and is virtually constant. Provided that the maximum permissible junction temperature is not exceeded, the breakdown is reversible and non-destructive.

The three Zener voltages quoted in the table indicate the tolerances of diodes of the same type, and not the variations in breakdown voltage of an individual diode. Each individual diode will have its own constant reference voltage within the limits quoted.

These Zener diodes find many uses in a great variety of circuits which can be divided intro three main groups:

- voltage reference circuits;
- voltage shifting circuits;
- voltage clipping circuits.



Static Zener characteristics of the BZY88-series diodes.

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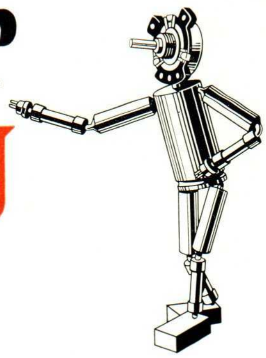


TRANSISTORIZED SHORT-WAVE CONVERTER

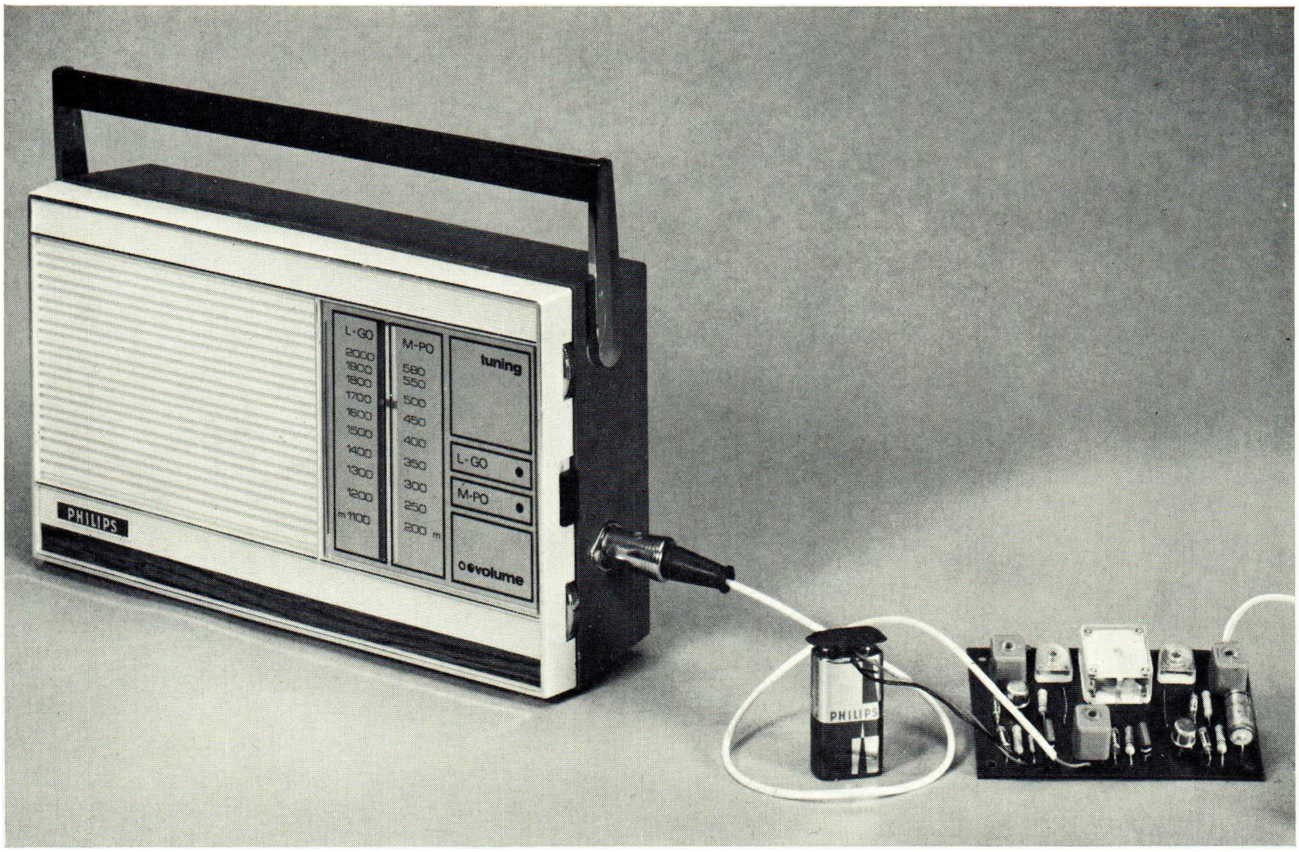
Dear Experimenter,

If you are a short-wave enthusiast the four words printed above will convey a message to you and it will suffice to add that

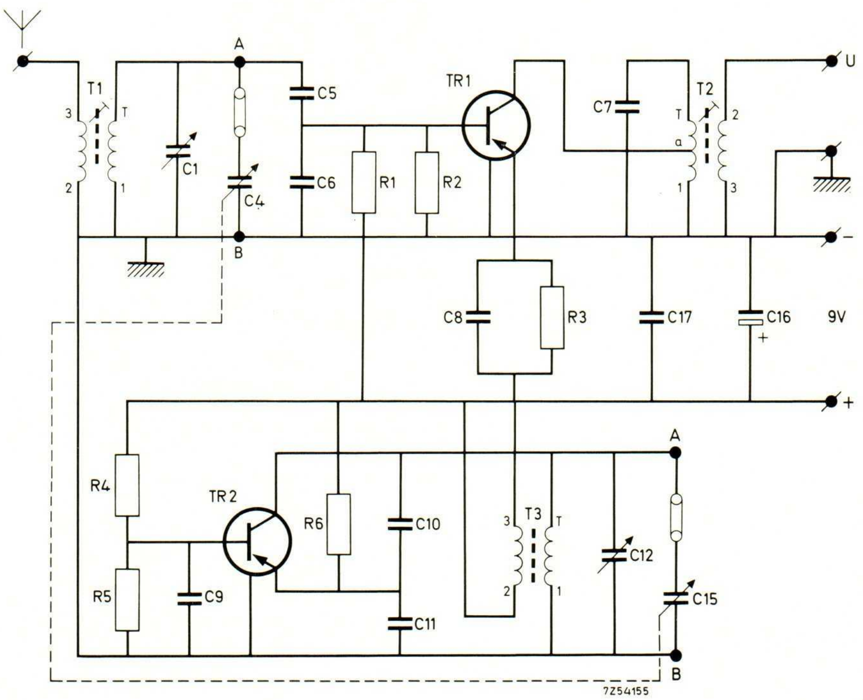
- the unit has a remarkable performance in the 18 - 7 MHz (16 - 42 m) bands;
- the circuit is simple;
- the costs are low.

Those of you who have had less experience with wireless receivers may like to refresh their memory as to what a converter is, and why and how it must be built and used. We will tell you more overleaf.

We can also tell you that Dutch radio amateurs who have built the converter are enthusiastic, so we hope you will decide to "have the world at your doorstep": BBC's World Service (15.1 MHz), The Voice of America (Washington, 15.19 MHz), Radio Nederland Wereldomroep (15.21 MHz), The Voice of America (Africa, 15.225 MHz), Radio Moscow (German broadcasts, 15.28 MHz), BBC's Overseas Service (15.38 MHz), etc. You will find it great fun to spend an hour or so assembling your own converter.



Circuit Diagram of the Transistorized Short-wave Converter



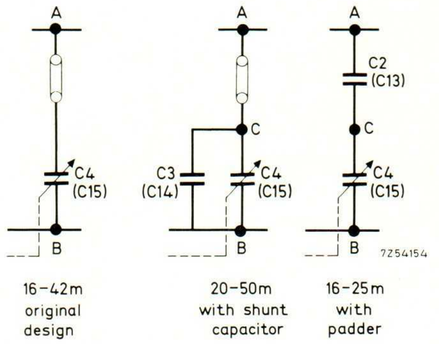


Fig. 1.

Parts List

			Catalogue number
Printed circuit board			9390 077 90701
Transistors			
TR1			AF 185
TR2			AF 185
Coils			
T1			3122 991 62513
T2			3122 991 62532
T3			3122 991 62513
Capacitors			
C1	60 pF	variable capacitor	2222 808 21001
C2	500 pF	polystyrene capacitor	2012 303 02729
C3	80 PF	polystyrene capacitor	2012 303 02707
C4 - C15	2 x 275 pF	tuning capacitor	2222 807 10033
C5	40 pF	polysterene capacitor	2012 303 02705
C6	100 pF	polysterene capacitor	2012 303 00872
C7	60 pF	polysterene capacitor	2012 303 02706
C8	100 nF	flat foil capacitor	2222 342 44104
C9	100 nF	flat foil capacitor	2222 342 44104
C10	40 pF	polysterene capacitor	2012 303 02705
C11	300 pF	polysterene capacitor	2012 303 00502
C12	60 pF	variable capacitor	2222 808 21001
C13	300 pF	polystyrene capacitor	2012 303 00502
C14	120 pF	polystyrene capacitor	2012 303 00499
C15 see C4			
C16	125 μF/16 V	electrolytic capacitor	2222 001 15131
C17	10 nF	flat foil capacitor	2222 342 44103
Extension shaft for tuning capacitor			9390 131 40000

Scope of Converter

You may have asked yourself: Why do I need a converter? Because the simpler types of receivers — whether equipped with electron tubes or with transistors — only seldom cover the interesting wavebands between 16 and 50 metres. Apart from buying a more expensive all-wave receiver — or building one yourself — the only possibility is to make your, let's say medium-wave, receiver suitable for short-wave listening by connecting to it a factory-made or home-built converter. This will "translate" the signals coming in from a s.w. station to which you have tuned in into one fixed frequency in your (m.w.) receiver's range (usually between 150 to 500 m approx). All you have to do is to connect the converter's input terminal to an aerial of *appropriate length and height,* and the converter's output to the aerial terminal of the m.w. receiver. Provided you have tuned the latter properly to the fixed frequency it will reproduce the signals from the s.w. station as if it were a station operating on the fixed frequency in the m.w. band. Using the tuning knob on the converter you can search through the wavebands covered by the converter without having to turn any of the knobs on the m.w. receiver.

The selectivity and sensitivity of this combination are very high due to the fact that the superheterodyning (conversion) of the received signals takes place twice, once in the converter, a second time in the m.w. receiver. Reception can even be better than with all-wave receivers. Naturally, distant stations — whether manned by broadcasters or radio amateurs — can only be received well with the aid of a good aerial as high as possible on the roof: remember that the signal strength increases almost proportionally with aerial height and that, conversely, the noise level decreases rather steeply as the aerial is placed higher.

So, have a look at the Circuit Diagram alongside, designed for the frequency range of 18 to 7 MHz (16 - 42 m), whereas it has to be connected to a m.w. receiver tuned to 180 m. You can shift the range to 10 - 6 MHz (30 - 50 m) by connecting a capacitor in parallel to each of the tuning capacitors. When, instead of the shunt capacitors, two padders are connected in series with the main tuning capacitors, the frequency range is limited to 16 - 25 m. It is somewhat easier to tune the converter in this limited band; still, we would advise you to use a vernier tuning knob. Under the circuit diagram you find details of the tuning circuits for these ranges; the layout drawing will help you making the various connections on the printed-circuit board 9390 077 90701.

Brief Description of Signal Path

See Fig. 1.

The signal picked up by the aerial enters at point 3 of coil T1. The input circuit is tuned by means of C1 and variable capacitor C4. C4 is ganged to the tuning capacitor C15 in the oscillator circuit. The signal developing at point 3 of oscillator coil T3 is applied to the emitter of mixing transistor TR1; the base of this transistor receives the original signal picked up by the aerial.

In our design the fixed frequency in the medium-wave band is 1.62 MHz (180 m). To this end the oscillator is kept tuned to a frequency 1.62 MHz higher than the carrier sent out by the transmitter to which we have tuned the converter. Therefore the difference frequency of 1.62 MHz will be produced in the collector lead of the mixing transistor. Coil T2 and capacitor C7 form a resonant circuit at 1.62 MHz so that at the output U a fully modulated medium-wave signal is developed with a carrier of 1.62 MHz.

Instructions for Mounting

See layout drawing, Fig. 2.

1. Make sure, when putting the transistors in position that the tab on the envelope is pointing in the right direction and that the wires are projecting through the holes in the correct sequence. Mount the transistors about 1/5″ (5 mm) above the printed circuit board, so that the wires may be held with a pair of pliers while they are being soldered.
2. Before putting tuning capacitor C4+C15 permanently in position, pass the terminal pins through the holes and then secure this capacitor to the assembly board with the two short bolts.
   Important: Insert insulating washers under the heads of the bolts.
3. The adjustable capacitors are secured by soldering the three connecting pins.
4. The correct position of coils T1, T2 and T3 is shown in the layout drawing by an arrow indicating the location of the inscription. Note that some of the holes are not used.
5. When putting C16 in position, make sure that it is correctly oriented, which can be checked by the location of the groove at the positive end.
6. Fit all components as close as possible to the p.c. board; in short-wave equipment long wires should be avoided.

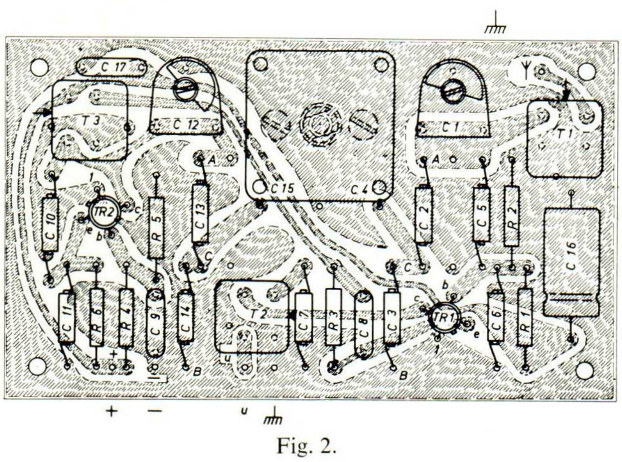


Fig. 2.

Use good quality screened cable (mcirophone cable) for the connection to the radio. Connect the core of the cable between the aerial socket on the radio and point U on the assembly board. Connect the screening between "earth" on the radio and the broad copper area near U on the p.c. board.

Any battery providing 9 V may be used. The positive terminal is connected via a switch to the plus contact on the p.c. board, and the negative terminal to the minus contact.

Finally, connect the aerial to the appropriate point near T1. A convenient object such as a waterpipe may be used as an earth, and should be connected to the broad copper band running around the p.c. board.

It is a very good idea to install the converter in a metal housing, which will provide an excellent screen between the converter and the radio. Secure the extension shaft to the tuning capacitor by the long screw, so that the tuning knob can be easily fixed.

2. Connect the signal generator to the common connection point R1-R2 and "earth" via a capacitor of about 10 000 pF.

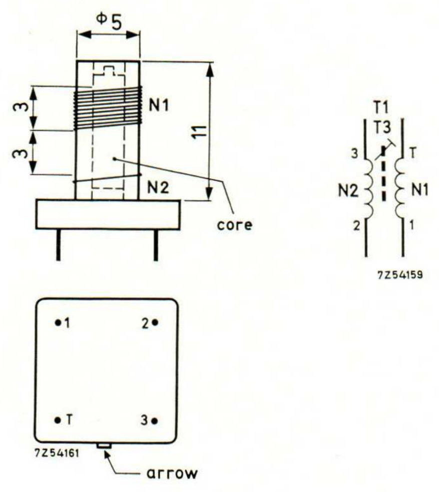
To ensure that the equipment works properly, the converter must be correctly adjusted with the aid of a r.f. signal generator, modulated by a low-frequency signal, 400 Hz, for example. If you have no such generator available, you may find your radio dealer willing to co-operate in this respect. The cores or the coils must be turned in or out with a trimming tool made of insulating material.

Adjustment is carried out as follows:

1. Connect the converter to the radio, which should be tuned to 180 m (1 620 kHz), preferably at a point where no broadcasts are normally received.
3. Tune the signal generator to the same frequency as the radio (about 1 620 kHz).
4. Set the core of T2 at maximum volume. If this maximum position is difficult to find, include a capacitor of about 100 pF in the connection between the converter (U) and the radio. If necessary, detune the radio slightly.
5. Now connect the signal generator to the aerial and earth sockets of the converter. Turn the tuning capacitor as far to the right as it will go. Tune the signal generator to 7 MHz. First set the coil of T3 and then that of T1 to maximum volume (when you are using the parallel capacitors C3 and C14 tune the transimitter to 5.9 MHz).
6. Turn the tuning capacitor as far to the left as it will go. Tune the signal generator to 20 MHz (or to 10 MHz when you are using C3 and C14) and set first C12 and then C1 to maximum volume.
7. Repeat steps 3 - 6 a few times.

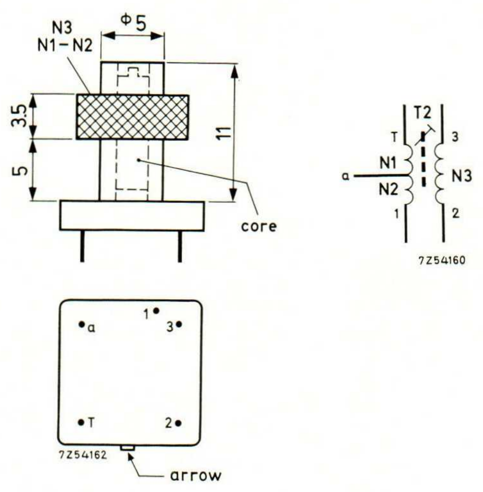
Finally, check the voltages between the emitter (point e) and the positive terminal: at TR1: 1.33 V and at TR2: 2.9 V, using a 20 000 ohm/volt voltmeter.

Technical data for T_1 and T_3



$N_1 = 0.85\ \mu H = 10^3/_4$ turns 0.2 ø enamelled copper wire
$N_2 = 1^1/_4$ turns 0.2 ø enamelled copper wire

Technical data for T_2



$N_1 = 117^7/_8$ turns litze wire 16 x 0.04
$N_2 = 4^6/_8$ turns litze wire 16 x 0.04
$N_3 = 12^1/_8$ turns litze wire 16 x 0.04
$N_1 + N_2 = 172\ \mu H$

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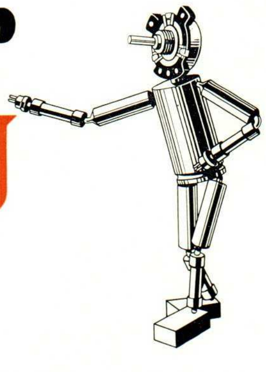


SIMPLE TRANSISTOR TESTER

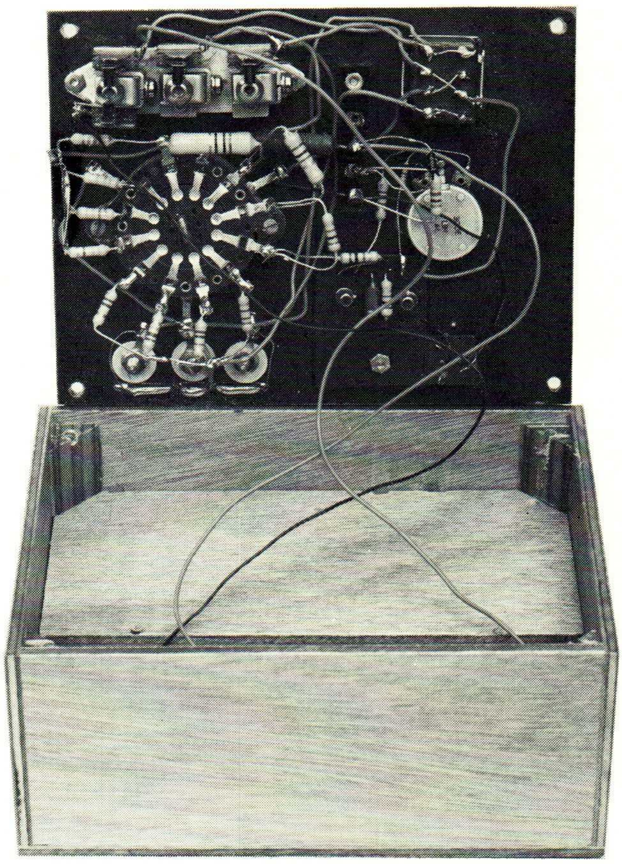
Dear Experimenter,

You remember that very expensive power transistor which you overloaded and then replaced because you didn't trust it any longer . . . and that small stock of switching transistors, all used in some circuit or other and now almost forgotten in your "junk box", marks nearly gone? Well, of course you would like to know how much (or little) your power transistor was damaged . . . you could go to the shop and have it tested . . . but then it would come out how careless you have been . . . and no one likes to be laughed at . . .

We have another suggestion: why not build the Simple Transistor Tester described in this leaflet and find out for yourself how large the *collector-to-emitter quiescent current* of your power transistor is and how high the *static current amplification factor*. Or use it to tell your friend that there is no short-circuit between *the collector and emitter* of his driver transistor (so that something else must be the matter with his circuit!). With this home-built, inexpensive and robust aid determining if an unknown transistor is n-p-n or p-n-p is a matter of seconds.

Following the description of the tester we give you a tabulated survey of the most frequently used transistors and the "test values" for them all.

Whatever you do with it, please remember that the Tester is a *precious aid,* not a *precision instrument.*



Circuit Diagram of the Transistor Tester

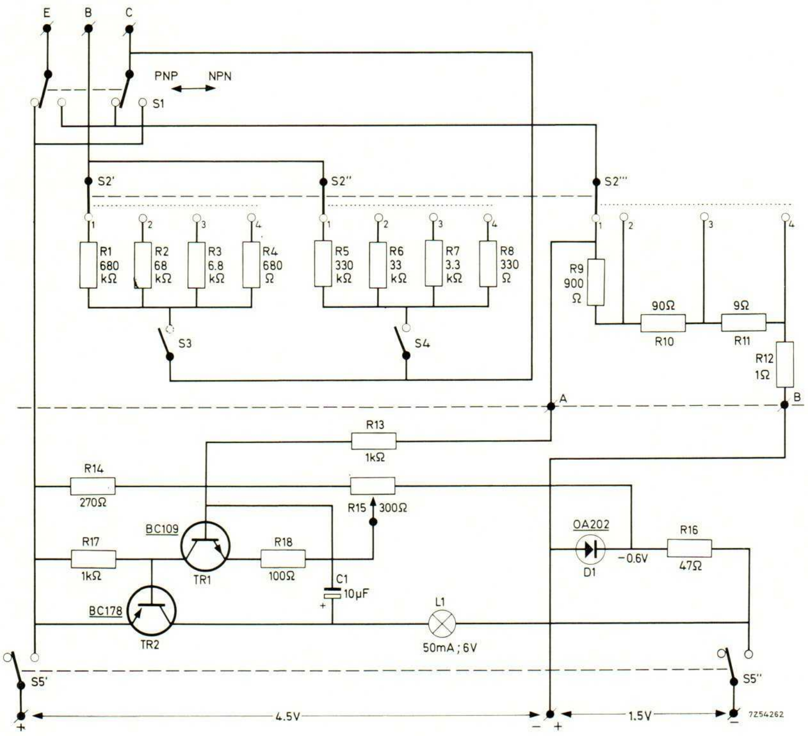


Fig. 2.

Parts List

		Catalogue number
TR1	(Silicon transistor)	BC109
TR2	(Silicon transistor)	BC178
D1	(Silicon diode)	OA202
S1	(Switch 2 change-over contacts 2 positions)	any type
S2	(Switch 3 change-over contacts 4 positions)	any type
S3=S4	(1 make contact)	any type
S5	(2 make contacts)	any type
L1	(Signal lamp) 6 V - 50 mA)	
C1	(Electrolytic capacitor 10µF - 16 V)	2222 001 15109
R1	(Carbon resistor 680 K ½ W)	2322 10163684
R2	(Carbon resistor 68 K ½ W)	2322 101 63683
R3	(Carbon resistor 6K8 ½ W)	2322 101 63682
R4	(Carbon resistor 680 Ohm ½ W)	2322 101 63681
R5	(Carbon resistor 330 K ½ W)	2322 101 63334
R6	(Carbon resistor 33 K ½ W)	2322 101 63333
R7	(Carbon resistor 3K3 ½ W)	2322 101 63332
R8	(Carbon resistor 330 Ohm ½ W)	2322 101 63331
R9	(Carbon resistor 900 Ohm 2 x 1K8 ½ W par)	2322 101 63182
R10	(Carbon resistors 90 Ohm 2 x 180 Ohm ½ W par)	2322 101 63181
R11	(Carbon resistors 9 Ohm 2 x 18 Ohm 1 W par)	2322 101 73189
R12	(Carbon resistor 1 Ohm 8 W)	2322 323 14108
R13	(Carbon resistor 1 K ½ W)	2322 101 63102
R14	(Carbon resistor 270 Ohm ½ W)	2322 101 63271
R15	(Potentiometer, linear, 300 Ohm)	2322 350 70619
R16	(Carbon resistor 47 Ohm ½ W)	2322 101 63479
R17	(Carbon resistor 1 K ½ W)	2322 101 63102
R18	(Carbon resistor 100 Ohm ½ W)	2322 101 63101

Design Principle

When designing the Transistor Tester we had to consider the following facts. The quality of a transistor depends strongly on the "leakage current" between collector and base (I_{CBO}). This is normally so small that a highly sensitive instrument is needed to measure it. However, the leakage current between collector and emitter is about h_{FE} times I_{CBO} and hence much easier to check (h_{FE} is static current amplification factor). It is true that the method has a disadvantage: when the transistor under test has a very large h_{FE}, the I_{CEO} value may be found to be so large that the transistor would have to be rejected whereas in reality it is a good one.

Another difficulty is that the I_{CEO} values vary from one transistor type to another. In the case of a good silicon transistor our Tester will show a value near zero, also when a power type is being examined. Germanium transistors show a much higher leakage current, and a germanium power transistor is normal to need full scale deflection.

Although determining whether a transistor is faulty or not apparently is not simple, we found the solution in providing you with a printed scale (Fig. 2) which you can cut out and stick under the relevant control knob. The scale shows three *areas* of I_{CEO} values, none of the values being given, and the associated h_{FE} values (also see under "Circuit Description").

Circuit Description

See Fig. 1.

Two parts may be distinguished: one part above the dashed line and in which the voltage to be measured is "made", the other part under the dashed line and where this voltage is amplified and changed into a visible signal.

The part mentioned first comprises from top to bottom:

— *three terminals* for the transistor which is to be tested, marked E(mitter, B(ase) and C(ollector);

— *switch* S_1 which connects either the collector of the transistor under test to one of the resistors R_9-R_{12} (position "p-n-p"), or the emitter (position "n-p-n");

— *switch* S_2 which selects the base resistor from R_1-R_4 when S_3 is closed, and from R_5-R_8 when S_4 is closed; it also selects the collector resistor from R_9-R_{12};

— switches S_3 and S_4 which connect the base of the transistor under test, via the base resistor selected by means of S_2, to the collector;

— points A and B between which the voltage to be measured develops.

The part under the dashed line is a kind of electronic voltmeter; the voltage is not read from a milliammeter but is indicated by a small incandescent lamp which is either off, on, or intermittently on. The circuit comprises two amplifier stages; the signal lamp is connected to the amplifier output. Part of the voltage across the lamp is fed back to the input of TR_1 via electrolytic capacitor C_1. If now R_{15} is so adjusted that the closed-loop gain of the two amplifier stages is greater than 1, the amplifier becomes an oscillator. The frequency of oscillation is about 4 Hz and the lamp will flicker in this rythm. The control knob of R_{15} can then be calibrated to indicate collector current (or emitter current) of the transistor under test, and, on another scale, the static current gain. As already stated, we have done the calibrating for you.

The three areas on the prepared scale shown alongside signify:

white area: transistor is good;

hatched area: small transistors: medium to bad quality; power transisitors: good to medium quality (the larger the power-handling capability, the higher the permissible leakage currents).

We advise you to experiment a little with the Tester, comparing the results obtained with different transistors. You will soon get enough experience to decide whether a transistor is good or bad.

Assembling Instructions

See Fig. 3.

Push-button switches S_5, S_3 and S_4 are seen fitted at the bottom on the left-hand side, and R_{15} on the right. This means that during testing S_5 (plus S_3 or S_4) must be kept pressed with the left hand, and R_{15} at the same time turned with the right hand. When you are left-handed you may decide in favour of another arrangement.

Terminals *E, B* and *C* may be of the screw-type or the knife-contact type; In Fig. 3 both types are depicted.

You are advised to use 4 dry cells of the 1½ V type. Smaller cells may give difficulties when you are testing power transistors drawing a higher current.

Suitable dimensions for a wooden casing for the tester are:

length 17 cm
width 13 cm
height 7 cm

Instructions for Use

Before starting a test see to it that S_2 is in position "1". Make a habit of touching the transistor under test every now and then to make sure that it is not overheated.

Testing an Unknown Transistor (h_{FE} test)

1. Connect the transistor. Press buttons S_5 and S_3 at the same time and adjust R_{15} until the lamp flickers. If R_{15} indicates zero, then switch S_1 to the other position. You have now found out whether the transistor is of the n-p-n or the p-n-p type, as indicated by the position of S_1.

   If you wish, you may proceed with the operations described below.

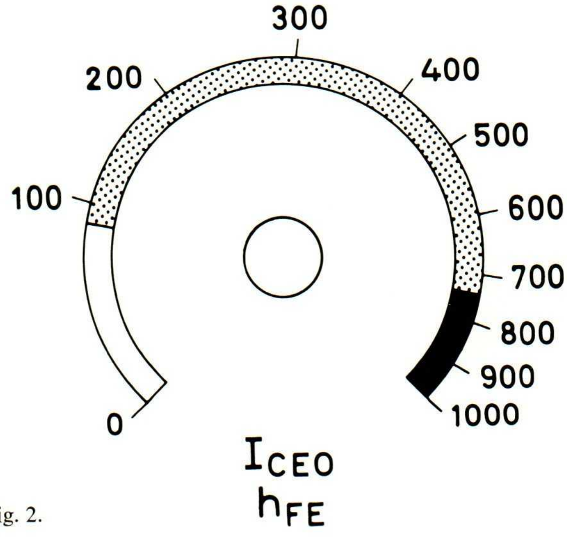


Fig. 2.

Testing a Known Transistor

2. *I_{CEO} Test*
Connect the transistor. Make sure that S_1 is in the proper position. Press button S_5 and adjust R_{15} until the lamp flickers. Note the area of the scale indicated by the pointer of R_{15}. Remember that these are areas of I_{CEO} values, indicating:

white area:	transistor is good;
hatched area:	small transistors – medium to bad quality; power transistors – good to medium quality;
black area:	transistor is bad.

When the pointer is very close to the zero position, the transistor may of course be of very good quality (in most instances you will find that it is a silicon type), but in case of doubt just try moving S_1 to the other position (or, if you are sure that S_1's position is correct, check whether the transistor is connected in the right way to terminals *E, B* and *C*). When the pointer is up at the other end of the scale you may well make the same checks. Should it be impossible to make the lamp flicker, then set switch S_2 to position "2". With the lamp remaining on you may conclude that there is a short-circuit in the transistor (to make sure, switch to position "3").

3. *h_{FE} Test*

S_2 back to "1". Depress S_5 and S_3 simultaneously. Adjust R_{15}, and read the h_{FE} value on the scale. Release S_3 and depress S_4 instead, while keeping S_5 down. Adjust R_{15}. The h_{FE} value should now be about twice that found first. If not, set S_2 to "2", even to "3" and, in the case of power transistors, to "4', and repeat the h_{FE} test until the second value is twice that found first.

Note: The base current with S_2 in position "1" and S_5+S_3 depressed is about 6 μA, with S_5+S_4 depressed about 12 μA. With S_2 in position "2" these values are multiplied by 10, in position "3" by 100, in position "4" by 1000.

SURVEY OF H_{FE} VALUES OF COMMONLY USED TRANSISTORS

Type	h_{FE}	Type	h_{FE}
AC125 (PNP)	50 - 100	BC147 (NPN)	110 - 435
AC126 (PNP)	65 - 140	BC108 (NPN)	110 - 435
AC127 (NPN)	abt. 100	148	
AC128 (PNP)	55 - 175	BC109 (NPN)	210 - 800
AC187 (NPN)	100 - 500	149	
AC188 (PNP)	100 - 500	BC157 (PNP)	abt. 140
AD149 (PNP)	30 - 100	177	
AD161 (NPN)	80 - 320	BC158 (PNP)	abt. 180
AD162 (PNP)	80 - 320	178	
AF121 (PNP)	abt. 80	BC159 (PNP)	abt. 290
AF124 (PNP)	abt. 150	179	
AF126 (PNP)	abt. 150	BD124 (NPN)	abt. 75
BC107 (NPN)	110 - 435	BF115 (NPN)	45 - 165

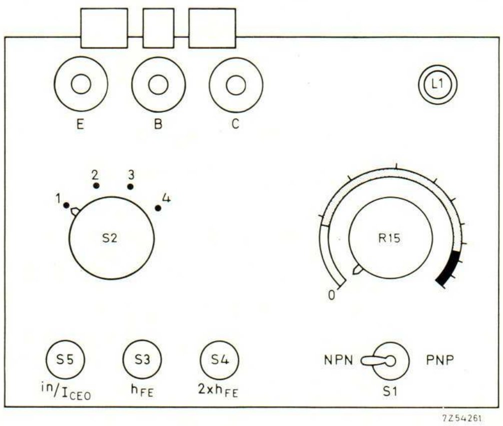


Fig. 3.

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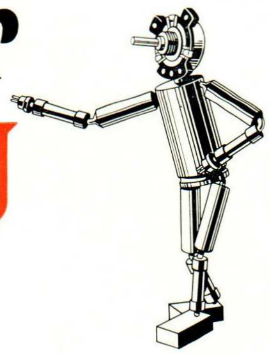


SINGLE-THYRISTOR LIGHT DIMMER

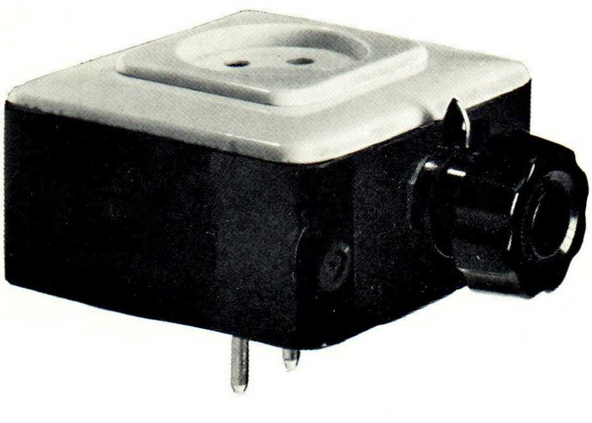
Dear Experimenter,

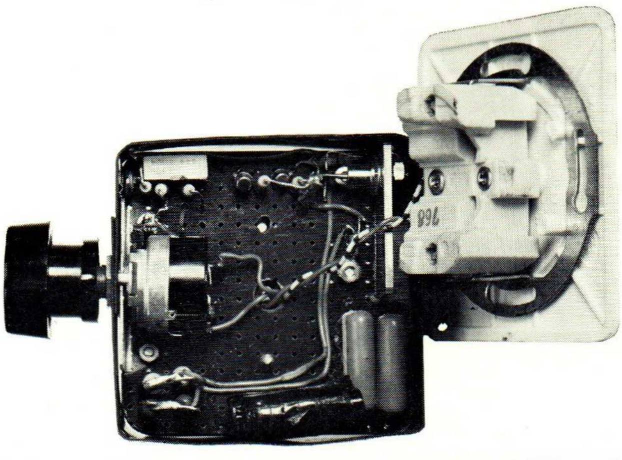
The subject of "Electronics for You", Number 10, is the smooth control of a.c. power used for lighting purposes. Since the introduction of the semiconductor device called *thyristor* (a word derived from the name of a gas-discharge tube called *thyr*atron, and that of another semiconductor device, the trans*istor*), power control equipment has become much simpler and less expensive.

Maybe you are wondering what you have got to do with "smooth control of a.c. power". This is an unmistakable indication that you are not in the habit of showing films and/or transparencies at home, and that you are neither an aviary-keeper nor an aquarist. If you were, you would no doubt have recognized that here at last was the light dimmer you have been waiting for. You know, when one shows a film or transparencies to one's friends, it does not do to switch the main lights in the room on and off abruptly – it lends a professional touch to one's performance when the lights come on and go out ever so slowly and gradually . . . And when one keeps birds in an aviary or fish in a tank one will, of course, know that there is nothing better for these animals than the morning and evening twilight. There are also some more egoistic applications for the light dimmer, such as adjusting the room lighting level to the brilliance of the TV picture! Anyway, we will show you how to build a light dimmer (and may tell you how to make it automatic in a next issue).

Now, before you turn to the next pages, may we remind you of the essentials of thyristors? It is a semiconductor device; it can either conduct current or block it almost completely – so, much like a switch it has either no resistance or an almost infinitely high resistance; it is very small yet can handle high powers; it has three electrodes: an anode and a cathode – which represent the two contacts of a switch and, like these, should be in the power circuit – and a gate or control electrode, which is fed from an auxiliary circuit. See Fig. 1, where the power circuit is drawn in more solid lines.

We think it only fair to conclude these introductory notes with a warning. Thyristor circuits generate spurious signals, and these either reach the mains via the power circuit or else are propagated through the air over a certain distance. We will tell you how to minimize the interference caused by your light dimmer but you must promise us to check the effectiveness of the measures we will propose. We don't want you to be a nuisance to your neighbours!





The Thyristor

The thyristor is such a wonderful little workhorse that it deserves our full attention. Those who know all about it may confine themselves to the "List of Ratings and Characteristics" printed on the last page for the BT101-500R, others may well benefit from a brief description.

The reverse-blocking triode thyristor which you will be using in your light dimmer (type BT101) is built up of four layers of semiconductor material, as shown diagrammatically in Fig. 2*a*. Three of these are brought out, viz. the two outer layers and the inner *p*-layer. The currents we must observe are anode current I_a, cathode current I_k, gate current I_g and leakage current I_l.

The thyristor *triggers* (starts to pass current from anode to cathode) when, at a sufficiently high anode-cathode voltage, the voltage on the gate exceeds a certain *triggering threshold*. The device remains conductive, whatever the gate voltage, unless the anode-to-cathode voltage drops to zero.

The operation can be explained by means of the two-transistor analogue, illustrated by Fig. 2*b*. We see that the thyristor may be considered as a two-stage current amplifier (with a loop gain which is the sum of the h_{FB} values of the two transistors). Even with the anode at a positive and the cathode at a negative voltage, both transistors will be nonconductive if there is no gate voltage. When a small positive voltage is applied to the gate *TR*1 is made conductive and the resulting collector current will make *TR*2 also conductive. This occurs so quickly that we can speak of a short-circuit between anode and cathode. With the loop in operation, the gate is ineffective, but conduction naturally stops when the anode-to-cathode voltage is zero.

Now, when the supply source is a 50 Hz mains, V_{a-k} is zero during a very short period occurring at intervals of about one-hundredth of a second (see Fig. 3 which shows the output of a full-wave rectifier such as you will construct for the light dimmer).
This means that the end of the conductive interval is fixed and that we must vary the beginning of this interval if we want to vary the amount of power passed. This becomes possible when we adopt a method called *phase control;* it is the auxiliary circuit which provides the variable trigger pulses for the gate and for this reason it is called trigger circuit. We will combine the description of the trigger circuit with that of the whole circuit of the light dimmer.

Light Dimmer Circuit

See Fig. 5.
In the circuit diagram the "power part" has again been drawn in a more solid line than the "control part". Diodes *D*1-*D*4 form a full-wave rectifier bridge; *L1-L2-C1-C2 form a filter which prevents the spurious signals, produced by the thyristor when it switches on and off, from reaching the mains; R9 limits any switch-on transients.*

Realizing that it is *TR1* which should become conductive first and drive *TR2* into conduction, we can say that the all-important condition is: *M* must be more positive than *N* before a trigger pulse is passed on to the gate of *TH*.

Fig. 4 gives a graphical illustration of what goes on. The voltage at *N* (solid curve in Fig. 4*a*) is derived from that between *A* and *B* via voltage divider *R*3-*R*2, and hence the waveform is the same as that in Fig. 3. The voltage at *M*, also derived from that between *A* and *B* via *R*5-*R*8-*C*3-*R*7, may be adjusted by means of *R*8. The waveform in this case is a sawtooth due to

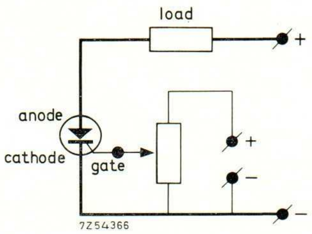


Fig. 1.

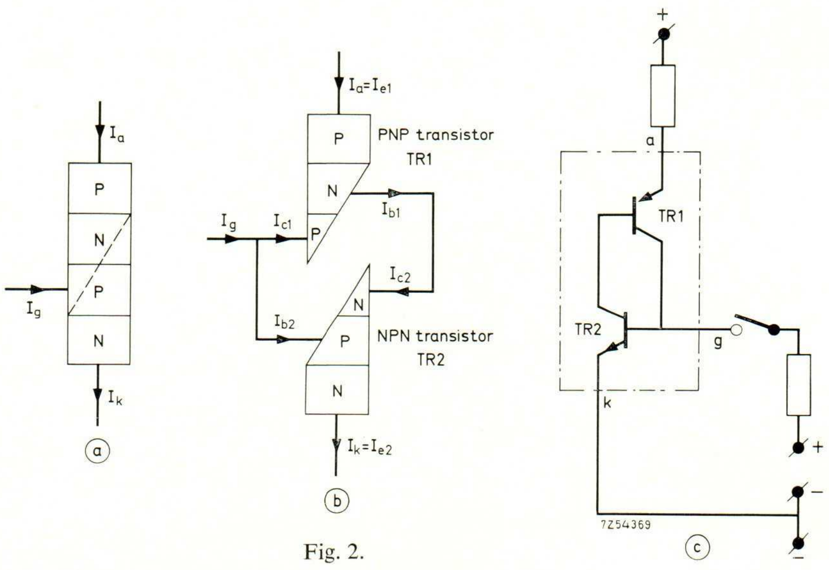


Fig. 2.

the presence of $C3$. The rate of charge of this capacitor depends on the value of $R8$ (see the dashed and the dash-dotted curve). At points $Q1$ and $Q2$ the voltage at M will slightly exceed that at N and the thyristor will then conduct, allowing the capacitor to discharge rapidly. In Fig. 4*b* the variations in the anode-to-cathode voltage of TH are depicted: when TH starts to conduct V_{a-k} suddenly drops to zero and remains zero during the conductive interval represented by angle α.

In this way a simple potentiometer enables us to vary the power supplied to lamp L from about 10 W (minimum conduction angle about 15°) to about 400 W (maximum conduction angle about 165°). $R7$ serves for fine adjustment of the minimum conduction angle.

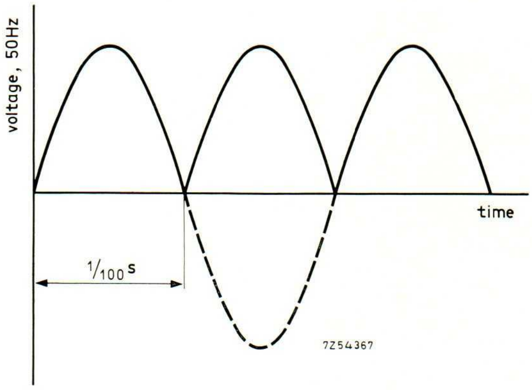


Fig. 3.

Parts list

			Catalogue number
R1	(carbon resistor	330 Ω, ¼ W)	2322 101 43331
R2	(carbon resistor	150 kΩ, ½ W)	2322 101 63154
R3	(carbon resistor	12 kΩ, ¼ W)	2322 101 43123
R4	(carbon resistor	560 Ω, ¼ W)	2322 101 43561
R5	(carbon resistor	100 kΩ, ¼ W)	2322 101 43104
R6	(carbon resistor	2.2 kΩ, ¼ W)	2322 101 43222
R7	(carbon trimming potmeter	0.1 MΩ, 1/10 W)	2322 410 05011
R8+S	(linear carbon potmeter	1 MΩ,)	2322 351 00714
R9	(carbon resistor	10 Ω, ¼ W)	2322 101 43109
D1, D2, D3, D4	(silicon diodes)		BY 126
D5	(silicon diode)		BA145
C1	(polyester capacitor	220 nF, 630 V)	2222 342 60224
C2	(polyester capacitor	220 nF, 630 V)	2222 342 60224
C3	(polyester capacitor	100 nF, 250 V)	2222 342 45104
TH	(p-gate silicon thyristor)		BT 101/500R
TR1	(n-p-n silicon transistor)		BC107
TR2	(p-n-p silicon transistor)		BC177
L1	(coil)		abt. 1.5 mH
L2	(coil)		abt. 1.5 mH

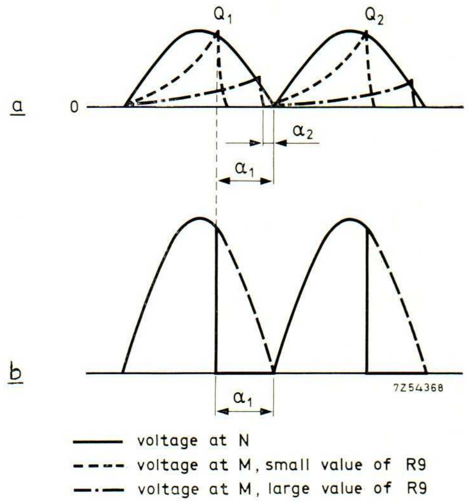


Fig. 4.

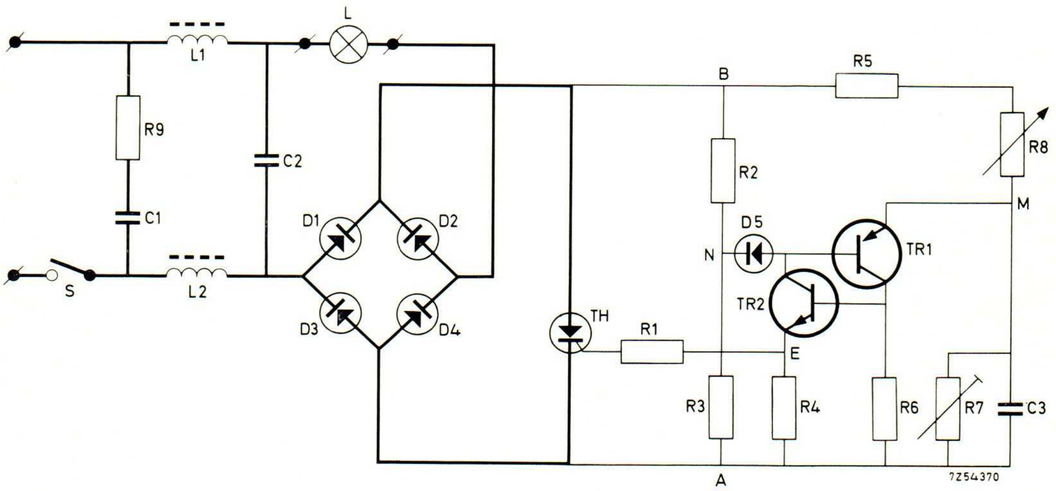


Fig. 5.

Spurious Signals

The spurious signals produced when the thyristor is triggered have very high frequencies; on entering the mains their amplitude should not be above 2 mV from 0.15 to 0.5 MHz or 1 mV from 0.5 to 3 MHz, and radiation should also be restricted. The filter (L1 etc.) protects the mains; spurious radiation can be minimized by providing an earthed metal can over the coils *L*1 and *L*2. CHECK THE EFFECTIVENESS OF THESE MEASURES!

Building the Unit

This will be a simple job. The housing shown in the photographs measured 8 x 8 x 4 cm. Attach the thyristor to a cooling plate (heat sink) of about 4 x 4 cm.

Coil Data

For winding the filter coils refer to Fig. 6.

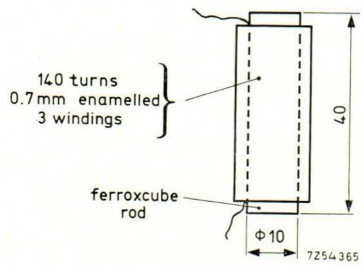


Fig. 6.

List of ratings and characteristics

BT101-500R Thyristor

V_{RWM}	=	Maximum working reverse voltage	400 V
V_{DWM}	=	Maximum working off-stage voltage	400 V
V_T	=	Maximum on-state voltage (I_T = 20 A; T_j = 25° C)	2.3 V
I_{TAV}	=	Average forward current	max. 6.4 A
I_{Trms}	=	Forward on-state root mean square current	max. 15 A
I_{TSM}	=	Non-repetive peak forward current (t = 10 ms)	55 A
I_{GT}	=	Gate current to trigger when off-state voltage V_D = 6 V and T_j = 25° C	10 mA
T_j	=	Junction temperature	max. 125 °C

We apologize for having omitted the following CARBON RESISTORS from the Parts List for the Transistorized Short-wave Converter ("Electronics for You" No. 8).

R1	10 kΩ,	1/8 W	2322 10133 103
R2	47 kΩ,	1/8 W	2322 10133 473
R3	1 kΩ,	1/8 W	2322 10133 102
R4	2.7 kΩ,	1/8 W	2322 10133 272
R5	5.6 kΩ,	1/8 W	2322 10133 562
R6	4.7 kΩ,	1/8 W	2322 10133 472

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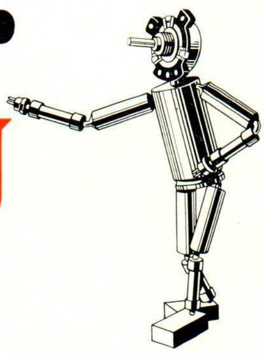


WINDSCREEN WIPER INTERMITTER

Dear Experimenter,

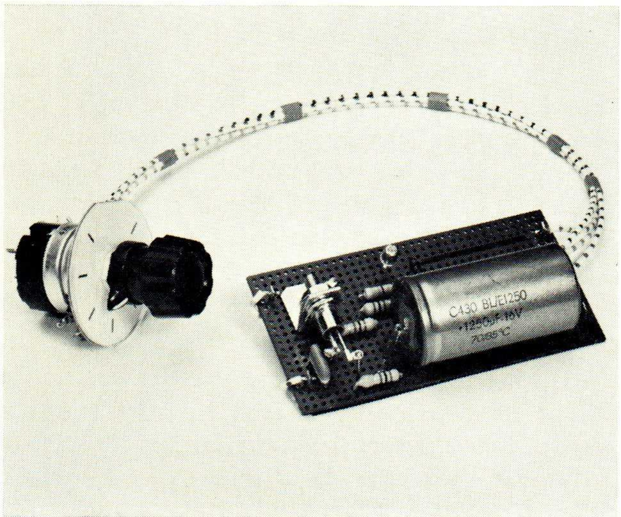
If you are (or know) a car owner who looks upon his car as being not merely a vehicle of transport but also a complex mechanism worthy of attention and care, you will be glad to read about Car Electronics in this pamphlet, the eleventh in the series "Electronics for You".

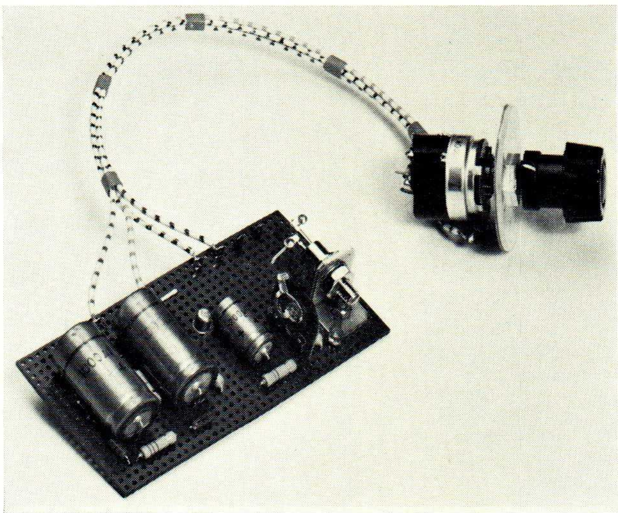
If, moreover, you are (or your friend is) aware of the necessity to drive safely, you can have only one reason for not being delighted with the actual subject – Windscreen Wiper Control –: it seldom rains in your country!

So, for the benefit mainly of those living in a country with normal rainfall, we will describe a Windscreen Wiper Intermitter. This is a simple yet valuable device using solid-state techniques (to put it in simpler terms: equipped with semiconductors), and enabling a driver to change the irritating and monotonous "swish-swish-swish" of the windscreen wipers to a more agreeable "swish - long pause - swish".

The unit is universal meaning that it can be used in cars with 6 V and 12 V systems, irrespective of whether the positive or the negative side of the battery is "earthed". It cannot, however, be employed in cars with an air motor for the windscreen wipers, nor in older cars where the wipers do not return to the rest position automatically.

Two typical circuits are given, the first causing the wipers to make a sweep (movement away from and back to the rest position or parking position), then to pause for an interval adjustable between 5 and 35 seconds, make another sweep, pause again, and so on. The second circuit differs from the first only in that it causes two sweeps to be made between pauses, thus allowing the window to be cleaned better, if necessary in combination with the water sprayers. In addition, the second circuit incorporates a pushbutton which can be mounted at a convenient position, for instance near the steering wheel, for operating the wipers during an interval.





Circuit Diagram of the Windscreen Wiper Intermitter

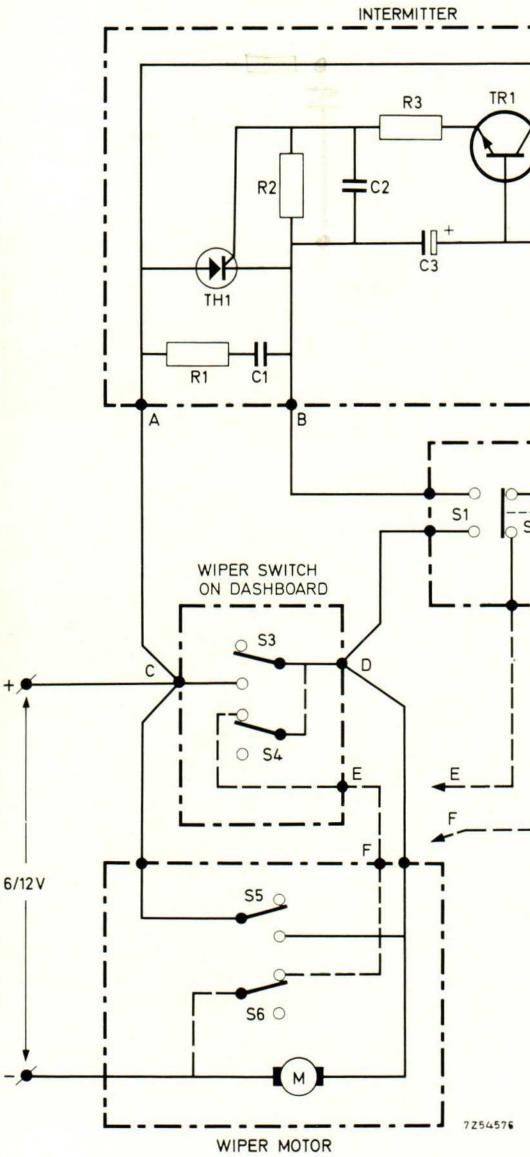


Fig. 1.

Parts list

For Circuit 1

		Catalogue number
TH1 (p-gate silicon thyristor)		BT100
		BT101
TR1 (silicon transistor)		BC107
D1 (silicon diode)		BA145
C1 (polyester capacitor	0.1 μF, 250 V)	2222 342 45104
C2 (polyester capacitor	22 nF, 250 V)	2222 342 45223
C3 (electrolytic capacitor	1250 μF, 16 V)	2222 063 15132
R1 (carbon resistor 2x10 Ω	parallel, ½ W)	2322 101 61109
R2 (carbon resistor	220 Ω, ½ W)	2322 101 63221
R3 (carbon resistor	100 Ω, ½ W)	2322 101 63101
R4 (carbon resistor	56 Ω, ½ W)	2322 101 63569
R5 (potentiometer, linear	100 kΩ, with switch)	2322 356 70311

Description of Circuit 1

See Fig. 1.

The essential component in the circuit is thyristor TH1 (for a description of thyristor operation see Electronics for You no. 10). Via terminals A and B and switch S1 it is connected in parallel with switch S3 (wiper switch on dashboard or section of this) and with switch S5 (this is operated by the wiper motor to make sure that the wipers return to the parking position). S5 is very important since, by closing, it short-circuits the thyristor thereby allowing it to turn off again.

As long as TH1 is off the battery voltage is present between its anode and cathode (via the motor); the timing capacitor, C35, is charged slowly via R5. This goes on until the voltage across C3 reaches a value high enough to make TR1 conductive. When that happens the gate-to-cathode current of TH1 will rise above the triggering threshold, thus causing TH1 to turn on. The motor starts running and S5 immediately closes, short circuiting TH1 and keeping the motor running until the wipers have returned to the parking position; in the meantime C3 discharges via R4 and D1 to the negative side of the battery. When this capacitor is "empty" TR1 becomes non-conductive, and the gate current of TH1 stops. At the end of the sweep S5 opens again, the motor stops, and C3 can re-charge. C1 and R1 provide a path for the induction voltage generated when the wiper motor stops and in this way two components protect TH1 against overloading.

The circuit operates on any voltage between 5 and 15 V. Care should be taken to connect A to the positive and B to the negative side.

Some car manufacturers provide switch S6, also operated by the wiper motor; this switch, in conjunction with switch S4 (ganged to the wiper switch), ensures rapid braking of the wiper motor in the parking position. If you possess a car with this arrangement you will have to interrupt the lead between S4 and S6 (between terminals E and F) to prevent damage to the thyristor. We suggest that you connect terminals E and F to the contacts of switch S2 because otherwise you would not be able to operate the wipers when the intermitter broke down (at least not without ducking under the instrument panel and, bent double on your back, head resting on the pedals, trying to re-connect S4 with S6).

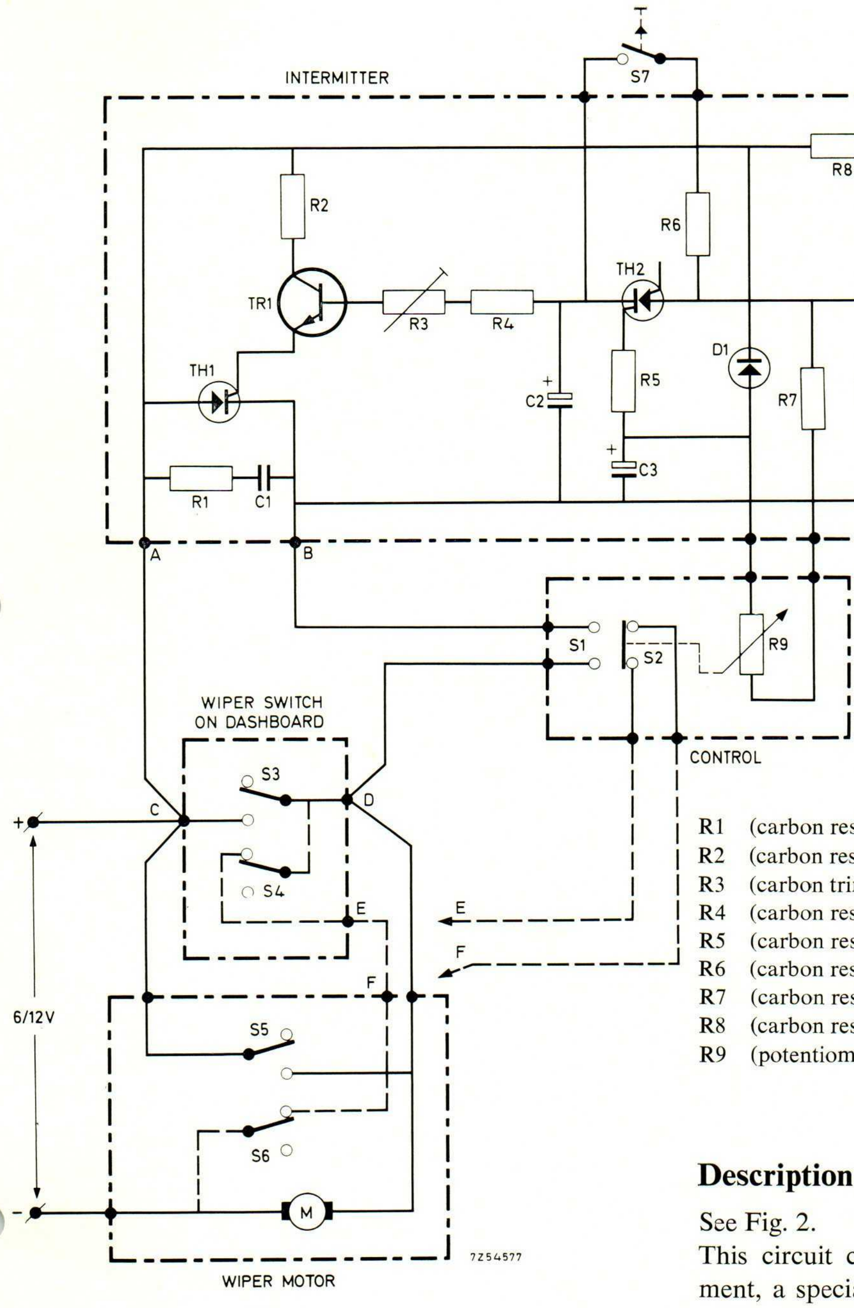


Fig. 2

R1	(carbon resistor 2x10 Ω parallel, ½ W)		2322 101 61109
R2	(carbon resistor	270 Ω, ½ W)	2322 101 61271
R3	(carbon trimming potentiometer	10 K)	2322 410 05007
R4	(carbon resistor	470 Ω, ½ W)	2322 101 61471
R5	(carbon resistor	6.8 kΩ, ½ W)	2322 101 61682
R6	(carbon resistor	10 Ω, ½ W)	2322 101 61109
R7	(carbon resistor	3.3 kΩ, ½ W)	2322 101 61332
R8	(carbon resistor	220 Ω, ½ W)	2322 101 61221
R9	(potentiometer, linear	100 kΩ, with switch)	2322 356 70311

Parts list for Circuit 2

		Catalogue number
TH1	(p-gate silicon thyristor)	BT100 BT101
TH2	(silicon controlled switch)	BRY39
TR1	(silicon transistor)	BC107
D1	(silicon diode)	BA145
D2	(zener diode)	BZY88 C4V7
D3	(silicon diode)	BA145
C1	(polyester capacitor 0.1 μF, 250 V)	2222 342 45104
C2	(electrolytic capacitor 200 μF, 10 V)	2222 001 14201
C3	(electrolytic capacitor 1000 μF, 10 V)	2222 023 14102
C4	(electrolytic capacitor 1000 μF, 10 V)	2222 023 14102

Description of Circuit 2

See Fig. 2.

This circuit comprises an additional controlling element, a special thyristor or Silicon Controlled Switch (SCS) of the type BRY39. It can also be regarded as a p-n-p transistor built into one envelope with an n-p-n transistor; all electrodes of the pair are accessible. See Fig. 3.

As long as TH1 does not conduct, the battery voltage is present between its anode and cathode (via the motor), and capacitor C4 will be charged rapidly via R8 and D3. The maximum voltage across this capacitor is limited to 4.7 V by Zener diode D2. Timing capacitor C3 is slowly charged via R7 and R9 and, when the voltage across it has reached a value of about 1.8 V, the p-gate current of TH2 will be large enough to make the SCS conductive. This results in part of C4's charge being transferred to C2.

With the voltage across C2 at about 3 V, TR1 becomes conductive. Consequently TH1 also turns on, the wiper motor starts and the wipers make one full sweep. On completion of this sweep TH1 turns off due to S5 opening but it is immediately re-triggered into conduction by C2 discharging through R4, R3 and TR1; the wipers then make the second sweep. R3 should be so adjusted that the base current of TR1 stops while the wipers are making the second sweep; in this way no third sweep will be made. Afterwards C3 re-charges via R7 and R9.

Again the circuit can operate from any voltage between 5 and 15 V. The function of switches S2, S4 and S6, and of C1 and R1 is the same as in Circuit 1.

Pushbutton switch S7 provides the means to let the wipers make a few sweeps during an interval, for instance when a passing car has been spraying dirt and mud all over your windscreen!

SILICON CONTROLLED SWITCH BRY39

A silicon controlled switch (SCS), of which the BRY39 is a typical example, is a p-n-p semiconductor device that structurally resembles a small thyristor except that all four electrodes are accessible. Functionally it is comparable to a low-power transistor combined with a holding circuit. The interaction between and the accessibility of the four electrodes open new and advantageous ways of carrying out many switching and logic operations for which two or more active elements would otherwise be needed.

Figure 3 is the simplified representation of the SCS and Figure 4 shows the symbol and electrode designations.

In principle it can be regarded as two transistors connected to each other as shown in Figure 5.

Quick Reference Data

anode-emitter voltage	V_{AE} max. 70 V
collector-emitter voltage	70 V $\geqq V_{CE} \geqq V_{AE}$
base-emitter voltage	V_{BE} max. - 5 V
emitter current d.c.	I_E max. 100 mA
emitter current, peak value	I_{EM} max. 500 mA
forward on-state voltage	
$I_A = 50$ mA; $I_C = 0$ $R_{BE} = 10$ KΩ	$V_{AE} < 1.4$ V
$I_A = 1$ mA; $I_C = 10$ mA	$V_{AE} < 1.2$ V
holding current	
$I_C = 10$ mA; $-V_{BB} = 2$ V; $R_{BE} = 10$ KΩ	$I_H < 1.0$ mA
total power dissipation up to $T_{amb} = 25$ °C	P_{tot} max. 250 mW
junction temperature	T_j max. 150 °C
collector current (d.c.)	I_C max. 50 mA
collector current (peak value)	I_{CM} max. 100 mA

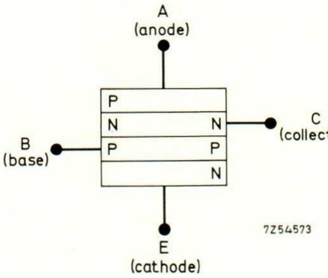


Fig. 3.

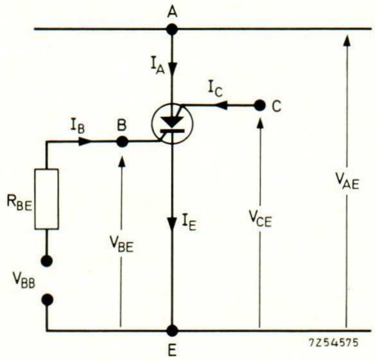


Fig. 4.

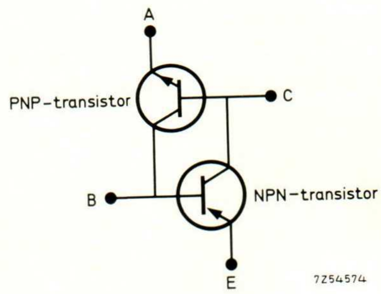


Fig. 5.

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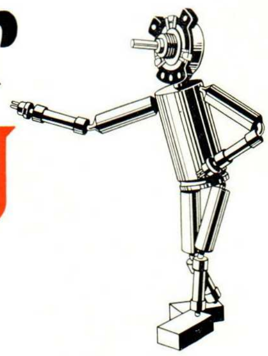


Fluorescent Lighting in Boat, Caravan or Tent

Dear Experimenter,

If you are in the habit of spending your holidays in a hotel or hired apartment you will be wasting your time by reading any further. This may disappoint you — if so, we feel sorry and can only say:

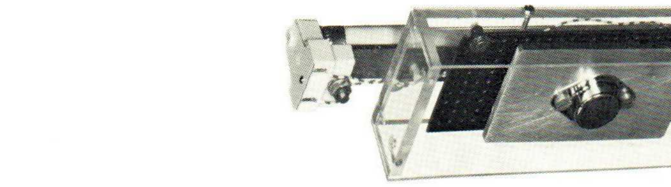
Please try again next month!

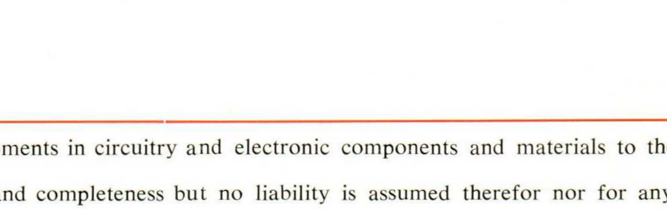
If, on the other hand, you own a motorboat, or like to spend your free time camping or caravanning, we can recommend you to try your hand at perfecting the lighting system in your boat, caravan or tent. This recommendation does not lose any of its force if you have already got past the candle and oil lamp stages and are quite content with a simple incandescent lamp connected to the battery of your motorboat or car. For, if you look at the table on the second page and compare the efficiency of an incandescent lamp with that of a fluorescent lamp, you will agree that the former does not give you too much light for the number of watts you have to put into it.

Assuming that you would like to try for yourself how fluorescent lighting suits you, we give the necessary information — starting with a description of the fluorescent lamp and its operation — in the following pages.

Wishing you many pleasant hours in your well-lit motorboat, tent or caravan, we ask you to remember

Optimum Results with Philips Products Only





Circuit Diagram of the Transistor Tester

TL

These letters stand for *tubular lamp* and form a kind of code name for our fluorescent lamps. These consist of a glass tube containing about 20 mg of mercury. The heat produced when the tube is ignited makes the mercury evaporate; eventually a vapour pressure of abt. 6×10^{-6} atm obtains. Further there are two electrodes, one at either end. In the 8 W TL which we are going to use the voltage necessary to heat the electrodes to the proper working temperature is 8 to 10 V (current about 150 mA); they then emit electrons (thermal emission). On the inside the glass tube is covered with a fluorescent powder.

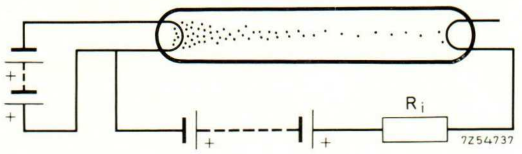


Fig. 1.

To ignite the lamp a high voltage is applied between the two electrodes. With the aid of Fig. 1 you can visualize what happens: the electrons emitted by the warm negative electrode start swarming towards the positive electrode. On this trip they collide with the few mercury-vapour atoms which are present even in the "cold" state. As these collisions multiply and the temperature rises the mercury will continue to evaporate as well as ionize. Eventually a current is conducted (which will be sustained when the low-voltage electrode supply is switched off).

In this "conductive" state the impact of the collisions is such that electrons are temporarily brought up to a higher energy level. On returning to their original level they emit invisible ultra-violet light (wavelength 0.254 μ) which, when striking the walls, excites the fluorescent powder to produce visible light rays (wavelengths between 0.4 and 0.7 μ).

For an 8 W TL the ignition voltage is 100 V; once the ionization of the mercury vapour has progressed sufficiently, conduction is maintained by a voltage as low as 40 V. Due to the high-internal resistance of the conversion circuit the supplied voltage automatically drops to this lower value as the current through the load (that is: the lamp) rises from 0 to 150 mA.

As already mentioned, we give you the data for building a circuit which converts the 6 or 12 V d.c. from your battery into a 40 kHz a.c. voltage of the required amplitude. This voltage is, however, not accurately sinusoidal, hence one of the electrodes functions as a cathode for a much longer interval than the other. This is why, as shown in Fig. 1, only that electrode is heated at the start.

A metal strip, running close to and parallel to the lamp, and connected to one of the electrodes, facilitates ignition by increasing the fieldstrength inside the lamp and thus enhancing ionization.

Some people advocate the ignition of TL's by a "cold start" — only a voltage of about 250 V being applied between the electrodes and no heater voltage to either of them. This method is not be recommended since it is harmful to the electrodes.

Compare a Fluorescent with an Incandescent Lamp

	Fluor. lamp 8 W		Incand. lamp 8 W
	colour 33 (cold white)	colour 29 (warm white)	
Luminous flux per W, 50 Hz supply	49 lm	50 lm	10 lm
Operating life	5000 h when the lamp is NOT used longer than 3h at a stretch. Strongly influenced by total number of starts		About 500 h

The conversion of the low-voltage d.c. (supplied by your battery) to a high-voltage a.c. (required by the lamp) is done in a circuit which has an efficiency of 80%. However, the high voltage has a frequency of 40 kHz and measurements have shown that the luminous flux of a fluorescent lamp at frequencies above 5 kHz is about 20% higher that at the mains frequency as given above. So your conclusion may be: "I get five times as much light from a fluorescent lamp than from an incandescent lamp."

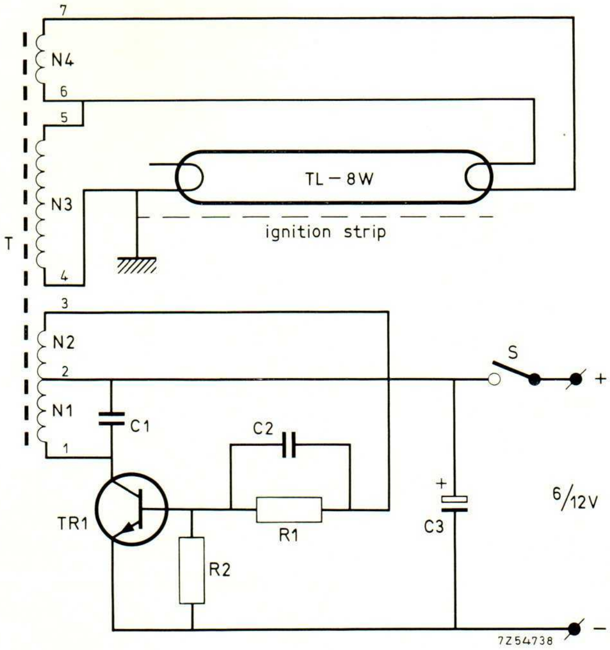


Fig. 2.

Parts List

		Catalogue number
TR1	(silicon power transistor)	BDY 20 or BDY 38
R1	(carbon resistor 100 Ω, ½ W, 6 V)	2322 101 63101
	(carbon resistor 1000 Ω, ½ W, 12 V)	2322 101 63102
	The value of these resistors has to be altered if the current drain differs from 1,7 A at 6 V resp. 0,8 A at 12 V	
R2	(carbon resistor 68 Ω, ½ W)	2322 101 63689
C1	(polycarbonate capacitor 0,047 uF, 100 V)	2222 344 20473
C2	(polycarbonate capacitor 0,1 uF, 100 V)	2222 344 20104
C3	(electrolytic capacitor 640 uF, 16 V)	2222 023 15641
T	{E 30/30/17 transformer} 2 x E-core E 30/15/17	4322 020 34630
	mounting parts (clasp)	4322 021 20170
	(spring)	4322 021 20230
	coilformer	4322 021 20250
L	TL - 8 W colour 33 white	9280 010 033..
	colour 29 warm white	9280 010 029..
	2 x holder for TL 61495/02	9145 000 014..
S	(switch)	any type

Building the Transformer

Take two E-cores of grade 3E1 ferroxcube, with the dimensions shown in Fig. 3, the coil former (made of reinforced polyester, with soldering pins arranged to fit the grid of printed-wiring boards), Fig. 4, and the mounting parts, Figs. 5 and 6, and a spool of enamelled copper wire of 0.25 mm diameter and 0.6 mm diameter. Then proceed as follows:

1. Wind winding *N1* — 25 turns of 0.6 mm wire (first layer); place insulating foil around this winding.

Circuit Description

See Fig. 2

Essentially the conversion circuit is a simple blocking oscillator with TR1 as the active component. Windings S1 and S2 of the transformer are wound in such a way that positive feedback takes place from collector to base. R1 differs according to the battery voltage: about 100 ohms for 6 V and about 1000 ohms for 12 V batteries. Capacitor C1 determines the frequency of oscillation (which should be about 40 kHz) and reduces the effects of higher harmonics that might cause radio interference. Winding S3 raises the collector voltage to a peak value of close to 100 V (under no-load conditions), and winding S4 provides enough power for heating the electrodes of the TL until this ignites.

C3 is included to ensure stable oscillation. The total current drain is about 1.7 A at 6 V and about 0.8 A at 12 V. The battery voltage should be kept between 4.5 and 8 V, and 9 and 15 V, respectively.

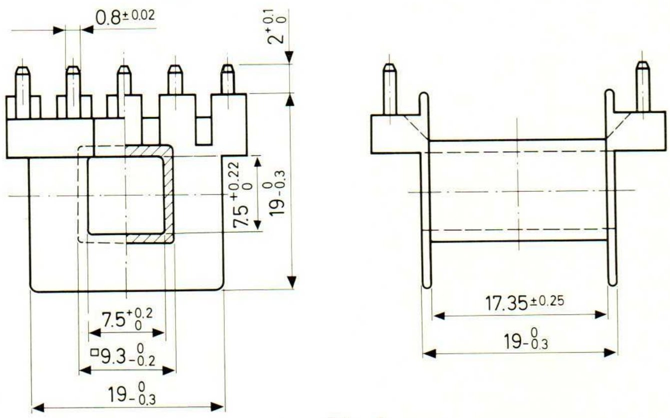


Fig. 4.

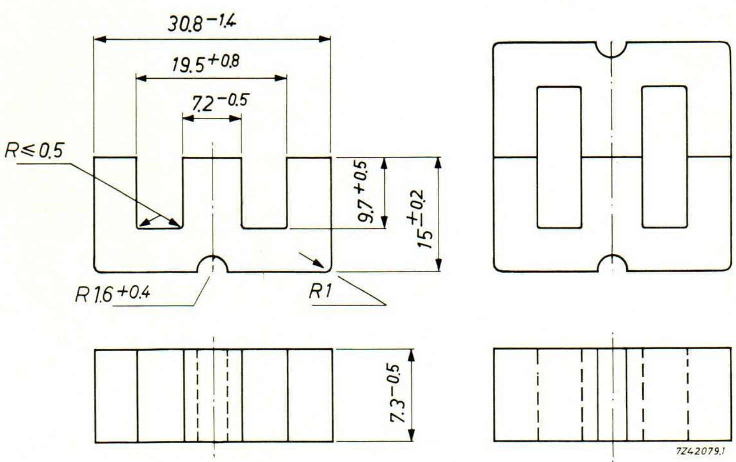


Fig. 3.

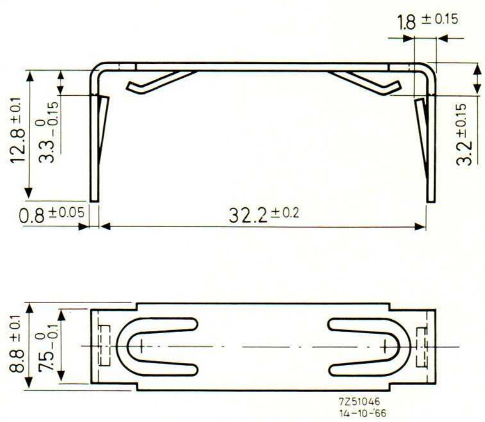


Fig. 5.

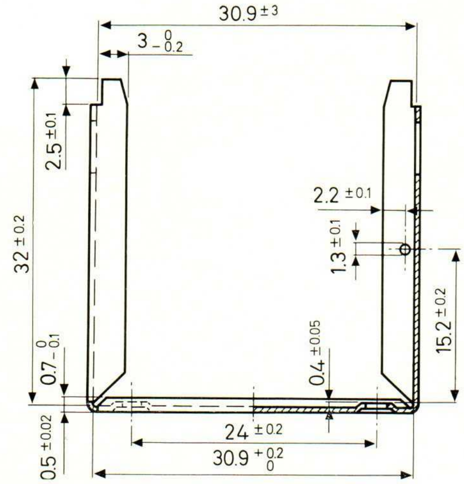


Fig. 6.

2. Wind winding *N*2 — 16 turns of 0.25 mm wire (second layer); place insulating foil.
3. Wind winding *N*3 — four layers of 50 turns of 0.25 mm wire, with insulating foil between consecutive layers. (3rd, 4th, 5th and 6th layer).
4. Wind winding *N*4 — 20 turns of 0.25 mm wire (7th layer); apply final layer of insulating foil.
5. Stick a piece of thin cardboard to each of the legs of one of the E-cores to provide for an air gap of about 0.5 mm between the legs of the two cores.
6. Place the two cores around the coil.
7. Place the clasp around the cores. Next push the spring over the legs of the clasp in such a way that lips A of the spring catch in the square holes in the clasp.

Building the Circuit

The electronic parts of the circuit are best housed in a simple oblong box. Make sure that the transistor is fitted on an aluminium heat sink measuring 4 x 5 cm and being 2 to 3 mm thick. Four or five ventilation holes in the oblong box suffice.

The additional ignition strip is fitted to the box in the way shown in the photograph, close to the lamp (in our prototype the lamp holders were attached to this strip). The strip is connected to point 4 of transformer winding *N*3, which should be earthed.

Silicon Diffused Power Transistor BDY38

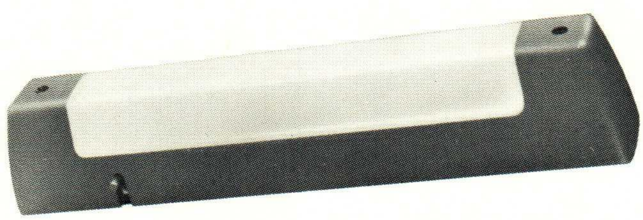
This is an n-p-n transistor in a TO-3 metal envelope that is well suited for the conversion job it has to perform in our circuit.

QUICK REFERENCE DATA

Collector-base voltage (open emitter)	V_{CBO}	max.	50 V
Collector-emitter voltage (open base)	V_{CEO}	max.	40 V
Collector current (peak value)	I_{CM}	max.	6 A
Total power dissipation up to $T_{mb} = 25$ °C	P_{tot}	max.	115 W
Junction temperature	T_j	max.	200 °C
D.C. current gain			
$I_C = 2$ A; $V_{CE} = 4$ V	h_{FE}	$>$	30
Transition frequency at f = 1 MHz			
$I_C = 1$ A; $V_{CE} = 4$ V	f_T	typ.	1 MHz

Philips Transistor Fittings for Fluorescent Lamps, 8 W, 6 and 12 V d.c.

Should you be interested in buying complete transistorized fittings, then ask your dealer for the
TCT 001/10806, 6 V, 2 A, 16 kHz, colour 33 - catalogue number 9100 250 203. .
colour 29 - catalogue number 9100 250 204. .
or the
TCT 001/10812, 12 V, 1 A, 16 kHz, colour 33 - catalogue number 9100 250 200. .
colour 29 - catalogue number 9100 250 201. .
The photograph below shows what you will get!



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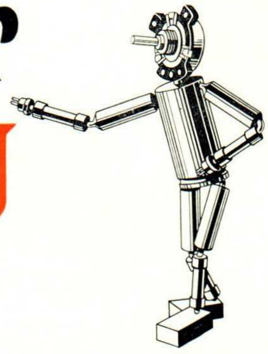
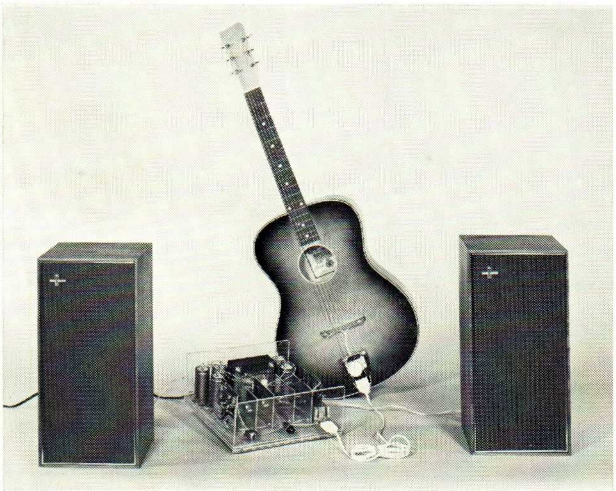


Stereophonic Guitar

Dear Experimenter,

Over the last years the popularity of the electric guitar has really taken wing. This is not in the last place due to the Beatles. Because of them this instrument is in great demand with the teenagers and twens, so that sales received such impetus that at present electric guitars are the best sold music instruments. A simple guitar is not too expensive, and it does not take too long to learn how to finger it. There are many kinds of guitars, each with its characteristic timbre, depending on shape, construction, the kind of wood used, strings, etc. Most guitars can easily be made electric with a magnetic pick-up coil, so that the volume can be increased and the timbre can be changed.

It was a job for the electronics engineer to design special distortion units with which the sound could be distorted to such an extent that the instrument could hardly be recognized for what it was. And yet, the pure sound of guitar music always wins in the end. Build your own electric guitar as described here, with hi-fi amplifiers to reproduce its original sound, but remember:



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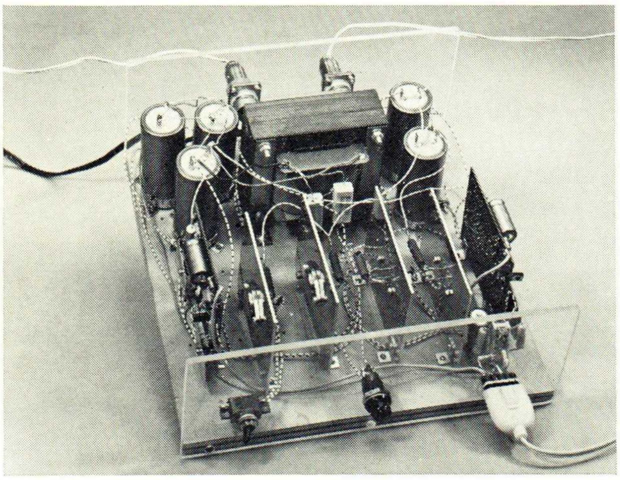
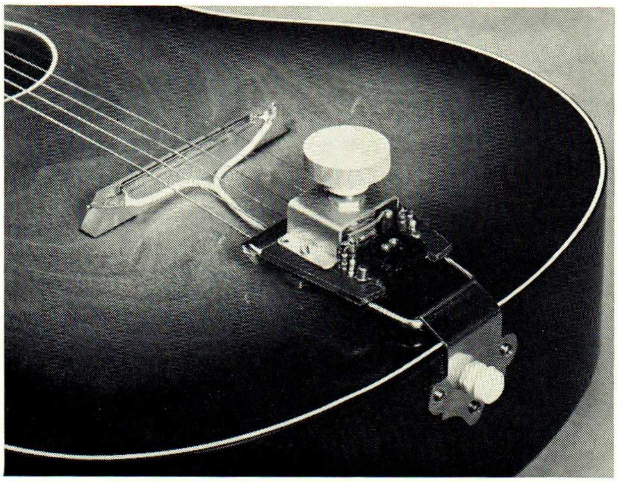




Piezoelectric Ceramics

It is a characteristic of ceramic PXE (piezoxide) material to produce electric voltages as soon as it is subjected to mechanical stress. This piezoelectric effect is widely employed to transduce mechanical vibration into electricity, and the other way round. There are various kinds of PXE, the most important being PXE3, PXE4 and PXE5. Each of them has its particular range of application:

PXE3 has excellent resonance properties and is therefore suitable for the filtering of high frequencies;

PXE4 combines in it considerable power handling and high resonant frequencies. It is often used, therefore, to produce strong ultrasonic vibrations, and is also suitable to produce high voltage peaks such as required for the ignition of combustion engines.

PXE5 has no resonant frequency, but is capable of transducing mechanical vibration into voltages with hardly any distortion. It is therefore used in pick-ups, microphones, etc. It is found to be quite useful as transducers in electric guitars.

Piezoelectricity was discovered in 1880 by Jacques and Pierre Curie. It occurs in natural crystals, such a quartz, tourmaline, Rochelle salt, etc. In contrast with modern ceramics, it is not always easy to give natural crystals the shape required for the purpose they are intended for.

In the future we shall have more to do with PXE's, and discuss them in further detail. We recommend those interested in this subject matter to order the Philips Application Book "Piezoelectric Ceramics" (order no. 9399 493 02001).

Description

We shall now describe how an electric guitar can be made to give a stereophony effect. This is done by means of Ceramic Transducers which can easily be fitted and have excellent reproduction qualities. A guitar with stereophony effect gives the impresson that the instrument has become much larger. This impression will be all the more striking if a hi-fi amplifier is used for sound reproduction. Ceramic transducers have the following great advantages over the conventional magnetic pick-up coils:

- Hi-fi reproduction
- Simple design thanks to small dimensions
- Stereophony effect
- Low price
- Suitable for both steel and nylon strings
- Can be fitted on any stringed instrument
- Each string can have its own transducer

Design

The ceramic transducers, called PXE chips for short, used for this purpose have very small dimensions: 5 mm diameter (round) and 1 mm thick. For mono reproduction one chip is placed under each string (Fig. 1). The chips are clamped between two brass conductors which are silver plated one side to make electric contact with the chips. All six chips are connected in parrallel. The strings press down on string "holders", round pieces of metal, 5 mm in diameter, with a groove across the centre. They serve to provide an effective mechanical coupling between the vibrating string and the chip, so that there will be a strong output signal (about 100 mV). At the top, the bridge is provided with six holes, ample 5 mm in diameter, to receive the chips and string holders. The dimensions of the bridge must, of course, correspond to those of the original one. Preferably a strip of felt is clamped between bridge and sound box of the instrument to reduce undesirable noises caused by bumps or friction on the sound box.

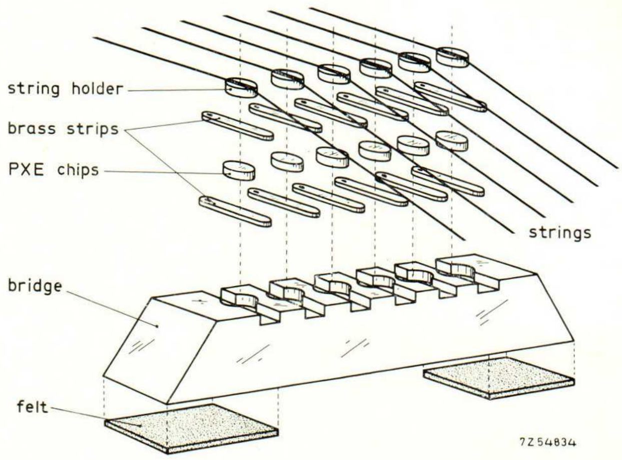


Fig. 1

For stereophony reproduction the procedure is different (see Fig. 2). The bridge then consists of two parts, a hard wooden or perspex base, and a metal rod with a diameter of about 5 mm fitting in the bridge. The rod has grooves through which the strings run, and is supported at each end by a PXE chip. The vibrations are distributed over the two chips in such a way that strings directly above sound louder than the others, which gives an impression of stereophony. The voltages produced by the chips are fed to the preamplifier by means of a screened microphone lead. As shown on the drawing, the upper parts of the chips are interconnected and earthed via the sceening of the lead; the lower parts of the chips are sensitive and are connected to the base of the BC109 in the preamplifier via the core of the lead. The output per chip in loaded condition is about 30 mV.

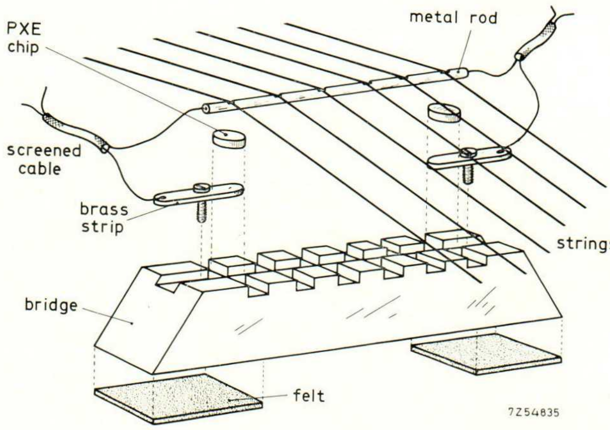
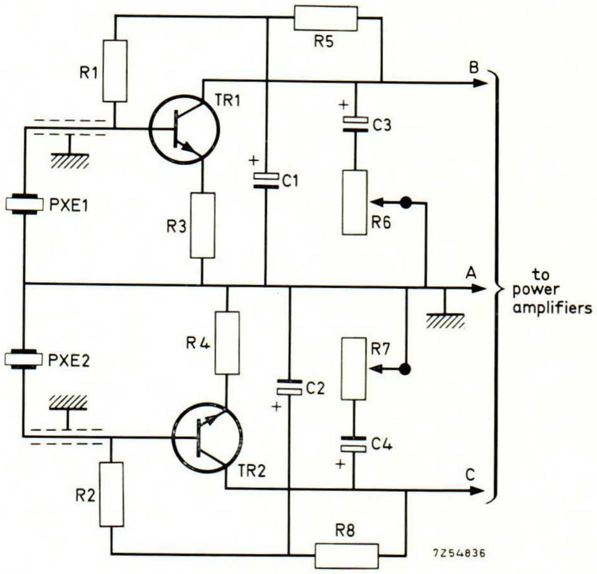


Fig. 2

The Preamplifier

The preamplifier amplifies the signal from the PXE chip about eight times. The transistors (BC109) are so connected that the input resistance matches the internal resistance of the PXE chips. Hence the non-de-coupled emitter resistances *R1* and *R2* (Fig. 3).

The preamplifier is fed from the power amplifier. Since the connection with the guitar consists of two single-core screened wires, the supply and the output signal must run through one wire. That is why the collector resistors of the BC109 are housed in the power amplifier. The base current is provided by the collector voltage via the resistors *R1* + *R5* and *R2* + *R8* respectively, with a decoupling by *C1* and *C2*, respectively. The volume is controlled with a logarithmic tandem potentiometer *R6* and *R7*, short circuiting the output signal as need be via isolating capacitors *C3* and *C4*.



Parts List of Pre-Amplifier

			Catalogue number
PXE1	piezoelectric ceramic disk 5 mm ø, 1 mm thick		8222 29306 070
PXE2	piezoelectric ceramic disk 5 mm ø, 1 mm thick		8222 29306 070
TR1	n-p-n silicon transistor		BC109
TR2	n-p-n silicon transistor		BC109
R1	carbon resistor	0.47 MΩ, 1/8 W	2322 10133 474
R2	carbon resistor	0.47 MΩ, 1/8 M	2322 10133 474
R3	carbon resistor	1 kΩ, 1/8 W	2322 10133 102
R4	carbon resistor	1 kΩ, 1/8 W	2322 10133 102
R5	carbon resistor	0.47 MΩ, 1/8 W	2322 10133 474
R6 } R7 }	23 mm tandem carbon potentiometer 47 kΩ (log.)		2322 36070 629
R8	carbon resistor	0.47 MΩ, 1/8 W	2322 10133 474
C1	electrolytic capacitor	10 μF / 16 V	2322 001 15109
C2	electrolytic capacitor	10 μF / 16 V	2322 001 15109
C3	electrolytic capacitor	10 μF / 16 V	2322 001 15109
C4	electrolytic capacitor	10 μF / 16 V	2322 001 15109

Parts List of Power Amplifier

			Catalogue number
C1	electrolytic capacitor	2.5 μF / 64 V	2222 00118 258
C2	electrolytic capacitor	2.5 μF / 64 V	2222 00118 258
C3	ceramic capacitor	2.7 nF / 500 V	2222 56302 272
C4	electrolytic capacitor	160 μF / 64 V	2222 02318 161
C5	polycarbonate cap.	22 nF / 250 V	2222 34245 223
C6	electrolytic capacitor	50 μF / 40 V	2222 00117 509
C7	ceramic capacitor	27 pF / 500 V	2222 56302 279
C8	ceramic capacitor	390 pF / 500 V	2222 56302 391
C9	polycarbonate cap.	10 nF / 250 V	2222 34245 103
C10	polycarbonate cap.	0.1 μF / 250 V	2222 34245 104
C11	electrolytic cap.	1600 μF / 64 V	2222 06018 162
C12	electrolytic cap.	640 μF / 25 V	2222 02316 641
C13	electrolytic cap.	1600 μF / 64 V	2222 06018 162
C14	electrolytic cap.	1600 μF / 64 V	2222 06018 162
C15	electrolytic cap.	1600 μF / 64 V	2222 06018 162
C16	polyester capacitor	0.1 μF / 250 V	2222 34189 104
C17	polyester capacitor	0.1 μF / 250 V	2222 34189 104
RL	loudspeaker	8 Ω, 30W	22 RH 480
T	transformer, secondary, 35 V-3 A		any type
S	switch		any type
TR1	p-n-p silicon transistor		BD178
TR2	n-p-n silicon transistor		BD137
TR3	n-p-n silicon transistor		BC148
TR4	p-n-p silicon transistor		BD138
TR5	n-p-n silicon transistor		BD137
TR6	n-p-n silicon power transistor		BDY20
TR7	n-p-n silicon power transistor		BDY20

			Catalogue number
D1	silicon diode		BY126
D2	silicon diode		BY126
R3	silicon diode		BY126
D4	silicon diode		BY126
R1	carbon resistor	10 kΩ, 1/4 W	2322 10143 103
R2	carbon resistor	150 kΩ, 1/4 W	2322 10143 154
R3	carbon resistor	150 kΩ, 1/4 W	2322 10143 154
R4	carbon resistor	33 Ω, 1/4 W	2322 10143 339
R5	carbon resistor	4.7 kΩ, 1/4 W	2322 10143 472
R6	carbon resistor	39 kΩ, 1/4 W	2322 10143 393
R7	carbon resistor	1.5 kΩ, 1/4 W	2322 10143 152
R8	carbon resistor	1 kΩ, 1/4 W	2322 10143 102
R9	carbon resistor	5.6 kΩ, 1/4 W	2322 10143 562
R10	carbon resistor	2.2 kΩ, 1/4 W	2322 10143 222
R11	carbon trimming potentiometer, 1 kΩ		2322 41100 004
R12	carbon resistor	1.2 kΩ, 1/4 W	2322 10143 122
R13	carbon resistor	47 Ω, 1/4 W	2322 10143 479
R14	carbon resistor	220 Ω, 1/4 W	2322 10143 221
R15	carbon resistor	1.5 kΩ, 1/4 W	2322 10143 152
R16	carbon resistor	68 Ω, 1/2 W	2322 10163 689
R17	carbon resistor	68 Ω, 1/2 W	2322 10163 689
R18	carbon resistor	10 Ω, 1/2 W	2322 10163 109
R19	wire wound resistor	0.47 Ω, 2 W	2322 32651 477
R20	wire wound resistor	0.47 Ω, 2 W	2322 32651 477
R21	carbon resistor	1 kΩ, 1/2 W	2322 10163 102
R22	carbon resistor	2.2 kΩ, 1/2 W	2322 10163 222
R23	carbon resistor	4.7 kΩ, 1/2 W	2322 10163 472

Output Amplifiers

See Fig. 4.

The two output amplifiers recommended for this installation can supply 25 W each. The output is intended for a low-ohmic loudspeaker of 8 Ω, such as the 30 W Philips loudspeaker used in the box type 22 RH 480 which box has separate high and low tone reproduction channels. In these amplifiers all phase-converting element such as output transformers have been avoided, so that a heavy feedback can be used resulting in very low distortion and a linear frequency characteristic from 20 Hz to 27 kHz. Furthermore a great deal of attention has been paid to stabilization against temperature and supply voltage fluctuations. The quasi-complementary output stage consists of two series-connected n-p-n silicon transistors *TR6* and *TR7* of the type BDY20. They are driven by a complementary driver stage consisting of *TR4* (n-p-n silicon transistor BD137) and *TR5* (a p-n-p silicon transistor of the BD138 type). A transistor *TR3* is connected between the two bases of the driver transistors to ensure a constant voltage difference which is about equal to the sum of the base-to-emitter voltages of *TR4, TR5* and *TR6*. The base currents of *TR4* and *TR5* can be so adjusted with *R11* that the ouput draws about 40 mA under no-load conditions. Cross-over distortion is then negligible.

The driver stage is controlled by a pre-driver transistor *TR2*. To ensure full drive of the two output transisitors *TR4* must be capable of supplying a sufficiently positive control signal to the base of *TR5*. This is done by applying positive feedback via *C6*, from the output to the junction between *R8* and *R9*. The pre-driver is d.c. coupled to *TR1*. With resistors *R2* and (*R3* + *R4*) the base of *TR7* is brought to a voltage which is about equal to half the supply voltage. The emitter of *TR1* receives the output voltage direct via *R5*. All transistors are so d.c. coupled that there is a heavy d.c. feedback keeping the output voltage equal to the base voltage of *TR7* plus the voltage drop across *R5* and the V_{BE} of *TR1* (thus about $\frac{1}{2}\ V_b$). The amplifier is in this way made insensitive to temperature variations; in addition, symmetric drive is maintained under supply-voltage fluctuations, whereas the spread in transistors is compensated at the same time. Via voltage divider *R15/R5—R4* and capacitor *C4* part of the output voltage is fed back to the input. The result is a 70-fold negative feedback which reduces distortion to such an extent that no more than 1% is measured under full load conditions (under no-load conditions $< 0.2\%$). The supply need not be stabilized. The maximum voltage is about 45 V at full load, and about 50 V under no-load conditions; the total current does not exceed 2 A; there is one supply for both amplifiers. The output transistors require a heat sink of about 80 cm², and the driver transistors are provided with a heat sink of about 12 cm². The input of the amplifier is connected to +15 V via resistor *R1* which is the collector resistor of one of the preamplifiers on the guitar (Fig. 3).

25W Silicon Output Stage with the BDY20

Performance data for a nominal load of 8 Ω

Output power at $d_{tot} = 1\%$ and f = 1 kHz	24.8 W
Input impedance	150 kΩ
Input sensitivity (for 25 W)	400 mW
Total harmonic distortion at onset of clipping	
f = 1 kHz	$< 0.15\%$
Intermodulation distortion	0.6%
Frequency response	20 Hz to 27 kHz
Supply voltage	45 V

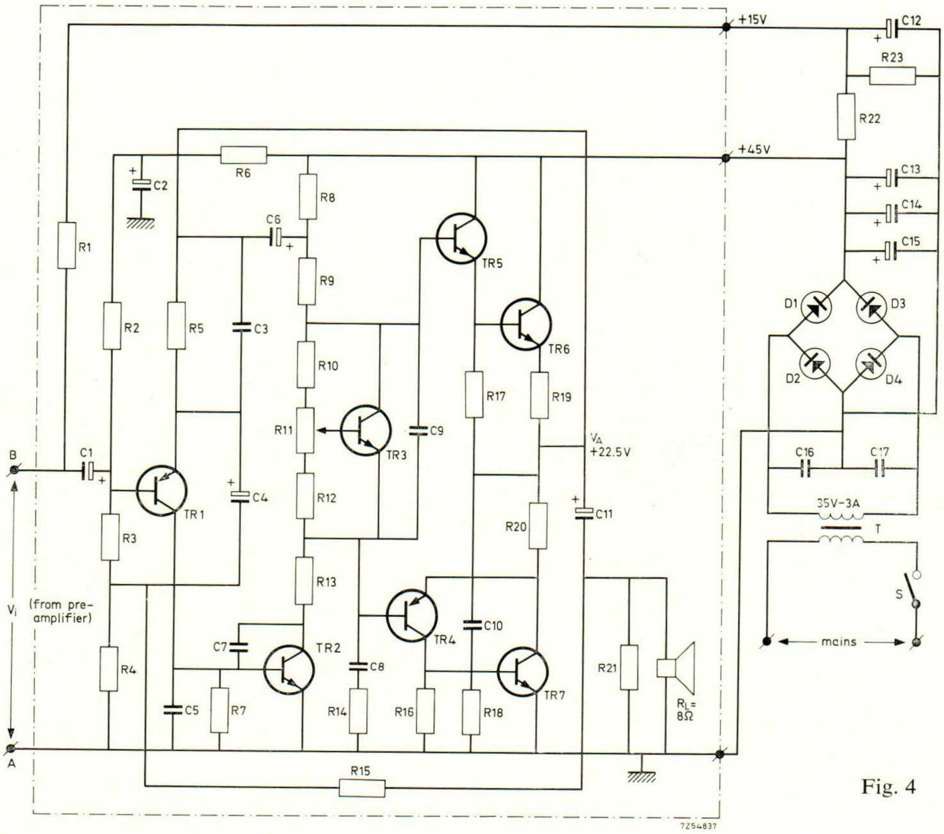


Fig. 4

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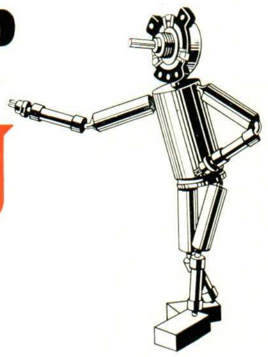

Light-dependent Intelligence Testers

Dear Experimenter,

Please don't think that we want you to dab at Psychology this time — it is "Electronic Riddles" or rather "Riddles Solved by Electronic Means" for which we are asking your attention.

Giving riddles is a favourite pastime in many countries, and in quite a number of cases they are rather complicated. The amount of fun which can be derived from this game then depends chiefly on the patience of the person who is giving the riddle — if he is very impatient he ends up giving you the answer. . . .

Perhaps, by building the circuits described in this leaflet, you may be able to strengthen the patience of any riddle giver. In any case the uninitiated will regard you as a magician provided that you

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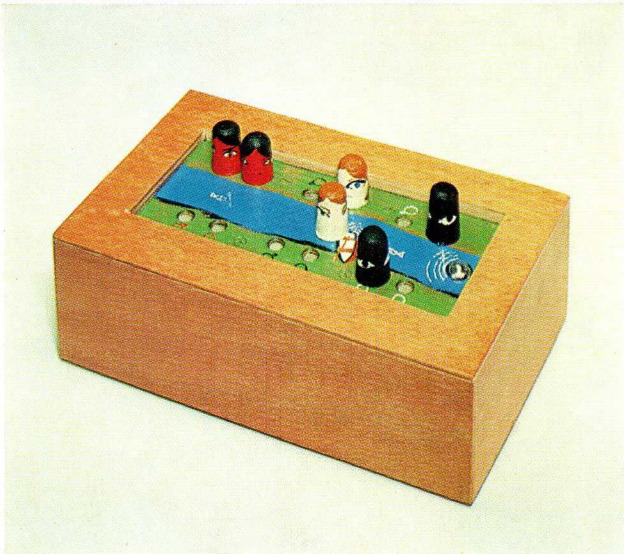


Riddle No. 1

Suppose you are a farmer and have to take a wolf, a goat and a large cabbage to the market. You know that you will have to cross a wide river in your small rowing boat which can carry only yourself and either the wolf, or the goat, or the cabbage. How are you going to do it?

Solution

There are two dangerous situations — when you leave the wolf and the goat unguarded the wolf will surely attack the other animal. When you leave the cabbage with the goat you won't have any cabbage to sell on the market!

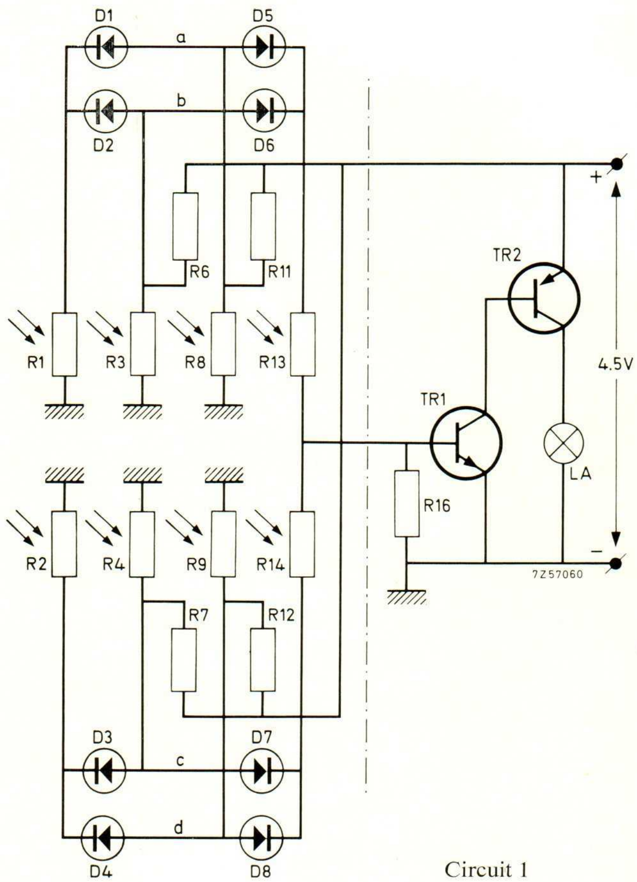
However, nothing will happen when you leave the wolf with the cabbage. You wil have to make your trips according to the following schedule:

	goat wolf cabbage		
1	− goat	→	+ goat
2		←	
3	− cabbage	→	+ cabbage
4	+ goat	←	− goat
5	− wolf	→	+ wolf
6		←	
7	− goat	→	+ goat
	− −		goat + wolf + cabbage

Circuit 1

Briefly, the Light-dependent Intelligence Tester 1 warns you when the situation is becoming dangerous. To this end the circuit consists of two parts, one which analyzes the situation (see Circuit Diagram 1 to the left of the vertical dash-dotted line), the other translates the findings of the analysis into either a danger signal (pilot lamp on) or a safe signal (pilot lamp off).

The essential components in the first part are eight LDRs, four on this side of the river (R1 - R3 - R8 - R13) and four on the other side (R2 - R4 -R9 - R14). Each has its specific function:
to be in the dark, that is, to have a high resistance as long as
the goat is on this side (R1), or on the other side (R2);
the cabbage is on this side (R3), or on the other side (R4);
the wolf is on this side (R8), or on the other side (R9);
the farmer is on this side (R13), or on the other side (R14).
Of course, the arrangement being symmetrical, there is no difference between this side and the other.



Circuit 1

Parts List — Circuit 1

		Catalogue Number
TR1	n-p-n Si transistor	BC107
TR2	p-n-p Si transistor	BC177
D1 - D8 incl.	silicon diode	BA145
R6, R7, R11, R12	carbon res., 68 kΩ, ¼ W	2322 101 43683
R16	carbon res., 22 kΩ, ¼ W	2322 101 43223
LA	pilot lamp, 6 V, 50 mA	
R1, R2, R3, R4, R8, R9, R13, R14	light-dependent resistor	2322 600 94001

The second part of the circuit is a simple d.c. amplifier with one n-p-n and one p-n-p transistor. Pilot lamp LA draws about 50 mA; when it is off, the total current consumption of your Intelligence Tester is less than half a milliamp. That is why we have not included an on/off switch — you may, however, decide to incorporate one with the idea of making people solve the riddle without the help of the lamp!

In the initial situation the farmer, his two animals and the giant cabbage are all on one side. So, the resistances of R1, R3, R8 and R13 (or R2, R4, R9 and R14) are all high and consequently there will be a positive voltage on lines *a* and *b* (or on *c* and *d*). Should the farmer leave his position alone, then the resistance of "his" LDR (R13 or R14, as the case may be) will become very low, the positive voltage on the corresponding lines is passed on to the d.c. amplifier, and the lamp gives the danger signal. Due to the presence of R11 and R6 (or R12 and R7) the same thing will happen when the farmer should take either the wolf or the cabbage with him. But, when he takes the goat with him, the positive voltage flows away to the negative lead, and no danger signal is given.

Hence, if you don't adhere to the schedule given under "Solution", the lamp will light to show you that you have made a mistake.

Building the Intelligence Tester No. 1

The photograph gives just an example of what the Tester can be made to look like. You may well decide to make it smaller or bigger — to add an on/off switch — to add a device showing on which side of the river the boat is — to add a compartment where the figures can be stored, etc. The main thing is to make the figures representing the farmer, the goat, etc., so big that they completely shield their LDR's from the light. The LDR's are neatly "buried" in holes along the river banks in such a way that the ambient light can easily reach the windows unless the figures are put over them. Make sure to play the game where there is sufficient light.

Riddle No. 2

This is very similar to Riddle No. 1 — again there is the river which has to be crossed in a boat too small for the purpose: it can hold only two persons. Three couples are waiting to cross, each man knowing that he cannot leave his wife alone, not even for a single moment because she then runs the risk of being molested by one of the other men. How do they get across?

Solution

To get themselves out of this tricky situation the fools will have to make the fool's number — eleven — of trips; a possible schedule is the following:

Mr. A + Mrs. A
Mr. B + Mrs. B
Mr. C + Mrs. C

1	– (Mrs. A + Mrs. B)	→	+ Mrs. A + Mrs. B
2	+ Mrs. B	←	– Mrs. B
3	– (Mrs. B + Mrs. C)	→	+ Mrs. B + Mrs. C
4	+ Mrs. C	←	– Mrs. C
5	– (Mr. A + Mr. B)	→	+ Mr. A + Mr. B
6	+ Mr. A + Mrs. A	←	– (Mr. A + Mrs. A)
7	– (Mr. A + Mr. C)	→	+ Mr. A + Mr. C
8	+ Mrs. B	←	– Mrs. B
9	– (Mrs. A + Mrs. B)	→	+ Mrs. A + Mrs. B
10	+ Mr. C	←	– Mr. C
11	– (Mr. C + Mrs. C)	→	+ Mr. C + Mrs. C
	----		Mr. A + Mrs. A Mr. B + Mrs. B Mr. C + Mrs. C

Circuit No. 2

In the main the same observations can be made as for Circuit No. 1 which was, however, less complicated. Also, the second part of Circuit No. 2 is not a d.c. amplifier but an amplifier followed by an astable multivibrator. Therefore in this case the pilot lamp flashes to indicate a dangerous situation.

The first part of the circuit comprises six LDRs on one side of the river and six on the other:
R3 (R4) for Mr. A; R14 (R16) for Mrs. A;
R21 (R22) for Mr. B; R32 (R33) for Mrs. B;
R38 (R39) for Mr. C; R49 (R51) for Mrs. C.
Transistors TR1 (TR2), TR3 (TR4) and TR5 (TR6) are connected between the "male" and "female" LDRs in such a way that they are conductive as long as the respective "male" LDRs are in the dark. All the time one of these transistors is conducting there can be no positive voltage across the associated "female" LDR, hence no positive signal can reach the base of TR7 (via lines a, b, c, or d, e, f) and no danger signal is given.

However, when a "male" LDR receives light (that is, when one of the husbands has left his wife) the corresponding transistor becomes non-conducting, and the voltage across the corresponding "female" LDR rises, resulting in a danger signal being given.

The circuit is fool-proof — if all three husbands have left their wives the positive voltages across the respective "female" LDRs will have been fed away via the low-resistance "male" LDRs — no signal. The circuit only fails when the illumination of the LDRs is inadequate — apparently in the dark everything is permitted!

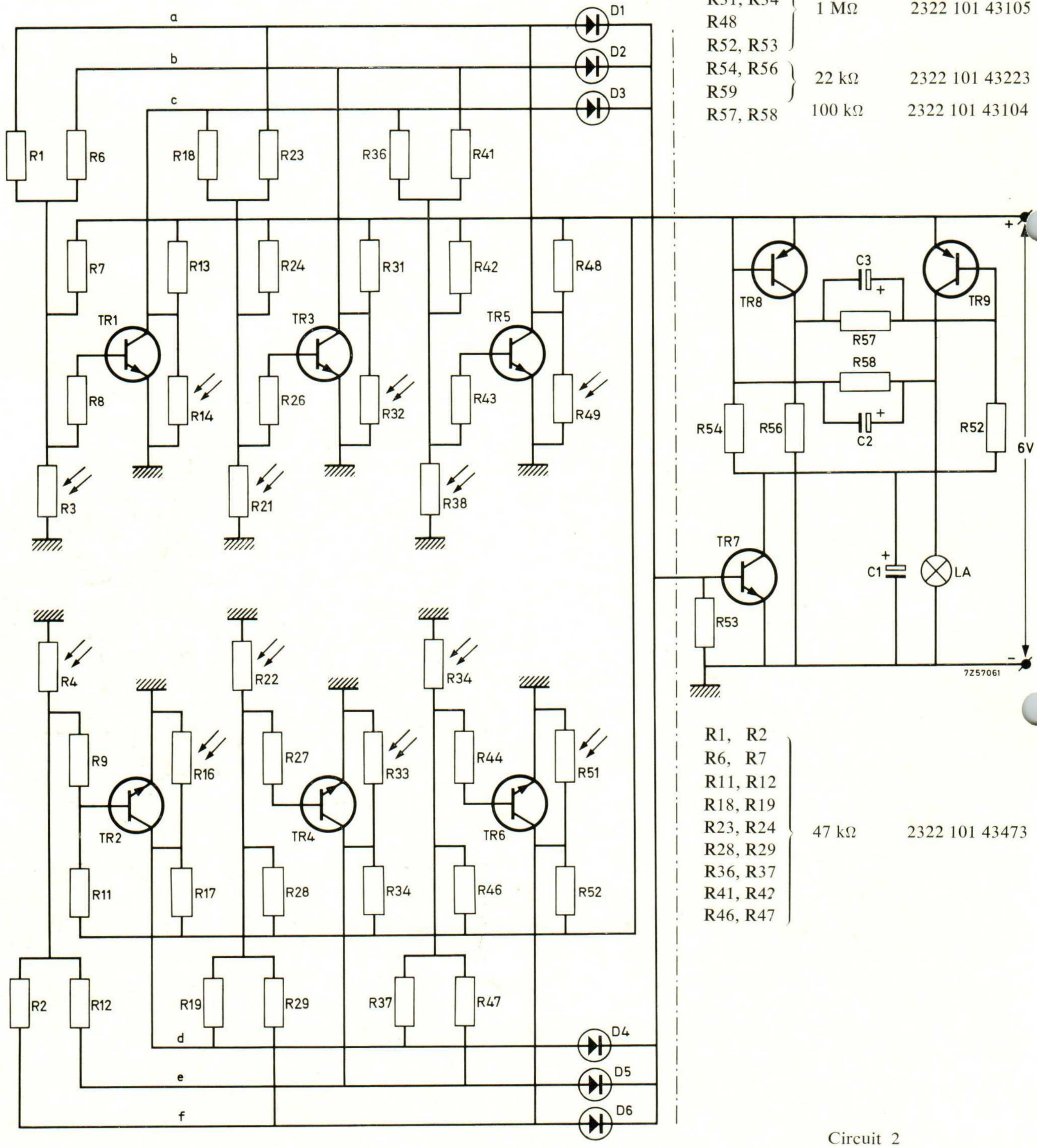
Building Intelligence Tester No. 2

Please re-read the advice given for the building of the other Tester.

Parts List — Circuit 2

		Catalogue Number
C1	Electrol. cap. 1.6 μF, 25 V	2222 001 16168
C2, C3	Electrol. cap. 6.4 μF, 25 V	2222 001 16648
LA	Pilot lamp 6 V, 50 mA	
TR1 - TR7 incl.	n-p-n Si transistor	BC107
TR8, TR9	p-n-p Si transistor	BC177
D1 - D6 incl.	silicon diode	BA145

		Catalogue number
R3, R4; R14, R16; R21, R22; R32, R33; R38, R39; R49, R51	Light dependent resistors	2322 600 94001
Carbon resistors, ¼ W		
R8, R9; R26, R27; R43, R44	680 kΩ	2322 101 43684
R13, R17; R31, R34; R48; R52, R53	1 MΩ	2322 101 43105
R54, R56; R59	22 kΩ	2322 101 43223
R57, R58	100 kΩ	2322 101 43104
R1, R2; R6, R7; R11, R12; R18, R19; R23, R24; R28, R29; R36, R37; R41, R42; R46, R47	47 kΩ	2322 101 43473



Circuit 2

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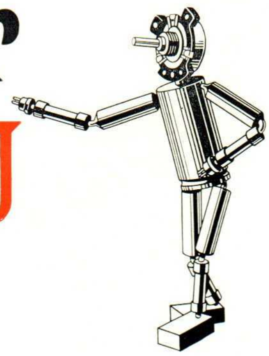
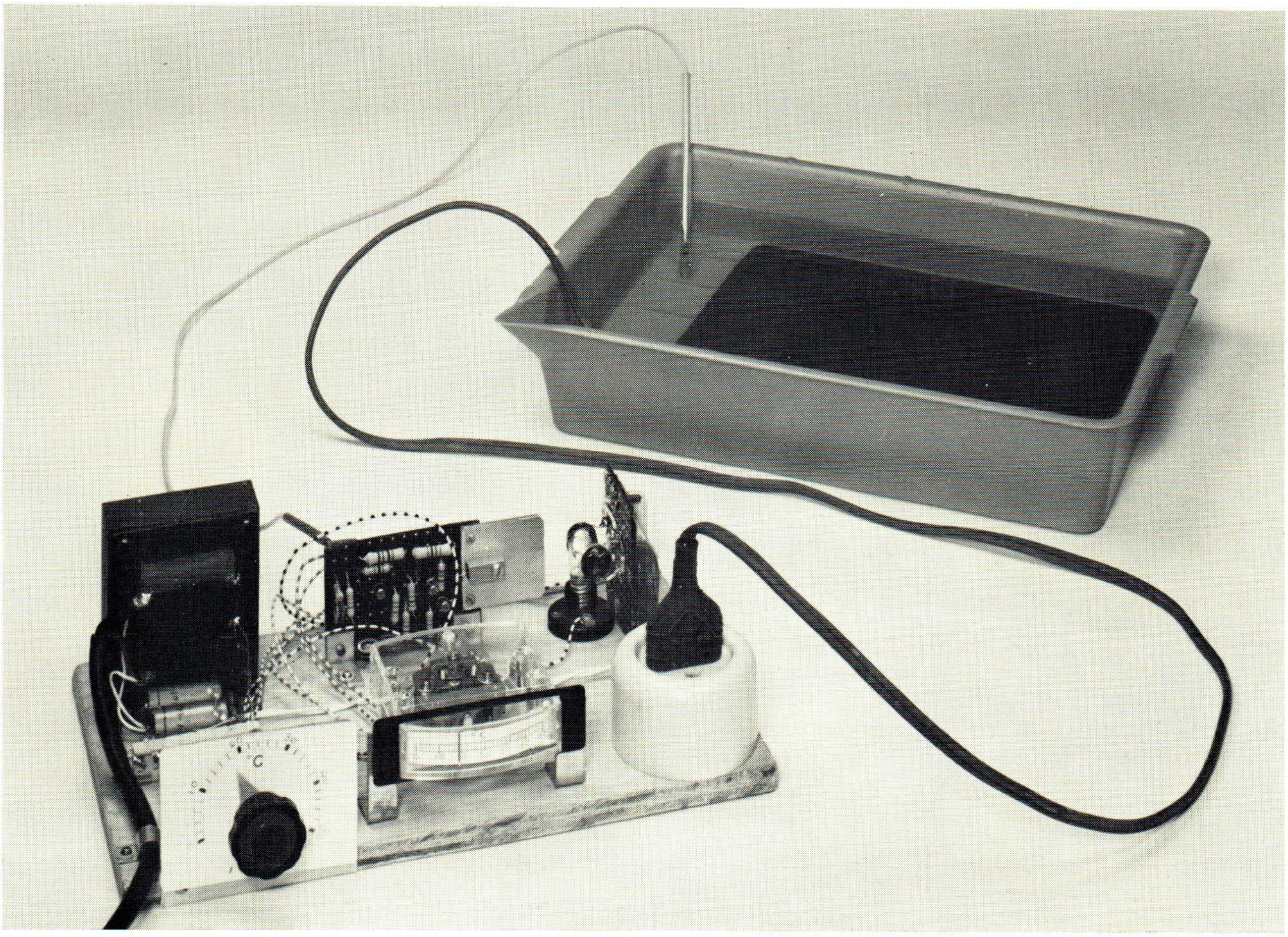


Automatic Heating System

Dear Experimenter,

We have called this month's subject "Automatic Heating" although we realize that, in the true Jules Verne spirit, we ought to have used a more descriptive phrase, such as "Controlling Heat by Light"... Poor Jules Verne, to have lived in utter unawareness of the many functions that would be performed long after his death by small objects not bigger than Captain Nemo's ring and called *semiconductors* . . .

Enough about Jules Verne – back to processes that require the temperature of a certain volume of liquid to be substantially constant. Whether you like to (or have to) do some chemical experiments, or are a develop-it-yourself photographer, or again spend much time and money breeding rare tropical fish – you have to keep the temperature in some tank and/or basin constant within very narrow limits. Assuming that you are also the right kind of *electronic* experimenter we enable you this time to bring a number of semiconductor devices with widely differing characteristics together in a circuit with which you can control heat by light.



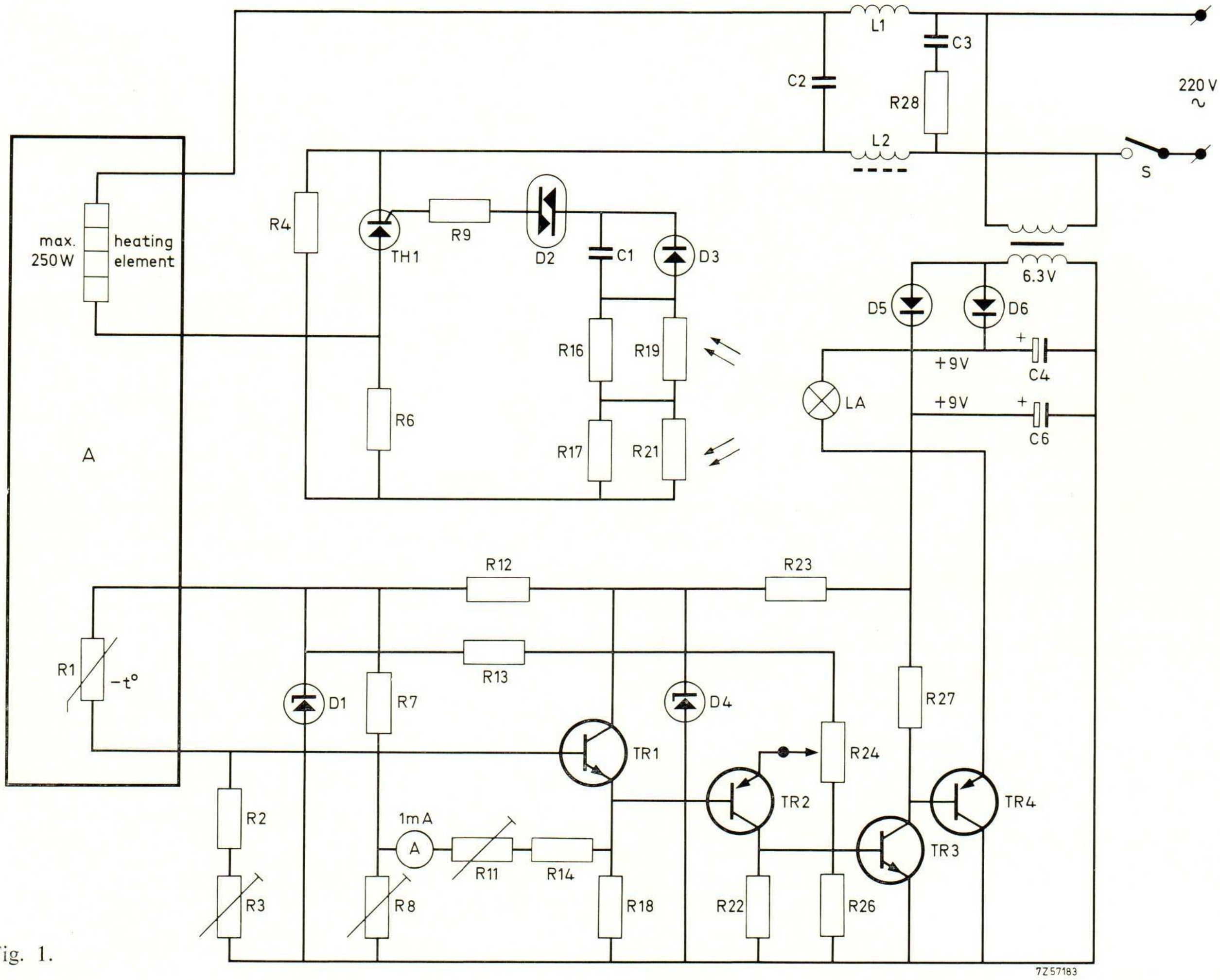
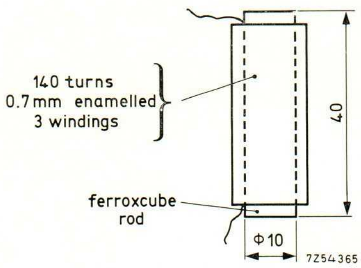


Fig. 1.

Parts List

			Catalogue number
R1	NTC thermistor		2322 627 11472
R2	carbon resistor	1.5 kΩ, ¼ W	2322 101 43152
R3	trimming potentiometer	2.2 kΩ	2322 401 05005
R4	carbon resistor	15 kΩ, 1 W	2322 101 73153
R6	carbon resistor	27 kΩ, 1 W	2322 101 73273
R7	carbon resistor	470 Ω, ¼ W	2322 101 43471
R8	trimming potentiometer	220 Ω	2322 101 05002
R9	carbon resistor	100 Ω, ¼ W	2322 101 43101
R11	trimming potentiometer	1 kΩ	2322 101 05004
R12	carbon resistor	68 Ω, ¼ W	2322 101 43680
R13	carbon resistor	1 kΩ, ¼ W	2322 101 43102
R14	carbon resistor	1.5 kΩ, ¼ W	2322 101 43152
R16	carbon resistor	0.22 MΩ, ¼ W	2322 101 43224
R17	carbon resistor	0.22 MΩ, ¼ W	2322 101 43224
R18	carbon resistor	2.2 kΩ, ¼ W	2322 101 43222
R19	LDR		2322 600 95001
R21	LDR		2322 600 95001
R22	carbon resistor	1 kΩ, ¼ W	2322 101 43102
R23	carbon resistor	47 Ω, ¼ W	2322 101 43470
R24	carbon potentiometer	1 kΩ	2322 350 70604
R26	carbon resistor	1 kΩ, ¼ W	2322 101 43102
R27	carbon resistor	560 Ω ¼ W	2322 101 43561
R28	carbon resistor	10 Ω, ¼ W	2322 101 43109
C1	polycarbonate cap.	0.33 μF, 250 V	2222 342 44334
C2,C3	polyester capacitors	220 μF, 630 V	2222 342 60224
C4,C6	electrolytic cap.	1500 μF, 16 V	2222 026 15182



TR1	n-p-n silicon transistor		BC107
TR2	p-n-p silicon transistor		BC177
TR3	n-p-n silicon transistor		BC107
TR4	p-n-p germanium transistor		AC188orBD136
D1	voltage regulator diode		BZY88/C5V1
D2	diac		BR100
D3	silicon diode		BA100
D4	voltage regulator diode		BZY88/C6V8
D5	silicon diode		BA100
D6	silicon diode		BA145
TH1	thyristor		BT100A/500R
A	mA meter 1 mA		any type
LA	lamp 6 V, 0.2 A		any type
L1	coil	abt. 1.5 mH	any type
L2	coil	abt. 1.5 mH	any type

Principle of Operation

Both electrically and functionally the system consists of two main sections — one in which the temperature in the liquid is first measured and next compared with a reference (or wanted) temperature *(measuring section),* and another section which makes sure that just enough heating power is supplied to reach and maintain the wanted temperature *(power section).*

The input voltage for the measuring section is produced by a *N*(egative)*T*(emperature)*C*(oefficient) thermistor, placed in the liquid of which the temperature has to be controlled. This voltage is first passed through an amplifier to obtain a signal that can be shown by a milliammeter. The meter is calibrated in degrees Celsius and serves as an accurate thermometer.

Next the signal is compared with a reference signal, in this case the voltage across a potentiometer. When the "NTC" signal is stronger than the "potentiometer" signal, the temperature in the liquid is too low (and vice versa). When the difference is more than about 0.7 V, a transistor is driven into full conduction and as a result a 6 V incandescent lamp comes on. When the "NTC" signal is between 0.5 and 0.7 V stronger than the potentiometer signal, the lamp will glow faintly and with a difference of less than 0.5 V it will go out.

The light produced by the lamp falls on two LDRs forming part of the power section. So we may say that the only "connection" between the two sections is provided by light. In this way the power section, which is connected direct to the mains, is isolated properly from the measuring section. The intensity of the light falling on the LDRs determines how much power is passed by a thyristor to the heating element: when the lamp is fully alight the amount of power is maximum, but this decreases as the lamp glows more faintly. Finally a stable situation is established in which the temperature remains constant.

Circuit Description

See Fig. 1.

The bottom half of the diagram constitutes the measuring section; the supply voltage for this section is first stabilized at 6.8 V by Zener diode D4 and next at 5.1 V by Zener diode D1. This is done to make the voltage across NTC thermistor R1 insensitive to mains voltage as well as load variations. R3 serves to vary the voltage across R1 and thus to adapt the temperature calibration of milliammeter A to the user's needs.

The voltage across R1 is amplified by emitter follower TR1 and next shown by the milliammeter. R8 is for adjusting the minimum temperature that one wants to read, R11 for the maximum temperature.

The emitter voltage of TR1 is compared with the voltage at the wiper of R24; the difference voltage is amplified by TR2, TR3, TR4. In this arrangement the current through TR4 may vary considerably so that the voltage for lamp LA in its collector circuit has to be taken from a different rectifier branch than the supply voltage for the measuring section. Also, TR4 has to be cooled properly – it is imperative that a heat sink of at least 3 x 4 cm be provided.

The rectifier branches, the 6.3 V/1 A transformer, the interference suppression filter with C2, C3, L1, L2, D28 and the heating element form the power section proper. What remains is the power *control* circuit that really makes for the smooth and accurate handling of heating energy. It consists of thyristor TH1 and its triggering circuit.

The operation of thyristors was described in some detail in Electronics for You no. 10 which dealt with a single-thyristor light dimmer.

The components of the triggering circuit can be seen to be: LDRs R19 and R21 with their shunt resistors R16 and R17; diac D2 about which more information will be given on the final page; resistors R4, R6 (forming a voltage divider) and R9; capacitor C1.

With the lamp full on – hence with the LDR resistance being minimum – C1 becomes charged to the breakover voltage of diac D2 very soon after the positive half-cycle of the mains voltage has started. The diac then becomes conductive, so that the voltage across C1 can reach the thyristor gate and trigger the thyristor into conduction. Power is thus supplied to the heating element during almost the entire positive half-cycle. With the lamp producing half the maximum amount of light the diac will break over, and the thyristor become conductive, about half-way the positive half-cycle. Finally, when the lamp is not on, the resistance of the LDRs will be maximum, in this case so high as to prevent C1 from acquiring sufficient charge during the positive half-cycle. This means that the thyristor remains in the off-state so that no power is supplied to the heating element.

Naturally, the voltage across the LDRs must remain within the limits stated. That is why two series-connected LDRs are employed and why voltage divider R4, R6 is incorporated. Diode D3 prevents the thyristor gate from being damaged by negative voltage pulses. The thyristor should furthermore be mounted on a heat sink of at least 3 x 4 cm. The interference suppression filter mimizes the chance that transients produced by the thyristor are a nuisance to other users of the same electric mains.

Building the Unit

The photograph on the front page illustrates one possible arrangement:

— the supply circuit (to the left);
— the measuring section (background centre);
— the power section (to the right);
— the milliammeter (foreground centre);
— the temperature-setting potentiometer (foreground left).

The LDRs and lamp LA are visible because the housing around them was removed before the photograph was taken; the housing is necessary since all ambient light must be kept away from the LDRs.

Winding data for coils L1 and L2 are to be found in the sketch under the circuit diagram on page 2.

Mount the NTC thermistor in a plastic or glass tube made watertight at either end with a plug of e.g. Araldite or a similar material through which the leads can be brought out.

Draw the temperature scale for the milliammeter with the aid of a thermometer of good quality. Establish the point of 0 °C by using a cube of ice taken from the refrigerator, and the 37 °C point by measuring the temperature of your body (unless you feel feverish).

Brief Specifications for the Main Components

LDR type 2322 600 95001

Dark resistance value	> 10 MΩ (measured after 30 min. in total darkness)
Light resistance value	75-300 Ω (measured at 1000 lux)
Recovery rate	> 200 kΩ/s (resistance rise per second at falling light intensity)
Permissible voltage	150 V (peak)
Capacitance	< 6 pF
Ambient temperature range	—20 °C to + 60 °C
Encapsulation	plastic

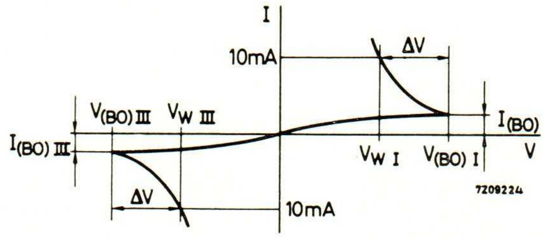
P-gate Silicon Thyristor BT100A/500R

Quick reference data

Crest working reverse voltage		400	V
Crest working off-state voltage		400	V
Average forward current	max.	2	A
Non repetitive peak forward current ($t = 10$ ms)	max.	40	A
Junction temperature	max.	100	°C
Current to trigger all devices $V_D = 6$ V; $T_j = 25$ °C	>	10	mA

Diac type BR100

This is a double diode especially designed for the triggering of thyristors (including triacs or bidirectional triode thyristors). The voltage-current characteristic is shown below.



When the voltage applied across a diac exceeds the breakover value ($V_{(BO)}$), its resistance turns negative.

Quick reference data

Breakover voltage	28 to	36	V
Breakback voltage at $I_F = 10$ mA	>	6	V
Repetitive peak current ($t \leqq 20$ μs)	max.	2	A

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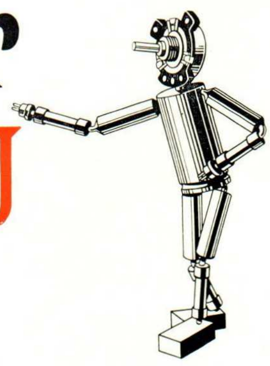

Automatic on/off Switch

Dear Experimenter,

There isn't much to tell about controlling light by means of light, it's such a straightforward thing to do. So, by way of introduction let's just say that the circuit to be described in the following pages makes some light or lights come on when it becomes dark — *how* dark can be set accurately — or off when it is light enough. It is so designed that the current drain under rest conditions is very low, and it is very easy to build.

If this is all, what makes this Automatic on/off Switch so attractive? Its usefulness! It can be made to control car parking lights, boat mast lights, obstacle lights on roads, and a host of other lights one so easily forgets to switch on or off manually.

Besides, there's something special about the new type of LDRs used in the circuit, so be sure to read about these on page 3 and . . . . be sure to

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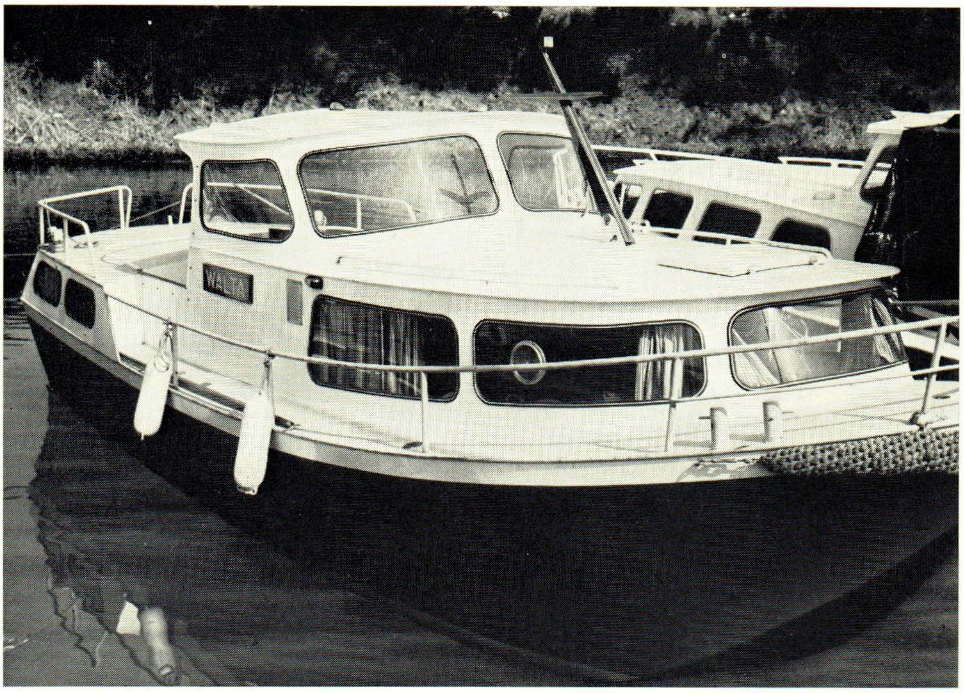


Circuit Diagram of the Automatic on/off Switch

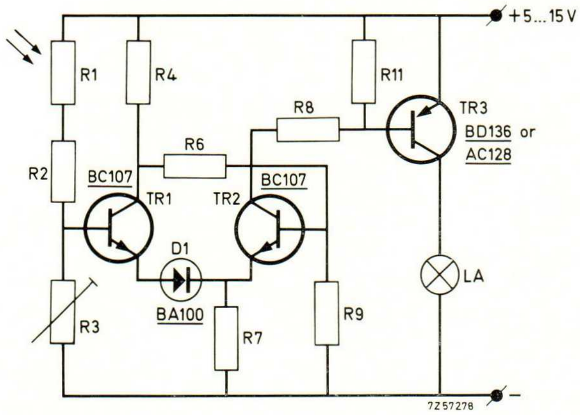


Fig. 1.

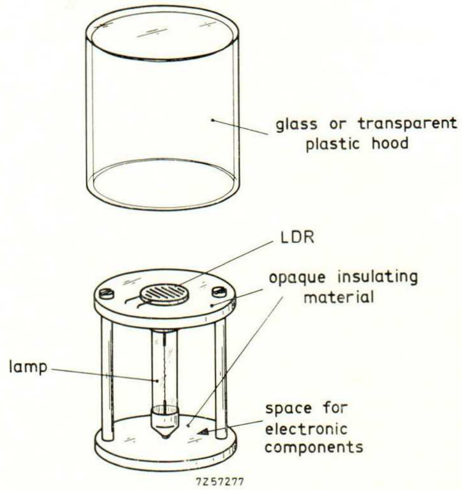


Fig. 2.

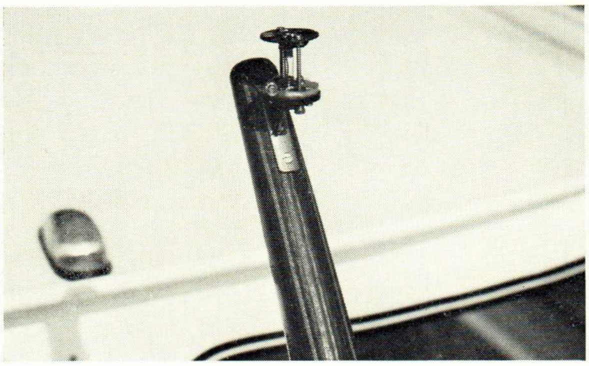


Fig. 3.

Parts List

			Catalogue number
TR1, TR2	n-p-n Si transistor		BC107
TR3	p-n-p transistor		BD136 or AC128
D1	Si diode		BA100
R1	light-dependent resistor		2322 600 93001
		or	2322 600 94001
		or	2322 600 95001
		or	RPY58
R2	carbon res. 2.7 kΩ, 1/4 W		2322 101 43272
R3	trimming potentiometer of 4.7 kΩ		2322 411 02206
	or (miniature version)		2322 410 05006
R4	carbon res. 15 kΩ, 1/4 W		2322 101 43153
R6	carbon res. 6.8 kΩ, 1/4 W		2322 101 43682
R7	carbon res. 47 Ω, 1/4 W		2322 101 43470
R8	carbon res. 220 Ω, 1/4 W		2322 101 43221
R9	carbon res. 10 kΩ, 1/4 W		2322 101 43103
R11	carbon res. 470 Ω, 1/4 W		2322 101 43471
LA	incandescent lamp, 6 V or 12 V, max. 350 mA		any type

Our New LDRs

A new method of manufacturing cadmium-sulphide cells on the basis of *monograin layers* (layers one grain of 40 microns thick!), developed in the Philips Research Laboratories, enables us to produce such cells to narrow tolerances and with an amazing stability over life. Already in Electronics for You no. 4 (An Electronic Exposure Meter) we announced that new cells would become available which would be highly suitable for measuring purposes. Assuming that you know the terms used in describing photo-conductive devices we think it may interest you to know that the new production method makes it rather simple for us to pre-set

- the light resistance over a wide range
- the steepness of the illumination-versus-resistance curve
- the colour response.

Fig. 4 shows the light resistantce plotted against illumination intensities between 1 and 1000 lux of the RPY58, the type of cell with which the new production was started. This consists of two cells connected in series and is intended for general applications, including simple indoor equipment and toys. A low price was therefore essential and this is why we allowed a relatively large spread to remain in the light-resistance values at 50 lux and a colour temperature of 2700° K: our Data Sheets mention a maximum-to-minimum ratio of 4 : 1. This is fully acceptable for on/off switching applications such as the one we are dealing with now.

Circuit Description

See the Circuit Diagram on the opposite page. The circuit comprises a Schmitt trigger with transistors TR_1 and TR_2, and a switching transistor, TR_3. In the rest condition, when the lighting level exceeds a certain value, the resistance of the LDR will be low, TR_1 will be conductive and TR_2 non-conductive. As it grows darker the resistance of the LDR will rise until it reaches the (pre-set) value at which TR_1 becomes non-conductive, driving TR_2 conductive. As a result TR_3 is also driven conductive and then *LA* in its collector circuit will come on.

R_7 is the common emitter resistor for TR_1 and TR_2, producing the positive feedback arrangement on which the proper operation of the bistable multivibrator circuit depends. The circuit exhibits a form of hysteresis in its switching action, resulting in the lamp *LA* being extinguised at a slightly higher lighting level than the one at which it is switched on. This relative insensitivity for changes from dark to light has been built in to prevent the circuit from responding to small changes in the lighting level, such as may be experienced when cars drive past in the dark with their headlights on. The moment of switching can be adjusted with the aid of R_3. Silicon diode D_1 raises the emitter voltage of TR_1 by about 0.7 V and, in so doing, allows the value of R_3 to be chosen higher. As a result, changes in R_1 have a stronger influence on the base voltage of TR_1.

The resistors have been so chosen that under rest condition (high enough lighting level, lamp out) the current consumption is not higher than 2 mA at 6 V, and not higher than 4 mA at 12 V.

Building the Unit

Fig. 2 illustrates one possible construction for the Automatic on/off Switch:

- the LDR is mounted on a disc of opaque insulating material fitted over lamp *LA* (the light from this lamp should not be allowed to reach the LDR!); the LDR is embedded in a thick layer of transparant synthetic resin;
- a second disc of insulating material carries the other part of the fitting for lamp *LA*, as well as the electronic components following the LDR; these components are also embedded in synthetic resin; this second disc is attached to the mast by means of a suitable bracket; the two bolts used to keep the two discs together protrude through the top one over a length which is greater than the thickness of the LDR;
- a hood made of glass or another transparent material such as plastic, and having a suitable height, is placed over the assembly.

A final warning: Make sure that the hood cannot be blown off — if the leads of the LDR should become wet your automatic switch may fail!

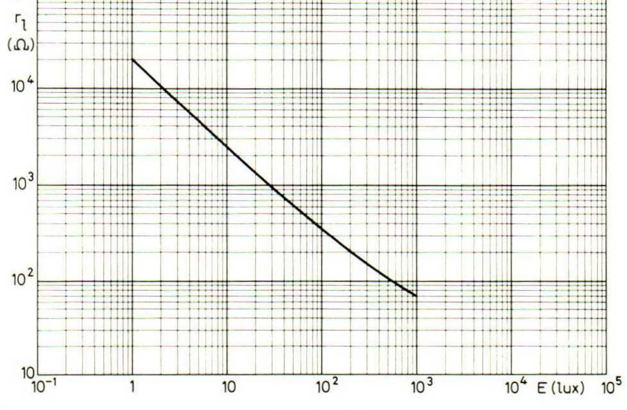
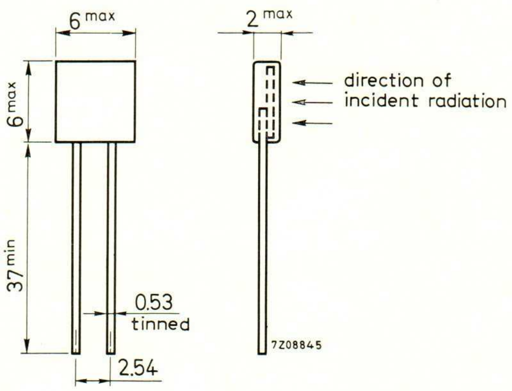
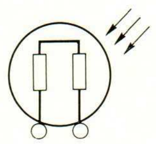


Fig. 4.

Quick Reference Data of RPY58

Power dissipation at $T_{amb} = 40$ °C P max. 200 mW
Voltage, d.c. and repetitive peak V max. 50 V
Resistance at 50 lux,
2700 °K colour temperature r_{lo} 0.4-1.6 kΩ





Outline dimensions and drawing symbol of the RPY58.

RPY58.

Rectification

"Electronics for You" No. 10

In the circuit diagram TR_1 should be TR_2, and vice versa.

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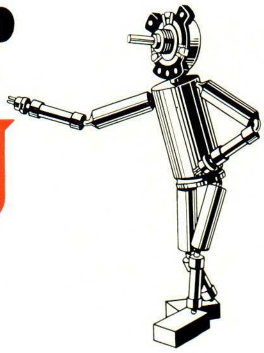


Telephone Amplifier with TAA263

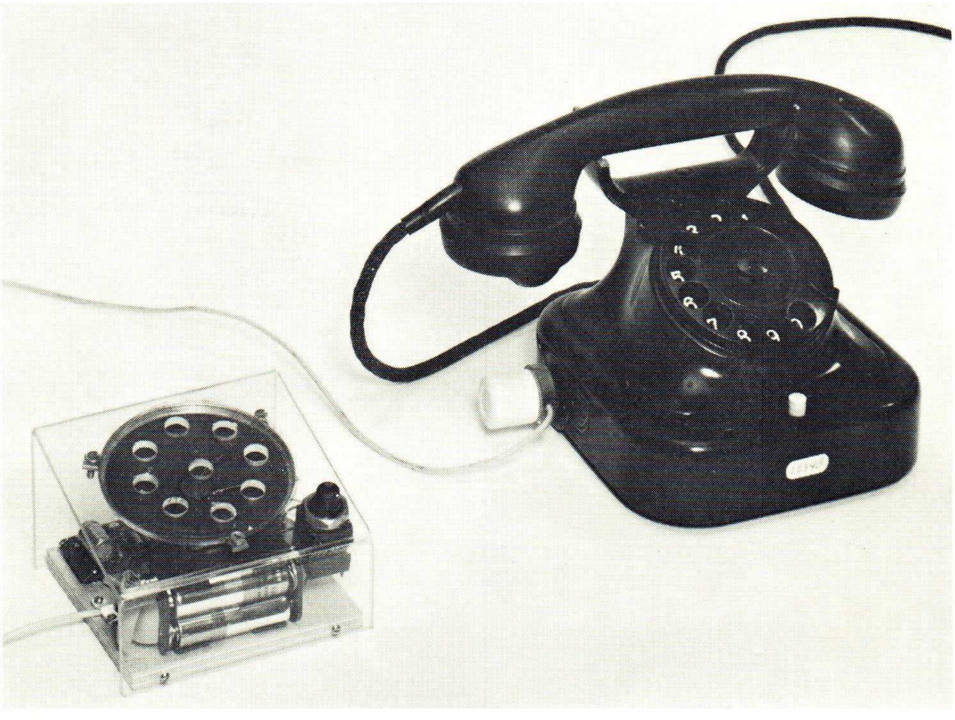
Dear Experimenter,

Only people who carry the notion of "privacy" to excess maintain that they will never need such a thing as a telephone amplifier. The average telephone subscriber will often want to share the ear-to-ear link with others in his company. This is not only so in the home when he is compelled to pass the receiver from one person to another — all the time seeing his telephone bill rise! — but even more in the office. When the connection is not too good, or the conversation is held in a foreign language, the message should be received by more than one person who between them can make sure afterwards that they really did get the information right. And what about listening in on the hour-long conversations your wife has with her friends ?

We therefore can recommend you to have a go at the Telephone Amplifier described in the following pages. It incorporates our TAA263 integrated circuit as a low-level amplifier stage, giving the same gain as three discrete transistors. The telephone authorities do not object to your using the gadget, and will not charge you for it — after all, you are not changing anything in the telephone set.

We wish you good luck and good listening but remember to use

Philips Components for best Results!



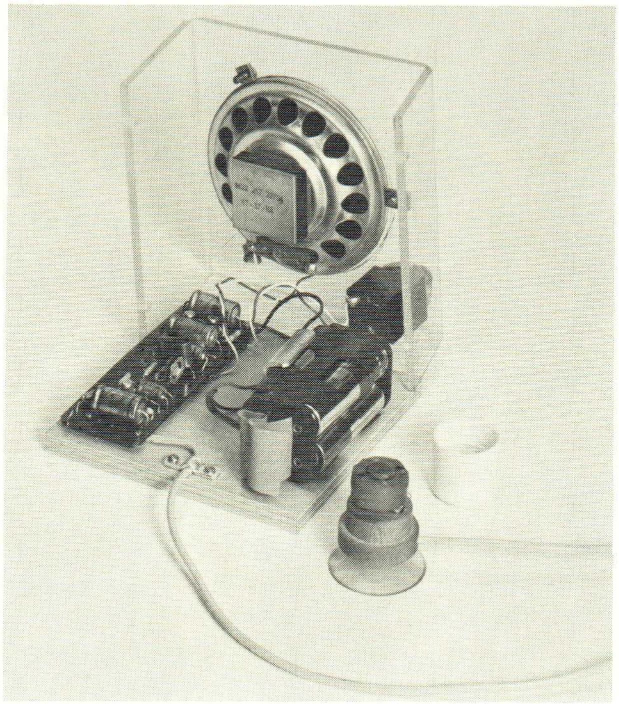
What Your Telephone Amplifier Will Do

Every telephone set has a transformer built in for two reasons:

(a) to separate the internal circuit from the external one;

(b) to make the incoming speech signal suitable for being heard in the receiver.

Like alle transformers, the one in your telephone set has a stray magnetic field, the strength of which varies in the rhythm of the speech signals (incoming and outgoing). A coil placed, outside the telephone set, in the stray field will respond to the changes by reproducing the speech signals. What we make the telephone amplifier do is amplify the weak speech signals until they are strong enough to be heard in a loudspeaker. And, most important, we do this without modifying the telephone set in any way.



Showing the lay-out of the Telephone Amplifier, with opened coil.

Description of the Circuit Diagram

The circuit diagram (Fig. 1) shows two parts: to the left of the dash-dotted line we have the telephone amplifier proper, whereas the part to the right of the line is only an auxiliary circuit. It is an electronic time switch, making sure that the amplifier is switched off some time after the moment that it is no longer needed, thus protecting the batteries.

In the diagram L_1 is the "pick-up" coil; it will be described in more detail on the back page (Figs 2 and 3). Provided with a "suction foot" it is to be stuck to the casing of your telephone set, at a spot where the stray field of the transformer is strong enough (see photo on first page).

Next in the circuit diagram is the type TAA263 integrated circuit; more about this, too, on the back page. We should note here that this IC has been designed for incorporation into hearing aids, where the supply voltage is about 1.5 V. For this reason we have to limit the voltage at the first two stages of the TAA263 (consult Fig. 4) to not more than 2 V; otherwise the amplifier might be driven into oscillation. The third stage gets the full voltage, however, as required for driving the power transistor TR_1. Terminal 3 (final collector) of the TAA263 is connected direct to the power transistor, which is an emitter follower with the loudspeaker in its emitter circuit. The output of your telephone amplifier is about 80 mW, amply sufficient for the purpose.

To minimize distortion the direct voltage across the loudspeaker should be about 2 V; the current flowing through the loudspeaker coil then is about 80 mA, and the d.c. power to be dissipated by TR_1 about 250 mW. This is almost the maximum the transistor is allowed to dissipate so we recommend you to provide a cooling fin.

R_4 serves to adjust the d.c. negative feedback from the emitter of TR_1 to the base of the TAA263, and thus to obtain the required direct voltage (2 V) across the loudspeaker. A.C. negative feedback is to be avoided, therefore C_3 is included to provide a bypass to the minus lead. R_3 and C_2, in the emitter lead of the TAA263, stabilize the circuit against temperature

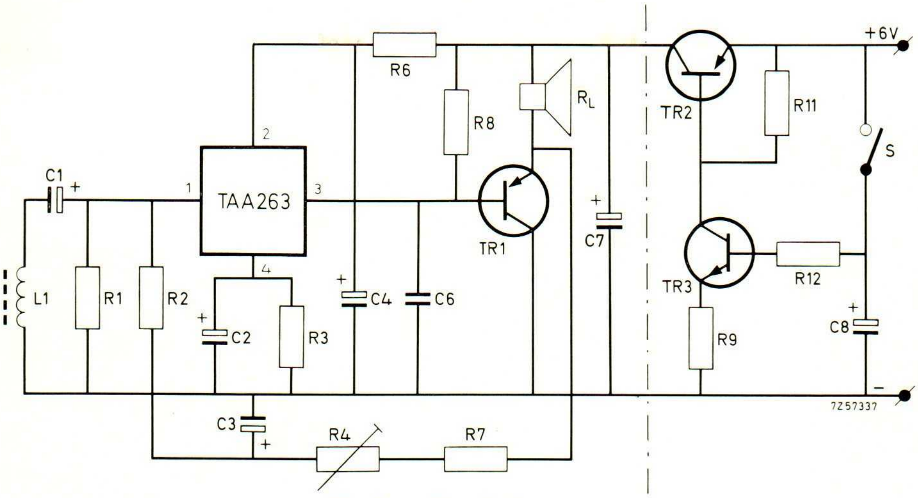


Fig. 1 — Circuit diagram.

Parts List

The right-hand column gives type number or catalogue numbers which you should use when ordering.

R1	carbon resistor	100 kΩ, ¼ W	2322 101 43104
R2	carbon resistor	56 kΩ, ¼ W	2322 101 43563
R3	carbon resistor	330 Ω, ¼ W	2322 101 43331
R4	carbon trimming potentiometer	100 kΩ	2322 410 05011
R6	carbon resistor	22 kΩ, ¼ W	2322 101 43223
R7	carbon resistor	56 kΩ, ¼ W	2322 101 43563
R8	carbon resistor	2.2 kΩ, ¼ W	2322 101 43222
R9	carbon resistor	330 Ω, ¼ W	2322 101 43331
R11	carbon resistor	2.2 kΩ, ¼ W	2322 101 43222
R12	carbon resistor	27 kΩ, ¼ W	2322 101 43273
C1	electrolytic capacitor	2.5 μF, 16 V	2222 001 15258
C2	electrolytic capacitor	2.5 μF, 16 V	2222 001 15258
C3	electrolytic capacitor	470 μF, 6.3 V	2222 007 13471
C4	electrolytic capacitor	10 μF, 6.3 V	2222 006 13109

C6	polyester capacitor	47 nF, 250 V	2222 342 45473
C7	electrolytic capacitor	470 μF, 6.3 V	2222 007 13471
C8	electrolytic capacitor	470 μF, 6.3 V	2222 007 13471
	Integrated circuit		TAA 263
TR1	p-n-p Si transistor		BC 177/178/179
TR2	p-n-p Si transistor		BC 177/178/179
TR3	n-p-n Si transistor		BC 107/108/109
L1	coil (see Fig. 2)		
RL	loudspeaker	25 Ω, 3 inch dia.	2422 257 23704
S	pushbutton switch (closes when button is pressed, opens when button is released)		any type

variations, as well as voltage fluctuations between 6 and 3 V. At supply voltages below 3 V you will experience a rapid deterioration of the unit's performance, distortion becoming intolerable.

The loudspeaker is a 3-inch type, impedance 25 Ω at 1000 Hz. The peak in the frequency response curve at 3000 Hz makes it highly suitable for speech reproduction and its sensitivity is remarkably good for its size.

The circuit does not contain a volume control because if there were one you would usually turn it fully up. So, if the loudspeaker is too loud, you will have to try moving the "pick-up" coil along the casing of the telephone set, watching out for distortion.

Electronic Time Switch

See circuit diagram (Fig. 1) to the right of dash-dotted line. When the contact of pushbutton switch *S* is closed by the button being pressed, electrolytic capacitor C_8 is charged to 6 V. After the button has been released C_8 discharges slowly via R_{12}, TR_3 and R_9. As long as the discharge current is strong enough TR_3 will conduct, and a base current will flow through TR_2; the latter will therefore also be conductive.

Within three minutes the discharge of C_8 has progressed to the extent where TR_3 and TR_2 become less conductive. From then on the sound level will go down accordingly which is a sign that the button has to be pressed again if the conversation is to continue.

Pick-up Coil

See Figs 2 and 3.

The signal produced by the pick-up coil is mainly governed by the coil size: the larger the coil the stronger the signal. Fig. 2 shows minimum dimensions for the coil. With the ferroxcube core having the dimensions shown (length 30 mm, diameter 10 mm)

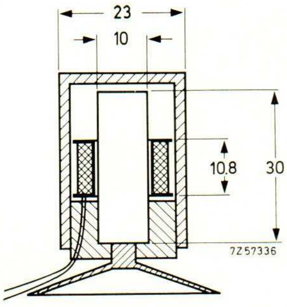


Fig. 2.

you may use the type 4322 021 30330 coil former (belonging to the P26/16 pot core). On this wind about 2000 turns of enamelled copper wire, diameter 0.1 mm, thus obtaining a coil with a self-inductance of about 150 mH. Insulate the winding with candle grease — do not use adhesive tape since this will attack the enamel. Connect the wire ends to the wires of a thin flex, about 50 cm long. Mount the coil on a disc of suitable insulating material into which a sucking cup can be inserted. Make sure that no force can be exerted on the thin flex. Place a plastic cap over the coil and make it fit tightly on the mounting disc — do not use metal for this cap.

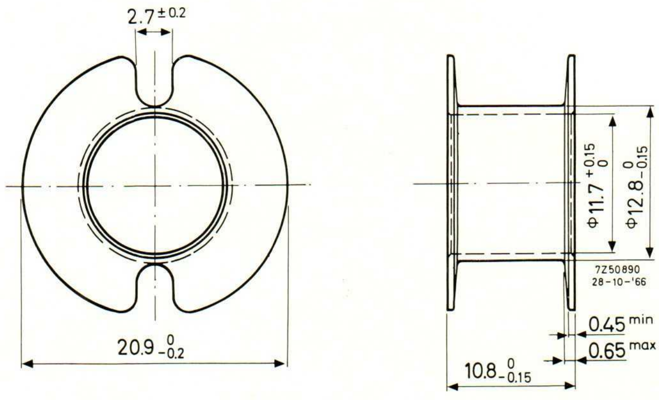
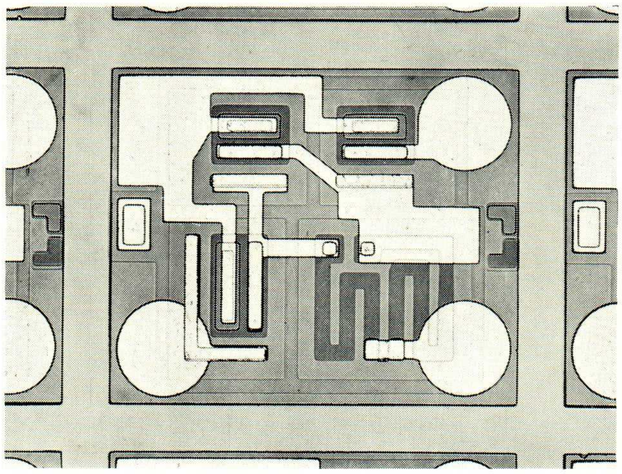


Fig. 3.

TAA263 Integrated Circuit

The type TAA263 integrated circuit, which serves as the pre-amplifying stage in our telephone amplifier, is a member of the analogue or *linear* family, mainly intended for amplifying purposes. There is a *linear* relationship between the input voltage and the output voltage within the limits set by the positive and negative saturation of the IC. The family should be clearly distinguished from the digital family, to be used with pulse drive, hence in computers. When the type number starts with a T you can be sure that the IC in question is a linear one; digital ICs are identified by a code number starting with an F.

Fig. 4 illustrates that the TAA263 is built up of three transistors and two resistors, brought together in a chip with a surface area of not more than half a square millimetre (shown much enlarged in the photo alongside). The transistors are all direct coupled so that the circuit can be stabilized against temperature and supply voltage variations by means of d.c. negative feedback. This low-level amplifier can be used from d.c. up to frequencies of 600 kHz.



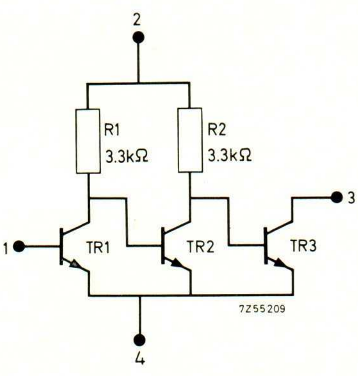


Fig. 4.

Quick Reference Data

Supply voltage	V_B	max.	8	V
Output voltage	V_{3-4}	max.	7	V
Output current	I_3	max.	25	mA
Transducer gain at $P_o = 10$ mW				
$R_L = 150\ \Omega$; $f = 1$ kHz	G_{tr}	typ.	77	dB
Operating ambient temperature	T_{amb}	−20 to + 100		°C

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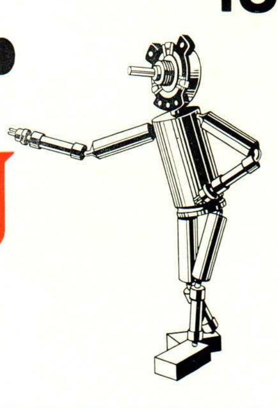


18

Radio Control
Part I

Dear Experimenter,

You will, we hope, agree that *Remote Control of Toys* by means of electronic circuits is a fairly old, yet still fascinating subject. And that it is fascinating partly because of the results one can obtain, partly because it tests one's knowledge of a number of techniques which include electronics. Anyway, fathers and sons all over the world derive equal pleasure from embarking on a radio control project.

In your country the long holidays will be over now and a new schoolyear will have started. And, unless you are living in a tropical country, you will be preparing for another winter, in which one festive period around the figure of Santa Claus breaks the monotony of dark and cold days.

These are all reasons why we should like to present to you, in three leaflets — this one and two subsequent ones — the circuits necessary for radio controlling a boat model (we might, of course, have chosen one of the modern digital control systems used by aeromodellers, but felt that the financial consequences might keep you from building it!).

We think it only fair to draw your attention to two factors which you should consider before you start. First: the electronic part of our radio control system may well turn out to be the least expensive, compared with the motor(s), the battery or batteries, and the boat model. Second: local regulations will probably require you to obtain a licence for operating the transmitter.

In the present leaflet we shall deal with the r.f. part of the transmitter, in the next with the modulator, the tone generator and the power supply, and in the third with the receiver and associated equipment.

You will be building a simple three-channel radio control system, with a separate channel for each of the following commands:

— Port;

— Starboard;

— Ahead — Stop — Astern.

With these commands you will have no difficulty in navigating your boat model through any "waterway", provided you stick to

Philips Components for Best Results

The Regulations

It was agreed internationally that a rather narrow band of frequencies, the *citizen's band*, be reserved for such purposes as radio control, and that these activities be governed by regulations.

In most contries the following frequencies are available: 26.995 MHz; 27.045 MHz; 27.095 MHz; 27.145 MHz; 27.195 MHz and 27.255 MHz.

So, you will have to use one of these frequencies and have your transmitter tested by the authorities named in your local regulations. We have done everything possible to make sure that, when properly built and tuned, the transmitter described below will pass the test.

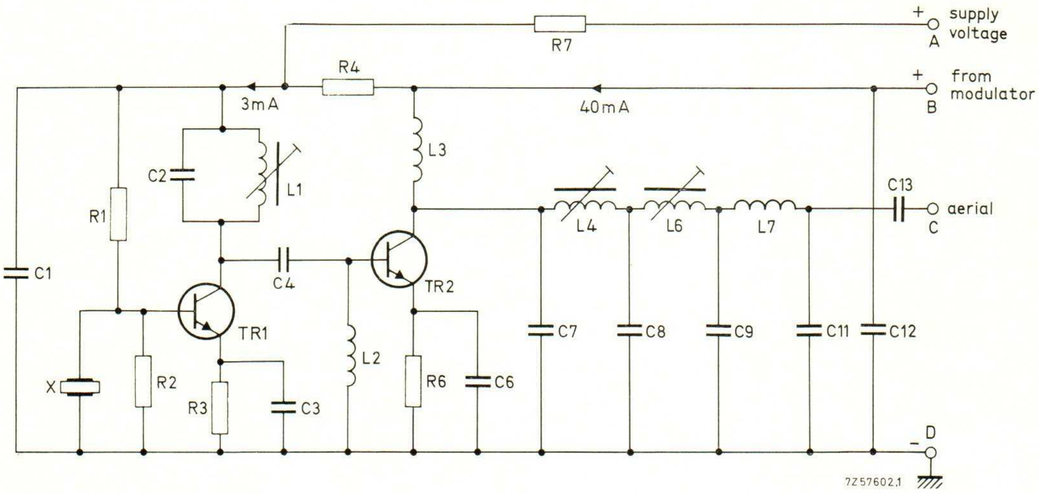


Fig. 1.

Parts List

The right-hand column gives type numbers and catalogue numbers which you should use when ordering

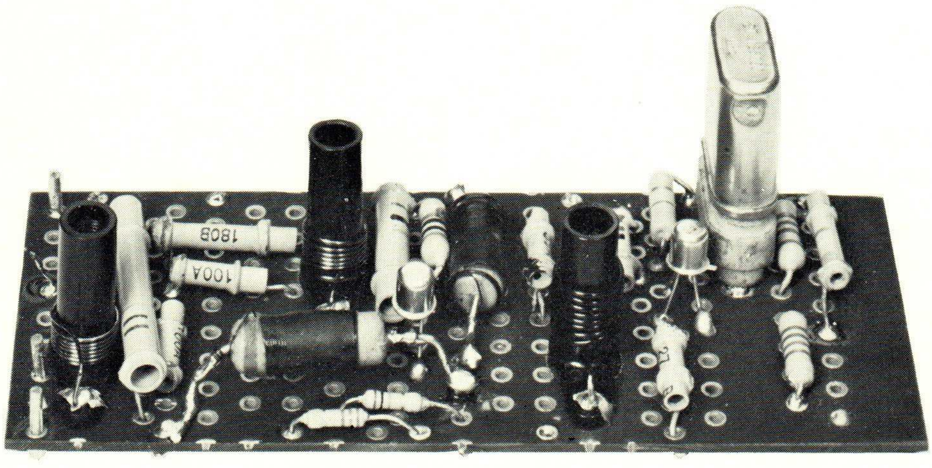
R1	carbon resistors (¼ W)	5.6 kΩ	2322 101 43562
R2		2.2 kΩ	2322 101 43222
R3		330 Ω	2322 101 43331
R4		560 Ω	2322 101 43561
R6		10 Ω	2322 101 63100
R7		1 kΩ	2322 101 43102

L1	coil	0.4 μH	*
L2	r.f. choke	10 μH	*
L3	r.f. choke	4 μH	*
L4	coil	0.25 μH	*
L6	coil	0.25 μH	*
L7	coil	0.15 μH	*

* See Figs 2, 3 and 4.

C1	ceramic capacitors (500 V)	4.7 nF	2222 552 03472
C2		24 pF	2222 555 57279
C3		68 pF	2222 555 56689
C4		39 pF	2222 555 56399
C6		10 nF	2222 552 03103
C7		100 pF	2222 555 56101
C8		180 pF	2222 555 56181
C9		100 pF	2222 555 56101
C11		100 pF	2222 555 56101
C12		100 pF	2222 555 56101
C13		10 nF	2222 552 03103

X	crystal	any type
TR1	n-p-n silicon transistor	BF 115
TR2	n-p-n silicon transistor	BFX 43 or 44



R.F. part of the transmitter.

The Master Oscillator

Fig. 1 shows the circuit diagram. We have chosen a crystal-controlled master oscillator so as to obtain the highest possible stability. The quartz crystal should be of the *AT*-cut type, driving from its *third overtone* in the 27 MHz band. Together with capacitor C_3 in the emitter circuit of TR_1 and the negative resistance of the base-emitter part of this transistor, the crystal forms a tuned circuit. Oscillations will be set up when the other resistances in the circuit are smaller than the negative base-emitter resistance. The combination of L_1 and C_2 in the collector circuit of TR_1 ensures that the third overtone of the crystal's fundamental frequency only is used. With this circuit the frequency can be stabilized to within 1 cycle per 500 000 as required in most countries.

The Power Amplifier

Via coupling capacitor C_4 the oscillator is coupled to a power stage where the few milliwatts delivered by the oscillator are amplified to sligthly over 100 mW. L_2 is an r.f. choke; it ensures that the base of TR_2 is at a negative potential and at the same time it prevents the r.f. signal from leaking away to the minus lead.

TR_2 is a Class-*C* amplifier which means that only the peaks of the sinewave are amplified, a method often adopted for transmitters (efficiency is high, about 75%). A drawback is the high harmonic content of the amplified signal, about one-quarter of the output power being contributed by harmonics. For this reason the r.f. signal is filtered before it reaches the aerial.

The Harmonic Filter

Roughly, the output power contributed by harmonics should remain below 10 microwatts. As we have seen it actually amounts to about 25 mW, so a harmonic attenuation of about 2500 times will have to be introduced, without a loss on the fundamental of more than a few per cents. The triple-pi filter introduces a harmonic attenuation of about 500 times (L_4-L_6-L_7-C_7-C_8-C_9-C_{11}), the aerial does the rest.

The Aerial

See Fig. 2.

Theoretically a quarter-wave aerial would give the best results *) but since we would then have to use an aerial more than two-and-a-half metres long we turn to the centre-loaded coil method. The aerial length is less than ⅛ of the wavelength, but it is electrically made longer by a coil inserted about half-way. This aerial introduces an attenuation of the harmonics of 10–20 times. It should be connected with its left-hand tip to the aerial terminal *C*.

* See the book "Radiogolven" by J. F. van Oort (Centrex Publishing Company, Eindhoven, The Netherlands) of which an English translation is in preparation.

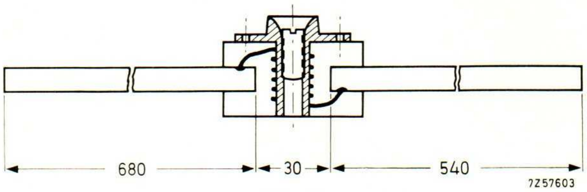


Fig. 2.

Coil Winding Data

Oscillator Coil L_1: Filter Coils L_4, L_6 and L_7; Aerial Loading Coil

With the exception of L_7 these coils should be made tunable, for instance by means of powder-iron screw cores; the data given in Figs 2 and 3 apply to a coil former that is highly suitable for the purpose and bears the catalogue number 4022 102 02811. The screw cores are available in two lenghts either of which may be employed:

— length 6 mm
  (catalogue number 4322 020 65900);
— length 13 mm
  (catalogue number 3122 104 90990).

For winding the coils proceed as follows (use enamelled copper wire, 0.5 mm dia.):

L_1 = about 0.4 μH — 8 turns
L_4 and L_6 = about 0.25 μH — 6 turns
L_7 = about 0.15 μH — 6 turns (no core) — coil former 8 mm dia., 10 mm long
Aerial loading coil — 30 turns

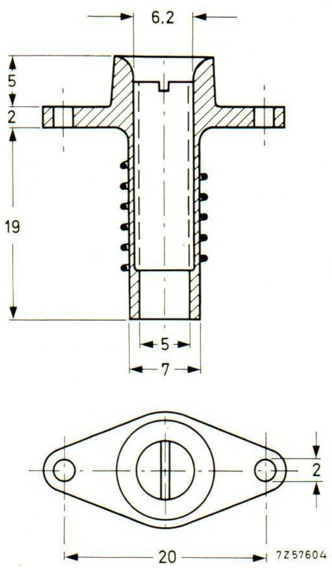


Fig. 3.

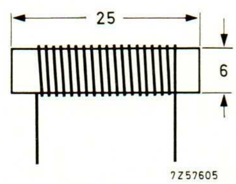


Fig. 4.

R.F. Chokes L_2 and L_3

Fig. 4 illustrates how, on a rod of insulating material 6 mm in diameter and 25 mm long, 65 turns of enamelled copper wire, 0.2 mm dia., are wound for L_2 and 40 turns for L_3.

Checking

Trimming

Fig. 5*a* shows a simple circuit for trimming the aerial and the transmitter. First adjust the cores of L_1, L_2 and L_3 until the meter reading is maximum; then adjust the aerial loading coil for minimum meter reading (the aerial current is then maximum).

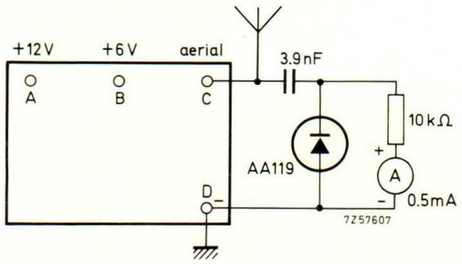


Fig. 5*a*.

Quick Test of Output Power

A test lamp which can be connected instead of the aerial will always be very handy, see Fig. 5*b*; a small incandescent lamp of the type shown will burn at about half its maximum intensity.

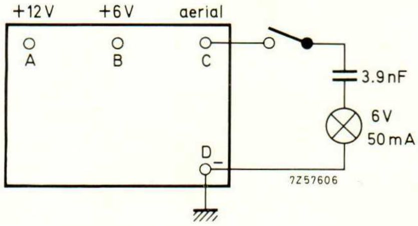


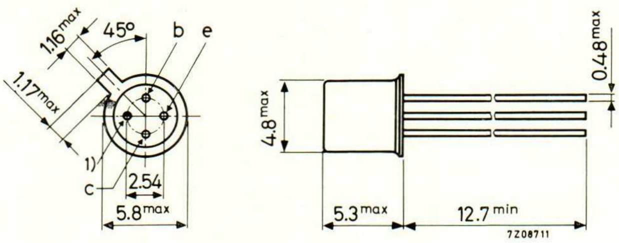
Fig. 5*b*.

Quick reference data BF115

Collector-base voltage (open emitter)	V_{CBO}	max.	50 V
Collector-emitter voltage (open base)	V_{CEO}	max.	30 V
Collector current (d.c.)	I_C	max.	30 mA
Total power dissipation up to T_{amb} = 45 °C	P_{tot}	max.	145 mW
Junction temperature	T_j	max.	175 °C
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	typ.	230 MHz

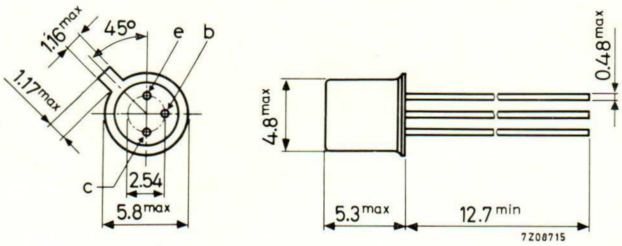
Quick reference data BFX43

Collector-base voltage (open emitter)	V_{CBO}	max.	30 V
Collector-emitter voltage (open base)	V_{CEO}	max.	15 V
Collector current (peak value)	I_C	max.	250 mA
Total power dissipation up to T_{amb} = 25 °C	P_{tot}	max.	360 mW
Junction temperature	T_j	max.	200 °C
Transition frequency I_C = 1 mA; V_{CE} = 10 V	f_T	>	500 MHz



1) = shield lead (connected to case)

Dimensions in mm of BF115.



Dimensions in mm of BFX43.

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Radio Control
Part II

Dear Experimenter,

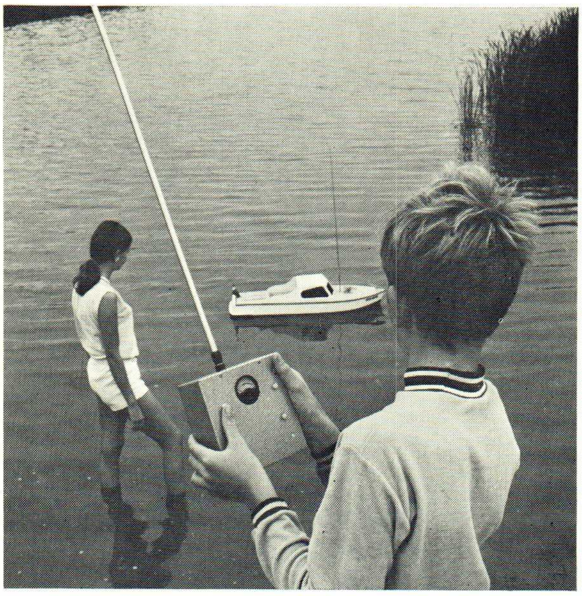
Impatient to go on building the radio control system for your boat model, you may disagree entirely with our policy of publishing three articles where there should be one!

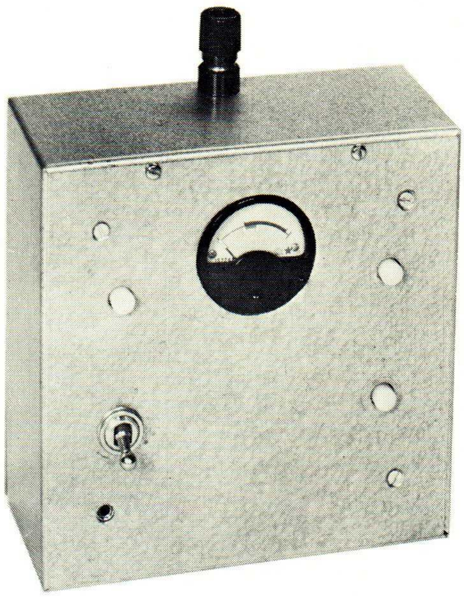
Well, although we do apologize for any real inconvenience we caused you, we have our reasons. .

For one thing, we are sure that there are excellent ways in which you can spend your time while waiting for the next article to appear: you can discuss the problems involved in radio control with other members of the local "modellers club" (if there is no such club, why shouldn't you take the initiatieve and *found* one ?), or just with your neighbours who may have very sound ideas.

Anyway, in the present leaflet (no. 19) you will find the description of the tone generator and the modulator. In the first, three signals are generated, one for each of the commands you will have to use in navigating your boat model. The modulator serves for impressing these signals on the carrier produced in the r.f. part of the transmitter which you have already built. We hope that the result so far will be satisfactory and that you will stick to

Philips Components for Best Results





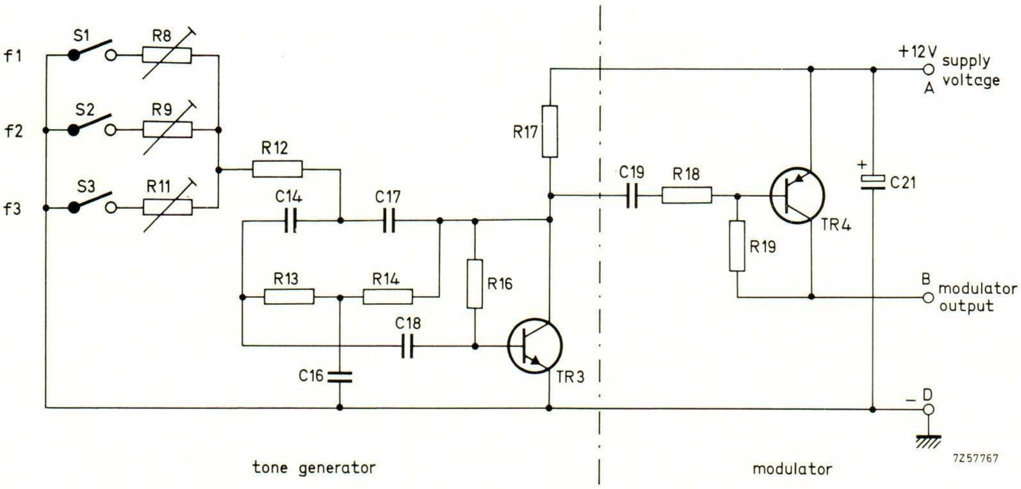


Fig. 6.

Parts List

The right-hand column gives type numbers and catalogue numbers which you should use when ordering

TR3	n-p-n Si transistor		BC 107
TR4	p-n-p Si transistor		BC 177
R8	trimming potentiometer	4.7 kΩ	2322 410 05006
R9	trimming potentiometer	1 kΩ	2322 410 05004
R11	trimming potentiometer	1 kΩ	2322 410 05004
R12	carbon resistor (1/4 W)	150 Ω	2322 101 43151
R13	carbon resistor (1/4 W)	27 kΩ	2322 101 43273
R14	carbon resistor (1/4 W)	27 kΩ	2322 101 43273
R16	carbon resistor (1/4 W)	330 kΩ	2322 101 43334
R17	carbon resistor (1/4 W)	4.7 kΩ	2322 101 43472
R18	carbon resistor (1/4 W)	10 kΩ	2322 101 43103
R19	carbon resistor (1/4 W)	27 kΩ	2322 101 43273
C14	polycarbonate capacitor	10 nF/250 V	2222 342 44103
C16	polycarbonate capacitor	22 nF/250 V	2222 342 44223
C17	polycarbonate capacitor	10 nF/250 V	2222 342 44103
C18	polycarbonate capacitor	0.1/μF/250 V	2222 342 44104
C19	polycarbonate capacitor	0.1/μF/250 V	2222 342 44104
C21	polycarbonate capacitor	100/μF/ 16 V	2222 001 90038

S_1, S_2, S_3 switch		any type
Nine Ni-Cd cells, insulated version,	without soldering tags	2422 541 00108
	with soldering tags	2422 541 10108

The Tone Generator

In the tone generator the three signals are produced which, after being transmitted, and picked up by the receiver, make the boat model

— turn to port, or

— turn to starboard, or

— go ahead — stop — go astern,

as the case may be.

They must, therefore, unambiguously represent these commands, which in our case means: be highly stable in frequency, even under temperature and supply-voltage fluctuations.

Being intended for operation by amateurs, the tone generator must also be easy to build, adjust and put into service.

These requirements of stability and simplicity are met by a double-*T*-network oscillator. Our tone generator therefore comprises a double-*T* network, see the circuit diagram (Fig. 6), and Fig. 7 (page 3). This network, with C_{14}-C_{17}-(R_{12} + R_8 or R_9 or R_{11}) in one *T*, and R_{13}-R_{14}-C_{16} in the second *T*, has a resonant frequency

$f_r = 1/2\pi\sqrt{2} \text{ x } 1/\sqrt{R.R_x C}$

where $R = R_{13} = R_{14}$;

$R_x = R_{12} + R_8$ or R_9 or R_{11};

$C = C_{14} = C_{17}$;

$R_x/R = C/C_{16} = 1/2$.

Tone generator and modulator part of the transmitter.

f_r can be varied by means of R_x. Making use of the components mentioned in the Parts List we can make the tone generator oscillate at three frequencies between 1000 and 3000 Hz, pre-set by means of trimmers R_8, R_9 and R_{11}, and switchable by means of S_1, S_2 and S_3, respectively. The choice of the three frequencies is not critical, provided they are later made exactly equal to the resonant frequencies of the filters in the receiver. It is also advisable to make sure that none of them is a harmonic of the others — we suggest using

f_1 = 1000 Hz,
f_2 = 1700 Hz,
f_3 = 2500 Hz.

The collector of TR_3 is coupled to the base of TR_4 via C_{19} and R_{18}. The resistance of R_{18} (10kΩ) is chosen so large that the stability of the tone generator is not affected by the modulator, yet TR_4 in the latter is driven to a maximum.

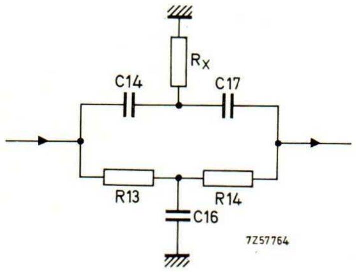
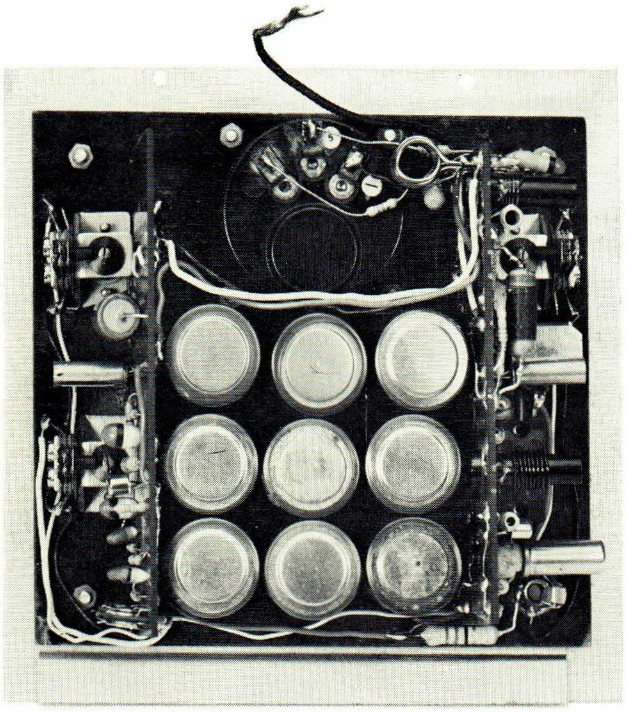


Fig. 7.

The Modulator

The type of modulation used in our radio control equipment is *amplitude modulation* (that is: the amplitude of the carrier is varied in the rhythm of the signal from the tone generator — see Fig. 8 where "modulated carrier" is the waveform of the carrier, modulated in amplitude by a sinewave).



The circuit which enables us to amplitude-modulate the carrier, generated in the r.f. part, comprises the modulation transistor TR_4. The components are so chosen that the collector-emitter voltage is about half the supply voltage (hence 6 V in our case). It is true that this arrangement (called series modulation) reduces the efficiency of the transmitter, but it does away with the expensive modulation transformer.

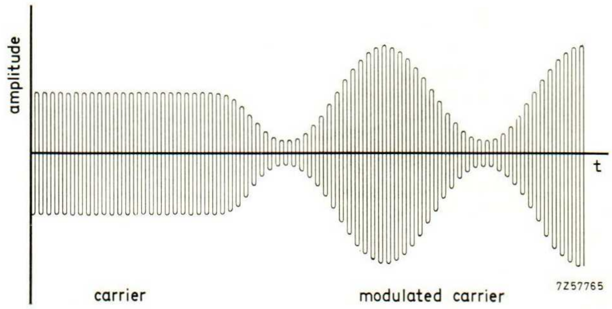


Fig. 8.

Since TR_4 has to dissipate so much power we advise you to provide it with a sufficiently large heat sink.

R.F. Part plus Tone Generator-Modulator

When you have completed building the tone generator and the modulator you will have to connect points A, B and D of Fig. 1 (see Part I) with the identical points of Fig. 6.

Summarizing the transmitter operation we can say that a current signal from TR_3 causes the base current of TR_4 to vary; consequently the collector-emitter voltage (6 V under no-signal conditions) may fluctuate between 1 V and 11 V. The result is that the output of the power amplifier — and to a lesser extent also that of the master oscillator — is varied accordingly. The modulation of the power stage can be as high as 90% without appreciable distortion occurring; the modulation depth of the master oscillator is kept below 50% by resistors R_4 (in series with the modulator output) and R_7 (in series with the 12 V supply).

Constructional Notes

Assuming that you have managed to assemble the r.f. part on a suitable printed-circuit board (as shown in Part I) and the tone generator plus modulator on a similar board, you will not find it difficult to construct an easy-to-carry, all-metal casing which can accommodate the two boards as well as the 12 V d.c. supply. The transmitter shown alongside contained nine nickel-cadmium cells connected in series; these cells will be described separately below, but we must point out here that they have safety valves which should not be closed off.

Connect the negative pole of the supply source to the metal casing. Arrange the various switches (not forgetting the test switch with lamp of Fig. 5*b*, Part I) in a convenient manner on some control panel. Pay special attention to the clamping device for the aerial which is to be connected to point *C* of the r.f. part; mechanically this device must be fairly strong — electrically it should make excellent contact possible.

Last but not least, make sure that the casing does protect the electronic circuits against moisture. You may like a little rain at times, your transmitter certainly doesn't!

The Nickel-cadmium Cells

We have decided in favour of nickel-cadmium cells because of their great advantages:

- the cell voltage is relatively constant during discharge (in technical terms: they have a relatively *flat discharge characteristic*);
- they are hermetically sealed and maintenance-free;
- their performance is good at high and low temperatures;
- since they use one of the best electrochemical systems known they have a *low self-discharge rate* (that is: the discharge current is very low when the cell is not connected to a load) and a long shelf life;
- they can be *recharged* many times and are not easily damaged by *overcharging* (charging which goes on after the cells have regained their full capacity);
- they will stand more abuse than any other cell also mechanically, by shocks, vibrations and rough handling.

The cells we recommend you to use are of the dry cylindrical type. The two electrodes are sheets of metal gauze onto which a suitable compound has been sintered (containing nickel hydroxide for the positive and cadmium hydroxide for the negative electrode). The two sheets are rolled up with a leaf of separator material between them, and dipped into potassium hydroxide which acts as the electrolyte.

The nickel-plated steel can consists of the cylindrical housing and a sealing cap. The negative electrode is connected to the bottom of the housing, the positive electrode to the cap, which is properly insulated from the housing. In the cap there is a safety valve which opens when the pressure in the cell should exceed 5 atmospheres.

The electrolyte is immobilized in the electrodes and the separator so the cells will not leak; some potassium carbonate may, however, collect at the rim of the seal. For the same reason the cells may be mounted in any position. Philips supply cells with and without insulating blue PVC sheath — we recommend you to use the insulated ones.

One final warning: Even these high-quality cells will be ruined if you connect them incorrectly to your battery charger — OBSERVE THE POLARITY just as conscientiously as the charging current.

The technical data are given below. Notice that the ampere-hour capacity is given at the 5 h rate, that is: under very heavy drain. Normal practice is to state the capacity at the 10 h rate, which will yield a higher value. The same goes for the end-point voltage. You will play safe when:
at an open-circuit voltage $>$ 1.4 V you stop charging,
at a closed-circuit voltage 1.1 V you stop draining.
Between these two values there is no electrical way of telling quickly how much of the battery capacity is left.

Capacity, 5 h rate	C	1 Ah
Discharge current, 5 h rate,	$C/5$	0.2 A
Average discharge volt, 5 h rate	V_a	1.25 V approx.
Fully discharge voltage, 5 h rate	V_f	1.0 V
Charging current, 13 h rate	$C/13$	0.1 A
Terminal voltage during charging		1.3 V rising to 1.5 V

Internal resistance in fully-charged condition		
d.c.		40 m Ω
a.c., at	50 Hz	25 m Ω
at	100 Hz	25 m Ω
at	1000 Hz	23 m Ω
Weight		45 g

Full charging specification is as follows:

Constant charging current (mA)	Charging time	Charge condition of cell
10	continous	"trickle charging"
60	24 hours	irrespective of
100	12-14 hours	charge condition of the cell
200	7 hours	cell virtually fully discharged

Continuous charging at a constant charging current of 10 mA only serves for maintaining the state of charge.
In addition, it is permissible to overcharge our 1 Ah cells with the undermentioned currents and during the time indicated.

Charging current (continuous)	Max. charging time
10 mA	continuous
60 mA	30 days
100 mA	7 days

Overcharging with a current of 10 mA is permissible only a few times a year. Prolonged overcharging will considerably shorten the cell's life. For overcharging with currents exceeding 100 mA consult the manufacturer.

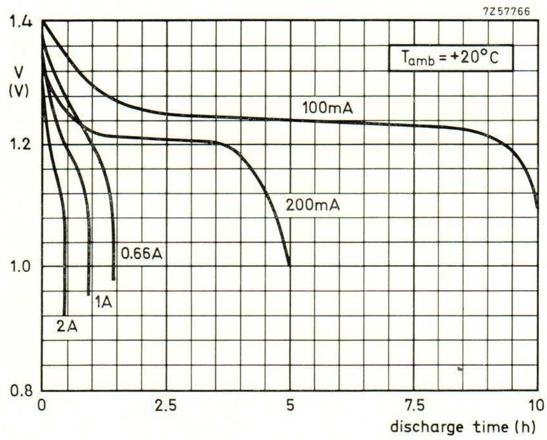


Fig. 9 — Discharge characteristics.

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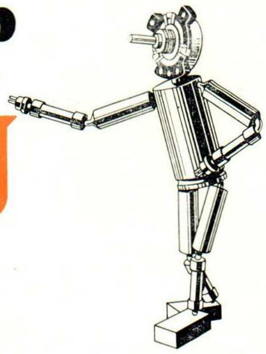
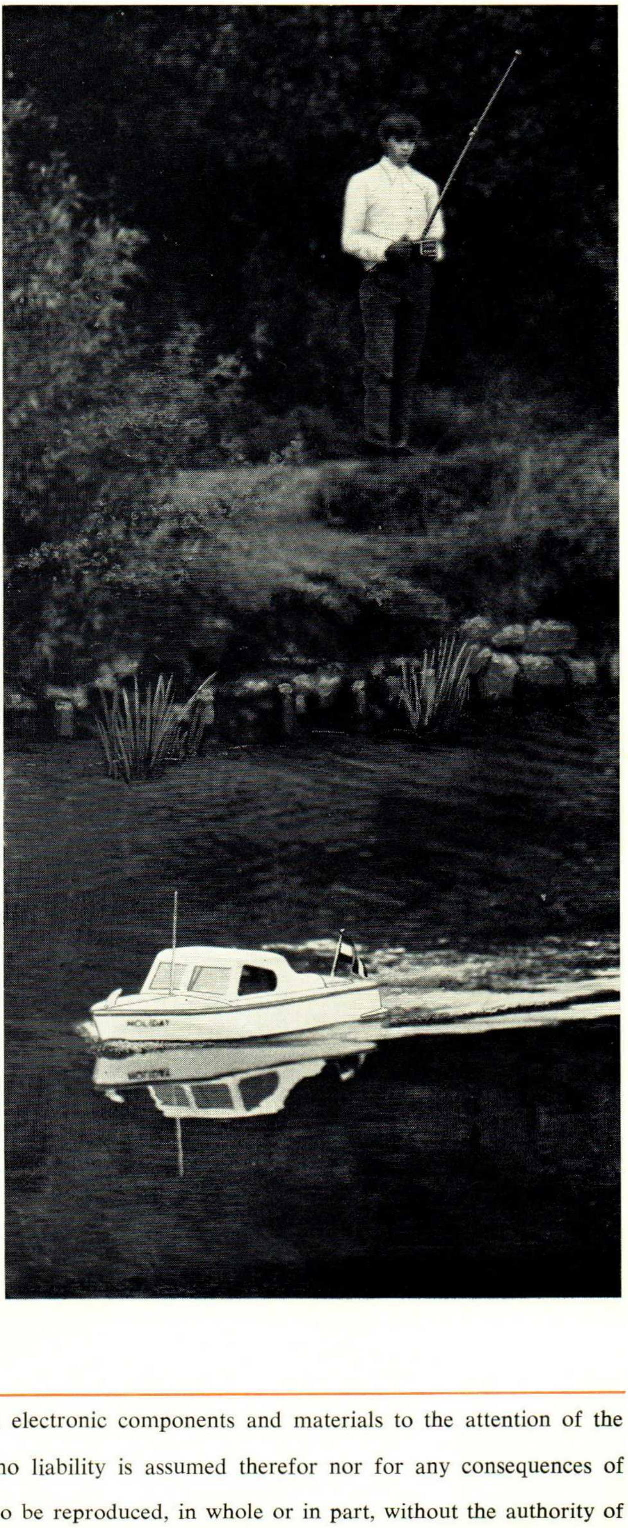
20



Radio Control
Part III



Dear Experimenter,

Electronics for You No. 20 contains the final part of the description of a radio control system for boat models. It deals with three rather difficult units: the receiver proper, the filter unit, and the mechanical system. Especially in building the latter you will have to exercise great care and to use good tools — it is evident that the motor, the propeller shaft and the steering mechanism, although small, are very important links in the whole chain. We have tried to make the description as short as possible without impairing the clarity. READ IT THOROUGHLY BEFORE YOU DO ANY BUILDING — check what you have done after each step — do not disregard our advice

Use Philips Components for Best Results

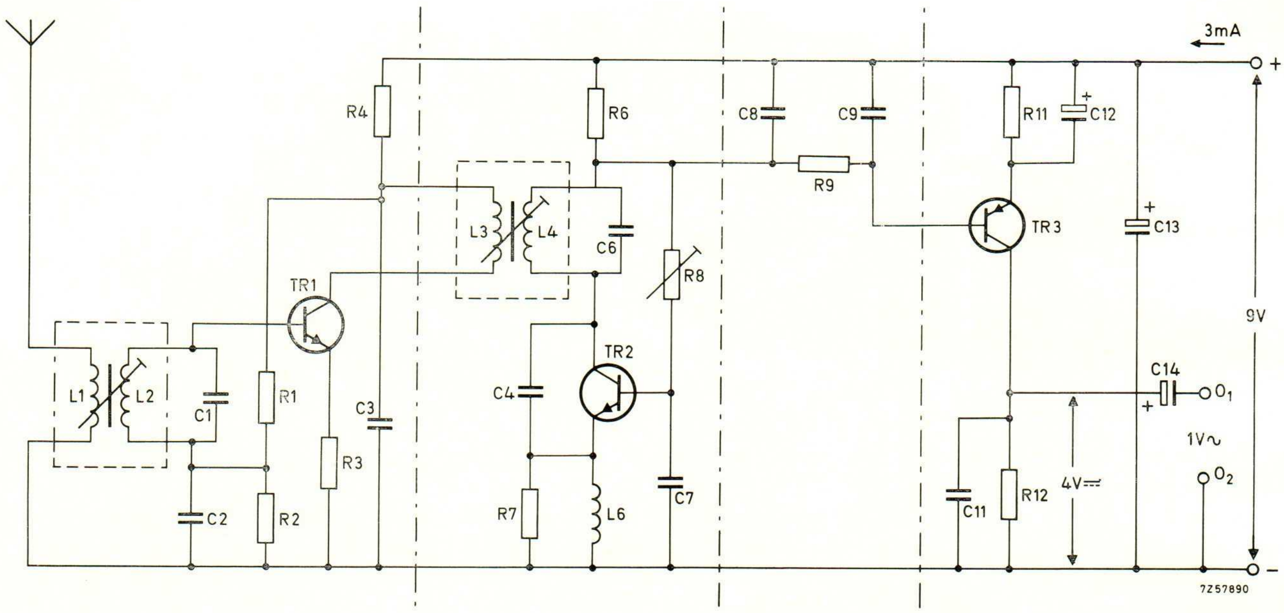


Fig. 10 — Circuit diagram of receiver.

Parts List, Receiver

The right-hand column gives type numbers and catalogue numbers which you should use when ordering

TR1	n-p-n Si transistors		BF 167
TR2	n-p-n Si transistors		BF 167
TR3	p-n-p Si transistor		BC 177
R1	carbon resistors	22 k Ω/¼ W	2322 101 43223
R2	carbon resistors	4.7 k Ω/¼ W	2322 101 43472
R3	carbon resistors	560 Ω /¼ W	2322 101 43561
R4	carbon resistors	560 Ω /¼ W	2322 101 43561
R6	carbon resistors	1 k Ω/¼ W	2322 101 43102
R7	carbon resistors	1 k Ω/¼ W	2322 101 43102
R8	trimming potentiometer	220 k Ω/¼ W	2322 410 05012
R9	carbon resistors	2.2 k Ω/¼ W	2322 101 43222
R11	carbon resistors	560 Ω /¼ W	2322 101 43561
R12	carbon resistors	2.2 k Ω/¼ W	2322 101 43222
C1	ceramic capacitors	22 pF /500 V	2222 563 02229
C2	ceramic capacitors	2.7 nF /500 V	2222 563 02272
C3	ceramic capacitors	2.7 nF /500 V	2222 563 02272
C4	ceramic capacitors	22 pF /500 V	2222 563 02229
C6	ceramic capacitors	22 pF /500 V	2222 563 02229
C7	ceramic capacitors	390 pF /500 V	2222 563 02391

C8	polyester capacitors	22 nF /500 V	2222 342 45223
C9	polyester capacitors	22 nF /500 V	2222 342 45222
C11	polyester capacitors	10 nF /500 V	2222 342 45103
C12	electrolytic capac.	100 μF /6,4 V	2222 001 13101
C13	electrolytic capac.	100 μF /16 V	2222 001 90038
C14	electrolytic capac.	10 μF /16 V	2222 001 15109

L1	3 turns	0.2 mm enamelled copper wire, Fig. 11.	coil former	3122 990 60230
L2	16 turns		copper can	3122 990 94120
			coil former	3122 104 91630
L3	3 turns		screw cores	3122 990 60230
L4	16 turns		copper can	3122 990 94120
			screw cores	3122 104 91630
L6	75 turns	0.1 mm enamelled copper wire, Fig. 12	coil former 5 mm ∅ insulating material	

The Receiver

Circuit diagram   See Fig. 10.

Type Superregenerative receiver.

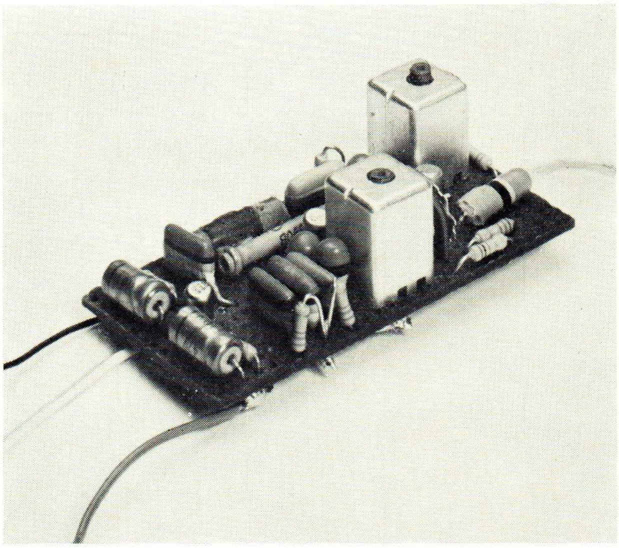
Plus-points Simple — highly sensitive.

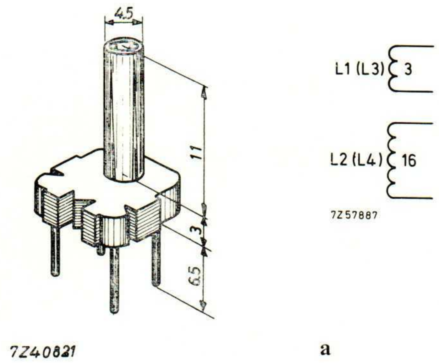
Minus-points Poor selectivity — rather strong background noise — relatively high distortion — spurious radiation.

Special measures Selectivity and sensitivity are raised by insertion of r.f. stage with its filter circuit; this stage also separates aerial from super-regenerative circuit, thus reducing spurious radiation.

Operation

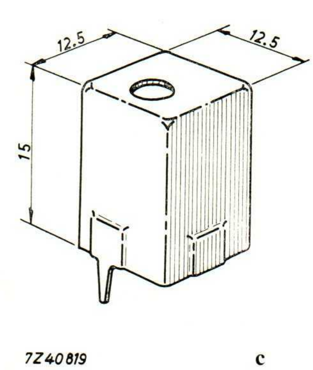
The tuned circuit for TR_2 (L_4-C_6) is so dimensioned that TR_2 oscillates at the carrier frequency of the transmitter in the 27 MHz band. The values of base resistor R_8 and capacitor C_7 have been so chosen that the oscillations are interrupted (quenched) at a frequency which varies around 100 kHz. Thus the quenching frequency varies in the rhythm of the tones used to modulate the carrier, and so does the average collector current of TR_1. The result is that the detected signal appearing across R_6 is made up of two components: the modulation signal used in the transmitter (slightly distorted) and a quenching-frequency signal. The latter is removed by low-pass filter C_8-R_9-C_9 and the clean signal is amplified by TR_3.





a

b



c

Fig. 11 — Coil data of L_1-L_2 and L_3-L_4:
a. Coil former and number of turns (enamelled copper wire of 0.2 mm diameter);
b. Screw core;
c. Copper can.

Construction

The lay-out of the receiver components is not critical but you have to make sure that the coils are not too close together and that all connections are as short as possible. See the photograph alongside and Figs 11 and 12.

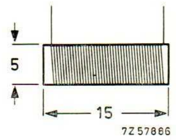


Fig. 12 — Typical dimensions of coil former for L_6 (enamelled copper wire of 0.1 mm diameter).

Trimming

With the transmitter off, adjust R_8 for 4 V d.c. to appear across R_{12} (and about 2 V d.c. across R_6). Connect earphones to O_1 and O_2 — a very strong receiver noise will then be heard.

Next position the transmitter a few hundred metres from the receiver and switch it on. Tune L_3-L_4 for maximum transmitter signal (minimum background noise) and re-check voltage across R_{12}; if necessary, re-adjust R_8. Then tune L_1-L_2 for maximum transmitter signal.

Should trimming be impossible because no background noise is audible at all, then check all coils for short-circuit between turns or windings. If this does not help, check all transistors.

When your receiver is allright, the output voltage becoming available at O_1 and O_2 should be about 1 V.

The Filter Unit

Circuit diagram See Fig. 13.

Lay-out Three filter sections, one for each channel (Ch. I for the command "Port", Ch. II for "Starboard", Ch. III for "Ahead - Stop - Astern"). Each section comprises a resonant circuit (L_7-C_{19}; L_8-C_{21}; L_9-C_{22}); an amplifier stage (with TR_4, TR_6 and TR_7, respectively) and a switching transistor or a relay (TR_8, TR_9 and RA).

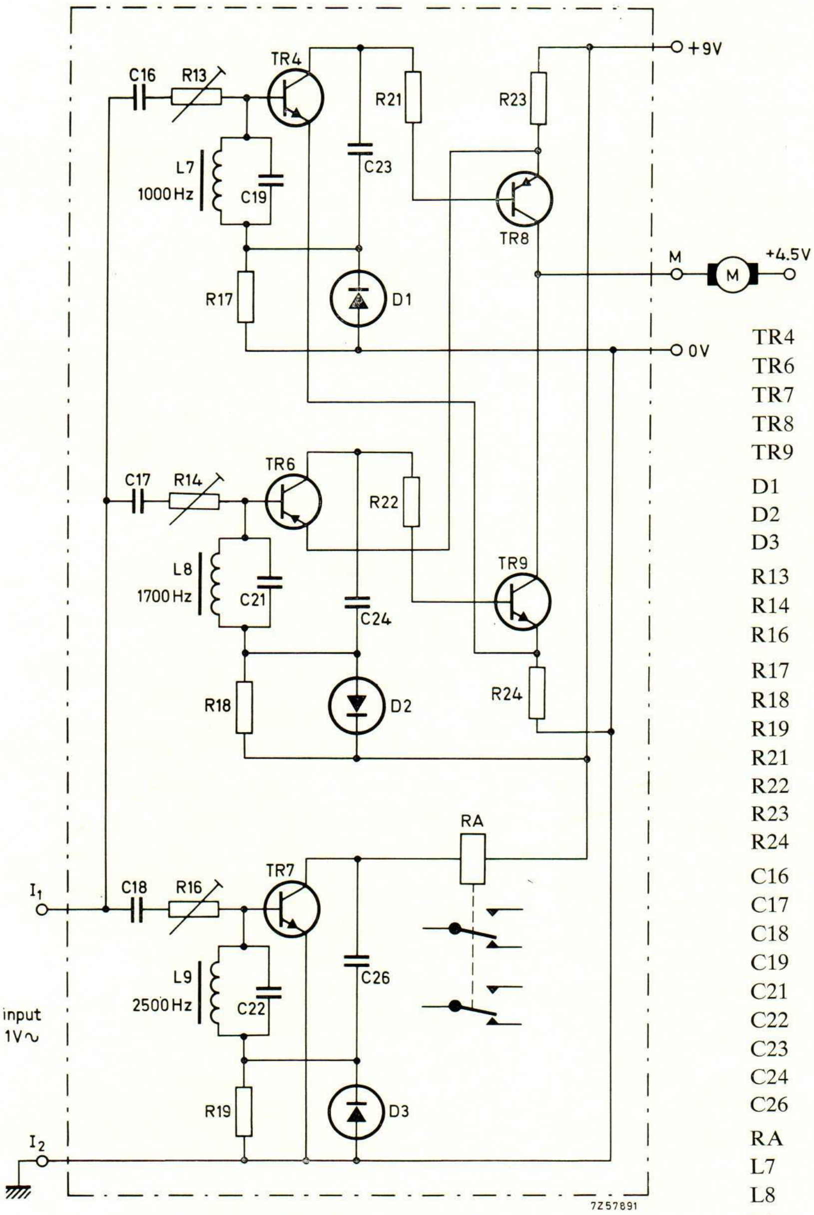


Fig. 13 — Circuit diagram of filter unit.

Parts List, Filter Unit

The right-hand column gives types numbers and catalogue numbers which you should use when ordering

TR4	n-p-n Si transistor		BC 107
TR6	p-n-p Si transistor		BC 177
TR7	n-p-n Si transistor		BC 107
TR8	p-n-p Si transistor		BD 136
TR9	n-p-n Si transistor		BD 135
D1, D2, D3	Ge diode		AA 119
R13, R14, R16	miniature carbon trimming potentiometer	220 k Ω	2322 410 05012
R17	carbon resistors	22 k Ω/¼ W	2322 101 43223
R18	carbon resistors	22 k Ω/¼ W	2322 101 43223
R19	carbon resistors	22 k Ω/¼ W	2322 101 43223
R21	carbon resistors	1 k Ω/¼ W	2322 101 43102
R22	carbon resistors	1 k Ω/¼ W	2322 101 43102
R23	carbon resistors	2 Ω / 1 W	2322 101 63208
R24	carbon resistors	2 Ω / 1 W	2322 101 63208
C16	polyester capacitor	10 nF /250 V	2222 342 45103
C17	polyester capacitor	10 nF /250 V	2222 342 45103
C18	polyester capacitor	10 nF /250 V	2222 342 45103
C19	polyester capacitor	33 nF /250 V	2222 342 45333
C21	polyester capacitor	15 nF /250 V	2222 342 45153
C22	polyester capacitor	10 nF /250 V	2222 342 45103
C23	polyester capacitor	100 nF /250 V	2222 342 45104
C24	polyester capacitor	100 nF /250 V	2222 342 45104
C26	polyester capacitor	100 nF /250 V	2222 342 45104
RA	relay 500-1000 Ω		any type
L7	potcore coil 770 mH	To be constructed according to Figs 16 to 21, inclusive.	
L8	potcore coil 585 mH	To be constructed according to Figs 16 to 21, inclusive.	
L9	potcore coil 410 mH	To be constructed according to Figs 16 to 21, inclusive.	

Operation

O_1 and O_2 of the receiver proper are connected with I_1 and I_2 of the filter unit. The 1 V input signal is fed via capacitors C_{16}, C_{17} and C_{18}, and via the miniature trimming potentiometers R_{13}, R_{14} and R_{16} to the three resonant circuits. The trimming potentiometers serve for adjusting the selectivity and sensitivity of the filter unit. The three filter circuits resonate at the frequencies of the tones produced in the tone generator, that is at, e.g., 1000, 1700 and 2500 Hz (refer to Part II).

When a signal having the frequency of, say, channel I arrives at the filter-unit input, it will cause oscillations to be set up in L_7-C_{19}; as a result TR_4 will become conductive. The collector voltage is rectified by D_1 via C_{23}; the resulting positive voltage across R_{17} reaches the base of TR_4, making it more conductive until the collector voltage drops to only 1 or 2 V. As a consequence TR_8 becomes conductive so that terminal M of the drive motor is connected to + 9 V — the drive motor starts running anticlockwise.

In response to a signal entering through channel II it is TR_6 that will start to conduct, and TR_9 that will connect terminal M of the drive motor to the minus lead — the drive motor will then start running clockwise.

The third filter section is equipped with a relay as this will give the desired results with practically all types of electric-motor-driven programme switches used to actuate the steering motors in the model boats.

It can be seen that the emitters of TR_4 and TR_6 are connected to those of TR_9 and TR_8, respectively; this is done to prevent damage to the two switching transistors, should these become conductive at the same time. When, for instance, TR_8 is conductive, a low negative voltage will develop across R_{23} which is a two-ohm resistor. This negative voltage will drive TR_6 further into non-conduction, and thus will make it almost impossible for TR_9 to become conductive. If, despite this precaution, a very strong signal on the base of TR_6 would tend to drive TR_9 into conduction, then the total current through R_{23} will increase to such an extent that TR_6 is kept blocked. The arrangement is foolproof.

Making the Filter Coils L_7, L_8, and L_9

We recommend you to use *potcores* for the filter coils. Fig. 14 shows the dimensions of the two halves

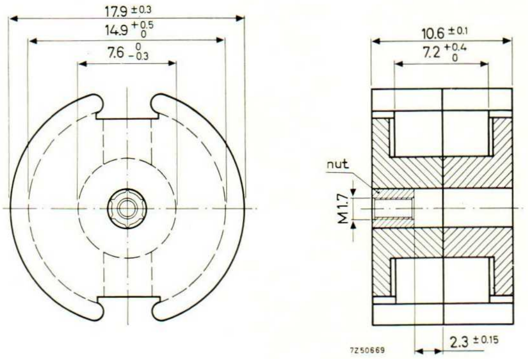


Fig. 14 — Pre-adjusted Potcore for L_7, L_8 and L_9, dimensions in mm. With nut - catal. no. 4322 022 2 . . .; without nut - catal. no. 4322 022 0 . . ..

of the P 18/11 type of ferroxcube potcores. The material of which these are made is 3H1 ferroxcube; other grades of ferroxcube are also suitable (the calculations given below can then still be used, since deviations of the resonant frequencies can easily be eliminated by tuning the tone generator in your transmitter).

The potcores depicted in Fig. 14 are called "pre-adjusted" because in the factory the centre "pole" of each half is ground to leave an air gap between the poles when the two halves are fitted together. The width of this air gap is very important since it governs the *relative effective permeability* μ_e, and this determines the number of turns required to obtain a certain coil inductance. The *nut* mentioned in Fig. 14 in both the cross-sectional view and the legend where the catalogue numbers are stated, is intended to hold an *adjustor* with which the inductance can be varied a little either way (not required in your case since you can easily tune the tone generator in the transmitter).

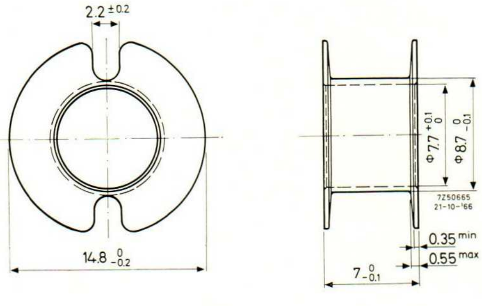


Fig. 15 — Single-section coil former for L_7, L_8 and L_9, dimensions in mm - catal. no. 4322 021 30270.

Fig. 15 shows the associated coil former which, after the single-winding coil has been wound around it, is placed in the potcore.

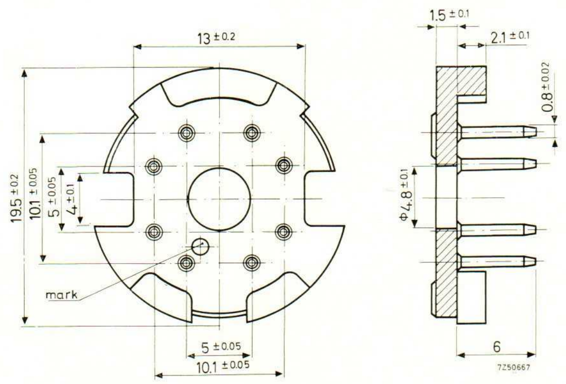


Fig. 16 — Reinforced polyester tag plate with phosphorbronze pins for L_7, L_8 and L_9, dimensions in mm - catal. no. 4322 021 30450.

Fig. 16 is the *tag plate* which can be used for making electrical connections as well as for mounting.

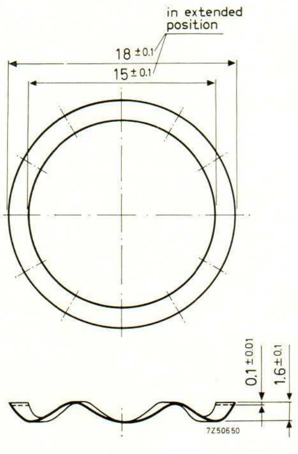


Fig. 17 — Chrome-nickel steel ring for L_7, L_8 and L_9, dimensions in mm — catal. no. 4322 021 30640.

Fig. 17 shows the *curved annular spring* that has to be inserted on top of the finished potcore when the latter is built into the *container* or can, see Fig. 18.

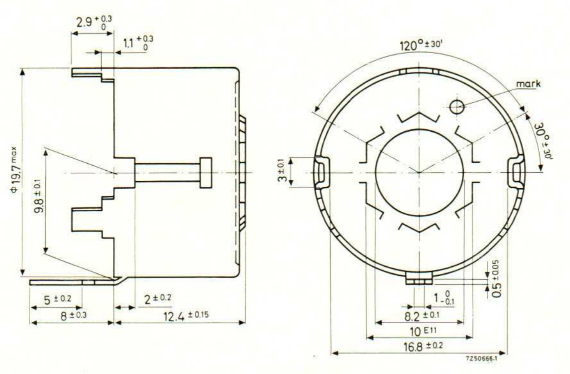


Fig. 18 — Nickel-plated brass can for L_7, L_8 and L_9, dimensions in mm — catal. no. 4322 021 30530.

In Fig. 19 we see the adjustor described before; it may be repeated that you do not need this item.

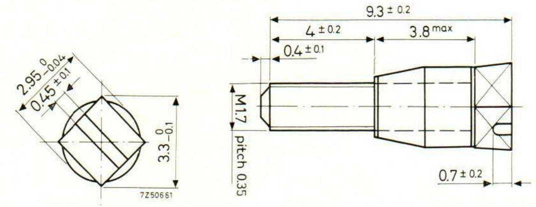


Fig. 19 — Adjustor (optional) for L_7, L_8 and L_9, dimensions in mm — catal. no. 4322 021 32080.

Finally, Fig. 20 is a cross-section of the assembled coil, also illustrating how it can be mounted.

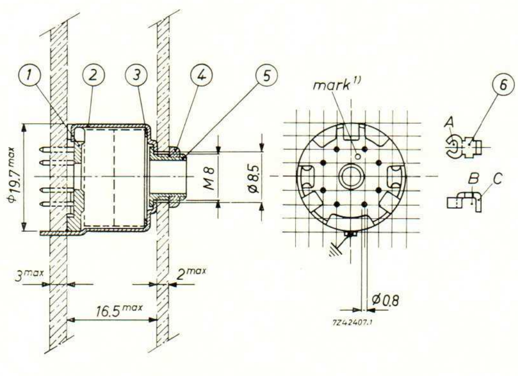
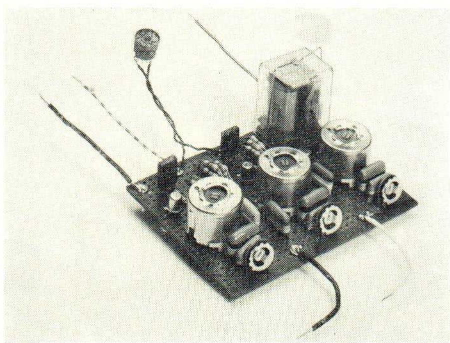


Fig. 20 — The coil assembled and mounted.
1 tag plate
2 brass container
3 spring

Other coil data can be gathered from the adjoining tables. From Table I you can derive the number of turns required to obtain a certain inductance with a potcore possessing a given relative effective permeability μ_e. Using a potcore with a μ_e value of, say, 220, you will need a coil of 46.5 turns to obtain an inductance of 1 mH. With the formula $N = \alpha\sqrt{L}$, where L is in millihenry, we can calculate other inductance values.

Table II shows the relationship between the inductance factor A_L and the μ_e value, and further presents the same information as Table I.



Calculating the number of turns for coils L_7, L_8 and L_9 on the basis of a μ_e value of 220, and hence an α of 46.5, we find:

Channel I, coil L_7

$f = 1000$ Hz $C = C_{19} = 33$ nF

$f = \dfrac{1}{2\pi\sqrt{LC}}$ hence $L \approx 770$ mH

$N = \alpha\sqrt{L} = 46.5\sqrt{770} \approx 1280$ turns

Enamelled wire, 0.1 mm diameter.

Channel II, coil L_8

$f = 1700$ Hz $C = C_{21} = 15$ nF

hence $L \approx 585$ mH

$N = 46.5\sqrt{585} \approx 1120$ turns

Enamelled wire, 0.1 mm diameter.

Channel III, coil L_9

$f = 2500$ Hz $C = C_{22} = 10$ nF

hence $L \approx 410$ mH

$N = 46.5\sqrt{410} \approx 945$ turns

Enamelled wire, 0.1 mm diameter.

Table I

Potcores with standard μ_e values

			catalogue No.	4322 022 2 . . . . with nut 4322 022 0 . . . . without nut		
μ_e	α	tolerance on inductance (%)	3B7	3H1	3D3	4C6
15	178	± 1	—	—	—	4810
22	147	± 1	—	—	—	4820
33	120	± 1	4030	4230	4430	4830
47	100.5	± 1	4040	4240	4440	—
68	83.6	± 1	4050	4250	4450	—
100	68.9	± 1.5	4060	4260	—	—
150	56.3	± 2	4070	4270	—	—
220	46.5	± 3	4080	4280	—	—
705	25.9	± 25	—	—	4400*	—
1750	16.5	± 25	4000*	4200*	—	—

Number of turns $N = \alpha\sqrt{L}$ (L in 10^{-3} H)
*)Only available without nut

Table II

Potcores with standard A_L factors

			catalogue No.	4322 022 2 . . . . with nut 4322 022 0 . . . . without nut		
A_L	corresponding μ_e - value	tolerance on inductance (%)	3B7	3H1	3D3	4C6
25	11.9	± 1	—	—	—	5810
40	19.0	± 1	—	—	5420	5820
63	30	± 1	5030	5230	5430	5830
100	47.5	± 1	5040	5240	5440	—
160	76	± 1	5050	5250	5450	—
250	119	± 1.5	5060	5260	—	—
315	149	± 2	5070	5270	—	—
400	190	± 2	5080	5280	—	—
630	298	± 3	5100	5300	—	—

Inductante $L = N^2 A_L$ (in 10^{-9} H)

The Mechanical System

Rudder Control

This is effected by means of a self-neutralizing servo motor of which many types are available. Below you find a brief description of the Graupner "Variomatic", a type that has proved to be strong enough and requires only 2.5 V to 3 V. Ask your technical-toy dealer for advice — remember that the type of servo motor you buy should match the speed and size of your boat.

Fig. 21 is a simplified drawing of the essential steering items. Segment *S* meshes with toothed wheel *T*; the latter is not rigidly fixed to its shaft but via a slip coupling. Springs *A* and *B* keep the segment in the neutral position when *T* is not actuated. The reduction gear between motor *M* and the shaft of *T* is so chosen that *T* makes one

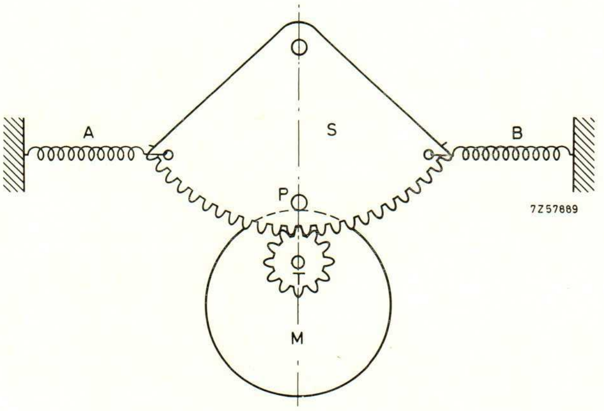


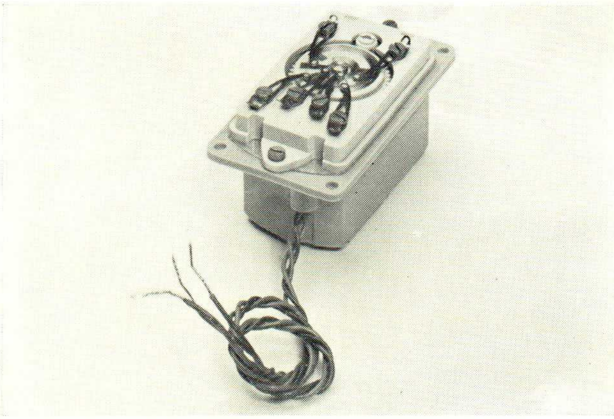
Fig. 21 — Simplified representation of steering mechanism.

revolution per second. With *S* in one of the two extreme positions the motor can go on running with the coupling slipping. When the control signal terminates, springs *A* and *B* make *S* return to the rest position. The motor armature will have to follow this movement without being braked magnetically — it must, therefore, be an ironless armature. Pin *P* attached to the segment serves for connecting the rudder.

"Go" Control

The boat's main engine or motor is always controlled in a fixed sequence: stop - ahead - stop - astern, etc. A fifth step is sometimes added: "slow ahead".

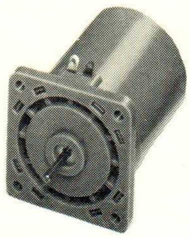
Various types of relays and switches are commercially available; the photograph shows the Polemat II, a five-position programme switch marketed by the firm of Schuco and actuated by relay *RA* in Fig. 13.



The motor built into the model boat depicted in the photographs was a windscreen-wiper motor with permanent-magnet stator, requiring 12 V at 1 A to 2 A. This is a powerful type only recommendable for larger boats — for smaller ones we advise you to take the 6 V motor marketed by Polymotor S.A., catalogue number 9904 120 07 . . ..

This small d.c. motor has a plastic moulded housing. The special flat commutator guarantees a long life. The motor can be delivered with and without a built-in spark suppression system. The standard motor is a 6 V version, but versions for other voltages (and speeds) can also be supplied. The efficiency is extremely high for such a small motor: 55%. The motor can be used in industrial devices, small household appliances, all kinds of motor driven toys, etc. Below we give some characteristics.

Voltage	6 V
Current at nominal load	390 mA
Current at no load	95 mA
Number of revolutions/min. at no load	4800
Number of revolutions/min. at nominal load	4000



Power Supplies

For receiver proper + filter unit + servo motor + programme switch: 9 V d.c. with tap for 4.5 V.
For main motor: depends on type of motor.
A suitable power supply for the windscreen-wiper type of motor can be built up with ten series-connected, 3.5 Ah nickel-cadmium cells (of which a new version, catalogue number 2422 510 14 . . ., will become available soon). The small Polymotor unit will operate smoothly from four series-connected 1.5 V cells.

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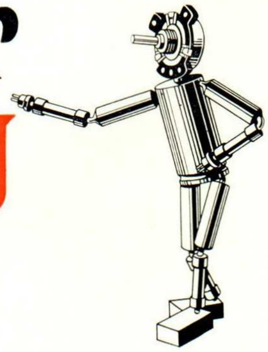


Dip Meter

Dear Experimenter,

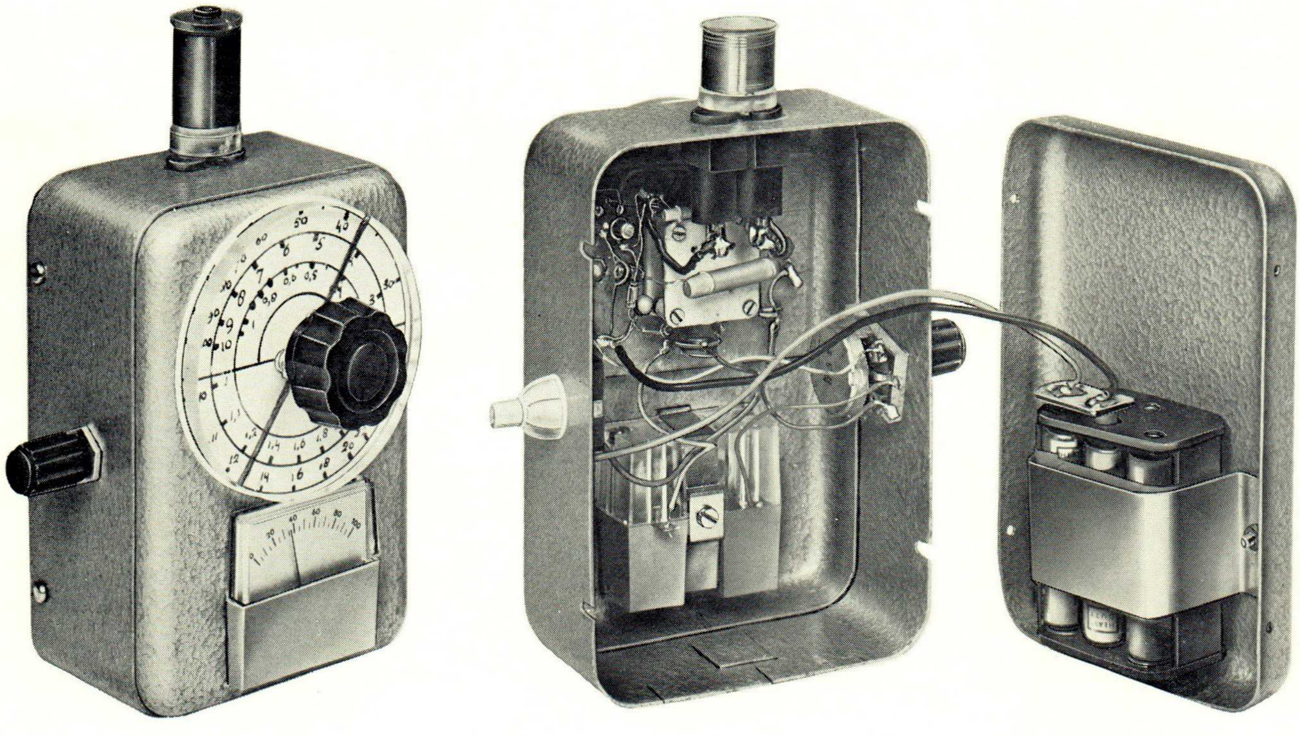
It is real fun to see how often the simplest instruments are the most popular ones. Take the Dip Meter. We can hear you say: "The very instrument we should have had at our disposal when building the radio control system described in Electronics for You 18, 19 and 20". Exactly!

We are therefore going to make one now. Of course it is not a precision instrument but it is hard to beat it when one wants a quick check on:

— the resonant frequency of a tuned circuit;
— the alignment (trimming) of a receiver;
— fieldstrengths;
— the frequency of an oscillator;
— capacitances, self-inductances and Q-factors (which includes finding a short-circuit in an electronic component).

To calibrate a Dip Meter you will need a good all-wave receiver. If you have not got one you will have to borrow it from that fellow-experimenter "across the road" — maybe it is the first time you speak to him but he will probably turn out a fine fellow! Apart from these human friends,

Philips Components Are Your Best Friends!



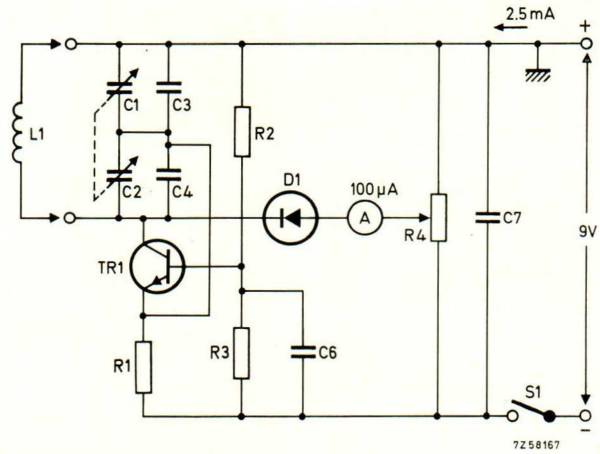


Fig. 1 - Circuit diagram

Operation

See Fig. 1

Coil L_1 is one of the following five coils, chosen for its frequency range and plugged into the sockets provided for the purpose:

Coil I — 320 kHz to 1 MHz
Coil II — 1 MHz to 3.2 MHz
Coil III — 3.2 MHz to 10 MHz
Coil IV — 10 MHz to 32 MHz
Coil V — 32 MHz to 100 MHz

Capacitor C_1C_2 is a variable capacitor — two sections of 385 pF connected in series — the rotor is connected to the emitter of transistor TR_1 (this connection provides the positive feedback path).

L_1 - C_1C_2 - C_3 - C_4 form the tuned circuit for a Colpitts oscillator, which has the advantage that it can be made to oscillate at any frequency in a rather wide range.

The r.f. voltage developing across the tuned circuit is rectified by diode D_1 and next measured with meter M_1. The higher the sensitivity of this meter the better (at least 0.1 mA f.s.d.; 50 μA f.s.d. is even better because of the smaller damping effect on the circuit).

Under these conditions coil L_1 emits some r.f. power; any circuit tuned to the same frequency and inductively coupled to the oscillator circuit will absorb some of this power, and the instrument reading will then drop sharply (the meter "dips"). A special use of the instrument is as an absorption meter for fieldstrength measurements. The Dip Meter is then *not* switched on, but the coil is used to receive any radiowave originating from, for instance, a transmitter, absorbing power from this wave which results in the meter deflecting. The deflection is maximum when the circuit L_1 - C_1 - C_2 - C_3 - C_4 is tuned to the frequency of the radio wave.

Parts List

The right-hand column gives type numbers and catalogue which you should use when ordering.

R1				
R2	carbon resistor,	4.7 kΩ		2322 101 43472
R3	¼ W			
R4	potentiometer	22 kΩ lin.		2322 350 70608
C1,C2	film-dielectric variable capacitor	2 x 385 pF		2222 807 10048
C3		100 pF,	500 V	2222 563 02101
C4	ceramic capacitors	4.7 pF,	500 V	2222 563 01478
C6		33 pF,	500 V	2222 563 02339
C7		4700 pF,	500 V	2222 563 02472
L1	see text			
TR1	n-p-n Si transistor			BF115, BF167, BF183, BF185
D1	Ge-diode			AA119
S1	push-button switch			any type
M1	meter 50 μA or 0.1 mA			any type
6	batteries, 1.5 V			any make

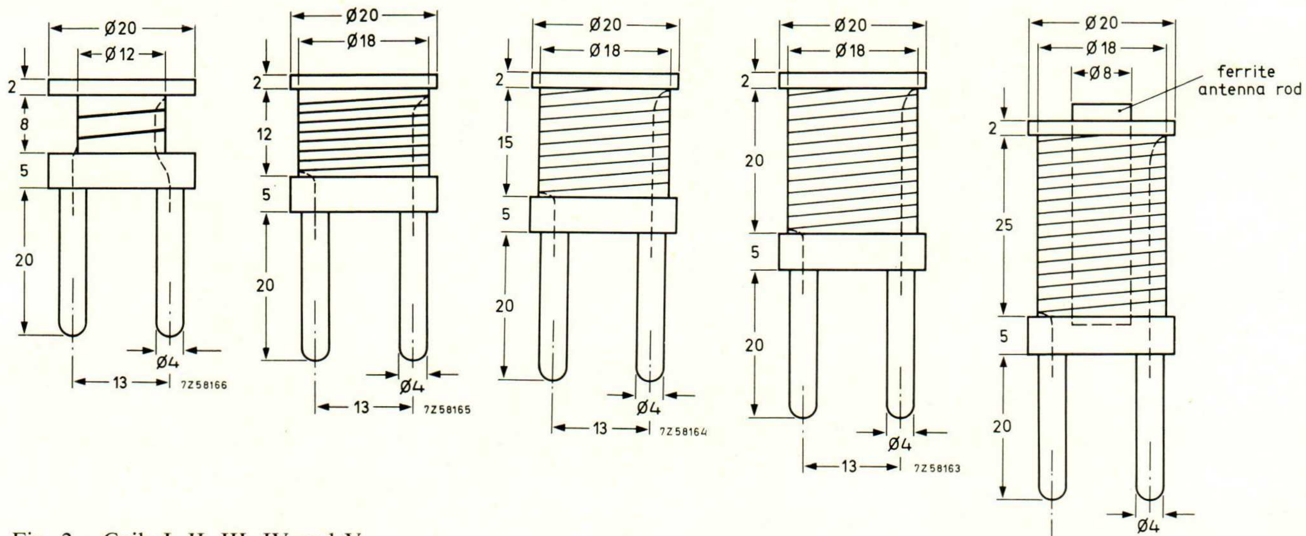


Fig. 2 - Coils I. II, III, IV and V

Notes on the Construction

See the photograph on page 1.

Make sure that all connections are short. Use a pair of good quality sockets for the coil. Insulate the spindle of the variable capacitor properly from the metal box (remember to use a control knob also made of insulating material). Employ a "press-to-switch-on" type of pushbutton switch for S_1, so that the instrument is not on unless you want it to be on.

Making the Coils

Fig. 2 shows a possible construction of the coils. When you use coil formers of the dimensions stated here, the winding data are as follows:

Coil I = 200 turns, enamelled copper wire, 0.1 mm dia. (the antenna rod is of the 4B1 type of ferrite, 8 mm dia., 30 mm long).

Coil II = 88 turns, enamelled copper wire, 0.2 mm dia.

Coil III = 27 turns, enamelled copper wire, 0.5 mm dia.

Coil IV = 8 turns, enamelled copper wire, 1 mm dia.

Coil V = 2 turns, enamelled copper wire, 1 mm dia.

Calibrating the Instrument

1. Get a good all-wave receiver, preferably one having easily readable frequency scales ranging from at least 300 kHz to 100 MHz. Switch it on and tune it to 300 kHz.
2. Plug in coil I (320 kHz to 1 MHz), and press S_1 on the Dip Meter. Turn the control knob on the instrument until a whistle is heard in the receiver — adjust the knob for minimum whistle. Mark the scale for this control knob — 300 kHz. If the mark is too far from where you would like the scale to begin, try adjusting the ferrite core of the coil.
3. Find the mark for the other end of the scale (1 MHz) in the same way. If you are satisfied with the positions of these marks, find those for the other frequencies in the subrange (e.g. 400, 500, 600, etc. kHz).
4. Repeat the above procedure for the other four coils. Since these coils are not provided with an adjustable core you will have to add or remove turns from the coil winding if the scales are not positioned in the way you like them to be (unless you prefer to make all coils with cores which could require some calculating on your part).

The Instrument's Main Uses

1. **Determining the Resonant Frequency of a Tuned Circuit**

   First of all estimate the unknown resonant frequency so that you can choose one of the coils; plug this in. Switch on the instrument and adjust the potentiometer (R_4) to obtain a deflection which is as large as possible. Next shift the instrument until the coil is near the coil of the tuned circuit. Turn the control knob until the meter dips. Read the wanted frequency on the appropriate scale. The "depth" of the dip is a measure for the circuit quality: the deeper and swifter the dip, the higher the Q.

2. **Aligning a Receiver**

   The Dip Meter can be used as a signal generator: the r.f. voltage across the coil results in weak radio waves emanating from the coil. If necessary, the strength of these waves can be increased by winding one end of a copper wire, about 1 metre long, a few turns around the coil of the instrument so that this wire serves as an aerial.

   The signal produced in this way can be employed for ganging the circuits of a receiver.

3. **Adjusting an Electromagnetic Field for Maximum Strength**

   In fieldstrength checks as necessary for matching an aerial to a transmitter (also see "Electronics for You", No. 18) the instrument is made to absorb r.f. power, not to emit it. For these checks the instrument is therefore not switched on, but its coil is held in the vicinity of the aerial. With the instrument tuned to the oscillator frequency, you will see the meter deflect; the idea is to find maximum deflection. The tuned circuit of the Dip Meter absorbs power emitted by the aerial.

4. **Checking Capacitances, Self-inductances and Q Factors**

   When one of the elements of an LC circuit is known, the other can be calculated after the resonant frequency has been found. The formula to use is the well-known formula:

$$f = \frac{1}{2\pi\sqrt{LC}}$$

where f = frequency in Hz,
L = self-inductance in henry,
C = capacitance in farad.

When we express the frequency in MHz, the self-inductance in μH and the capacitance in pF, the following formulae can be derived from the general one stated above:

$$C = \frac{25000}{f^2 L} \quad \text{and} \quad L = \frac{25000}{f^2 C}$$

Example: Suppose you have a capacitor of 100 pF and that you have found the resonant frequency to be 20 MHz. The value of L will then be:

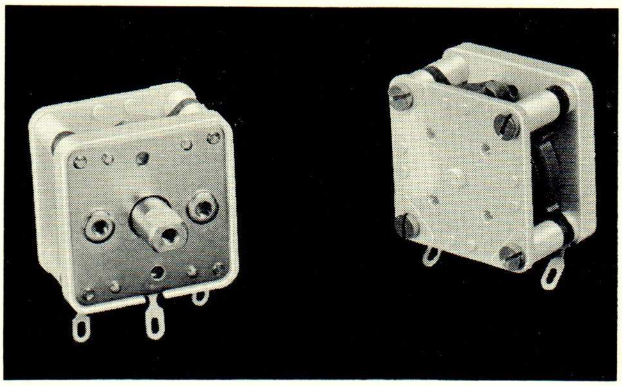
$$L = \frac{25000}{20^2 \times 100} = 0.63\ \mu\text{H}$$

The measuring procedure is described under 1. The quality factor of the coil is indicated by the nature of the "dip" — a fast, deep dip is a sure sign of a good quality. The check is very handy when you suspect a coil of suffering from a short-circuit.

Please remember not to couple the coil of the Dip Meter too tightly with that of the circuit to be checked. That would affect the accuracy which you should not expect to be better than 10%, anyway.

Film Dielectric Variable Capacitor

The most important component in the Dip Meter is the variable capacitor, type 2222 807 10048, composed of 2 sections, each of 385 pF (Figs 3 and 4). The dielectric consists of thin high-density polyethylene discs, which are shrunk over the stator vanes.



Technical Details

Capacitance swing of both sections 6-180°	385 pF
Zero capacitance of both sections	5 ± 1 pF
Max. working voltage	50 Vp
Test voltage	300 Vdc
Parallel damping at 1.5 MHz	3 MΩ
Insulation resistance	10^4 MΩ

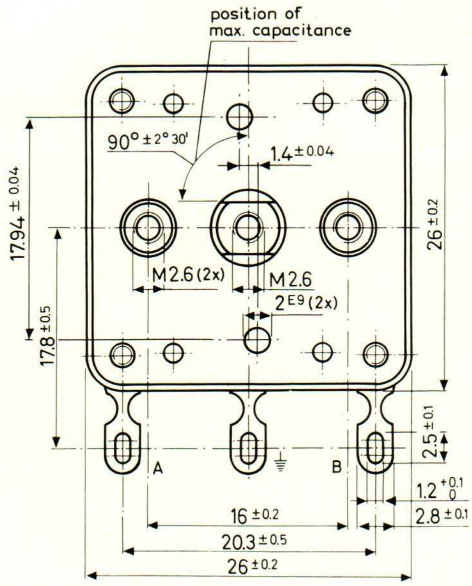


Fig. 3

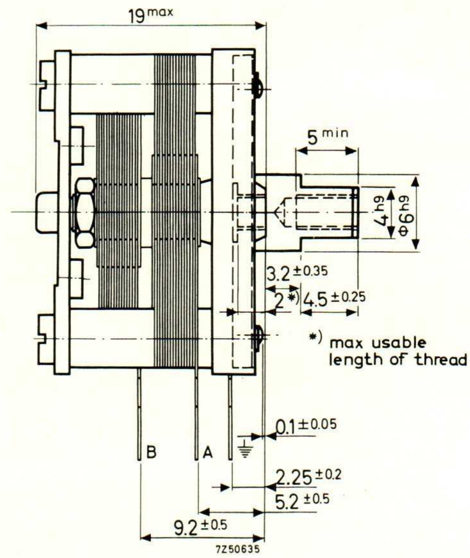


Fig. 4

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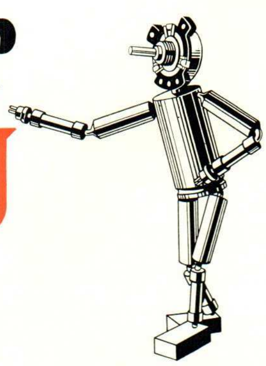


Reaction Time Tester

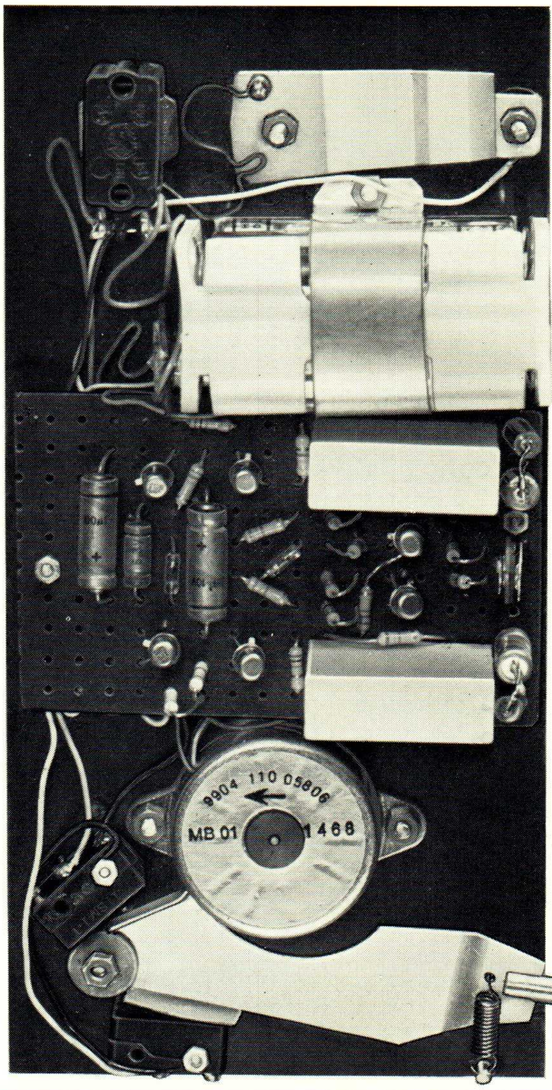
Dear Experimenter,

In practically all previous leaflets we have done our best to enable you to build a useful device, so you may wonder why we picked a "scientific instrument" this time.

We fully realize that there may not be many electronic experimenters who are sufficiently interested in time studies; therefore, as was the case with the Intelligence Testers (Electronics for You, No. 14), the Reaction Time Tester should mainly be considered as a highly fascinating toy. Unless you are a student of or a specialist in matters of reaction time, you should not draw any serious conclusions from the test results obtained with the device. But, if you are an expert you will find it an inexpensive, yet reasonably accurate piece of equipment. We can guarantee you one thing: show the instrument to your friends and they will start a contest! Whether they are sportsmen or just car drivers, they will want to know if their reactions are fast enough.

We wish you lots of success in testing the abilities of your friends, but remember

Philips Components Are Your Best Friends!



Features of this Reaction Time Tester

A Reaction Time Tester is an instrument which helps you to find out how much time you need to perform a simple task. In the case of the instrument we are going to build this task is, for instance, to stop a motor as soon as possible after it has started to run. It is the motor which is therefore the most important item to be incorporated into the Reaction Time Tester. Yet it is one of the least expensive of our special types of synchronous motors that can also be used as stepper motors, and is available under the catalogue number 9904 110 05806. In the tester it does operate as a stepper motor, driven by pulses produced by — and this is quite a feature — three simple multivibrators. The last of these is an astable multivibrator which alternates between periods of 20 ms, each time causing the motor to make a step. In twenty-four steps, hence 480 ms, the motor completes one revolution. A pointer, fitted to the motor spindle and moving over a scale calibrated in milliseconds, shows how many steps the motor has made from a reference position before it is stopped. In this way the time interval: start (from reference position) — stop (as soon as possible), is indicated with an accuracy of 20 ms. A good average is 180 ms.

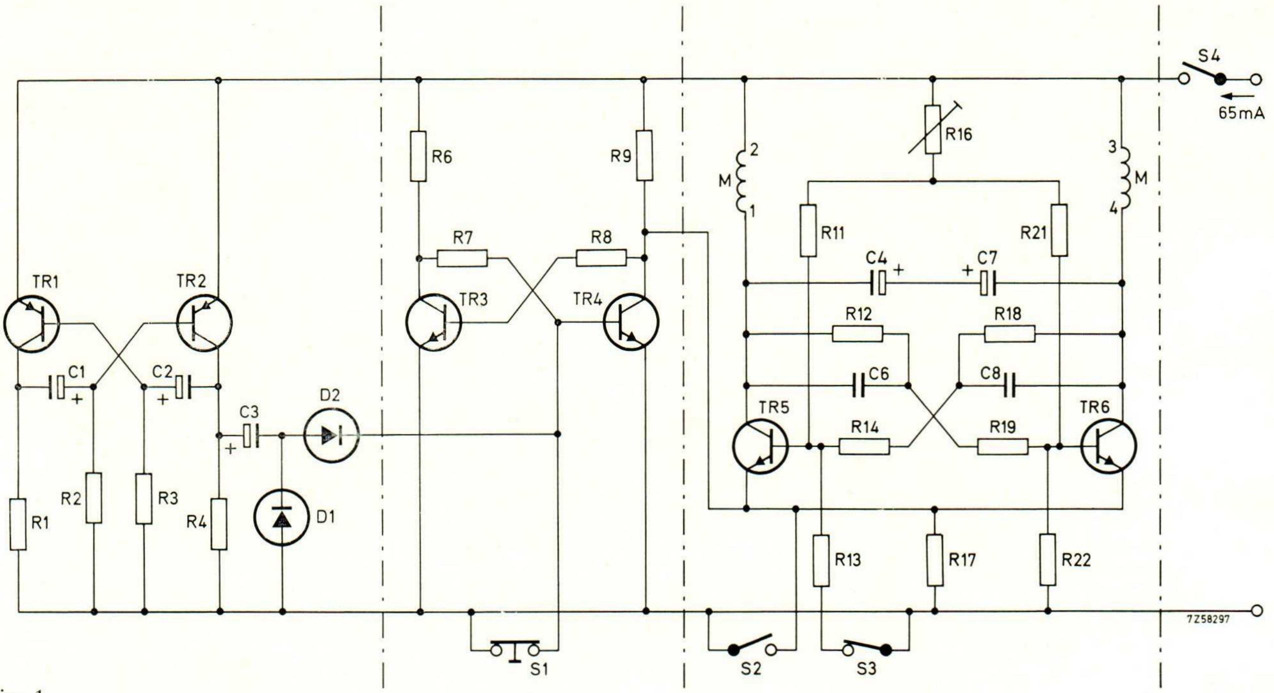


Fig. 1 - I II III

Parts List

The right-hand column gives type number and catalogue number which you should use when ordering.

TR1, TR2	p-n-p Si transistors		BC 177/178/179
TR3, TR4, TR5, TR6	n-p-n Si transistors		BC 107/108/109
D1, D2	Ge diode		AA 119
R1	carbon resistors ¼ W	1 kΩ	2322 101 43102
R2		22 kΩ	2322 101 43223
R3		22 kΩ	2322 101 43223
R4		1 kΩ	2322 101 43102
R6		330 Ω	2322 101 43331
R7		2.7 kΩ	2322 101 43272
R8		2.7 kΩ	2322 101 43272
R9		1 kΩ	2322 101 43102
R11		10 kΩ	2322 101 43103
R12		6.8 kΩ	2322 101 43682
R13		10 kΩ	2322 101 43103
R14		1.5 kΩ	2322 101 43152
R16	trimming potentiometer	4.7 kΩ	2322 410 05006
R17	carbon resistors ¼ W	47 Ω	2322 101 43479
R18		6.8 kΩ	2322 101 43682
R19		1.5 kΩ	2322 101 43152
R21		10 kΩ	2322 101 43103
R22		10 kΩ	2322 101 43103
C1	electrolytic capacitor	100 μF 16 V	2222 001 90038
C2		100 μF 16 V	2222 001 90038
C3		32 μF 10 V	2222 001 14329
C4		64 μF 10 V	2222 001 14649
C6	polycarbonate cap.	4.7 μF 100 V	2222 344 20475
C7	electrolytic cap.	64 μF 10 V	2222 001 14649
C8	polycarbonate cap.	4.7 μF 100 V	2222 344 20475
S1	switch		see text
S2	switch		any type
S3	switch		any type
S4	on/off switch		any type
M	synchronous motor 12 V d.c. clockwise rotation		9904 110 05806

Circuit Description

See Figs. 1 and 2.

The three multivibrators are:

- an astable multivibrator I with a switching time of approx. 3 seconds;
- a bistable multivibrator II;
- an astable multivibrator III with a switching time of 20 milliseconds.

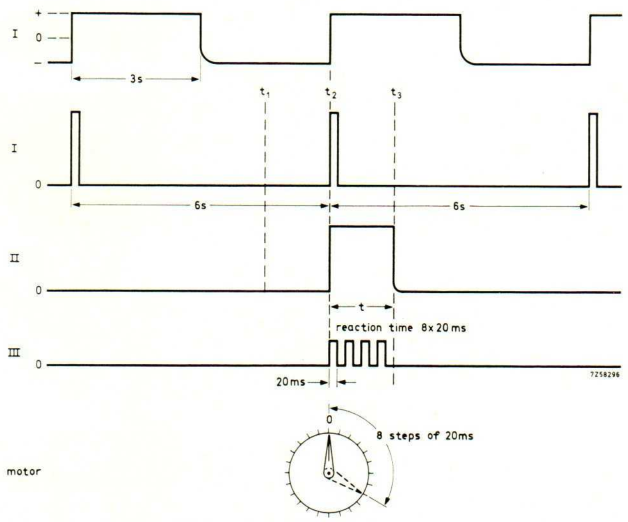


Fig. 2 - Output pulses of multivibrators

Fig. 2 shows the relationship between the output pulses of these three multivibrators. The upper waveform represents the situation preceding differentiating capacitor C_3, the second waveform shows the signal arriving at the base of TR_4 (negative parts of output of multivibrator I removed by diodes D_1 and D_2). This transistor is part of bistable multivibrator II which changes over every time a positive pulse arrives at the TR_4 base *with the switch S_1 being open.* Suppose that S_1 is opened at moment t_1, then multivibrator II will change over at moment t_2; TR_4 then becomes conductive (see waveform II). One cannot predict how long after the opening of S_1 the positive pulse will be produced by multivibrator II, since there is no way of telling how far in the cycle of multivibrator I the switch S_1 is opened.

Anyway, the moment TR_4 becomes conductive it shortcircuits the common emitter resistor R_{17} of TR_5 and TR_6, thus triggering multivibrator III into producing its 20 ms pulses (R_{16} serves for fine adjustment of the multivibrator frequency). These pulses are supplied to the field windings of the synchronous motor after being rounded off by electrolytic capacitors C_4 and C_7 (this ensures smooth running of the motor; recommended value 64 μF for either capacitor — sometimes another value may give better results). Resistors R_{12} and R_{18} make sure that the multivibrator does really remain in the condition it arrived in at moment t_3.

Fig. 2 also illustrates how the motor makes 8 steps of 20 ms each, when 8 pulses are produced by multivibrator III in the interval t_2 — t_3. It is this interval which represents the reaction time of the person who is testing himself.

Notes on the Mechanical Components

Fig. 3 shows the special *lever Le* which we have designed for re-setting the pointer (and thus the motor) to the zero reference point after a reading has been taken. This lever is pivoted at *P*, and carries an *arresting pin A* which protrudes through a slot in the top panel of the housing. When pushed down, lever *Le* opens *microswitch* S_3, and closes *microswitch* S_2. The opening of S_3 results in R_{13} to be disconnected from the zero line and hence multivibrator III to stop in a preferred condition (with TR_5 conductive and TR_6 non-conductive). The closing of S_2 starts multivibrator III and the motor runs until the pointer is stopped by pin *A*.

When released, lever *Le* is pulled back to the original position by *spring Sp;* first S_2 is opened (multivibrator III becomes inoperative, with TR_5 being conductive); next the pointer is released (but it does not move on since the multivibrator is no longer producing pulses) and S_3 is closed again (R_{13} is re-connected into the circuit, and as a consequence the multivibrator becomes symmetrical again).

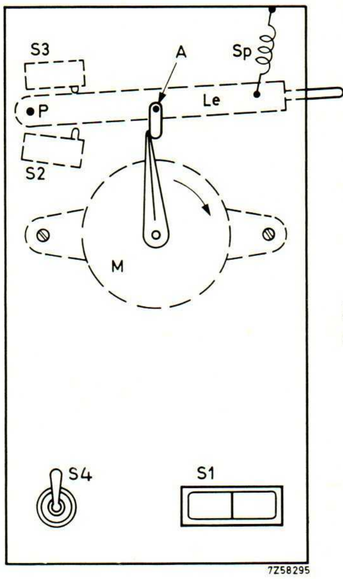


Fig. 3 - Pointer control (seen from the front)

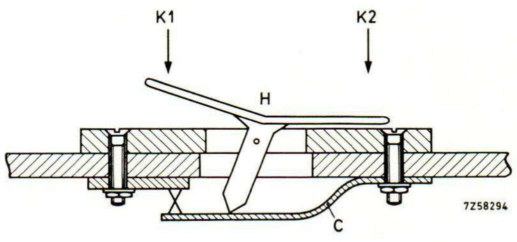


Fig. 4 - Design of switch S_1

Fig. 4 gives the details of the construction of switch S_1. Its design is not critical, however, provided that care is taken to make it as easy as possible for the "test subject" to open S_1 (force K_1) and next to close it again with one finger (force K_2).

Notes on the Construction

It is essential that the pointer is made of very light material and that its colour contrasts as much as possible with that of the scale. The latter must be marked with 24 divisions: 20-40-60 etc. to 480. The pointer must be so positioned on the motor spindle that it does not move when released by pin A.

Just one note on the construction of S_1: make sure that contact strip C is pushed down just enough to break the circuit; any extra travel of this strip only lengthens the reaction time.

Finally verify if S_2 and S_3 are so far apart that there is enough time for multivibrator III to switch to the preferred condition after S_3 has been opened but before S_2 is closed.

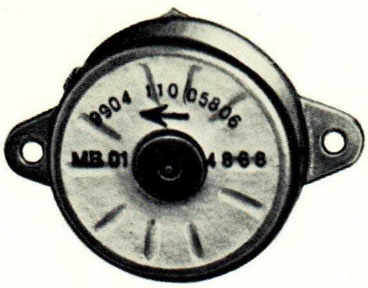
The photographs illustrate how these and other mechanical components can best be grouped around the electronic ones.

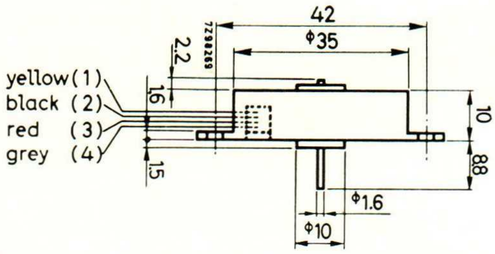
Synchronous Motor — Catalogue No. 9904 110 05806

This small synchronous motor owes its special properties to the magnetic material called *ferroxdure*. Ferroxdure is characterized by a high coercive force and a motor built with it can be provided with a large number of poles along the periphery of the armature. The ferroxdure armature of the motor under description has a diameter of only 14 mm — yet it carries twelve North poles, alternating with twelve South poles. The coercive force of the ferroxdure is not affected by the alternating magnetic field of the stator, which also has 12 pole pairs. These are so aranged that the motor runs in one direction only. The stator coil consists of two windings, of 611 turns each, of 0.2 mm dia. enamelled copper wire. Fig. 5 shows the dimensions of the motor. More information can be found in the booklet

"Small Synchronous Motors and Gearboxes"

which is available upon request.





Motor 9904 110 05806
or 9904 110 05808.

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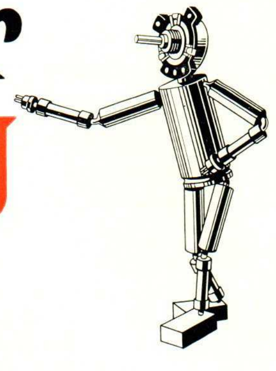


Enlarger Exposure Meter
Annex Luxmeter

Dear Experimenter,

Don't think you are the only hobbyist-photographer in the world yearning to add a good Enlarger Exposure Meter to his dark-room equipment. On the contrary, commercially available meters are so expensive that you are one of a **crowd !**

So we'll try to help this crowd — at the same time, of course, boosting our sales of electronic components — by supplying the information necessary for the home-construction of a good instrument. We'll give you some theory, the circuits, a number of constructional hints and . . . the urgent advice to

Use Philips Components for Optimum Results

The Problem of Correct Exposure

The problem of finding the correct exposure time for any dark-room job has two aspects: one must know the quality of the paper, but also the amount of light that falls on the paper. Paper quality, in its turn, depends on sensitivity and contrast grade.

The *sensitivity* of photographic paper is expressed in *lux-seconds*. Example: A sensitivity of 32 lux-seconds means that exposure for 64 seconds by ½ lux, or for 16 seconds by 2 lux, etc., will cause maximum blackening of the print.

The *contrast grades* of photographic paper are given in *black-to-white ratios*. Just look at the enclosed photo of strips made of 6 different grades of paper of a well-known make. The strips in the bottom row were exposed to 1 lux for 1 second, those in the row one higher up to 1 lux for 2 seconds, and so on. It can be seen that the Extra Soft grade marked BEW is no longer white after 1 lux-second, and almost black after 128 lux-seconds. The b/w ratio here is 1 : 128. The Extra Hard grade BEH is still white after 4 seconds of exposure to 1 lux and already black after 32 seconds — b/w ratio 4 : 32. The other grades: RW - Soft; BS - Special; BN - Normal, and BH - Hard, have b/w ratios between those mentioned so far.

In a similar way the highlights, middle tones and dark shadows in negatives determine whether the negative is soft (b/w ratio, for instance, 1 : 8) or hard (1 : 256). Hard enlarging paper is preferably used with soft negatives, and vice versa. This general rule is, of course, too rough to give good results in all cases. After all, there are a number of factors than can make the light produced by the enlarger change (the enlargement factor, the wattage of the lamp, the enlarger-diaphragm opening, the quality and nature of the negative, etc.) and evidently the requirements imposed on the photographic paper vary accordingly.

The Principles of the Exposure Meter - Luxmeter

The essential part of our instrument is a bridge having a light-dependent component connected in one of its branches. Changes in the electrical quantities of this component can be balanced out by means of potentiometers in another branch. The balanced condition of the bridge is indicated by an indicator tube lighting up, or a measuring instrument reading zero. It is the positions of the knobs on the potentiometers that provide the wanted information: the exposure time or the amount of light.

Two Different Versions

Two different versions of an Enlarger Exposure Meter will be described — the first uses a light-dependent resistor as the sensing element and is operated from the 220 V mains; the second is equipped with a CdS cell and is battery-operated.

Version I

(See Fig. 1 and the associated Parts List)

The bridge circuit has the four branches:

a) The LDR R_4
b) Potentiometers R_6, R_7 and resistor R_8
c) Resistor R_1 + filament of V_1
d) Resistor R_2 + filament of V_1

The 220 V from the mains is reduced to about 50 V by voltage divider C_1-R_1 + filament of V_1 + R_2. The voltage at the filament of V_1 is about 25 V, the voltage drop across it 1.4 V, and the current through it 25 mA. This tuning indicator tube will be about to light up (that is, to draw current) when the voltage at junction $R_3/R_4/R_6$ is 2 to 3 V below that at its filament.

When the bridge is in the balanced condition the resistance of the LDR equals the sum of the resistances of R_6, R_7 and R_8. The potentiometer to be adjusted for bridge balance when there is little light is R_6, and with much light, R_7. When R_6 is used, R_7 must be in the zero position, and vice versa. R_3 prevents the grid current of V_1 becoming too high when the resistance of the LDR is low (that is, at a high level of illumination).

Version II

(See Fig. 2 + Parts List)

The bridge circuit in this case has two main parts: R_1 + R_2 + R_3 and R_9 + R_{11} + R_{12} + R_{13}. In the balanced condition the voltages at the bases of TR_1 and TR_2 wil be equal, and meter A will read zero. When the bridge is unbalanced, there will be a difference between the collector currents flowing through R_4 and R_7, and the meter will deflect accordingly. Diodes D_1 ... D_4 make sure that the current through the meter always has the same direction. The balancing potentiometers are R_{12} (little light) and R_{13} (much light).

R_{14} is included to keep the current through the photoconductive cell R_9 within safe limits if the resistance of this cell becomes exceedingly low and high levels of illumination; without R_{14} the cell current might exceed the rating of 25 mA.

Notes on the Construction

You can suit yourself in assembling the electronic circuits, with the exception of the two "probes" which contain the light-dependent resistor and the photoconductive cell, respectively. A possible construction for these probes is shown in the photos on page 1 where, on the left, you see the model of Version I, with the tuning indicator tube visible through a slot in the cover which carries the two potentiometers and their scales, both calibrated in seconds. On the right is Version II, with the milliammeter, and the two controls calibrated in lux.

You will do wise to build in a small 6 V, 50 mA pilot lamp into the milliameter (see LA in Fig. 2) in such a way that the meter scale is faintly illuminated. Otherwise you will have to use a dark-room lamp (green or red) to read the meter, and the light of the lamp may affect the lux measurements.

Notes on Scale Calibration

Unless you can get hold of a luxmeter-on-loan you need the photo of the test strips enclosed herewith to calibrate the scales in seconds. First you will have to prepare a similar series of test strips for one grade of paper, preferably the grade which you use most. So, you expose the first strip for one second, the next for two seconds, the third for four seconds, and so on. Then you compare the strips with those on the photo. Let us suppose that your 16-second strip is just as dark as the 4-lux-second one on the photo. In other words: you needed four times the exposure time, or your illumination level is ¼ lux. Choosing the diaphragm two stops larger you will obtain one lux.

Having thus made sure that the amount of light produced by the enlarger is 1 lux, you place the probe in the beam of light. Then adjust the potentiometer until the dot of the exclamation mark displayed by the tuning indicators starts to glow. Mark the corresponding position of the potentiometer by putting the figure 1 on the scale. Subsequently reduce the diaphragm opening by one stop at a time, each time doubling the figure put on the scale (2, 4, 8, 16, 32, etc.). You will then have prepared a scale calibrated in time intervals for an illumination level of 1 lux and for the photographic paper concerned. As can be seen from the test-strip photo enclosed, correction factors will have to be found when other grades of paper are employed.

Figs. 3 and 4 illustrate what scales calibrated in lux may look like. In Fig. 3 is the scale for potentiometer R_{12}, in Fig. 4 the (overlapping) scale for R_{13}. In view of the spread in the characteristics of the photoconductive cell and of the potentiometers you are advised to make your own scales with the aid of a good luxmeter. When necessary, small deviations can be eliminated by R_2.

Operational Notes

Whether you have calibrated the scales in lux or in seconds — by the way, it is quite feasible to make both types of scale, and make them interchangeable — you can use both versions of the instrument to

- determine the grade of some "unknown" sheet of photographic paper;
- find the correct exposure time for making prints or enlargements,

provided you consult the test-strip photo.

When the instrument is provided with a lux scale you can use it to measure the amount of ambient light in any room.

(contd. on page 4)

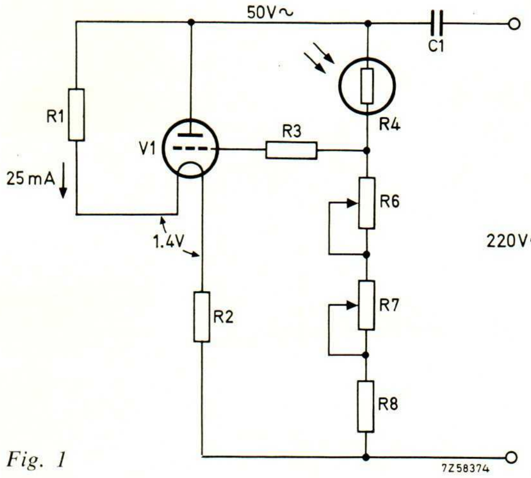


Fig. 1

Parts List Fig. 1

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

V_1 indicator tube			DM70
R_1 carbon resistor	1.2 kΩ	1W	2322 101 73122
R_2 carbon resistor	1.2 kΩ	1W	2322 101 73102
R_3 carbon resistor	470 kΩ	¼W	2322 101 43474
R_4 light-dependent resistor			2322 600 94001
R_6 potentiometer	2.2 MΩ lin.		2322 350 00715
R_7 potentiometer	220 KΩ lin.		2322 350 00712
R_8 carbon resistor	3.3 kΩ	¼W	2322 101 43332
C_1 polycarbonate capacitor	330 nF		2222 342 61334

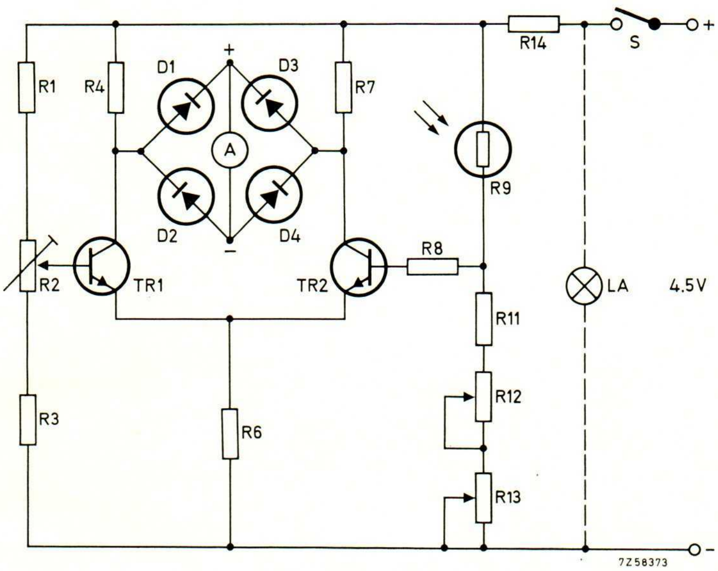


Fig. 2

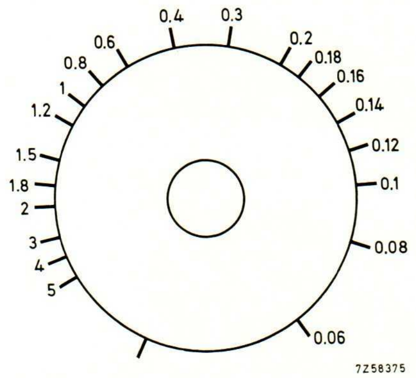


Fig. 3

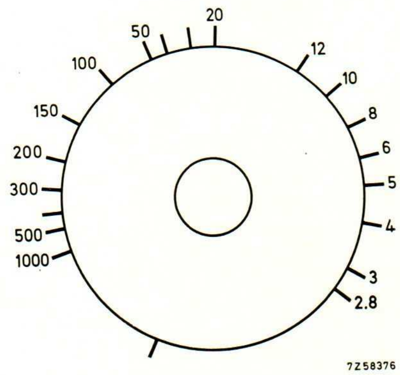


Fig. 4

Parts List Fig. 2

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

TR_1	n-p-n- Si transistor			BC109 / BC149
TR_2	n-p-n- Si transistor			BC109 / BC149
D_1 D_2 D_3 D_4	Ge diode			AA119
R_1	carbon resistor	4.7 kΩ	¼W	2322 101 43742
R_2	trimming potentiometer	1 kΩ		2322 411 02204
R_3	carbon resistor	4.7 kΩ	¼W	2322 101 43472
R_4	carbon resistor	1 kΩ	¼W	2322 101 43102
R_6	carbon resistor	680 Ω	¼W	2322 101 43681
R_7	carbon resistor	1 kΩ	¼W	2322 101 43102
R_8	carbon resistor	47 kΩ	¼W	2322 101 43473
R_9	CdS cell			RPY58
R_{11}	carbon resistor	33 Ω	¼W	2322 101 43330
R_{12}	potentiometer	1 MΩ log		2322 350 70634
R_{13}	potentiometer	10 kΩ log		2322 350 70627
R_{14}	carbon resistor	100 Ω	¼W	2322 101 43101
A	mA-meter	1 mA		any type

(contd. from page 2 Operational Notes)

Whichever measurement you are carrying out using the version containing the CdS cell, you will have to wait for some seconds before reading the scales when there is only little light. Under these conditions the cells, although accurate, may be rather slow.

Dark-room measurements are best carried out in complete darkness; the light from a red or green lamp is also picked up by the probe! In this respect it might interest you to know roughly how much light is produced by a number of light sources:

the sun	——	100 000 lux;
lighting system in average sitting room	——	500 lux;
the full moon	——	0.25 lux;
the average enlarger	——	0.05 - 2 lux.

LIGHT DEPENDENT RESISTORS

L(ight) D(ependent) R(esistors) are made of cadmium sulphide, a material which, when prepared properly, contains no or very few free electrons when kept in complete darkness. Its resistance is then quite high. When it absorbs light, electrons are liberated and thus the material becomes more conducting. Cadmium sulphide is therefore called a photoconductor. The electrons are free for a limited time only, and when the light is switched off, they are captured by the "holes". Thus the conductor again becomes an insulator. The resistance-to-luminous flux graph of the LDR is given here.

The resistance in total darkness is minimum 10 MΩ.

The resistance measured at 1000 lux is 75 to 300 Ω.

CADMIUM SULPHIDE PHOTOCONDUCTIVE DEVICE RPY58

Cadmium-sulphide photoconductive device with side sensitivity in plastic encapsulation. The device consists of two cells connected in series and is intended for general applications.

Soldering

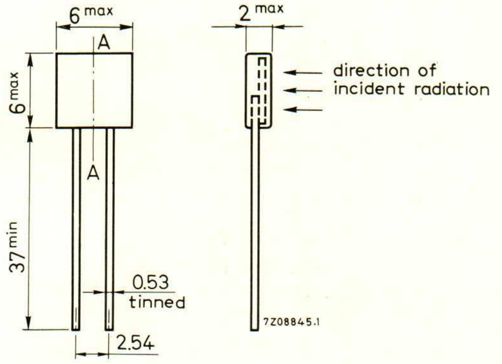
The device may be soldered direct into the circuit but heat conducted to the tablet should be kept to a minimum by the use of a thermal shunt.

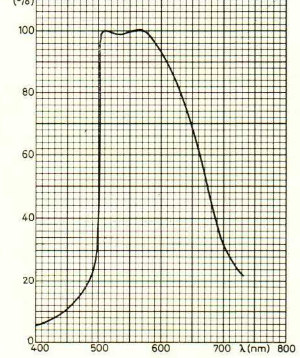
It may be dip-soldered at a solder temperature of 270 °C for a maximum of 2 s up to a point 6 mm from the envelope.

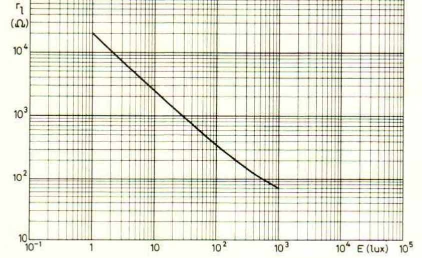
Quick reference data

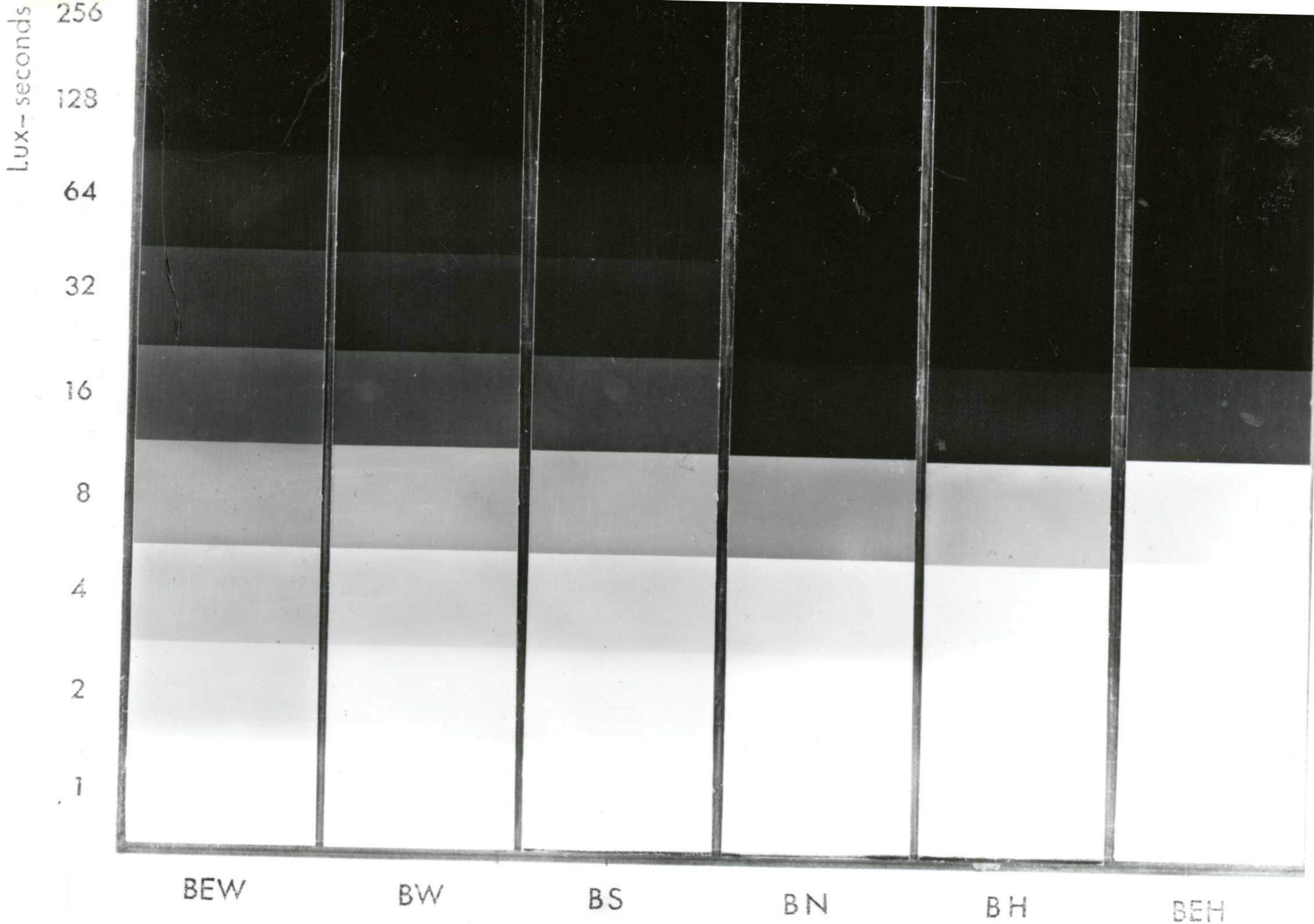
Power dissipation at T_{amb} = 40 °C	P	max.	200 mW
Voltage, d.c. and repetitive peak	V	max.	50 V
Resistance at 50 lux, 2700 °K colour temperature	r_{lo}		600 Ω
Spectral response curve			see below
Cell current d.c. and r.m.s.	I	max.	6 x 6 x 2 mA
Outline dimensions		max.	25 mm

RPY58 — From left to right: dimensioned sketches (with dimensions in mm); relative spectral response as a function of wavelength; resistance as a function of illumination









Test strips made of Agfa Brovira 1 paper

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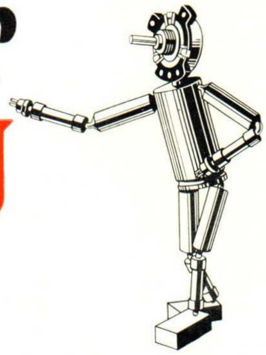
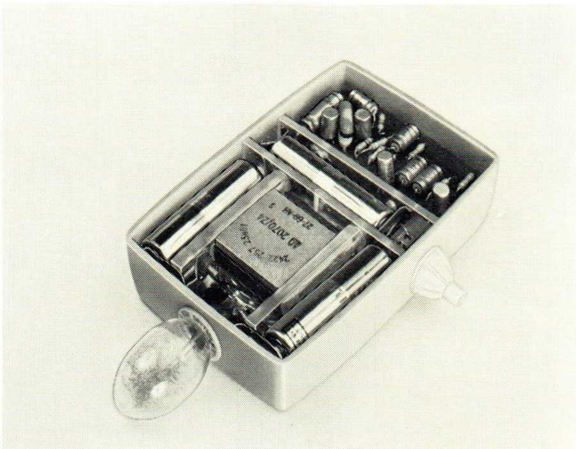


"Personal Panic Button"

Dear Experimenter,

One of the precoutions we take — and simply have to take — when preparing another leaflet in this series, is to discuss the technical aspects with competent experts. The subject of the present leaflet being a "crime-preventing device", we recently paid a visit to the Eindhoven Police Headquarters to demonstrate the prototype of our "Personal Panic Button".

The Insignia of the Netherlands Police



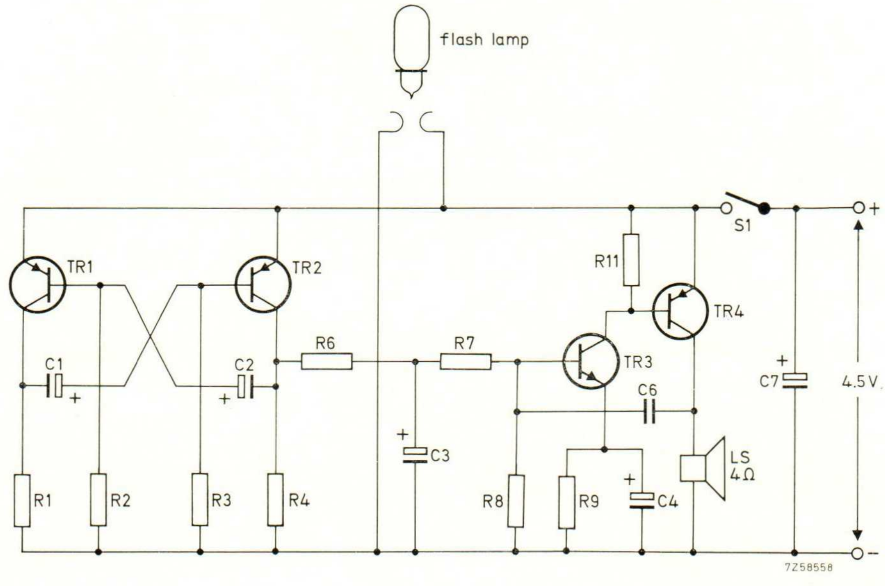
Naturally, we were highly pleased by the verdict the police experts gave: "This crime-preventing device is, without any doubt, the least complicated and expensive, yet most effective, device which we have seen demonstrated up till now". They were particularly impressed by our solution to the ever-recurring problem of how to make these "safety systems" less complicated and hence more reliable. Whereas we had been mainly thinking of the Personal Panic Button being employed by private persons, the police experts seemed more interested in its being suitable for use by people having to carry money to and from banks, supermarkets, etc. And it must be admitted: reading the daily papers one gets the impression that such transports are not properly safeguarded!

And you? Are you thinking mainly of the female persons among your acquaintances who, for whatever reason, have often to go out on the street after dark? Or of some aged or sick people living alone, and not being able to warn the outside world if they are in distress? Or are you considering the possibilities of preventing your car, your caravan, boat or tent from being burgled?

In all these cases a device is needed, simple to operate and producing such a pecular penetrating noise that people nearby cannot fail to be alarmed by it, and/or emitting a flash of light that will at least temporarily blind any assailant.

Such a device is the Personal Panic Button which, as the photographs alongside clearly show, can be inconspiciously accommodated in fairly small housings of various shapes. In the following pages you will find the details of the circuit, built up with

Philips Components for Optimum Results



Parts List

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

R1	carbon resistors (¼ W)	2.7 kΩ	2322 101 43272
R2	carbon resistors (¼ W)	22 kΩ	2322 101 43223
R3	carbon resistors (¼ W)	10 kΩ	2322 101 43103
R4	carbon resistors (¼ W)	2.7 kΩ	2322 101 43272
R6	carbon resistors (¼ W)	2.7 kΩ	2322 101 43272
R7	carbon resistors (¼ W)	10 kΩ	2322 101 43103
R8	carbon resistors (¼ W)	39 kΩ	2322 101 43393
R9	carbon resistors (¼ W)	47 kΩ	2322 101 43470
R11	carbon resistors (¼ W)	100 kΩ	2322 101 43101
C1, C2, C3, C4	electrolytic capacitors	50 μF 6.4 V	2222 001 13509
C6	polyester capacitor	100 nF 250V	2222 342 45104
C7	electrolytic capacitor	125 μF 10V	2222 001 14131
TR1	p-n-p Ge transistor		AC 126
TR2	p-n-p Ge transistor		AC 126
TR3	p-n-p Ge transistor		AC 127
TR4	p-n-p Ge transistor		AC 128
LS	loudspeaker	4 Ω (2½ in)	2422 257 23801
		(3 in)	2422 257 23701
S1	switch	any type	
	Philips Photoflux flash lamps with holder		

Circuit Description

(See Circuit Diagram and Parts List)

The circuit consists of two main parts: an oscillator producing a signal which can be made audible via a loudspeaker, and an astable multivibrator changing the frequency of this signal in a certain rhythm. The resulting sound resembles that of a siren as installed on police cars, fire engines, etc.

The oscillator frequency has been chosen around 1000 Hz because at that frequency

— the human ear is highly sensitive;
— the small loudspeakers which are recommended for use in the device are still operating in a favourable region of their response curves.

Thus, we can produce the loudest possible sound using the simplest possible circuit.

The oscillator is a kind of blocking oscillator; the circuit comprises transistors TR_3 and TR_4, and positive feedback is effected via C_6. The capacitance of C_6 is the main factor governing the oscillator frequency — in the Parts List 0.1 μF is mentioned. At this value the oscillator frequency is about 1000 Hz — smaller capacitors will result in a higher frequency.

At the recommended supply voltage of 4.5 V short current pulses flow through the loudspeaker (about 1 amp when the loudspeaker impedance is 4 ohms) and these become audible as a loud and penetrating howl. The pitch of this howl is not constant due to the presence of the astable multivibrator with TR_1 and TR_2. When TR_2 is conductive, electrolytic capacitor C_3 is charged, when the transistor is non-conductive C_3 discharges (mainly via resistors R_4 and R_6). The astable multivibrator changes over every three-quarter second so that C_3 charges and discharges at 1½-second intervals. Consequently the tone frequency is "swept" through the range 700 - 1300 Hz.

We can fully recommend our type 2422 257 23801 two-and-a-half inch loudspeaker for use in the device. However, if you prefer a higher power-handling capacity we can also recommend the 3-inch type 2422 257 23701.

Notes on the Construction

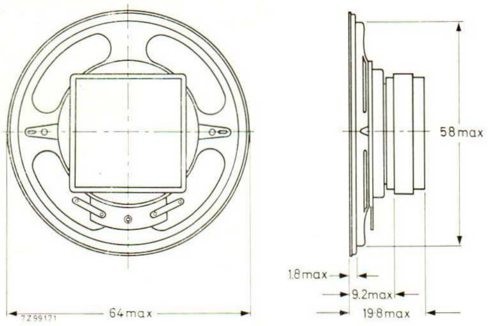
The electronic circuit is very simple and the layout of the components not critical. There is one important aspect that you should not overlook, however, when selecting a suitable housing. The "soap box" type of housing which you can see on page 1 (dimensions 7.5 x 11 x 12.5 cm) has one disadvantage: if it is knocked out of your hands and falls on the ground with the loudspeaker down, the sound will be muffled. So you will have to drill holes in the rear cover as well as in the front.

A (discarded) electric torch, if equipped with a reflector of at least 2.5 in diameter, is perhaps more suitable: the loudspeaker then takes the place of the reflector, and the holder for the photo flash lamp is fitted to the side of the reflector part. Such a housing will never land on the road with the speaker down. Maybe you can think of an even better type of housing !

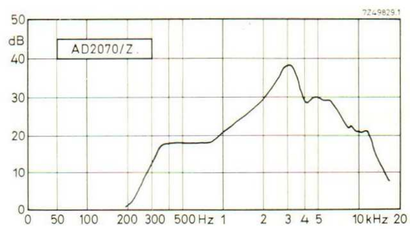
The construction, and especially the housing, may have to be modified so as to adapt the device to some special application. Thus, it may be necessary to control the device from a remote position so that either the pushbutton or the loudspeaker is not built into the housing. Also, when the device is used to "boobytrap" a briefcase, a valise, or the entrance to a boat, a house, a tent, etc., special provisions must be made.

$2^1/_2$ in Standard Loudspeaker AD2070/Z

Dimensions in mm



Technical performance



Application
Small transistorized radios.

Construction
Flat square magnet of Ferroxdure 300R.

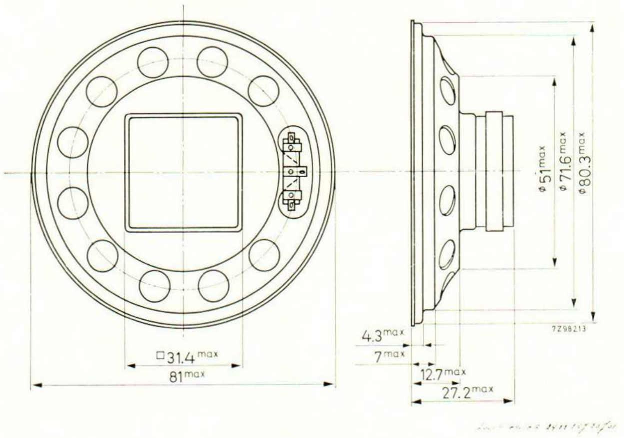
Magnet mass	20 g
Total magnetic flux	63 μWb (6300 Mx)
Flux density	$>$ 740 mT ($>$ 7400 Gs)

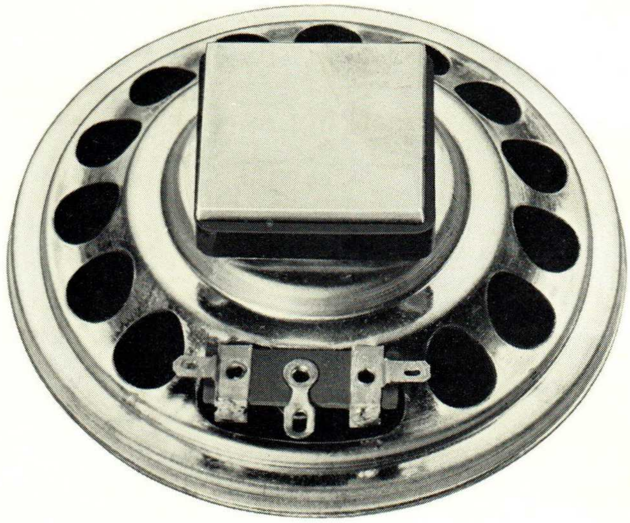
Baffle hole diameter 59 mm
One tag is indicated by a red mark for in-phase connection with other loudspeakers or our range.
Weight: 65 g

Version	*Nominal impedance* (Ω)	*Power handling capacity* (*W*)	*Resonance frequency* (*Hz*)	*Catal. number*
Z 4	4	0,5	360	2422 257 23801
Z 8	8	0,5	360	2422 257 23802
Z 15	15	0,5	360	2422 257 23803
Z 25	25	0,5	360	2422 257 23804

3 in Standard Loudspeaker AD3070/Y

Dimensions in mm





Application

Portable receivers

Construction

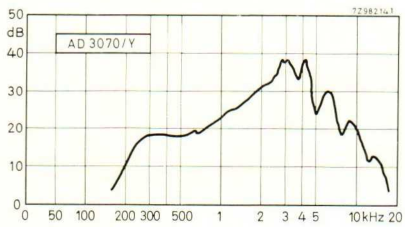
Flat square magnet of	Ferroxdure 300R.
Magnet mass	20 g
Total magnetic flux	63 μWb (6300 Mx)
Flux density	> 740 mT (> 7400 Gs)

Baffle hole diameter 72 mm

One tag is indicated by a red mark for in-phase connection with other loudspeakers or our range.

Weight: 75 g

Technical performance

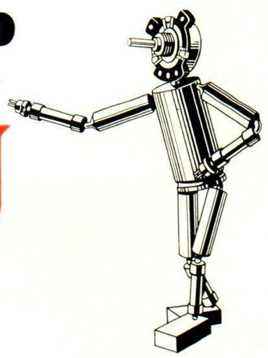


Version	*Nominal impedance (Ω)*	*Power handling capacity (W)*	*Resonance frequency (Hz)*	*Catal. number*
Y 4	4	1	250	2422 257 23701
Y 8	8	1	250	2422 257 23702
Y 15	15	1	250	2422 257 23703
Y 25	25	1	250	2422 257 23704

PHILIPS

ELECTRONIC COMPONENTS AND MATERIALS DIVISION

electronics for YOU



The Image of Sound

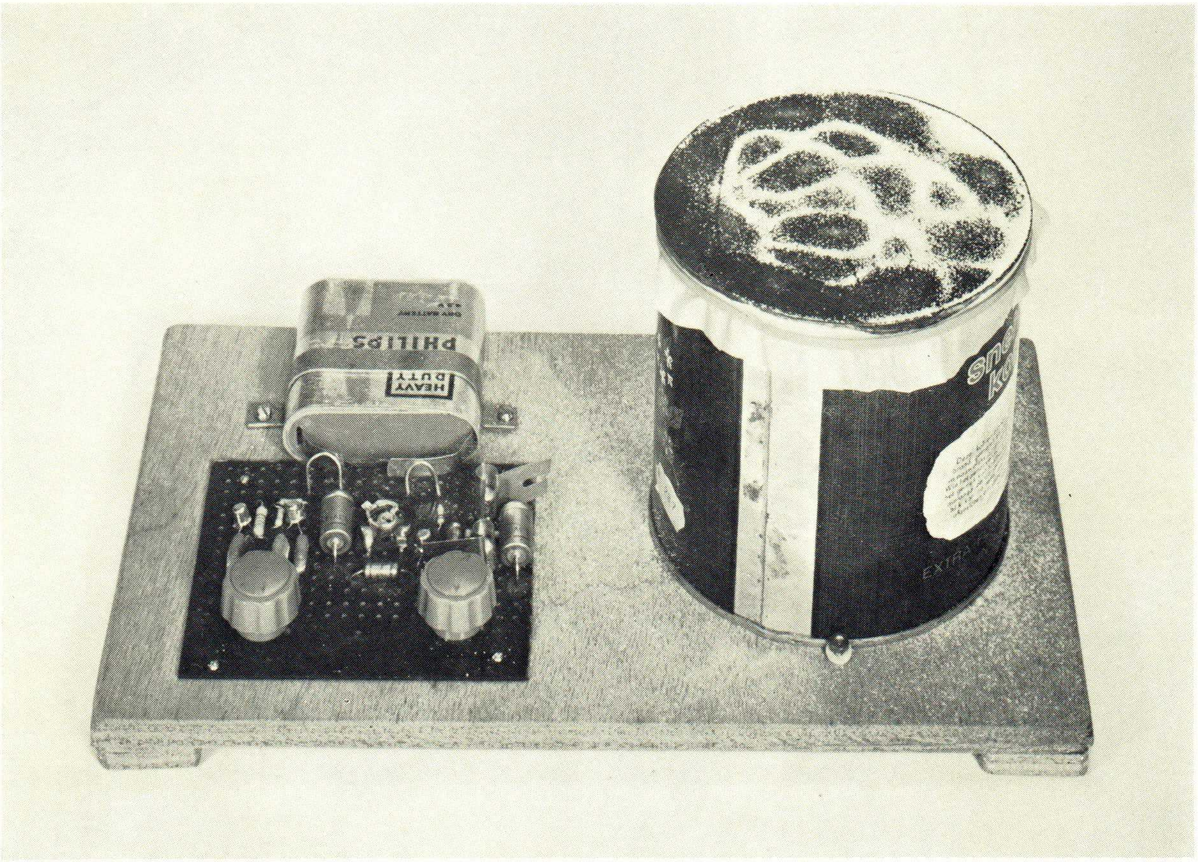
Dear Experimenter,

The title "Image of Sound" may sound confusing (or even incongruous) to you, but it will no longer if we explain to you that it is about making sound vibrations visible by means of **Chladni's figures.**

This pamphlet, the **twenty-fith in the series,** will show you that like Chladni, the "Father of Acoustics", you can make vibrations give rise to symmetrical mathematical figures such as you will have to study in Euclidian geometry (hyperbolas, parabolas, etc.). The photograph below is no exaggeration. And if you have ever studied a catalogue issued by a supplier of experimental apparatus for schools you will have found there something like the cylinder shown in the photo and called **Oscillograph!**

In mother's kitchen you may find the non-electronic parts you need: an empty tin, a rubber glove, a rubber band that fits not too tightly around the tin, and a teaspoonful of table salt (in the catalogue you will see that **lycopodium powder** is recommended for the purpose). To build the electronic circuit you should order a 4.5 V battery and a handful of components.

Go To Your Nearest Philips Dealer for Best Results!



First a Little Theory

A simple experiment with a stretched string that we make to vibrate shows us the relationship between the frequency of the vibrations, the tension resulting from the stretching force, and the mass of the string.

In Fig. 1a the free end of the long string is jerked up and down at such a frequency that the waves travelling back and forth along the string form three nodes (where there is no displacement from the zero position) and two antinodes (where the displacement is at a maximum). The length of the string now is the wavelength.

In Fig. 1b the stretching force is four times that in case (a), whereas the frequency of jerking remains the same. We see that the length of the string now is half the wavelength. Obviously:

wavelength $\approx$ root of stretching force F_S

or $\lambda \approx \sqrt{F_S}$

Fig. 1c illustrates the situation with both the frequency and the stretching force being as in case (a), but the mass of the string per unit length being four times as large. The wavelength then again proves to be equal to the string length, which means that

wavelength $\approx$ the reciprocal of the root of mass

$$\text{or } \lambda \approx \frac{1}{\sqrt{m}}$$

Using the fundamental equation for the relationship between wavelength λ, velocity of propagation along the string V, and frequency f:

$$\lambda = \frac{V}{f},$$

we find that

$$V = \sqrt{\frac{F_S}{m}}$$

Where V is in metres per second
F_S is in Newtons
m is in kilogrammes per metre.

Now, causing a rubber membrane to vibrate instead of a string, we get a pattern of nodes and antinodes spread all over the membrane. The nodes and antinodes will be spaced according to the frequency of the vibrations, the tautness and thickness of the membrane, and its shape (a round one gives a different pattern from a square or hexagonal one). The idea is to sprinkle fine salt or sand on the membrane so that the pattern becomes visible as the grains arrange themselves along nodal lines, whereas they are "thrown off" the antinodal lines.

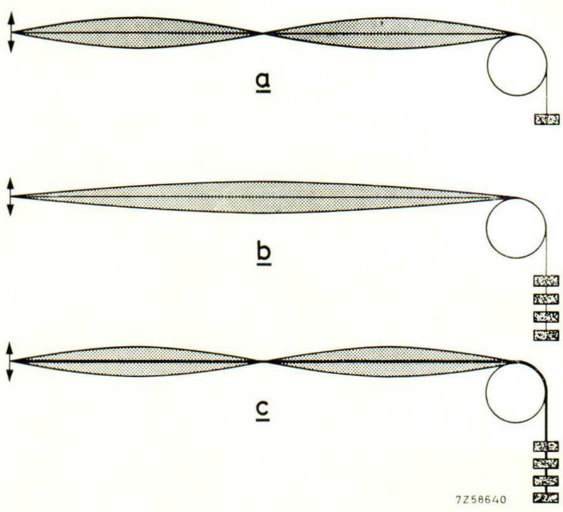


Fig. 1

The clearest Chladni's figures will be found at frequencies between 250 and 1000 Hz, with the waves being as purely sinusoidal as possible (with a minimum of harmonic frequencies). Some practising will be needed in adjusting the frequency and amplitude of the vibrations.

Principle

Our "Image of Sound" device consists of an oscillator (Fig. 2) with a frequency range of 200 to 2000 Hz. A simple loudspeaker, connected to this oscillator, is fitted under the bottom end of a cylinder which is closed off at the other end by the rubber membrane (Fig. 3). When the loudspeaker reproduces a tone, the membrane vibrates with the air column in the cylinder. So, the grains of salt or sand sprinkled on the membrane are forced to arrange themselves along the nodal lines according to patterns that vary with the frecuency of the tone.

Circuit Description

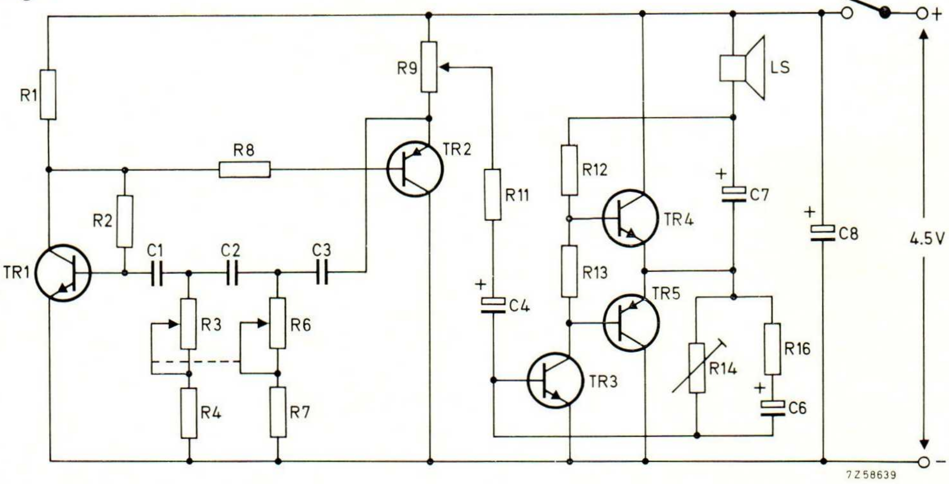
Fig. 2

Amplifier TR_1 is followed by a phase-shifting R-C network, and TR_2 as an emitter follower. The latter's output signal is fed back to TR_1 through the R-C network. With R_3 and R_6 the network can be made to cause a phase shift of 180° to a signal having a certain frequency. When this happens, TR_1 starts to oscillate at the adjusted frequency. R_3 and R_6 have been so chosen that stable oscillations occur at any frequency set between 200 and 2000 Hz.

When higher or lower frequencies are required, C_1, C_2 and C_3 will have to be chosen differently.

TR_3 is a driver for the two complementary output transistors TR_4 and TR_5. To have these on the verge of becoming conductive, the voltage at the junction of the two emitters must be half the supply voltage, that is 2.25 V. This can be adjusted by means of R_{14} which affects the current through TR_3, and hence the voltage drop across R_{12} and R_{13}.

Fig. 2



The circuit has the advantage that almost no current is drawn when volume control R_9 is turned down. At full drive the current consumption is about 100 mA.

Notes on the Construction

The lay-out of the electronic components is not critical. It is quite convenient to have one knob for the ganged potentiometers R_3 and R_6 (see the description overleaf), and another for potentiometer R_9 combined with switch S, see the photograph on the first page.

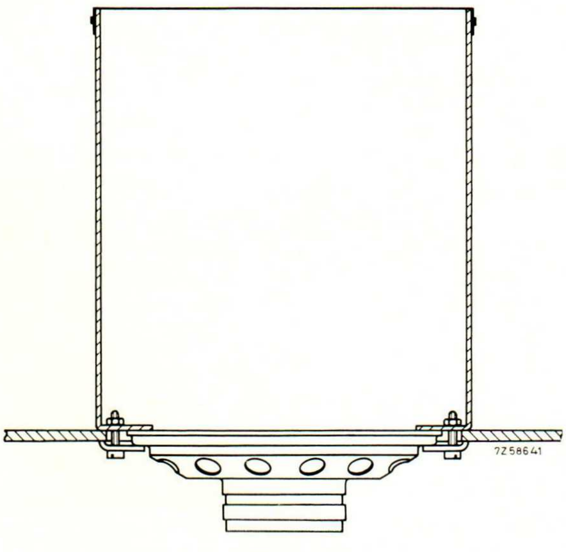


Fig. 3

Parts List

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

TR1	n-p-n Si transistor			BC 108
TR2	p-n-p Si transistor			BC 178
TR3	n-p-n Si transistor			BC 108
TR4	n-p-n Ge-transistor			AC 127
TR5	p-n-p Ge transistor			AC 128
R1	carbon resistor	4.7 kΩ	¼ W	2322 101 43472
R2	carbon resistor	0.33 MΩ	¼ W	2322 101 43334
R3/R6	16mm tandem carbon potmeters	10 kΩ	lin.	2322 390 71107
R4	carbon resistor	220 Ω	¼ W	2322 101 43221
R7	carbon resistor	220 Ω	¼ W	2322 101 43221
R8	carbon resistor	22 kΩ	¼ W	2322 101 43223
R9	16mm single carbon potmeter with switch	1 kΩ	log.	2322 387 71124
R11	carbon resistor	3.3 kΩ	¼ W	2322 101 43332
R12	carbon resistor	33 Ω	¼ W	2322 101 43339
R13	carbon trimming potmeter	100 kΩ		2322 411 02211
R14	carbon resistor	10 kΩ	¼ W	2322 101 43103
R16	carbon resistor	330 Ω	¼ W	2322 101 43331
C1,C2,C3	polycarbonate capacitor	68 nF	250 V	2222 342 44683
C4	electrolytic capacitor	4 μF	10 V	2222 001 14408
C6	electrolytic capacitor	4 μF	10 V	2222 001 14408
C7	electrolytic capacitor	640 μF	6.4 V	2222 023 13641
C8	electrolytic capacitor	640 μF	6.4 V	2222 023 13641
LSP	loudspeaker	8 Ω		2422 257 23702
		4 Ω		2422 257 23701

The cylinder may be made of any tin available in an ordinary kitchen. The thickness of the rubber membrane should be between 0.3 and 0.5 mm — a discarded rubber household glove may provide a piece sufficiently large for the purpose. As already mentioned, some practising may be necessary to find out how tautly the membrane must be stretched over the cylinder to obtain the best figures. Of course, the diameter of the tin must be large enough to accommodate the loudspeaker.

Modifications

As already mentioned, a school experiment can be imitated with an instrument similar to ours and called oscillograph. The main difference is that the patterns are not shown by sand sprinkled on the membrane. Instead, a small mirror is placed on the membrane, and this is made to reflect a light beam on a projection screen or on the ceiling. When the membrane vibrates, the light spot will be deflected according to the position of the mirror.

Another modification is to use fluorescent powder to sprinkle on the membrane. The patterns can then be viewed in the dark, which can be quite a sight if the membrane has been stretched properly.

TANDEM CARBON POTENTIOMETERS

Resistance law	linear and logarithmic
Resistance range	
linear resistance law	1 kΩ - 2.2 MΩ
logarithmic resistance law	1 kΩ - 1 MΩ
Maximum permissible dissipation at 40 °C	
linear resistance law	0.1 W
logarithmic resistance law	0.05 W

APPLICATION

For use in a wide variety of electronic equipment, especially where small dimensions are required, e.g. transistorized apparatus for stereophonic purposes.

CONSTRUCTION

The tandem potentiometers are composed of two annular carbon tracks, fitted on base plates of resin bonded paper, which are situated in one housing. The base plates are placed in such a way that the tracks are opposite each other. The soldering tags are connected to the ends of the carbon track; another soldering tag is connected, via a contact ring, to the slider contact.

Potentiometers with logarithmic resistance law can be supplied with a tap at 20% of the nominal resistance value.

The potentiometers are available with soldering tags suited for use in conventional wiring, as well as with pins suited for connection to printed-wiring boards.

Auxiliary Start-supply Unit

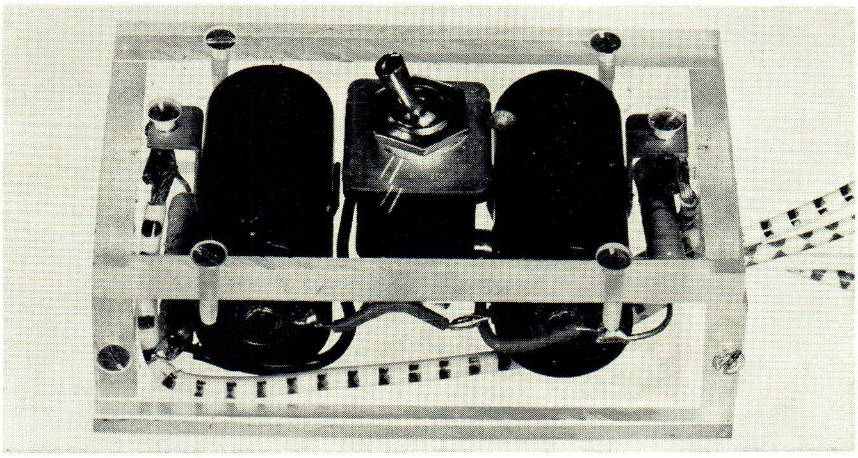
Dear Experimenter,

- car owner, mechanic or seller! -

you will without any doubt be highly interested in the simple device we are showing you how to build this time. You all know what a nuisance it can be to have difficulties in starting a car. The Auxiliary Start-supply Unit will help you to overcome such difficulties. There is one condition, however: **your car must be in reasonably good condition — we do not pretend that the Unit will remedy any serious failure in one of the vital systems of a car.** But you will find it invaluable when

— your battery has gone flat because you have been careless just once;
— the ambient temperature is either too high or too low for your car to feel really "happy";
— you inadvertently made the fuel-air mixture either too rich or too lean.

Enjoy making and using the Auxiliary Start-supply Unt. You need only a few components.



The Principle

What is at the root of the starting difficulties mentioned above? With a few exceptions it is the fact that not enough electrical tension is abailable to ignite the combustive mixture. Knowing this, we can apply a simple trick: **we raise the voltage in the ignition circuit during starting.** This could be done with some dry batteries as used in electric torches and the like, but these show the disadvantage that they are not rechargeable. For this reason we recommend you to employ the 1.2 Ah nickel-cadmium cells described on page 4. Two of these are to be fitted, together with a couple of resistors and either a mechanical switch or a relay, in a suitable housing. The unit thus obtained is to be connected in series with the car's battery in such a way that the starter motor does not get a higher voltage but the ignition coil does.

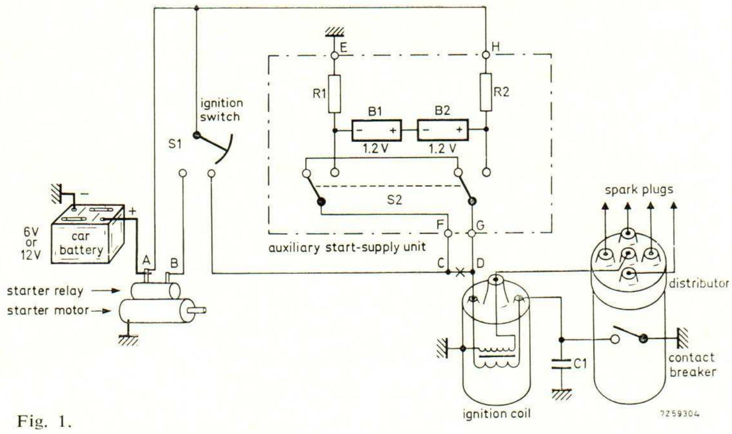


Fig. 1.

Constructional and Operational Notes

See Figs. 1 and 2

In the circuit diagram (Fig. 1) the negative side of the battery is shown earthed. If, in your case, the positive side is earthed, you must not forget to reverse the Ni-Cd cells.

The left-hand part of Fig. 1 is a simplified representation of the layout of the car battery, the starter relays and motor (with terminal A in the circuit for the starter motor and terminal B in that for the starter-relay coil), and a typical ignition switch (drawn fully open, and having two other positions — one step clockwise from the drawn one, then the ignition circuit is closed, and two steps clockwise when in addition the starter-relay circuit is closed; to reach the latter position the ignition key must be kept pressed).

It can also be seen that the Auxiliary Start-supply Unt has four terminals: E, F, G and H. Of these:

- E is connected to the body (earth);
- F and G are connected to the two loose ends obtained when the wire running from the starting switch to the ignition coil is interrupted between C and D;
- H is connected to the side of the battery which is not earthed.

With S_2 in the position drawn, C and D are reconnected, whereas the Ni-Cd cells are disconnected from the ignition circuit but connected into the charging circuit. R_1 and R_2 keep the charging current so small that overcharging will not occur (2-4 mA when the car battery is one of 6 V, 5-10 mA with a 12-V battery). The other position of S_2 is the one for starting, when the Ni-Cd cells B_1 and B_2 are connected between C and D, thus raising the ignition voltage by 2.4 V. S_2 may well be a pushbutton switch with contacts capable of carrying the ignition current of a few amps and which must be depressed when a higher voltage is needed for starting. You may also use a relay which closes as soon as switch S_1 connects terminal B to the positive side of the battery. This solution is a very elegant one **if you are not in the habit of making short trips, with frequent starts.** If you are, the batteries may be discharged in a rather short time. If you are not, you will find that the circuit operates automatically and to your satisfaction for a long time. See Fig. 2. The relay should still operate at a supply voltage as low as 4 V in the case of a 6 V battery or 8 V for a 12 V one, and its contacts should also be capable of carrying a few amps of ignition current.

The Unit may be fitted, in any suitable housing of insulating material, at a convenient spot on, behind or under the dashboard, as long as the (pushbutton) switch remains within easy reach. The relay version may be housed at a cool spot under the bonnet in the engine compartment.

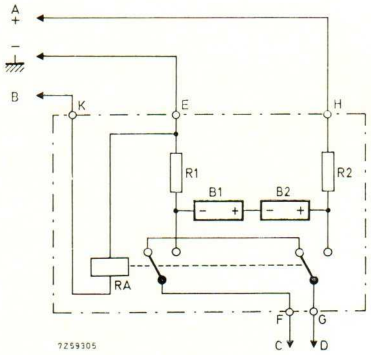


Fig. 2.

Parts List

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

R1 R2	Carbon resistors 1 W 1 kΩ	2322 212 14102 2322 212 14102
B1 B2	Nickel-cadmium cells	2422 541 10108
S2 RE1	Relay	any type

Turn to the next page for salient information on the 1.2 Ah nickel-cadmium cells.

The Nickel-cadmium Cells

We have decided in favour of nickel-cadmium cells because of their great advantages:

- the cell voltage is relatively constant during discharge (in technical terms: they have a relatively *flat discharge characteristic);*
- they are hermetically sealed and maintenance-free;
- their performance is good at high and low temperatures;
- since they use one of the best electrochemical systems known they have a *low self-discharge rate* (that is: the discharge current is very low when the cell is not connected to a load) and a long shelf life;
- they can be *recharged* many times and are not easily damaged by *overcharging* (charging which goes on after the cells have regained their full capacity);
- they will stand more abuse than any other cell also mechanically, by shocks, vibrations and rough handling.

The cells we recommend you to use are of the dry cylindrical type. The two electrodes are sheets of metal gauze onto which a suitable compound has been sintered (containing nickel hydroxide for the positive and cadmium hydroxide for the negative electrode). The two sheets are rolled up with a leaf of separator material between them, and dipped into potassium hydroxide which acts as the electrolyte.

The nickel-plated steel can consists of the cylindrical housing and a sealing cap. The negative electrode is connected to the bottom of the housing, the positive electrode to the cap, which is properly insulated from the housing. In the cap there is a safety valve which opens when the pressure in the cell should exceed 5 atmospheres.

The electrolyte is immobilized in the electrodes and the separator so the cells will not leak; some potassium carbonate may, however, collect at the rim of the seal. For the same reason the cells may be mounted in any position. Philips supply cells with and without insulating blue PVC sheath — we recommend you to use the insulated ones.

One final warning: Even these high-quality cells will be ruined if you connect them incorrectly to your battery charger — OBSERVE THE POLARITY just as conscientiously as the charging current.

The technical data are given alongside. Notice that the ampere-hour capacity is given at the 5 h rate, that is: under very heavy drain. Normal practice is to state the capacity at the 10 h rate, which will yield a higher value. The same goes for the end-point voltage. You will play safe when:

at an open-circuit voltage > 1.4 V you stop charging,
at a closed-circuit voltage 1.1 V you stop draining.
Between these two values there is no electrical way of telling quickly how much of the battery capacity is left.

Technical data

Capacity, 5 h rate	C	1 Ah
Discharge current, 5 h rate	$C/5$	0.2 A
Aver. discharge volt, 5 h rate	V_a	1.25 V approx.
Fully discharge volt, 5 h rate	V_f	1.0 V
Charging current, 13 h rate	$C/13$	0.1 A
Terminal volt. during charging		1.3 V rising to 1.5 V
Internal resistance in fully-charged condition		
dc		40 M Ω
a.c., at 50 Hz		25 M Ω
at 100 Hz		25 M Ω
at 1000 Hz		23 M Ω
Weight		45 g

Full charging specification is as follows:

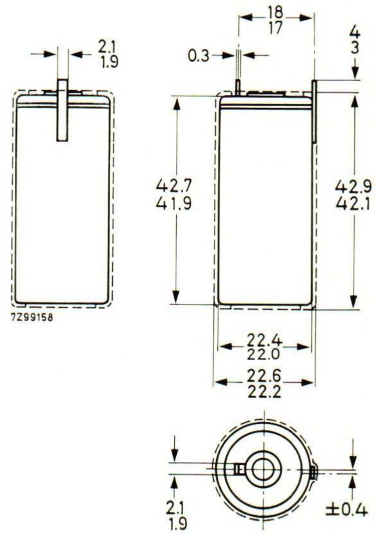
Constant charging current (mA)	Charging time	Charge condition of cell
10	continuous	"trickle charging"
60	24 hours	irrespective of
100	12-14 hours	charge condition of the cell
200	7 hours	cell virtually fully discharged

Continuous charging at a constant charging current of 10 mA only serves for maintaining the state of charge.

In addition, it is permissible to overcharge our 1 Ah cells with the undermentioned currents and during the time indicated.

Charging current (continuous)	Max. charging time
10 mA	continuous
60 mA	30 days
100 mA	7 days

Overcharging with a current of 10 mA is permissible only a few times a year. Prolonged overcharging will considerably shorten the cell's life. For overcharging with currents exceeding 100 mA consult the manufacturer.



⑨ 9399 020 92601

PHILIPS
ELECTRONIC COMPONENTS
AND MATERIALS DIVISION

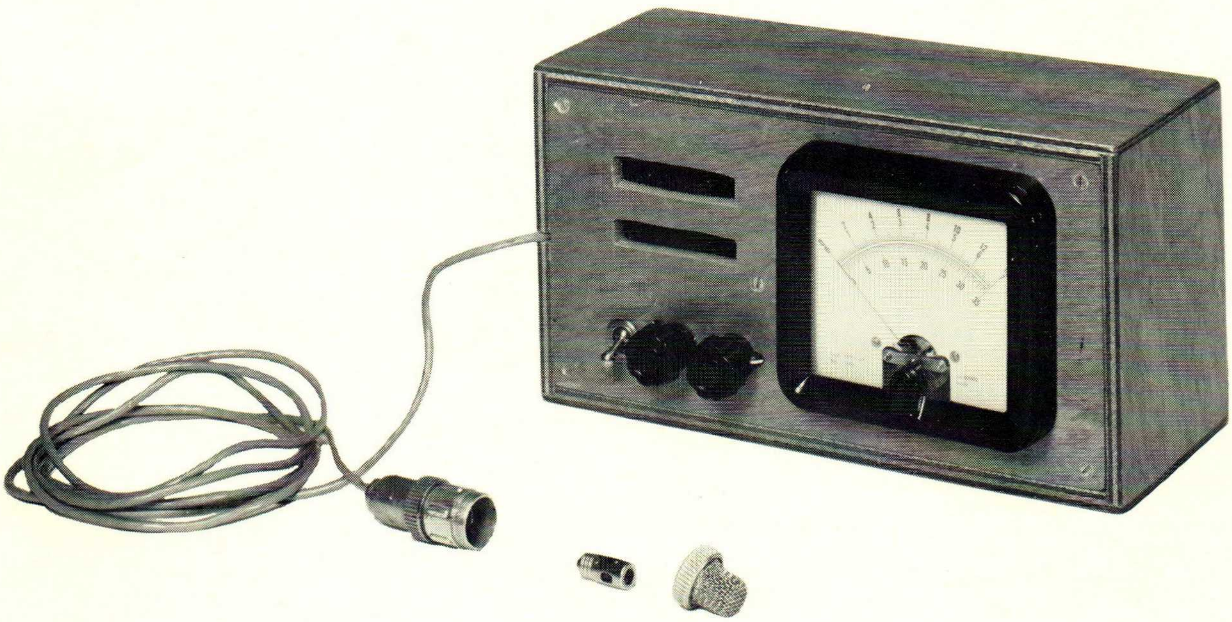
electronics for YOU

Gas Detector

Dear Experimenter,

The presence of dangerous gases in the air should not be taken lightly — the fact that "Keep the Air Clean" campaigns are being organized in so many countries proves that this notion is rapidly gaining ground. On top of this, the increasing use of natural gas as a fuel in unattended equipment multiplies the dangers of explosions etc., occurring. Making sure that such gases are detected in time is, therefore, an act of self-preservation.

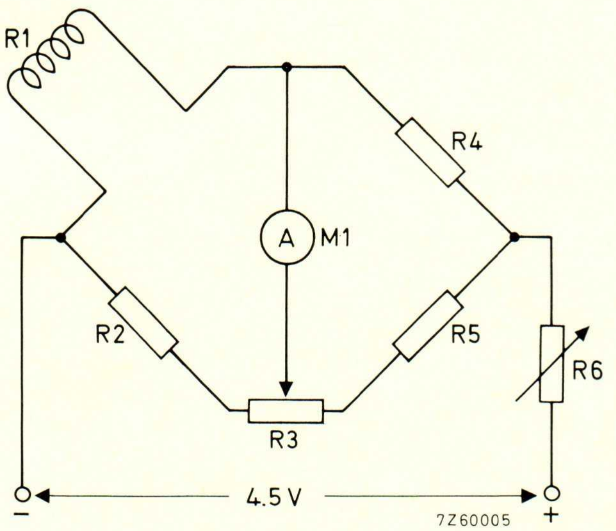
Gas detectors come in many sizes; the device which is the subject of this leaflet is a small one, which can be carried about as well as mounted in a permanent housing. In garages (and in cars!), caravans, motor-boats, hothouses, lonely farms and villas, and quite a number of other places it can protect your life and that of other people, detecting small amounts of natural gas, butane, propane, carbon monoxide and petrol vapours, to mention just a few of the commonest hazards.



Principle

Actually, our Gas Detector works on the same principle as the special type of electric gas igniter which you may have seen used in the kitchen — only, we make sure that **in our case no gas is ignited** ! The essential part in the device is a filament which is made to carry a current. In normal air the current is so small that the filament hardly glows, but in a combustible mixture of air and gas it is hot enough to accelerate the oxidation of the gas. As a result of the oxidation heat is released and hence the filament is surrounded by a layer of 'warm' molecules. It then becomes hotter, making the rate of oxidation increase again, and so on until combustion occurs. As already stated, we make sure that combustion cannot occur, in technical terms: we prevent the heat front from travelling at the high rate necessary for combustion. How? By surrounding the filament with a fine metal gauze.

Fig. 1



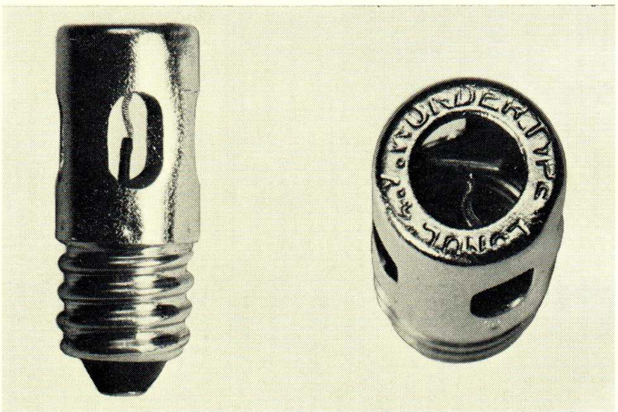
Parts List Fig. 1

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

R_1	filament	
R_2	carbon resistor 47Ω, 0.67W	2322 101 63479
R_3	carbon potentiometer 100Ω	2322 450 00701
R_4	carbon resistors (2, 3 or 4) of 10Ω, 1.15W in parallel (see text under "Constructional Tips")	2322 214 13109
R_5	carbon resistor 47Ω, ½ W	2322 101 63479
R_6	wire-wound potentiometer 2.2Ω, 3W	2322 003 51228

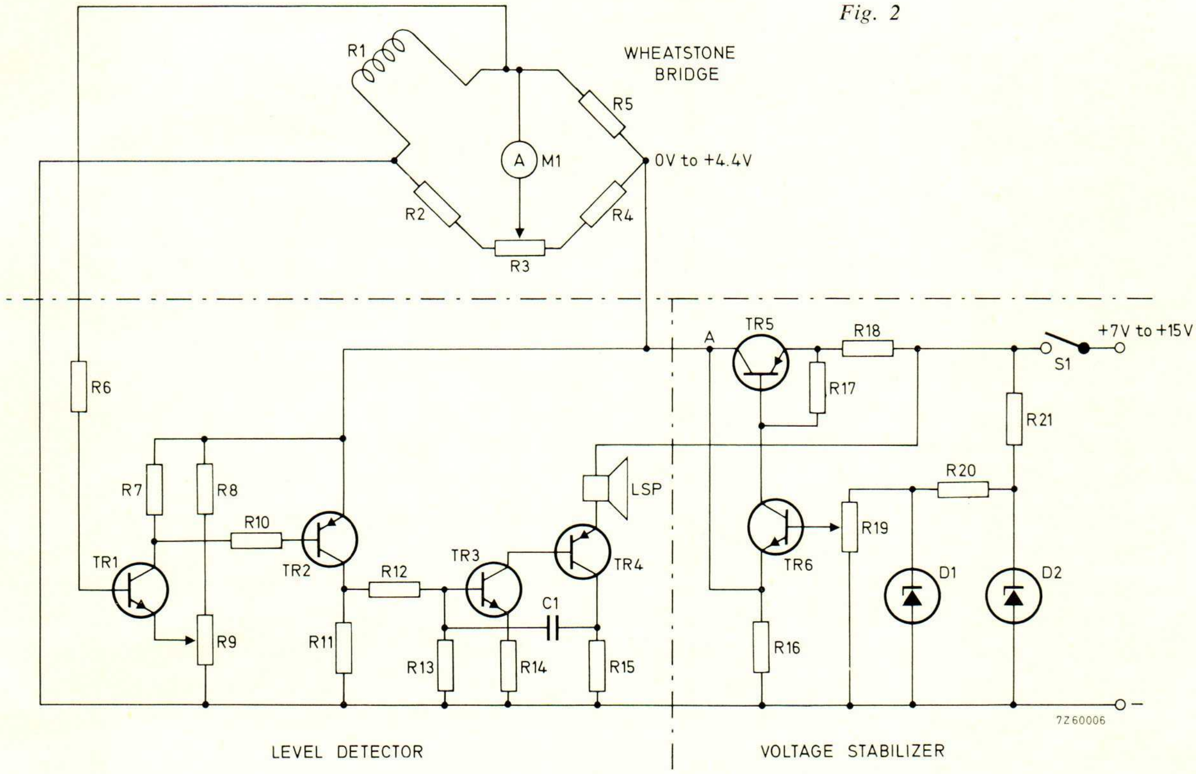
You may ask again: How can I make use of the fact that the filament rises in temperature as soon as a combustible air-gas mixture is present? The answer is: The hotter the filament becomes, the higher its electrical resistance will be. In fact, the filament resistance is a measure for the concentration of the gas. So, all we have to do is to connect the filament in a suitably arranged Wheatstone bridge, which is easy to calibrate. Fig. 1 shows such an arrangement: R1 is the resistance of the filament, R4 is a resistor with about the same resistance as the filament has under normal conditions (see under "Constructional Tips"); R2, R3 and R5 are the resistors in the other arms of the bridge, R3 being adjustable for purposes of calibration; R6 is a potentiometer for adjusting the supply voltage to such a value that the filament is just glowing faintly. It can be seen that, once R3 has been adjusted for zero meter deflection, any change in the resistance of the filament (R1) will be signalled by the meter, the needle deflection being dependent on the two ratios R1 : R4 and (R2 + left-hand part of R3): (right-hand part of R3 + R5). So, the knob for R3 can be calibrated in (experimentally determined) gas-concentration values.

The device we can build along these lines shows a number of disadvantages, so we can recommend you to try the more elaborate one of Fig. 2. In either case you are advised to use the platinum filament found in kitchen igniters — the long thin type for 4.5 V giving better results than the short thick one for lower voltages. The photos below depict such a filament.



Description of Circuit 2

In circuit 2 the Wheatstone bridge described above is connected to a level detector. In principle, the circuit causes an audible signal to be given when the gas concentration exceeds a pre-determined value; to this end a d.c. amplifier is used with TR1 and TR2. When the voltage developing across R1 exceeds a level adjusted by means of R9, it causes both transistors to become conductive.



Parts List Fig. 2

The right-hand columns give type numbers and catalogue numbers which you should use when ordering.

R_1	filament (see text)	
R_2	carbon resistor 47Ω, ½W	2322 101 63479
R_3	carbon potentiometer 100Ω	2322 450 00701
R_4	carbon resistors (2, 3 or 4) of 10Ω, 1.15W in parallel (see text under "Constructional Tips")	2322 214 13109
R_5	carbon resistor 47 Ω, ½ W	2322 101 63479
R_6	,, ,, 470 Ω, 0.2 W	2322 210 03471
R_7	,, ,, 1 kΩ, 0.2 W	2322 210 03102
R_8	,, ,, 330 Ω, 0.2 W	2322 210 03331
R_9	carbon potentiometer 470Ω, linear	2322 350 70703
R_{10}	1 kΩ, 0.2 W	2322 210 03102
R_{11}	2.2 kΩ, 0.2 W	2322 210 03222
R_{12}	56 kΩ, 0.2 W	2322 210 03563
R_{13}	carbon resistors 10 kΩ, 0.2 W	2322 210 03103
R_{14}	,, ,, 470 Ω, 0.2 W	2322 210 03471
R_{15}	,, ,, 27 Ω, 0.2 W	2322 210 03279
R_{16}	,, ,, 220 Ω, 0.2 W	2322 210 03221
R_{17}	,, ,, 150 Ω, ½ W	2322 101 63151

R_{18}	2 or more carbon resistors of 33Ω, 1.15 W in parallel (see text under "Constructional Tips")	2322 214 13339
R_{19}	carbon trimming potentiometer 2.2 kΩ	2322 411 02205
R_{20}	carbon resistor 18Ω, 0.2 W	2322 210 03189
R_{21}	carbon resistor 120Ω, ½ W	2322 101 63121
C_1	polyester capacitor 0.1 μF 250 V	2222 342 45104
TR_1	n-p-n Si transistor	BC 108
TR_2	p-n-p Si transistor	BC 178
TR_3	n-p-n Si transistor	BC 108
TR_4	p-n-p Ge transistor	AC 128
TR_5	p-n-p Ge power transistor	AD 149 or ASZ 15-18
TR_6	n-p-n Si transistor	BC 109
D_1	zener diode	BZY 88-C5V1
D_2	zener diode	BZY 88-C5V6
LSP	loudspeaker 4Ω (3 in)	2422 257 23701
S_1	pushbutton switch	any type
M_1	mA-meter 1 mA	any type

With TR1 and TR2 conductive, a base current is supplied to TR3, and the generator comprising TR3 and TR4 is actuated. As a result the loudspeaker will produce an audible warning signal. For a description of the generator, refer to Electronics for You no. 24.

Another disadvantage of the circuit of Fig. 1 is that it can only be applied if the supply voltage is constant. We therefore complete the circuit with a Voltage Stabilizer as already described in Electronics for You no. 7.

The essential components in the voltage stabilizer are zener diodes D2 (which regulates the supply voltage at about 5.7 V) and D1 (very constant zener voltage of about 5.1 V). With potentiometer R19, connected in parallel with D1, the base voltage of TR6 can be adjusted between 0 and 5.1 V. Depending on the output voltage (at point A), the emitter voltage of TR6 will be about 0.7 V below the base voltage. Any change in the output voltage will affect the current through TR6 — and consequently that through TR5 — in such a way that the output-voltage change will be eliminated.

To keep dissipation losses in TR5 low, resistor R18, maximum value 15 ohms, is connected in series with supplies of between 10 and 15 V; it is shorted out when the supply voltage is below 10 V. The exact value of this resistor depends on the current drawn, so it must be determined by the trial-and-error method (see under "Constructional Tips").

Constructional Tips

The Filament

The photo on page 1 shows one method of constructing the "sniffler" containing the filament. Other constructions are possible, as long as the filament is kept behind a fine metal gauze. Please notice that draughts of air may cool the filament and thus affect the operation of the Gas Detector.

Determining the Value of R4 and R18

In either case it may be necessary to take up to four resistors of the value specified in the Parts Lists. R4 should be chosen such that manipulation of potentiometer R3 gives the desired results. R18 should be chosen such that the output voltage of the voltage stabilizer remains constant over the full range of supply voltages available. If the output voltage does not remain constant, R18 is too large and must be shunted by an adequate number of similar resistors.

The Housing

In the photo on page 1 the housing for the Gas Detector measures 25 x 13 x 10 cm. The supply source comprises five 1.5 V heavy-duty batteries or six 1.2 V nickel-cadmium cells.

Transistor TR5 is fitted to a heat sink of at least 5 x 8 cm; conditions may require, however, a larger heat sink.

Potentiometers R3 and R9 must remain accessible from the outside for adjusting purposes (R9 is a trimming potentiometer which must be set to match R1 + R2).

Operational Tips

The Gas Dectector is not foolproof if mixtures of oxygen and hydrogen or oxygen and acetylene are to be detected.

Use the following table to obtain the best results.

Gas or vapour	Explosive mixture in %	Hazardous to health in p.p.m.	Detection threshold in p.p.m.
Carbon monoxide	12.5 to 74.2	50	odourless
Butane	1.5 to 8.5	1000	5000
Propane	2.1 to 9.5	1000	odourless
Petrol vapour	≈1 to ≈7	500	30 - 300
Benzene	1.2 to 8	10	60
Methanol	5.5 to 31	200	2000
Spirit	3.5 to 15	1000	50
Acetone	2.5 to 13	1000	320

Hence, the meter should be adjusted for full-scale deflection at the lowest percentage figures. The very small concentrations mentioned in columns 3 and 4 are hardly or not at all measurable.

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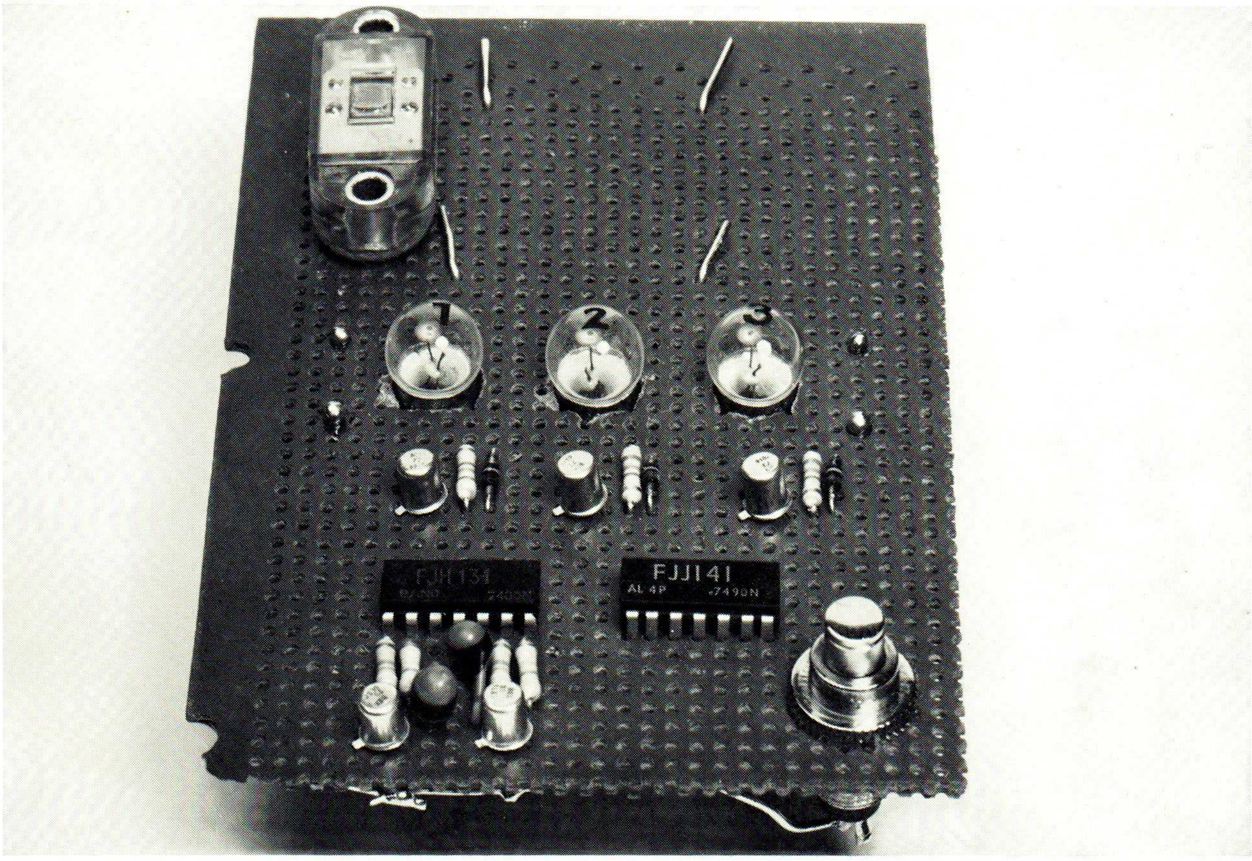
28

Mini Toto Computer

Dear Experimenter,

Once you have started using the gadget described below you may prefer to call it the Jolly Jotter — it has such a jolly way of showing you which figures to jot down on the cards or forms used, for instance, for your football pool. Or, if you are a football fan and do not need computer assistance, it can help you in "random betting" in any system.

Whatever you will be using it for, your friends will marvel at the many functions performed by the two miniature subassemblies, the integrated circuits types FJJ141 and FJH131. These have been specially designed for use in digital equipment and without them our computer would be maxi rather than mini!



Principle

The prototype of our M(ini) T(oto) C(omputer) was developed with an eye to the requirements of those who want to gamble on the results of football matches by using the digits 1, 2 and 3. Statistics show that in fifty per cent of all cases the digit 1 will have to be used, in twenty per cent the digit 2 and in thirty per cent the digit 3 (some people maintain that the percentages for the digits 2 and 3 should be reversed).

The block diagram of Fig. 1 shows four main parts:

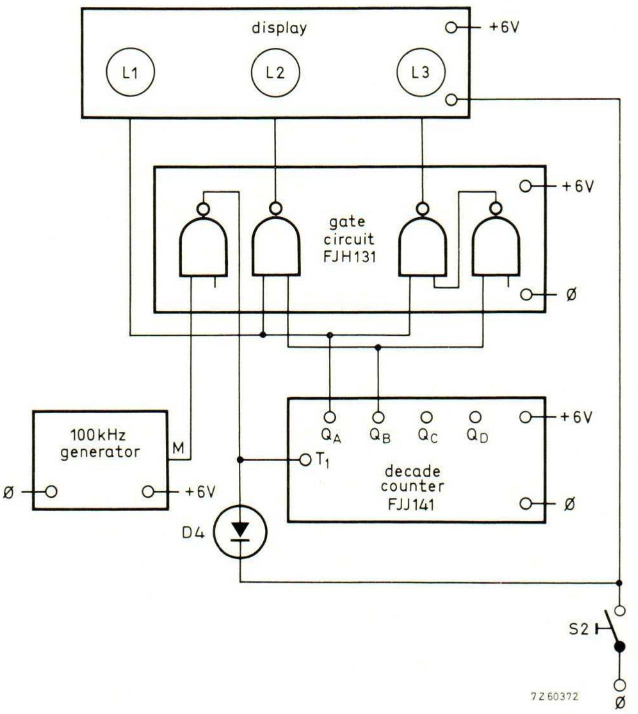


Fig. 1 Block diagram

(1) a 100 kHz pulse generator

(2) a decade counter (quadruple flip-flop integrated circuit type FJJ141) which splits up the 100 000 pulses per second into 10 000 groups of 10 pulses each

(3) a gating unit (quadruple NAND-gate integrated-circuit type FJH131) which makes combinations of 5, 2 and 3 pulses in each group of 10

(4) a display panel with three lamp circuits.

Now, certain negative pulses (chance-distribution ratio 5:2:3) are used to cause one of the three switching transistors in the lamp circuits to become conductive and thus to apply the supply voltage to the corresponding lamp. This lamp will then light up — which one it will be is impossible to predict!

Description

The pulse generator is shown in some more detail in Fig. 2 (transistors TR4 and TR5 form an a-stable multivibrator). Its output signal consists of slightly rounded-off pulses at M (Fig. 3a), but these appear

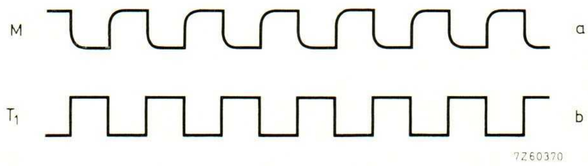


Fig. 3

at point T1 of the FJJ141 as true square-wave pulses (Fig. 3b) after having been passed through the first NAND-gate of the FJH131 which acts as a pulse shaper.

Outputs Q_A, Q_B, Q_C and Q_D are the separate outputs of the four flip-flop circuits in the FJJ141, each of which acts as a frequency divider in such a way that, out of each group of ten pulses, five appear at output Q_A, two-and-a-half at Q_B, one-and-a-quarter at Q_C and five-eights at Q_D. See Fig. 4 (a, b, c, d, e).

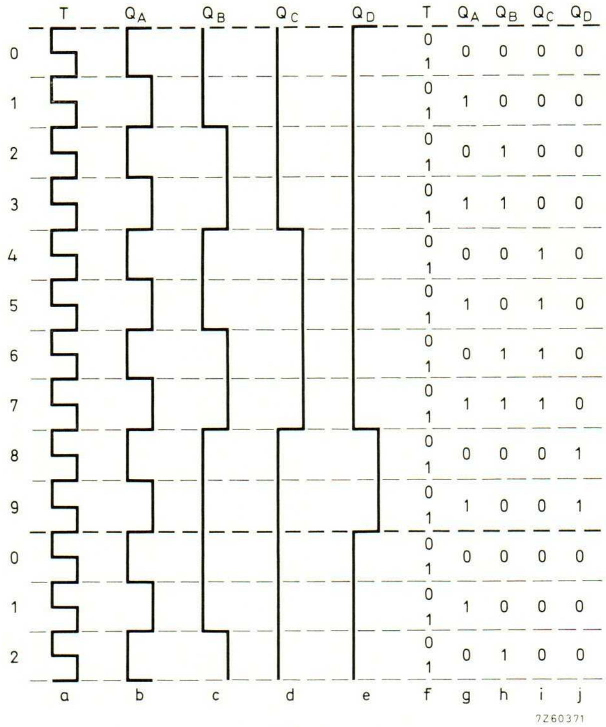


Fig. 4

At the end of the ninth pulse the decade counter is returned to the initial state; to effect this re-set, input T2 must be interconnected with output Q_A.

It can be seen that in each group of ten pulses the numbers 0, 2, 4, 6, 8 make output Q_A negative. These five negative pulses are applied, via D1 and R1, to transistor TR1 so that this becomes conductive and closes the positive lead for lamp L1.

Parts List Fig. 2

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

$TR_1 = TR_2 = TR_3$		p-n-p Si transistor	BC 178
$TR_4 = TR_5$		n-p-n Si transistor	BC 108
$D_1 = D_2 = D_3 = D_4$		Si diode	BA 145
$R_1 = R_2 = R_3$		carbon resistor 2.7 kΩ, 0.2 W	2322 210 03272
$R_4 = R_7$		carbon resistor 4.7 kΩ	2322 210 03472
$R_5 = R_6$		carbon resistor 47 kΩ	2322 210 03473
$C_1 = C_2$		ceramic cap. 125 V 100 pF	2222 563 02101
		Integrated circuit	FJH 131
		Integrated circuit	FJJ 141
S_1		Switch	any type
S_2		Push button	any type

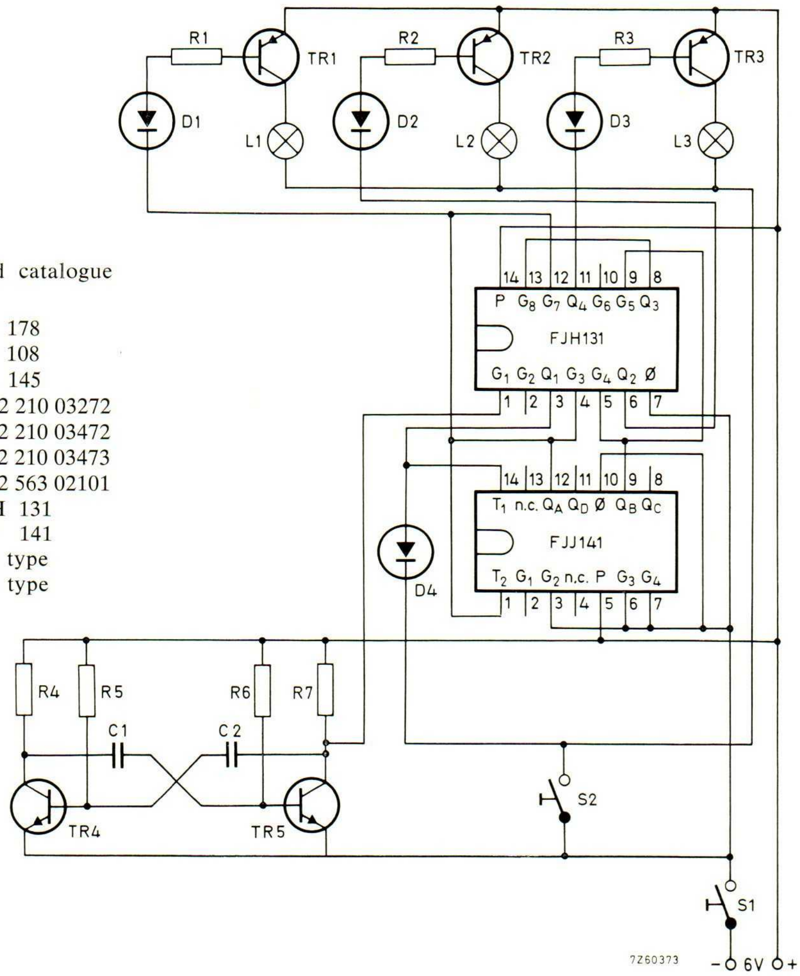


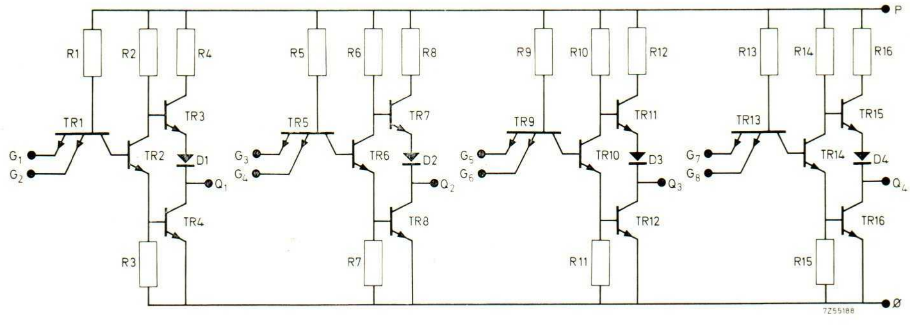
Fig. 2 Circuit diagram

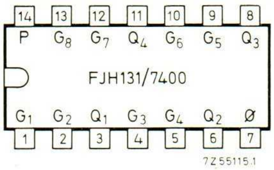
Further, in the same group of ten pulses, we see the numbers 3 and 7 making both Q_A and Q_B negative. Since both outputs are connected to the second NAND-gate of the FJH131, this gate will open and produce negative pulses corresponding to pulses 3 and 7; as a result the positive lead for L2 is completed. So, this lamp will be on during two of the ten pulses, if the supply circuit is completed.

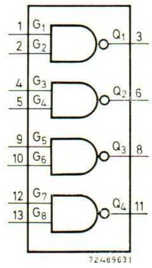
The pulses which have as yet no function are the numbers 1, 5 and 9; these cause Q_A to be positive and Q_B negative. The latter output is, however, also connected to the fourth NAND-gate in the FJH131. This produces a negative output pulse in return for the positive one at the input; the former is passed, together with the Q_A output pulse, through the third NAND-gate. In this way transistor TR5 is caused to connect L3 to the positive side of the battery. As already stated, this happens for three pulses out of each group of ten.

Now, when pushbutton S2 is depressed, the minus lead for the lamps is closed, the pulse trains are interrupted, and T1 is connected to the minus lead via D4. Depending on where in the pulse train the interruption takes place, one of the lamps will light up, and it is the digit represented by this lamp that you will have to use for your "random betting"!

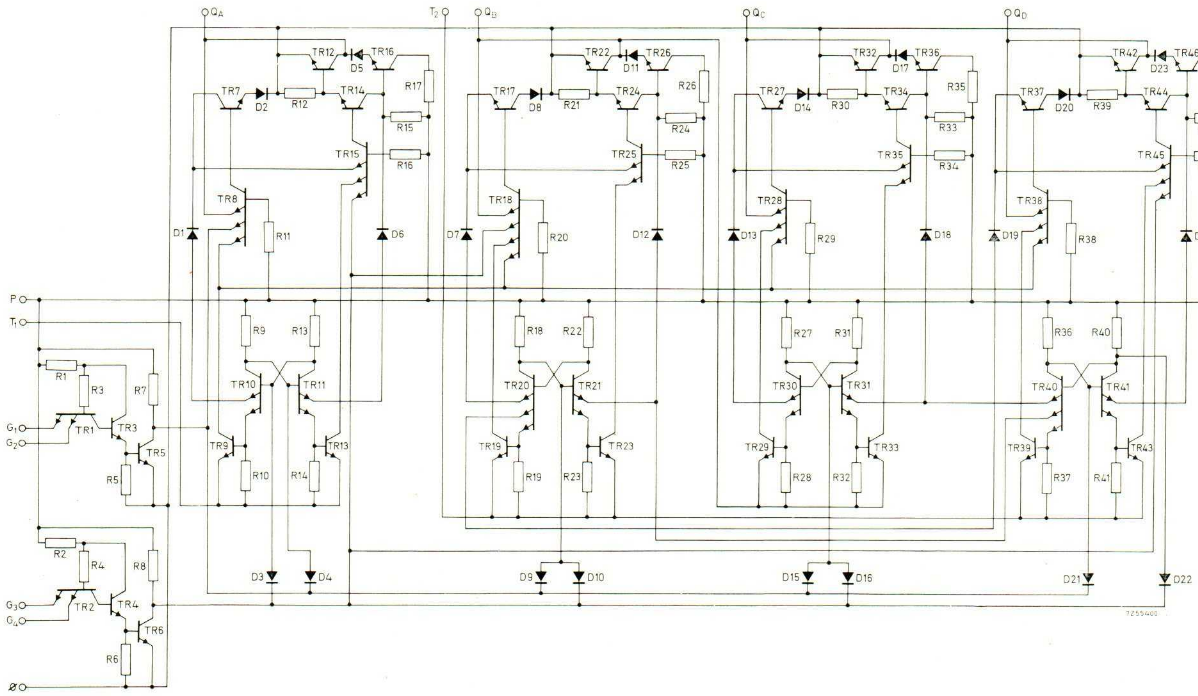
FJH 131

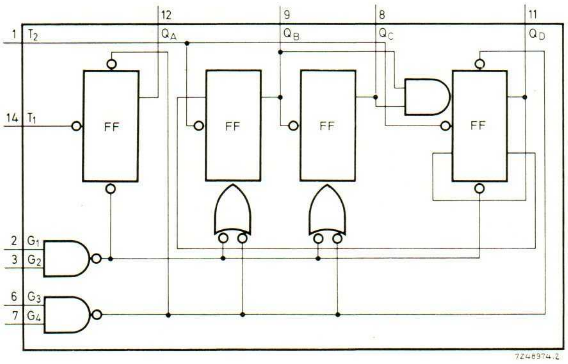


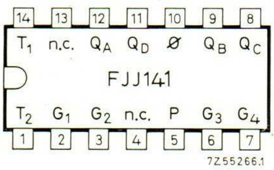




FJJ 141







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29

ELECTROMAGNETIC BURGLAR ALARM

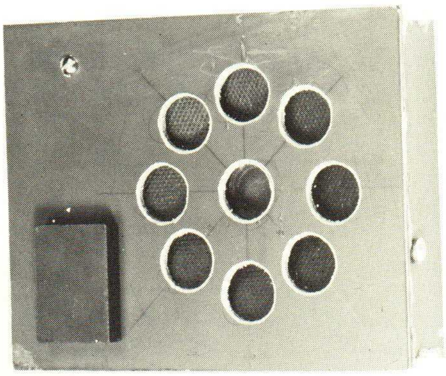
DEAR EXPERIMENTER

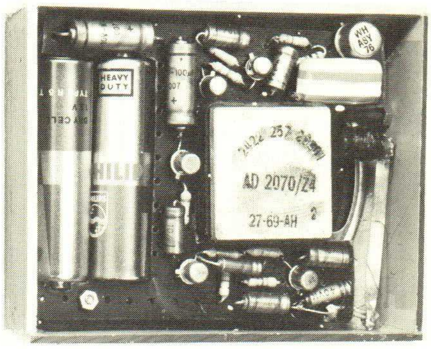
"Light come, light go" is an old proverb with local variants in almost all countries. For it is generally accepted that an article of value is more easily given up as it is acquired with less effort.

Now it seems as if in our affluent society the ancient adage is stretched to such an extent that we no longer protect our valuables as they should be – as if we don't care! How else can one explain the many successful bank robberies, burglaries, car thefts and other felonies?

You may – or may not – have valuables to protect but, being the experimenter you are, you will certainly enjoy building the rather unorthodox burglar alarm device described in this leaflet. It is so unorthodox that nicknames such as "Hooligan Hooter", "Burglar Buzz" or "Safety Sentry" present themselves automatically.

We wish you lots of success on top of the fun of experimenting.





DESIGN CONSIDERATIONS

Our main consideration in designing the device was:
"Whoever it is who wants to carry off something not belonging to him, he cannot fail to cause some movements (if not a stir!). So, all we have to do is to make sure that we can detect such small movements".

At this stage another brainwave occurred: "Suppose we make the device produce an audible warning signal, via a loudspeaker (that will boost our loudspeaker sales!). The loudspeaker will have a good strong magnet. With that magnet we can stick the device to a steel surface, a metal window frame, and the like. And if we just suspend a t i n y c o i l in the loudspeaker's magnetic field, this coil will produce a signal when it is forced to move in the magnetic field. We can amplify the signal and change it in such fashion that the loudspeaker starts squealing like a pig (or howling like a siren, should one prefer that!). Just imagine..... we would not need any supply wires which some smart chappy could cut..... we would really have outwitted the bunch of them..... Only ..... there must be a way of making the circuit inoperative for such periods as we wish..... oh well, any of our reed switches will do the trick". Thus we thought!

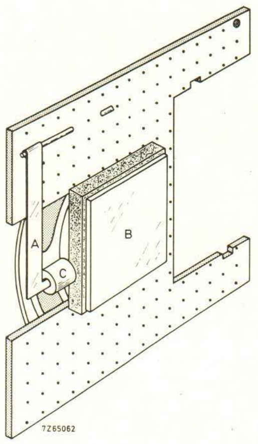


Fig. 1.

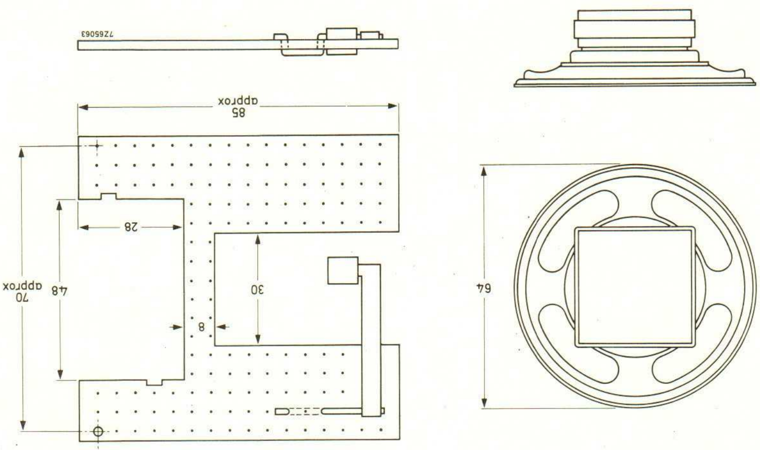


Fig. 2.

BUILDING THE DEVICE

So much for thinking! If you care to follow us through Figs 1 and 2 – and perhaps the photos as well – we can together work out these ideas. First we take a suitable piece of perforated laminate such as used for printed circuits. We cut out two rectangles from this piece. The larger of the two is rather critical in size if you have decided to build the device exactly as we have built the prototype; the horizontal dimension must be about one-and-a-half times the width of the magnet system of the loudspeaker we have chosen for the purpose; the vertical dimension must be just right for the board to be clamped behind the loudspeaker magnet. In this way the laminate is anchored on one side, and one or two screws on the other side suffice. The other rectangle must be big enough to accommodate two 1.5 V "pen-light" cells, one with the positive terminal up, the other with this terminal down.

Fig.3 shows details of the coil which is the heart of the unit. Just 500 turns of 0.1 mm wire, on any coil former of about the dimensions given, will do. A strip of thin, resilient copper or brass serves for fitting this coil to the laminate in such a way that the coil can move to and fro near the loudspeaker magnet.

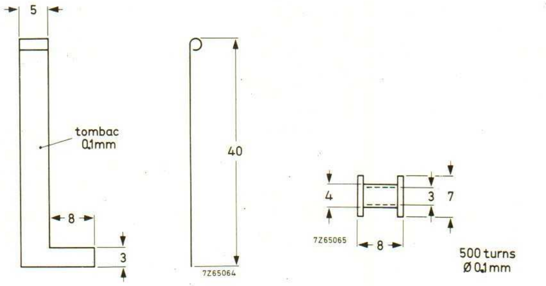


Fig. 3.

Some experimenting may be required to find the best location for the reed switch which we agreed to use to make the circuit inoperative for certain intervals. The reed contacts of our type RI 20 switch being magnetically actuated, we can use a small permanent magnet (in disc or rectangular shape) for this blocking purpose provided we make sure that this magnet is always capable of doing its work despite the presence of the loudspeaker magnet. The magnet must also be easily kept in the proper blocking position, preferably by its own magnetic force. In our prototype the RI 20 is safely embedded in the hollow between the two cells, close to the front panel of the device. The photograph shows how the external magnet, actuating the reed switch, is kept in the "silencing" position by its magnetic force acting on the cells. All we have to do make the device operative is to take away this magnet. The other photo shows the devive with the rear cover taken off; notice that this rear cover should be made of non-magnetic material not thicker than 0.5 mm, because otherwise it will not be possible to stick the device to a metal surface by means of the loudspeaker magnet.

The rest of the housing may be made of any suitable material provided it is kept light. The dimensions of the housing of our prototype are 7.5 x 9 x 2.5 cm.

BRIEF CIRCUIT DESCRIPTION (Fig.4)

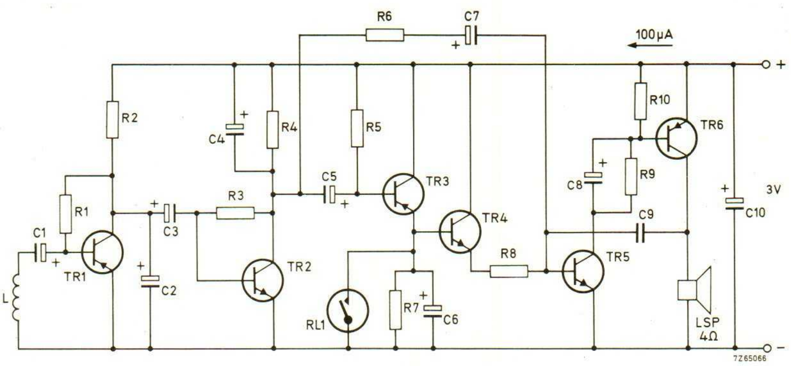


Fig. 4.

In the circuit diagram we see first of all the amplifier transistors TR_1 and TR_2 which raise the voltage induced into coil L from a few millivolts to 2.5 V peak-to-peak. This is high enough to make TR_3 conductive; the collector current which then flows charges C_6 until TR_4 is made conductive. Via R_8 the tone generator TR_5 – TR_6 is then made to operate, and the loudspeaker starts howling. As long as RL_1 is open, this audible warning signal only stops when the coils stops swaying to and fro, the exact length of time being dictated by the stiffness of the tongue to which the coil is fitted, the coil mass, the maximum amplitude of the excursions, and the time constant of the combination $C_6 - R_7$ (1 to 2 minutes). The other RC combination, $R_6 - C_7$, has been included to enable part of the signal across R_4 to be fed direct to the base of TR_5, and in this way to give the warning signal a kind of vibrato in the rhythm of the coil's movements. Finally, C_2 and C_4 filter out high-frequency components.

The transistors must be chosen for minimum current drain on the batteries – remember that the device will have to remain switched on all the time. For TR_1 and TR_2 the silicon type BCY57 will be the most suitable, for TR_6 the germanium type ASY76. With this compliment the prototype of the device could operate for about 10 000 hours on one pair of penlights cells. Of course, when an alarm is given the current drain rises to a much higher level (about 100 millilamps) but usually someone will be there to make it inoperative again within a few minutes.

PARTS LIST

The right-hand column gives type numbers and catalogue numbers which you should use when ordering.

R1 = 4.7 MΩ,	0.2 W, carbon resistor		2322 210 03475
R2 = 47 kΩ,	0.2 W, carbon resistor		2322 210 03473
R3 = 3.3 MΩ,	0.2 W, carbon resistor		2322 210 03335
R4 = 33 kΩ,	0.2 W, carbon resistor		2322 210 03333
R5 = 68 kΩ,	0.2 W, carbon resistor		2322 210 03683
R6 = 33 kΩ,	0.2 W, carbon resistor		2322 210 03333
R7 = 0.47 MΩ,	0.2 W, carbon resistor		2322 210 03474
R8 = 3.9 kΩ,	0.2 W, carbon resistor		2322 210 03392
R9 = 390 Ω,	0.2 W, carbon resistor		2322 210 03391
R10 = 1 kΩ,	0.2 W, carbon resistor		2322 210 03102
C1 = 8 μF,	4 V,	electrolytic capacitor	2222 001 12808
C2 = 0.64 μF,	64 V,	electrolytic capacitor	2222 001 18647
C3 = 8 μF,	4 V,	electrolytic capacitor	2222 001 12808
C4 = 0.64 μF,	64 V,	electrolytic capacitor	2222 001 18647
C5 = 8 μF,	4 V,	electrolytic capacitor	2222 001 12808
C6 = 125 μF,	4 V,	electrolytic capacitor	2222 001 12131
C7 = 8 μF,	4 V,	electrolytic capacitor	2222 001 12808
C8 = 32 μF,	4 V,	electrolytic capacitor	2222 001 12329
C9 = 0.47 μF,	250 V,	electrolytic capacitor	2222 342 44474
C10 = 125 μF,	4 V,	electrolytic capacitor	2222 001 12131
TR1 n-p-n Si transistor			BCY56 to BCY59
TR2 n-p-n Si transistor			BCY56 to BCY59
TR3 p-n-p Si transistor			BC177 to BC179
TR4 n-p-n Si transistor			BC107 to BC109
TR5 n-p-n Si transistor			BC107 to BC109
TR6 p-n-p Si transistor			ASY76, ASY77 (AC128)

L1 = coil 500 turns 0.1 mm enamelled copper wire
coil former 4 mm ϕ (Fig.4)

RL1 = Reed switch RI 12
or RI 20

LSP = 2½ in loudspeaker 4 — 2422 257 23801

QUICK REFERENCE DATA RI 12

Contact	S.P.S.T. normally open	
Switched power	5	W
Switched voltage	50	V
Switched current	100	mA
Contact resistançe (unitial)	60	mΩ
Failure rate	$<5 \times 10^{-8}$	

QUICK REFERENCE DATA RI 20

Contact	S.P.S.T. normally open	
Switched power	max. 1.0	W
Switched voltage	50	V
Switched current	20	mA
Contact resistance (unitial)	100	mΩ
Failure rate	$<10^{-9}$	

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30

Radio Controlled Camera

Dear Experimenter,

In this edition of Electronics for You, we discuss a simple and effective radio system for the remote control of a camera shutter. If your interests happen to be far removed from photography, do not despair: this article may still interest you since the device described can have a variety of uses outside of the photographic field. We'll list a few ideas and leave you to realize even more imaginative tasks for the gadget. You could use it for:

- conjuring tricks
- opening and closing a valve
- opening and closing a garage door or a garden gate
- ringing a bell from a distance (useful for elderly people)
- operating a burglar alarm from a remote position
- operating a bird-scarer located in an orchard
- toys
- film or slide projector operation.

One of the more common tasks performed by a remotely controlled camera is the recording of wild-life studies: a second popular application is where the photographer wishes to include himself on the photograph he is taking. In neither of the foregoing cases is radio control of the camera essential but it does greatly simplify the problems attached to both. Let us examine these two examples before discussing the main topic of constructing the device.

Until the advent of sophisticated remote control methods, the photographic recording of wild-life required many qualities in the photographer not usually associated with his art. He had to build a camouflaged hut, or *hide,* near his selected subject and ensure that this was not startlingly unlike the local landscape. He had to choose this time and take care that, in building his hide, he did not frighten his potential subject away for ever. Finally, he needed the patience and immobility of a statue to remain in what was probably a most uncomfortable position – for many hours – in order to take the photograph. A single movement, or a slight sound at the critical moment, and all his plans were undone.

Wild-life photographs can now be taken with very much less effort and a far greater chance of success. The camera is rigidly fixed in a tree or on a tripod and directed at the place where the subject is known to appear. The site is then observed through binoculars from some distance until the critical moment when the simple task of pressing a button captures nature as the photographer intended.

Illustration of the short-comings in the old-fashioned system of taking photographs which include the photographer himself is quite straightforward. How often have you seen those group snaps where the photographer is *almost* in position? Or where everyone is looking tense because they wern't sure just *when* the camera would operate? Or where the entire group is in profile, some sound having distracted them at the *unknown* crucial moment? Invariably something goes wrong when the photographer sets his camera so that the shutter functions automatically after a predetermined delay.

The problems of taking a first-class group snap which includes the photographer are similarly reduced. He can assume his position among the group and *then* determine the correct instant for the picture to be taken. No longer is it necessary to await the printed result in anguish, not knowing until too late whether or not it has been a success. By the time a print is available, the group has almost certainly dispersed and it may never again be possible to recapture that particular scene.

Nearly every camera is provided with a cable inlet as an alternative method of operating the shutter and it is this facility we shall make use of in adapting our camera to radio control. Both the electronics and mechanics of the system have been kept sufficiently simple to permit rapid and easy construction.

Our radio control system consists of a transmitter and receiver to which is coupled a mechanical linkage for operating the camera shutter mechanism. The electronic part of the system alone can perform many switching applications – a light, a heater, an electric bell or electric motor, etc. Its range of uses is wide indeed.

Transmitter Circuit Description

The transmitter consists of a balanced oscillator, so-called because the entire circuit is symmetrical (Fig.1). The tuned circuit is formed by coil L_1 and capacitor C_3 which are connected between the collectors of transistors TR_1 and TR_2. Each transistor receives a positive feedback voltage at its base (via C_1 or C_2) derived from the collector of the other, thus fulfilling the requirement to maintain oscillation. The base bias voltage is determined by the values chosen for resistors R_1 and R_2. Aerial coupling to the tuned circuit is achieved by connecting the aerial to coil L_2. This consists of 8 turns of wire wound over the tuned circuit coil.

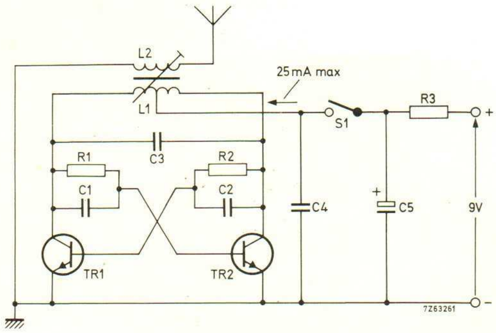


Fig. 1. Transmitter circuit diagram.

The positive supply to the circuit is made via a centre-tap provided on coil L_1. In order to reduce the bulk and weight of the complete transmitter, only a small battery is used. Since this alone cannot supply the current necessary at the time a transmission is actually made, a $1000\mu F$ electrolytic capacitor C_5 is connected across the supply. The capacitor charges via resistor R_3 and, at the instant the push-button switch is operated, the accumulated energy is released to meet the transmitter circuit requirements. Using this method, transmission lasts for only a few seconds but it is quite sufficient for our needs. It also allows us to employ a small battery since the *maximum* current needed is only 25 mA: a continuous signal would involve two large 4½ V torch batteries.

The Transmitter Aerial

The aerial required is approximately one metre in length and, for convenience, a telescopic aerial is advised.

If you are building this transmitter to control a slide projector, the aerial can be put to a good secondary use by using it as a pointer to depict various items of interest to the audience. In fact, the audience need not know that your pointer is an aerial – the slide changes without any apparent assistance – how does he do it?

Transmitter Construction

The electronic heart of the transmitter is mounted on a perforated panel (measuring 3 cm x 4.5 cm), the holes in which are metalized so that solder connections can be made. The first component to be mounted on this panel is the coil-former. Coil L_1, consisting of 6 turns of wire with a centre-tap, is then wound and, over this, the 8 turns for L_2. The free ends of both coils are soldered in the holes indicated in Fig.2*a*. Once the coils have been

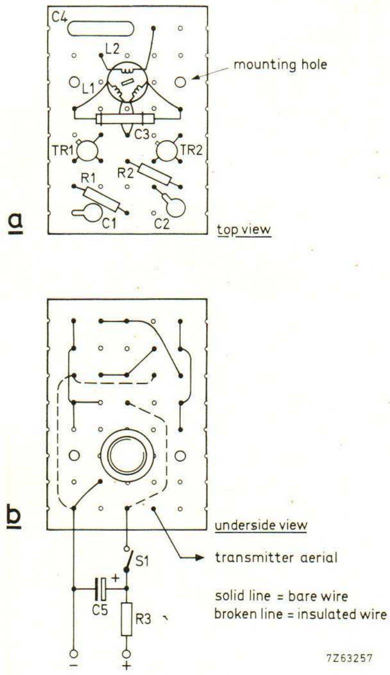


Fig. 2. Transmitter wiring.

correctly attached, the wires of the remaining oscillator components are inserted in the appropriate holes (again see Fig.2*a*), soldered in place and the protruding ends cut off. Interconnection of the components is carried out on the *reverse* side of the panel following the illustration given by Fig.2*b*.

Assembly of the remaining parts is shown in Fig.3. The push-button switch S_1 and the aerial are mounted on a rigid piece of resin-bonded paper or perspex (measuring 3.2 cm x 10 cm) which forms a sturdy base for the transmitter. The remaining components – battery contacts and electrolytic capacitor – are mounted on a small board which is finally attached at right-angles to the base board. The actual positioning of these parts requires a certain amount of forethought to ensure that your finished transmitter looks like the one shown in Fig.3.

The battery contacts we use are those removed from a spent 9 V battery of the same type. These are secured to the small board; using screws or rivets, alongside the electrolytic capacitor. The push-button switch is fixed to the base board then the aerial is fitted behind it – use a strong clamp for this. When the transmitter is completely assembled, these two items should fit neatly beneath the electrolytic capacitor.

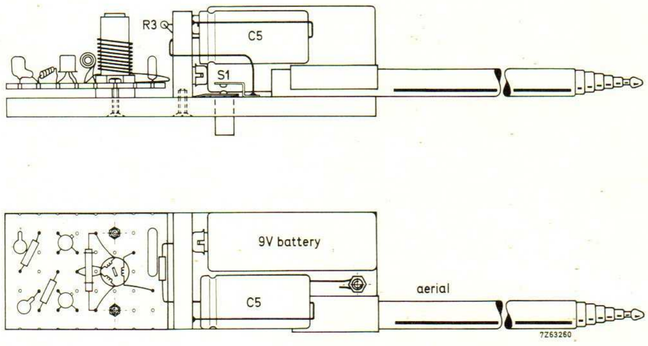
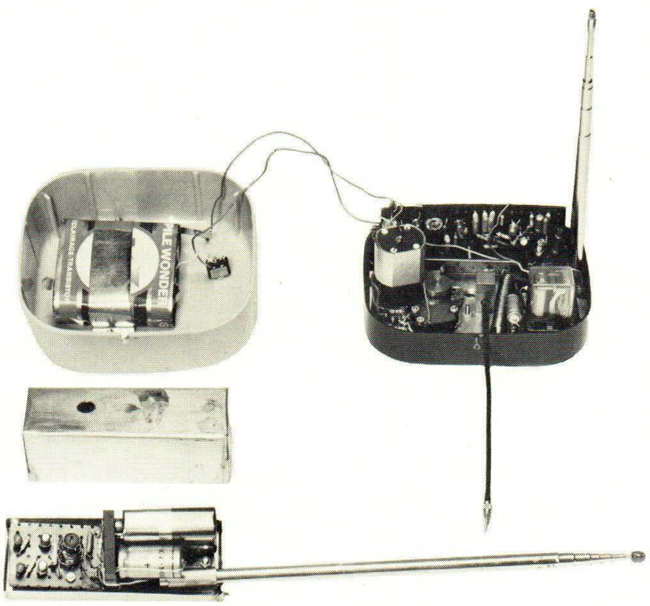


Fig. 3. Transmitter layout.

Having mounted all of the components, it remains only to solder the final connections and house the finished transmitter in a *metal* box (see photo). The size of this box should be 3.5 cm x 3.5 cm x 10.5 cm. A plastic box cannot be used for this purpose due to a phenomena called *hand affect*: meaning that the transmitter frequency is affected when it is handled. Hand affect does not occur with a metal box. When it is connected to the negative side of the battery, it screens the transmitter. Handling by the operator provides a form of earthing. A hole must be provided in the metal box through which the powder-iron core of L_1/L_2 can be adjusted.



Receiver Circuit Description

The receiver used here is of the *super-regenerative* type (Fig. 4). The receiver stage itself consists of a single transistor, a tuned circuit and just a few other components. A super-regenerative receiver is basically an oscillator operating at the transmitter carrier frequency. However, the stage is not allowed to oscillate continuously: a voltage is produced 50 000 times every second which suppresses (or *quenches*) the oscillation. As the circuit conditions change from quenched to oscillating, the sensitivity of the stage passes through a maximum and, although this occurs for only a very brief period each time, it happens at a frequency of 50 kHz. This ensures reasonable reception and is quite adequate for our needs.

A super-regenerative receiver produces a good deal of noise, unless a carrier is present. This noise is caused by incidental signals which occur when the receiver is at its most sensitive, atmospheric conditions and fluctuations within the transistor itself. It is this apparent disadvantage that we actually use: our receiver is designed so that a relay reacts to the *absence* of noise.

The output from the receiver is taken at point "*P*" (Fig. 4). When there is no carrier being received, this signal consists of noise mixed with a strong 50 kHz signal. The latter is removed by a filter which consists of resistors R_5, R_6 and capacitors C_6, C_7, C_8: at point "*Q*" there is virtually only noise. To convert this small noise signal into a useful voltage, it is considerably amplified by transistors TR_2 and TR_3 and at point "*K*" it is strong enough to be heard through headphones. The amplified noise at TR_3 collector is fed to diodes D_1 and D_2 where it is rectified and the resultant negative voltage applied to the base of transistor TR_4. This is held cut off by the applied voltage and consequently holds TR_5 in a similar condition. No collector current flows through TR_5 and hence relay *RA* remains de-energized.

If the transmitter is operating and a carrier is therefore being received, the noise disappears with a consequent loss of the negative voltage at TR_4 base. The base now rises to a positive potential determined by the voltage divider resistors R_{14}, R_{15} and the transistor conducts. Transistor TR_5 also conducts and the current flowing in its collector circuit energizes relay *RA*.

The range over which this control system can be expected to function satisfactorily is approximately 100 metres in open country. Indoors, or in a built-up area, this range will be greatly reduced. Hence the inclusion of variable resistor R_{10} in the receiver circuit which enables it to be set for correct operation at the extreme of its effective range.

In the receiver described here, relay *RA* is used to switch the supply to a small motor but, with a different type of relay, the receiver can just as easily be used to switch heavier currents and higher voltages. Where an application requires the *mains* supply to be switched, we suggest the use of a Siemens relay type Trls 154 d bzw.k, with a 4.5 V coil. It should be remembered, however, that the receiver is very sensitive and will pick up a good deal of interference: the receiver aerial should be kept as far away as possible from all interference sources and any electrical equipment being controlled must be properly suppressed.

Since the receiver may need to be left switched on for a considerable time without receiving a carrier, its quiescent current is very low, approximately 5 mA. This may increase to a few hundred milliamperes when a carrier is received.

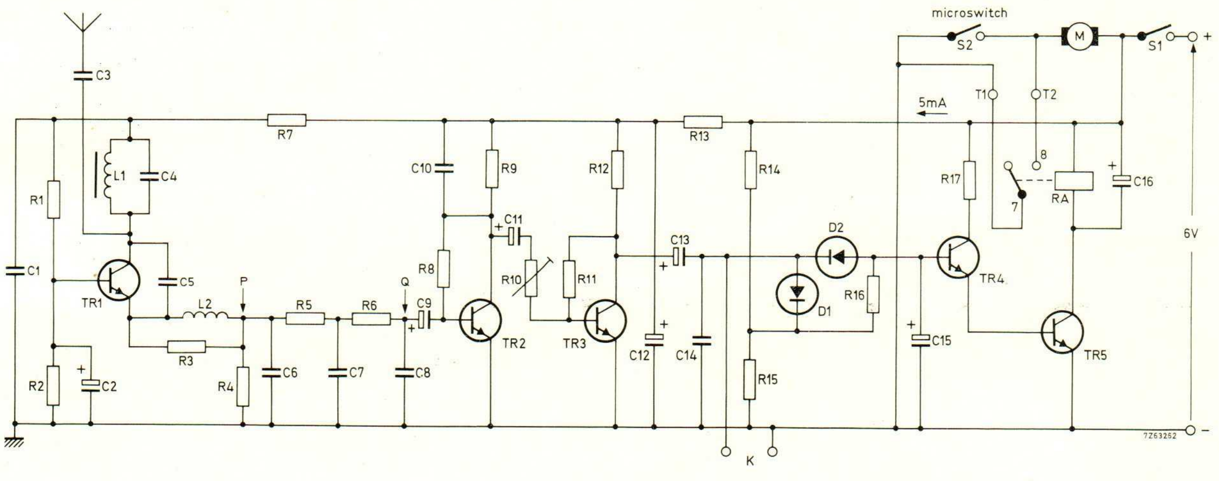


Fig. 4. Receiver and amplifier circuit diagram.

Receiver Construction

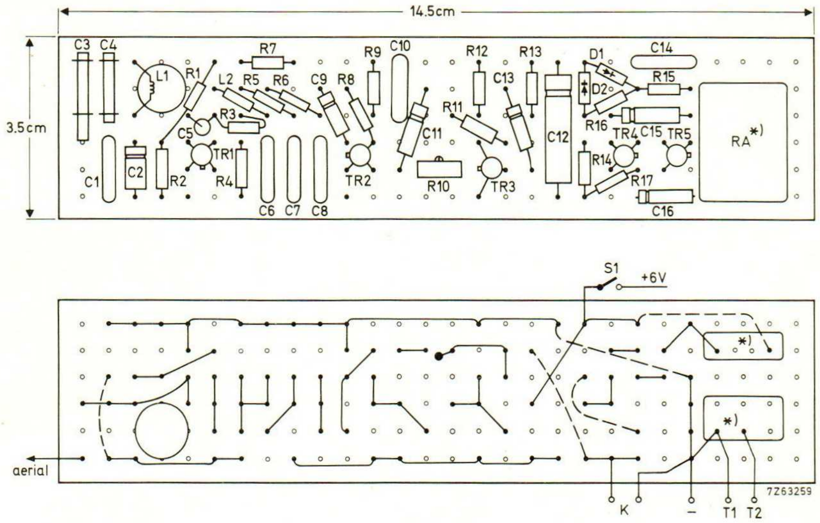
The component location for the receiver is shown in Fig.5. The method of construction is identical to that used for the transmitter oscillator.

Mechanism

No detailed description is given here of the mechanism design since this will tend to vary slightly with the type of camera (or whatever your receiver controls) and the parts which are immediately to hand. However, you may find the ideas outlined in the following paragraphs to be of some assistance.

The mechanism discussed is illustrated in Fig.6. Since the motor shaft rotates far too rapidly for our purposes, it must be geared down considerably. This can be achieved either by using a home-made device or by using a motor with a built-in gearbox. The Philips motor type 9904 120 53101 with a 27:1 reduction ratio is particularly suitable as it generates very little noise. The reduction is still not quite sufficient for our needs and the output shaft speed must be further reduced by 5:1 to give an overall reduction ratio of 135:1.

The function of the mechanism can be understood by studying Fig.6. Its operation is initiated by pressing the transmitter push-button switch. As soon as the carrier is received, the relay energizes and its contacts complete the supply to the motor: the motor shaft rotates and drives the larger gear to which is attached a cam and a screw. As the gear turns, this screw releases the button of a microswitch: its contacts close forming a second supply path to the motor. At the same time, the spring lever at the top of the assembly is pulled quickly down the cam-step: the lever is linked to the shutter control and – snap – the photograph is taken.



* The pin location may differ if another relay is used – ensure that connections correspond with those shown on the circuit diagram.

Fig. 5. Transmitter wiring.

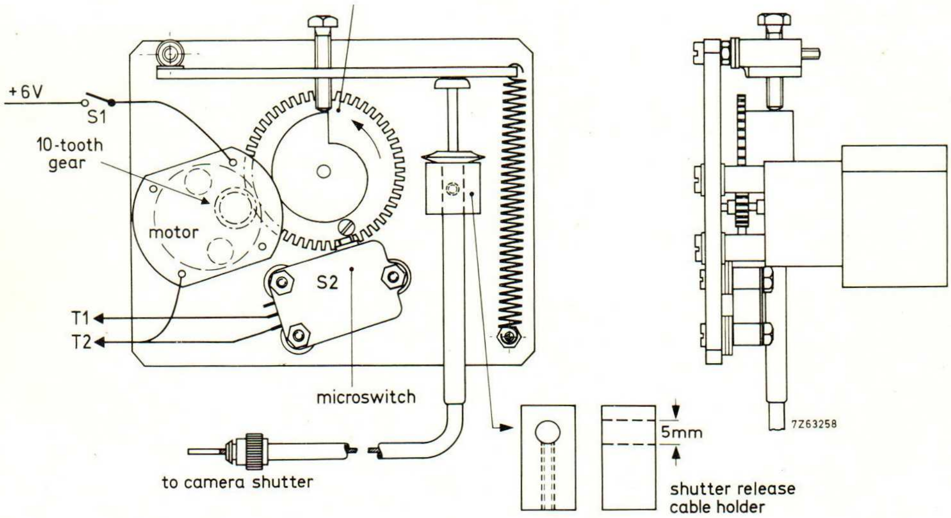
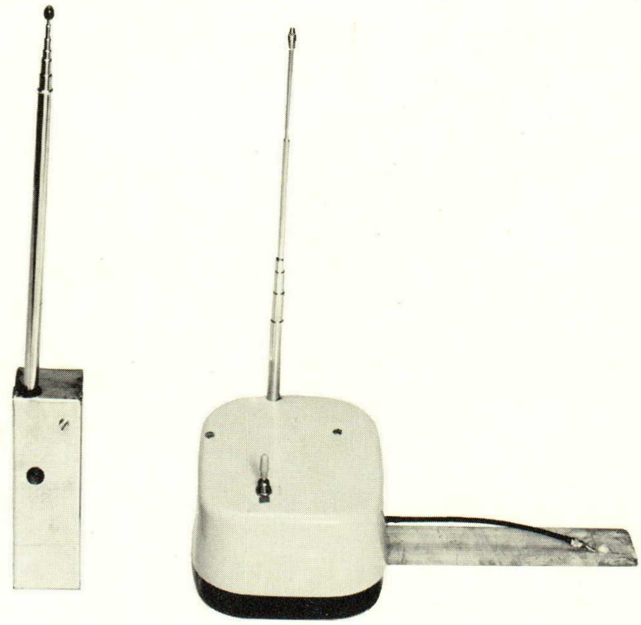


Fig. 6. Shutter release cable mechanism.

As previously mentioned, the transmitted signal lasts for only a short time and as soon as it ceases the relay de-energizes. However, this does not immediately affect the operation of the mechanism since the motor supply is maintained via the closed contacts of the microswitch. The cam continues to rotate, preparing the shutter actuating lever for a subsequent photograph: it is only when the screw on the gear opens the microswitch contacts again that the motor stops. This condition persists until another signal is received.

The receiver, the battery and the mechanism are housed in a box measuring 10 cm x 8 cm x 6 cm. This must be either attached to the camera or between the camera and its tripod in such a way that shutter operation is not impeded.



Transmitter Parts List

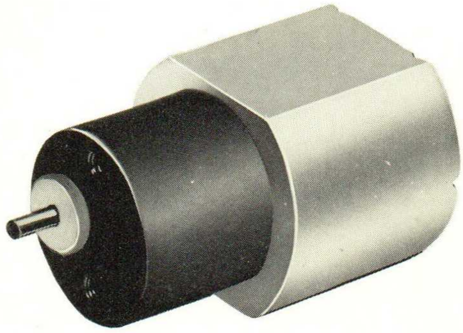
The right-hand column gives type numbers and catalogue numbers.

R1		68 kΩ	2322 101 33683
R2	Carbon resistor 0.33 W	68 kΩ	2322 101 33683
R3		1 kΩ	2322 101 33102
C1	Ceramic capacitor	10 pF	2222 555 05109
C2	Ceramic capacitor	10 pF	2222 555 05109
C3	Ceramic capacitor	100 pF	2222 555 06101
C4	Ceramic capacitor	10 nF	2222 565 02103
C5	Electrolytic capacitor	1000 μF, 10 V	2222 017 54102
TR1	n-p-n Si transistor		BC108
TR2	n-p-n Si transistor		BC108
S1	Switch on-off		any type
L1	6 turns 0.5 mm enamelled wire. Tap in the middle. Coil-former 7 mm ϕ with powder iron screw core.		
L2	8 turns 0.5 mm enamelled wire over L1.		

Receiver Parts List

R1		15 kΩ	2322 101 33153
R2		10 kΩ	2322 101 33103
R3		5.6 kΩ	2322 101 33562
R4		3,3 kΩ	2322 101 33332
R5	Carbon resistor 0.33 W	2.2 kΩ	2322 101 33222
R6		2.2 kΩ	2322 101 33222
R7		100 Ω	2322 101 33101
R8		220 kΩ	2322 101 33224
R9		1 kΩ	2322 101 33102
R10	Trimming pot.	22 kΩ	2322 410 05008
R11		220 kΩ	2322 101 33224
R12		1 kΩ	2322 101 33102
R13		47 Ω	2322 101 33479
R14	Carbon resistor 0.33 W	5.6 kΩ	2322 101 33562
R15		2.2 kΩ	2322 101 33222
R16		2.2 kΩ	2322 101 33222
R17		1.5 kΩ	2322 101 33152
C1	Polyester capacitor	10 nF	2222 342 44103
C2	Electrolytic capacitor	32 μF, 4 V	2222 001 12329
C3	Ceramic capacitor	2.2 pF	2222 555 57228
C4	Ceramic capacitor	56 pF	2222 555 56569
C5	Ceramic capacitor	47 pF	2222 555 56479
C6	Ceramic capacitor	2.2 nF	2222 552 03222
C7	Polyester capacitor	22 nF	2222 342 44223
C8	Polyester capacitor	22 nF	2222 342 44223
C9	Electrolytic capacitor	10 μF, 16 V	2222 001 15109
C10	Polyester capacitor	33 nF	2222 342 44333
C11	Electrolytic capacitor	4 μF, 10 V	2222 001 14408
C12	Electrolytic capacitor	320 μF, 6.4 V	2222 001 13321
C13	Electrolytic capacitor	10 μF, 16 V	2222 001 15109
C14	Polyester capacitor	33 nF	2222 342 44333
C15	Electrolytic capacitor	10 μF, 16 V	2222 001 15109
C16	Electrolytic capacitor	100 μF, 6.4 V	2222 001 13101
TR1	n-p-n Si transistor		BF115
TR2	n-p-n Si transistor		BC108
TR3	n-p-n Si transistor		BC108
TR4	n-p-n Si transistor		BC108
TR5	n-p-n Si transistor		BC108
D1	Ge diode		AA119
D2	Ge diode		AA119
RE1	Relay 2.8 to 12 V Siemens Trls 154d bzw k Tkfs 97d		
M	Motor with gearbox 75 rev/mm		9904 120 53101
S1	Switch on-off		any type
S2	Microswitch		any type
L1	6 turns 0.5 mm enamelled wire on coil-former of 7 mm ϕ with powder iron screw core		
L2	100 turns 0.1 mm enamelled wire 3 mm ϕ 12 mm long.		

DIRECT CURRENT MOTORS
with reduction



Quick Reference Data

catalogue number	nominal voltage (V_{dc})	reduction ratio	speed (rev/min)	input power (W)	torque (gcm *)
9904 120 53101	3	27 : 1	96	0.45	150
9904 120 53102	3	15.8 : 1	162	0.45	90
9904 120 53103	3	10 : 1	258	0.45	55
9905 120 53104	3	1.6 : 1	1600	0.45	11

*) 1 gcm $\approx 10^{-4}$ Nm.

APPLICATION

These small d.c. motors with reduction have been mainly designed for servo purposes in professional and industrial applications, which require high reliability and smooth running.

Examples:

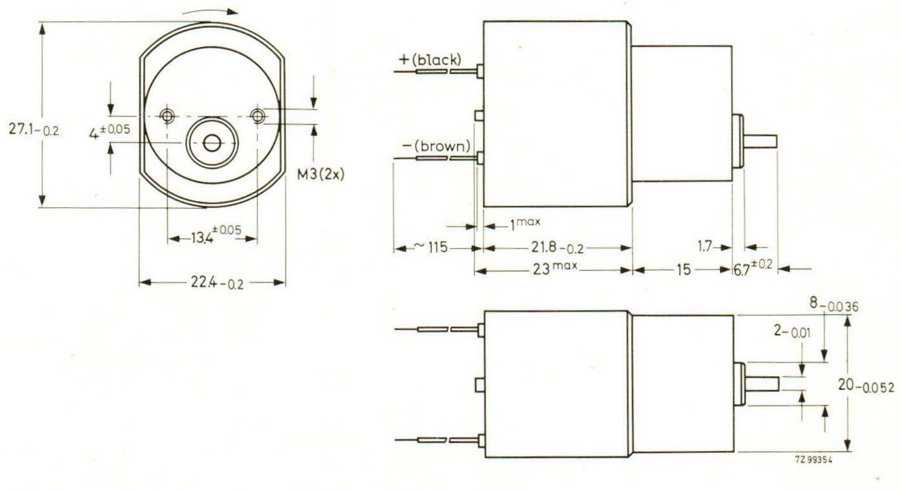
- film cameras (film drive and zoom lens drive)
- slide projectors
- portable recording instruments (chart drive and pen drive)
- instruments for automation.

DESCRIPTION

The motors have been provided with a housing of sintered iron. A reduction of the motor speed has been obtained by means of a high-precision reduction gear, mounted in a steel housing, which is fitted to the motor. A special construction of a flat collector, a light brush construction and a built-in spark suppressor (VDR) guarantee a smooth running.
The motors are suitable for use with an electronic remote control unit.
They can be used in tropical environments.

TECHNICAL DATA

Dimensions in mm.



The direction of rotation is given in connection with the polarity.

Weight: approx. 65 g.

The values given below apply to an ambient temperature of 22 ± 5 °C, an atmospheric pressure of 860 - 1060 mbar and a relative humidity of 45–75 %.

Nominal values

Catalogue number 9904 120	53101	53102	53103	53104	
Reduction ratio	27 : 1	15.8 : 1	10 : 1	1.6 : 1	
Voltage	3	3	3	3	V_{dc}
Torque	150	90	55	11	gcm *)
Speed at nominal load	96 ± 12	162 ± 20	258 ± 31	1600 ± 180	rev/min
at no load	110 ± 12	190 ± 20	298 ± 31	1870 ± 200	rev/min
Current at nominal load	⩽0.15	⩽0.15	⩽0.15	⩽0.15	A
at no load	⩽0.05	⩽0.05	⩽0.05	⩽0.05	A
Starting voltage at no load	<1	<1	<1	<1	V_{dc}
Starting torque	⩾750	⩾450	⩾285	⩾55	gcm *)
Input power	⩽0.45	⩽0.45	⩽0.45	⩽0.45	W
Maximum radial force on the bearings	200	200	200	100	g *)

*) 1 gcm $\approx 10^{-4}$ Nm
1 g $\approx 10^{-2}$ N.

Induced voltage at 3000 rev/min (rotor speed):	between 2.6 and 3.1 V
Rotor resistance measured statically with brushes:	4.5 Ω ± 10 %
Direction of rotation:	clockwise, see dimensional drawing
Ambient temperature range:	–10 to +50 °C
Maximum axial force:	100 g *)
Maximum axial play:	0.2 mm
Rotor inertia:	4.10^{-3} $gcms^2$
Housing, material of motor:	sintered iron
material of gearbox:	steel

PHILIPS

ELECTRONIC COMPONENTS
AND MATERIALS DIVISION

electronics for YOU

31

Electronic Door-lock

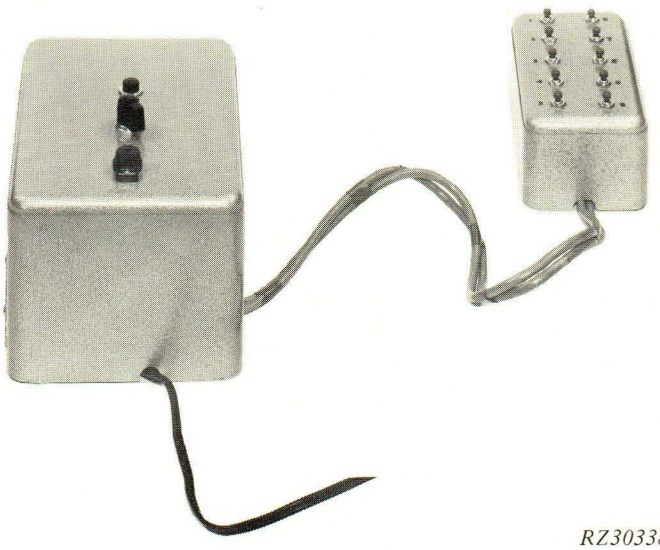
Dear Experimenter,

How many burglaries have there been in your area recently? Has someone, perhaps, even had the nerve to break into your own home and make off with your choicest possessions?

If there has been nothing of the kind that you know of, you may consider yourself fairly lucky – unfortunately, incidents of this nature are becoming more and more common. Even though police all over the country are doing their utmost to prevent such outrages, a large portion of the responsibility for the security of your home rests with you.

It is obviously an open invitation to a burglar if you go out and leave all the doors unlocked and, of course, you'd never do that. However, what may appear to us as taking adequate precautions might well be laughable to the modern burglar. Over the years, a good deal of information has been gleaned concerning the operation of conventional door-lock mechanisms – any self-respecting house-breaker can open most of them with the special tools he's devised and made.

The answer seems to be to try and stay one jump ahead of the burglar: use up-to-date methods of security that he hasn't had time to learn much about. This edition of Electronics for You describes, therefore, an electronic door-lock operated by a combination of numbers.



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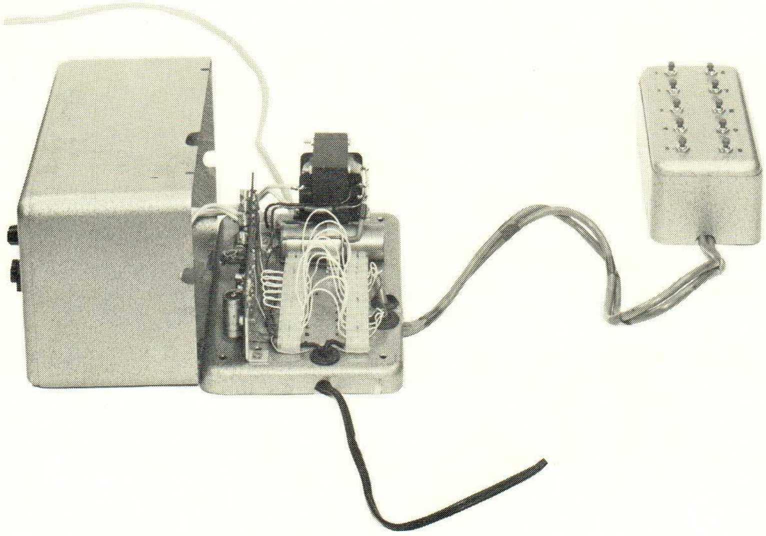
An electronic lock in addition to your ordinary lock will make the house much safer and there is no key-hole for a potential burglar's special tools. You *can* forget the combination but it is of your own choosing and you are able, therefore, to ensure that it's a number not easily forgotten – the date of your birthday, for instance. If you are still worried that you may forget it, you can always write it down in some corner known only to you. Electronic locks, such as the one described, have already found numerous applications – and been succesful – where only a limited number of people are allowed access: factory halls, stores, summer houses, garages, safes, strongrooms, etc. In cases like these, the ordinary lock is usually left open by the one person who holds the key and then anyone knowing the combination can pass. If the number-combination is regularly changed it will provide a first-class form of security indefinitely.



Circuit Description

The block diagram for a battery-powered system is given in Fig. 1a and for a system which has a mains power supply circuit in Fig. 1b. It should be noted that with electronic locks using a mains supply, the positive d.c. supply for the lock and for the electronics must be kept separate (Fig. 1b). This is to prevent voltage variations, caused when the lock is activated, from affecting the operation of the electronics. The system consists of two main units: a small cabinet housing the ten numbered push-buttons and an electronic unit. An 11-core cable is used to interconnect the two.

Fig. 2 shows the circuit diagram of the system. The electronic unit is based on a circuit containing four BRY39 silicon controlled switches (TH_1 to TH_4). The cathode gate of each of the silicon controlled switches (SCS) is connected to one of the ten push-button switches, the choice of switch being arbitrary. This determines the four numbers of the combination and the sequence in which the push-buttons must be operated. The four SCS are in series and each will begin to conduct when its cathode gate becomes positive, *but only if its anode is already positive.* The anode, in fact, can only be positive if the preceding SCS is conducting (with the exception of TH_1): TH_1 must, therefore, conduct before TH_2 and so on. This governs the sequence of the number combination.

When the push-button connected to TH_1 is pressed, TH_1 conducts and TH_2 anode becomes positive. It is now possible for TH_2 to conduct when the appropriate button is pressed. TH_3 and TH_4 function in the same way and when all four SCS are conducting, the cathode of TH_4 will be positive and, since it is connected to the base of transistor TR_1 (via resistor R_{14}), TR_1 conducts. TR_2 consequently conducts and provides the current necessary to activate the lock – the door is free to open.

The operation of one of the push-buttons connected to an SCS provides a voltage step which is differentiated by capacitor C_2, C_4, C_6 or C_8. The resultant positive pulse (just sufficient to ensure that the SCS conducts) is applied to the appropriate gate. C_3, C_5, C_7 and C_9 are included to form a path to the negative side of the supply for any interference voltages.

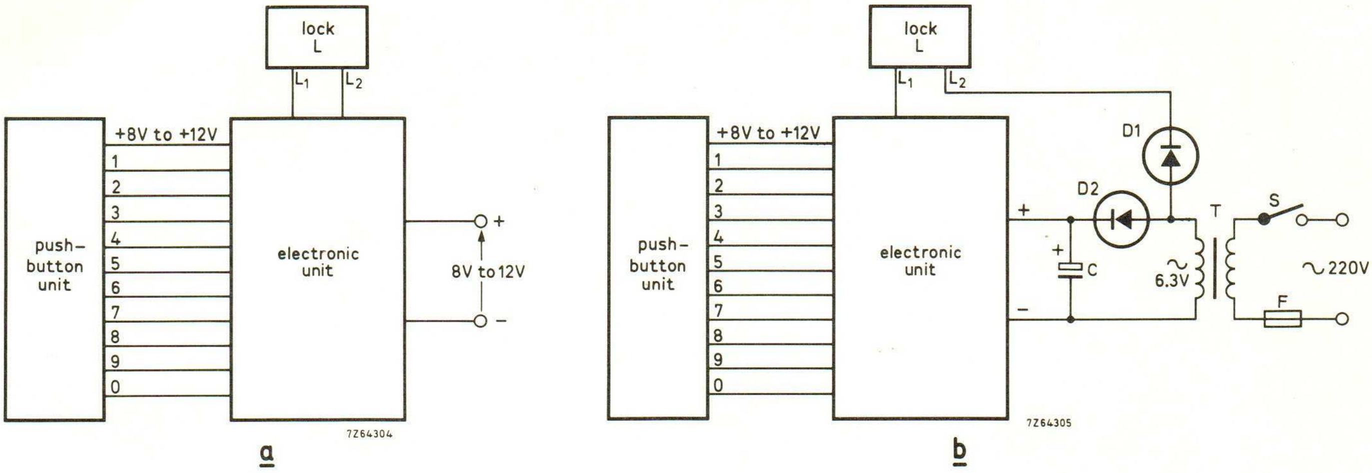


Fig.1. System block diagrams and mains supply circuit.

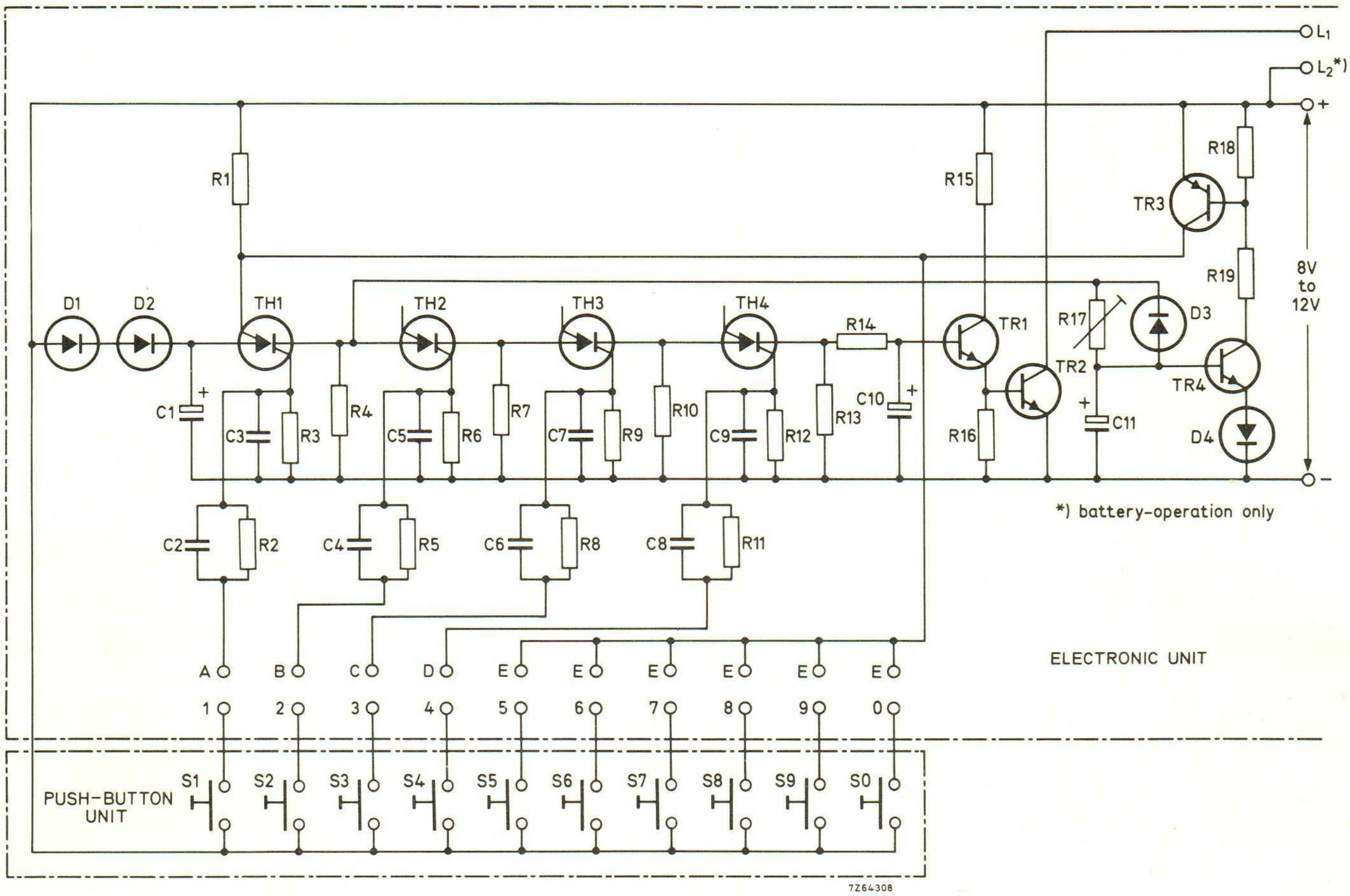


Fig.2. System circuit diagram.

The operation of a push-button connected to one of the E terminals returns the anode gate of TH_1 to the positive supply line. TH_1 cuts-off and consequently any SCS that had previously been conducting also cuts-off. The number-sequence must now be recommenced. This feature helps to prevent a person who does not know the correct combination, but who has selected one or two numbers by accident, from opening the lock.
One condition for switching an SCS from the conducting to the non-conducting state is to make the anode gate more positive than the anode. Diodes D_1 and D_2 reduce TH_1 anode voltage to approximately 1.4 V below that of the supply – when an incorrect push-button is pressed, the anode gate is returned to the supply voltage via the switch and TH_1 cuts-off. A similar action occurs if TH_1 anode gate is returned to the supply via transistor TR_3, as will be seen later.

A time limit has been incorporated which comes into operation the moment the first correct push-button is pressed, i.e. when TH_1 conducts. TH_1 cathode is then positive and capacitor C_{11} charges via potentiometer R_{17}. After a predetermined delay, the base voltage of transistor TR_4 will be large enough for the transistor to conduct: TR_3 will also conduct. As a result, TH_1 again cuts-off. In other words, unless the correct sequence is selected in a certain time, the circuit reverts to its initial state. R_{17} allows the time to be adjusted from 0 to 30 seconds. The value set is for a total operating time, i.e. the time taken to operate the correct push-buttons plus the time for which the lock remains open – the longer selection takes, the shorter the time there is to open the door.

As soon as TH_1 cuts-off, the electrolytic capacitor C_{11} will discharge rather quickly via diode D_3 and resistor R_4. If D_3 were omitted, C_{11} would discharge slowly.

Power Supplies

The supply voltage for the electronic door-lock may be anything from 8 V to 12 V and, with a battery-operated system, six single 1.5 V cells are quite adequate since the quiescent current is zero. The current consumption of the system when the lock is open depends largely upon the type of lock used – typically it will be between 0.2 A and 1.0 A. However, the lock only remains open for a maximum of 15 seconds and the battery life should be quite long.

With a mains supply circuit (Fig. 1b), a standard 6.3 V heater transformer of 10 W to 20 W is used to obtain the supply voltage. For the electronic unit, this is rectified and smoothed but for the lock itself it is simply rectified. This results in the lock vibrating and a noticeable hum when it is open – when it hums, the door is free to be opened.

Construction

The electronic unit is constructed on a perforated panel (5 cm x 16 cm), the holes of which are metalized and set 0.5 cm apart. Fig. 3a shows the component arrangement on one side of the panel and Fig. 3b shows the connections necessary on the reverse side.

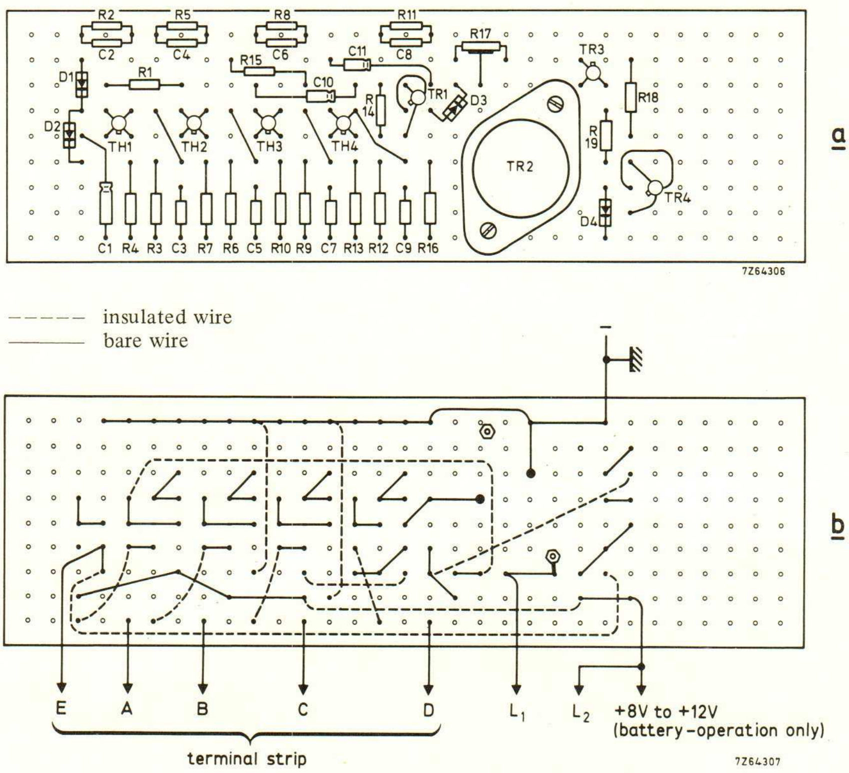


Fig.3. Electronic unit wiring.

The electronic unit and its supply circuit or batteries are housed in a cabinet measuring approximately 20 cm x 14 cm x 10 cm. Another small cabinet, about 14 cm x 8 cm x 6 cm is needed for the push-button unit.

The push-button unit should either be attached to the door with the electronic unit almost immediately behind it on the inside, as shown in Fig. 4, or on the wall quite close to the door. The type of electric lock shown in the photograph is one designed to be attached to the door-post and it is this type of lock on which our description is based. Wires from the electronic unit to the lock can be either routed above or below the door.

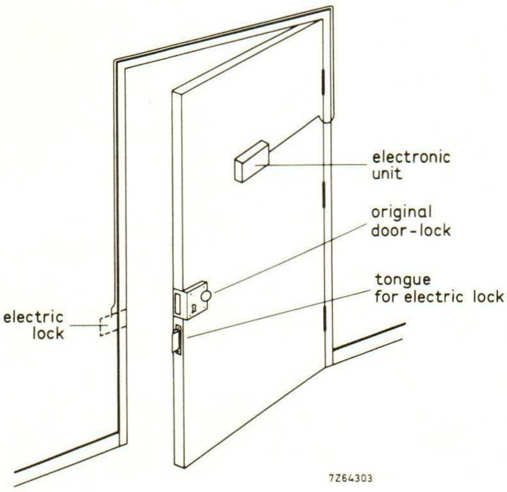


Fig.4. Layout of items.

Setting the Combination

The combination is set by connecting wires between terminals 1 to 0 and A to E respectively (Fig. 2). Remember that you not only set the numbers of the combination – you set the sequence in which the buttons must be pressed too.
For example, if connections are made between:

terminals 2 and A
terminals 5 and B
terminals 0 and C
terminals 3 and D

and terminals 1, 4, 6, 7, 8 and 9 are connected to E, the opening combination is 2503 – 2053 will not open the lock at the first try (see "Chances of Accidental Opening"). The terminal strips on which the combination interconnections are carried out can be seen in the photograph.

Chances of Accidental Opening

A person who knows only that the lock can be opened with a combination of four figures has a 1 in 10 000 chance of success. If he also knows that the same numbers cannot be used twice in a combination, he has a better chance: 1 in 5000 approximately. For someone with an understanding of the electronics involved, the possibility of opening the lock is again increased.

Although the sequence and the numbers for opening the lock first time are fixed, if the correct four numbers are selected often enough in the wrong order, the lock will eventually open. This is because an SCS will remain conducting once it is switched on unless an incorrect push-button is pressed.

Let us take an example, a correct combination of 2503. When this sequence is selected, first TH_1 conducts (Fig. 2), then TH_2, then TH_3 and finally TH_4 which opens the lock. Now, if the buttons are pressed in the reverse order (3052), the following occurs:

- push-button 3 pressed: nothing happens
- push-button 0 pressed: nothing happens
- push-button 5 pressed: nothing happens
- push-button 2 pressed: TH_1 conducts

If the sequence is repeated:

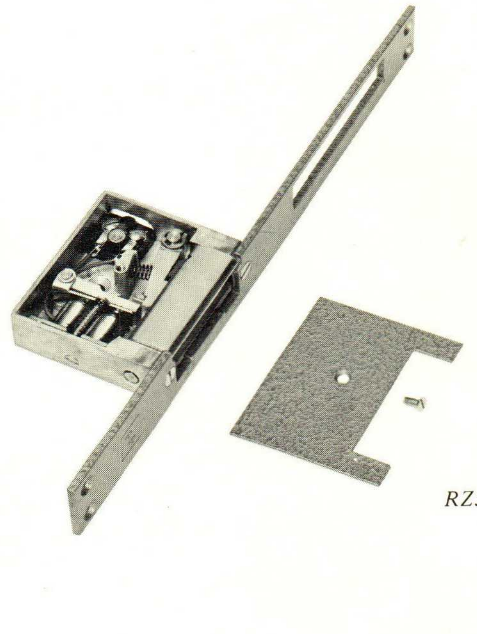
- push-button 3 pressed: TH_1 conducting
- push-button 0 pressed: TH_1 conducting
- push-button 5 pressed: TH_1 conducting and TH_2 conducts
- push-button 2 pressed: TH_1 and TH_2 conducting

From this it can be seen that if the correct numbers are selected in the wrong order four times, the lock will open – but it must be done within the 0 to 30 seconds delay set by R_{17}. A more realistic figure for the chance of opening the lock by accident is given if the sequence is ignored. This is:

$$\frac{4! \cdot 6!}{10!} = \frac{4}{10} \cdot \frac{3}{9} \cdot \frac{2}{8} \cdot \frac{1}{7} = \frac{1}{210}$$

– a chance of 1 in 210.

Since this gives a relatively high chance of success, the delay of 0 to 30 seconds has been incorporated. It is now no longer possible to calculate the chance of opening the lock by random selection since it depends upon how quickly the push-buttons can be operated and how long the delay is set for.



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Parts list

Electronic Unit

R1	carbon resistor	5.6	kΩ,	0.5	W	2322 212 13562
R2, R5, R8, R11	carbon resistor	1	MΩ,	0.5	W	2322 212 13105
R3, R6, R9, R12	carbon resistor	10	kΩ,	0.5	W	2322 212 13103
R4, R7, R10, R13	carbon resistor	2.2	kΩ,	0.5	W	2322 212 13222
R14, R16, R18	carbon resistor	1	kΩ,	0.5	W	2322 212 13102
R15	carbon resistor	100	Ω,	0.5	W	2322 212 13101
R17	carbon pot.	220	kΩ,	0.5	W	2322 411 07212
R19	carbon resistor	560	Ω,	0.5	W	2322 212 13561
C1	electrolytic cap.	33	μF,	16	V	2222 016 15339
C2, C4, C6, C8	polyester cap.	0.33	μF,	250	V	2222 342 44334
C3, C5, C7, C9	polyester cap.	0.01	μF,	250	V	2222 342 44103
C10	electrolytic cap.	15	μF,	16	V	2222 015 15159
C11	electrolytic cap.	470	μF,	6.3	V	2222 016 13471
D1, D2, D4	silicon diode					BAX13
D3	germanium diode					AA119
TH1, TH2, TH3, TH4	thyristor tetrode					BRY39
TR1, TR4	n-p-n Si transistor					BC108
TR2	n-p-n Si transistor					BDY20, BDY38, 2N3055 or BD131 *
TR3	p-n-p Si transistor					BC178

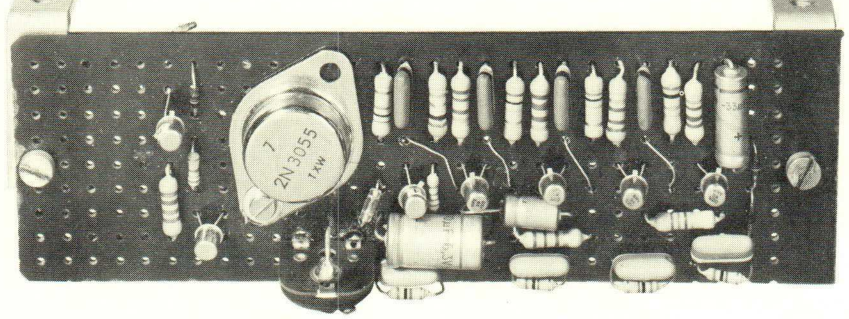
Push-button Unit

S1 to S0	push-button switch	any type

Mains Supply Circuit

C	electrolytic cap.	2000	μF,	25	V	2222 063 56202
D1, D2	silicon diode					BY126
F	fuse, 1A					any type
S	on/off switch					any type
T	transformer, 6.3 V secondary					any type
L	electric lock 6 V to 10 V, 1 A (max.)					any type

* The BD131 is a plastic encapsulated transistor (TO-126) and of different appearance to the 2N3055 seen on the photograph.



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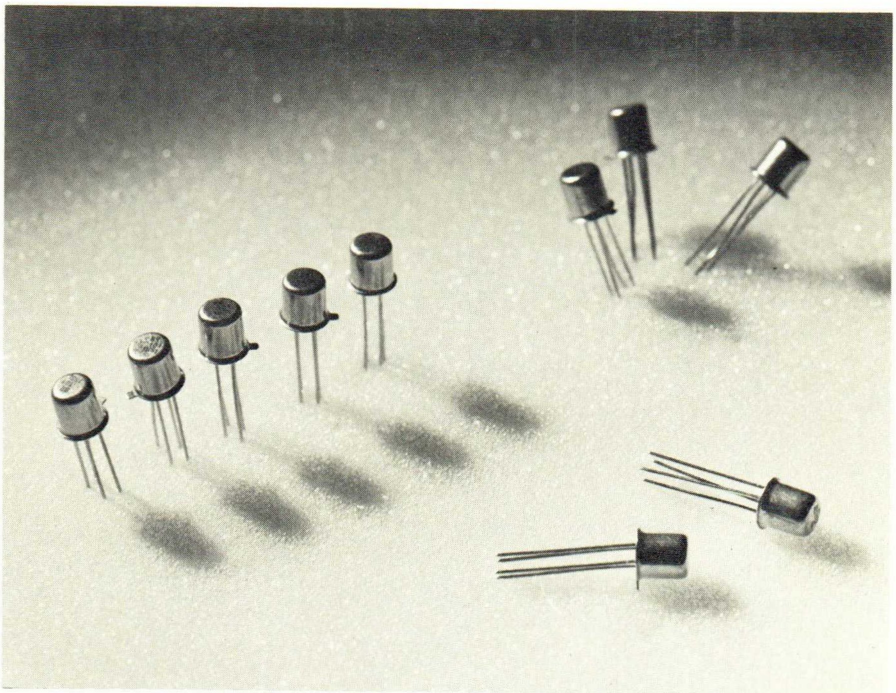

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The BRY39 Thyristor Tetrode

The BRY39 is a general-purpose, low-power, silicon planar p-n-p-n device in a TO-72 metal envelope. The device comprises an integrated pnp-npn transistor pair of which all electrodes are accessible. Many switching and logic operations requiring two or more conventional active elements can, therefore, be performed with only one BRY39.

As a four-layer device, the BRY39 has the following outstanding features:

- high sensitivity
- no *dv/dt* rate problem
- Few circuit components and hence few connections required
- low cost
- better matched than two separate transistors.

Fig. 5 shows the schematic representation of the build-up of the layers of the p-n-p-n silicon controlled switch. Fig.6 shows that this representation can be split into an equivalent circuit comprising two interconnected transistors. Fig. 7 gives the symbol for our new device, *a* stands for anode , *ag* for anode gate, *kg* for cathode gate and *k* for cathode.

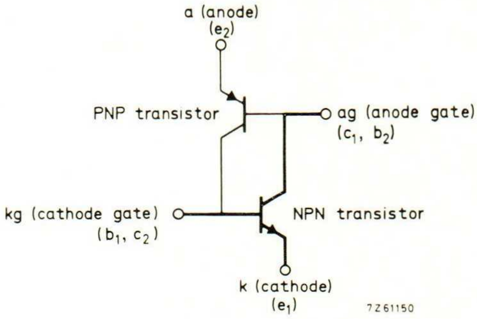

Fig.6. Equivalent circuit of the BRY39.

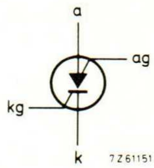

Fig.7. Symbol of the BRY39.

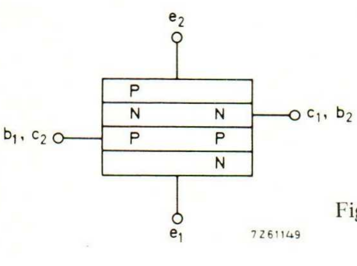

Fig.5. Schematic build-up of the p-n-p-n SCS.

Application as a Silicon Controlled Switch

Quick reference data

P-N-P transistor				
Emitter-base voltage (open collector)	$-V_{EBO}$	max.	70	V
N-P-N transistor				
Collector-base voltage (open emitter)	V_{CBO}	max.	70	V
Repetitive peak emitter current				
$t = 10\ \mu s$, $\delta = 0.01$	$-I_{EM}$	max.	2.5	A
Total power dissipation up to $T_{amb} = 25\ ^\circ C$	P_{tot}	max.	275	mW
Junction temperature	T_j	max.	150	°C
Forward on-state voltage				
$I_A = 50$ mA; $I_C = 0$; $R_{BE} = 10\ k\Omega$	V_{AE}	<	1.4	V
Holding current				
$I_C = 10$ mA; $-V_{BE} = 2$ V; $R_{BE} = 10\ k\Omega$	I_H	<	1.0	mA
Turn on time	t_{on}	<	0.25	μs
Turn off time	t_q	<	5.0	μs

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