CATALOGUE No. L 97 - 100

INSTRUCTION SHEET

No. 1083 / 6001

GRIFFIN - CLARKESMITH MECHTRONICS SET

Griffin

GRIFFIN & GEORGE (SALES) LIMITED

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LIST OF CONTENTS

Quantity	Part No	Description
1	1	Box
1	2	Baseboard with supports.
1	6	Pentode panel assembly.
1	7	Diode panel assembly.
1	8	Transformer
1	10	50,000 ohm potentiometer.
1	11	100 ohm potentiometer.
1	12	500,000 ohm potentiometer.
1	13	Relay.
1	15	Buzzer.
1	16	Loudspeaker.
1	29	Relay bracket.
1	41	Loudspeaker stand.
1	53	Potentiometer bracket.
4 feet	46	Insulated flex wire - black.
4 feet	47	Insulated flex wire - red.
4 feet	48	Insulated tinned copper wire - blue
4 feet	49	Insulated tinned copper wire - yellow
4 feet	50	Insulated tinned copper wire - red.
4 yards	51	Bare tinned copper wire.
1	18	Screwdriver.
1	19	BIB wire stripper and cutter.
1	9	Instruction book, including layout diagrams.
1 Pkt. containing	4	2. Selector switch arms.
	5	2. Key switch arms.
	44	4. Black polythene balls.
1 Pkt. containing	20	2. Lampholders.
1 Pkt. containing	24	1. EF91 valve.
	26	2. OC71 transistors.
	25	1. EB91 valve.
	27	1. OA81 crystal diode.
	31	1. Neon indicator lamp.
	32	2. M.E.S. bulbs 6.3 volt 40 mA.
1 Pkt. containing	42	50. Electrolinx.
	43	50. Electrolinx Caps.
1 Pkt. containing	33	1. Capacitor 25 microfarads.
	34	1. Capacitor 100 microfarads.
	35	2. Capacitors 8 microfarads.
	229	1. Capacitor 0.1 microfarad.
	230	2. Capacitors 0.01 microfarad.
	231	1. Capacitor 100 picofarads.
	232	1. Capacitor 250 picofarads.
1 Pkt. containing	218	1. Resistor 1 Megohm.
	219	1. Resistor 470,000 ohms.
	220	1. Resistor 220,000 ohms.
	221	1. Resistor 100,000 ohms.
	222	1. Resistor 47,000 ohms.
	223	1. Resistor 10,000 ohms.
	224	1. Resistor 3,300 ohms.
	225	1. Resistor 1,000 ohms.
	226	1. Resistor 220 ohms.
1 Pkt. containing	36	4. Round head screws 6 BA x ¼ inch.
	37	50. Round head screws 4 BA x 3/8 inch.
	40	6. Round head screws 4 BA x 5/8 inch.
	38	16. Nuts 4 BA.
	39	30. Washers 4 BA.

INSTRUCTIONS FOR GRIFFIN - CLARKESMITH MECHTRONICS SET

In the past, the student of electronics has tended to neglect the experimental side and to rely on unsupported theory because of the time taken up in making soldered connections and in drilling and cutting the chassis. The Mechtronics Kit has, therefore, been devised to incorporate a unique system for the rapid connection of components.

The Mechtronics system consists of a base board perforated with numerous holes, each of which can be identified uniquely, by a cross reference of numbers and letters. These holes are used to affix spring connectors specially designed for rapid and reliable interconnection of components and wires. No soldering iron is required to make these connections and the components can be removed or replaced easily and quickly. With the exercise of a little care, components will last almost indefinitely. Thus it will be seen that the experimenter is encouraged to explore the effects of changing values of components in circuits. A number of such experiments has been outlined in these instructions. These initial experiments are not intended to be exhaustive but to serve as an introduction to basic electronic circuitry.

Fig. 1 represents the baseboard.

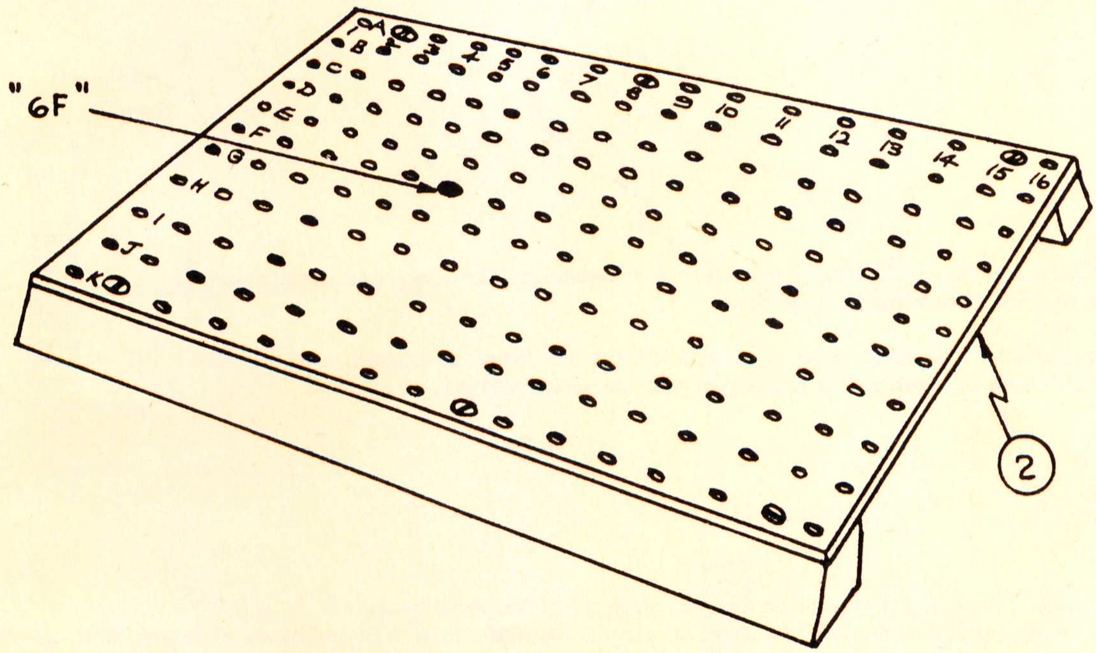


Fig. 1

In order to identify a particular hole in the board a combination of figure and letter is quoted. For example, the hole marked black in Fig. 1 would be quoted as number 6 letter F or 6F.

The spring connectors are known as 'Electrolinx' and are attached to the baseboard as shown in section in Fig. 2.

The Electrolinx are so dimensioned as to screw directly on to the thread of the screws provided in the manner of a nut. It is desirable to avoid overtightening as this makes the spring difficult to remove. When dismantling, the Electrolinx should be held tightly in the fingers and the screw removed with a screwdriver.

The method of clamping the wires in the connectors is shown in section in Figs. 3A and 3B.

The spring is pulled upwards, Fig. 3A, expanding the turns just sufficiently to slip the wires in or out. Do not use too much force or the spring may be permanently stretched, and will not grip the wires when released. Alternatively, bend the connector so as to separate the turns on one side, Fig. 3B, thread the wire and release spring so that it clamps down on the wire and holds it fast. Two or three wires can be clamped in the same connector. Components fitted with integral wires can be directly connected and supported with Electrolinx, interconnections made with 22 or 24 S.W.G. tinned copper wire, while components with solder tags may have Electrolinx fitted to them by threading one end of the spring through hole in tag and turning clockwise so that one or two coils of the spring project at the back of the tag (Fig. 4).

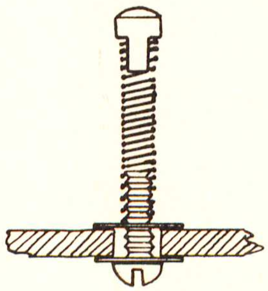


Fig. 2

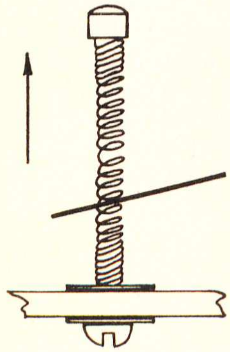


Fig. 3A

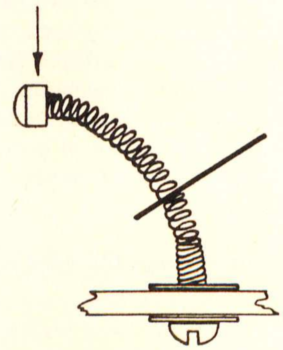


Fig. 3B

Valveholders are supplied already mounted on sub-panels. The electrode connections are brought out to Electrolinx for easy access.

The components have been chosen to enable a wide range of experiments to be conducted and they can be used again and again without deterioration.

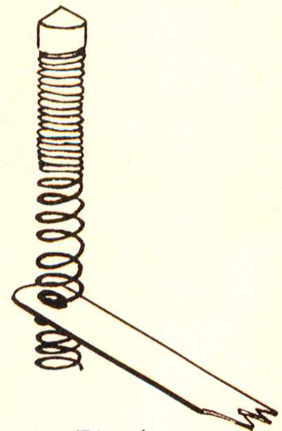


Fig. 4

The Switches. Three types of switch can be made with the parts supplied

(a) Selector switch (Figs. 5A and 5B) from a simple On/Off, to a multi-contact selector with up to eight ways.

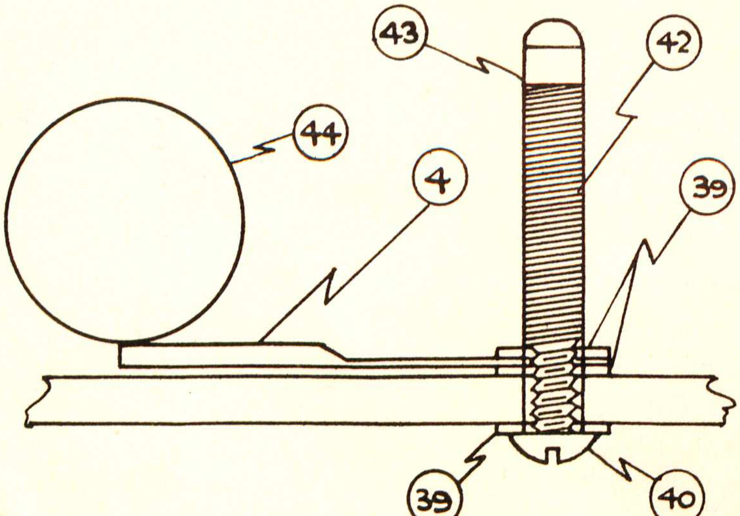


Fig. 5A

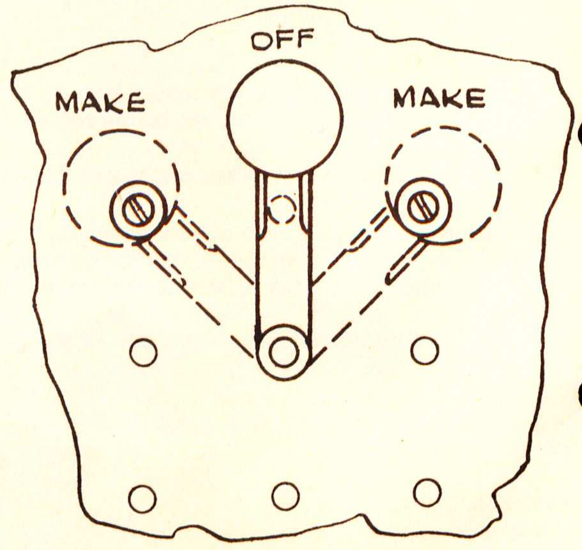


Fig. 5B

These are assembled with the following parts:-

(Part 4) Switch Arm "A"
(Part 44) Knob
(Part 37) 3/8 inch Screw.
(Part 39) Washers, 3
(Part 42) Electrolinx

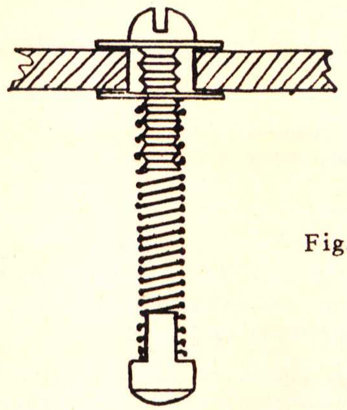


Fig. 6.

Contacts are made simply by fitting 3/8 in. screws with washers in appropriate holes in platform and fixing with a washer and Electrolinx below platform, Fig. 6.

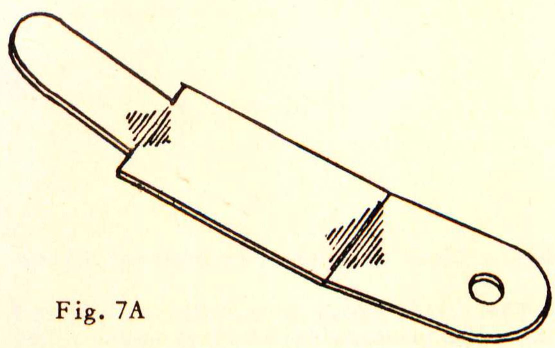


Fig. 7A

(b) Key Switch. These are assembled with the following parts.

(Part 5) Switch Arm "B" (See Fig.7A)
(Part 44) Knob
(Part 40) 5/8 in. Screw
(Part 39) Washers, 3
(Part 42) Electrolinx
(Part 38) Nuts, 2

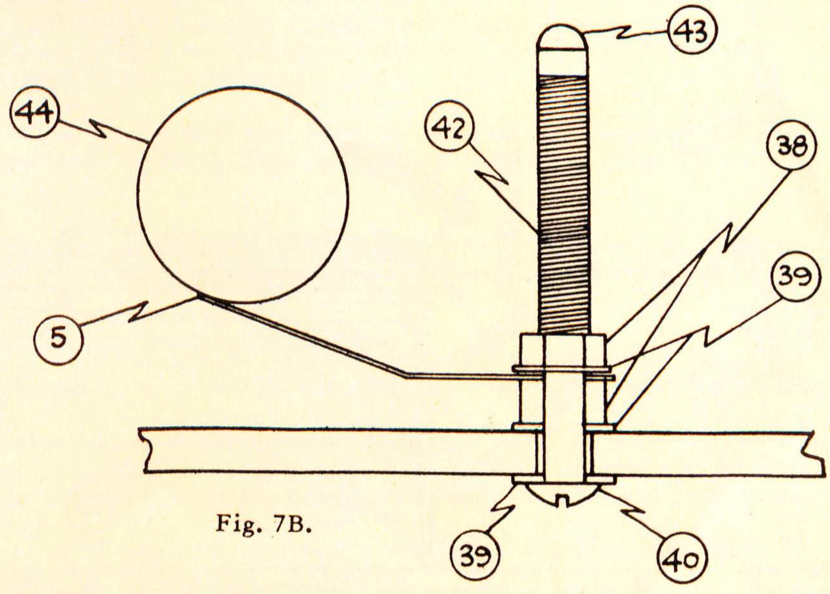


Fig. 7B.

Assembly Instructions - Key switch - (See Fig. 7B). Thread a washer (part 39) on to 5/8 in. screw (part 40) and insert screw through appropriate hole in the platform. Thread a further washer (part 39) on to the screw and clamp tight with a nut (part 38). Thread the switch Arm (part 5) on to the screw and clamp with a further washer and nut. An Electrolinx (part 42) can be screwed on to the projecting thread of the screw.

(c) Key switch with back contact: Proceed as in (b) Fig. 7B and add the back contact as follows: -

Parts required:
(Part 4) Switch Arm "A"
(Part 40) 5/8 in. screw
(Part 38) Nuts
(Part 39) Washers
(Part 42) Electrolinx.

Assemble the switch arm "A" as in Fig. 7B. The assembly should be mounted at right angles to the switch arm "B" as shown in Fig. 8.

A contact screw should be mounted under the switch arm "B" so that when that arm is pressed down it breaks contact with arm "A" and touches the contact screw (Fig.8)

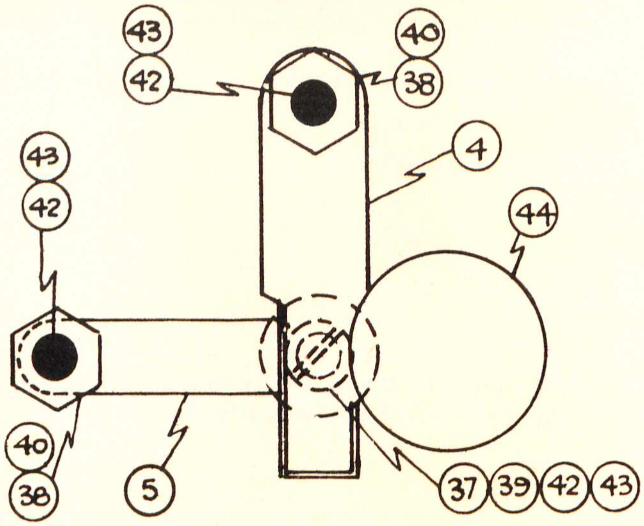
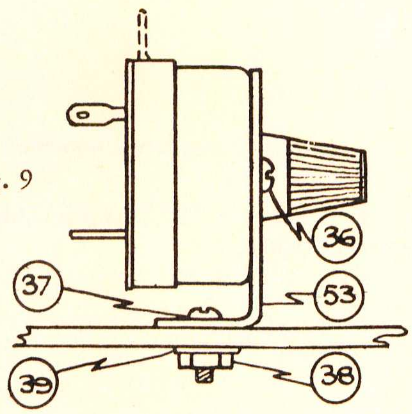


Fig. 8

Valve Holder Panels - These are mounted by inserting screws.

Potentiometers - The potentiometer is mounted with ¼ inch screws (part 36) on a bracket (part 53) which is bolted to the platform as shown in Fig. 9.

Fig. 9



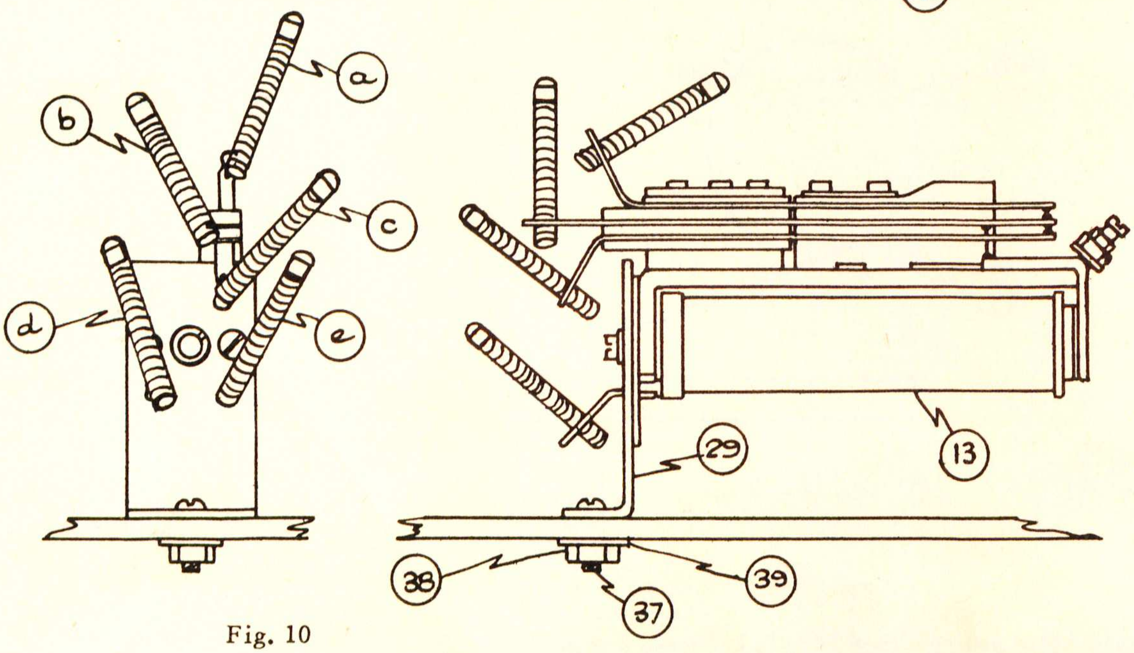


Fig. 10

Relay (part 13). The bracket (part 29) provided should be attached to the relay by means of the screws and insulated washers which are already on the relay. The bracket is fixed above the platform as in Fig. 10

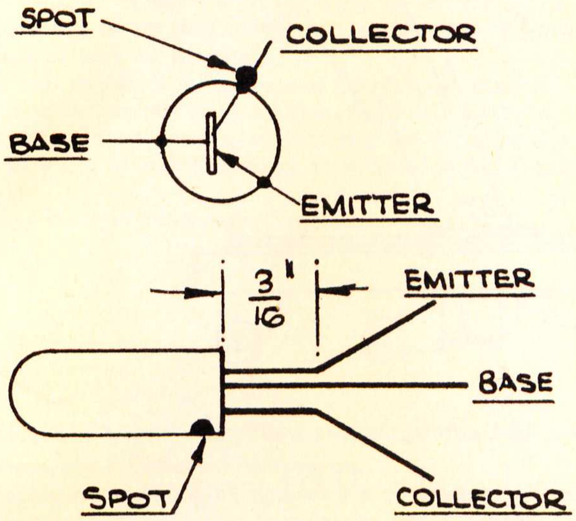


Fig. 11

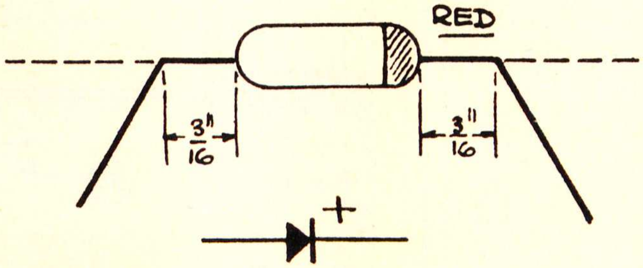


Fig. 12

Transistor This is a recent invention which functions in a similar manner to the more familiar triode valve. That is to say, will amplify a small signal and can be made to "oscillate". It is composed of three sections, made of material which is semi-conducting i.e. is neither a good insulator nor a good conductor. Each section is connected to a wire brought out at one end. These sections are known as "emitter", "base" and "connector". The form of the transistor is shown in Fig. 11 with symbol for use in diagrams.

Note that the wire nearest the coloured spot is to the collector, the centre wire is to the base and the remaining one is to the emitter. It is important to get this right as the transistor will only function correctly when properly connected in the circuit.

Wires are thin and care must be taken to avoid breaking them. The envelope is of thin glass, so should be handled with a reasonable degree of care. The transistor should not be connected directly across the battery terminals as this may damage it.

Crystal diode Fig. 12. This consists of two parts connected to wires which are brought out at either end. They correspond to the anode and cathode of the diode valve, the end coloured red being the cathode.

The diode will conduct electricity freely when connected anode to positive, cathode to negative but offers a very high resistance when the polarity is reversed. It will, therefore, rectify small alternating currents and is mainly used as a "demodulator" for extracting the audio components from a modulated radio frequency signal.

Loudspeaker This is of moving coil type with a permanent magnetic field. The AC reactance of the coil is 3 ohms. A bracket is provided for mounting the loudspeaker.

Wire-Ended Components These are suspended between Electrolinx by their integral wires which may have to be bent. Do not, however, bend the wires close up against the components but at least 3/16 inch away, as shown in Figs. 11 and 12, they will then be less liable to break, and with this aim in view it is suggested that having once bent the wires to a suitable angle further bending should be avoided as far as possible.

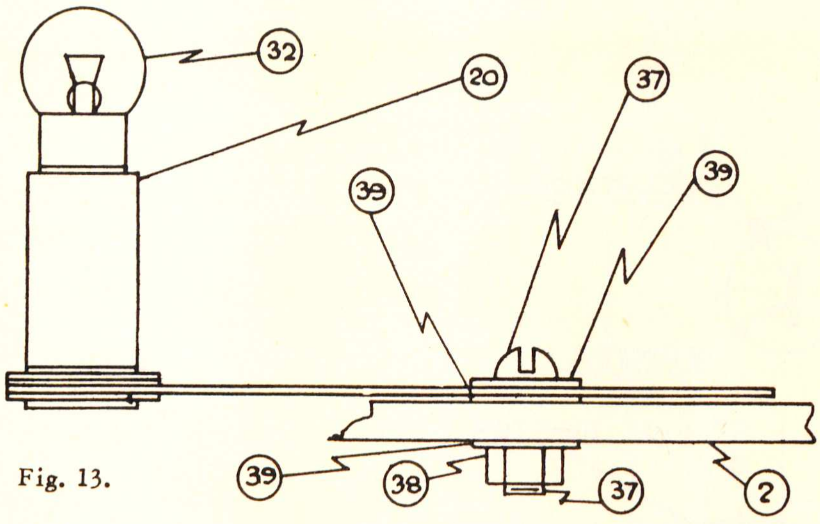


Fig. 13.

Lamp Holders are mounted by bolting them to the platform with a 4BA screw, nut and washer, as shown in Fig.13

The Buzzer Fig. 14. Basically this consists of a coil of wire (i), wound on a soft-iron yoke (ii), a soft-iron armature fixed to a flat spring (iii), and a pair of contacts (iv) and (vii) which, in the position of rest are touching together. To operate it, a battery of some four to six volts is connected to the upper contact and one end of coil, the other end of the coil being joined as shown to the lower contact. As soon as the battery is joined, current will flow around the coil causing the yoke (ii) to become magnetised. The armature (v) is attracted by the magnet and moves downwards, separating the two contacts (iv) and (vii) so that the flow of current is interrupted. With no current through the coil, the iron parts lose most of their magnetisation and the armature is returned by the spring until the contacts touch again. This cycle of events is repeated so rapidly that a buzzing sound is made by the vibrating armature. The mechanism is very similar to that of the more familiar electric bell, except that the armature of the latter is provided with an extension carrying a hammer for striking the gong.

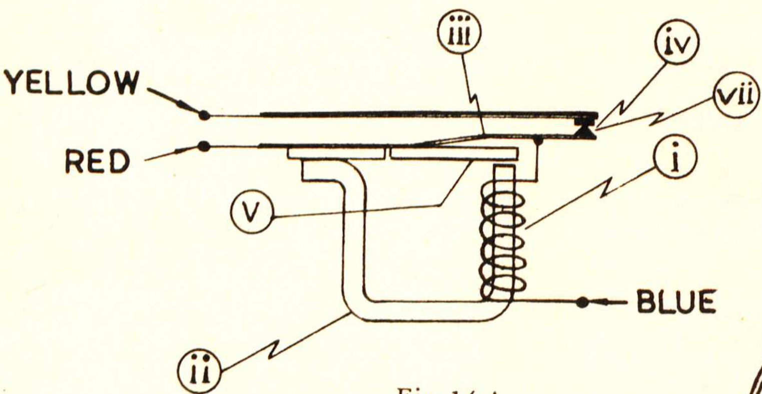


Fig 14 A

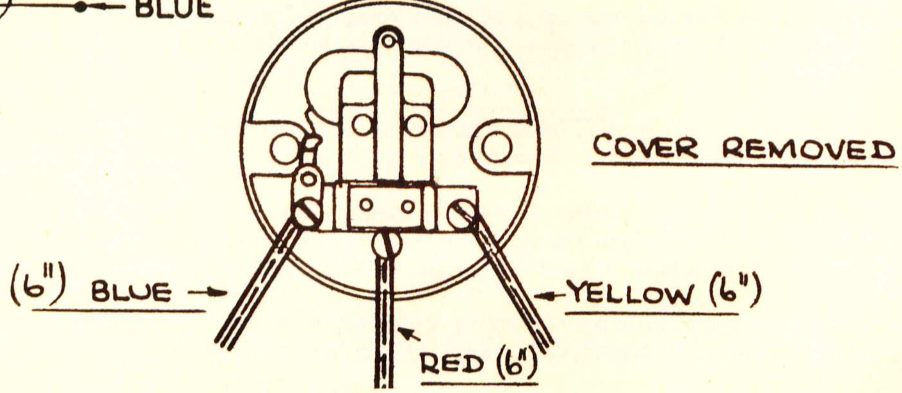


Fig. 14B

The buzzer is used in the experiments for morse signalling, for producing an interrupted DC voltage, which can be stepped up or down in a similar manner to AC, and as a signal source for testing.

The Transformer The basic form of a low frequency transformer consists of two coils wound on a closed iron core. This core is "laminated" or built up with a number of thin plates of iron to reduce the losses which would occur if a solid core were used.

The purpose of such a transformer is to step up or down the value of an alternating or varying voltage in accordance with the relative numbers of turns of wire on the coils.

The coil to which the source of power is connected is known as the "primary" and the output is taken from the "secondary".

The transformer supplied with the Mechtronics kit is wound with four sets of coils in order to make it adaptable for a number of different purposes.

It may be represented as Fig. 15

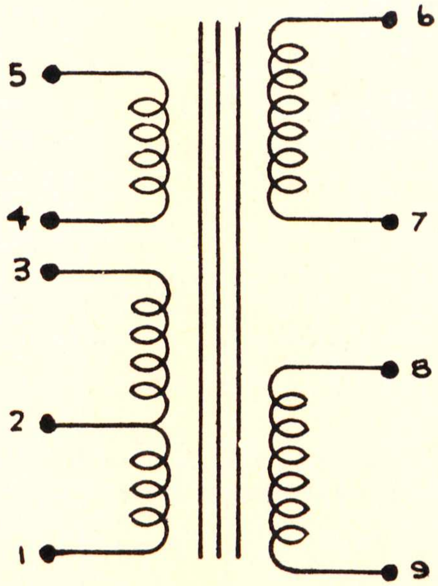


Fig. 15

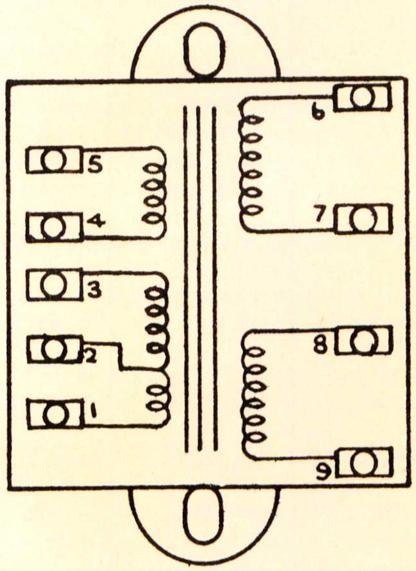


Fig. 16

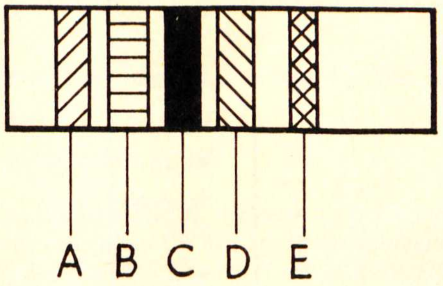


Fig. 17

These coils can be connected in a number of ways to give different ratios of output to output voltages. The ends of the windings are brought out to tags on an insulated panel and identified by numbers: See Fig. 16.

Batteries. These are not included in the set but for experiments 1-12 a 4½ volt bell battery Drydex No. 45 or a 120 volt high tension battery Drydex No. 120 are required. They are included in the list of spare and component parts at the end of this instruction booklet.

Board Layout Diagrams. Complete layout diagrams are included in these instructions for experiments 1-12 to enable the beginner to compare his arrangements of components with the correct layout. Where components are to be mounted or wires are to be led, below the board, they are indicated by dotted lines. For the more advanced quantitative experiments 13-22 the user will have become familiar with the methods of arrangement and no layout diagrams are supplied, in order to encourage the user to work from the circuit wiring diagrams.

Colour Code for Resistors. Two methods of marking have been adopted for miniature resistors of fixed values. These are known as the coloured band method and the body, tip and spot (or central band) method.

In the first, Fig.17 which is generally preferred, three, four or five bands of colours are marked round, and nearer one end of, the body of the resistor. When noted in order from this nearer end, the colours of the band signify, respectively, the first figure, the second figure, the multiplying factor, the tolerance on the value so indicated, and the grade of the resistor.

In the body, tip and spot Fig. 18A (or central band Fig. 18B) method the colours are noted in the order: body of resistor, end (tip) of resistor , spot (or band) midway along the body. The colours have the same significance as the bands in the other methods, and, where the tolerance is given, this appears as the colour of the second tip.

The following table gives the values of the colours.

Colour	First figure	Second figure	Multiplying factor	Tolerance	Grade
Silver	-	-	10^{-2}	± 10%	-
Gold	-	-	10^{-1}	± 5%	-
Black	-	0	1	-	-
Brown	1	1	10	-	-
Red	2	2	10^{2}	-	-
Orange	3	3	10^{3}	-	-
Yellow	4	4	10^{4}	-	-
Green	5	5	10^{5}	-	-
Blue	6	6	10^{6}	-	-
Violet	7	7	10^{7}	-	-
Grey	8	8	10^{8}	-	-
White	9	9	10^{9}	-	-
Salmon pink	-	-	-	-	Grade 1
None	-	-	-	± 20%	-

Figures 17, 18A and 18B, in which A is red, B violet, C blue, D gold and E salmon pink, show a resistor of 27 megohms ± 5%, Grade 1.

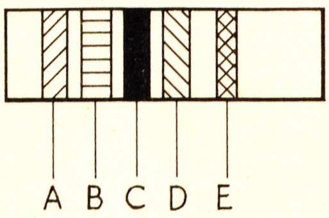


Fig. 17

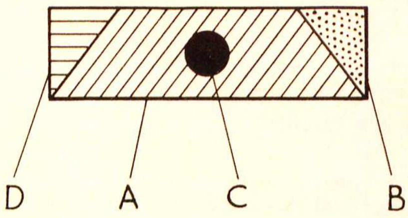


Fig. 18A

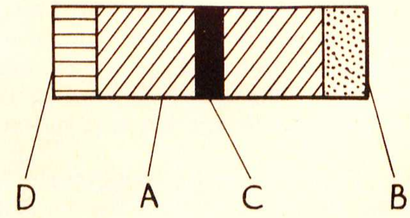
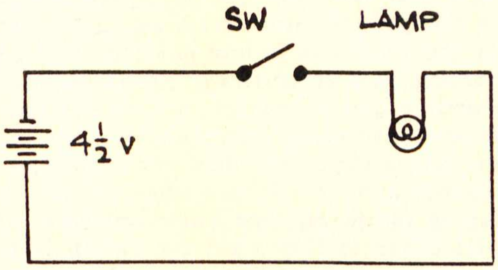


Fig. 18B

EXPERIMENT 1

Single lamp and switch



This simple experiment shows that electricity will only flow freely when the circuit is completed through suitable conductors, in this case the tinned copper wire, the lamp, and the switch. When the switch is in the "Off" position there is a break in the conducting circuit and the current ceases to flow, as shown by the extinguished bulb.

When an electric current flows through a conductor, heat is produced. The amount of heat produced depends on (i) the cross-sectional area of the conductor (ii) the material of the conductor (iii) the length of conductor (iv) the amount of current flowing. Items (i) (ii) and (iii) determine the "resistance" of the conductor.

The resistance of the connecting wire and the currents used in all of the experiments are very small and little heat is produced. The filament of the lamp, on the other hand, has a high resistance because the material and dimensions are specially chosen. Because of this, the filament becomes very hot and produces light.

Parts required:

1 each of Parts 2, 4, 20, 32, 38, 44
5 of Part 37,
11 of Part 39
6 of Part 42

a) Mount Electrolinx in positions 1D and 1H.

b) Mount switch parts and contacts (parts 4, 37, 39, 42, 44) in positions shown on board layout diagram. (See also Figs. 5B and 6 (page 3,4) for arrangement of parts).

(c) Before mounting the lamp holder (part 20) the two Electrolinx should be fitted (See also Fig. 4 Page 3). The lamp-holder should now be fitted in position shown on board layout diagram (See also Fig. 13 Page 7).

Having mounted the components, the wiring of the circuit can now be commenced.

(d) Unwrap the bare copper wire and carefully unroll, avoiding any kinks. Fasten one end of the wire to the Electrolinx in position 1D (See Fig. 3 Page 3). Keeping the wire straight, slip it between the coils of one of the Electrolinx of the lampholder. Cut the wires approximately ¼ in. longer than required, using the "BIB" tool (Part 19), Similarly, connect a piece of tinned copper wire between: -

(i) 9I and the other Electrolinx on the other side of lampholder.
(ii) 8I and 1H.

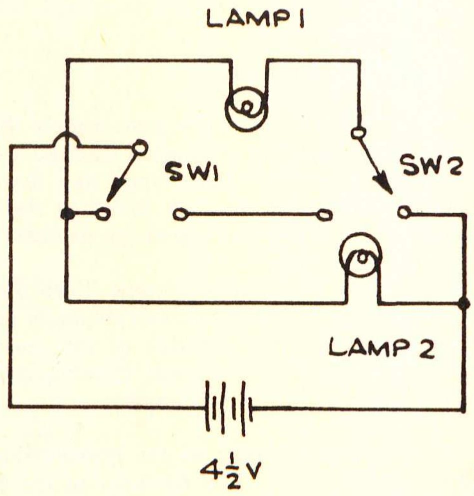
(e) The platform wiring is now complete and the lamp (part 32) may be screwed into the holder.

The last component to be connected is a 4½ V battery L82-597. It is essential before connecting the battery that the circuit is carefully checked and any mistakes corrected. This warning will apply to a greater extent when more elaborate circuits are made. To connect the battery into the circuit, connect a single covered wire from Electrolinx 1D to the negative terminal (-) of the battery. Each end will have to be stripped for approximately ½ in. and the BIB tool should be used. In a similar manner a second single covered wire should be connected between 1H and the positive terminal (+) of the battery.

The circuit may now be tested by moving the switch arm so that it makes contact with the switch contact. The lamp should glow. It is instructive to reverse the battery connections so that 1D is connected to the (+) terminal and 1H to the (-) terminal. Upon switching "ON", the lamp will still glow as brightly. This shows that the heating effect does not depend on which way the electric current flows.

EXPERIMENT 2

Verification of Ohms law



It was shown in Experiment (1) that an electric current is able to produce heat and light. That is to say, electrical energy supplied by the battery is changed into heat energy and light energy. The electrical energy supplied by the battery is in turn produced by chemical energy when a suitable conducting path is provided, but although an unconnected battery is unable to supply electrical energy, we can say that it is potentially able to do so as it is connected. A simple analogy can be taken. Consider a water tap. When the tap is turned on, then water will flow from the tap. In the same way an electric current will flow when the switch is turned on. When, however, the tap is turned off then water ceases to flow. Similarly the electric current will cease to flow when the switch is turned off. We know, however, that the water is under pressure and as soon as the tap is again turned on the water will flow. We say, therefore, that the water pressure is potentially able to produce a water flow. It should also be noted that the rate of water flow will depend on whether the tap is fully opened or only partially opened. We can say the rate at which it flows depends on the resistance which the water pressure has to overcome. If the tap is partially opened so that it has a resistance to the water flow, then the rate of water flowing will depend on the pressure, and alternatively if the pressure remains the same then the rate of water flowing will depend on how far the tap is opened.

Substituting electrical terms for the pressure, water flow and resistance, we can say that the rate at which electric current flows depends on the pressure which the battery has across its terminals and the resistance which is in the circuit. The pressure is measured in volts. The battery has a voltage across its terminals. The rate at which electric current flows is measured in amperes. The resistance which the current flow encounters is measured in ohms.

Since the rate at which electric current flows depends on resistance and on the voltage (pressure), there is a law which connects all these quantities. This law is called 'Ohms Law' after its discoverer. Mathematically expressed as follows:-

(i) $\frac{V}{I} = R$ (ii) $V = IR$ (iii) $I = \frac{V}{R}$

where V = voltage (volts)
I = current (amp)
R = resistance (ohms)

Expressed in words:-

If in any given conductor the voltage across its ends is compared with the current flowing through it, there is found to be a constant relationship between the voltage and the current, provided the temperature is constant. If the voltage is halved the current is halved and if the voltage is doubled the current is doubled. This constant is called the 'Resistance' and is measured in ohms.

The experiment is designed to show this law in a simple manner. In this case the voltage will remain constant and the relationship used will be (ii) above.

Parts required:

1 each of Parts 2, 38,
2 each of Parts 4, 20, 32, 44,
9 of Part 37,
19 of Part 39,
12 of Part 42

a) Mount Electrolinx in positions 1D and 1H.

b) Mount switch parts and contacts (part 4, 37, 39, 42, 44) in positions shown on board layout diagram . (See also Figs. 5B and 6 (page 3-4)

c) Mount two lampholders (part 20) in the position shown on diagram, fitting Electrolinx to the lampholder tags by the method shown in Fig. 4 (page 3).

d) Proceeding as in Experiment 1, connect with tinned copper wire as under:-

(i) 1D to right hand tag of upper lampholder.
(ii) Left hand tag of upper lampholder to corresponding tag of lower lampholder.
(iii) Right hand tag of lower lampholder to arm of right hand switch.
(iv) Right hand tag of upper lampholder through 12G to right hand switch upper contact.
(v) Left hand tag of lower lampholder through 7H to left hand switch upper contact.
(vi) Left hand switch arm to 1H.
(vii) Connect together the two lower switch contacts, passing the wire through 7J and 10J.
(viii) Connect 4½ volt battery L82-597 to 1D and 1H.

The experiment is in three sections:-

Section 1 - Left hand switch to contact at row H, right hand switch to contact at row J. This is the same as Experiment 1 where only one lamp is in circuit and it will glow brightly.

Section 2 - Both switches to contact at row J. This puts the two lamps in series and both lamps will glow dimly. The extra lamp acts as an additional resistance and diminishes the rate at which the current is flowing. Since there are now two lamps instead of one, the resistance has been doubled and from the relation(ii) above, this means that the current has been halved.

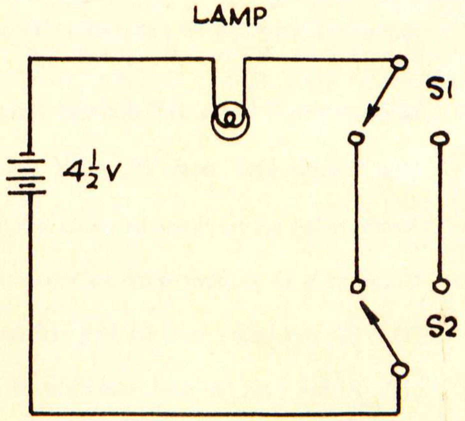
Section 3 - Both switches to contact at row H. In this part of the experiment the extra lamp is connected across or in parallel with the lamp used in Section 1. It will be noticed that both lamps glow brightly, therefore the current flowing through each lamp must be the same and equal to that which flowed through the single lamp in Section 1. This means that the total current is double that of Section 1 and the resistance is halved. When two equal resistances (lamps in this case) are joined in parallel, their combined resistance is half that of a single resistance.

EXPERIMENT 3

Controlling a light with two switches independently

This circuit illustrates how a light can be controlled from two positions independently, such as for instance a corridor lamp which can be switched 'On' at one end of the corridor, Off' at the other end, and vice versa.

Parts required:



1 each of Parts 2, 20, 32, 38,
2 each of Parts 4, 44,
9 of Part 37,
19 of Part 39,
10 of Part 42.

a) Mount Electrolinx in positions 1D, 1H.

b) Mount switch parts and contacts (Parts 4, 37, 38, 39, 42, 44) in positions shown on the board layout diagram. (See also Figs 5B and 6 page 3-4)

c) Mount the lamp holder (part 20) in the position shown on the board layout diagram. See also Figs. 4 (page 3) and 13 (page 7).

d) Proceeding as in Experiment 1, connect with tinned copper wire as under:-

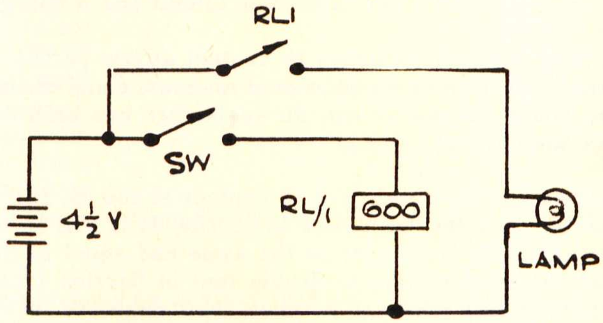
(i) 1D to one side of lampholder.
(ii) The other side of the lampholder to 7D.
(iii) 6E to 6I
(iv) 8E to 8I
(v) 7H to 1H, (using covered wire)

e) The platform wiring is now complete and the lamp (part 32) may now be screwed into the holder.

f) Connect a 4½v battery L82-597 as in Experiment 1.

The lamp can now be switched 'ON wnd OFF' with either switch, irrespective of the position of the other switch.

EXPERIMENT 4



Lamp switching with relay

Relays are frequently used to enable a comparatively large electrical power to be switched by a much smaller power. The relay will operate when the current through its coil is a few thousandths of an ampere. Its contacts can make and break a much heavier current of the order of 1 ampere.

Experiment 4 demonstrates this in a simple manner. The relay is a switch operated by means of an electro-magnet which is energised by about 7 milliamps from a 4½ volt battery. The contacts close and switch on the lamp which takes 40 milliamps.

The telegraph is an instance of the use of relay. Here a small current sent along lines from some distant station is used to operate a relay which switches on a local battery which has sufficient power to operate a sounder, or ring an alarm bell etc.

Parts required:

1 each of Parts 2, 4, 13, 20, 29, 32, 44
6 of Part 37.
2 of Part 38.
12 of Part 39.
10 of Part 42.

a) Mount Electrolinx in positions 1D and 1H.

b) Mount switch parts and contact (parts 4, 37, 39, 42, 44) in positions shown on board layout diagram.

c) Fix lampholder part 20, with two Electrolinx attached, by nut and bolt through hole 12I.

d) Mount relay on brackets in position shown on board layout diagram with four Electrolinx fitted.

e) Connect with copper wire as under:-

(i) 1D and relay coil (d Fig. 10 page 5)

(ii) Relay coil (d) and one side of lampholder.

(iii) Other side of lampholder and upper relay spring (a Fig. 10).

(iv) Centre relay spring (b Fig. 10) to switch contact at 6I passing wire through 7H.

(v) 6I to 1H bringing wire up through 5I.

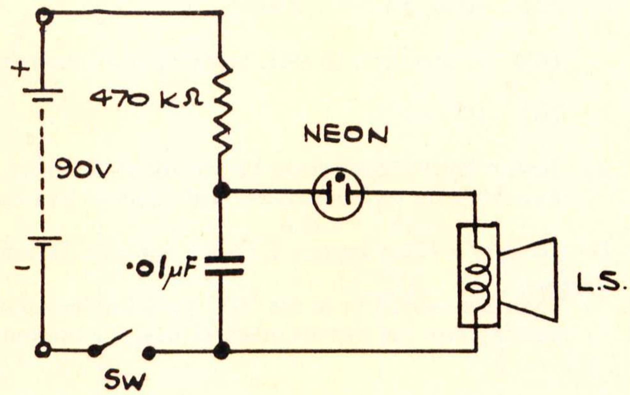
(vi) 6H (switch arm) to free end of relay coil (e Fig. 10).

f) Fit a lamp, part 32, in the lampholder and connect a 4½ volt battery L82-597 to 1D and 1H.

Operating the switch will now cause the relay to close its contacts which will in turn light the lamp. When the switch is opened, the relay is no longer energised and the lamp is extinguished.

EXPERIMENT 5

Use of a neon lamp as an oscillator



The neon lamp consists of two electrodes sealed in a glass envelope containing neon gas at reduced pressure. It behaves as a very high resistance until the voltage across the electrodes reaches such a value that the neon gas ceases to be an insulator and becomes a conductor, i.e. the gas becomes 'ionised' and the neon strikes (about 65 volts). When striking occurs, the resistance becomes very low. It is for this reason that the neon lamp should never be connected to a high voltage source without a resistance in series with it to limit the current. This resistance should be chosen so that not more than 1 milliamp passes through the lamp.

A capacitor consists basically of two conducting plates separated by a non-conductor. It has the property of 'storing' electricity. The amount of electricity stored depends on four factors:-

(i) The area of the conducting plates.

(ii) The material of the non-conductor.

(iii) The distance between the conducting plates.

(iv) The voltage applied.

When a capacitor is connected across a voltage source it becomes 'charged', i.e. it stores electricity. If now the battery is removed the stored electricity will remain in the capacitor. To remove the stored electricity it is necessary to discharge the capacitor. This can be accomplished by connecting a resistance across the capacitor which dissipates the stored electricity.

In the following experiment a capacitor is charged from a battery through a high resistance. The high resistance will slow down the storing of electricity in the capacitor and the higher the value of the resistance or the value of capacitor, the slower this 'charging' becomes. When a neon lamp is connected across the capacitor and the voltage across the capacitor reaches the striking voltage of the neon lamp, it will discharge the capacitor, since the neon lamp acts as a low resistance. As soon as the voltage across the capacitor has dropped sufficiently so that the neon no longer glows, the discharge will stop and the capacitor will start to re-charge. In this way the capacitor is automatically charged and discharged and a simple form of 'oscillator' can be constructed. By varying the values of the series resistance or the capacitor the repetition rates of the oscillator can be altered. This is called changing the 'frequency' of oscillation. The oscillations can be heard in the loudspeaker. A higher pitch shows that the frequency is higher.

Parts required:

1 each of Parts 2, 4, 16, 31, 41, 44, 219, 230

11 each of Parts 37, 42.

2 of Part 38,

20 of Part 39

a) Fit Electrolinx in positions 1D, 1H, 10D, 10F, 10H, 12F, 12H.

b) Mount switch and contact (parts 4, 37, 39, 42 and 44) in positions shown on board layout diagram. See also Figs. 5B and 6 (pages 3, 4).

c) Suspend the 470,000 ohm resistance (part 219) between 10D and 10F.
Suspend the 0.01 μF capacitor (part 230) between 10F and 12H.
Suspend the neon lamp (part 31) between 10F and 12F.

d) Connect with copper wire as under:-

(i) 1D to 10D

(ii) 1H to 6H (switch arm)

(iii) 6I (contact) to 10H, bringing wire through 7I

(iv) 10I to 12I.

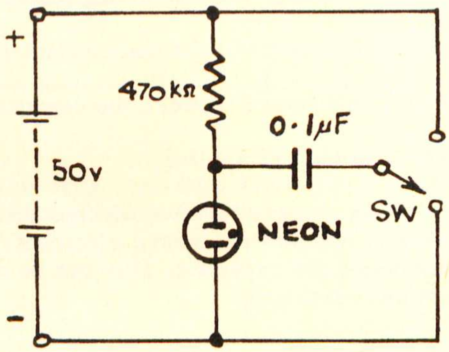
e) Mount loudspeaker (part 16) on its stand (part 41) with 4 BA screws, nuts and washers. Connect two lengths of covered wire to loudspeaker and connect free ends to 12F and 12H.

f) Connect a 120 v battery L82-605 between 1D and 1H, using the 108 v tapping.

When the switch is in the 'ON' position the neon lamp will flash on and off. Repetition rate can be varied by connecting into the circuit other values of resistances and capacitors.

EXPERIMENT 6

Voltage doubling circuit



This experiment shows how the voltage across a charged capacitor can be added to that of a battery.

The battery voltage applied to the circuit is insufficient to cause the neon to strike, but must not be less than half the striking voltage.

The capacitor is charged through the high resistance when the key is depressed. Since the neon does not strike, no current flows in this part of the circuit. When the key is released, the negative side of the capacitor is joined to the positive of the battery and since the resistance is high, the charge on the capacitor will only leak away slowly in this part of the circuit, but now the neon has a battery voltage plus the capacitor voltage across it, causing it to strike and thereby discharging the capacitor, In a later circuit it will be demonstrated that an alternating voltage can be used instead of a switch, to give continuously an AC output which is nearly double that of the input voltage.

Parts required:

1 each of Parts 2, 4, 5, 31, 44, 219, 229,
6 of Part 37,
2 each of Parts 38, 40,
16 of Part 39,
8 of Part 42.

a) Fit Electrolinx in positions 1D, 1H, 6D, 6F, 6H,

b) Mount key switch with back contact, as in Fig. 8 (page 5) in the position shown on board layout diagram.

c) Suspend the 470,000 ohm resistance (part 219) between 6D, 6F.
Suspend the 0.1 μ F capacitor (part 229) between 6F and switch (9F).
Suspend neon lamp (part 31) between 6F and 6H.

d) Connect with copper wire as under:-

(i) 1D to 6D

(ii) 6D to 10E (switch)

(iii) 10F (Contact) to 6H, bringing wire out through 9G

(iv) 6H to 1H.

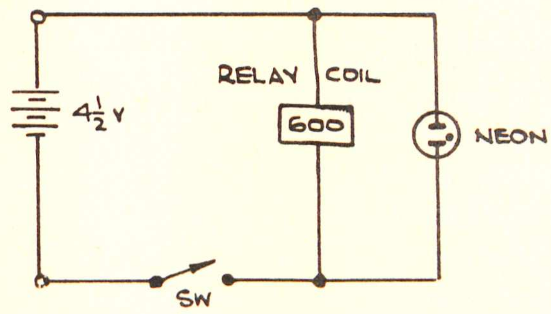
e) Connect a high tension battery L82-605 using the 60 V tapping between 1D and 1H.

On depressing the key the condenser will be charged. When the key is released the neon will be observed to flash. The process can be repeated as often as desired.

EXPERIMENT 7

Production of high voltage on breaking an Inductive circuit

In this experiment the coil of the relay is used. The relay can be considered to consist of three parts.



Part 1 - the electro-magnet. This consists of a large number of turns of wire wound upon an iron core. When a current is passed through the winding, the iron core becomes magnetised, and behaves in a similar manner to a permanent bar magnet.

Part 2 - the armature. This consists of an L-shaped piece of iron which is pivoted about its angle. When the core becomes magnetised it attracts the armature which moves towards the core, and because it is pivoted, raises the contacts.

Part 3 - the contacts. These are actuated by the armature and enable other electrical circuits to be switched. Thus by switching the relay coil (one circuit) a number of other circuits can be controlled.

The creation of the magnetism in the core is not instantaneous, but is retarded by the fact that any change in the magnetism induces a voltage in the coil which opposes that of the battery. Eventually a steady state is reached when the opposing voltage falls to zero and the full battery voltage is applied. The magnitude of the opposing voltage (induced voltage) depends on how rapidly the magnetism in the core is changing. If now the battery is disconnected, the magnetism will rapidly vanish, and in doing so will induce a high voltage across the ends of the coil. This is shown in the following Experiment.

Parts required:

1 each of Parts 2, 4, 13, 29, 31, 38, 44,
5 of Part 37,
13 of Part 39,
6 of Part 42

a) Mount Electrolinx in positions 1D and 1H,

b) Mount switch and contact (parts 4, 37, 39, 42 and 44) in position shown on the board layout diagram. See also Figs. 5B and 6 (pages 3, 4).

c) Mount relay (part 13) and bracket (part 29) in the position shown on board layout diagram. (See also Fig. 10 page 5). Mount two Electrolinx to the relay lugs (d) and (e) as shown in Fig. 10 (page 5).

d) Connect with copper wire as under:-

(i) 1 D to relay Electrolinx (d) see Fig. 10

(ii) Relay Electrolinx (e) Fig. 10, to 6I, passing through 7H

(iii) 6H to 1H.

e) Suspend neon lamp (part 31) between the relay Electrolinx.

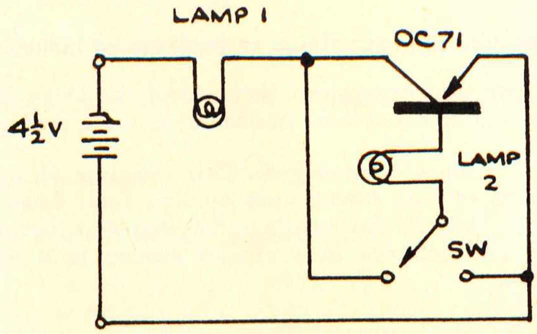
f) Connect a 4½ V battery L82-597 between 1D and 1H.

On 'making' the switch, no glow from the neon will be observed because the voltage cannot rise above that of the battery. Immediately the switch is 'OPENED' a flash will be observed from the neon. The neon lamp supplied requires a minimum of 65 volts to enable it to light (or strike) and it is obvious that the induced voltage across the coil must reach this value. The high voltage 'induced' across the coil when the circuit is broken accounts for the sparking which is often observed across switch contacts.

EXPERIMENT 8

Action of Transistor

This experiment demonstrates in a simple way how an electric current flowing between emitter and collector may be controlled by a much smaller current through the base electrode.



Parts required:

1 each of Parts 2, 4, 26, 44,

2 each of Parts 20, 32, 38,

10 of Part 37,

22 of Part 39,

12 of Part 42.

Procedure

a) Fit Electrolinx in positions 1D, 1H, 7E, 7F, 7G.

b) Mount switch and contacts (parts 4, 37, 39, 42 and 44) in position shown on the board layout diagram. See also Figs. 5B and 6 (pages 3, 4).

c) Suspend transistor (part 26) as shown on the board layout being careful to join the collector electrode (spot) to 7E

d) Mount lampholders (part 20) at 6C and at 6J. Electrolinx connectors should be fitted to lampholders before mounting.

e) Connect with copper wire as under:-

(i) 1D and one lampholder Electrolinx at 6C.

(ii) The other lampholder Electrolinx at 6C and 7E.

(iii) 7E and 4E, bringing wire up through 5E.

(iv) 3F and one lampholder Electrolinx at 6J.

(v) The other lampholder Electrolinx at 6J and 7F, using covered wire.

(vi) 7G and 4G bringing wire up through 5G.

(vii) 1H and 7G, using covered wire.

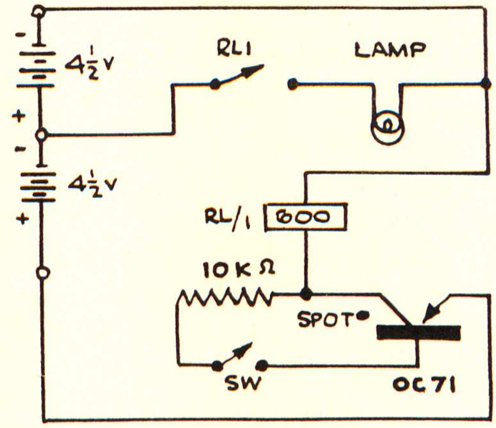
f) Join 4½ v battery L82-597 terminals (+) to 1H and (-) to 1D.

Setting switch to contact 4E the 'collector' lamp (6C) will glow, indicating that a current flows from the battery through the emitter to the collector of the transistor and back to the battery. Swinging the switch arm to 4G will extinguish the lamp. In the first case the base is connected to the negative side of the battery through the base lamp (6J). It should be noted that this lamp does not glow, showing that the current through the base is considerably less than that flowing from emitter to collector. Used in this way a small current through the base controls a much larger current from emitter to collector, i.e. the transistor behaves as a current amplifier. When the switch is connected to 4G the base is connected to the positive side of the battery through the base lamp and no current flows through the transistor. In general use, the base is connected to a point more negative than the emitter, as it is when the switch arm is at 4E.

EXPERIMENT 9

A) Transistor-operated relay

B) Transistor as a photo cell



A) In this experiment a change in current between emitter and collector when the base current is changed is used to operate a relay. The contacts on the relay are used to light a lamp.

B) In this part of the experiment the photo-cell action of the transistor is utilised by bringing a light source near to the transistor.

Parts required:

1 each of Parts 2, 5, 13, 20, 26, 29, 32, 40, 44, 223,
10 of Part 37,
2 each of Part 38,
21 of Part 39,
16 of Part 42.

a) Fit Electrolinx in positions 1D, 1H, 1F, 6B, 6C, 6F, 6G and 6H.

b) Mount key switch and contact in positions shown on board layout diagram. See also Figs 6 (page 4) and 7B (page 4).

c) Mount relay in position shown (9F) (See also Fig 10, page 5).

d) Suspend transistor (part 26) in position shown on board layout diagram taking care that the collector (spot) is joined at position 6F. Suspend the 10,000 ohm resistance (part 223) between 4F and 6F.

e) Fit lampholder with 9 in. lengths of covered flex wire, joining the free ends to positions 6B, 6C. Insert lamp in lampholder.

f) Connect with copper wire as under:-

(i) 1D to 6B.

(ii) 6C to relay contact (a Fig. 10, page 5)

(iii) Other relay contact (b Fig. 10) to 1F, using covered wire.

(iv) 1D to relay coil (d Fig. 10)

(v) Other side of relay coil (e Fig. 10) to 6F.

(vi) 1H to 6H.

(vii) 6G to 4G, passing wire through 5G.

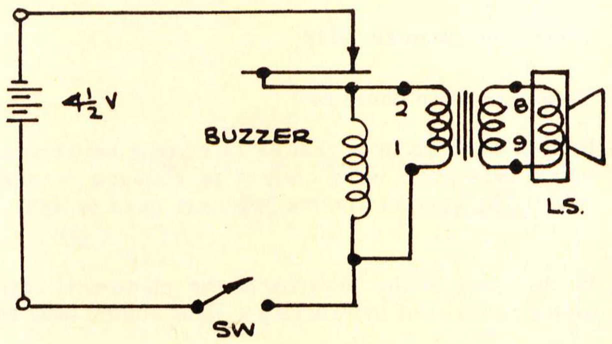
g) In this experiment two 4½ volt batteries L82-597 must be used and must be connected one between 1F and 1D with (+) at 1F, the other between 1F and 1H with (-) at 1F.

A) When the key is depressed a small current is fed to the base of the transistor, thereby causing a larger current to flow from emitter to collector. This current must pass through the relay coil, causing the relay to operate and a lamp to light. When the key is released the relay contacts will open and the lamp goes out.

B) Hold the lamp very closs (¼ in.) to the transistor and depress the key. On releasing the key the lamp will remain alight, showing that current is still passing through the transistor and relay. This condition will persist so long as sufficient light falls on the transistor. If the light is interrupted or diminished the relay will open and the light goes out.

EXPERIMENT 10

Buzzer with key and loudspeaker



This experiment shows how the buzzer can be used to interrupt periodically the DC current which can be used to operate a loudspeaker. If desired, the loudspeaker wires may be extended so as to send messages over a short distance using the morse code. For this circuit the transformer must be used.

Parts required:

1 each of Parts 2, 5, 8, 15, 16, 40, 44,
10 of Part 37,
3 of Part 38,
20 of Part 39,
11 of Part 42.

a) Fit Electrolinx in positions 1D, 1H, 8E, 10F, 10G, 11F, 11H.

b) Mount key switch and contact in position shown on board layout diagram. See also Figs. 6 and 7B (page 4).

c) Mount buzzer in position shown on board layout diagram. See also Fig. 14 (page 7).

d) Connect with copper wire as under: -

(i) 1D to 8E.

(ii) 10F to 11F.

(iii) 10G to 11H.

(iv) 10G to 7H (switch).

(v) 1H to 7I (contact).

e) Join yellow covered wire from buzzer to 8E.
Join blue covered wire from buzzer to 10G.
Join red covered wire from buzzer to 10F.

f) Mount transformer in position shown on board layout diagram. Connect 11F and (2) on transformer with copper wire. Connect 11H and (1) on transformer with copper wire.

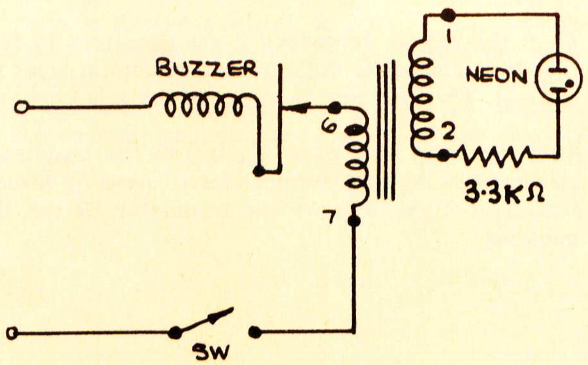
g) Connect covered leads to the loudspeaker and join to numbers (8) (9) on transformer.

h) Connect a 4½ v battery L82-597 between 1D and 1H.

By using a loudspeaker, messages may be sent over quite a distance, 20 yards or more, using the morse code, whilst the operator can hear the buzzer.

EXPERIMENT 11

A high AC voltage from a low DC voltage



A transformer is used to 'step up' the periodic interrupted DC voltage produced by the buzzer. The neon lamp is used to indicate that a high voltage has been obtained.

Parts required:

1 each of Parts 2, 5, 8, 15, 31, 40, 44, 224,
10 of Part 37,
3 of Part 38,
20 of Part 39,
14 of Part 42.

The construction follows that of Experiment 10, with the exception that the transformer should be turned round and the red lead of the buzzer is not required.

a) Connect with copper wire as under:-

(i) 1D and 8E.

(ii) 1H and 7I, bringing wire through 6I.

(iii) 7H and 11H.

(iv) 11H to (6) on the transformer.

(v) (7) on transformer to 10G.

b) Suspend the neon lamp (part 31) between (1) and (4) on transformer.
Suspend the 3,300 ohm resistance (part 224) between (4) and (2) on transformer

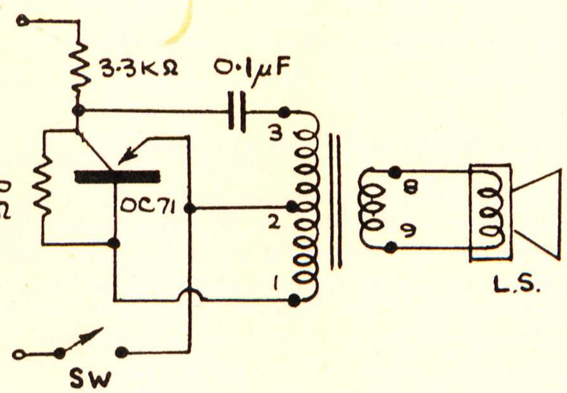
c) Connect a 4½ v battery L82-597 between 1D and 1H.

Upon operating the key switch the primary of the transformer is connected intermittently to the DC supply through the buzzer contacts. The transformer ' steps up' the pulsating voltage to above that which is needed to 'strike' the neon (65 V), which will therefore glow. A series resistance is required in order to limit the current through the neon lamp to a safe value.

EXPERIMENT 12

Transistor Oscillator

In experiment 8 it was shown that a transistor could be used as an amplifier. By using the transistor in this way but feeding some of the output back into the input it is possible to make an oscillator, i.e. the output voltage continually fluctuates about a mean value at a frequency determined by the component values.



Parts required:

1 each of Parts 2, 5, 8, 16, 26, 40, 44, 220, 224, 229,
9 of Part 37,
3 of Part 38,
18 of Part 39,
10 of Part 42.

a) Fit Electrolinx in positions 1D, 1H, 10E, 10F, 10G and 10C.

b) Mount switch key and contacts in position shown on board layout diagram.
See also Figs. 6 and 7B (page 4).

c) Mount transformer (part 8) in position shown on board layout diagram.

d) Suspend 3,300 ohm resistance (part 224) between 10C and 10E.
Suspend 220,000 ohm resistance (part 220) between 10E and 10F.
Suspend transistor (part 26) between 10E, 10F, 10G, taking care that the collector (spot) is joined to 10E.
Suspend the 0.1 μ F capacitor (part 229) between 10E and (3) on the transformer.

e) Join with copper wire as under:-

(i) 1D and 10C.

(ii) 1H and 6H (key).

(iii) 6I (contact) and 10G, bringing wire through 7I.

(iv) 10G and (2) on the transformer.

(v) 10F and (1) on the transformer using covered wire.

f) Join the loudspeaker with covered leads to (8) and (9) on the transformer.

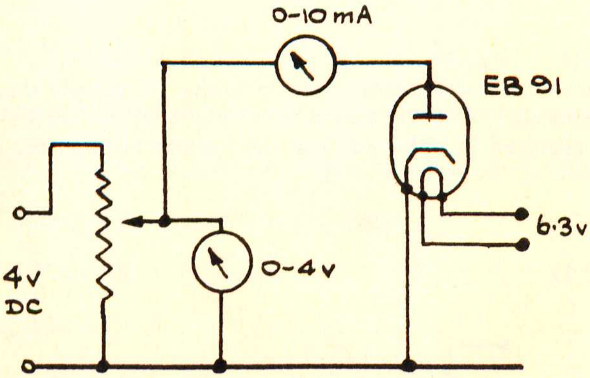
g) Connect two 4½ v batteries L82-597 between 1D (-) and 1H (+).

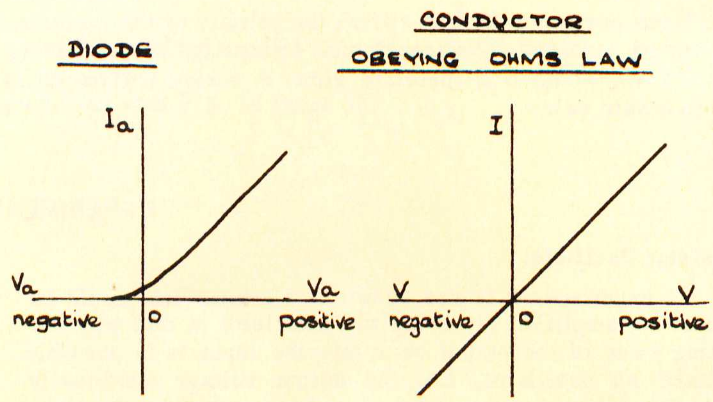
When the key is depressed a note will be heard in the loudspeaker.

The frequency of the note can be varied by altering some of the component values 220,000 ohm to 100,000 ohm and 0.1 microfarad to 0.01 microfarad.

NOTE: - In experiments 13 - 22 use is made of the Griffin-Clarkesmith electronic instrument series L97-150-L97-160. Separate instruction sheets are supplied with these instruments, and should be studied before experiments 13-22 are attempted.

EXPERIMENT 13





To plot the characteristics of a diode

Set up the diode valve panel (part 7) on platform and connect the two heater terminals to a 6.3 volt supply. The valve supplied (EB 91 part 25) contains two diodes in the same envelope. One cathode and the corresponding anode may be left unconnected for this experiment. Connect the other cathode to the negative pole of a DC source, the voltage of which can be varied from zero to about four volts. Join a voltmeter having a resistance not less than 100 ohms/volt across this source so that the voltage can be set up in small steps. Join the positive pole to the diode anode through a milliammeter with a range of 0 to 10 milliamp.

With the anode voltage (V_a) set to zero, switch on the power supplies and allow half a minute or more to elapse for the cathode to heat up. Take a reading of the anode current (I_a). Even though the anode voltage is zero there will be a small current reading caused by the drift of electrons to the anode. Now increase the anode voltage in as small steps as pssible (say 0.25V) noting with each increase the milliammeter reading. Continue taking readings until the current reaches 9 milliamp, which is the maximum the valve can safely pass continuously without damage.

Complete the experiment by reversing the polarity of the anode supply and proceed as before from zero volts. It will be found that a very small voltage increase will completely cut off the current and further increments will have no effect.

Plot these results on squared paper with volts along the horizontal axis and current on vertical axis. Draw a smooth curve through the points plotted.

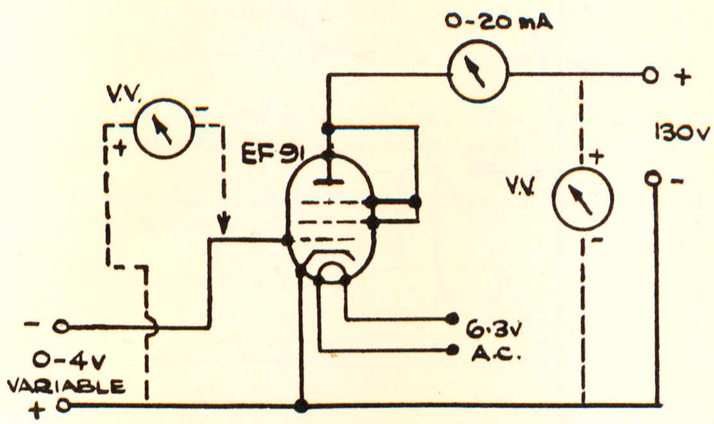
Conclusions

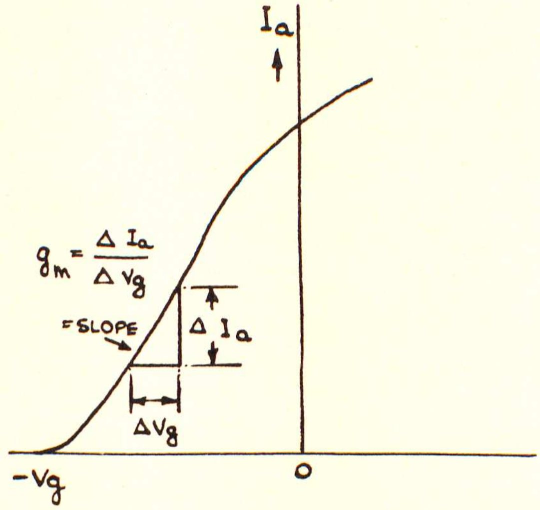
1) The current rises slowly at first from a slightly negative potential and then more rapidly. The anode to cathode path therefore does not conform to Ohms Law and thus cannot be regarded as a pure resistance. (See diagrams).

2) Current will hardly flow at all unless the anode is made positive with respect to the cathode. This is because the anode, when it is negative, repels back the (negative) electrons emitted from the cathode. The small current which flows when the anode is at zero volts, or is only slightly negative, is due to the electrons being shot out of the hot cathode at such speed that the repulsion is too weak to prevent these from reaching the anode.

The fact that hardly any current will flow through the valve until the anode is made positive, is made use of in converting alternating to direct current (rectification).

EXPERIMENT 14





Mutual conductance of triode

Set up the pentode valve panel (part 6) on the platform and connect up as in circuit diagram. The pentode valve supplied (EF 91 part 24) is converted to a triode by connecting the anode, screen and suppressor together to form a single anode so that the valve now consists effectively of a cathode emitting the electrons, a control grid controlling their flow and an anode collecting them. Using valve voltmeter, L97-160 for this experiment the power feeds at the rear of the instrument supply the valve, and the voltmeter may be used to measure either the grid voltage (V_g) or anode voltage (V_a).

Connect the valve heater to the AC and E screw terminals at the back of the instrument, setting the 'AC volts' control to MAX.

Connect the HT 1 screw terminal to anode through a 0 - 20, milliammeter and the negative screw terminal to grid, setting the 'Volts - E' (bias) control to MAX.

Connect E screw terminal and the C socket at front of instrument to valve cathode.

Set the front range switch to V x 25, the front hand switch to DC and connect a wire from the DC socket to valve anode.

Plug the EF 91 valve (part 24) into the valve socket and switch on power. Allow time to warm up and adjust anode volts to 130 with the HT1 control. Adjust bias control until milliammeter just shows a reading. Readjust anode volts if necessary and transfer voltmeter to read voltage between grid and cathode (V_g). Read off V_g on meter 0 - 10 range (V x 1). Note anode current (I_a) and (V_g).

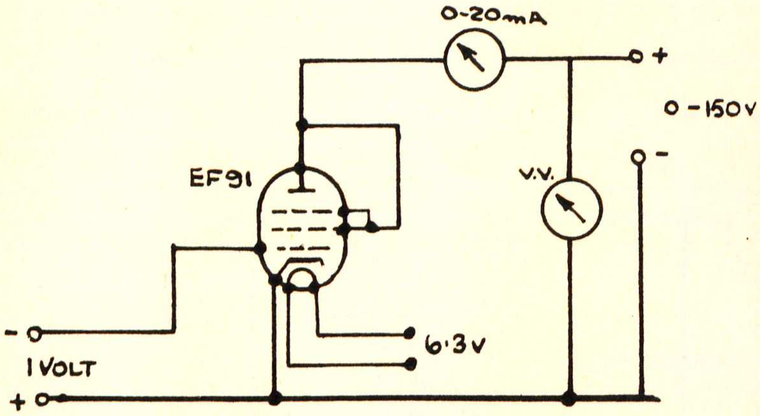
Reduce V_g in half volt steps, noting the anode current (I_a) at each step, keeping the anode voltage (V_a) constant at 130 v. It will be found that I_a increases as V_g decreases and the process should be stopped if I_a reaches 20 milli-amps. Then plot the results as a graph. If time allows, plot further curves keeping V_a constant at say 110v, 90v. etc.

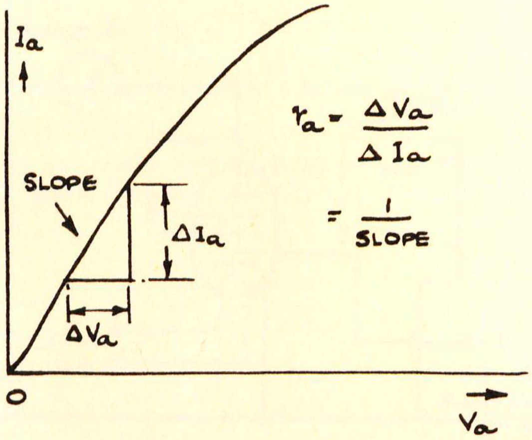
Determine the mutual conductance (g_m) of the valve at any value of grid bias from the graph by noting the change of the anode current resulting from a small change of grid bias around the chosen value.

$$\text{Mutual Conductance} = \frac{\text{Change of anode current}}{\text{Change of grid bias}}$$

$$\text{i.e.} \quad g_m = \frac{I_a}{V_g}$$

EXPERIMENT 15





Anode characteristic of a triode

Using the same arrangement as for the previous experiment, switch on the power and adjust the negative grid bias V_g to one volt. This is to remain constant throughout the experiment.

Set the anode volts to minimum and read anode volts and current from the meters. Increase the anode supply in (say) ten volt steps up to maximum, noting current in each case.

Repeat with different values of grid bias and draw a curve of anode current against anode voltage for each value of grid potential.

From the figures so obtained one can deduce the 'anode characteristic' (sometimes called 'AC resistance') by dividing a small change of anode volts by corresponding change of anode current.

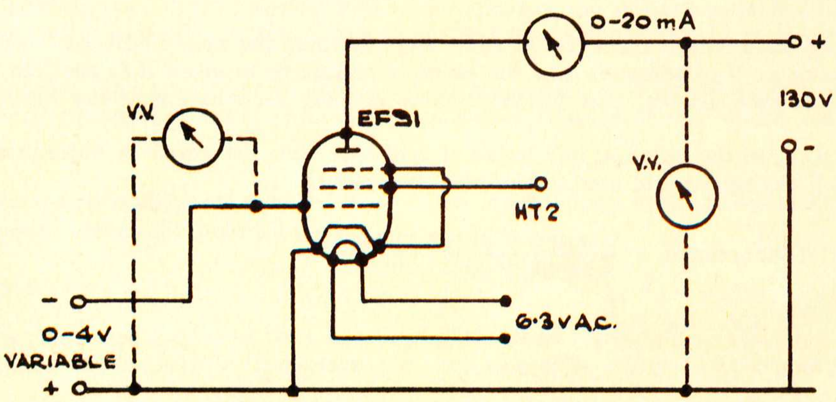
$$r_a = \frac{V_a}{I_a} \quad (I_a \text{ expressed as fraction of an ampere})$$

By combining the results of this experiment with the previous one the 'voltage amplification factor' (μ) may be calculated from:-

amp factor = AC resistance x mutual conductance.

$$\mu = V_a \times g_m$$

EXPERIMENT 16



SEE CURVE IN EXPERIMENT 14

Mutual conductance of pentode

Use the same appartus as for the two previous experiments, the connections to the valve panel being modified so as to use the EF. 91 valve (part 24) as a pentode. This is effected by disconnecting the screen grid from the anode and joining it to HT 2 at the back of the valve voltmeter. Also join suppressor grid (g3) direct to cathode.

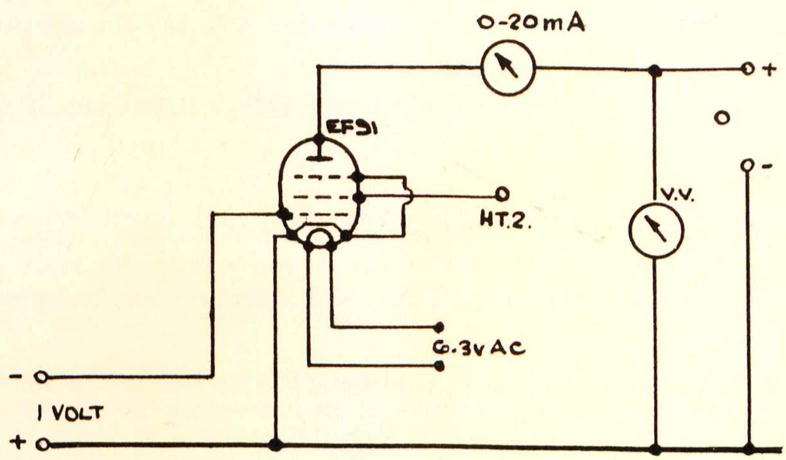
Switch on power unit, adjust negative grid volts to MAX and both HT 1 and HT 2 to 130 volts.

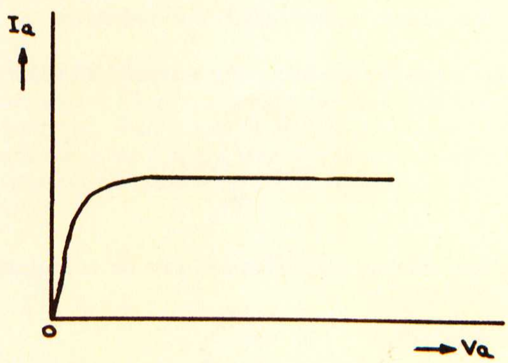
Adjust the grid volts in steps as was done with the triode (Experiment No. 14) noting the anode current for each step and from the results draw graph of I_a and V_g. Calculate the mutual conductance from the formula $g_m = \frac{I_a}{V_g}$. It will be noted that for the same valve the g_m when used as triode is somewhat greater than when pentode connected.

Repeat the above with screen volts reduced to 100 V and again with 50 V maintaining the anode at 130 V. Curves should be drawn on the same paper as the original curve to show the effect of varying the screen voltage.

Note. It is essential to check and adjust the anode volts with each change of grid volts as the voltage will drop as the current is increased.

EXPERIMENT 17





Anode characteristics (pentode)

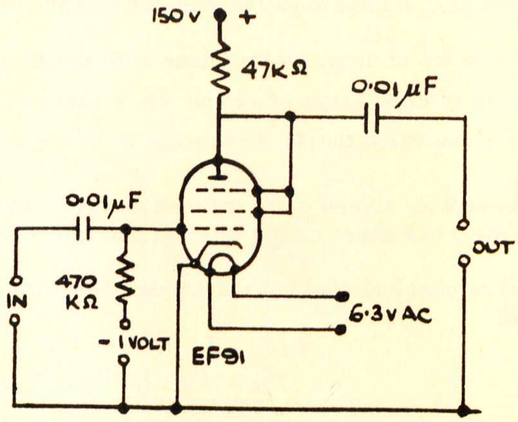
With the same circuit arrangements as in experiment 16 set the grid bias to -1, the screen voltage to 130V. and the anode voltage to minimum. Read anode volts and anode current.

Increase anode volts in 10 volt steps, noting current in each case and maintaining screen and grid volts constant.

Repeat above with grid volts - 1.5 V and again with - 2.0 V. Plot graphs of I_a against V_a. Compare with I_a/V_a curves of triode.

The pentode curve rises rapidly as the anode volts are increased from zero to 100, but above that voltage the curve flattens out. This means that over the working part of the curve the resistance of a pentode is very high.

EXPERIMENT 18



The triode as a voltage amplifier

Mount the pentode valve panel (part 6) on the base board and join anode to screen grid and suppressor grid in order to use the valve EF.91 (part 24) as a triode. Fit Electrolinx to the base board in convenient positions so that the resistors and capacitors can be connected as shown in the circuit diagram.

Using the valve voltmeter L97-160 connect the valve heaters to A.C. and E screw terminals, setting the A.C. volts control to MAX.

Connect the free end of the 47,000 ohm anode resistor (part 222) to H.T.1, setting the H.T.1 control to MAX.

Connect E to valve cathode.

Connect - VE to free end of the 470,000 ohm grid resistor (part 219). Switch on power and adjust - VE to 1.0 volt using the valve voltmeter Vxl D.C. range.

Set the voltmeter to A.C. 10 volts (V x 1) and join the black socket to cathode and the A.C. red socket to free end of the anode capacitor.

Connect the A.F. output of the signal source L97-155 to the points marked "IN" on the circuit diagram, using the screened cable provided making sure to join the cable screen to the cathode and the central wire to the grid capacitor.

Plug valve EF 91 (part 24) in socket.

Set up the signal source to 1000 cycles per second and switch on the power supply to this instrument. When the valves have thoroughly warmed up adjust the input signal until the voltmeter on the valve anode reads 10 volts.

Deduce the amplification or gain of the stage by dividing the output (10 volts) by the input volts shown by the settingof the signal source controls.

$$a = \frac{V_{out}}{V_{in}}$$

If the valve characteristics are known, the voltage amplification can be calculated from the formula:

$$a = \frac{\mu R}{r + R}$$

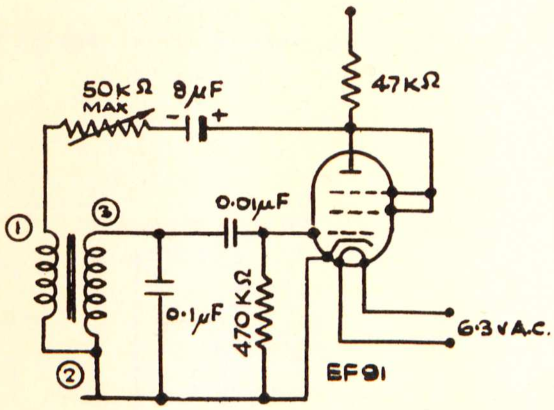
Where a = amplification
μ = amplification factor of the valve
R = external resistance in anode circuit
r = anode a.c. resistance of valve

From the EF 91 (part 24) in triode connection, μ = 60 and r = 7000 ohms

$$\therefore \quad a = \frac{60 \times 47000}{7000 + 47000} = \frac{60 \times 47}{54} = 52 \text{ approx.}$$

Repeat the experiment with anode resistors of 220,000 ohms (part 220) and 100,000 ohms (part 221) and note the effect on the gain.

EXPERIMENT 19



Triode oscillator

Experiment 18 has shown how the triode can be used as a voltage amplifier, i.e. a small A.C. voltage applied to the grid produces a much larger voltage at the anode. If, instead of connecting a signal source to the grid, we use a part of the voltage appearing at the anode and feed it back to the grid in the right sense, the circuit will start to oscillate at a frequency determined by the circuit parameters.

We cannot, however, take the circuit of Experiment 18 and make it oscillate by joining the output to the input terminals, for the reason that when the grid voltage is increasing the anode voltage is decreasing, i.e. they are in opposite phase. Some means has to be found, therefore, to reverse the phase so that the change of voltage at the grid will increase the change at the anode instead of reducing it.

One way of doing this is to use a transformer where the phase can be reversed by simply changing over the ends of one of the windings.

The amplifier circuit will now be modified as shown in the circuit diagram. No bias voltage is necessary, because when the valve is oscillating, the grid will periodically become positive, so collecting electrons and causing grid current to flow through the grid resistor, the value of which is chosen to produce a suitable bias voltage. When the power is switched on, a tone should be heard in the loudspeaker, the frequency being determined by the tuned circuit comprising the inductance of the transformer coil connected across the input terminals and the capacity of the parallel capacitor, according to the formula : -

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

where L = inductance in Henries
C = capacitance in Farads
f = frequency in cycles per second

The variable resistance in the feedback should be adjusted so that the circuit is just oscillating and if the oscilloscope L97-150 is connected across the tuned circuit it will be seen that the waveform is considerably distorted if the feedback is excessive. Change the capacitor of the tuned circuit to 0.01 μf and readjust series resistance. The frequency will rise to approximately three times the original.

It may be noted that oscillations are generated even when there is no capacitor connected across the transformer coil. This is due to the self-capacity of the winding which resonates with the inductance.

EXPERIMENT 20

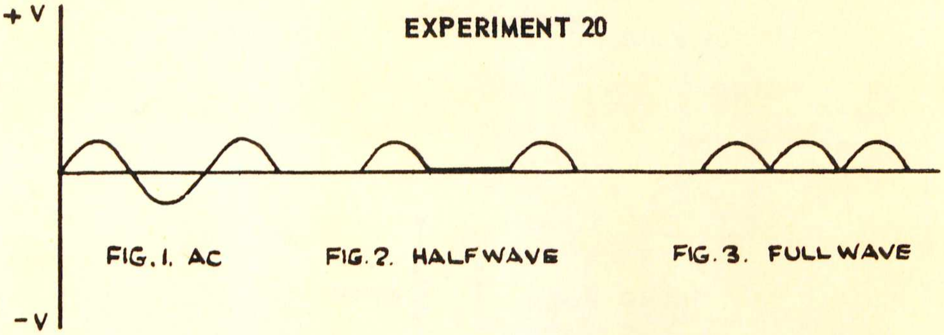
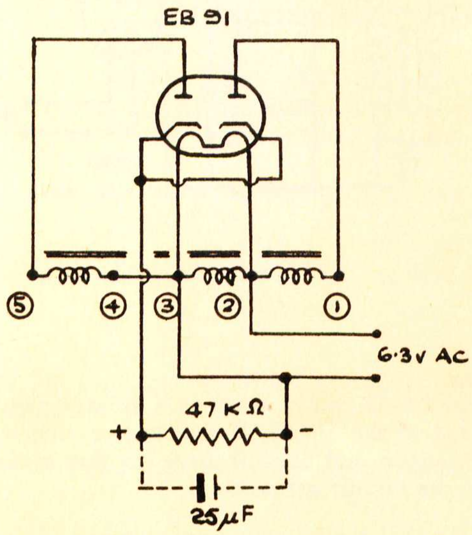


FIG. 1. AC   FIG. 2. HALFWAVE   FIG. 3. FULL WAVE



Half and full wave rectifications

Set up the EB.91 valve panel (part 7) join the two cathode terminals together with a short piece of wire and connect the heater to the AC and E screw terminals at rear of valve voltmeter, setting the A.C. control to MAX.

Fit Electrolinx to tags 1, 2, 3, 4 and 5 of the transformer (part 8) joining 3 and 4 and taking a wire from this junction to one side of the valve heater. Connect the other heater to transformer tag 2. Join tag 1 to one of the valve anodes.

Clamp a 47,000 ohm resistor (part 222) between two Electrolinx fixed at a suitable distance apart on the baseboard and join one end to the valve cathode and the other to the junction of the transformer windings as shown on the circuit diagram.

The transformer in this arrangement is being used as an auto-transformer. The part winding between 2 and 3 is used as the primary and is fed with 6.3 volts A.C. The two full windings 1 to 3 and 4 to 5 become a centre tapped secondary, delivering about 10 volts to each anode in opposite phase.

Plug the EB.91 valve (part 25) into its socket and switch on the power. Connect the oscilloscope across one of the transformer secondaries, say to tags 4 and 5 and adjust the controls to give a steady sine wave trace as in Fig. 1 Remove the oscilloscope leads and connect them across the 47,000 ohm resistor (part 222). The trace now appears as in Fig 2 and it will be seen that one half of the A.C. wave has been completely removed. The polarity does not reverse as it does with A.C. and a check with a D.C. voltmeter will show that the cathode end of the resistor is positive.

Connect transformer tag 5 to the second anode. The trace will now be as shown in Fig. 3, the gaps shown in Fig. 2 have been filled in. This is known as full-wave rectification.

The rectified waveform as shown by the oscilloscope is undirectional but is obviously not D.C. If, however, we now connect a large capacitor (25 microfarads part 33) across the load resistor, the ripple will be smoothed out and the result is an unvarying D.C. voltage, the value of which can be read on a D.C. voltmeter.

Measure the A.C. volts between either anode and cathode and then measure the D.C. volts across resistor with capacitor connected. It will be found that the D.C. reading is higher than the A.C. input. This is because the capacitor charges up almost to the peak A.C. which is $\sqrt{2}$ x the RMS value as read by the meter. Thus if the transformer gives 10 volts, the D.C. output will show approximately 14 volts D.C.

EXPERIMENT 21

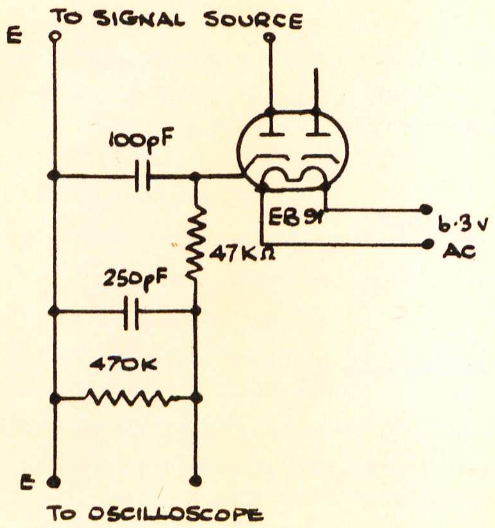


FIG. 1

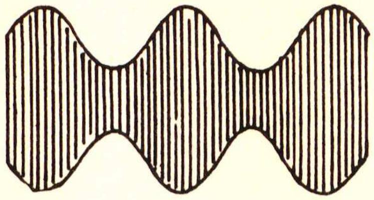
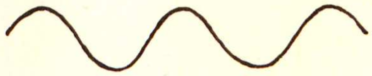


FIG. 2.



The diode as a demodulator or 'detector'

Set up the circuit shown in the diagram, using the EB.91 valve panel (part 7) and fitting Electrolinx to the base board in positions convenient for connecting the resistors and capacitors.

Adjust the signal source L97-155 to give maximum output R.F. at 200 kc/s modulated to 50% at 1000 c/s and connect the output cable to the oscilloscope L97-150 adjusting the controls of the latter until the trace looks like Fig. 1. This is the waveform of a modulated high-frequency alternating voltage which is produced by varying the amplitude of the high frequency voltage at a much lower frequency (in this case 1000 times per second). This is the type of waveform which is sent out from a transmitting station and to render 1000 cycle note audible we have to "detect" or "demodulate" the composite waveform.

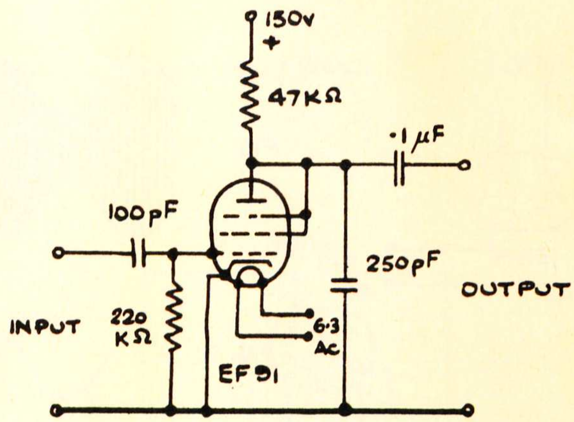
Transfer the signal source to anode and load resistor of the EB.91 (part 25) as shown in the diagram and connect the oscilloscope across the 470,000 ohm resistor (part 219.) Switch on the valve heater supply and note when the oscilloscope trace appears it shows the 1000 c/s waveform only (Fig. 2).

The diode has rectified the high frequency A.C. and the capacitor-resistor network has smoothed out the uni-directional pulses to produce a D.C. voltage in a similar manner to that shown by Experiment No. 20.

Note, however, that the capacitors are much smaller than that used for the low frequency experiment. The values chosen are such that they behave almost as a short-circuit to the 200 kc/s pulses but offer a considerable impedance to 1000 c/s. If a 25 microfarad capacitor (part 33) is temporarily paralleled across the 250 picofarads (part 232) the modulation will disappear and a steady D.C. will result.

Repeat the experiment with other depths of modulation. A measure of the demodulation efficiency may be obtained by comparing the amplitudes of the modulation waveforms before and after the valve.

EXPERIMENT 22



The triode as a detector

The triode may be used as a combined detector and amplifier of modulated high-frequency signals and probably the most commonly used circuit is that shown in the diagram. This is known as the leaky grid detector.

Considering first the input circuit, it will be seen that initially there is no negative bias on the grid which will therefore conduct freely when it is made positive with respect to the cathode but opposes the flow of current in the opposite direction. In this respect it behaves as a diode (see Experiment 20) converting an applied A.C. signal to D.C. the polarity of which is such as to bias the grid negatively. The value of this D.C. voltage is determined by the amplitude of the applied signal and the value of the grid resistor. If an unmodulated R.F. signal is connected to the input a steady state is reached when the power extracted from the signal is just sufficient to maintain the bias voltage across the grid resistor.

If now the signal amplitude is reduced, the capacitor will discharge through the resistor until a new state of equilibrium is reached.

Using a modulated R.F. signal, the negative voltage at the grid will vary in sympathy with the modulation about the mean or operating point of the I_a, V_g curve, provided suitable values of R and C are chosen.

Considering now, the valve as an amplifier, we have a varying voltage on the grid which we know from Experiment 18 produces a magnified replica across a resistor connected to the anode. A small capacitor joined between anode and cathode by-passes the radio frequency pulses, leaving the low frequency almost unaffected. This low frequency may be made audible by connecting a pair of headphones, or further amplified so as to energise a loudspeaker.

An oscilloscope connected to the output will show the modulation waveform. It should be observed that the operating point moves along the I_a, V_g curve of the valve according to the amplitude of the input signal. This is because more grid current flows when the amplitude of the input signal is large so, increasing the potential drop across the grid resistor. There will be a certain value of input at which detection will be most satisfactory. Too high or too low an input will produce distortion of the output waveform due to curvature of the valve characteristic.

Take measurements of the output voltage for various values of input signal for determination of overall efficiency using the oscilloscope to check distortion.

SPARE PARTS FOR L97 - 100 - 160

L97-195/05	**Valve base assemblies**, 1 each pentode (part 6) and diode (part 7)
L97-195/10	**Switch Kits**, comprising 6 each selector and key switch arms (parts 4 and 5), 12 each screws (part 37) nuts (part 38), washers (part 39), screws (part 40), Electrolinx and caps (parts 42 and 43) and polythene balls (part 44)
L97-195/15	**Transformer** (part 8)
L97-195/20	**Potentiometers,** 1 each of parts 10, 11 and 12
L97-195/25	**Board layout diagrams,**, packet of 1 doz. complete sets
L97-195/30	**Loudspeaker,**(part 16)
L97-195/33	**Lamp Kit,** comprising 4 lampholders (part 20) 2 neon lamps (part 31) and 4 M.E.S. bulbs (part 32)
L97-195/40	**Relay,** (part 13) complete with bracket (part 29)
L97-195/45	**Electrolinx** (part 42) packet of 30 complete with caps, with 30 each washers and screws (parts 39 and 37) and 6 nuts (part 38)
L97-195/50	**Condensers, electrolytic,** 1 each of parts 33, 34 and 35
L97-195/55	**Resistors,** 2 each of parts 218-226 inclusive
L97-195/60	**Valve,**, EB91, (part 25) double diode with separate cathodes, for L97-100, L97-150 and L97-160
L97-195/65	**Ditto,** EF91, (part 24) high slope general purpose R.F. pentode, for L97-100
L97-195/70	**Ditto,** ECC81, medium amplification factor double triode with separate cathodes for L97-155
L97-195/75	**Ditto,** ECC82, low amplification factor double triode with separate cathodes, for L97-155 and L97-160
L97-195/80	**Ditto,** ECL80, combined triode and output pentode, for L97-150
L97-195/85	**Transistor,** OC71, part 26 all-glass junction
L97-195/90	**Crystal diode,** OA81, (part 27) germanium point-contact, all glass.

360

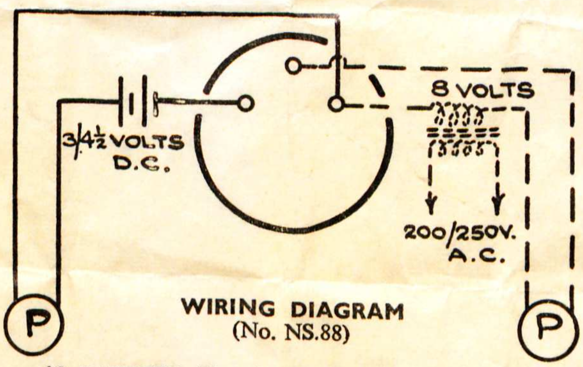
CAUTION
Both Pushes should not be pressed simultaneously.

GENTS' OF LEICESTER

Fig. 384

DUO-TONE

Miniature BUZZER



WIRING DIAGRAM
(No. NS.88)

1. **For use with BATTERY** (Ever Ready No. 800 or No. 126) Pull off cover of Buzzer. Feed two wires through hole in base and attach one to each **outer** terminal. (Ignore centre terminal.) Connect **other** end of one wire to one terminal of Push and other wire to one side of Battery. Connect other terminal of Push to other side of Battery. Screw Buzzer down **firmly** for best results. Replace cover.

2. **For use with TRANSFORMER** (Gents' Fig. 1139) Pull off cover of Buzzer. Feed two wires through hole in base and attach one to centre terminal. Ignore blue marked terminal and attach the other to the unmarked terminal (as shown on diagram above). Connect other end of one wire to one terminal of Push and other wire to 8-volt terminal of Transformer. Connect other terminal of Push to other 8-volt terminal of Transformer. Connect Transformer to mains supply. Replace cover.

3. **For use with Battery AND Transformer (for 2 Pushes).** Carry out instructions as for 1 and 2 above, noting that in this case two wires are attached to the outside unmarked terminal (see diagram).

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